Case No.

file #1

407

Application, Transcript,
Small Exhibits, Etc.

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
DEC 3 1952

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

TRANSCRIPTION OF HEARING

CASE NO. 407

November 20, 1952

E. E. BREESON
ADA DEARNLEY
COURT REPORTERS
BOX 1503
PHONES 5-9422 AND 5-9546
ALBUQUERQUE, NEW MEXICO

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

NOVEMBER 20, 1952

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In the Matter of:

(Cont'd. from September and October hearings) The Commission's motion for extension of Section "G", Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary 80-Acre Proration Units.

Case No. 407

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(Notice of Publication read by Mr. Graham.)

MR. SPURRIER: The meeting will come to order, please. Before we take up the next case, which is 407, I would like to read an announcement which Judge Foster handed me. "A meeting of Texas oil operators will be held in Dallas, Texas, on Tuesday, November 25," that is next Tuesday, November 25, "at 10:00 o'clock a.m., in rooms 1509 and 1510 of the Magnolia Building, for the purpose of discussing the proposed changes of the Railroad Commission of Texas, of Statewide Rules 24 and 25, pertaining to the production proration and allocation of gas from gas wells which will be considered by the Railroad Commission at a hearing which has been called for nine a.m., December 9th, at the Commodore-Perry Hotel, Austin, Texas". Now, we will proceed with Case 407.

MR. SPURRIER: Mr. McKellar.

MR. MC KELLAR: Mr. Spurrier. As a member of the committee that the Commission has appointed to study this matter the committee held a meeting in Lovington this past Monday which was a most inconvenient date in my - - for me, because I couldn't attend. I didn't see the notice of the meeting until Friday and because of previous arrangements I couldn't be there but I had a representative and there is a misunderstanding between myself and certain others of the committee as to what our mandate from the Commission is. There has been various arguments injected into the committee's 40 acres versus 80 acres and vice versa back and forth and my understanding of one mandate was that we were to adopt a proposed recommendation. The Commission had, on its motion, taken a case under advisement. At least for my personal benefit, if I am to serve as a member of the committee with any value at all, I wish that the Commission would reissue in more detail form the mandate to the committee members. I understand that a wire has been sent to the Commission by the Chairman of this committee to the effect that it was unanimously agreed that the case be continued. My representative had no such authority to agree to any such continuance. He tells me that he did not knowingly agree to any such continuance, so there is obviously a misunderstanding although I am sure it was in good faith between the Chairman of the committee and Magnolia's representative.

This case has been carried on this Docket this is the third

month. Aside from my duties as a committee member and speaking now only on behalf of my client, Magnolia Petroleum Company, we want the case brought before the Commission at the earliest possible date and I am now on my feet here today to make certain recommendations on behalf of my company. We feel it is our opinion that any 80 acre spacing order, temporary 80 acre spacing order, along the lines of that proposed by this Commission should embody certain sections. One of those is that the order should be effective at the depth of 10,000 feet which the Commission proposed. Number two is, if you remember when I was here three months ago to discuss this matter, I was of the firm opinion that no time limit should be placed on this proposed order, that it should, the criterion should be five wells. After going into the matter at some length and discussing it I realise that such a proposal could be abused by operators to the injustice and prejudice of other operators and possibly royalty interest. So I now make my recommendation and would like to recommend to the Commission that this proposed order be for a period of 18 months or five wells, whichever should occur sooner, so that no operator could drill four wells and simply sit back. Of course, realizing that in 18 months if we had only drilled two wells an operator could come in and ask for further continuance of the temporary order and that matter could be heard on its merits but I think in all fairness to the royalty owners and the other operators that an 18 month time limit is reasonable. That is hard work for me to say since I have told George Graham I thought

it was highly unreasonable. I want to tell you, George, I have come around to your line of thinking. I was wrong about it. The third essential that I think the order should embody is that these wells be placed on a fixed spacing pattern, placed in diagonal quarter sections with possibly the discovery well setting the pattern. Now, I have a proposed temporary 80 Acre spacing rule which is not original with me. I discussed the points that my company thought should be embodied in such a rule with a great many operators who were present here in Santa Fe, practically all I could contact. I discussed this plan with them and we changed it from time to time and I would like to read into the record a suggested Statewide Rule that our company agrees with and then I would like to submit it to the Commission Staff for their study. I will read this, it will just take a moment. First paragraph,"After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres." Second paragraph, "The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located withinin 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each

quarter section shall be divided into two proration units, running either north and south or east and west." Paragraph three, "Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well or within eighteen months after the completion date of the discovery well, whichever shall occur first, a hearing shall be set for the purpose of determining whether or not 80 acre spacing should be continued in effect." Fourth paragraph, "Certified plats of proration units shall be filed with the Commission and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing."

I would like to submit this not for an exhibit but just for the Commission's consideration.

In summing up my remarks, Mr. Chairman, I would like to urge the Commission to, as I say, issue a new mandate to the committee urging upon the Chairman to call the meeting at least a week ahead of the next statewide hearing. We have the Oil and Gas Association coming up in Albuquerque the first of the month. It may be that we can meet in conjunction with that hearing for a short time or at some other time, but at least enough time to where we can meet with the committee and take its recommendations back to our clients. Along with that mandate I think it would be well if the Commission, if their staff have any definite thoughts, which I am sure they have on this matter, to submit a proposal, a proposed rule to the Committee and ask the Committee for their recommendations and considerations of that

proposed rule.

That is all I have to say. If there is any question that anybody has as to what my company's position is in the matter I will be glad to answer them.

MR. SPURRIER: Does anyone have a question of Mr. McKellar? Anyone else to be heard in this case?

MR. HILTZ: R. G. Hiltz, with Stanolind. Our original thoughts on the question were submitted by letter to the Committee. It was our letter from Mr. C. F. Bedford, dated October 20, 1952, filed RGM 5247-175. I would like to request that letter be made a part of the record of this case. Our original thoughts differed very slightly from the rules which were proposed by Mr. McKellar but I would like to state that we have now reviewed the suggested rule and we are in full accord with the suggestion as read into the record. In addition I would like to point out that since the rule would operate in any case on a temporary basis I fail to see how it would adversely affect any of the interested parties. It simply means in the early stages of the development of the field we could be assured of an intelligent, uniform manner of development until sufficient data became available to determine the optimum spacing pattern for the complete field development. Prior to making a decision in this case we could acquire the necessary facts to support the right conclusion. We feel that this is a realistic progressive development in conservation in New Mexico and we strongly urge the Commission to adopt a rule of that sort.

MR. KELLAHIN: Mr. Kellahin, Phillips. Mr. Chairman, I attended the meeting of the Committee that Mr. McKellar referred to, as an alternate member. I would like to second his statement made as a result of that Committee meeting. There was considerable confusion as to the purpose of the Committee and discussion seemed to center around the merits of 80 acre spacing. I would like to second the recommendation that the Commission issue a little - - further clarify its instructions as to what is desired of the Committee if it is to continue to function. Also, Mr. McKellar stated that the telegram that was sent by the Committee Chairman said it was a unaminous request that the hearing be continued or postponed and that was certainly not my understanding of the results of the meeting. The representative of Magnolia certainly did not agree to the postponement, nor did I.

MR. SPURRIER: Thank you. Before we go any further I probably should have read this to begin with. This telegram that is in question or has been mentioned here, sent to the Commission by G. T. Hanners, acting Chairman. "Your Committee on spacing, Case No. 407, met at Lovington Monday morning, 17 of November, with Committee members Leonard Christy, Dan Glidden and Hanners present. Wally J. Ford, Magnolia engineer present in behalf of Committee member McKellar. Mr. Kellahin , attorney, present in behalf of Committee member Foster and W. Glen Staley, of Operators Committee, and DuPont of U.S.G.S. and with representatives of New Mexico Educational Association and other interested

parties present. Importance of the case and complexity of questions will require additional time for preparation and submission of Committee report and recommendations. Your Committee recommends, unaminously, postponement of November 20 hearing and resetting the case for a later convenient date".

There are people here prepared to testify today and although this telegram, the meaning of the telegram, is not quite clear to me. I assume that they mean that the case should be continued rather than the testimony should not be presented today. Therefore, the Commission will take any testimony that you may be ready to present. Are there any other members of the Committee present? Mr. Christy.

MR. CHRISTY: I am also a member of the Committee and attended the meeting as the telegram indicates. I did agree to a continuance, in hopes that the Committee might get together with some kind of a proposal. I might add it would be a hope on the thing. I believe, however, that if the Commission is going to take this under advisement I would concur in the proposed rules as given by Mr. McKellar, and urge their adoption. The Committee was asked - - the Committee charged a few members of the Committee, the engineering members particularly, to propose these rules and I have discussed the rules with two other members of the Committee, the representatives of the Engineer Department, and I am reasonably sure that these are the rules that the Committee would propose. Whether all the members of the Committee will agree to it or not I can not answer that be-

cause they haven't all seen them. I certainly urge the adoption of the rules given by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. FOSTER: Mr. Foster, representing Phillips Petroleum Company. We have already had the report of Mr. Kellahin who attended the Lovington, New Mexico meeting. My representative placed on the Committee. Of course, Phillips Petroleum Company came here prepared to put on some testimony this morning. We have witnesses and we would like the opportunity to do that. I might add that we are very much in accord with the suggested recommendations made by Magnolia on the rule. I believe that these suggested changes in the rules meets with the general approval of all the operators and perhaps before the meeting is over all the operators will have expressed themselves on the matter. When I got the letter appointing me as a member of that Committee I viewed the letter as requiring the Committee to consider the suggested temporary 80 acre proration unit order on the basis that it was assumed that the Committee or that the Commission was considering the adoption of such an order. I did not understand that the Committee would go into any discussions of whether you should or should not have 80 acre proration units established in the State of New Mexico. As far as I am concerned I think it would ba a useless procedure to have the Committee consider the question of whether you are going to have 80 acres or 40 acres. Further I think it would be contrary to what the established policy of this Commission

already is because the Commission has granted 80 acre units: there are four of them in effect in the state now. I take it that the purpose of the Commission in appointing this Committee was simply to find some workable way to implement the policy of the Commission that had already been established by way of the granting of applications for 80 acre proration units. As far as I am concerned I just don't want to get into any argument now, as a member of that Committee, on the question of 40 acres versus 80 acres. The Committee can't decide that. It seems to me that the letter that the Commission sent out, the letter that you, Mr. Spurrier, sent out, was perfectly clear that we were to proceed on the theory that we were to discuss only the proper sort of order that should be made establishing 80 acres. If that isn't clear I want to add my voice to that of the Magnolia representative that it be made clear to this Committee what their functions are, so that if we do have another meeting there won't be that chance or opportunity of argument between members of the Committee as to what they are to do. Now, whenever everybody else gets through expressing themselves about this matter I want to put on a little testimony about this matter.

MR. SPURRIER: I think I might help the status of the record if I would read the proposed Rule 407, as we proposed it some time ago. "One, temporary 80 acre proration units are hereby established for wildcat wells as defined in Rule 104A completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505A. Two, after the effective

date of this order no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production. Upon completion of five wells to the same producing formation within a radius of two miles of such wildcat wells the proration units shall be established at 40 acres unless the operator can establish by clear and convincing evidence that one well will efficiently and economically drain the 80 acres assigned to the well. And such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at the said hearing."

I might say that we, the Commission, appointed this Committee. They were appointed to advise the Commission on this proposed rule. The Commission realized that the question of 80 versus 40 acre spacing was a part of the thing at hand but we did not intend that the Committee should report to us whether they recommended 40 or 80 acre spacing. We intended that they report to us or recommend to us on this proposed rule. On matters of depth specifically I set out in my letter at what depths should order be effective, how many wells should be drilled before the hearing is called and should there be a time limit for the date of the hearing.

MR. GRAHAM: Was it not also your idea, Mr. Spurrier, that there probably would be a majority report and a minority report, that we might have both sides?

MR. SPURRIER: I wouldn't say that I thought there probably would be, I thought there was a possibility there would be.

MR. ADAMS: Mr. R. E. Adams, Cities Service Oil Company. As I understand the proposed rule by the Commission, that wouldn't fix the 80 acre spacing pattern for the field. As I understand Mr. McKellar the recommendation of the Committee would. In other words if you drilled a discovery well below 10,000 feet you wouldn't offset that discovery well under the Magnolia recommendation, is that correct?

MR. SPURRIER: That is the way I understand it.

MR. MC KELLAR: That is correct but that is not the recommendation of the Committee. That was entered. That is, I am speaking only for Magnolia Petroleum Company. I said they weren't original with me. I have discussed them with a good many operators. That is not a Committee, that is neither the Majority nor the Minority Committee report. That is something I have entered on behalf of Magnolia. You are correct, you could not, unless because of the data that you received from drilling your discovery well, come in and ask that your discovery well be declared an exemption under the rule and then drill a 40 acre offset and throw your discovery well out for your later deliberation. The attorney put that in because you come up here after locating the proration units and you drill five wells and you have 40 acre wells.

MR. ADAMS: Not necessarily.

MR. MC KELLAR: Not necessarily but it often happens. I realize by having the definite step out and I realize it is highly controversial, it was the thought of my company that it would force an operator if he wanted 80 acres, if that is what he wanted.

MR. ADAMS: An operator might not want 80 acres if he drills a discovery below 10,000 feet. I think that a reasonable operator would offset that well. We have done it down here and we will do it again.

MR. MC KELLAR: That is a point to be considered, the Commission's original proposed rule did not say can not, it said "will not have to", or words to that effect.

MR. ADAMS: That is the way I understood the proposed rule.

MR. MC KELLAR: My proposal on behalf of Magnolia differs from that. That is not a Committee recommendation it is just my --

MR. ADAMS: (Interrupting) Cities Service wishes to go on record as opposing the Magnolia proposal for discovery well on 80 acre spacing. If we go below 10,000 feet we want the permission to offset that well on 40 acres if we so desire.

MR. SPURRIER: Anyone else?

MR. SHAVER: Charles Shaver, representing the Humble Oil and Refining Company. We concur in the proposed rule submitted by Mr. McKellar and also his recommendations. We feel that these rules are not only proposed rules, not only appropriate

but adequate and we would like to urge the Commission to adopt the Statewide Rule along these lines.

MR. SPURRIER: Anyone else?

MR. BALLOU: My name is Ballou, representative from the Sun Oil Company. We went on record in September as favoring the proposal of the Commission. The feeling of the Sun Oil Company that the proposed 80 acre rule suggested by Mr. McKellar would bring about orderly development and also permit a more rapid delineation of a new producing reservoir. We favor the proposal.

MR. SPURRIER: Anyone else?

MR. RAY: Carl Ray, with the Texas Company. We have expressed our views on this proposed order to the members of the Committee. The proposal of the Magnolia Company essentially embodies our proposals in this matter. We are especially desirous of having the fixed spacing provision in that order and we wish to urge the proposal of the Magnolia Company be seriously considered by the Commission in writing such an order.

MR. SPURRIER: Anyone else?

MR. ADAMS: Cities Service is not opposed to 80 acre spacing below 10,000 feet but we do feel that an operator that drills a discovery well should have the option of making the next location as he sees fit. The 80 acre step out, I don't know how many feet that would be, it would be well in excess of 660.

MR. MC KELLAR: 660. No, it would be 1800 and some feet with the next step out, I think. We would like to make a direct

offset to the discovery well.

MR. SPURRIER: Anyone else?

MR. WALKER: Don Walker, with Gulf. We would like to go on record as concurring with the proposed rules as recommended by the Commission and as modified by the statement in the suggested changes as read by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. CROCKER: J. H. Crocker, with Mid Continent Petroleum Corporation. In view of our interpretation of the statutes of New Mexico we think that the Commission is rightfully on its own motion made a suggestion for consideration with respect to this temporary 80 acre proposition. We wholeheartedly support the position as taken by Mr. McKellar with respect to the points made by Mr. Adams. We feel that any operator if he wants to directly offset the wildcat that came in on 40 acre pattern this Commission is always open to applications for exceptions. As I understand this Commission has no authority to require wells to be drilled on a density that is more than necessary for adequate drainage. If one well will adequately drain 80 acres and the Commission agrees with that position it has just one position it can take and that is to authorize a stand back of 80 acre spacing. I think until that question of changed conditions that the pattern that can adequately be drained, the largest pattern is the one that the state should adopt and we agree with the positions that have been taken.

MR. SPURRIER: Anyone else?

MR. HOWARD: R. E. Howard, with Atlantic Refining Company. We would also like to concur with proposal submitted by Mr. Mc Kellar on behalf of Magnolia Petroleum Company. I believe that at the September hearing we went on record at that time as favoring temporary 80 acre spacing for wells below 10,000 feet. We would like to concur with the rules as, the proposed rules as submitted by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. GRAY: Ralph Gray, of Buffalo Oil Company. Our company would like to see some type of temporary 80 acre spacing program adopted. We ourselves have spent close to half a million dollars drilling one of these deep wells and we don't see how even a major can drill those kind of wells indiscriminately. I would be inclined to with-hold recommendations as to the exact spacing program that should be followed until this Committee has its final say. I think that the Committee should, if they're going to continue to study this problem, should put their stress on determining if it is feasible to have anything other than just a strict diagonal spacing pattern adopted, so maybe they can come out with something that will be a little more satisfactory along that score.

MR. SPURRIER: Anyone else?

MR. SELINGER: If the Commission please I would like to point out a couple of matters in connection with this rule. First I would like to point out that this is the third month this matter has come up. It came up in the September, October

and November hearings. I believe that in the September and October hearings the matter of 40 acre versus 80 acres was at least given an opportunity to all express their views. Secondly I would like to point out that in connection with the suggestion made by Mr. Adams of the Cities Service that the difference between a diagonal and direct 40 acre offset is a difference between 1300 and 2000 feet and 1870 feet. I think comparatively speaking it is an inconsequential footage, you're going to a deep hole test. I would like to say in defense of the Commission, if they need any, I think their letter directed to this Committee was as clear and concise as anything possibly could be because attached to that was a proposed order of 407 which deals exclusively with 80 acres and the three questions propounded to the Committee in the form of instructions propounded by Mr. Spurrier are also definite and clear. I imagine the purpose of the letter of December 24th as compared to the proposed rule heretofore in the September and October hearings was the fact that there was no time element in the original proposed 407 Rule and the Committee was instructed to discuss that time element question. The suggestion of the Statewide Rule as proposed this morning, insofar as Skelly Oil Company is concerned, meets with our approval. There seems to be some question as to whether or not the Commission should go ahead with testimony this morning on this matter or not. It would be, I think, poor judgement to allow a portion of testimony to go in now and leave it hanging, dangling, until a continuation of the hearing and it is our suggestion that after

all the views are expressed that the matter be set over to the December hearings, let the Committee as appointed re-read Mr. Spurrier's directions of September 24th in connection with the Rule 407 as attached to that letter, let the Committee come back at the December hearing, make its suggestion and then the entire matter can be decided with the conclusion of testimony at that hearing.

MR. SPURRIER: Mr. Dailey.

MR. DAILEY: Perhaps some of the members are opposed to 80 acre spacing and that they think that by writing any rule like this it would be favoring something that actually they are opposed to. In other words it would put them in a position where they could present a Committee report that is a workable rule and it would prevent them from testifying against the adoption of such a rule.

MR. SPURRIER: Anyone else?

MR. MC KELLAR: I would like to, in defense of the Committee members that differ with me, that are not here, I would like to point out that it is perfectly feasible for reasonable minds to differ on anything that is written down. If it was not we lawyers would be hard pressed to making a living. We would have to go back to engineering.

MR. SELINGER: That may be the trouble of the oil business today.

MR. MC KELLAR: Those men are conscientious as well as Christy and Foster and myself in wanting to represent the clients

and serve the Commission. We simply disagree among ourselves as to what the instructions were. We read those things more than a casual glance, I am sure. I do want the Commission to give us something else to work on or discharge us as it is we didn't agree on the - - what the mandate is. We read those things.

MR. SPURRIER: Incidentally, I don't know that it is a point that is too serious but the Governor could not be here today because he had a meeting of the Canvassing Board. Does anyone else have a comment in the case? As far as the Commission is concerned anyone that cares to put in testimony in this record may do so, the choice is yours. If you want to take Mr. Selinger's suggestion that is up to you. If you do not we are ready to take the testimony.

MR. FOSTER: This case will be heard in December, will it not?

MR. SPURRIER: The Commission said it will, December 16th we will continue the case to that date for receiving further testimony and/or the recommendations of this Advisory Committee.

MR. FOSTER: I came here, of course, prepared to put on some testimony. I didn't know about this telegram until I got here. I brought a witness here but I don't want to take up the Commission's time to do it when it might not be as effective as if we waited until the December hearing.

MR. SPURRIER: Judge Foster, only as a suggestion I mention the fact that Governor Mechum could not be here.

MR. FOSTER: Yes.

MR. SPURRIER: Perhaps you would like to have a full Commission hear this case.

MR. FOSTER: I would indeed, I would like to have a full Commission because we would just have to repeat it again so that everyone would know what the record is. I realize that some members of the Commission don't have time to read these records.

I believe as far as Phillips is concerned we will just not put on any testimony now if that is really going to be set for hearing on the 16th of December. Is the fact that you're going to set it does that include a statement that in all probability it won't be continued again.

MR. SPURRIER: I don't believe we could rule on that, Judge, it depends upon the testimony and the recommendations of that Committee, I suppose.

MR. FOSTER: Of course it is obvious to me that if the Committee members are going to maintain the attitude that they have about what their directive is from this Commission that you're not going to get any report out of this Committee that is going to be of any help to this Commission or anybody else. So, I just wanted to get that in the record. I like to look at these things realistically, not just be kidding myself here about anything. We are very much in earnest about this temporary 80 acre rule. As far as I am concerned personally and as far as Phillips Petroleum Company is concerned we just can't see how anybody could have any reasonable objection to a temporary rule. Certainly

no one would contend, it seems to me, that if one well will adequately and economically drain 80 acres that you ought to drill two wells on it. I just can't find any basis in my reading or thinking for anybody to be opposed to a temporary order. In view of that it seems to me that the only question to be considered is just what kind of a temporary order you are going to have, not whether you are going to have one or not. That, I thought, was to be the function of the Committee. If the Committee can get together and discuss that thing I am sure, on that basis, I mean, if we could get all the Committee members to approach it on that basis it seems to me we ought to come up with some recommendations. Maybe we will be divided numerically three and three on some matters, four and two on others, and five and one on others. It seems to me that this Commission will now make it clear to all members of this Committee that they are not to consider whether we are going to have 80 acre temporary order or not but what kind of an 80 acre temporary order we are going to have. Maybe three of us here who represent these predatory interests will be able to convince the other members of this Committee that they ought to sit down across the table with us and discuss a problem that is in my opinion and in a lot of the operator's opinions of a very serious nature to the real interest of the State of New Mexico. This isn't any laughing matter. I believe that if you can get a fellow to listen to you long enough you can make a little headway sometimes. Sometimes it seems like you have to get him to listen too long but in any event I believe that with the help

of the Commission now and directing these other members and asking them to call it within a reasonable length of time too -- the matter has dilly dallied along here for nearly 60 days before they called a meeting. They didn't consult with anybody as to what would be their convenience about a date, they just set it down and said "You be there". It just so happened that some of us could not be there because of previous committments. I believe that we should take all these things into consideration and make one more effort here to see if we can get something out of this Committee and maybe it might be of some help to the Commission. On that basis as far as Phillips is concerned we will just forego the presentation of any testimony at this time but I don't want to be understood as agreeing to any more continuances of this thing. We would like to get it heard. It looks like 90 days ought to be long enough.

MR. SPURRIER: Anyone else? I might say, in line with the Judge's suggestion, that I believe the Commission's letter instructing the Committee is pretty clear.

MR. FOSTER: I think it is crystal clear. I don't see how anybody could misconstrue it but apparently they did.

MR. SPURRIER: Anyone else? If not the case will be continued to the definite date of December 16, the next regular hearing.

MR. BALLOU: Before you go on that, Mr. Spurrier, the Cun Oil Company is still in the process of attempting to complete the well we mentioned at the September hearing. We hope sometime to

to be able to complete that well. It would be considerable help to Sun Oil Company to know whether we are going to have a diagonal rule or whether you can offset on the next 40 or what kind of rule you are going to have. We would like to urge that this thing be brought up and decided on at the December 16th hearing, so that we will know how to proceed with development if and when we complete this well. We think that the proposed rules are reasonable and it is something that everyone can abide by, if it is later proven that one well will not drain 80 acres you can go back to 40. Once you drill on 40 you can't undrill and put them on 80's.

MR. SPURRIER: Anyone else?

MR. BROWN: Brown, with Sun Oil. I have come to all these meetings and I have yet to find out who we are arguing about. It seems that everyone that comes says we want the rule. We just keep continuing. Nobody is objecting very seriously to anything. I would like to know if it is the wind we're fighting or what?

MR. SPURRIER: Mr. McKellar, would you like to answer his question?

MR. MC KELLAR: I don't want to seem as Mr. Moderator. I am not representing Mr. Hanners under any circumstances. No, seriously, I think possibly one reason that the opposition is not actively here is because working through their Committee members they are laboring under the impression that the matter will be continued. The Chairman submitted the recommendations

to the Commission and I certainly think in all fairness to those people that the Commission has no alternative other than to continue the matter. The first month we realized that such a controversial problem could not be decided, then the Commission appointed a Committee and the Committee Chairman recommended that the thing be continued to this time. The word went out and so the opposition, if that is the way you want to speak of it, at least the ones that probably are not here because of the fact that the Committee was appointed and their representatives on the Committee probably told them that it was recommended that the matter would be continued. There are some that oppose it.

MR. SPURRIER: Anyone else? We will take a five minute recess.

(Recess.)

STATE OF NEW MEXICO)
: ss
COUNTY OF BERNALILLO)

I HEREBY CERTIFY that the foregoing and attached transcript of hearing in Case No. 407 before the Oil Conservation Commission, State of New Mexico, at Santa Fe, on November 20, 1952, is a true and correct record of the same to the best of my knowledge, skill and ability.

DATED at Albuquerque, New Mexico, this 29th day of November, 1952.

Ada Dearnley
REPORTER

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 105-106, EL CORTEZ BLDG.
PHONES 7-9545 AND 5-9546
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CASE 407: OCC on own motion for Rule 508: Establishment of Temporary 80-Acre Proration Units (for wildcat wells)

Stone Exhibit — Case #07 (June 16 1953 hearing) 1

CUTLER'S RULE

THE ULTIMATE PRODUCTION FOR WELLS, OF EQUAL SIZE, IN THE SAME POOL, WHERE THERE IS INTERFERENCE, SEEMS APPROXIMATELY TO VARY DIRECTLY AS THE SQUARE ROOTS OF THE AREAS DRAINED BY THE WELLS.

2

PORTION OF HEALDTON FIELD, CARTER CO. OKLA.

FROM BUREAU OF MINES R.I. 4917 "PETROLEUM ENGINEERING STUDY OF HEALDTON OIL FIELD" FEBRUARY 1953

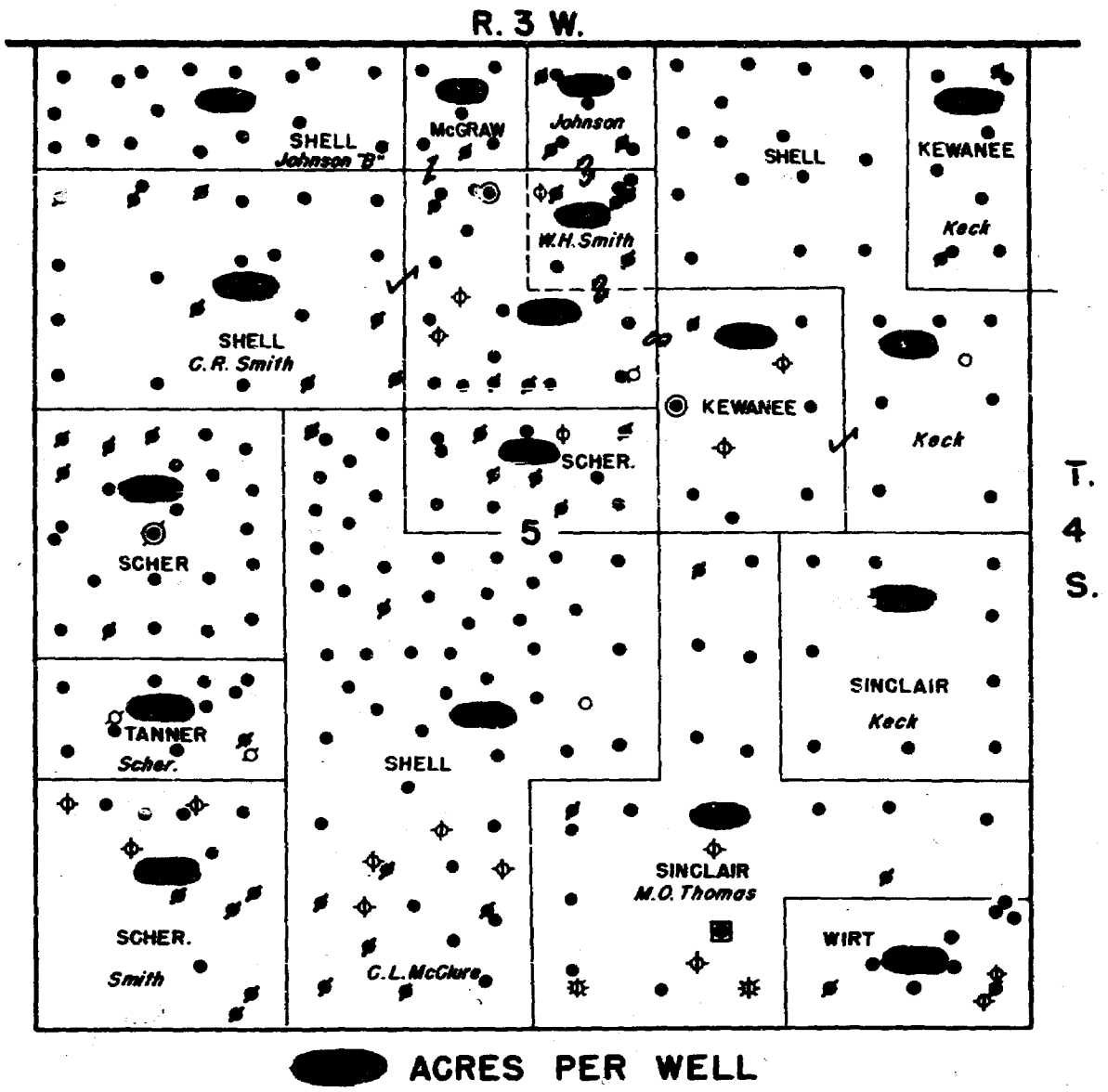
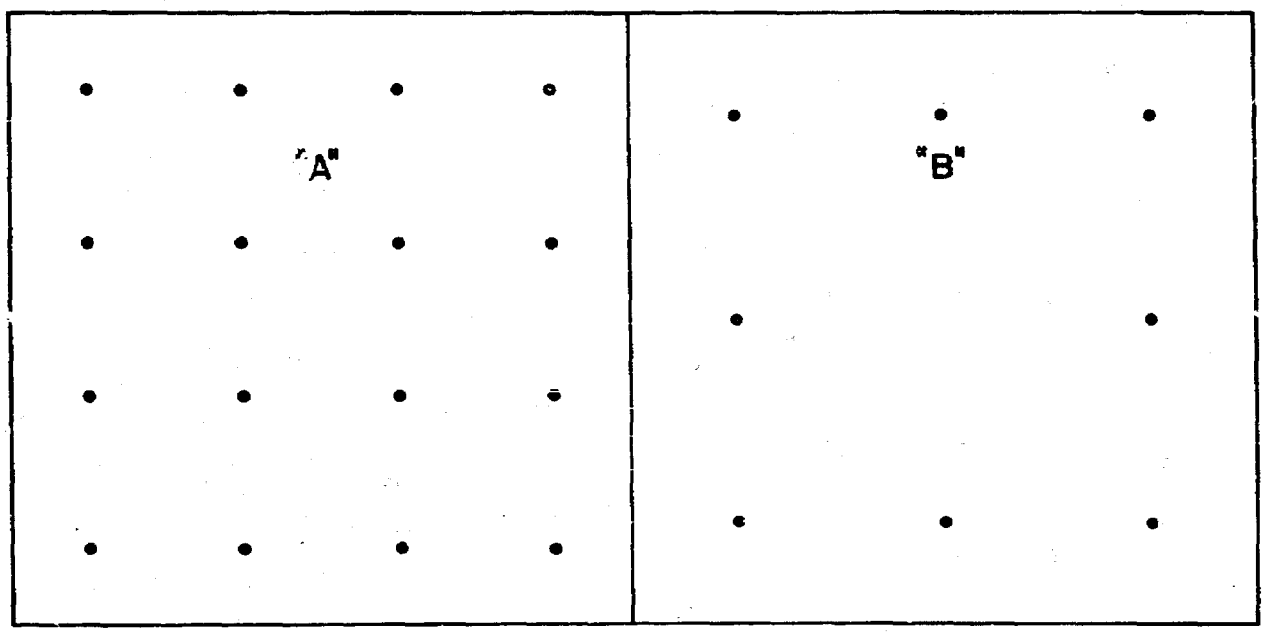
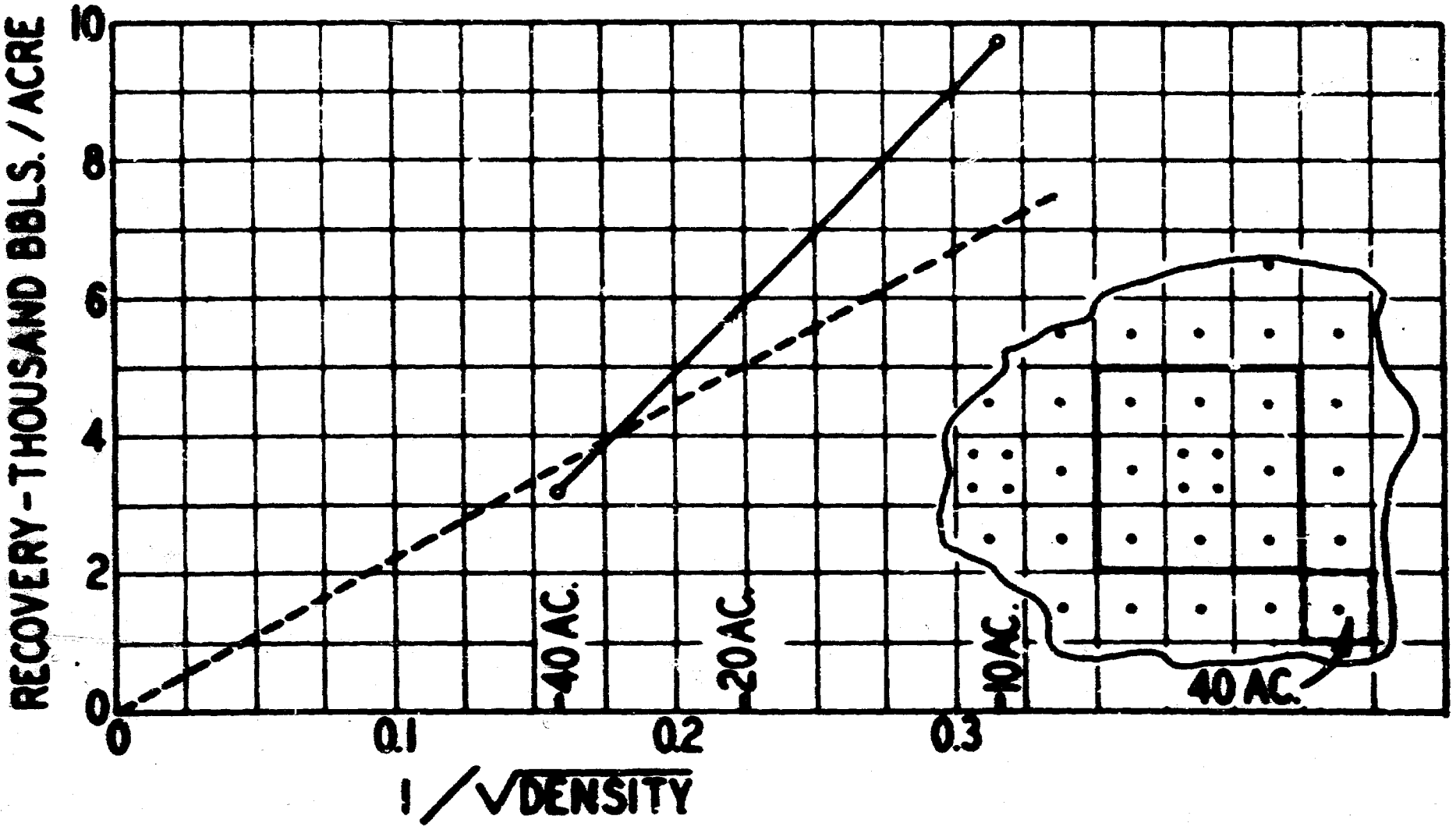


ILLUSTRATION OF CUTLER'S RULE

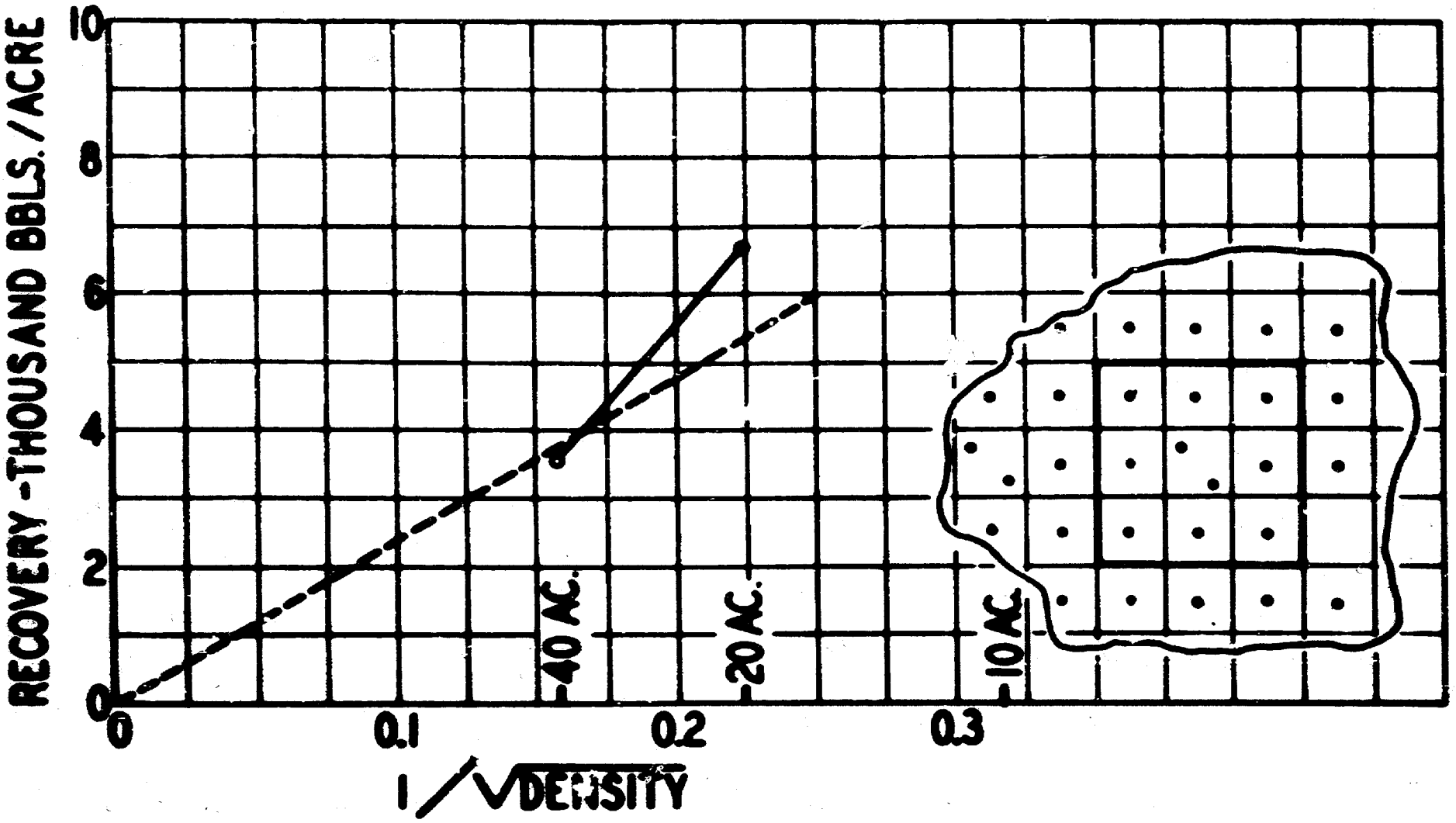


LEASE "A"	40 ACRES 16 WELLS	LEASE "B"	40 ACRES 8 WELLS
RECOVERY -	400,000 BARRELS 10,000 BBLS/ACRE 25,000 BBLS/WELL	RECOVERY -	283,000 BARRELS 7,070 BBLS/ACRE 35,400 BBLS/WELL

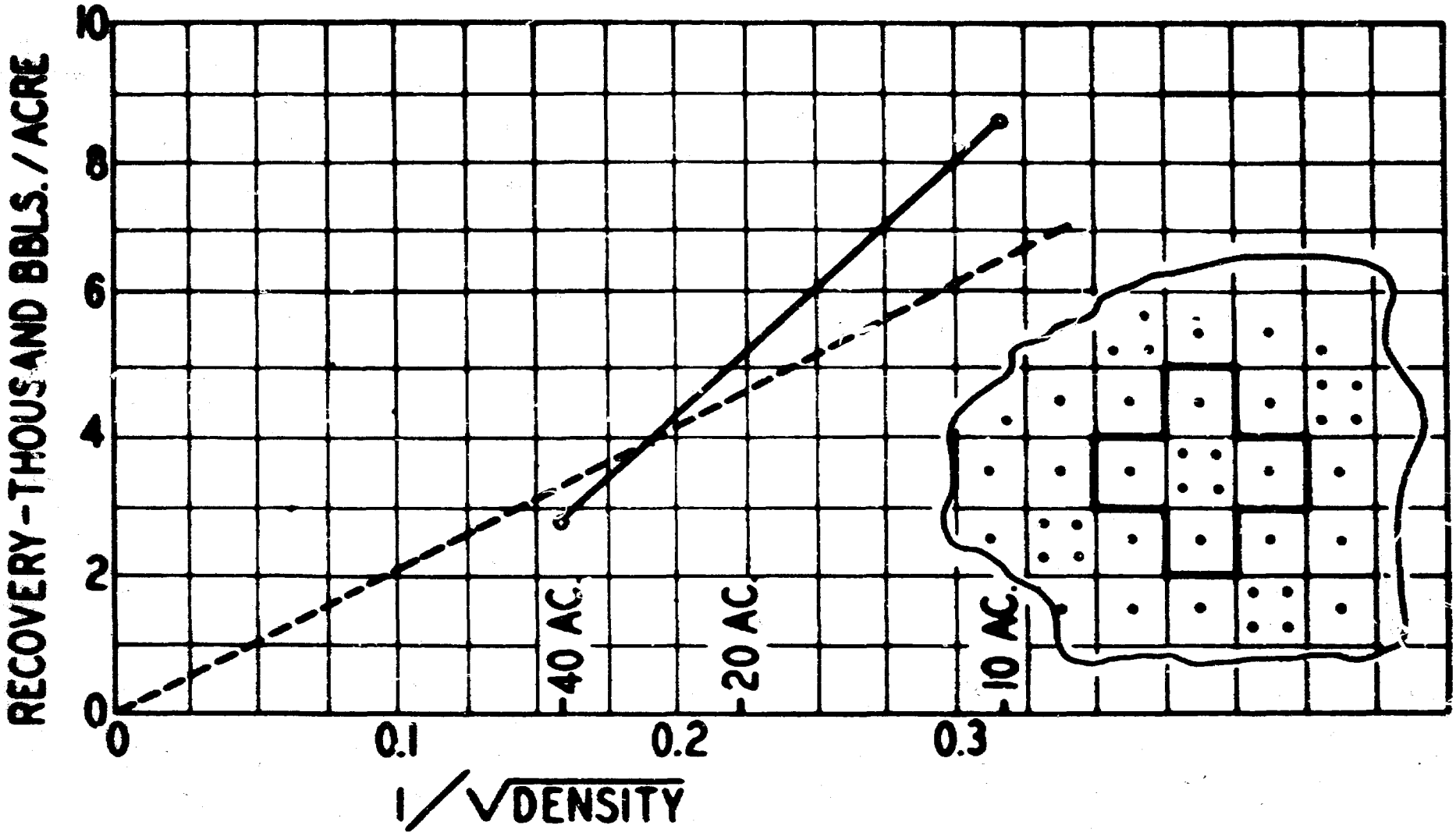
CASE 1


RECOVERY - THOUSAND BBLS. / ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
1/√DENSITY
40 AC.
20 AC.
10 AC.
40 AC.

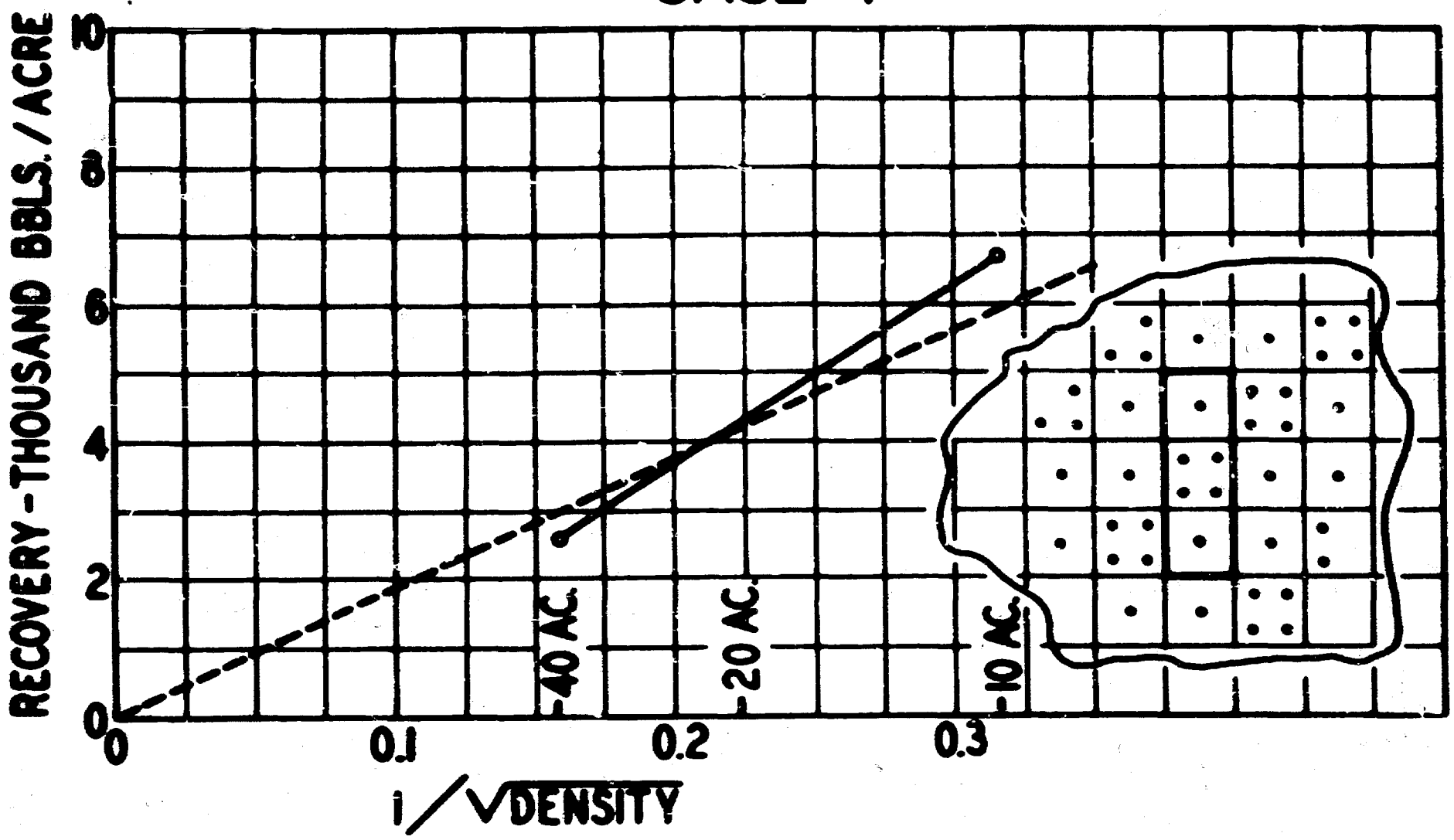
CASE 2


RECOVERY - THOUSAND BBLS./ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
1/√DENSITY
40 AC.
20 AC.
10 AC.

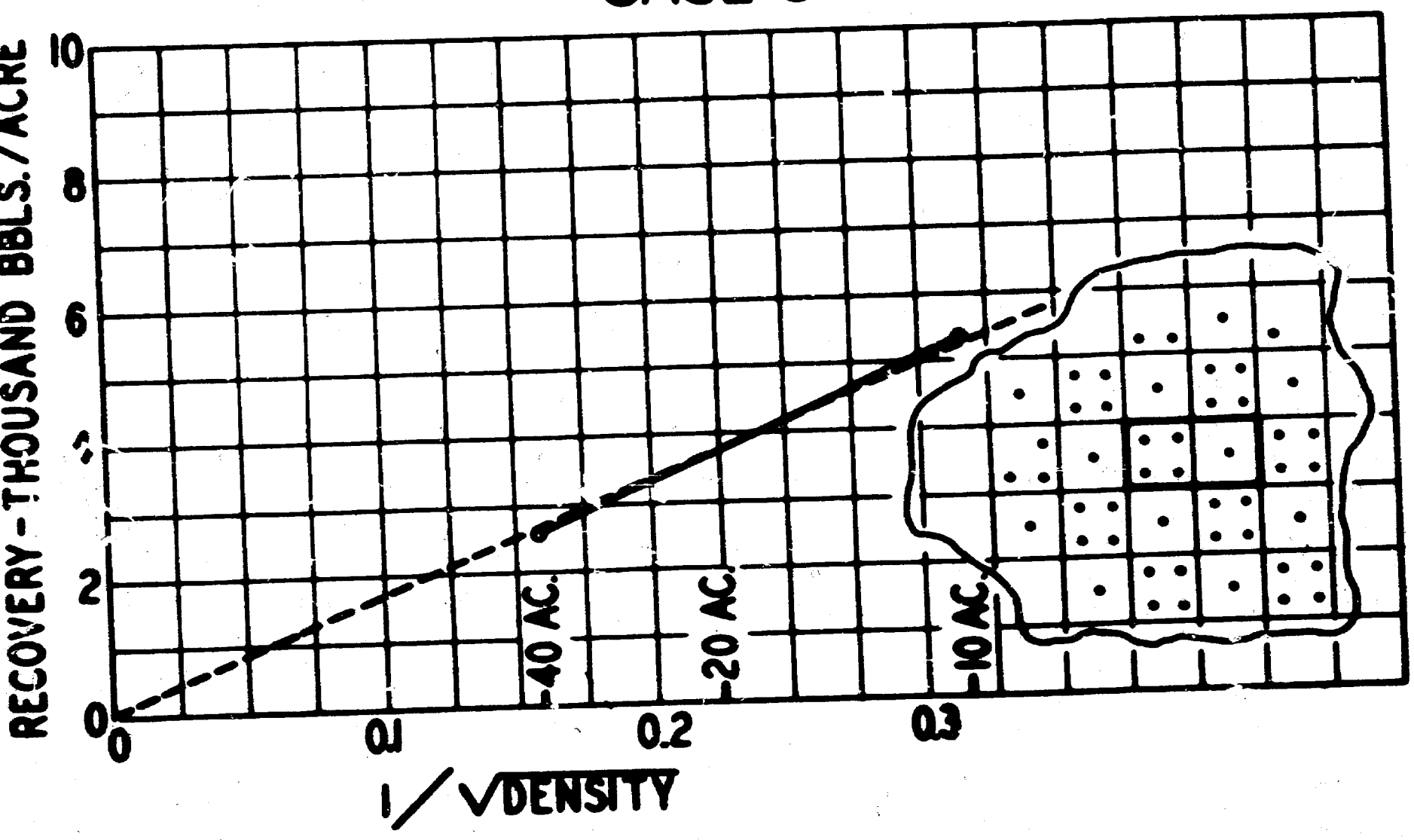
CASE 3


RECOVERY-THOUSANDS AND BBLS./ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
40 AC.
20 AC.
10 AC.
1/√DENSITY

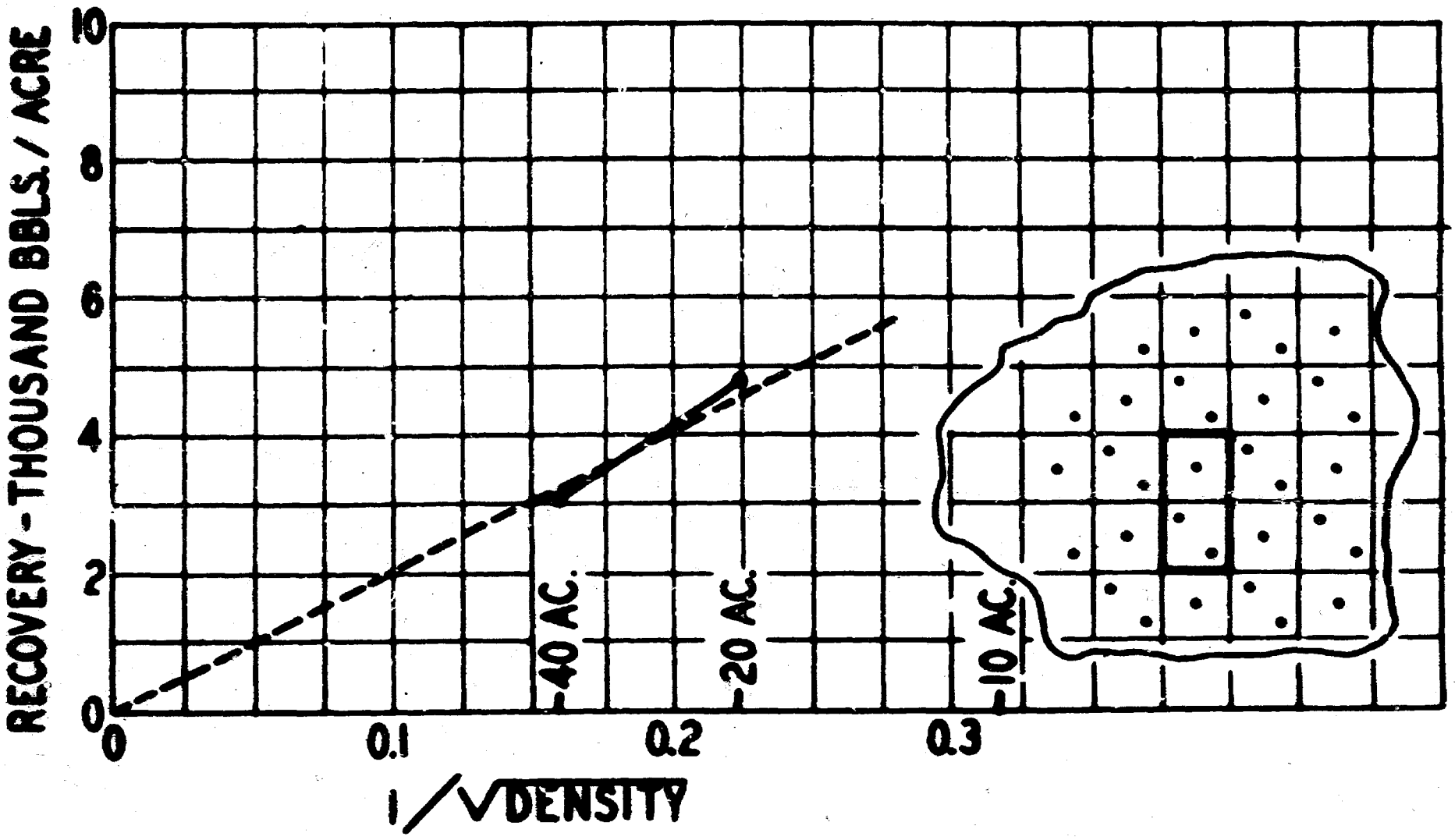
CASE 4


RECOVERY - THOUSAND BBLS. / ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
1/√DENSITY
-40 AC.
-20 AC.
-10 AC.

CASE 5


RECOVERY - THOUSAND BBLS./ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
1/√DENSITY
40 AC.
20 AC.
10 AC.

CASE 6

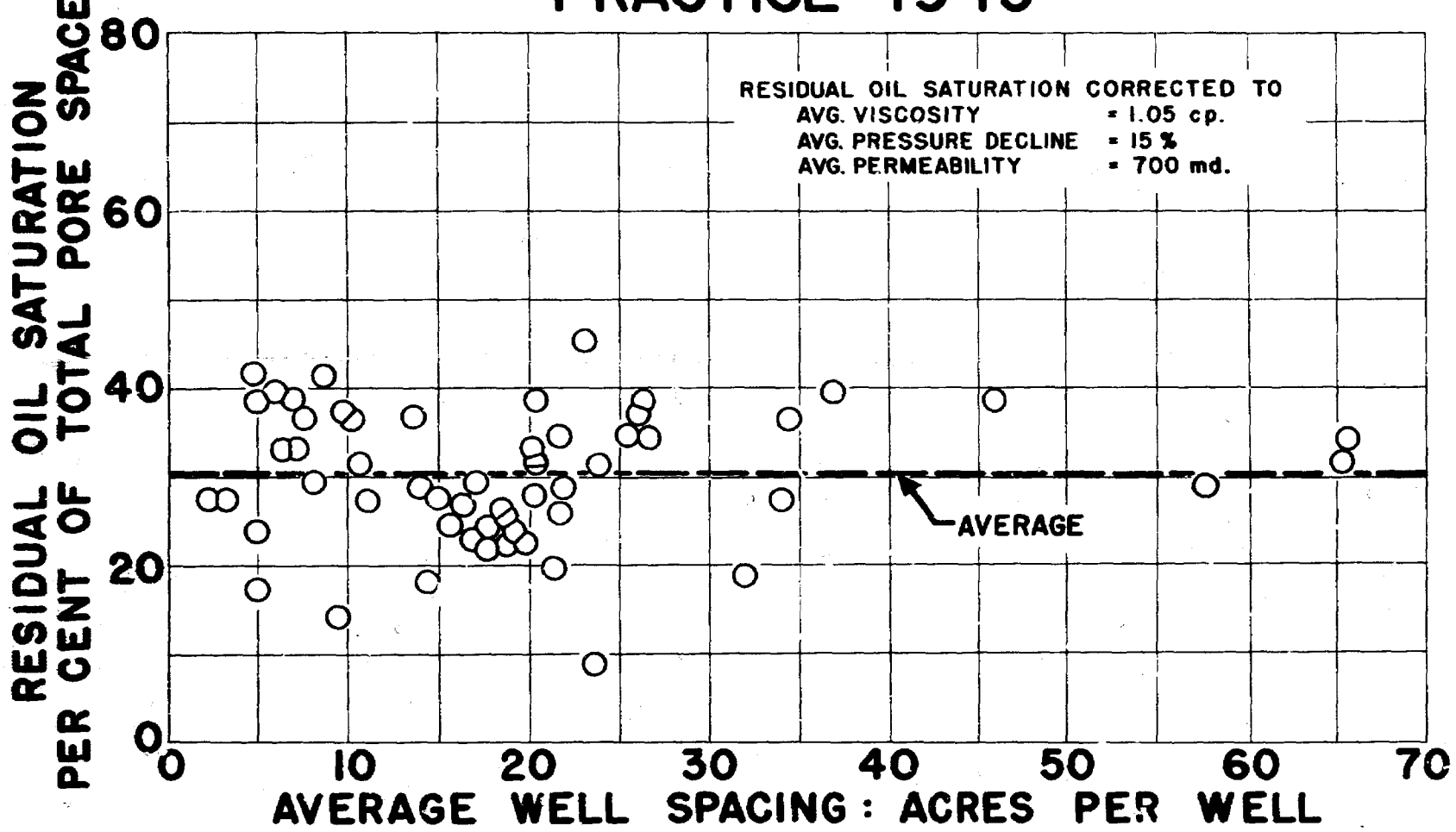

RECOVERY - THOUSAND BBLS. / ACRE
10
8
6
4
2
0
0
0.1
0.2
0.3
1/√DENSITY
40 AC.
20 AC.
10 AC.

EFFECT OF REGIONAL MIGRATION UPON RECOVERY FOR VARIOUS SPACING PATTERNS

CASE	1	2	3	4	5	6
Recovery—Bbls/Acre for 10-Acre Development	9,723	——	8,581	6,685	5,320	——
Recovery—Bbls/Acre for 20-Acre Development	——	6,630	——	——	——	4,784
Recovery—Bbls/Acre for 40-Acre Development	3,193	3,578	2,769	2,545	2,534	3,060
Recovery—Bbls/Acre Average	3,919	3,917	3,932	3,926	3,927	3,922
Recovery Ratio—Close to Wide Development	3.045	1.853	3.098	2.626	2.099	1.563
Recovery Ratio—Required by Cutler's Rule	2	1.414	2	2	2	1.414

(11)

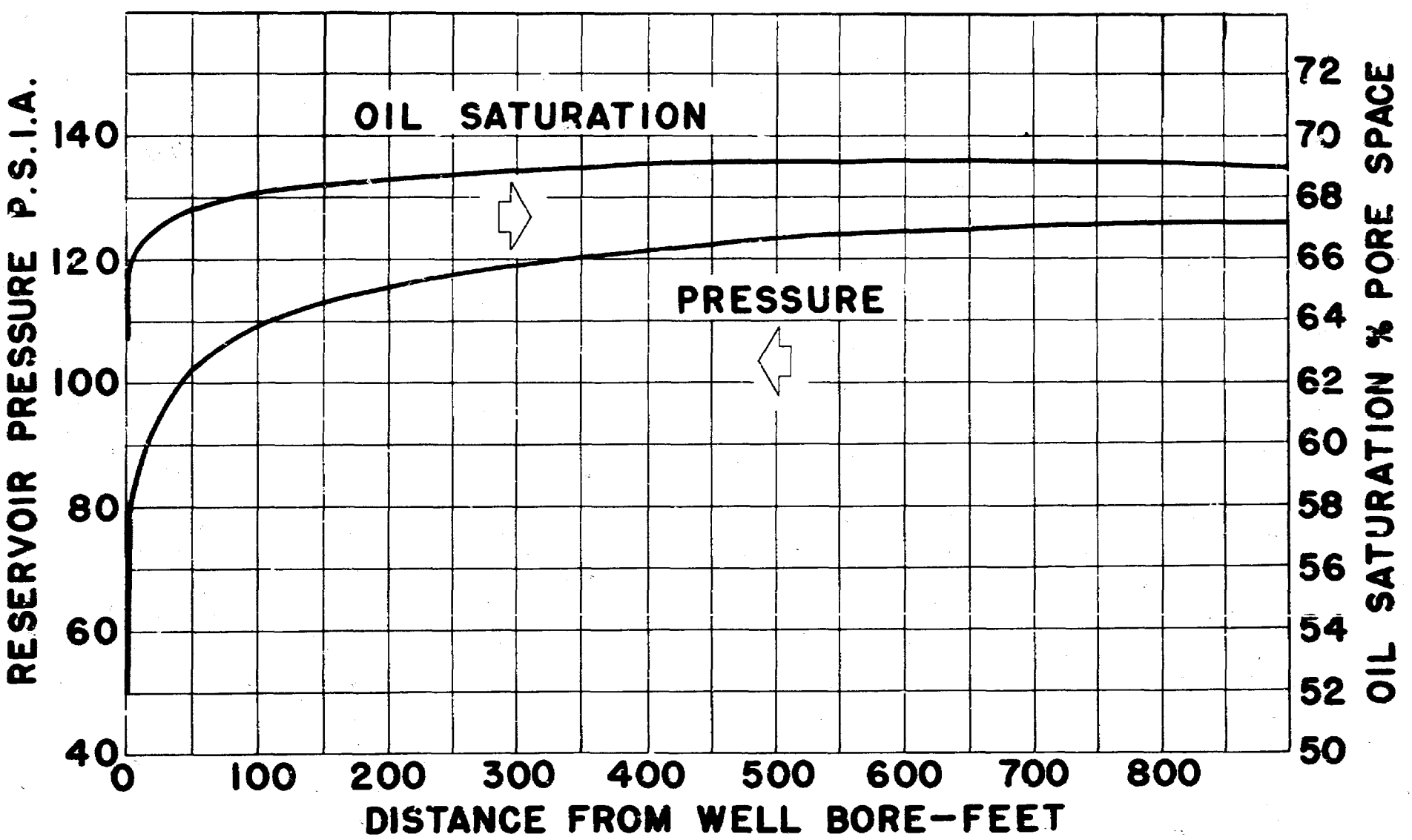
FIGURE 10 FROM "A FACTUAL ANALYSIS OF THE EFFECT OF WELL SPACING ON OIL RECOVERY" BY R.C. CRAZE & S.E. BUCKLEY. A.P.I. DRLG. & PROD. PRACTICE 1945



RELATION BETWEEN CORRECTED RESIDUAL OIL SATURATION AND WELL SPACING—WATER-DRIVE SAND FIELDS

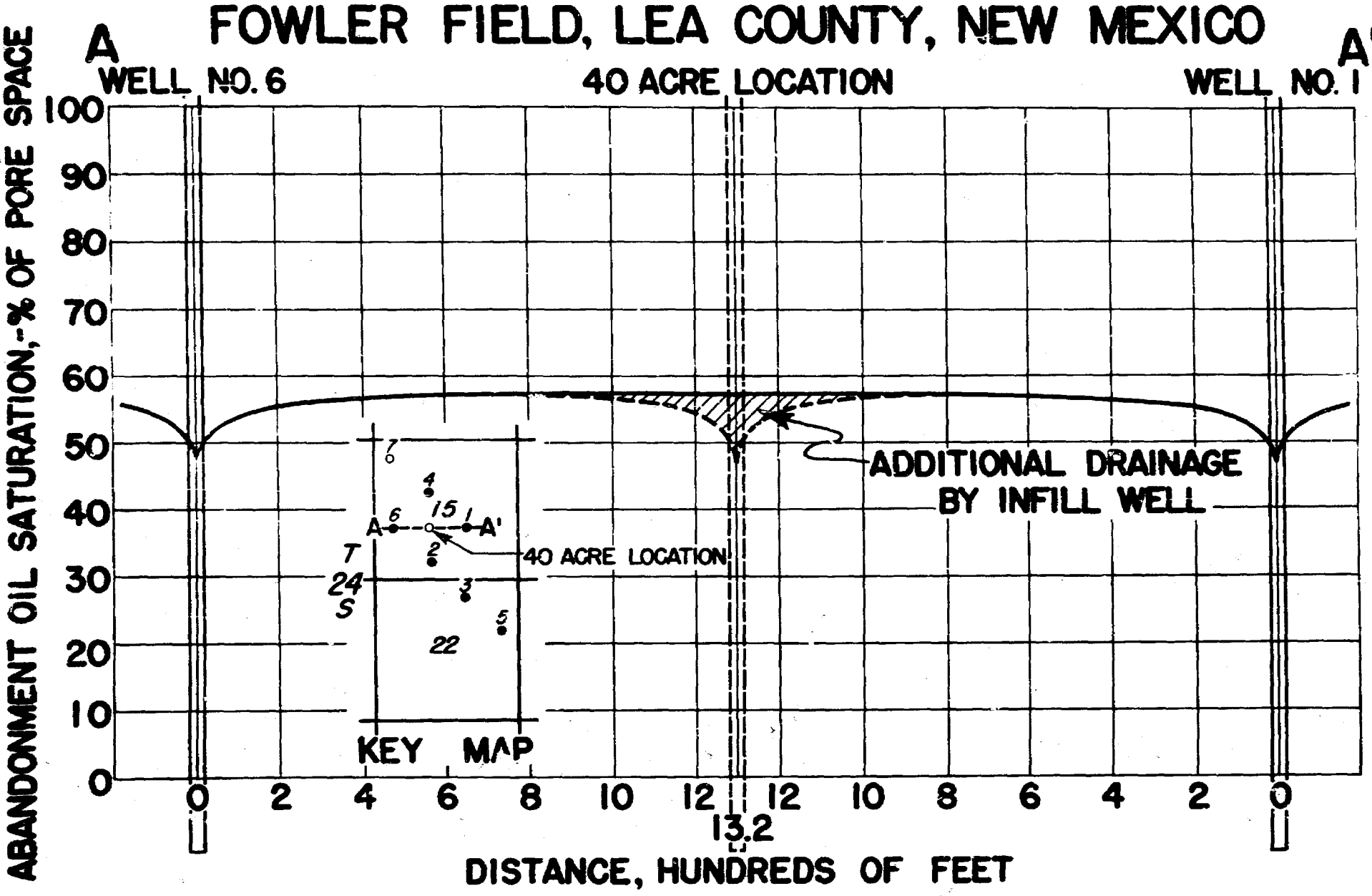
(12)

CALCULATED PRESSURE AND OIL SATURATION DISTRIBUTION AT ABANDOMENT

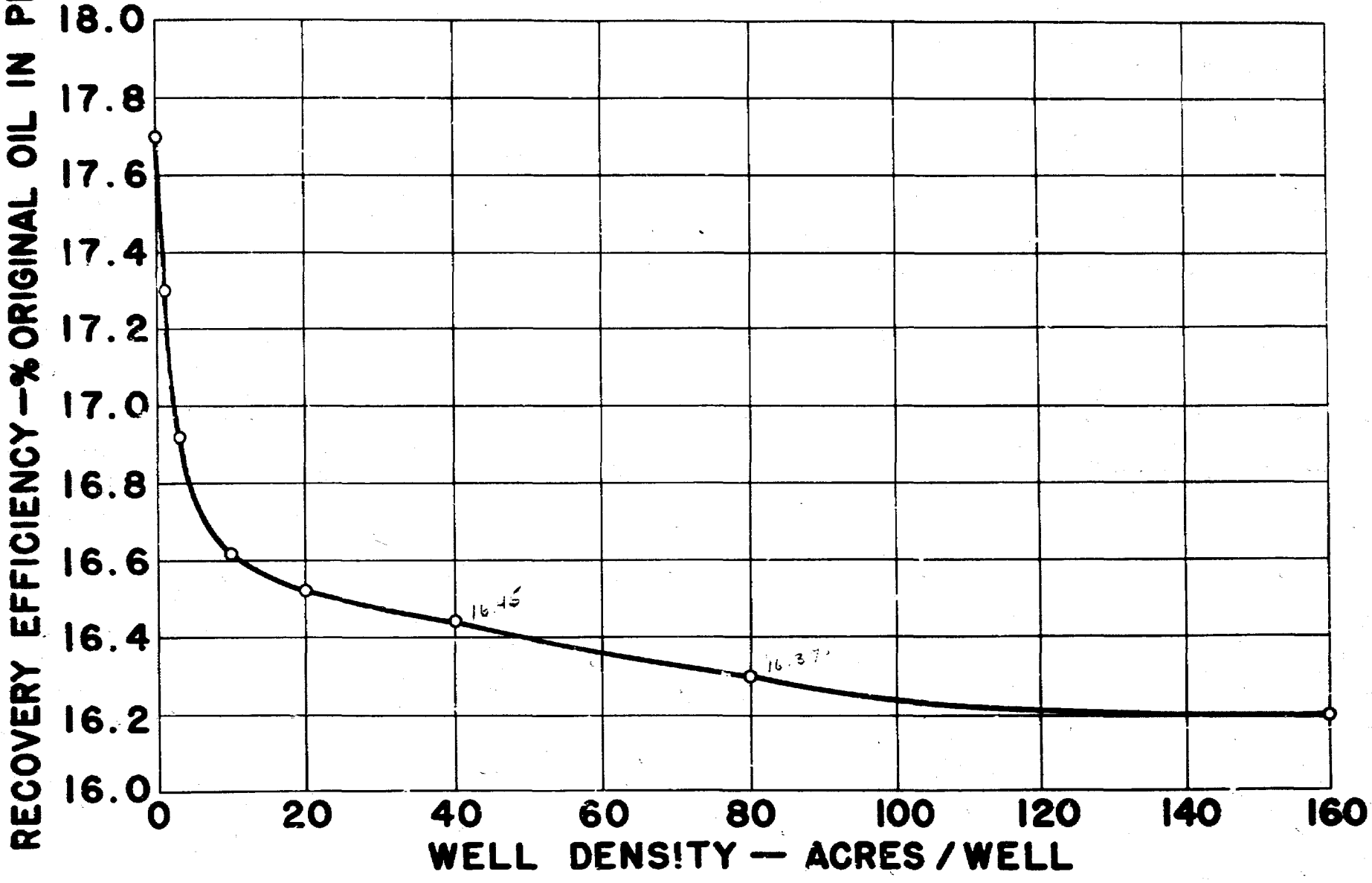


13

OIL SATURATION DISTRIBUTION AT ABANDONMENT CONDITIONS FOWLER FIELD, LEA COUNTY, NEW MEXICO

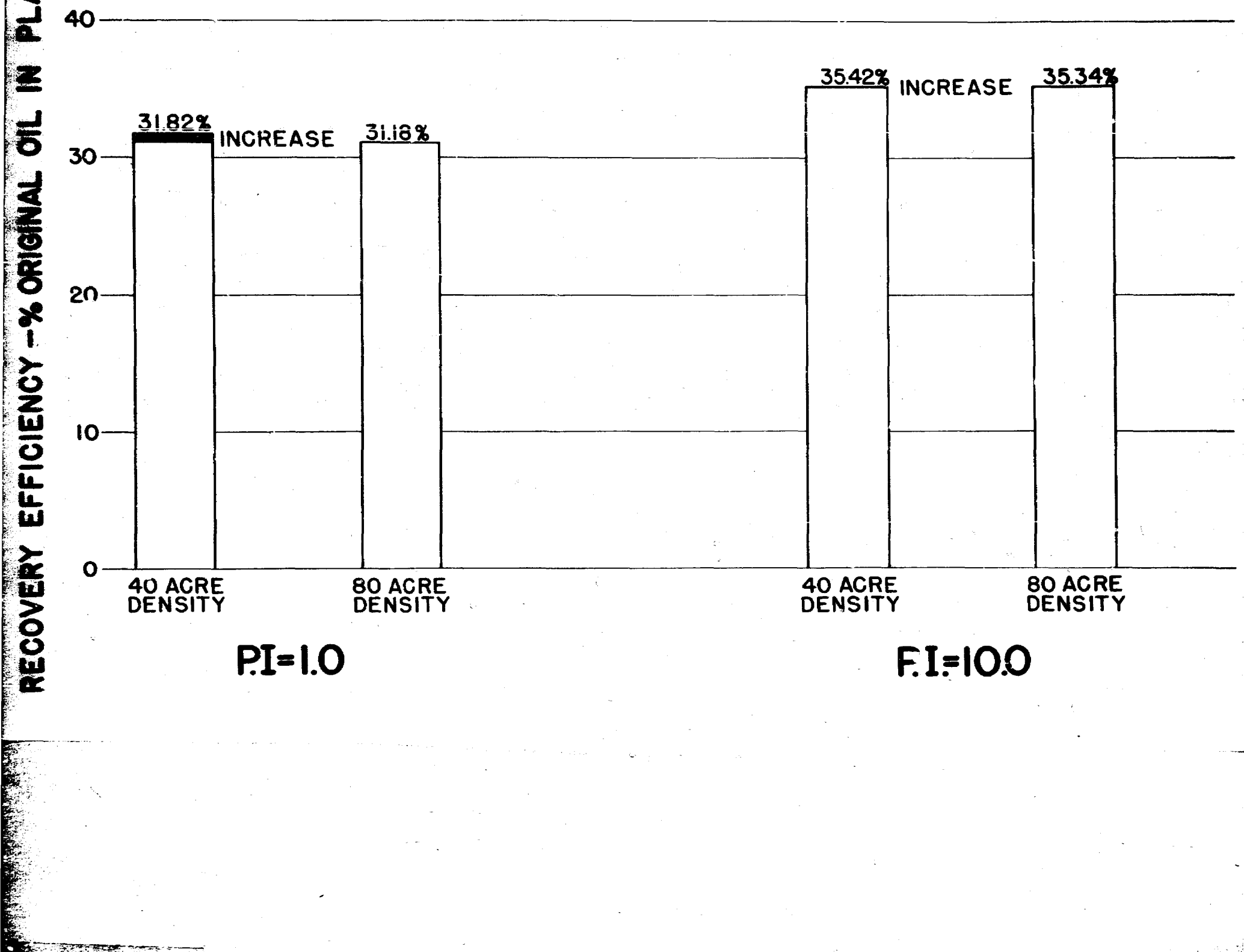


CALCULATED VARIATION IN RECOVERY EFFICIENCY WITH WELL DENSITY

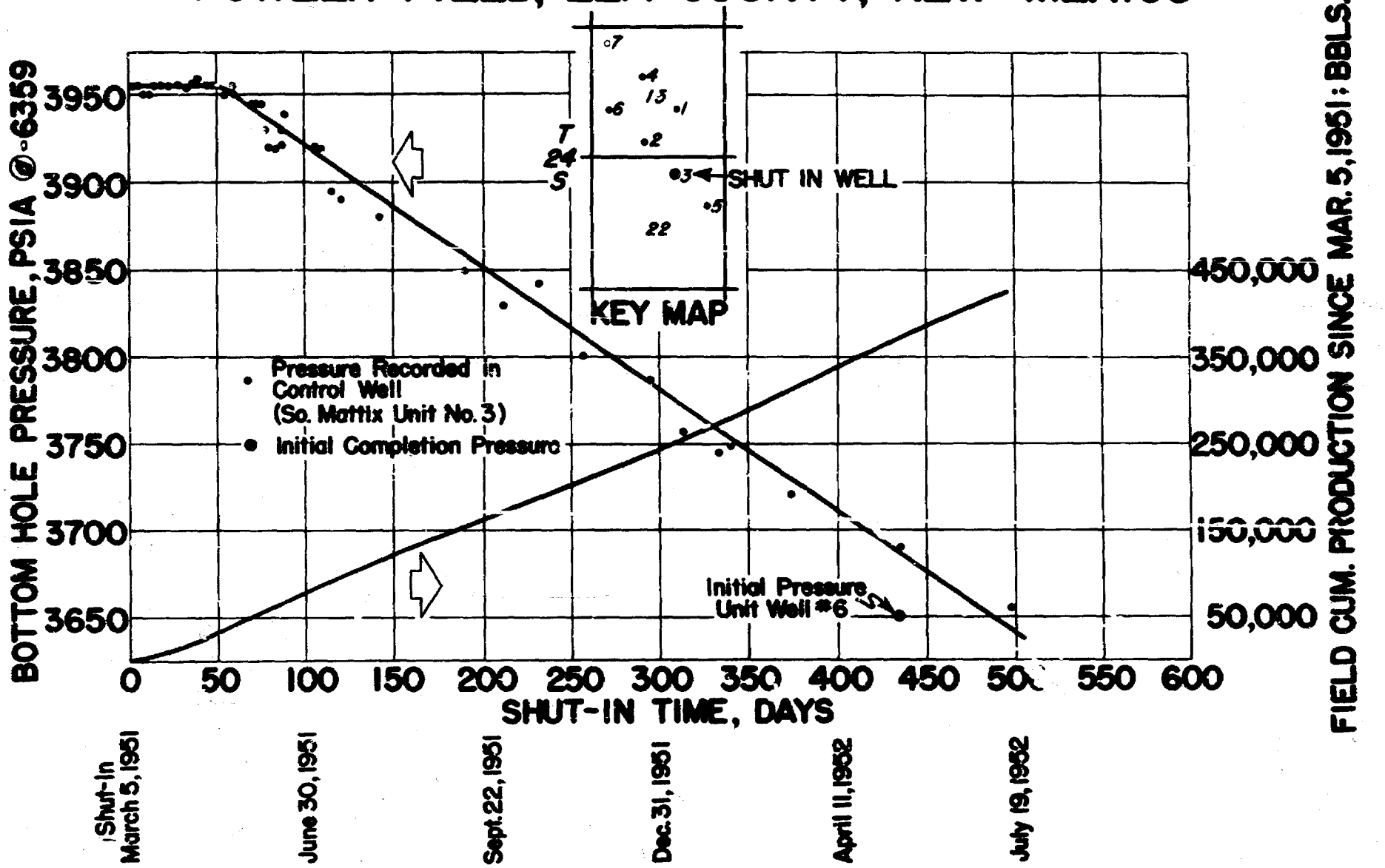


15

CALCULATED VARIATION IN RECOVERY EFFICIENCY WITH WELL DENSITY AND P.I.

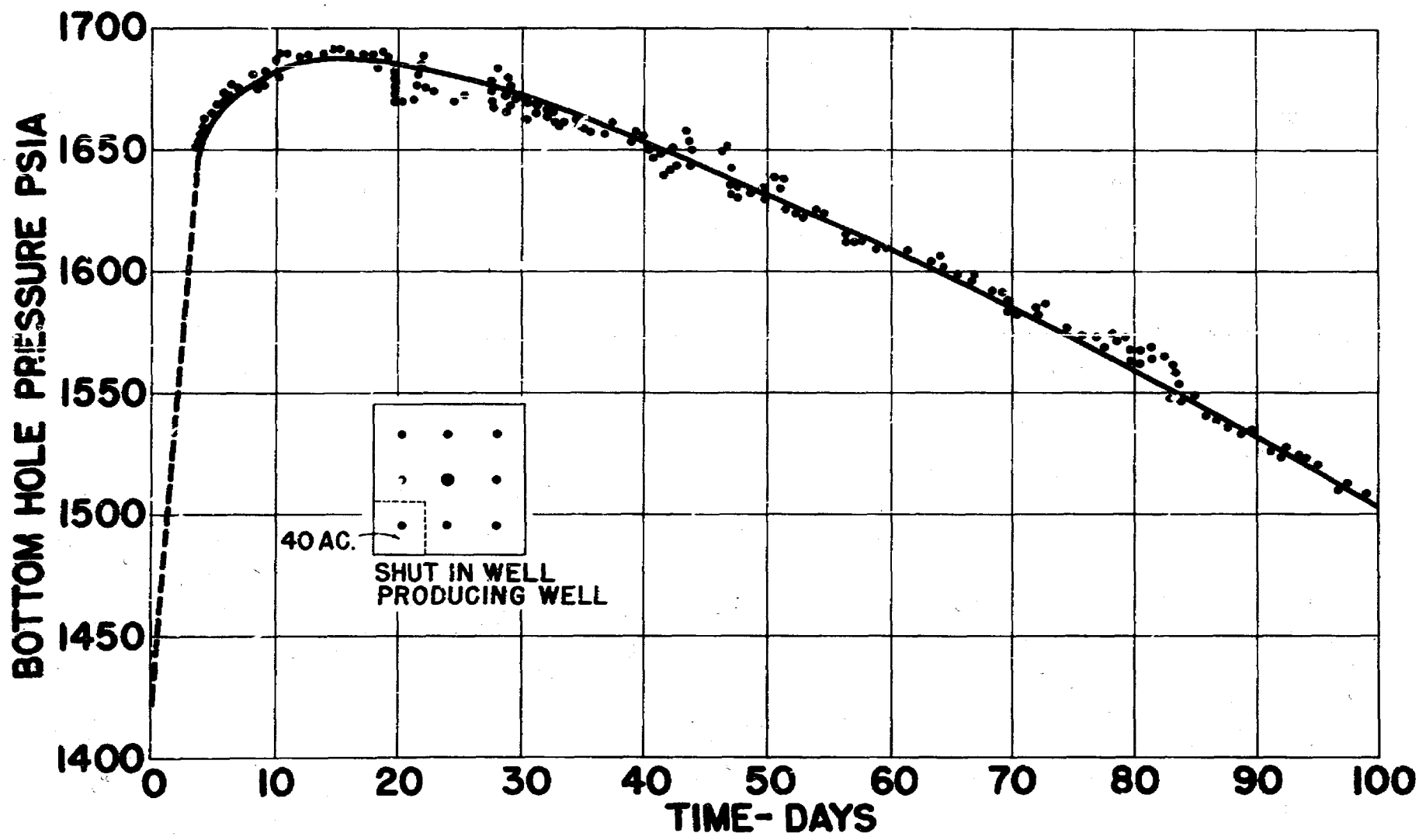


INTERFERENCE TEST DATA
FOWLER FIELD, LEA COUNTY, NEW MEXICO



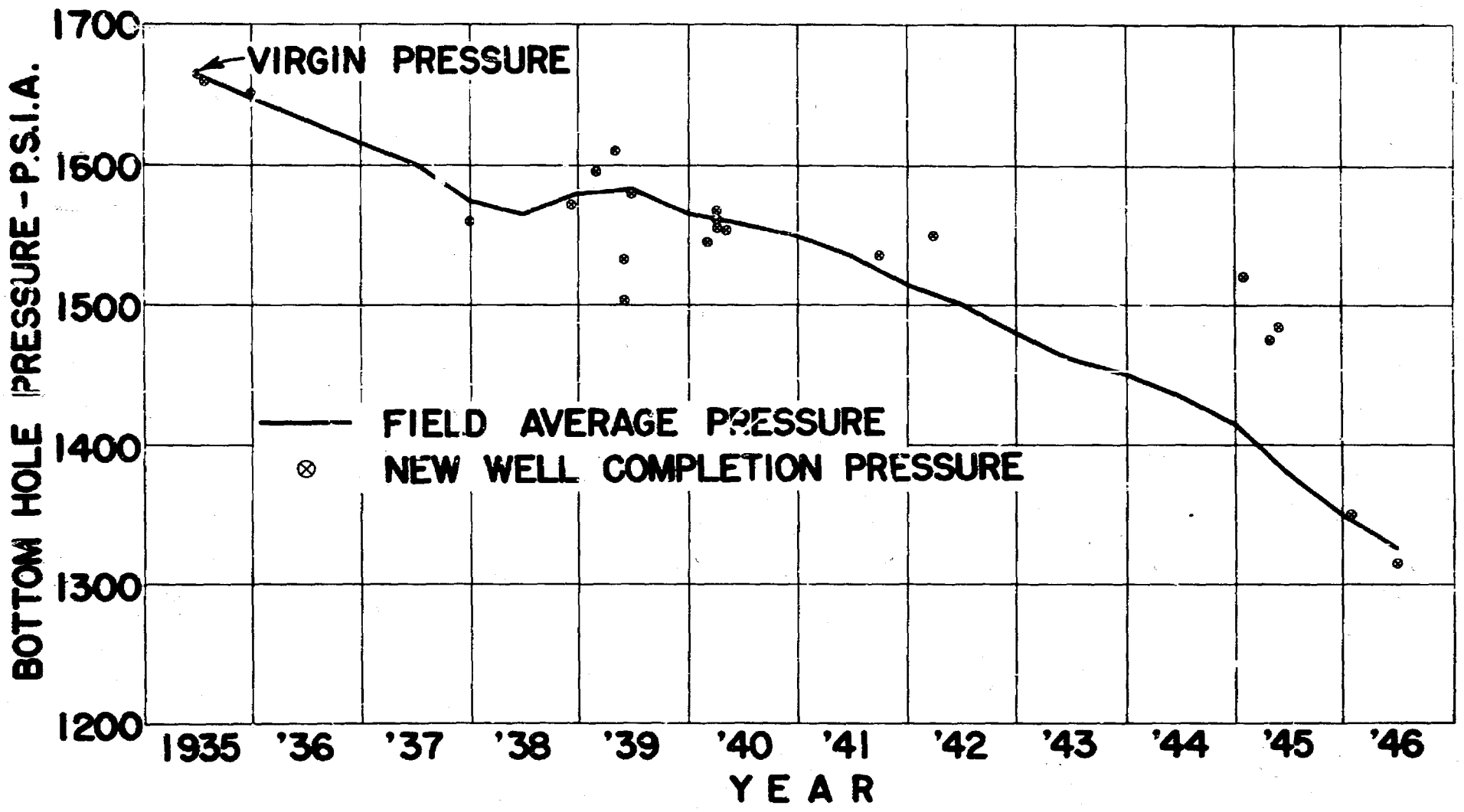
17

INTERFERENCE TEST DATA
ANTON-IRISH FIELD
LAMB & HALE COUNTIES, TEXAS



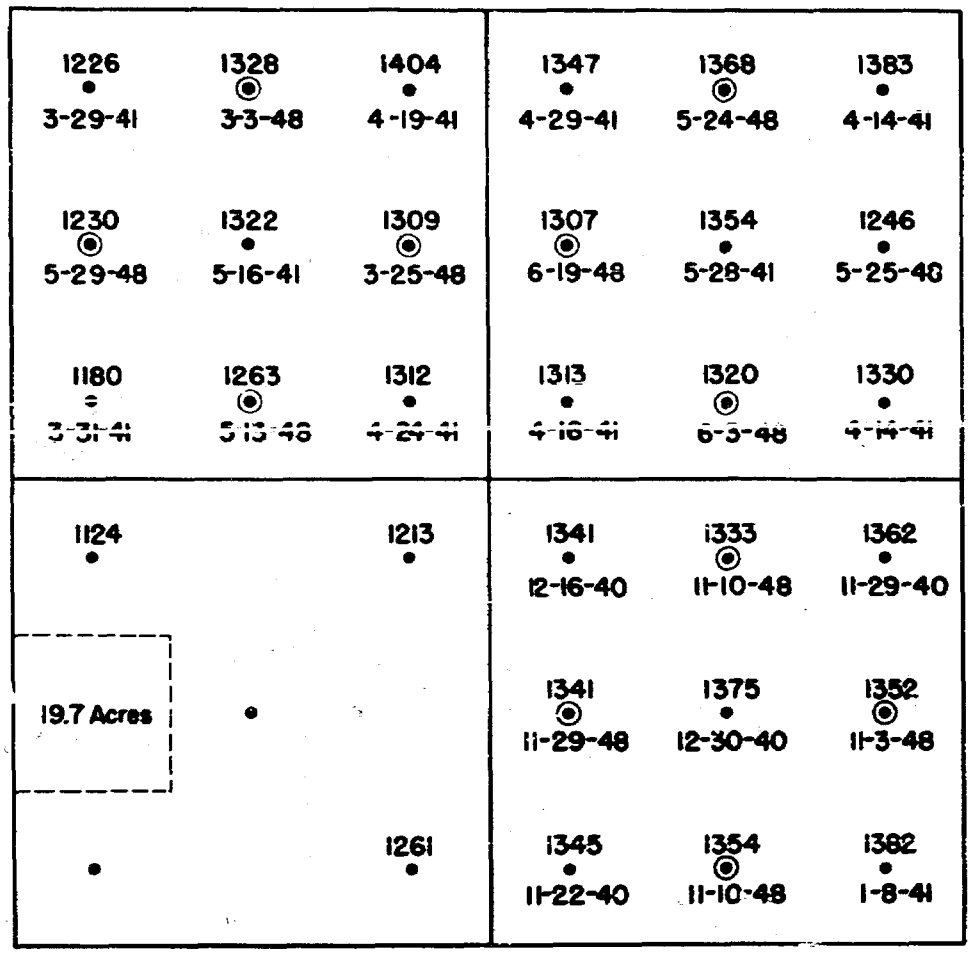
18

COMPLETION PRESSURE HISTORY
GOLDSMITH FIELD, SOUTH DOME
SAN ANDRES LIME
ECTOR COUNTY, TEXAS



COMPARISON OF COMPLETION PRESSURE OF LATER DRILLED INFILL WELLS AND OLDER WELLS SLAUGHTER FIELD

COCHRAN AND HOCKLEY COUNIES, TEXAS



LEGEND:

1350 B.H.P. MARCH 1949
• OLDER PRODUCING WELLS
4-11-41 COMPLETION DATE

1350 B.H.P. MARCH 1949
◉ INFILL DRILLED WELLS
5-12-48 COMPLETION DATE

INITIAL RESERVOIR PRESSURE = 1771 P.S.I.A.

AVERAGE PRESSURE OF OLDER WELLS = 1332 P.S.I.A.

AVERAGE COMPLETION PRESSURE OF INFILL WELLS = 1313 P.S.I.A.

AVERAGE PRESSURE DECLINE INFILL AREAS DUE TO DRAINAGE TO OLDER WELLS = 458 P.S.I.A.

(20) Case 407 (Stanolind)

COMPARISON OF COMPLETION GAS-OIL RATIOS OF INFILL WELLS WITH GAS-OIL RATIOS OF OLDER WELLS IN A DEPLETION TYPE RESERVOIR — SLAUGHTER FIELD

COCHRAN AND HOCKLEY COUNTIES, TEXAS

LEGEND:

770 GOR-4TH. QUARTER SURVEY - 1948

• OLDER WELLS

4-11-41 COMPLETION DATE

GOR-4TH. QUARTER SURVEY - 1948

◉ INFILL WELLS

6-10-48 COMPLETION DATE

1232 • 2-6-41	1663 ◉ 4-30-48	1900 • 4-28-41	1827 • 5-18-41	1790 ◉ 7-9-48	1005 • 5-4-41
1063 ◉ 4-2-48	1153 • 5-8-39	1883 ◉ 5-22-48	1995 ◉ 6-10-48	1901 • 5-12-41	1606 ◉ 6-30-48
945 • 4-16-41	785 ◉ 5-17-48	1163 • 4-21-41	1788 • 5-20-41	1221 ◉ 6-15-48	1433 • 6-6-41
918 • 3-12-41	745 ◉ 5-27-48	963 • 3-10-41	847 • 5-4-41	1864 ◉ 9-16-48	997 • 6-16-41
802 ◉ 5-20-48	1088 • 4-7-41	742 ◉ 8-17-48	1140 ◉ 8-27-48	912 • 6-2-41	1185 ◉ 10-6-48
1900 • 1-16-41	711 ◉ 6-21-48	888 • 6-30-39	1070 • 3-15-39	480 ◉ 9-4-48	647 • 3-29-41

INITIAL SOLUTION GAS-OIL RATIO = 470 CU. FT. / BBL.

AVERAGE COMPLETION GAS-OIL RATIO OF INFILL WELLS = 1228 CU. FT. / BBL.

AVERAGE GAS-OIL RATIO OF INFILL WELLS = 1229 CU. FT. / BBL.

Case 407 : 6-15-43

State Exhibits

1 - Cutler's Rule
2 - Addition Tract Spacing
3 - Illustration of Cutler's Rule
4 - Case 1
5 - " 2
6 - " 3
7 - "
8 - "
9 - "
11 - Engineer's from "A Factual - - -"
10 - " 7
12 - Calculated Pr. & Oil Saturation & Distribution
13 - Oil saturation
14 - Calculated Variation in Recovery Efficiency w/ well density
15 - Graph; Calc. Variation in Recovery Efficiency w/ well density & PI
16 - Interference Test Data, Fowler Field
" " Acton - Dusk Field
17 - "
18 - Completion Pr test - Goldsmith
19 - Comparison of Compl. Pr - 1F wells Slaughter Field
20 - Comp. of P & P Data - Slaughter Field

Case Exhibit. Case 4-7 : 6-15-43

1- Cutler Rule
2 - Hewitt Tuttle Spacing
3 - Illustration of Cutler Rule
4 - Case 1
5 - " 2
6 - " 3
7 - "
8 - "
9 - "
11 - Figure 1 from "A Factual ---"
10 - " 7
12 - Calculated Pr. & Oil Saturation & Distribution
13 - Oil saturation
14 - Calculated Variation in Recovery Efficiency w/well density
15 - Graph: Calc. Variation in Recovery Efficiency w/well density & PI
16 - Interference Test Data, Fowler Field
" " " Acton - Seal Field
17 - "
18 - Completion Pr test - Goldsmith
19 - Comparison of Compl. Pr - 17 wells Slaughter Field
20 - Comp. of C.P. Data - Slaughter Field

C O P Y C O P Y

NEW MEXICO SCHOOL OF MINES
Socorro, New Mexico

Petroleum Engineering Department

11 December 1952

Mr. Richard R. Spurrier
State Geologist
Santa Fe, New Mexico

Dear Dick:

I was greatly interested in the article, which appeared in this morning's 'Journal', quoting from a communication addressed to you by certain New Mexico 'educators', concerning oil and gas well spacing in the state.

The law which established the Conservation Commission finds its only legal basis in the 'Prevention of waste'. This waste can be measured in dollars as well as in barrels of oil.

I agree that oil and gas well spacing depends on such factors as porosity, permeability, etc. but it also depends on the cost of drilling and producing the wells, I can see how the cost of two wells might exceed the value of the oil obtained from them, whereas the same amount of oil could be obtained from one well at a profit. Certainly we cannot expect people to develope oil and gas pools unless they can reasonable expect a return on the investment. This is particularly true in the case of deep wells which may cost as much as a million dollars each, during their productive life.

I am not, and never have been, convinced that a uniform spacing was the best approach to conservation. It is entirely possible that the area drained by a single well might be as small as one acre or as great as 600. This drainage area, for a particular pool, can only be determined after certain parameters such as porosity, permeability, saturation, viscosity, water content, thickness, inclination, structure, uniformity, well drilling costs, well producing costs, and crude oil prices are established for the particular field. Unfortunately these are not fully determined until late in the life of the pool.

COPY COPY

It is logical that we should develope a new oil or gas pool slowly, and on a wide spacing, until we can establish the optimum spacing and location of wells for that pool. I do not believe that locating wells in the center of legal and sub-divisions has any validity. In a domal type of trap, with an active water drive, the wells should be located along concentric, sub-surface, structural contours, for the greatest ultimate recovery.

I realize, however, that the legal profession is not sufficiently advanced to appreciate this line of reasoning and that we will have to continue to adhere to present practice until the doctrine of unit operation of oil and gas pools can be substituted for the present tenet of 'correlative rights'.

The ruling in question is, in my opinion, a great step forward in the technique of oil field development and I hope it will receive your well considered support.

The educators should be brought to realize that they will receive any tax money from wells which are not drilled. If the establishment of temporary, wide, spacing will accelerate development of our resources then the answer is obvious.

I know that you have considered these matters but I want you to know that you can count on my support and assistance at any time.

Best regards,

/s/ Burt

Clarence B. Folsom, Jr.
Head of Department

R. W. TESCH
PETROLEUM ENGINEER AND GEOLOGIST
CONTINENTAL LIFE BUILDING
FORT WORTH, TEXAS

January 6, 1953

RWT - File 241 - 53

Mr. G. T. Hammers
Stanolind Bldg.
Levington, New Mexico

Mr. Harry Leonard
Box 872
Roswell, New Mexico

Mr. Jack Danglade
Levington, New Mexico

Gentlemen:

You have asked me to investigate and advise you in regard to the proposed state-wide order for New Mexico providing for 80-acre development for wells below ten thousand feet in depth.

I have investigated this matter and have come to the conclusion that such an order would be ill-advised, and that it would not be to the interests of many operators and royalty owners for such a rule to be passed by the Conservation Commission. On the contrary, it is my opinion that such an order could cause irreparable damage. In support of this general conclusion, I am attaching nine detailed conclusions, which I have developed as a result of my investigation.

It is my recommendation that you advise the Commission that you do not favor the proposed rule, and that you further advise them that it is your opinion that each field should be judged on its own particular conditions.

If I can be of further assistance to you in regard to this matter, kindly advise.

Yours very truly,

R. W. Tesch

RWT:hab

Enc.

BEFORE THE OIL CONSERVATION COMMISSION, SANTA FE, NEW MEXICO

IN THE MATTER OF THE COMMISSION'S MOTION FOR EXTENSION OF SECTION G (OIL PRORATION AND ALLOCATION) TO PROVIDE FOR ADDITIONAL RULE 508, ESTABLISHING OF TEMPORARY 80-ACRE PRORATION UNITS

Case No. 407

REPORT OF COMMITTEE

The letter appointing this committee directed it to report on three features of a proposed spacing rule and also to report on such other questions as the committee might desire. Wisdom of the proposed rule not being apparent, and the Phillips, Amerada and Magnolia members of the committee having advocated such a rule, the Chairman Harry Leonard, Acting Chairman G. T. Hanners and Committee Member F. J. Danglade felt that an independent, disinterested petroleum engineer should be consulted as to the questions and problems necessarily connected with the proposed rule before any attempt be made to report on the three specific features of the proposed rule.

After consultation with R. W. Tesch, an independent and disinterested petroleum engineer and geologist, of Ft. Worth, and after thorough study of the proposed rule, it is the considered opinion of the undersigned chairman and committee members that the features of it are so foreign to the orderly development of the oil pools of this state that no further consideration should be given to any of the features of the proposed rule, and that the proposed rule, in its entirety, should be rejected. Not only would the adoption of the proposed rule hamper the orderly development of any fields, but it would tend to the reduction of the ultimate recovery of oil, and, thereby, to the creation of waste.

We, therefore, recommend that the proposed rule be rejected for the following general reasons:

1. The adoption of such a spacing rule for new fields, in advance of their discovery, necessarily assumes that all fields will be identical and that one well will always adequately and efficiently drain and develop 80 acres, which experience in New Mexico fields has shown not to be true.

2. Each new field, after discovery, should be judged on its own particular conditions. And if peculiar conditions warrant an exception from normal rules, the same should be considered after the establishment of facts to warrant it, but the adoption in advance of exceptions is necessarily based on a false premise.

3. The public policy of New Mexico, as expressed in the recent session of the Legislature, is for the Commission, in establishing proration units, to consider, among other things, the rights of royalty owners and the reduced recovery, and physical waste, which might result from the drilling of too few wells; and the adoption of the proposed rule, in advance of the discovery of the field or any technical data or knowledge about it, would thwart the expressed intent of the Legislature.

4. Although the proposed rule is disguised as a temporary one, practical experience in such matters convince impartial observers that the actual effect of it would be to shift the burden of proof to the royalty owners, and that the rights of royalty owners, including the beneficiaries of our State lands, could be jeopardized.

5. That the orderly development of oil fields would be hampered by the adoption of any rule that sanctioned the drilling of fewer wells than reasonably necessary to efficiently and adequately drain and develop the field and that waste of natural resources would thereby be created.

A copy of the report of R. W. Tesch, petroleum engineer and geologist, setting forth his conclusions in more detail and in more technical manner, after study of the proposed rule and questions and problems necessarily connected with it, is attached to this committee report as Exhibit "A". Mr. Tesch is personally present, prepared to testify in support of his conclusions and in support of this committee report.

We respectfully recommend that the proposed rule, in its entirety, be rejected.

Chairman

Acting Chairman

Member

4-16-53

R. W. TESCH
PETROLEUM ENGINEER AND GEOLOGIST
CONTINENTAL LIFE BUILDING
FORT WORTH, TEXAS

January 6, 1953

RWT - File 241 - 53

CONCLUSIONS IN REGARD TO 80-ACRE PRORATION UNITS AS A STATE-WIDE ORDER IN NEW MEXICO

1. Many of the deeper structures have revealed steeply dipping flanks and complex faulting, thus staggered 40-acre spacing with 80-acre proration units could result in one operator forcing another operator to drill at a location which might be dry or located at an inferior structure position.

2. 80-acre development will result in less oil being recovered than with closer development.

3. Rule 505 of the Conservation Commission provides for higher allowables with depth and is based upon economic considerations so that an operator recovers his investment in approximately the same time for different depths. (Note: If there are unusual economic conditions in any particular field, then Rule 505 should be revised for that field.)

4. High concentrated withdrawals for dispersed wells could conceivably result in large quantities being trapped off by uneven encroachment or coning of water.

5. No oil-producing state has ordered state-wide 80-acre spacing for oil wells.

6. Nearly all oil-producing states inaugurate individual field rules after sufficient evidence has been obtained to determine the most applicable rules.

7. In the case of the Crossroads Field, the New Mexico Commission found that 80-acre development was improper and revised the rules for that field back to 40-acre development.

8. The proposed 80-acre rule is only a device to force the Commission to assume responsibility for acts by operators that are contrary to their lease contracts and obligations, and thus places the royalty owner (which includes the public schools, state and federal governments) in the position of being forced to sue the Commission for any illegal acts of an operator.

9. There are four fields in New Mexico in which the Commission has found that 80-acre development is proper, thus proving that there is no necessity for a state-wide rule providing for 80-acre development below ten thousand feet.

X-6740

COPY
MAGNOLIA PETROLEUM COMPANY

P. O. Box 900, Dallas 1, Texas

LEGAL DEPARTMENT

September 29, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
OCT 1 - 1952

Mr. Harry Leonard
Roswell, New Mexico

In re: New Mexico Oil Conservation Commission Case No. 407

Dear Mr. Leonard:

I have this date received a letter from Mr. R. R. Spurrier, advising that I have been chosen to serve on a Committee with you, as Chairman, to study and advise the Commission relative to the above matter. I will be greatly pleased to serve with you and the other members of the Committee.

Inasmuch as the Commission has testatively set this matter for the October 15th hearing, it is my thought that if the Committee is to make substantial and worthwhile recommendations that we should meet several days previous to the Commission hearing. Personally, I would prefer a meeting date sometime during the week of October 5th. A meeting during this week would afford an opportunity to discuss the issues, formulate some definite recommendations and suggestions, and would afford an opportunity for Committee members to clear these recommendations with the management of their respective companies or with their respective clients before the Commission hearing. I will be glad to meet you and your Committee members at Roswell or at any other place convenient to you and your Committee members.

I would appreciate hearing from you relative to this matter.

Yours very truly,

WEMcK:cc W. E. McKellar, Jr.

cc - Mr. R. R. Spurrier
State Geologist
Santa Fe, New Mexico

G.T. HANNERS
ATTORNEY-AT-LAW
STANSELL BUILDING
LOVINGTON, NEW MEXICO

September 29, 1952

Mr. R. R. Spurrier
Secretary-Director
Oil Conservation Commission
Santa Fe, New Mexico

Proposed 80-Acre Spacing
Case No. 407

Dear Mr. Spurrier:

I will be glad to serve on the committee to advise with the Commission on the proposed spacing rule in Case 407 as mentioned in your letter of September 24th, and I will be glad to meet such date as Mr. Leonard, the chairman, may suggest for a meeting of the committee.

Yours very truly,

GTH:mb

cc:

Mr. Harry Leonard
J.P. White Building
Roswell, New Mexico

Mr. C. G. Staley
Oil Conservation Commission
Hobbs, New Mexico

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
OCT 2 - 1952

Original Proposal

CASE 407:

In the matter of the application of the Oil Conservation Commission upon its own motion for an order extending Section 'G', Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary Eighty-Acre Proration Units, said proposed rule to provide as follows:

1. Temporary 80-acre proration units are hereby established for wildcat wells, as defined in Rule 104-a, completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505-a;

2. After the effective date of this order, no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production;

3. Upon the completion of five wells to the same producing formation within a radius of two miles of a wildcat well, the burden shall be on the operator to show by competent evidence that one well will efficiently and economically drain the 80 acres assigned to the well;

and such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at said hearing.

Orig. Proposal

CASE 407:

In the matter of the application of the Oil Conservation Commission upon its own motion for an order extending Section 'G', Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary Eighty-Acre Proration Units, said proposed rule to provide as follows:

1. Temporary 80-acre proration units are hereby established for wildcat wells, as defined in Rule 104-a, completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505-a;

2. After the effective date of this order, no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production;

3. Upon the completion of five wells to the same producing formation within a radius of two miles of a wildcat well, the burden shall be on the operator to show by competent evidence that one well will efficiently and economically drain the 80 acres assigned to the well;

and such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at said hearing.

Case 407

New Mexico
OIL CONSERVATION COMMISSION

GOVERNOR EDWIN L. MECHEM
CHAIRMAN

LAND COMMISSIONER GUY SHEPARD
MEMBER

STATE GEOLOGIST R. R. SPURRIER
SECRETARY AND DIRECTOR

P. O. BOX 871
SANTA FE, NEW MEXICO

September 24, 1952

To the Committee on 80-acre spacing - Case 407:

Mr. Harry Leonard, Chairman
Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge F. H. Foster
Mr. G. T. Hanners
Mr. Jack Danglade

Gentlemen:

The Commission has chosen you to advise them on certain questions relating to Case 407, namely,

1. At what depth should the order be effective;
2. How many wells should be drilled before the hearing is called;
3. Should there be a time limit for the date of the hearing.

and such other questions as the Committee may desire to report on.

The Committee may select anyone they choose to represent them as an alternate.

We appoint Mr. Harry Leonard as Chairman to organize the Committee and set a date for its meeting.

Very truly yours,

R. R. Spurrier
Secretary - Director

RRS:lh
One original copy mailed
to each member of the above
mentioned Committee and
carbon copy to Mr. Glenn Staley.

Aug 31 - 1952

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An Independent Newspaper

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E. P. PICKRELL.....Editor

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SUNDAY.....August 31, 1952

POLITICAL EYES ON TEXAS

The Texas state Democratic convention almost at our very door in Amarillo Sept. 9 will widely attract the nation's political eyes and serve as a tip-off as to whether the so-called solid south will stay solid for the Democrats or veer somewhat toward the Eisenhower column.

Texas Governor Shivers has repudiated Democratic Candidate Stevenson because he believed his election would be a "continuation of Trumanism" and appeals to Texas voters for "advice and counsel" when the state Democrats meet at Amarillo.

The chief objection of Shivers to Stevenson, of course, is that the Democratic candidate endorses the Truman policy which opposes state ownership of the rich oil tidelands.

Which brings from President Truman the reaction that the stand Stevenson has taken on the tidelands issue will not lose Texas to Stevenson because "there are a great many Texans who do not own oil wells and are not millionaires and who vote the Democratic ticket."

The Amarillo convention probably will decide whether Texas goes Republican in the presidential election or reluctantly stays with Stevenson. The Amarillo convention is now booked to be a momentous one in its decision on whether to follow Governor Shivers in bolting Stevenson.

SHOULD STAY AT HOME

Several state officials, including Oil Conservation Commission Secretary Spurrier and Land Commissioner Guy Shephard, will fly to Canada for a meeting of the Interstate Oil Company Commission in a private plane owned by a Texas independent oil operator.

Spurrier explains that until the oil operator had offered his private plane for the trip none of New Mexico's officials had planned to make the trip because of the expense to the state and time involved in train travel.

Spurrier says acceptance of the private oil operator's invitation would save the state about $541.

If the state can't afford to spend $541 to send its representatives to the Oil Company meeting, then we'd say [illegible] at home.

In the Capital

State Jury-Picking System At Issue in Appeals Court

By BOB BROWN
Of The Journal's
Santa Fe Bureau

SANTA FE, Aug. 30—New Mexico's entire system of picking jurors will be under scrutiny at a hearing before the U. S. Circuit Court of Appeals in Denver on Tuesday.

The appeal is from a decision of U. S. District Judge Carl A. Hatch, refusing to order release of Jesse Bailey from the state penitentiary on a writ of habeas corpus. In turning down the writ Judge Hatch said that court-appointed attorney Melvin Neal of Lea County had raised an interesting legal question and urged that it be taken to the higher tribunal.

Neal had argued that there had been what he called "systematic inclusion" of negroes on the jury which tried and found Bailey, himself a negro, guilty of murdering Marshal Bugler in February of 1950.

He insisted that deliberately placing negroes on a jury panel indicated discrimination just as much as deliberately leaving them off. The evidence presented indicated that the Lea County jury commissioners had deliberately chosen two Lovington negroes to serve on the jury panel after District Judge C. Roy Anderson directed them to make sure there was no discrimination against minority groups.

Neal argued that all names should be thrown in together—including those of minority groups—and jurors chosen indiscriminately.

The state—represented by Assistant Attorney General Jim Cooney—will argue that the state's juries are picked correctly. Cooney explains that the state has a law which allows jury commissioners to go beyond the list of certified registered voters if they know them to be qualified.

Bailey will be represented in Denver by a Colorado attorney appointed by the appeals court.

For a time it looked as though the same question might be raised in connection with a federal case—the trial of the two Acoma Indian brothers who are charged with the murder of State Patrolman Nash Garcia.

However, Phil Dunleavy, attorney for the brothers, said that he had found by checking that there is an Indian on the jury panel and that there have been Indians on past juries. He said he had decided that the question could probably not be raised in his case.

Recent major bus accidents across the country have caused the State Corporation Commission to turn its eyes on the protection given the public riding such vehicles.

Commissioner Jason Kellahin says that the agency has decided to review the self-insurance plan carried on by Pacific Greyhound and Southwestern Greyhound lines. He explains that all other motor carriers operating in the state carry separate insurance. However, under a provision of the law and an order signed several years ago by Commissioners Dan Sedillo and the late Eugene Allison, the big bus firms carry their own insurance.

Kellahin hastens to emphasize that this might not be wrong. He points out that the companies have large cash reserves and also carry what is known as [illegible]

National Whirligig

News Behind the News

(Copyright, 1952, McClure Newspaper Syndicate)

By JOHN FISHER

From now until Oct. 5, when Stalin recalls the All-Union Party Congress after a lapse of 13 years, world speculation will delve into its meaning.

Major Communist moves always have several goals and numerous by-paths, each increasing propaganda themes and directing effort to particular channels.

Among the top aims of this forthcoming 19th Congress is a new drive—epitomized by the 1951-1955 Fifth Five-Year Plan—to strengthen the physical might of the giant Soviet Union. Increased Russian production will require extra local sweat and the blood, sweat and tears of already drained satellites.

The eyes of outside economists are riveted on promises of expanded irrigation projects, the tripling of aluminum output and the doubling of electric power—all three "not war" potentials.

A 2000-mile web of irrigation canals will bring water to drouth-afflicted areas in the Crimea, Ukraine and the section between the Ural and Volga Rivers in Kazakhstan. This will result in more home-grown food for the armed services and a war-blockaded homeland.

Aluminum in record quantities is for a stepped-up jet plane program. Huge, new supplies of electric power are required to pump water into the new irrigation networks and—more important—to greatly expand atom bomb production.

Of course, a jump of 70 per cent in industrial output in five years could be merely peaceful economic progress. But when heavy industry goes up and consumers' goods remain in relatively limited supply, the suspicion that the purpose is chiefly military defense or aggression cannot be lightly dismissed. If Moscow intends eventually to wage war, it now is making the necessary preparations.

Goaded to Fresh Sacrifice. For months all kinds of information from Russia and its captive states reveals that the wretched people are bone-weary from overwork and hardship. Now these miserable victims are to be goaded to greater toil and fresh sacrifice in a land where the standard of living is low and life is drab, monotonous and clouded with constant fear and hopelessness.

One deception, employed by tricky bosses to spur flagging spirits, is the attempt to belittle the Marshall Plan. The commissars say in effect: "Work a little longer and harder. Then we will be strong because the Marshall Plan is a flop and our enemy neighbors are growing weaker through this American scheme."

Trud wails, "The shameless jobbery of the Americans is calling forth the growing indignation of the broadest masses of population in Western Europe . . . . The rulers of the United States have been saving their own crisis-shattered economy of West European states. And this was done at the cost of those states."

But the principal whip to lash weary sitters back on the toilsome road is the new "hate America" vehemence. The announcement of the scheduled Congress and the economic objectives are the explanation of the current boundless vituperation in the germ warfare lies and the Russian press and radio attacks that Americans are savages, cannibals and fiends.

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OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

October 28, 1952

Mr. Harry Leonard
J. P. White Building
Roswell, New Mexico

Dear Mr. Leonard:

I have your letter of October 6, 1952, relating to Case 607.

We want you to know that we greatly appreciate your assumption of Chairmanship of this Committee.

According to the minutes, the Commission continued the hearing in Case 607 from October 15 to November 20, 1952, upon its own motion.

I appreciate the inclusion of the United States Geological Survey and educational institutions of New Mexico.

I earnestly suggest that you consider a meeting of the Committee before November 20, so that recommendations may be included in the record on that date. While the final determinations of this case may take time, I believe that the matter should be kept alive and the Commission should be presented with recommendations or a motion on November 20th.

Sincerely,

R. R. Spurrier
Secretary - Director

RRS:ih
cc: Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge E. S. Foster
Mr. G. T. Hammons
Mr. Jack Dunglade
Governor Edwin L. Mechem
Commissioner Guy Shepard

Case 407

Harry Leonard
Roswell, New Mexico

October 6, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
OCT 8- 1952

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In view of the proximity of the Holiday Season and the fact that a new Commissioner of Public Lands will assume office January 1, 1953, I suggest the Commission hold in obeyance the consideration of Case 407, which I understand is set for October 16th.

I propose to have representatives of New Mexico Educational Institutions and the United States Geological Survey sit in with our Committee, with a view of furnishing the Commission with our recommendations early in the New Year. In the meantime, the Commission will be kept advised of progress being made by the Committee.

Very truly yours,

Harry Leonard.

HL/o

cc: Governor Edwin L. Mechem
Mr. Guy Shepard
Mr. Glenn Staley
Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
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Case 407

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I have your letter of September 24th, appointing me Chairman of a Committee to advise the Commission on certain questions relating to Case 407. I consider this a very important case, in which the schools of New Mexico, through the Commissioner of Public Lands, are vitally interested since they are the largest royalty owners; in addition to their 1/8th interest under all State oil and gas leases, they have a 37-1/2% interest in Federal oil and gas leases administered by the United States Geological Survey.

In view of the proximity of the Holiday Season and the fact that a new Commissioner of Public Lands will assume office January 1, 1953, I suggest the Commission hold in obeyance the consideration of Case 407, which I understand is set for October 16th.

I propose to have representatives of New Mexico Educational Institutions and the United States Geological Survey sit in with our Committee, with a view of furnishing the Commission with our recommendations early in tne New Year. In the meantime, the Commission will be kept advised of progress being made by the Committee.

Very truly yours,

Harry Leonard

HL/o

Harry Leonard.

cc: Governor Edwin L. Mechem
Mr. Guy Shepard
Mr. Glenn Staley
Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge E. H. Foster
Mr. G. T. Hanners
Mr. Jack Danglade

E.H. Foster

BEFORE THE OIL CONSERVATION COMMISSION

OF NEW MEXICO

IN THE MATTER OF THE APPLICATION OF THE OIL CONSERVATION COMMISSION UPON ITS OWN MOTION FOR AN ORDER EXTENDING SECTION G, OIL PRORATION AND ALLOCATION TO PROVIDE FOR THE ADDITION OF RULE 509 , ESTABLISHMENT OF TEMPORARY EIGHTY ACRE PRORATION UNITS

Case No. 407

REPORT OF COMMITTEE

In response to the letters of the Commission of Sept. 24, 1953, the undersigned members of the committee appointed by the Commission to report on the following questions:

1. At what depths should the proposed order establishing temporary 80-acre proration units be effective, and

2. How many wells should be drilled before a hearing is called, and

3. Should there be a time limit for the date of the hearing, and

4. Such other questions as the committee may desire to report on, having met in Santa Fe, New Mexico on June 15, 1953, desire to report as follows:

1. It is the recommendation of your committee that the order should specify a well depth of 10,000 feet and below.

2. It is the recommendation of your committee that five wells be drilled before a hearing is called, or

3. It is the recommendation of your committee that a time limit of 18 months be set for a hearing date, Unless within that time five wells have been drilled as recommended in Number 2, hereof, and.

4. After the effective date of the temporary order no operator in a new reservior established as the result of the completion of a wild cat well at a depth of 10,000 feet or more shall drill more than one well to each 80 acres, with the location of the discovery well setting the pattern for the location of additional wells drilled while temporary 80 acre proration units are in effect. Subsequent

wells drilling to the same reservior shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

5. Your committee also recommends that all fields on temporary 80 acre proration units shall revert to 40 acres permanent proration units, unless within not more than 18 months after the completion date of the discovery well or within 60 days after completion of the fifth well to the same producing formation, which ever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for the reservior. Upon such hearing the burden shall be upon the operator or operators to show that one well will efficiently and economically drain 80 acres, failing which such spacing pattern shall revert to 40 acres.

6. Your committee further recommends that certified plats of proration units shall be filed with the commission.

Respectfully submitted,

E. H. Foster
E. H. Foster, Member

E. P. Keeler
E. P. Keeler, Member

R. S. Christie
R. S. Christie, Member

MAGNOLIA PETROLEUM COMPANY

A SOCONY-VACUUM COMPANY

LEGAL DEPARTMENT

DALLAS 1, TEXAS

EARL A. BROWN
GENERAL COUNSEL
ROY C. LEDBETTER
RAYMOND M. MYERS
CHAS. B. WALLACE
R. T. WILKINSON, JR.
FRANK C. BOLTON, JR.
JACK VICKREY
SAM H. FIELD
ROSS MADOLE
FLOYD B. PITTS
W. E. McKELLAR, JR.
ASSISTANTS

Air Mail

October 20, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
OCT 22 1952

In re: Case No. 407

Mr. R. R. Spurrier, Director
Oil Conservation Commission
P. O. Box 871
Santa Fe, New Mexico

Dear Dick:

Messrs. E. H. Foster and R. S. Christie met with the undersigned October 15th and discussed the possibility of a committee meeting regarding the above case. It is imperative that such a meeting be held before the November hearing if the committee is to fulfill the purpose for which it was appointed.

Realizing that you were going to notify Mr. Leonard of the Commission's intention to hear this matter on November 20th, the above mentioned members requested that I write soliciting your assistance in requesting Mr. Leonard to call a committee meeting as soon after the November 4th election as practicable. Mr. R. S. Christie will not be available November 10th through the 15th because of previous engagements, but advised that he would send an alternate should the committee meeting be called during that time. In my opinion, the meeting should be held some days before the Commission hearing to afford representatives an opportunity to clear the committee's final recommendation with their respective clients and management. However, any date and place acceptable to Mr. Leonard will be satisfactory.

I sincerely appreciate your assistance in this matter, and surely hope that by the time you receive this letter you will have returned to your adobe and the Mrs. will be busy broiling elk steaks.

Yours very truly,

W. E. McKellar Jr.

W. E. McKellar, Jr.

WEMck:ec

cc - Mr. E. H. Foster
cc - Mr. R. S. Christie

cc
members
of comm.
Mirlam
Hayard

Dear Mr. Leonard

I have your letter of October 6 relating to Case 0407.

We want you to know that we greatly appreciate your assumption of Chairmanship of this Committee.

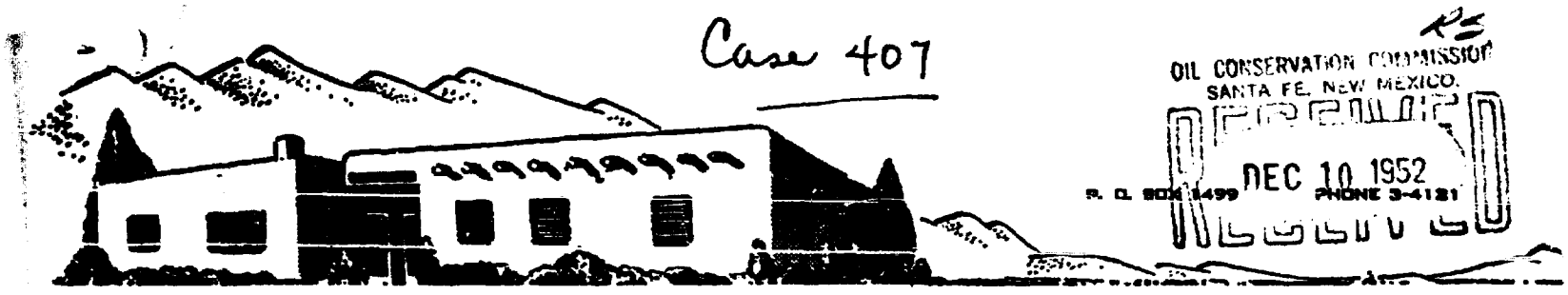
According to the minutes, the Comm. continued the hearing in Case 407 from October 15 to November 20 upon its own motion.

I appreciate the inclusion of the 2565 & Educational institutions of N.M.

I earnestly suggest that you consider a meeting of the Comm before Nov 20 so that recommendations may be included in the record on that date. While the final determination of this case may take time, I believe that the matter should be kept alive and the Comm should be presented with recommendations or a motion on Nov. 20

Sincerely,
LS

Typed, Signed + Mailed
10-28-52
Hayward



Case 407

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
DEC 10 1952

P. O. BOX 1499 PHONE 3-4121

New Mexico Education Association

113 EAST MARCY STREET
SANTA FE · NEW MEXICO

December 8, 1952

Mr. R. R. Spurrier, Member
Oil Conservation Commission
Santa Fe, New Mexico

Dear Mr. Spurrier:

We have received numerous communications from school people over the state expressing concern over the Case #407 before the Oil Conservation Commission. A hearing covering this case was held in Lovington on November 17, at which time, according to our information, no agreement was reached.

The school people are interested because so much school revenue accrues from leases of public lands. They want us to present their point of view to the commission. We feel that this point of view really coincides with the point of view of the members of the commission, and that the commission members will appreciate the interest of the members of the teaching profession.

The primary point of conservation is to assure to the public, the taxpayers and the royalty holders, that when oil is discovered the pool is thoroughly explored, that production will be steady over a long period of years, and when the pool is eventually abandoned it will be because the pool has been exhausted of all available oil.

The primary interest of school authorities is that the income from oil lands will be steady, and over a long period of years, rather than a rapid expansion and exhaustion over a short period of time. Ten million dollars per year for ten years would not be near as attractive as five millions per year for twenty years in terms of steady school support.

It seems entirely within reason to assume that 4 wells on 80 acre spacings would not be as efficient in releasing oil as 8 wells on 40 acre spacings. The variation in porosity is such that in many cases deep wells on the wider spacings would likely be abandoned before the maximum amount of oil had been released. The allocation of production to wells on 80 acre spacings would be much larger than on 40 acre spacings, thus encouraging the forcing of a well and thus risking spoilage by water or exhausting the sand at a more rapid rate than the underground drainage could supply.

JOHN P. STEINER
EXECUTIVE SECRETARY

CHAS. H. WOOD
FIELD SERVICE SECRETARY

MINNIE GILLILAND
ASST. EDITOR SCHOOL REVIEW

The fact that all producers entered the state with the understanding that 40 acre spacings were the rule in New Mexico and the fact that leases and royalties were sold on the basis of forty acres, indicates that to change now to 80 acre spacings would involve endless litigation over royalties and rights. A good deal of unfairness to small producers who may hold adjacent drilling rights could result. Being forced to drill in the center of an 80 acre offset might well place the well on the edge of the pool, whereas, a 40 acre offset could more nearly insure good production. It is well known that oil pools in New Mexico are long and narrow.

Big producers might consider it an advantage to be relieved of the responsibility of drilling on 40 acre offsets, being willing to take a good profit on a well, and therefore, willing to risk efficiency in total and final drainage. This, however, is not conserving the mineral resources and is therefore not in the interest of taxpayers, the recipients of tax funds, or the public at large.

We doubt that any lease holders will be willing to sell their drilling rights because they must drill on 40 acre spacings. If such a condition should eventuate, and buyers could not be found, the problem could then be given further consideration.

It is for these reasons that we hope the commission will deny the rights asked for in Case #407.

Very truly yours,

John P. Steiner
John P. Steiner
Executive Secretary

Tom Wiley
Tom Wiley
Supt. of Public Instruction

JPS:em

The fact that all producers entered the state with the understanding that 40 acre spacings were the rule in New Mexico and the fact that leases and royalties were sold on the basis of forty acres, indicates that to change now to 80 acre spacings would involve endless litigation over royalties and rights. A good deal of unfairness to small producers who may hold adjacent drilling rights could result. Being forced to drill in the center of an 80 acre offset might well place the well on the edge of the pool, whereas, a 40 acre offset could more nearly insure good production. It is well known that oil pools in New Mexico are long and narrow.

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We doubt that any lease holders will be willing to sell their drilling rights because they must drill on 40 acre spacings. If such a condition should eventuate, and buyers could not be found, the problem could then be given further consideration.

It is for these reasons that we hope the commission will deny the rights asked for in Case #407.

Very truly yours,

John P. Steiner
Executive Secretary

Tom Wiley
Supt. of Public Instruction

JPS:em

Submitted by major oil cos at Nov 20 hearing - not as clear as pars 3 of Comm proposal

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 1407

3rd Revision

1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

3. Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well or within eighteen months after the completion date of the discovery well, whichever shall occur first, a hearing shall be set for the purpose of determining whether or not 80 acre spacing should be continued in effect.

4. Certified plats of proration units shall be filed with the Commission

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

White Section

Submitted by: Representatives of Magnolia - Phillips and R. H. Christie

* COPY

3rd Rev.

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 407

1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

3. Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well or within eighteen months after the completion date of the discovery well, whichever shall occur first, a hearing shall be set for the purpose of determining whether or not 80 acre spacing should be continued in effect.

4. Certified plats of proration units shall be filed with the Commission

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

* The above submitted by major oil companies at November 20th, 1952 hearing.

(Copied November 25, 1952.)

2nd Revision

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

C
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P
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CASE 407:

1. Temporary 80-acre proration units are hereby established for wildcat wells, as defined in Rule 104-A, completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505-a;

2. After the effective date of this order, no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production;

3. Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well, the proration unit shall be established at 40 acres, unless the operator can establish by clear and convincing evidence that one well will efficiently and economically drain the 80 acres assigned to the well.

and such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at said hearing.

November 24, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
NOV 26 1952

Mr. Harry Leonard
J. P. White Building
Roswell, New Mexico

Dear Mr. Leonard:

In accordance with the wishes of your committee on 80-acre spacing in New Mexico, representatives of Magnolia Petroleum Company, Phillips Petroleum Company and the undersigned met and drafted a proposed rule for 80-acre spacing in New Mexico, a copy of which is attached.

Copies of the proposed rule were circulated for comment among the operators attending the statewide hearing in Santa Fe on November 20th, which met with majority approval. It was specifically pointed out that the proposed rule was not a committee report.

It is the opinion of the three above-named representatives that the proposed rule is simple and workable and will take care of the majority of 80-acre spacing locations. Any exceptions to the rule, and we think there will be very few, can be disposed of by special hearings.

Since there are a number of deep wells being drilled in New Mexico, and since the Conservation Commission proposed such a rule on its own initiative and therefore I assume are desirous of having such a rule, an 80-acre spacing rule should, in my opinion, be adopted with as little delay as possible.

Therefore, may I suggest that your committee reconvene as soon as convenient and if possible not later than ten to fourteen days prior to the next statewide hearing, December 16, 1952, and make another effort to agree on a proposed 80-acre spacing rule for the Commission's consideration. The Magnolia and Phillips' representatives concur in this suggestion.

You have no doubt been advised that the Commission continued Case 407 until December 16, 1952, at which time it again will be heard.

A copy of the proposed rule is being mailed to each member of the committee.

Sincerely yours,

R. S. Christie

RSC/mr
Enclosure

cc: Mr. Wm. S. McKellar, Jr.,
Magnolia Petroleum Company
P. O. Box 900
Dallas, Texas

Judge E. M. Fowler
Phillips Petroleum Company
Amarillo, Texas

Mr. G. T. Hammons
Stanolind Building
Lovington, New Mexico

Mr. Jack Campbell
Lovington, New Mexico

Mr. J. L. Burns
Superintendent of Schools
Jal, New Mexico

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 407

1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

3. Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well or within eighteen months after the completion date of the discovery well, whichever shall occur first, a hearing shall be set for the purpose of determining whether or not 80 acre spacing should be continued in effect.

4. Certified plats of proration units shall be filed with the Commission.

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

Conditions

Mayfield's suggested Rule
Case 407

DEC 3 1952

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 407

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4. Certified plats of proration units shall be filed with the Commission

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

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OIL CONSERVATION COMMISSION

P. O. BOX 871
SANTA FE, NEW MEXICO

September 24, 1952

To the Committee on 80-acre spacing - Case 407:

Mr. Harry Leonard, Chairman
Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge E. H. Foster
Mr. G. T. Hammers
Mr. Jack Danglade

Gentlemen:

The Commission has chosen you to advise them on certain questions relating to Case 407, namely,

1. At what depth should the order be effective;
2. How many wells should be drilled before the hearing is called;
3. Should there be a time limit for the date of the hearing.

and such other questions as the Committee may desire to report on.

The Committee may select anyone they choose to represent them as an alternate.

We appoint Mr. Harry Leonard as Chairman to organize the Committee and set a date for its meeting.

Very truly yours,

R. R. Spurrier
Secretary - Director

RRS:lh
One original copy mailed
to each member of the above
mentioned Committee and
carbon copy to Mr. Glenn Staley.

WESTERN UNION

W. P. MARSHALL, PRESIDENT

1220

SYMBOLS
DL=Day Letter
NL=Night Letter
LT=Int'l Letter Telegram
VLT=Int'l Victory Ltr.

(32)

...ations in STANDARD TIME at point of origin. ...DARD TIME at point of destination

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
NOV 19 1952

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...18 AM 9 47

R R SPURRIER=

SECRETARY, OIL CONSERVATION COMMISSION SANTA FE NMEX=

YOUR COMMITTEE ON SPACING CASE NO. 407 MET AT LOVINGTON MONDAY MORNING SEVENTEENTH WITH COMMITTEE MEMBERS LEONARD, CHRISTIE, DANGLADE AND HANNERS PRESENT AND WITH OLLIE J FORD MAGNOLIA ENGINEER, PRESENT IN BEHALF OF COMMITTEE MEMBER MCKELLAR AND JASON W KELLAHIN ATTORNEY PRESENT IN BEHALF OF COMMITTEE MEMBER FOSTER AND WITH GLENN STALEY OF OPERATORS COMMITTEE AND DUPONT OF U S GEOLOGICAL SURVEY AND WITH REPRESENTATIVES OF NEW MEXICO EDUCATIONAL [redacted] ASSOCIATION AND OTHER INTERESTED PARTIES PRESENT. [redacted] IMPORTANCE OF THE CASE AND COMPLEXITY OF QUESTIONS WILL REQUIRE ADDITIONAL TIME FOR PREPARATION AND SUBMISSION OF COMMITTEE REPORT AND RECOMMENDATIONS. YOUR COMMITTEE RECOMMENDS UNANIMOUSLY POSTPONEMENT OF NOVEMBER TWENTIETH HEARING AND RESETTING THE CASE FOR LATER CONVENIENT DATE=

G T HANNERS ACTING CHAIRMAN=

Case 407

THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

Case 407

Harry Leonard
Roswell New Mexico

November 12, 1952

NOV 14 1952

Mr. Tom Miley
State Superintendent of Education
Santa Fe, New Mexico

Dear Mr. Miley:

Under date of September 24, 1952, the New Mexico Oil Conservation Commission appointed the following Committee on 80-Acre Spacing, Case No. 407:

Harry Leonard, Chairman,
R. S. Christie, Amerada Petroleum Corp., Tulsa, Oklahoma,
Wm. E. McKellar, Jr., Magnolia Petroleum Co., Dallas, Texas,
Judge E. E. Foster, Phillips Petroleum Co., Amarillo, Texas,
G. T. Hammers, Lovington, New Mexico,
Jack Douglass, Lovington, New Mexico,

to advise the Commission regarding Case No. 407, and to report on such other questions as the Committee might desire, at the hearing before the Commission on November 20th.

The educational institutions of New Mexico, being the largest royalty owners in the State, are vitally concerned with 80-acre spacing and many other questions being presented to the Oil Conservation Commission. In view of the importance of this case, we believe it desirable that all interests, particularly the educational institutions, be invited to sit in at our Committee Meeting to be held in the office of Mr. Jack Douglass, Lovington, New Mexico, at 10:00 o'clock A. M., on November 17th. We hope you will be able to attend.

Very truly yours,

Harry Leonard.

HL/o

Above letter sent to:

Mr. Johnny Walker, Silver City, N. M.
Mr. H. C. Pannell, Lovington, N. M.
Mr. J. A. Anderson, U. S. G. S. Roswell, N. M.
Mr. Tom Miley, State Superintendent of Education
Mr. O. J. Holder, Bureau of Budgets, Santa Fe, N. M.

Case 407

Harry Leonard
Roswell, New Mexico

November 12, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
NOV 14 1952
RECEIVED

To The Committee on 80-Acre Spacing, New Mexico Oil Conservation Commission Case 407

Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge E. E. Foster
Mr. G. T. Hammers
Mr. Jack Danglade

Gentlemen:

A meeting of the above named committee will be held in the office of Mr. Jack Danglade, Lovington, New Mexico, at 10:00 o'clock A. M., November 17th.

The purpose of this meeting is to consider Case 407, which is set for hearing before the Oil Conservation Commission on November 20th, and to discuss such other questions as the committee may desire to report on.

Very truly yours,

Harry Leonard
Chairman

HL/o

cc: Governor Edwin L. Mechem
Mr. Guy Shepard
Mr. R. R. Spurrier
Mr. Glenn Staley

COPY

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OIL CONSERVATION COMMISSION

P. O. BOX 871
SANTA FE, NEW MEXICO

November 25, 1952

TO THE ADVISORY COMMITTEE - CASE 407:

Attention: Mr. Harry Leonard - Chairman

Gentlemen:

The Commission held the scheduled hearing on Case 407 at which Mr. Hanner's telegram of November 18, 1952, was read. The word "unanimously" was objected to by Committee members McKellar, Kellahin (alternate member) and Christie at the hearing. Since half the Committee was not present, the Commission continued the case to the regular December 16, 1952 hearing.

It was suggested by some operators that if the Committee intends to ask for further continuance, that all operators intending to testify be notified before hand so an unnecessary trip to Santa Fe may be avoided.

The Commission will expect a report from your Committee at the next hearing and if that will not be possible, please advise soon.

Very truly yours

R. R. Spurrier
Secretary - Director

RRSdh
cc:
Mr. R. S. Christie
Mr. Wm. F. McKellar, Jr.
Judge E. S. Foster
Mr. G. T. Hanner
Mr. Jack Douglas
Mr. James Kellahin
Governor E. L. Mechem
Land Commissioner Guy Shepard
Mr. J. S. Bush
Mr. E. S. Walker

GOVERNOR EDWIN L. MECHEM
CHAIRMAN

LAND COMMISSIONER GUY SHEPARD
MEMBER

STATE GEOLOGIST R. R. SPURRIER
SECRETARY AND DIRECTOR

New Mexico
OIL CONSERVATION COMMISSION

P. O. BOX 871
SANTA FE, NEW MEXICO

November 25, 1952

TO THE ADVISORY COMMITTEE - CASE 407:

Mr. Harry Leonard, Chairman

Gentlemen:

The Commission held the scheduled hearing on Case 407 at which Mr. Hanner's telegram of November 18, 1952, was read. The word "unanimously" was objected to by Committee members McKellar, Kellahin (alternate member) and Christie at the hearing, ~~saying that they did not wish the case to be continued~~. Since half the Committee was not present, the Commission did continue the case to the regular December 16, 1952 hearing.

It was suggested by some operators that if the Committee intends to ask for further continuance, that all operators intending to testify be notified before hand so an unnecessary trip to Santa Fe may be avoided.

The Commission will expect a report from your Committee at the next hearing and if that will not be possible, please advise soon.

Very Truly yours,

R. R. Spurrier
Secretary - Director

RRS:lh
cc: - 2
Mr. R. S. Christie
MR. Wm. E. McKellar, Jr.
Judge E. H. Foster
Mr. G. T. Hanners
Mr. Jack Danglade
Mr. Jason Kellahin
Governor E. L. Mechem
Land Commissioner Guy Shepard
Mr. J. S. Burk
Mr. E. S. Walker

K5

NEW MEXICO SCHOOL OF MINES

Socorro, New Mexico

Petroleum Engineering Department

Ca. 407

11 December 1952

Mr. Richard R. Spurrier
State Geologist
Santa Fe, New Mexico

Dear Dick:

I was greatly interested in the article, which appeared in this morning's 'Journal', quoting from a communication addressed to you by certain New Mexico 'educators', concerning oil and gas well spacing in the state.

The law which established the Conservation Commission finds its only legal basis in the 'Prevention of waste'. This waste can be measured in dollars as well as in barrels of oil.

I agree that oil and gas well spacing depends on such factors as porosity, permeability, etc. but it also depends on the cost of drilling and producing the wells. I can see how the cost of two wells might exceed the value of the oil obtained from them, whereas the same amount of oil could be obtained from one well at a profit. Certainly we cannot expect people to develope oil and gas pools unless they can reasonably expect a return on the investment. This is particularly true in the case of deep wells which may cost as much as a million dollars each, during their productive life.

I am not, and never have been, convinced that a uniform spacing was the best approach to conservation. It is entirely possible that the area drained by a single well might be as small as one acre or as great as 600. This drainage area, for a particular pool, can only be determined after certain parameters such as porosity, permeability, saturation, viscosity, water content, thickness, inclination, structure, uniformity, well drilling costs, well producing costs, and crude oil prices are established

for the particular field. Unfortunately these are not fully determined until late in the life of the pool.

It is logical that we should develope a new oil or gas pool slowly, and on a wide spacing, until we can establish the optimum spacing and location of wells for that pool. I do not believe that locating wells in the center of legal land sub-divisions has any validity. In a domal type of trap, with an active water drive, the wells should be located along concentric, subsurface, structural contours, for the greatest ultimate recovery.

I realize, however, that the legal profession is not sufficiently advanced to appreciate this line of reasoning and that we will have to continue to adhere to present practice until the doctrine of unit operation of oil and gas pools can be substituted for the present tenet of 'correlative rights'.

The ruling in question is, in my opinion, a great step forward in the technique of oil field development and I hope it will receive your well considered support.

The educators should be brought to realize that they will receive any tax money from wells which are not drilled. If the establishment of temporary, wide, spacing will accelerate development of our resources then the answer is obvious.

I know that you have considered these matters but I want you to know that you can count on my support and assistance at any time.

Best regards,

Burt

Clarence B. Folsom, Jr
Head of Dept.

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

January 12, 1953

C

TO THE ADVISORY COMMITTEE - CASE 487:

Attention Mr. Harry Leonard - Chairman

Gentlemen:

O

Mr. W. E. McKellar, Jr., has tendered his resignation to the Commission to enable the assumption of other duties with the Magnolia Petroleum Company.

P

We take this opportunity to express our appreciation of his fine service and to wish him success.

Mr. E. T. Keeler of the same company, same address, will replace Mr. McKellar.

Y

Very truly yours,

R. R. Spurrier
Secretary - Director

RRS:ih
cc:
Mr. R. S. Christie
Mr. Wm. E. McKellar, Jr.
Judge E. S. Foster
Mr. G. T. Shumway
Mr. Jack Campbell
Mr. Jason Kellahin
Governor Edwin L. Mechem
Land Commissioner E. S. Walker
Mr. J. L. Bushe, Jr.
Mr. E. T. Keeler

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

CASE 407:

1. Temporary 80-acre proration units are hereby established for wildcat wells, as defined in Rule 106-A, completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505-a;

2. After the effective date of this order, no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production;

3. Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well, the proration unit shall be established at 40 acres, unless the operator can establish by clear and convincing evidence that one well will efficiently and economically drain the 80 acres assigned to the well.

and such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at said hearing.

NOTE: The above was submitted by Governor Mechem.

C O P Y

COPY

OIL CONSERVATION COMMISSION

P. O. BOX 871
SANTA FE, NEW MEXICO

December 5, 1952

To the Advisory Committee on Case 497:

Mr. Harry Leonard, Chairman
Mr. R. S. Christie
Mr. Wm. B. McKellar, Jr.
Judge E. S. Foster
Mr. G. T. Rommere
Mr. Jack Douglass

Gentlemen:

Due to the illness of Mrs. Tesch, Mr. Tesch will be unable to attend the Commission hearing of December 14, 1952 as an expert witness.

The Commission will therefore ask continuance of Case 497 to the regular January 15, 1953 hearing.

In view of this, it will not be necessary for other Committee members to bring expert witnesses to the December 14, 1952 hearing.

Trusting that this will meet with the approval of all Committee members.

Very truly yours,

R. R. Spurrier

R. R. Spurrier
Secretary - Director

RRS:ih
cc:
Governor Edwin L. Mechem
Land Commissioner Guy Shepard
Mr. E. S. Walker
Mr. J. S. Buell
Mr. Jason Kellahin

OIL CONSERVATION COMMISSION

P. O. BOX 871
SANTA FE, NEW MEXICO

December 5, 1952

To the Advisory Committee on Case 497:

C

Mr. Harry Leonard, Chairman
Mr. A. L. Gholson
Mr. Wm. J. McAnlis, Jr.
Judge E. S. Foster
Mr. G. T. Hammers
Mr. Jack Douglass

O

Gentlemen:

P

Due to the illness of Mrs. Tosch, Mr. Tosch will be unable to attend the Commission hearing of December 14, 1952 as an expert witness.

Y

The Commission will therefore ask continuance of Case 497 to the regular January 15, 1953 hearing.

In view of this, it will not be necessary for other Committee members to bring expert witnesses to the December 14, 1952 hearing.

Trusting that this will meet with the approval of all Committee members.

Very truly yours,

R. R. Spurrier

R. R. Spurrier
Secretary - Director

RRS:th
cc:
Governor Edwin L. Mechem
Land Commissioner Guy Shepard
Mr. E. S. Walker
Mr. J. S. Buell
Mr. James Kellahin

STATE OF NEW MEXICO
OFFICE OF STATE GEOLOGIST
SANTA FE, NEW MEXICO

January 19, 1953

C
O
P
Y

Mr. W. E. Hilliker, Jr.
Magnolia Petroleum Company
Legal Department
Box 900
Dallas 1, Texas

Dear Mr. Hilliker:

We regretfully accept your resignation from the Oil and Gas Advisory Commission.

We are sending this to let you know how much we appreciate your assistance and to wish the best success possible in the new job.

Sincerely,

E. K. Spurrier
Secretary - Director

WBm

MAGNOLIA PETROLEUM COMPANY

A SOCONY-VACUUM COMPANY

LEGAL DEPARTMENT

DALLAS 1, TEXAS

EARL A. BROWN
GENERAL COUNSEL
ROY C. LEDBETTER
RAYMOND M. MYERS
CHAS. B. WALLACE
R. T. WILKINSON, JR.
FRANK C. BOLTON, JR.
JACK VICKREY
SAM H. FIELD
ROSS MADOLE
FLOYD J. PITTS
W. E. McKELLAR, JR.
ASSISTANTS

December 30, 1952

JAN 2 1953

Committee on New Mexico Conservation
Commission Case No. 407

Mr. R. R. Spurrier
New Mexico Oil Conservation Commission
Santa Fe, New Mexico

Dear Dick:

Effective January 1, 1953, I will no longer be assiciated with the Legal Department of Magnolia Petroleum Company. It is necessary therefore that I tender my resignation on the above Committee.

I have sincerely enjoyed working with you and the other members of the New Mexico Commission and it is with heartfelt regret that I tender this resignation.

Sincerely yours,

W. E. McKellar, Jr.

W. E. McKellar, Jr.

WEMcK:ec

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

Case 407

December 16, 1952

C

O

P

Y

Mr. J. L. Burke, Jr.
Superintendent of Schools
Jal, New Mexico

Dear Mr. Burke:

Thank you for your letter of identification, however, I knew all the time who you were but my secretary didn't.

I am glad to know you are serving on the Committee and will be looking forward to seeing you in January.

Very truly yours,

R. R. Spurrier
Secretary - Director

lh

JAL PUBLIC SCHOOLS
JAL, NEW MEXICO

J. L. Burke, Jr., Superintendent

December 9, 1952

Mr. R. R. Spurrier, Secretary-Director
Oil Conservation Commission
P. O. Box 871
Santa Fe, New Mexico

Dear Mr. Spurrier:

So that you will know to whom you are directing copies of your correspondence, the J. S. Burk on your list is none other than yours truly, J. L. Burke.

Will try to see you in January.

Cordially yours,

J. L. Burke

JLB/pk

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
DEC 12

EXECUTIVE OFFICE
SANTA FE, NEW MEXICO

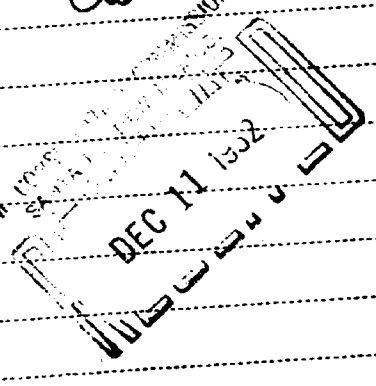
12/11/52, 195....

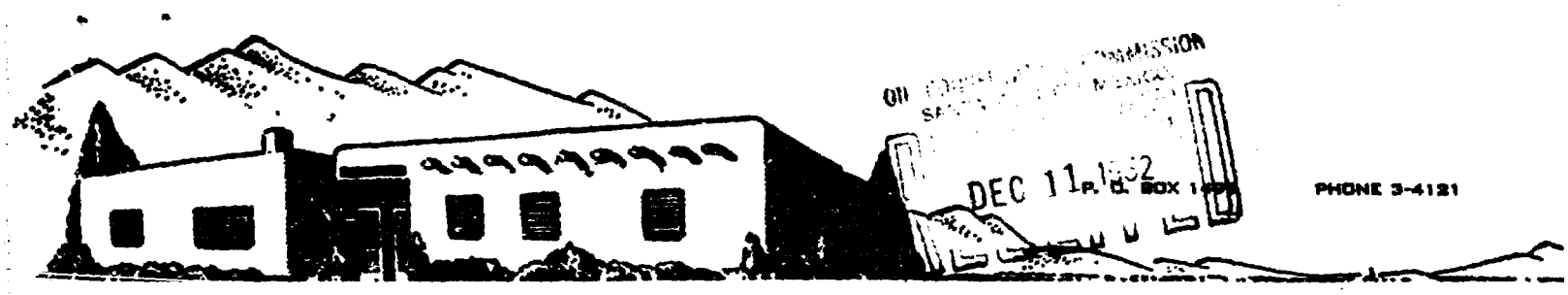
Respectfully referred to .....
Mr. Dick Spurrier
.....

for such action and report as in his opinion may seem necessary.

ELM
.....
GOVERNOR

Remarks: Case 407





OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
DEC 11 1952
P. O. BOX 1

PHONE 3-4121

New Mexico Education Association

114 EAST MARCY STREET
SANTA FE · NEW MEXICO

December 9, 1952

DEC 10'52

Correction on dictaphone

Acknowledge upon Dick returns Santa Fe Case #407

Governor Edwin L. Mechem, Member
Oil Conservation Commission
Santa Fe, New Mexico

Dear Governor Mechem:

We have received numerous communications from school people over the state expressing concern over the Case #407 before the Oil Conservation Commission. A hearing covering this case was held in Lovington on November 17, at which time, according to our information, no agreement was reached.

The school people are interested because so much school revenue accrues from leases of public lands. They want us to present their point of view to the commission. We feel that this point of view really coincides with the point of view of the members of the commission, and that the commission members will appreciate the interest of the members of the teaching profession.

The primary point of conservation is to assure to the public, the taxpayers and the royalty holders, that when oil is discovered the pool is thoroughly explored, that production will be steady over a long period of years, and when the pool is eventually abandoned it will be because the pool has been exhausted of all available oil.

The primary interest of school authorities is that the income from oil lands will be steady, and over a long period of years, rather than a rapid expansion and exhaustion over a short period of time. Ten million dollars per year for ten years would not be near as attractive as five millions per year for twenty years, in terms of steady school support.

It seems entirely within reason to assume that 4 wells on 80 acre spacings would not be as efficient in releasing oil as 8 wells on 40 acre spacings. The variation in porosity is such that in many cases deep wells on the wider spacings would likely be abandoned before the maximum amount of oil had been released. The allocation of production to wells on 80 acre spacings would be much larger than on 40 acre spacings, thus encouraging the forcing of a well and thus risking spoilage by water or exhaustion of sand at a more rapid rate than the underground drainage could supply.

JOHN P. STEINER
EXECUTIVE SECRETARY

CHAS. H. WOOD
FIELD SERVICE SECRETARY

MINNIE GILLILAND
ASST. EDITOR SCHOOL REVIEW

The fact that all producers entered the state with the understanding that 40 acre spacings were the rule in New Mexico and the fact that leases and royalties were sold on the basis of forty acres, indicates that to change now to 80 acre spacings would involve endless litigation over royalties and rights. A good deal of unfairness to small producers who may hold adjacent drilling rights could result. Being forced to drill in the center of an 80 acre offset might well place the well on the edge of the pool, whereas, a 40 acre offset could more nearly insure good production. It is well known that oil pools in New Mexico are long and narrow.

Big producers might consider it an advantage to be relieved of the responsibility of drilling on 40 acre offsets, being willing to take a good profit on a well, and therefore, willing to risk efficiency in total and final drainage. This, however, is not conserving the mineral resources and is therefore not in the interest of taxpayers, the recipients of tax funds, or the public at large.

We doubt that any lease holders will be willing to sell their drilling rights because they must drill on 40 acre spacings. If such a condition should eventuate, and buyers could not be found, the problem could then be given further consideration.

It is for these reasons that we hope the commission will deny the rights asked for in Case #407.

Very truly yours,

John P. Steiner

John P. Steiner
Executive Secretary

JPS:em

Tom Wiley,
Supt. of Public Instruction

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 407

1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

150' tolerance

3. Unless within not more than 18 months after completion date of the discovery well or within 60 days after completion of the 5th well to the same producing formation within a radius of 2 miles of such wildcat well, whichever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for said reservoir, such spacing pattern shall revert to 40 acres and upon such hearing the burden shall be upon such operator or operators to show that one well will efficiently and economically drain 80 acres, failing which, such spacing pattern shall revert to 40 acres.

4. Certified plats of proration units shall be filed with the Commission.

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

BEFORE THE

OIL CONSERVATION COMMISSION

STATE OF NEW MEXICO

TRANSCRIPT OF PROCEEDINGS

CASE NO. 407

Regular Hearing
October 15, 1952

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
OCT 30 1952

E. E. GREESON
ADA DEARNLEY
COURT REPORTERS
BOX 1305
PHONES 5-9422 AND 5-9546
ALBUQUERQUE, NEW MEXICO

BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

Santa Fe, New Mexico

October 15, 1952

In the Matter of:

(Continued from September 16 hearing)
The Commission's motion for extension of Section 'G', Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary 80-Acre Proration Units. Case: 407

TRANSCRIPT OF HEARING

(Notice of publication read by Mr. Graham.)

MR. SPURRIER: Anyone to be heard? Judge Foster.

MR. FOSTER: I don't know whether everybody knows it or not, but there was a Committee appointed to study the proposal and make its recommendation at this meeting. I am not the chairman of that Committee, I am just one of the members, but I just want to say there has been no Committee Meeting and I assume that there probably will be, and there will be some sort of report available for action by the Commission at the next hearing. I don't know. You might advise everybody who is on that Committee.

MR. SPURRIER: I will be glad to. I have a letter here from the Chairman of the Committee, Harry Leonard, dated October 6th. Incidentally, the members of that Committee are Judge Foster, R. S. Christie, Ed McKellar, G. T. Hanners and Jack Danglade. Here is what Mr. Leonard says on October 6th:

(Letter read.)

MR. SPURRIER: Does anyone have a comment on this case, or is there any testimony to be introduced, at this time?

MR. McKELLAR: I don't have any testimony to be introduced, but I would like to request on behalf of Magnolia that the matter be continued until the next hearing, which would be the November 13th hearing.

MR. SPURRIER: November 20th.

MR. McKELLAR: We are very much desirous of finishing this matter up at the earliest possible date. I see, personally, no reason why it should be continued until sometime in the spring. I would like to have the matter continued to the next meeting and be prepared, at that time, to put on some testimony.

MR. SPURRIER: In view of the indefinitness of this letter, the Commission, on its own motion, yesterday moved to continue the case to the November 20th hearing, a definite date.

MR. FOSTER: Will it be considered at that time?

MR. SPURRIER: Yes, sir.

MR. FOSTER: Has the chairman been notified that it will be continued to November?

MR. SPURRIER: No, but he will be notified, so will all the members of the Committee. Obviously the Committee should meet before the next hearing. Is there any further comment?

MR. SPELLMAN: I wonder if I might read into the record a comment I have.

D. K. Spellman. The Ohio Oil Company urges the adoption of the rule proposed by the Oil Conservation Commission for the establishment of temporary 80-acre proration units applicable to new oil pools discovered at depths exceeding 10,000 feet. We believe also that the proposed rule should be so written that it establishes some uniform pattern for the development. That is, it should specify that wells should be drilled in alternate 40-acre locations to the discovery well. For example, assuming that the discovery well is drilled in the northwest quarter of a quarter section, then other wells must be drilled in either northwest quarters or southeast quarters of each quarter section for as long as the 80-acre proration units are maintained within the pool. We believe also that the proposed rule should specifically permit 80-acre units to be so assigned that they may be elongated in a north-south direction or an east-west direction, at the operators discretion.

MR. SPURRIER: Anyone else? If not, we will move on to Case 410.

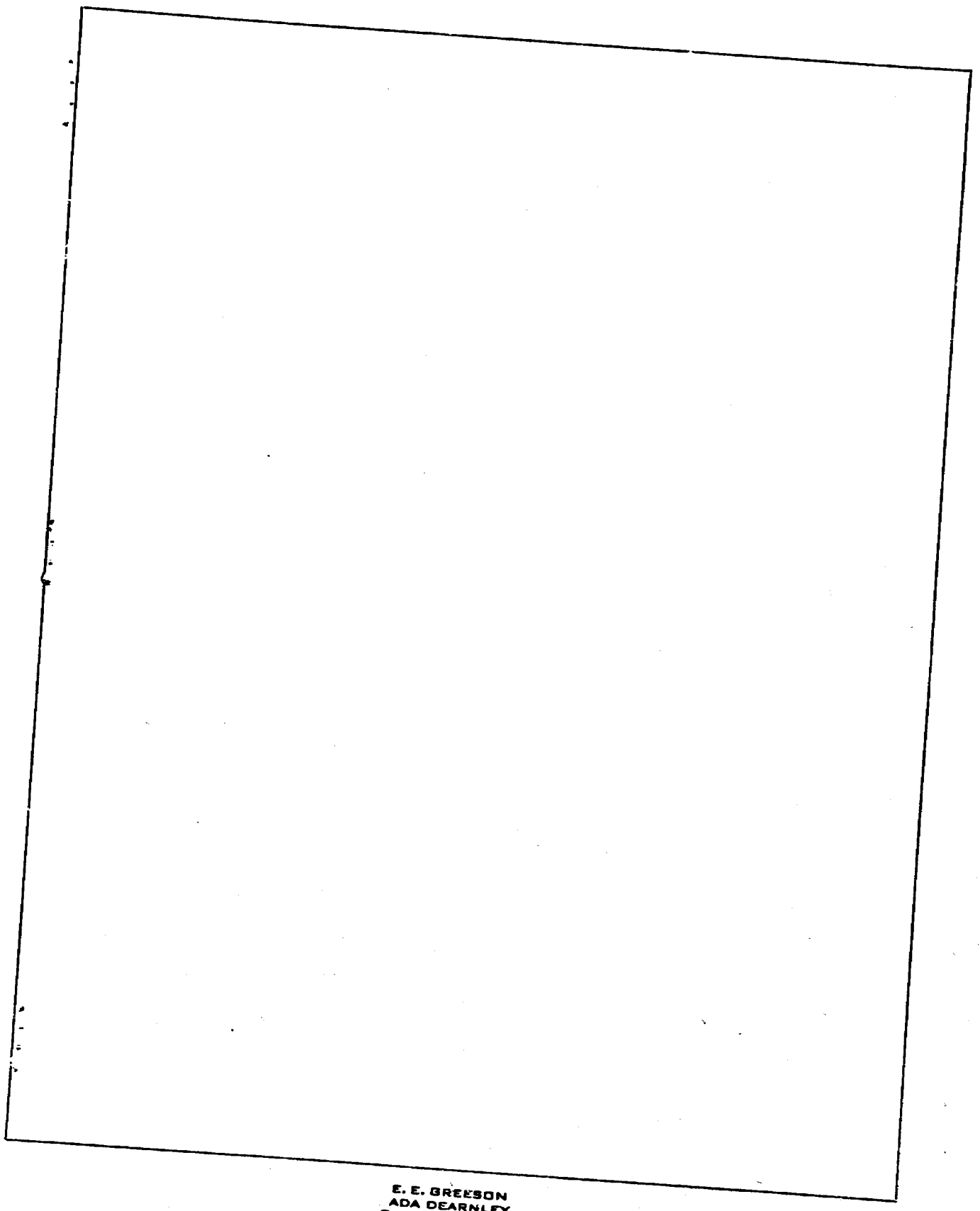
STATE OF NEW MEXICO)
: SS.
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, hereby certify that the above and foregoing transcript of proceedings in Case No. 407, taken before the Oil Conservation Commission on October 15, 1952, at Santa Fe, New Mexico, is a true and correct record.

Dated in Albuquerque, New Mexico, this 22nd day of October, 1952.

Notary Public

My Commission Expires:
June 19, 1955.



E. E. GREESON
ADA DEARNLEY
COURT REPORTERS
BOX 1303
PHONES 5-9422 AND 5-9546
ALBUQUERQUE, NEW MEXICO

BEFORE THE

OIL CONSERVATION COMMISSION

STATE OF NEW MEXICO

JAN 12 1953

CASE NO. 1 (Continued successively since September 16) The Commission's motion for extension of Section 'G', Oil Proration and Allocation, to provide for addition to Rule 506, Establishment of Temporary 80-Acre Proration Units.

REPORTER'S TRANSCRIPT OF HEARING

December 16, 1952

STATE OF NEW MEXICO)
) ss.
COUNTY OF BERNALILLO)

I, [illegible] CERTIFY That the within transcript of hearing in the matter styled and before the Oil Conservation Commission of the State of New Mexico is a true, correct and complete record to the best of my knowledge, skill and ability.

[illegible] at Albuquerque, New Mexico, December 16, 1952.

E. E. Gilbreath
Reporter

MR. SPURRIER: We will move on to Case 407.

(Mr. Graham reads the notice of publication.)

MR. SMITH: May it please the Commission, I am J. K. Smith of the Stanolind Oil & Gas Company.

I would like to suggest to the Commission this matter be continued for ninety days or to the March hearing. It has occurred to me that the most significant type of data to get with respect to the feasibility of 80-acre spacing or 40-acre or 20 or whatever it may be is reservoir performance. And perhaps the Commission might like to give some consideration to any interference tests which may be run during the interim period before March to determine whether or not the evidice is consistent with that which was developed at the Fowler Pool hearing which we put on. We would like to make that suggestion and ask that the hearing be postponed until the March hearing.

2

MR. SPURRIER: That is your motion?

MR. SMITH: Yes, sir.

MR. SPURRIER: Anyone else have a comment? Does anyone have an objection to counsel's motion for a continuance to March? Without objection, the case will be continued until the regular March hearing.

____o____



BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

Santa Fe, New Mexico
March 17, 1953

TRANSCRIPT OF HEARING
CASE NO. 407

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
MAR 31 1953

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 12, CROMWELL BLDG
PHONES 7-9645 AND 5-9546
ALBUQUERQUE NEW MEXICO

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

March 17, 1953

In the Matter of)
Case No. 407.)

TRANSCRIPT OF HEARING

MR. SPURRIER: The next case on the docket is case 407.

(Notice of Publication read by Mr. Graham)

MR. SPURRIER: Is there anyone here in case 407? If not, I guess I will have to dismiss it.

MR. McDOWELL: It was our understanding it was to be continued until the April hearing.

MR. SPURRIER: I don't believe our records show anything to that effect.

MR. SMITH: I make a motion that the case be continued.

MR. SPURRIER: Any objection to Mr. Smith's motion? Mr. Foster, did you wish to say something?

MR. FOSTER: E. H. Foster, representative of Phillips Petroleum Company. I am advised that the Governor couldn't be here for the hearing today and that the case would be continued. I don't know whether my information is wrong or not, but that is a statement for the record for whatever it is worth. I certainly don't want to see the case dismissed.

MR. SPURRIER: Very well, it is apparent that the Governor

is not here and Mr. Smith has made a motion to continue. Without objection that is what the Commission will do. The case will be continued to the regular April hearing, April the 17th.

REPORTER'S CERTIFICATE

I, ADA DEARNLEY, Court Reporter, hereby certify that the foregoing pages, numbered 1 and 2, constitute a complete and accurate record of the proceedings before the Oil Conservation Commission of New Mexico, in Case No. 407, on March 17, 1953, to the best of my knowledge, skill and ability.

Ada Dearnley
REPORTER

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 105-106, EL CORTEZ BLDG.
PHONES 7-9645 AND 5-9546
ALBUQUERQUE, NEW MEXICO

Ex. 2

Case 407

APRIL, 1953 SUMMARY

Field	Age Form	Depth Range	Tot. Wells	No. Marg. Wells	Tot. Allow.	Allow. Marg. Wells
Bagley-Siluro/Dev.	SD	10-11	21	6	5,779	1,024
Caprock, E. Devonian	Dev.	11-12	13	-0-	3,328	-0-
Caprock, E. Penn.	Penn.	10-11	1	1	35	35
Crossroads	SD	12-13	8	2	2,154	330
Denton	Dev.	11-12	57	5	14,162	850
Dollarhide, West	E	10-11	8	1	1,597	120
Echol, Devonian	Dev.	11-12	5	-0-	1,582	-0-
Echol, Dev. North	Dev.	12-13	1	1	12	12
Eidson (Penn.)	Penn.	10-11	1	-0-	211	-0-
Gladiola	Dev.	12-13	5	-0-	1,520	-0-
Hightower	Dev.	10-11	2	2	175	175
King, Wolfcamp	WC	10-11	1	1	124	124
Knowles	Dev.	12-13	6	6	1,082	1,082
Lovington, E. (Penn.)	Penn.	11-12	5	4	439	183
Lovington, Wolfcamp	WC	10-11	1	-0-	211	-0-
Maljamar Devonian	Dev.	13-14	1	1	115	115
Moore Devonian	Dev.	10-11	8	1	1,557	80
Saunders, South	P-Pe	10-11	2	2	77	77
Townsend Wolfcamp	WC	10-11	6	1	1,130	75
Undesignated Grp. 8		11-12	2	-0-	512	-0-
Undesignated Grp. 9		12-13	1	-0-	304	-0-
Totals- -			155	34 (21.93%)	36,106	4,282 (11.86%)

R. W. TESCH

FORM 929 2-49

Case 407

STANOLIND OIL AND GAS COMPANY

OIL AND GAS BUILDING

FORT WORTH, TEXAS

C. F. BEDFORD
DIVISION PRODUCTION SUPERINTENDENT

admitted as an exhibit on 16 April 53

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
OCT 23 1952

October 20, 1952

File: RGH-5241-175

Subject: New Mexico Oil Conservation Commission Case 407, 80-Acre

To The Committee on 80-Acre Spacing, New Mexico Oil Conservation Commission Case 407

Mr. Harry Leonard, Chairman
Mr. R. S. Christie
Mr. W. E. McKellar, Jr.
Mr. E. H. Foster
Mr. G. T. Hanners
Mr. Jack Danglade

Gentlemen:

Since you have been appointed as a committee by the New Mexico Oil Conservation Commission to advise them on Case 407 pertaining to the adoption of 80-acre spacing, we believe it is appropriate that our thoughts on this matter be conveyed to you for consideration in preparing recommendations to the Commission.

In general, the Stanolind Oil and Gas Company is very much in favor of the adoption of a rule of this type. We believe it is a desirable, progressive step which will result in the prevention of waste by eliminating the drilling of unnecessary wells. It will encourage deeper exploration and, by more quickly defining subsurface structures, such a rule will enable the operators to obtain more conclusive data on which to establish the most suitable spacing pattern.

In order to make this rule more effective, however, we recommend that consideration be given to the following additional points:

1. The rule should remain in effect until five wells have been completed. A hearing should then be held to determine the final spacing pattern and this rule should continue in effect until a formal order has been issued. This procedure should enable the operators to acquire the minimum necessary data to support an application for appropriate field rules. Since development of deeper horizons normally proceeds at a relatively slow rate, we do not believe a time limit should be placed on this rule. Limiting the period of time during which the order is effective might preclude the acquisition of sufficient reservoir data to determine the optimum spacing pattern.

2. This rule should apply to any newly discovered horizon in which all or any part of the producing interval is encountered below 10,000 feet. It is virtually impossible on initial drilling to determine the relative position of a well on a subsurface structure, and we believe that such a provision is necessary to give the rule desirable flexibility, since our experience has indicated that many deep structures have steeply dipping flanks with relatively high closure and may reveal complex faulting.

3. Provision should be made in the rule for controlling the locations of the first five wells drilled in order to assure uniform and orderly development should 80-acre proration units eventually be adopted in the field on a permanent basis. For the five initial wells, this would require development on an alternate 40-acre spacing pattern. Contingent upon the outcome of the hearing, then, it would be a simple matter to continue on uniform "80-acre spacing" or drill the necessary wells to increase the density to 40-acre spacing and proration units.

Yours very truly,

C. F. Bedford.

RGH:dhs
cc: New Mexico Oil Conservation Commission
Box 871
Santa Fe, New Mexico
Attention: Mr. R. R. Spurrier, Secretary

Stanolind Exhibit #1 in Case 407

STANOLIND OIL AND GAS COMPANY

Fort Worth, Texas

October 20, 1952

File RGH-5421-175

Subject: New Mexico Oil
Conservation Commission
Case 407, 80-acre Spacing

To the Committee on 80-acre Spacing, New Mexico Oil Conservation Commission Case 407

Mr. Harry Leonard, Chairman
Mr. R. S. Christie
Mr. W. E. McKellar, Jr.
Mr. E. H. Foster
Mr. G. T. Hanners
Mr. Jack Danglade

Gentlemen:

Since you have been appointed as a committee by the New Mexico Oil Conservation Commission to advise them on Case 407 pertaining to the adoption of 80-acre spacing, we believe it is appropriate that our thoughts on this matter be conveyed to you for consideration in preparing recommendations to the Commission.

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1. The rule should remain in effect until five wells have been completed. A hearing should then be held to determine the final spacing pattern and this rule should continue in effect until a formal order has been issued. This procedure should enable the operator to acquire the minimum necessary data to support an application for appropriate field rules. Since development of deeper horizons normally proceeds a relatively slow rate, we do not believe a time limit should be placed on this rule. Limiting the period of time during which the order is effective might preclude the acquisition of sufficient reservoir data to

COPY

determine the optimum spacing pattern.

2. This rule should apply to any newly discovered horizon in which all or any part of the producing interval is encountered below 10,000 feet. It is virtually impossible on initial drilling to determine the relative position of a well on a subsurface structure, and we believe that such a provision is necessary to give the rule desirable flexibility, since our experience has indicated that many deep structures have steeply dipping flanks with relatively high closure and may reveal complex faulting.

3. Provision should be made in the rule for controlling the locations of the first five wells drilled in order to assure uniform and orderly development should 80-acre proration units eventually be adopted in the field on a permanent basis. For the five initial wells, this should require development on an alternate 40-acre spacing pattern. Contingent upon the outcome of the hearing, then, it would be a simple matter to continue on uniform "80-acre spacing" or drill the necessary wells to increase the density to 40-acre spacing and proration units.

Yours very truly,

RGH:dhs

C. F. Bedford

cc: New Mexico Oil Conservation Commission
Box 871
Santa Fe, New Mexico
Attention: Mr. R. R. Spurrier, Secretary

COPY

SUGGESTED STATEWIDE RULE

NEW MEXICO OIL CONSERVATION COMMISSION

CASE 407

1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description tp that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

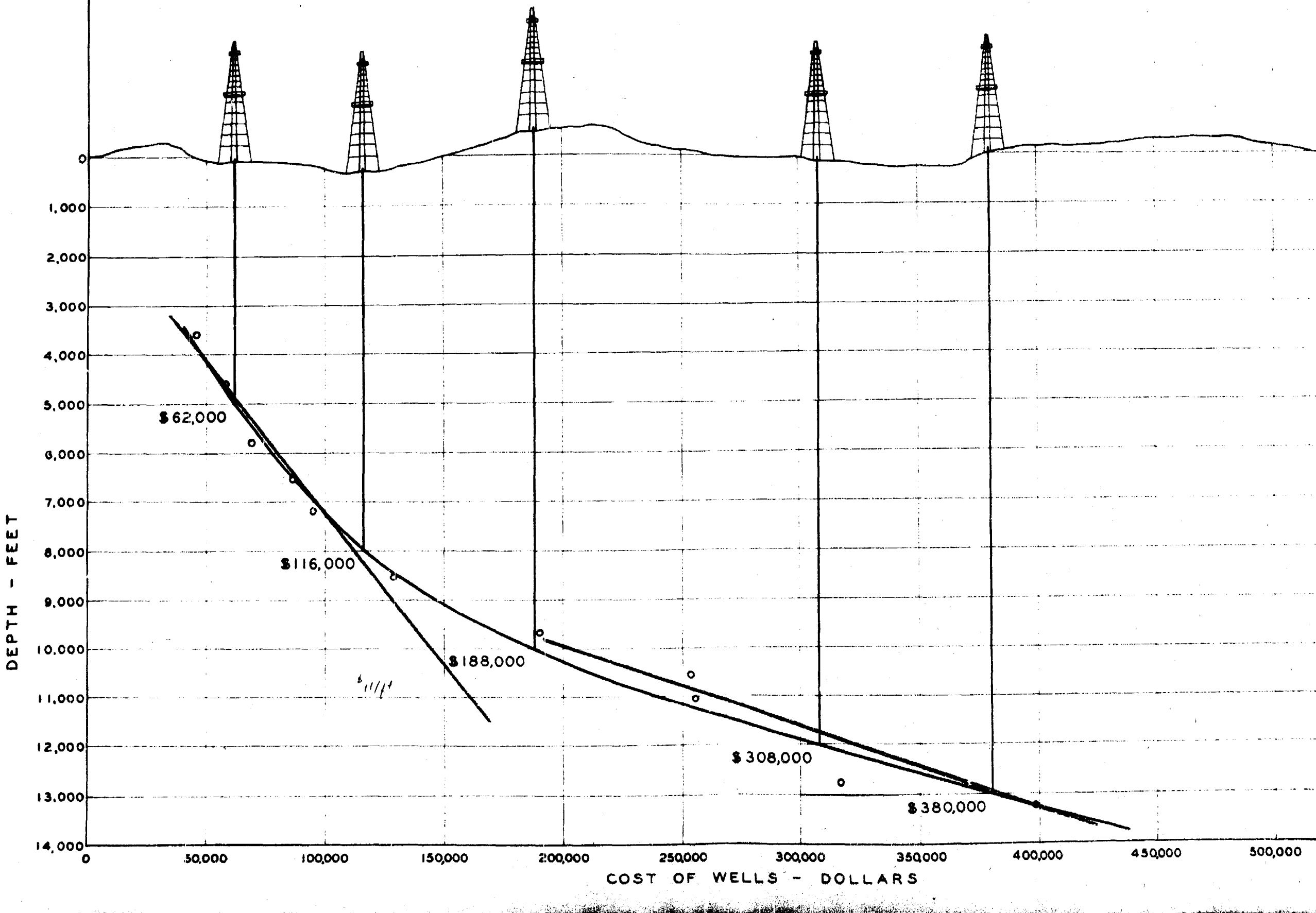
3. Unless within not more than 18 months after completion date of the discovery well or within 60 days after completion of the 5th well to the same producing formation within a radius of 2 miles of such wildcat well, whichever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for said reservoir, such spacing pattern shall revert to 40 acres and upon such hearing the burden shall be upon such operator or operators to show that one well will efficiently and economically drain 80 acres, failing which, such spacing pattern shall revert to 40 acres.

4. Certified plats of proration units shall be filed with the Commission.

and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing.

Phillips exhibit #2 in Docket 407

PHILLIPS PETROLEUM COMPANY
DRILLING COSTS VS. DEPTH
WEST TEXAS - NEW MEXICO AREA



explicitez en noe 407

R. W. TESCH

APRIL, 1953 SUMMARY

Field	Age Form	Depth Range	Tot. Wells	No. Marg. Wells	Tot. Allow.	Allow. Marg. Wells
Bagley-Siluro/Dev.	SD	10-11	21	6	5,779	1,021
Caprock, E. Devonian	Dev.	11-12	13	-0-	3,328	-0-
Caprock, E. Penn.	Penn.	10-11	1	1	35	35
Crossroads	SD	12-13	8	2	2,154	330
Denton	Dev.	11-12	57	5	14,162	850
Dollarhide, West	E	10-11	8	1	1,597	120
Echol, Devonian	Dev.	11-12	5	-0-	1,582	-0-
Echol, Dev. North	Dev.	12-13	1	1	12	12
Eidson (Penn.)	Penn.	10-11	1	-0-	211	-0-
Gladiola	Dev.	12-13	5	-0-	1,520	-0-
Hightower	Dev.	10-11	2	2	175	175
King, Wolfcamp	WC	10-11	1	1	124	124
Knowles	Dev.	12-13	6	6	1,082	1,082
Lovington, E. (Penn.)	Penn.	11-12	5	4	439	183
Lovington, Wolfcamp	WC	10-11	1	-0-	211	-0-
Maljamar Devonian	Dev.	13-14	1	1	115	115
Moore Devonian	Dev.	10-11	8	1	1,557	80
Saunders, South	P-Pe	10-11	2	2	77	77
Townsend Wolfcamp	WC	10-11	6	1	1,130	75
Undesignated Grp. 8		11-12	2	-0-	512	-0-
Undesignated Grp. 9		12-13	1	-0-	304	-0-
Totals- -			155	34 (21.93%)	36,106	4,282 (11.86%)

January 6, 1953

R W T - File 241 - 53

Mr. O. T. Hanners
Shamrock Bldg.
Lovington, New Mexico

Mr. Harry Leonard
Box 670
Hobbs, New Mexico

Mr. Jack Douglass
Lovington, New Mexico

Gentlemen:

You have asked me to investigate and advise you in regard to the proposed statewide order for New Mexico providing for 80-acre development for wells below ten thousand feet in depth.

I have investigated this matter and have come to the conclusion that such an order would be ill-advised, and that it would not be to the interests of many operators and royalty owners for such a rule to be passed by the Conservation Commission. On the contrary, it is my opinion that such an order could cause irreparable damage. In support of this general conclusion, I am attaching nine detailed conclusions, which I have developed as a result of my investigation.

It is my recommendation that you advise the Commission that you do not favor the proposed rule, and that you further advise them that it is your opinion that each field should be judged on its own particular conditions.

If I can be of further assistance to you in regard to this matter, kindly advise.

Yours very truly,

R. W. Tomb

R W Tomb

enc.

(Copy)

R. W. TESCH
Petroleum Engineer and Geologist
Continental Life Building
Fort Worth, Texas

January 6, 1953

RWT-File 241-53

CONCLUSIONS IN REGARD TO 80-ACRE PRORATION UNITS AS A STATE-WIDE ORDER IN NEW MEXICO.

1. Many of the deeper structures have revealed steeply dipping flanks and complex faulting, thus staggered 40-acre spacing with 80-acre proration units could result in one operator forcing another operator to drill at a location which might be dry or located at an inferior structure position.

2. 80-acre development will result in less oil being recovered than with closer development.

3. Rule 505 of the Conservation Commission provides for higher allowables with depth and is based upon economic considerations so that an operator recovers his investment in approximately the same time for different depths. (Note: If there are unusual economic conditions in any particular field, then Rule 505 should be revised for that field.)

4. High concentrated withdrawals for dispersed wells could conceivably result in large quantities being trapped off by uneven encroachment or coning of water.

5. No oil-producing state has ordered state-wide 80-acre spacing for oil wells.

6. Nearly all oil-producing states inaugurate individual field rules after sufficient evidence has been obtained to determine the most applicable rules.

7. In the case of the Crossroads Field, the New Mexico Commission found that 80-acre development was improper and revised the rules for that field back to 40-acre development.

8. The proposed 80-acre rule is only a device to force the Commission to assume responsibility for acts by operators that are contrary to their lease contracts and obligations, and thus places the royalty owner (which includes the public schools, state and federal governments) in the position of being forced to sue the Commission for any illegal acts of an operator.

9. There are four fields in New Mexico in which the Commission has found that 80-acre development is proper, thus proving that there is no necessity for a state-wide rule providing for 80-acre development below ten thousand feet.

Copy

BEFORE THE OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

IN THE MATTER OF THE COMMISSION'S MOTION FOR EXTENSION OF SECTION G (OIL PRORATION AND ALLOCATION) TO PROVIDE FOR ADDITIONAL RULE 508, ESTABLISHING OF TEMPORARY 80-ACRE PRORATION UNITS.

CASE NO. 407

REPORT OF COMMITTEE

The letter appointing this committee directed it to report on three features of a proposed spacing rule and also to report on such other questions as the committee might desire. Wisdom of the proposed rule not being apparent, and the Phillips, Amerada and Magnolia members of the Committee having advocated such a rule, the Chairman Harry Leonard, Acting Chairman G. T. Hanners and Committee Member F. J. Danglade felt that an independent, disinterested petroleum engineer should be consulted as to the questions and problems necessarily connected with the proposed rule before any attempt be made to report on the three specific features of the proposed rule.

After consultation with R. W. Tesch, an independent and disinterested petroleum engineer and geologist, of Ft. Worth, and after thorough study of the proposed rule, it is the considered opinion of the undersigned chairman and committee members that the features of it are so foreign to the orderly development of the oil pools of this state that no further consideration should be given to any of the features of the proposed rule, and that the proposed rule, in its entirety, should be rejected. Not only would the adoption of the proposed rule hamper the orderly development of any fields, but it would tend to the reduction of the ultimate recovery of oil, and, thereby, to the creation of waste.

We, therefore, recommend that the proposed rule be rejected for the following general reasons:

1. The adoption of such a spacing rule for new fields, in advance of their discovery, necessarily assumes that all fields will be identical and that one well will always adequately and efficiently drain and develop 80 acres, which experience in New Mexico fields has shown not to be true.

2. Each new field, after discovery, should be judged on its own particular conditions. And if peculiar conditions warrant an exception from normal rules, the same should be considered after the establishment of facts to warrant it, but the adoption in advance of exceptions is necessarily based on a false premise.

3. The public policy of New Mexico, as expressed in the recent session of the Legislature, is for the Commission, in establishing proration units, to consider, among other things, the rights of royalty owners and the reduced recovery, and physical waste, which might result from the drilling of too few wells; and the adoption of the proposed rule, in advance of the discovery of the field or any technical data or knowledge about it, would thwart the expressed intent of the Legislature.

4. Although the proposed rule is disguised as a temporary one, practical experience in such matters convince impartial observers that the actual effect of it would be to shift the burden of proof to the royalty owners, and that the rights of royalty owners, including the beneficiaries of our State lands, could be jeopardized.

5. That the orderly development of oil fields would be hampered by the adoption of any rule that sanctioned the drilling of fewer wells than reasonably necessary to efficiently and adequately drain and develop the field and that waste of natural resources would thereby be created.

A copy of the report of R. W. Tesch, petroleum engineer and geologist, setting forth his conclusions in more detail and in more technical manner, after study of the proposed rule and questions and problems necessarily connected with it, is attached to this committee report as Exhibit "A". Mr. Tesch is personally present, prepared to testify in support of his conclusions and in support of this committee report.

We respectfully recommend that the proposed rule, in its entirety, be rejected.

/s/ Harry Leonard
Chairman

/s/ G. T. Hammers
Acting Chairman

/s/ F. J. Danglade
Member

4-16-53

(Copy)

BEFORE THE OIL CONSERVATION COMMISSION

OF NEW MEXICO

IN THE MATTER OF THE APPLICATION OF THE OIL CONSERVATION COMMISSION UPON ITS OWN MOTION FOR AN ORDER EXTENDING SECTION G, OIL PRORATION AND ALLOCATION, TO PROVIDE FOR THE ADDITION OF RULE 508, ESTABLISHING TEMPORARY EIGHTY ACRE PRORATION UNITS

CASE No. 407

Order No. R-_____

ORDER OF THE COMMISSION

BY THE COMMISSION

This cause came on for hearing at 9 o'clock a.m., September 16, 1952, and for further hearing on November 20, 1952, January 15, 1953, April 16, 1953, and June 16, 1953, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission".

NOW, on this ____ day of _____, 1953, the Commission, a quorum being present, having considered all of the testimony adduced at said hearings, and having considered the exhibits offered, and being fully advised in the premises,

FINDS:

1. That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

2. That adoption of the proposed rule establishing temporary eighty acre proration units will promote and result in the conservation of oil and gas in New Mexico.

3. That the proposed rule will result in a prevention of waste, the drilling of unnecessary wells, and will protect the correlative rights of owners within a common reservoir.

IT IS THEREFORE ORDERED:

That the Rules and Regulations, New Mexico Oil Conservation Commission, Revised January 1, 1953, be, and the same hereby are amended to include Rule 508, as follows:

"RULE 508. TEMPORARY 80-ACRE PRORATION UNITS

"1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wild-cat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

"2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

"3. Unless within not more than 18 months after completion date of the discovery well or within 60 days after completion of the fifth well to the same producing formation within a radius of two miles of such wildcat well, whichever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for said reservoir, such spacing pattern shall revert to 40 acres and upon such hearing the burden shall be upon such operator or operators to show that one well will efficiently and economically drain 80 acres, failing which, such spacing pattern shall revert to 40 acres.

"4. Certified plats of proration units shall be filed with the Commission."

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

New Mexico Oil Conservation Commission

Edwin L. Mechem, Chairman

E. S. Walker, Member

R. R. Spurrier, Secretary

BEFORE THE OIL CONSERVATION COMMISSION

OF NEW MEXICO

IN THE MATTER OF THE APPLICATION OF THE OIL CONSERVATION COMMISSION UPON ITS OWN MOTION FOR AN ORDER EXTENDING SECTION G, OIL PRORATION AND ALLOCATION, TO PROVIDE FOR THE ADDITION OF RULE 508, ESTABLISHING TEMPORARY EIGHTY ACRE PRORATION UNITS

CASE NO. 407

Order No. R_____

ORDER OF THE COMMISSION

BY THE COMMISSION

This cause came on for hearing at 9o'clock a. m., September 16, 1952, and for further hearing on November 20, 1952, January 15, 1953, April 16, 1953 and June 16, 1953, at Santa Fe, New Mexico, before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission".

NOW, on this _____day of _____, 1953, the Commission, a quorum being present, having considered all of the testimony adduced at said hearings, and having considered the exhibits offered, and being fully advised in the premises,

FINDS:

1. That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

2. That adoption of the proposed rule establishing temporary eighty acre proration units will promote and result in the conservation of oil and gas in New Mexico.

3. That the proposed rule will result in a prevention of waste, the drilling of unnecessary wells, and will protect the correlative rights of owners within a common reservoir.

IT IS THEREFORE ORDERED:

That the Rules and Regulations, New Mexico Oil Conservation Commission, Revised January 1, 1953, be, and the same hereby are

amended to include Rule 508, as follows:

"RULE 508. TEMPORARY 80-ACRE PRORATION UNITS

"1. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wild-cat well at a depth range of 10,000 feet or more shall ~~be required to~~ drill more than one well to each 80 acres.

"2. The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units, running either North and South or East and West.

"3. Unless within not more than 18 months after completion date of the discovery well or within 60 days after completion of the fifth well to the same producing formation within a radius of two miles of such wildcat well, whichever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for said reservoir, such spacing pattern shall revert to 40 acres and upon such hearing the burden shall be upon such operator or operators to show that one well will efficiently and economically drain 80 acres, failing which, such spacing pattern shall revert to 40 acres.

"4. Certified plats of proration units shall be filed with the Commission."

"5. Not less than 90 days before expiration of temporary 80 acre spacing as defined in Section 3 above the operators in such pool shall provide the Commission with a certified list of all interest owners within the pool together with their addresses in order that the Commission may give such owner not less than 30 days notice of any proceeding with respect to the continuation or abolishment of 80 acre spacing in such area.

"6. Nothing herein shall be construed as a requirement by the Commission for any operator to drill any well at any location, or, as modifying any express or implied covenant in any lease agreement covering lands in the area affected."

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

NEW MEXICO OIL CONSERVATION COMMISSION

Edwin L. Mechem, Chairman

E. S. Walker, Member

R. R. Spurrier, Secretary

BEFORE THE OIL CONSERVATION COMMISSION
OF NEW MEXICO

IN THE MATTER OF THE HEARING
CALLED FOR THE PURPOSE OF
CONSIDERING:

CASE NO. 497
ORDER NO.
R-346

THE MATTER OF THE APPLICATION
OF THE OIL CONSERVATION COMMISSION
UPON ITS OWN MOTION FOR AN ORDER
EXTENDING SECTION G, OIL PRORATION
AND ALLOCATION, TO PROVIDE FOR AN
ADDITION OF RULE 508, RELATING TO
80 ACRE SPACING ON A STATEWIDE BASIS.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This matter came on for hearing on September 16, 1952, and for further hearings on November 20, 1952; January 15, 1953; April 16, 1953 and June 16, 1953, at 9:00 o'clock A. M., on said respective dates, at Santa Fe, New Mexico before the Oil Conservation Commission of New Mexico hereinafter referred to as the "Commission."

NOW on this 13th day of July, 1953, the Commission, a quorum being present, having considered the voluminous testimony adduced and exhibits received, and being fully advised in the premises,

FINDS:

1. That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

2. That testimony adduced relevant to temporary statewide 80 acre spacing for pools 10,000 and deeper indicates no advantage over existing spacing pattern.

3. That waste as defined in the Oil Conservation law will not be prevented or correlative rights protected in Temporary 80 acre spacing of deep pools.

IT IS THEREFORE ORDERED That the application of the Oil Conservation Commission upon its own motion for an order extending Section G, Oil Proration and allocation, to provide for the addition thereto of Rule 508 - establishment of Temporary Eighty-Acre Proration Units, be, and the same hereby is denied.

DONE at Santa Fe, New Mexico on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

E. L. Mechem

EDWIN L. MECHEM, Chairman

E. S. Walker

E. S. WALKER, Member

R. R. Spurrier

R. R. SPURRIER, Secretary

STANOLIND OIL AND GAS CO EXHIBITS CASE 407

OCC HEARING JUNE 16 1953

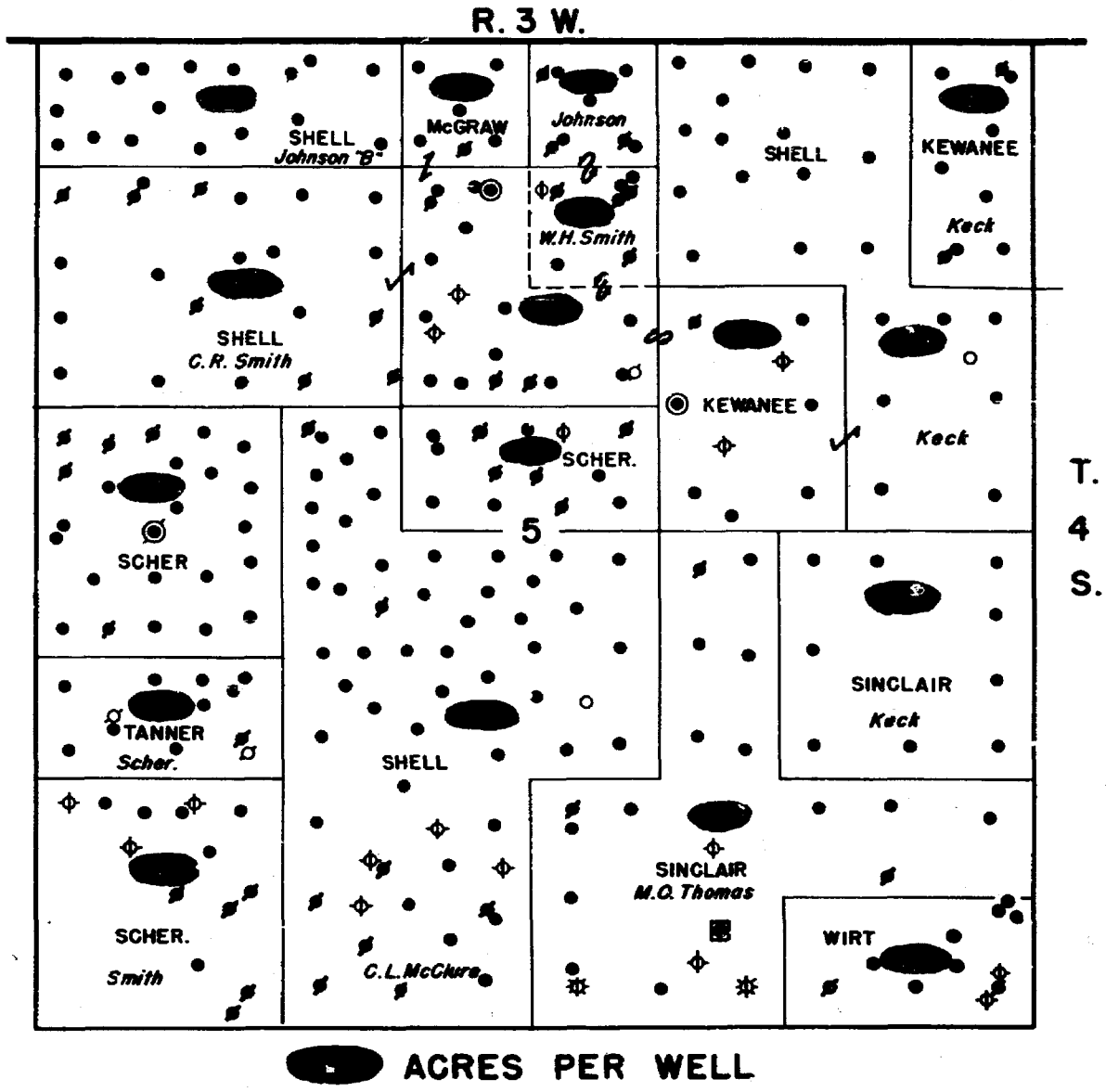
Stanolind #07
#1
June 16.
Hearing

CUTLER'S RULE

THE ULTIMATE PRODUCTION FOR WELLS, OF EQUAL SIZE, IN THE SAME POOL, WHERE THERE IS INTERFERENCE, SEEMS APPROXIMATELY TO VARY DIRECTLY AS THE SQUARE ROOTS OF THE AREAS DRAINED BY THE WELLS.

PORTION OF HEALDTON FIELD, CARTER CO. OKLA.

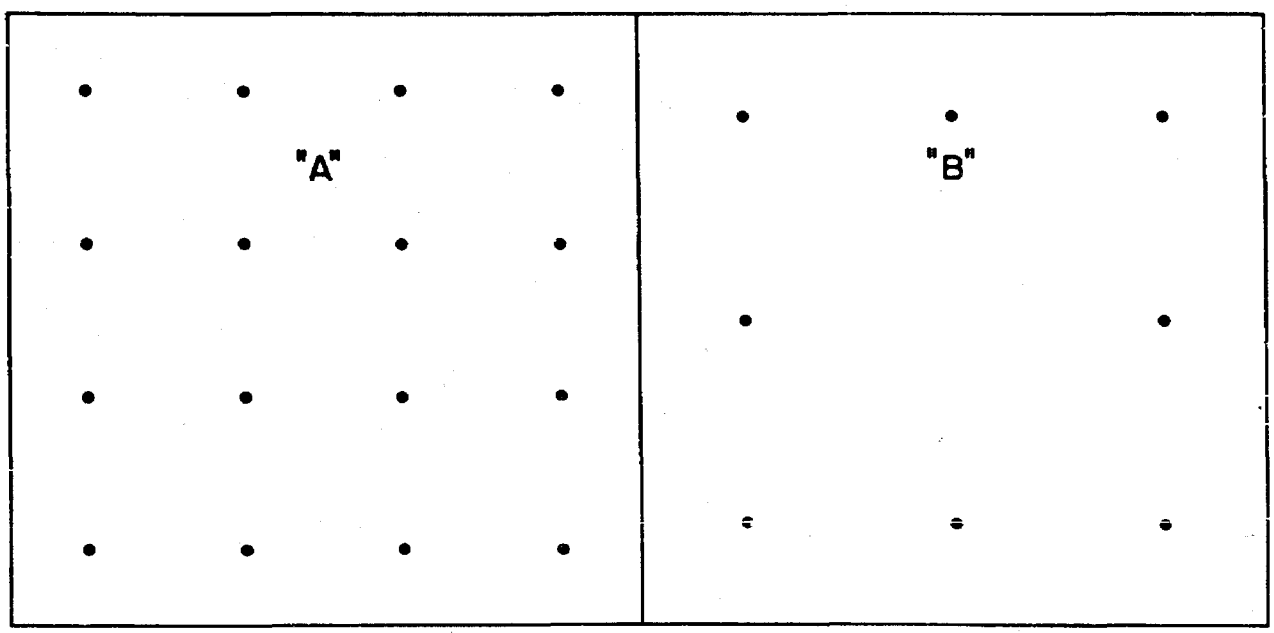
FROM BUREAU OF MINES R.I. 4917 "PETROLEUM ENGINEERING STUDY OF HEALDTON OIL FIELD" FEBRUARY 1953



Shaw-Pas
467

ILLUSTRATION OF CUTLER'S RULE

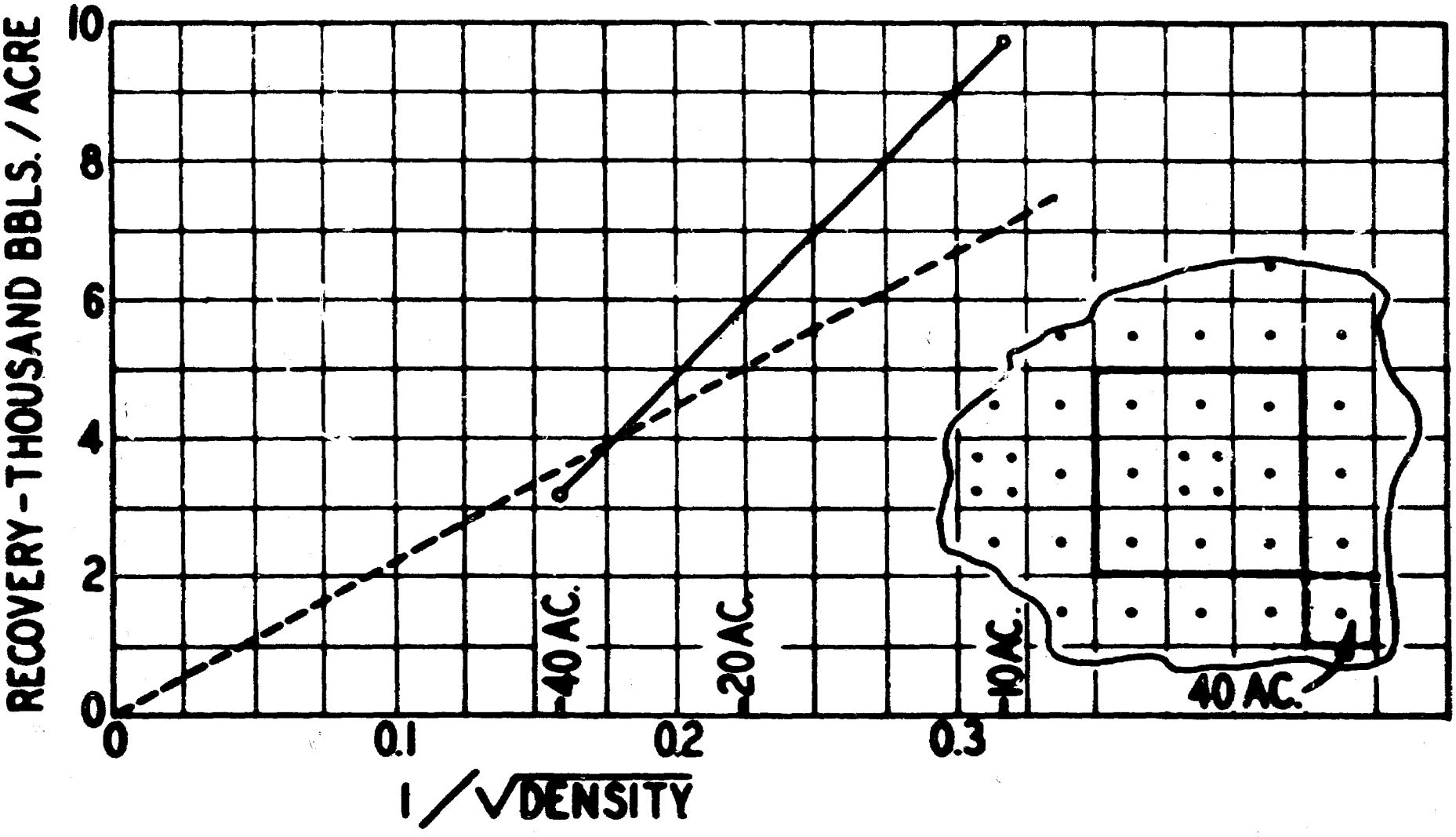
#3



LEASE "A"	40 ACRES 16 WELLS	LEASE "B"	40 ACRES 8 WELLS
RECOVERY =	400,000 BARRELS 10,000 BBLS/ACRE 25,000 BBLS/WELL	RECOVERY =	283,000 BARRELS 7,070 BBLS/ACRE 35,400 BBLS/WELL

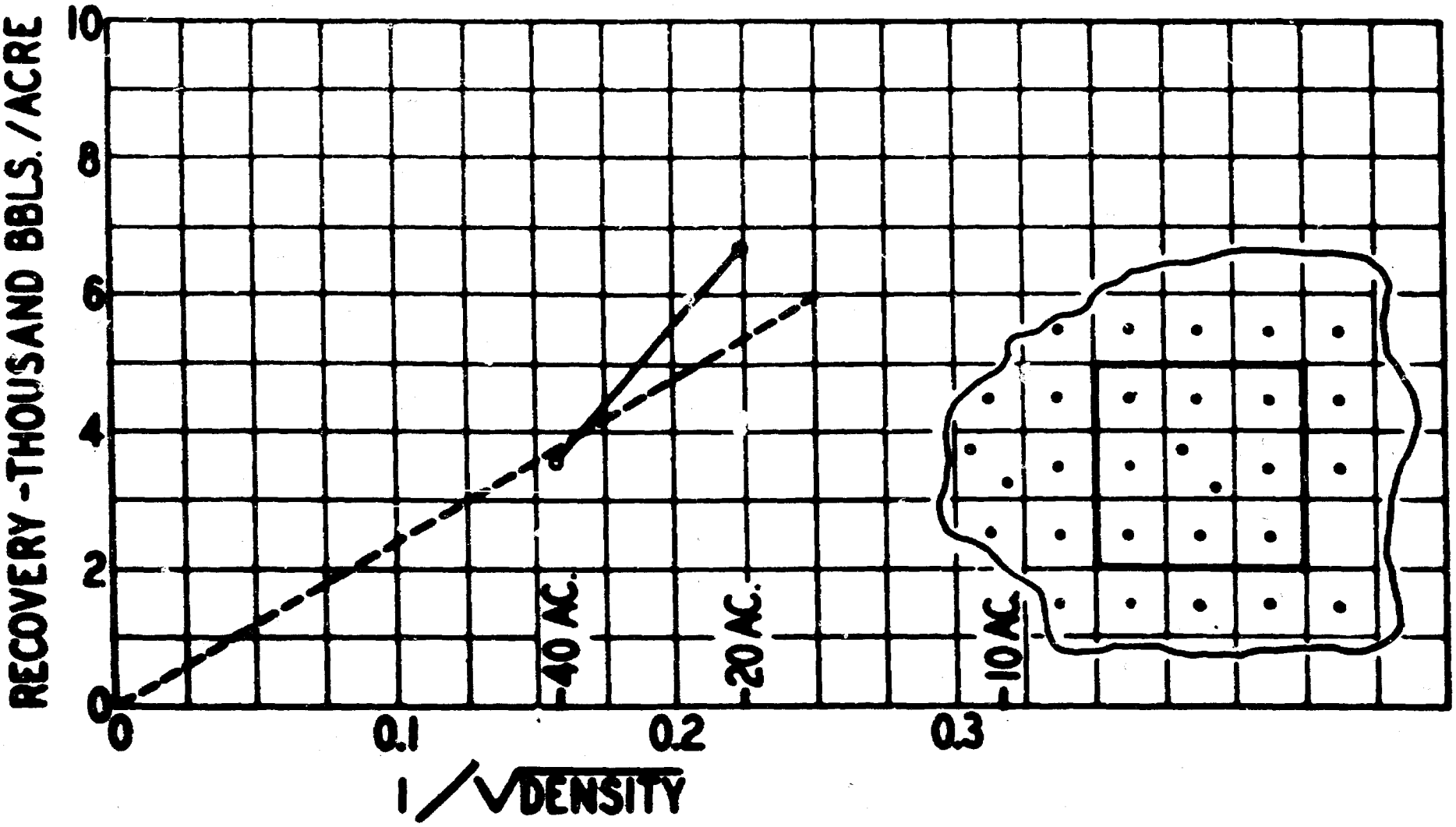
Stan. - Ca. - 407
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CASE 1



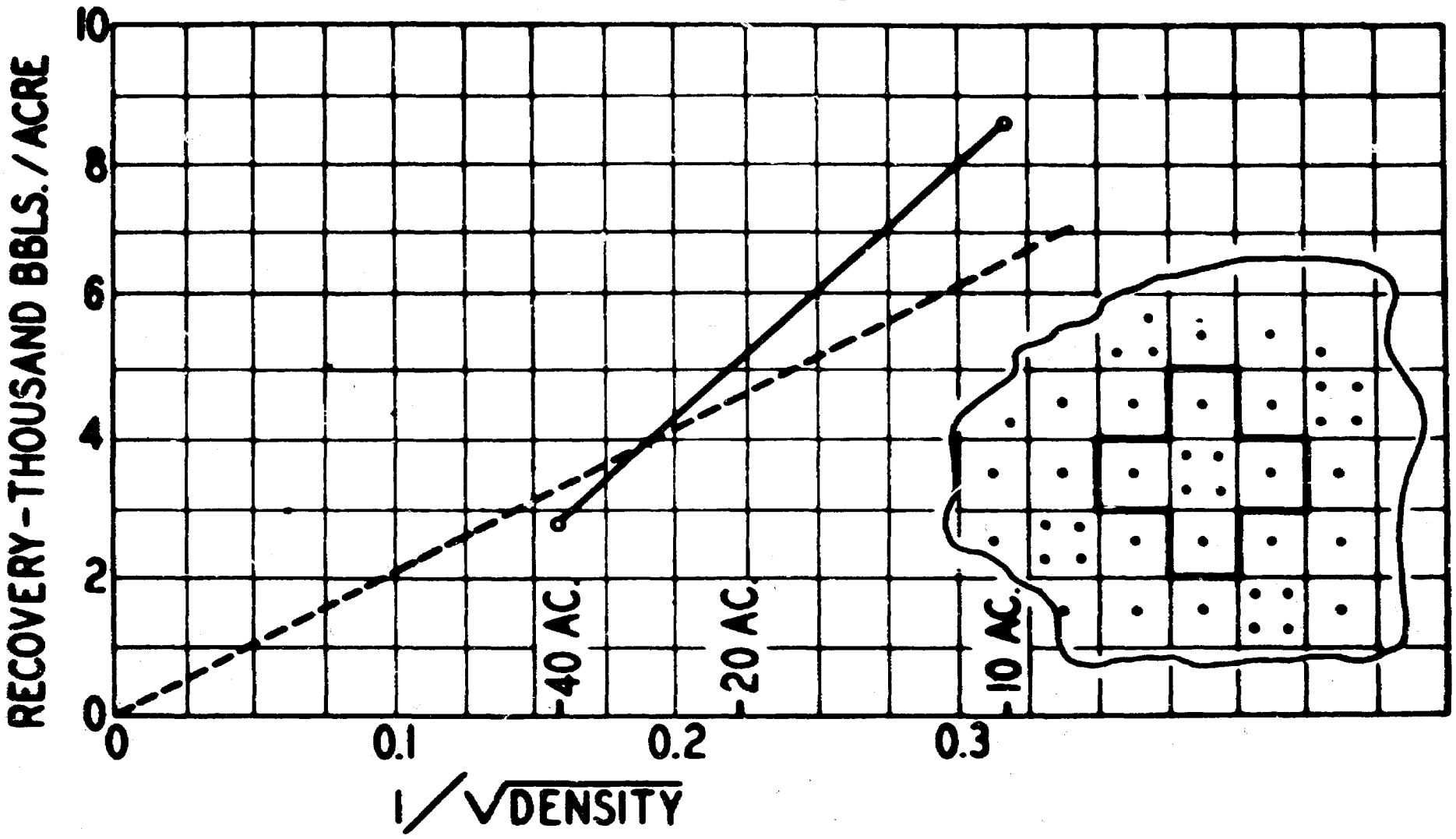
Hon. Case Exh
#5

CASE 2

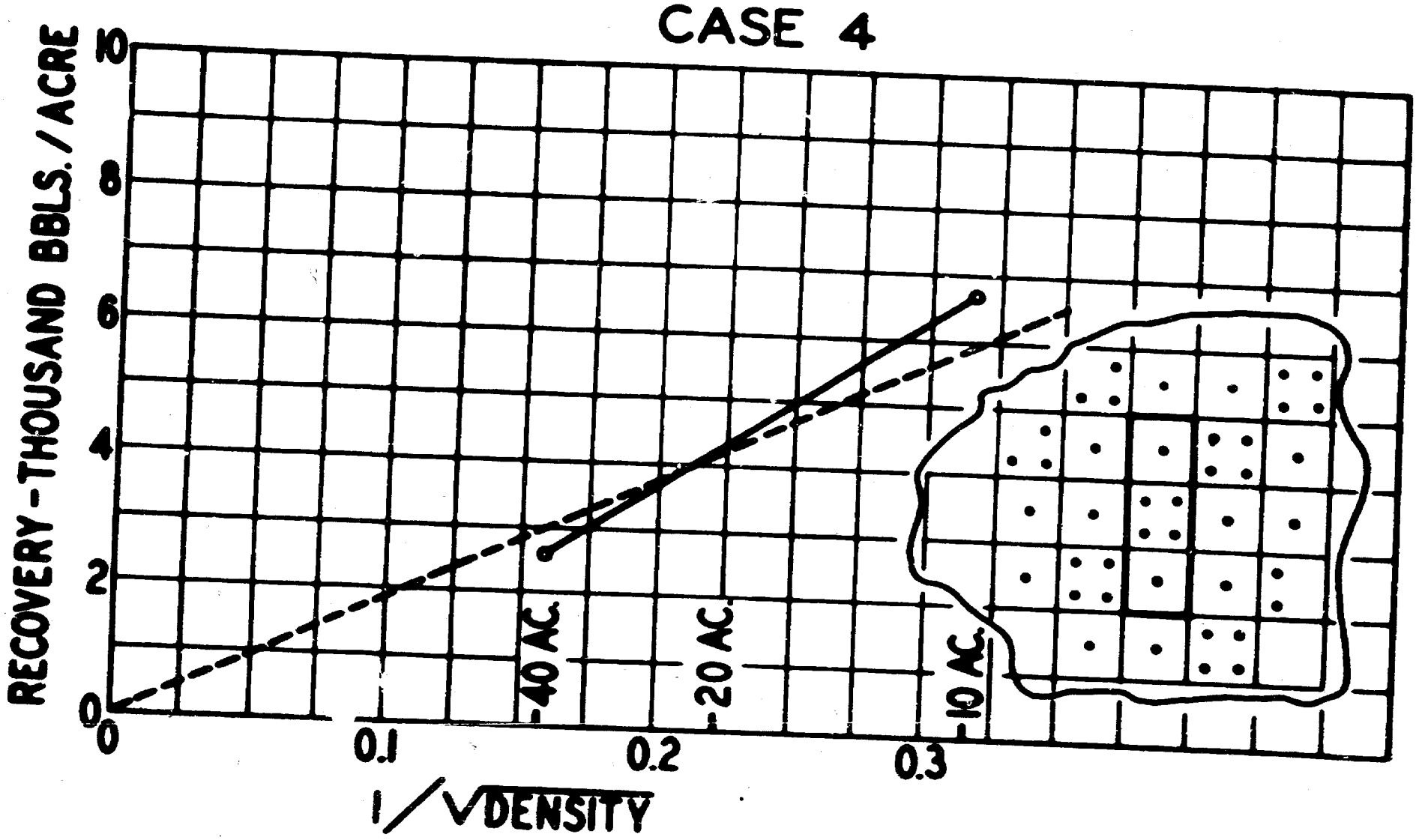


Stan - Case #7
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CASE 3

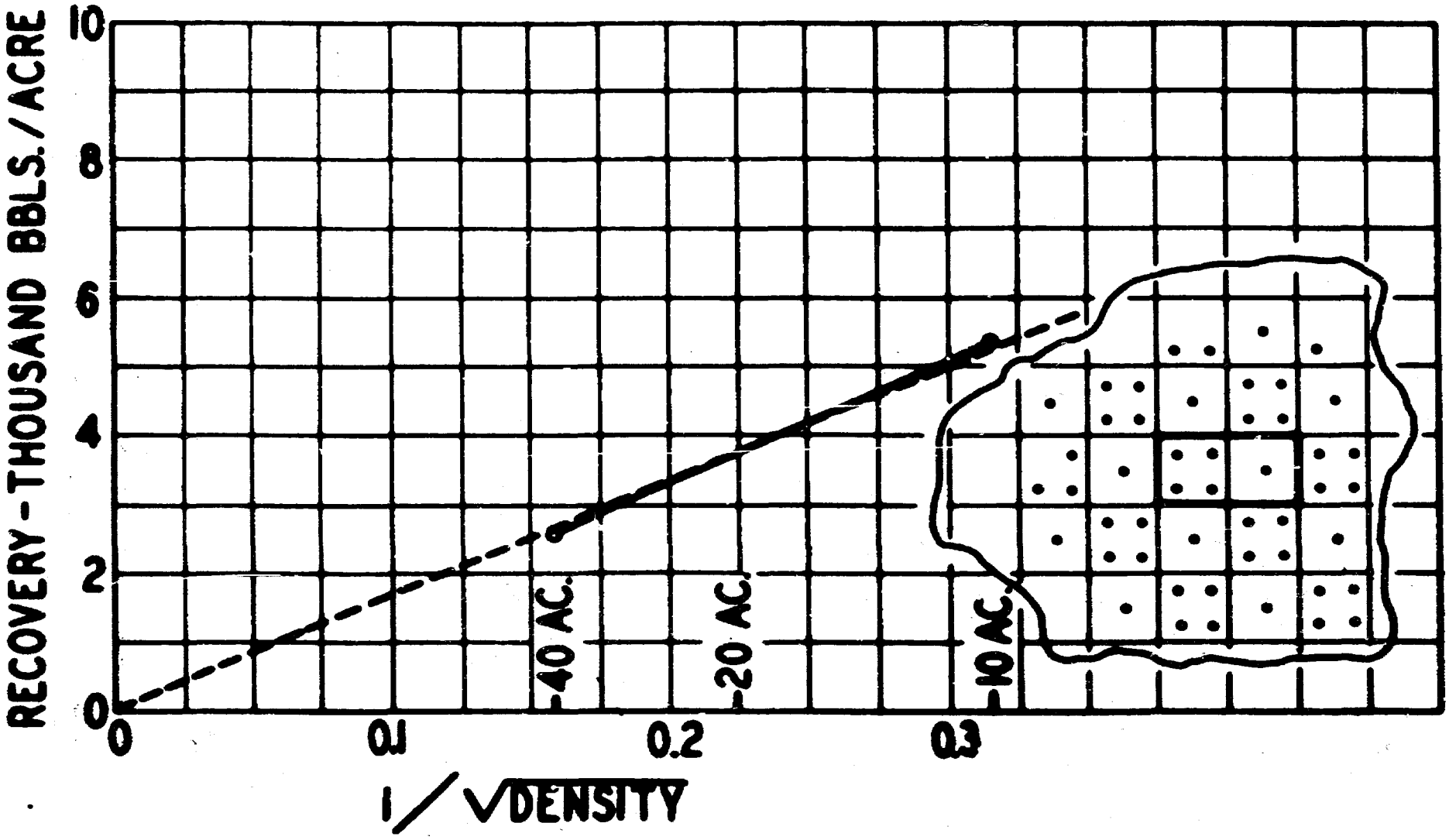


Stanolind - Case 407
#7

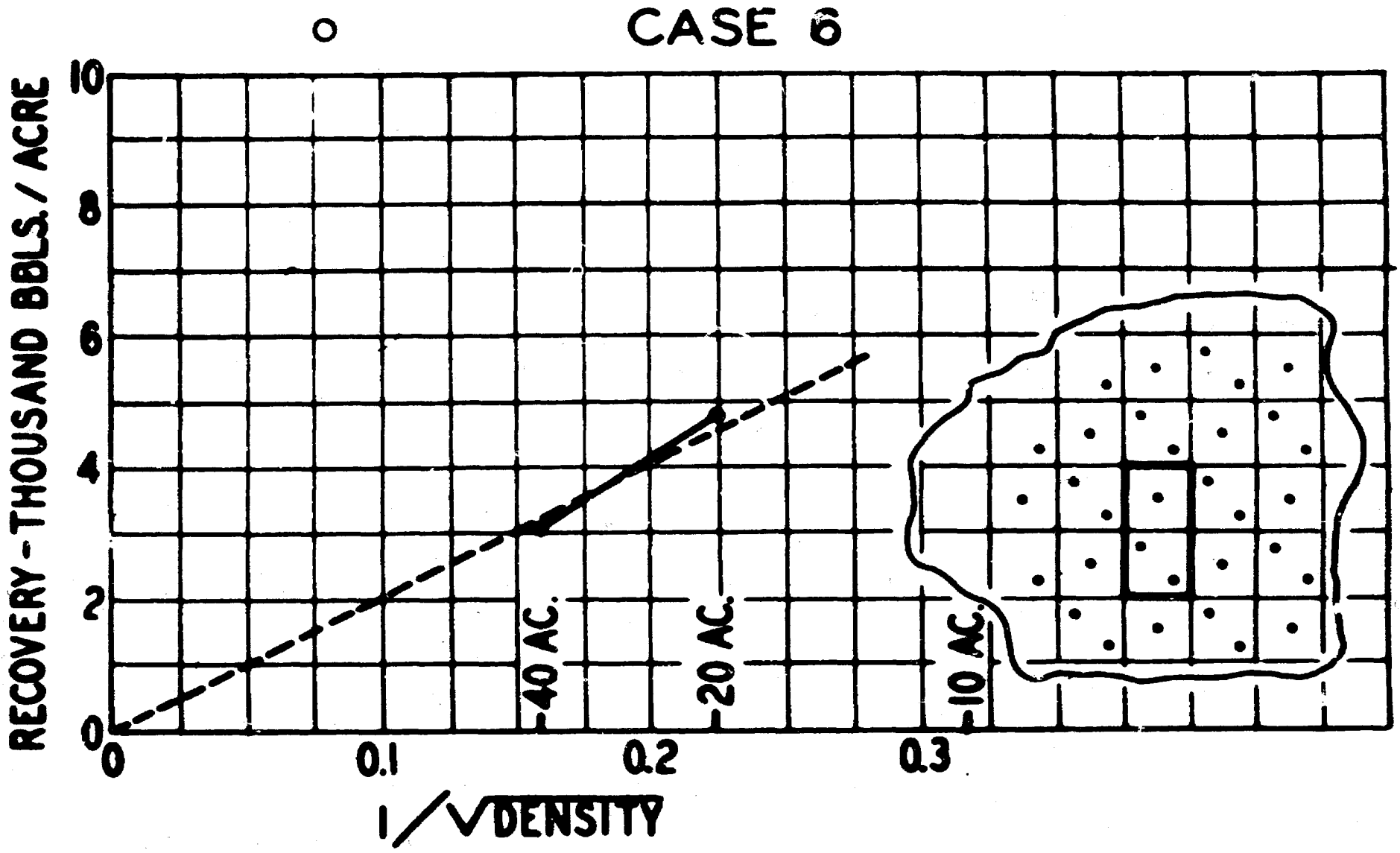


Simo-Pan 407
#8

CASE 5



Stan. Cau 407
#9



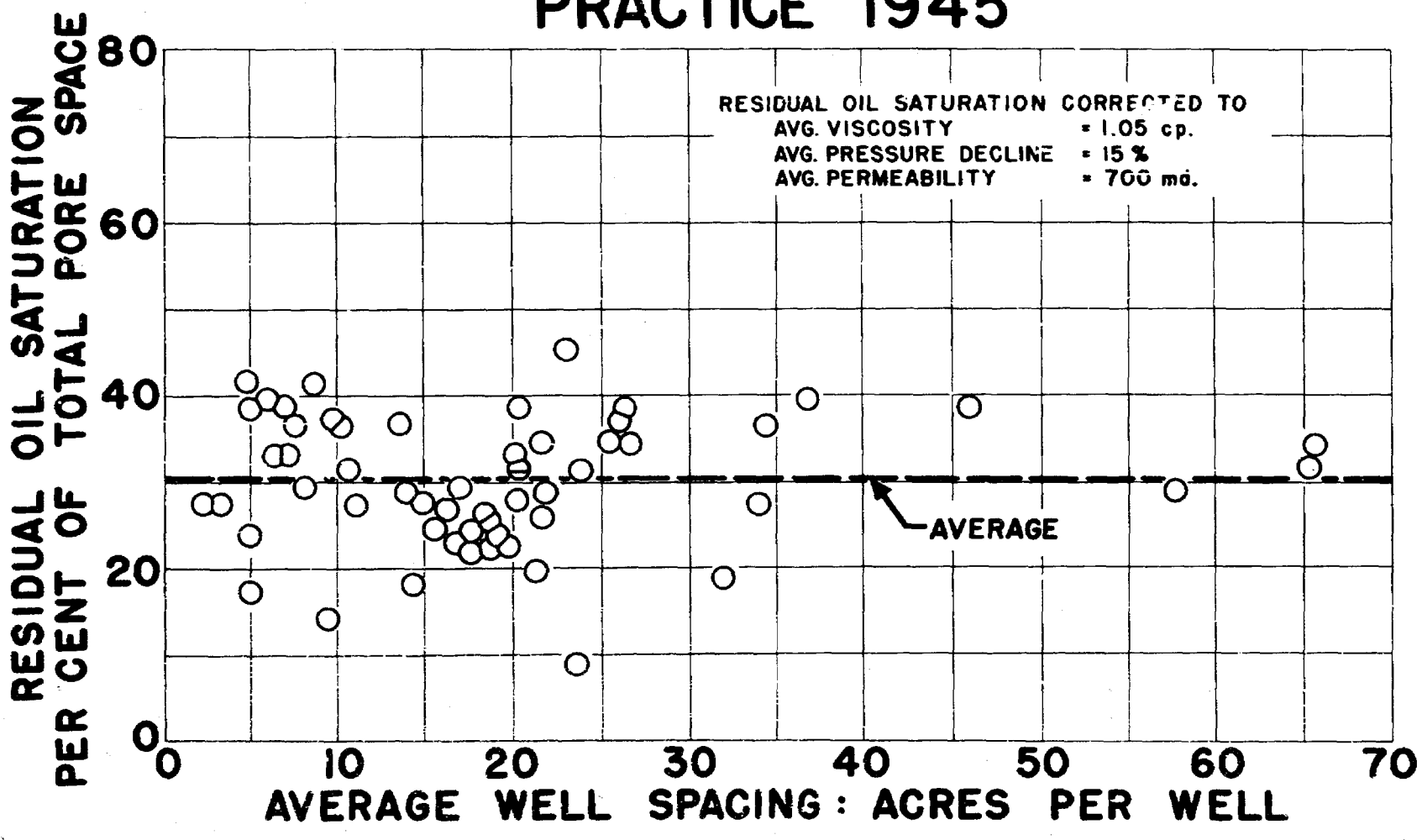
EFFECT OF REGIONAL MIGRATION UPON RECOVERY
FOR VARIOUS SPACING PATTERNS

CASE	1	2	3	4	5	6
Recovery—Bbls/Acre for 10-Acre Development	9,723	——	8,581	6,685	5,320	——
Recovery—Bbls/Acre for 20-Acre Development	——	6,630	——	——	——	4,784
Recovery—Bbls/Acre for 40-Acre Development	3,193	3,578	2,769	2,545	2,534	3,060
Recovery—Bbls/Acre Average	3,919	3,917	3,932	3,926	3,927	3,922
Recovery Ratio—Close to Wide Development	3.045	1.853	3.098	2.626	2.099	1.563
Recovery Ratio—Required by Cutler's Rule	2	1.414	2	2	2	1.414

Fow

Stan. Exh. 407
11

FIGURE 10 FROM "A FACTUAL ANALYSIS OF THE EFFECT OF WELL SPACING ON OIL RECOVERY" BY R.C. CRAZE & S.E. BUCKLEY. A.P.I. DRLG. & PROD. PRACTICE 1945



RELATION BETWEEN CORRECTED RESIDUAL OIL SATURATION AND WELL SPACING--WATER-DRIVE SAND FIELDS

Stanolind - Class 4-7
12

CALCULATED PRESSURE AND OIL SATURATION DISTRIBUTION AT ABANDOMENT

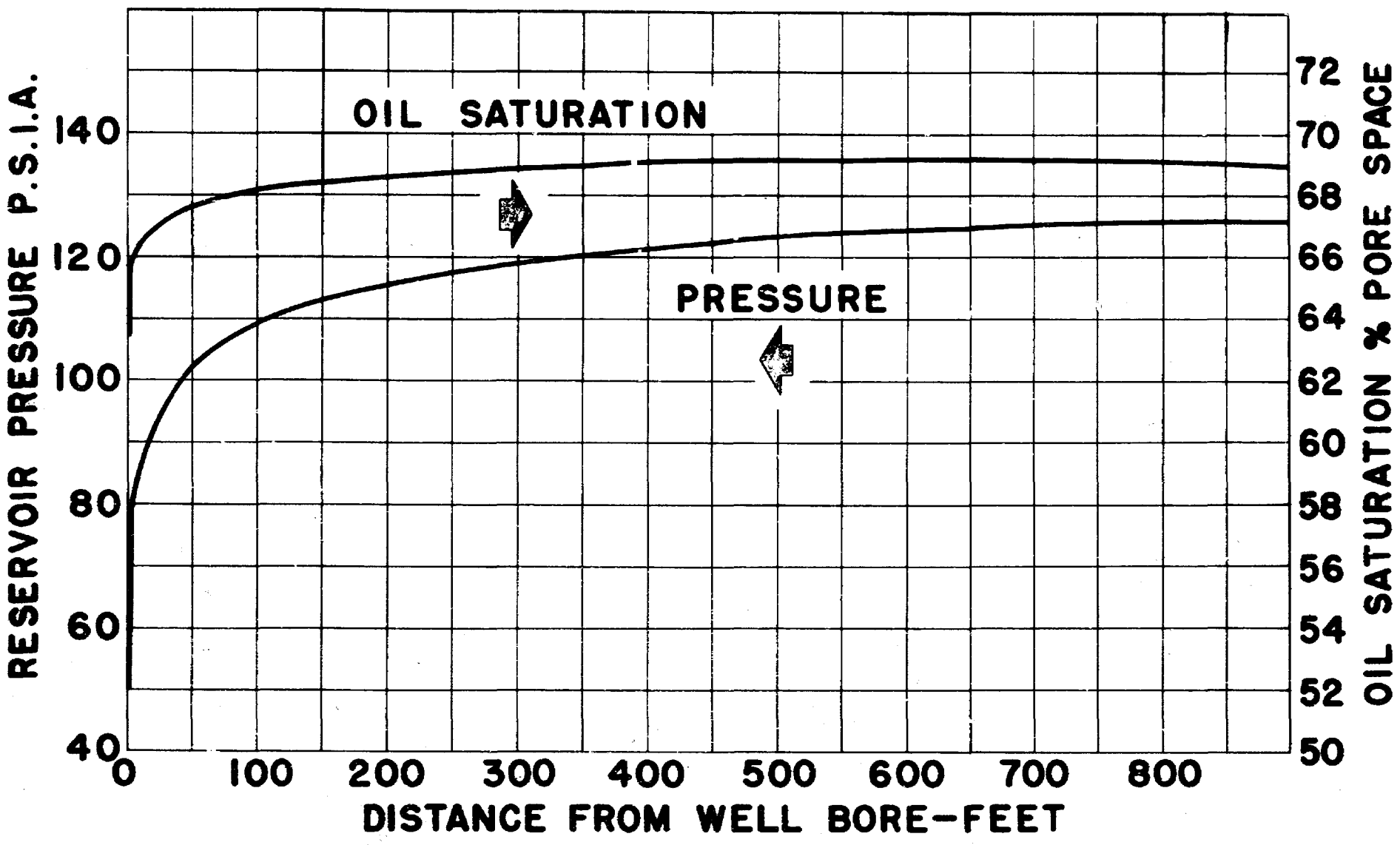
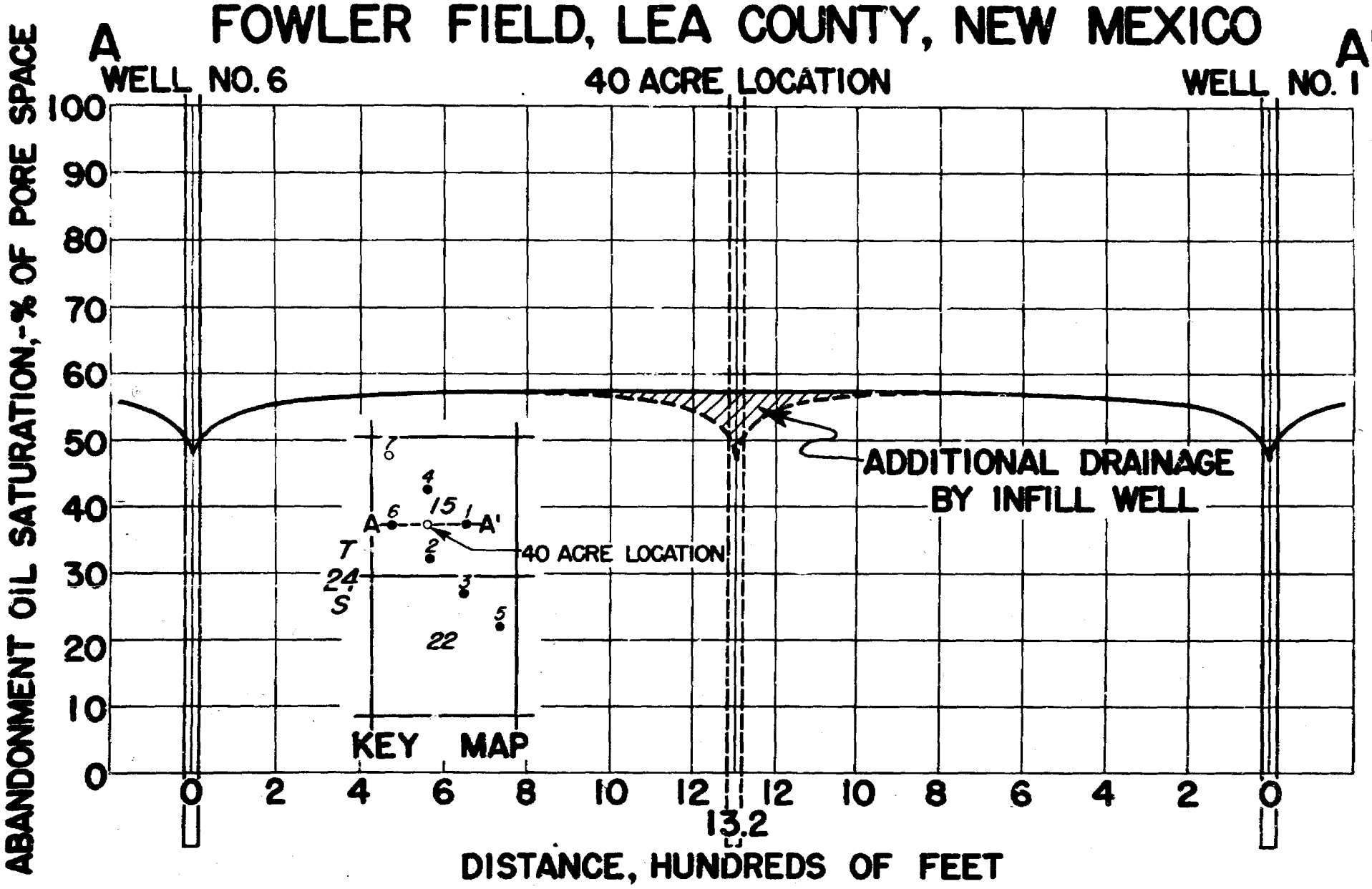


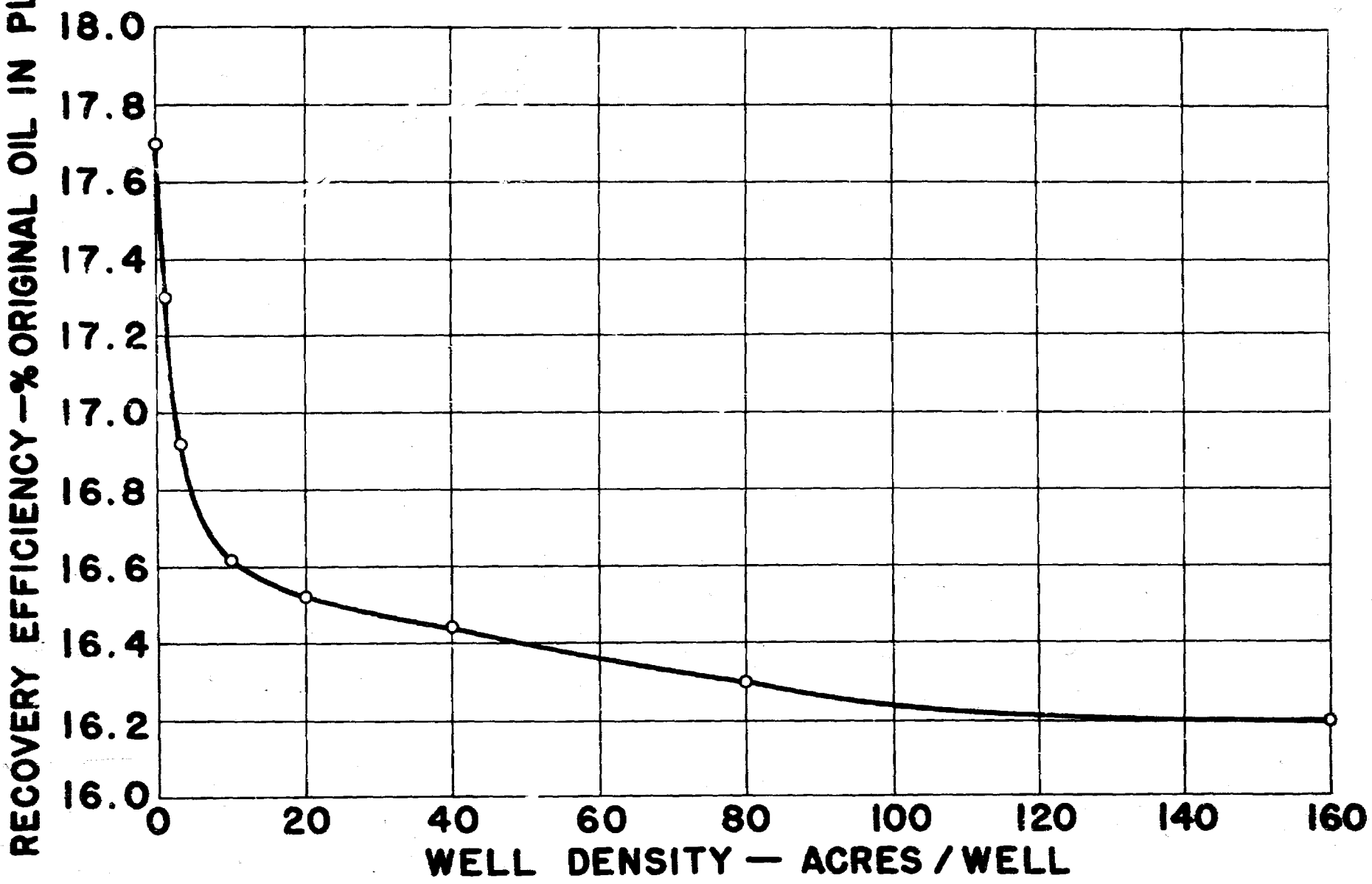
Exhibit - Case 407
#13

OIL SATURATION DISTRIBUTION AT ABANDONMENT CONDITIONS FOWLER FIELD, LEA COUNTY, NEW MEXICO



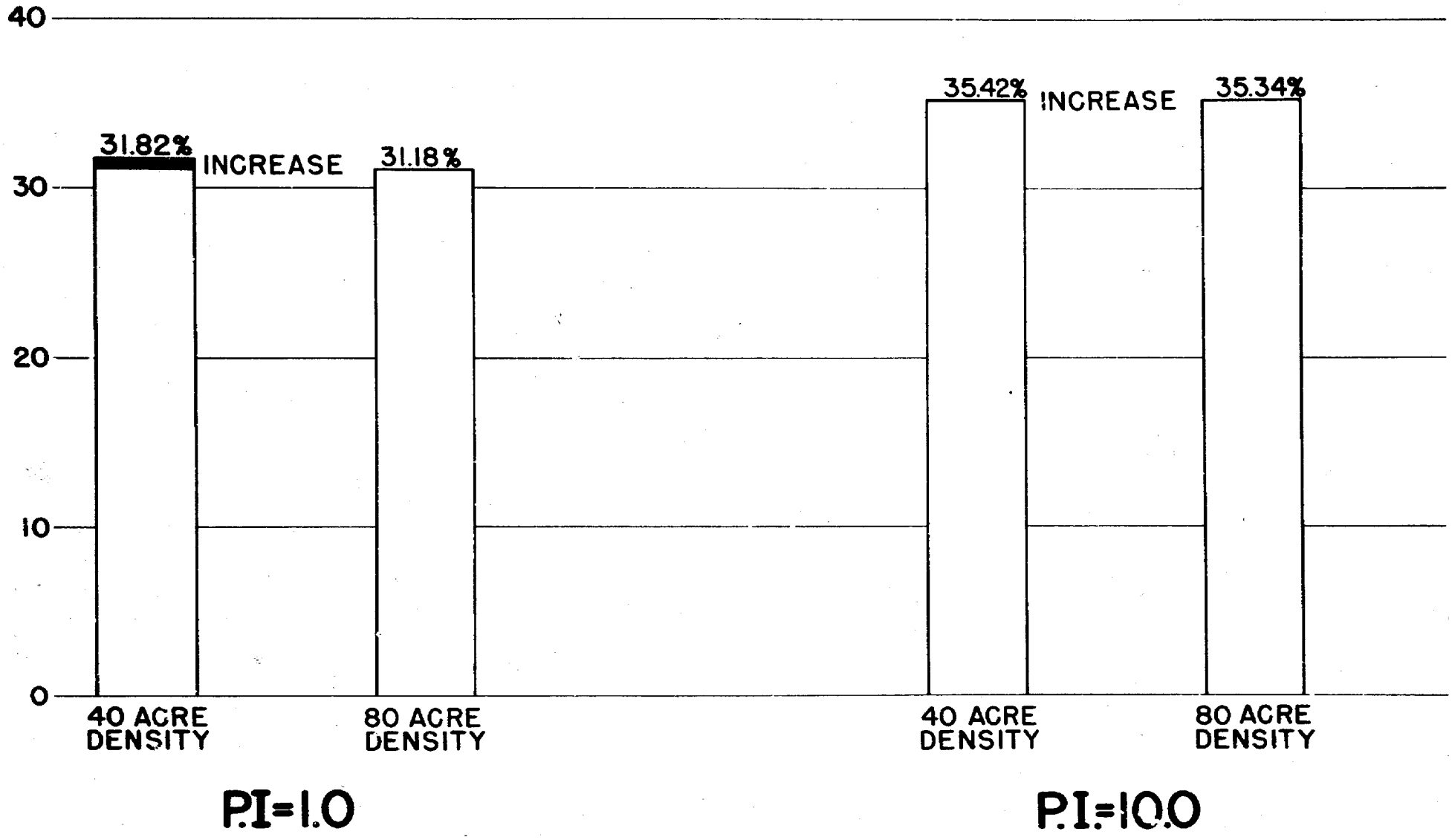
Atlas — Page 407
#14

CALCULATED VARIATION IN RECOVERY EFFICIENCY WITH WELL DENSITY



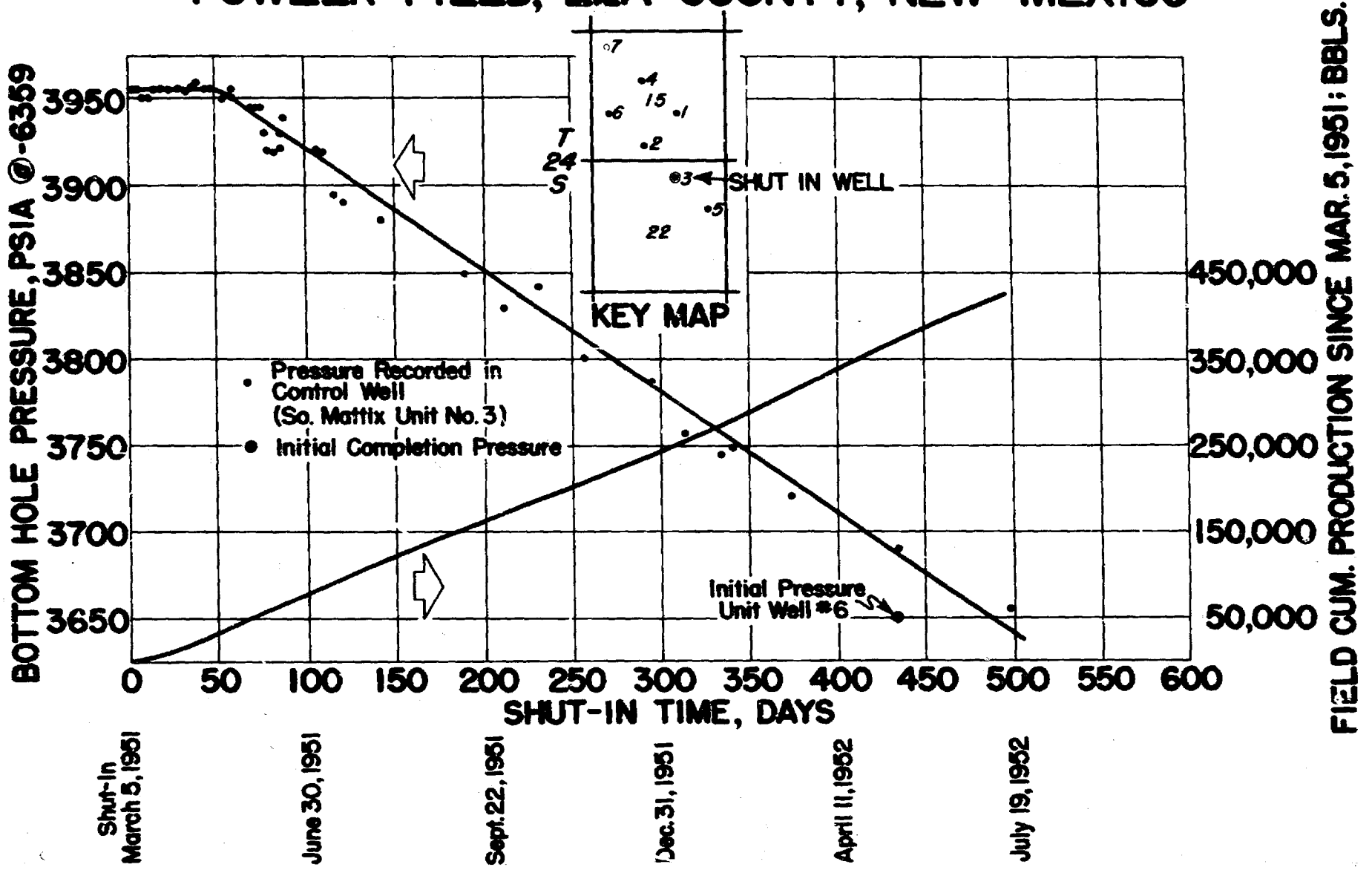
Stms - Cum 407
#15

CALCULATED VARIATION IN RECOVERY EFFICIENCY WITH WELL DENSITY AND P.I.



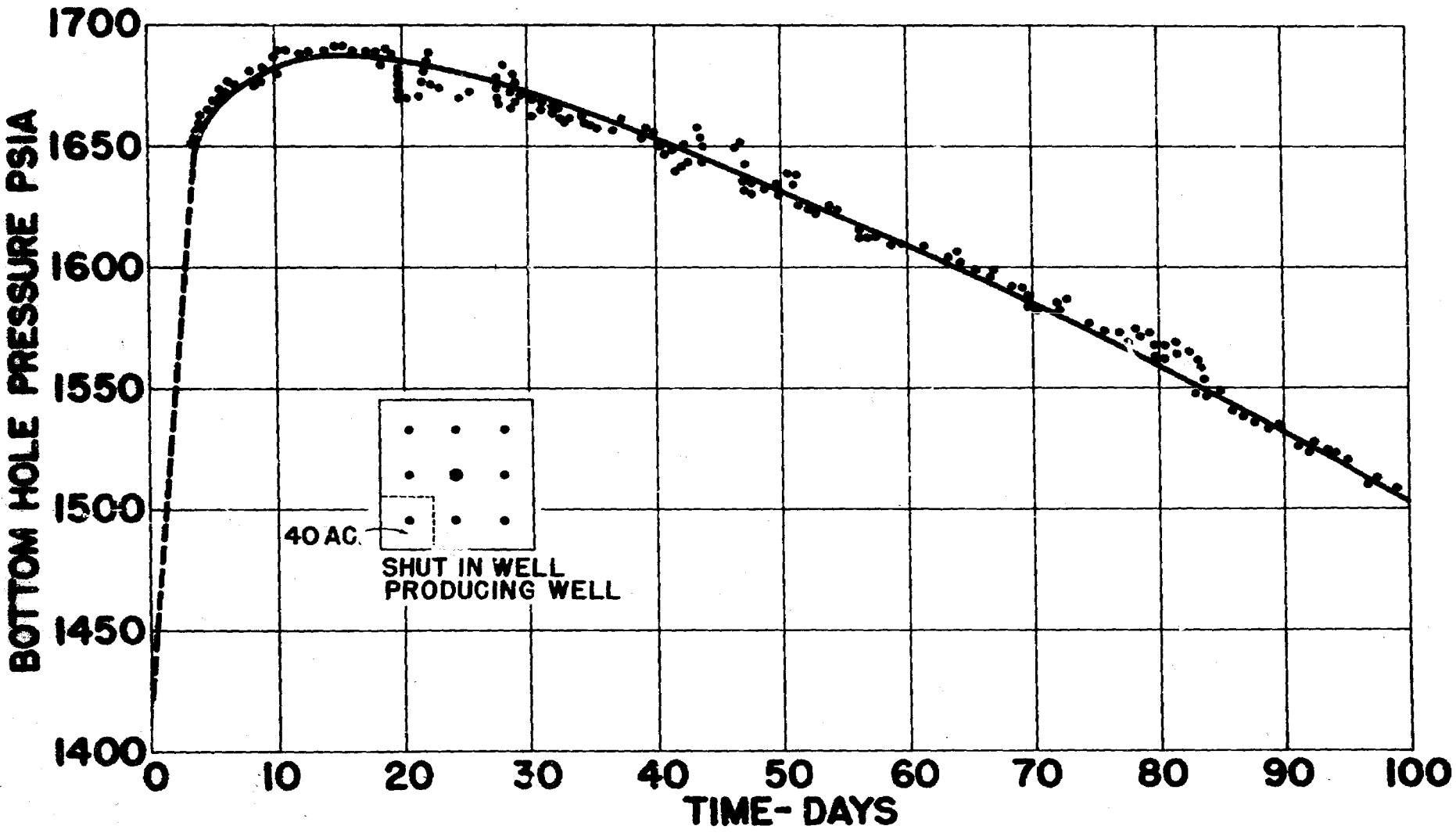
Hanna - Case 407
#16

INTERFERENCE TEST DATA
FOWLER FIELD, LEA COUNTY, NEW MEXICO



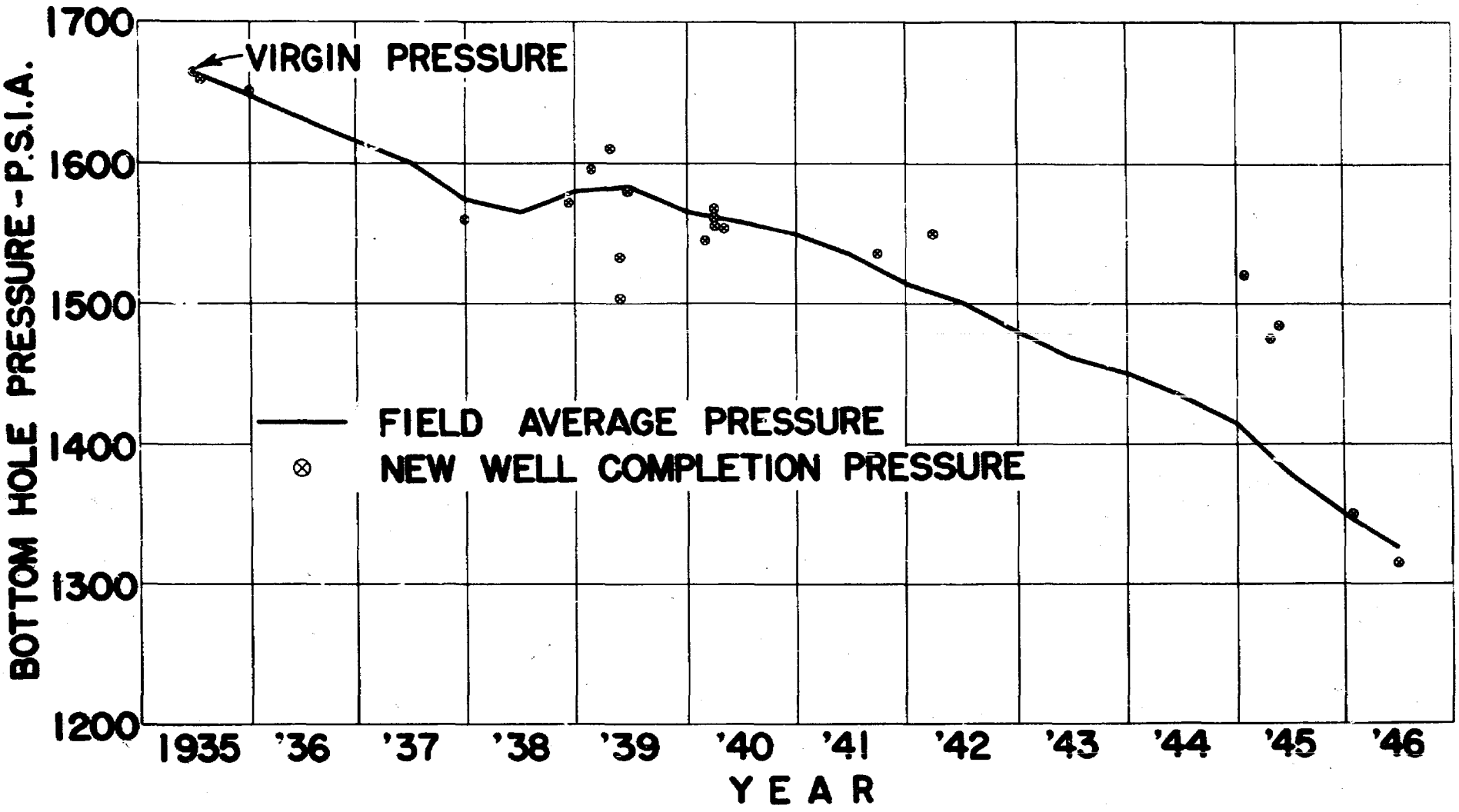
Stan-Chem 407
#17

INTERFERENCE TEST DATA
ANTON-IRISH FIELD
LAMB & HALE COUNTIES, TEXAS



Stano - Case #07
#18

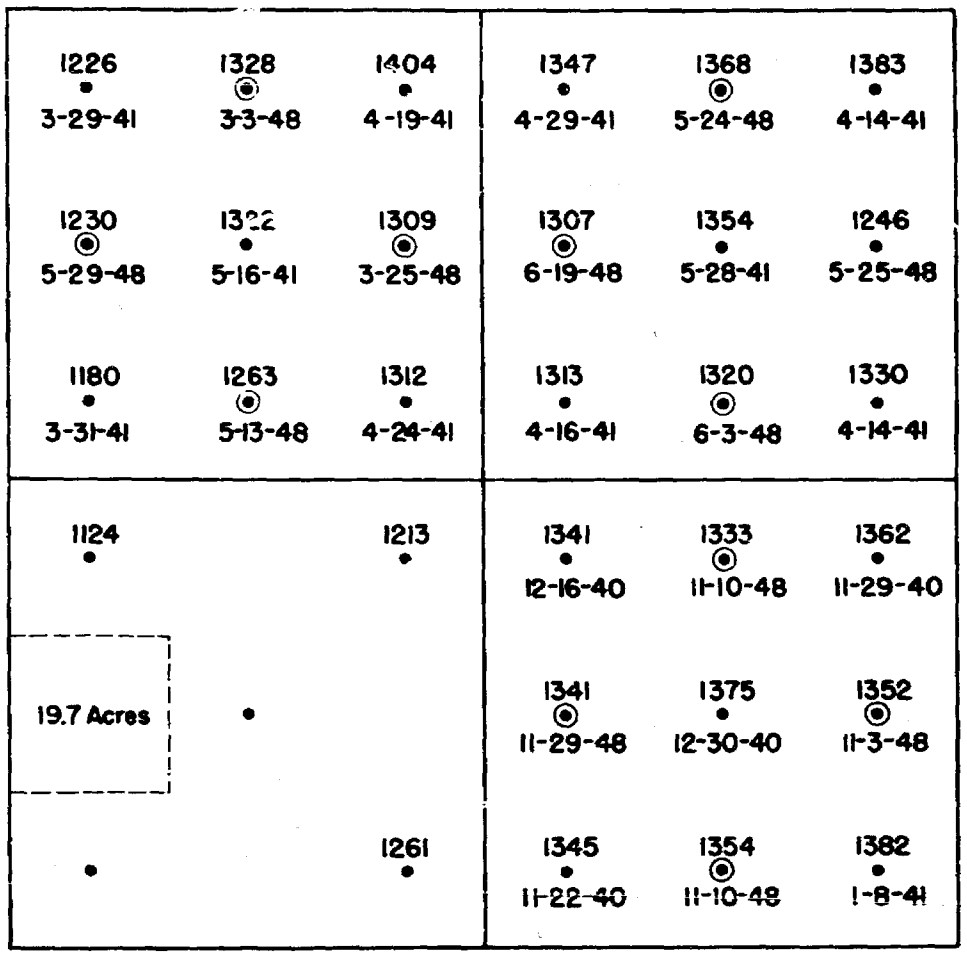
COMPLETION PRESSURE HISTORY
GOLDSMITH FIELD, SOUTH DOME
SAN ANDRES LIME
ECTOR COUNTY, TEXAS



Texas - Cons 407
#19

COMPARISON OF COMPLETION PRESSURE OF LATER DRILLED INFILL WELLS AND OLDER WELLS SLAUGHTER FIELD

COCHRAN AND HOCKLEY COUNIES, TEXAS



LEGEND:

1350 B.H.P. MARCH 1949
• OLDER PRODUCING WELLS
4-11-41 COMPLETION DATE

1350 B.H.P. MARCH 1949
◉ INFILL DRILLED WELLS
5-12-48 COMPLETION DATE

INITIAL RESERVOIR PRESSURE = 1771 P.S.I.A.

AVERAGE PRESSURE OF OLDER WELLS = 1332 P.S.I.A.

AVERAGE COMPLETION PRESSURE OF INFILL WELLS = 1313 P.S.I.A.

AVERAGE PRESSURE DECLINE INFILL AREAS DUE TO DRAINAGE TO OLDER WELLS = 458 P.S.I.A.

Stone - Case 407
20

COMPARISON OF COMPLETION GAS-OIL RATIOS OF INFILL WELLS WITH GAS-OIL RATIOS OF OLDER WELLS IN A DEPLETION TYPE RESERVOIR — SLAUGHTER FIELD

COCHRAN AND HOCKLEY COUNTIES, TEXAS

LEGEND:

770 GOR-4TH. QUARTER SURVEY - 1948

• OLDER WELLS

4-11-41 COMPLETION DATE

GOR-4TH. QUARTER SURVEY-1948

◉ INFILL WELLS

6-10-48 COMPLETION DATE

1232 • 2-6-41	1663 ◉ 4-30-48	1900 • 4-28-41	1827 • 5-18-41	1790 ◉ 7-9-48	1005 • 5-4-41
1063 ◉ 4-2-48	1153 • 5-8-39	1883 ◉ 5-22-48	1995 ◉ 6-10-48	1901 • 5-12-41	1606 ◉ 6-30-48
945 • 1-16-41	785 ◉ 5-17-48	1163 • 4-21-41	1788 • 5-20-41	1221 ◉ 6-15-48	1433 • 6-6-41
918 • 3-12-41	745 ◉ 5-27-48	963 • 3-10-41	847 • 5-4-41	1864 ◉ 9-16-48	997 • 6-16-41
802 ◉ 5-28-48	1088 • 4-7-41	742 ◉ 8-17-48	1140 ◉ 8-27-48	912 • 6-2-41	1185 ◉ 10-8-48
1900 • 1-16-41	711 ◉ 6-21-48	888 • 6-30-39	1070 • 3-15-39	480 ◉ 9-4-48	647 • 3-29-41

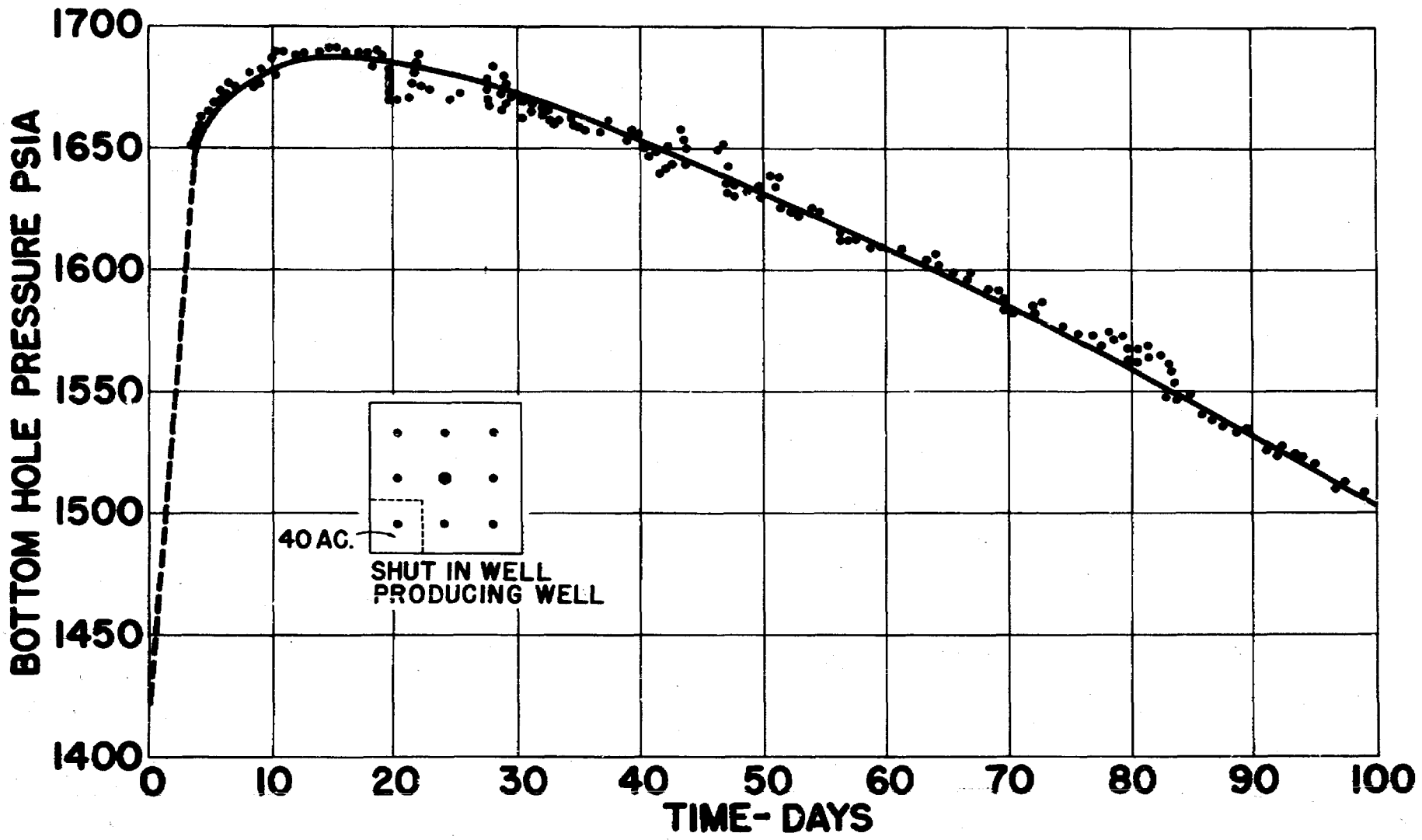
INITIAL SOLUTION GAS-OIL RATIO = 470 CU. FT. / BBL.

AVERAGE COMPLETION GAS-OIL RATIO OF INFILL WELLS = 1228 CU. FT. / BBL.

AVERAGE GAS-OIL RATIO OF INFILL WELLS = 1229 CU. FT. / BBL.

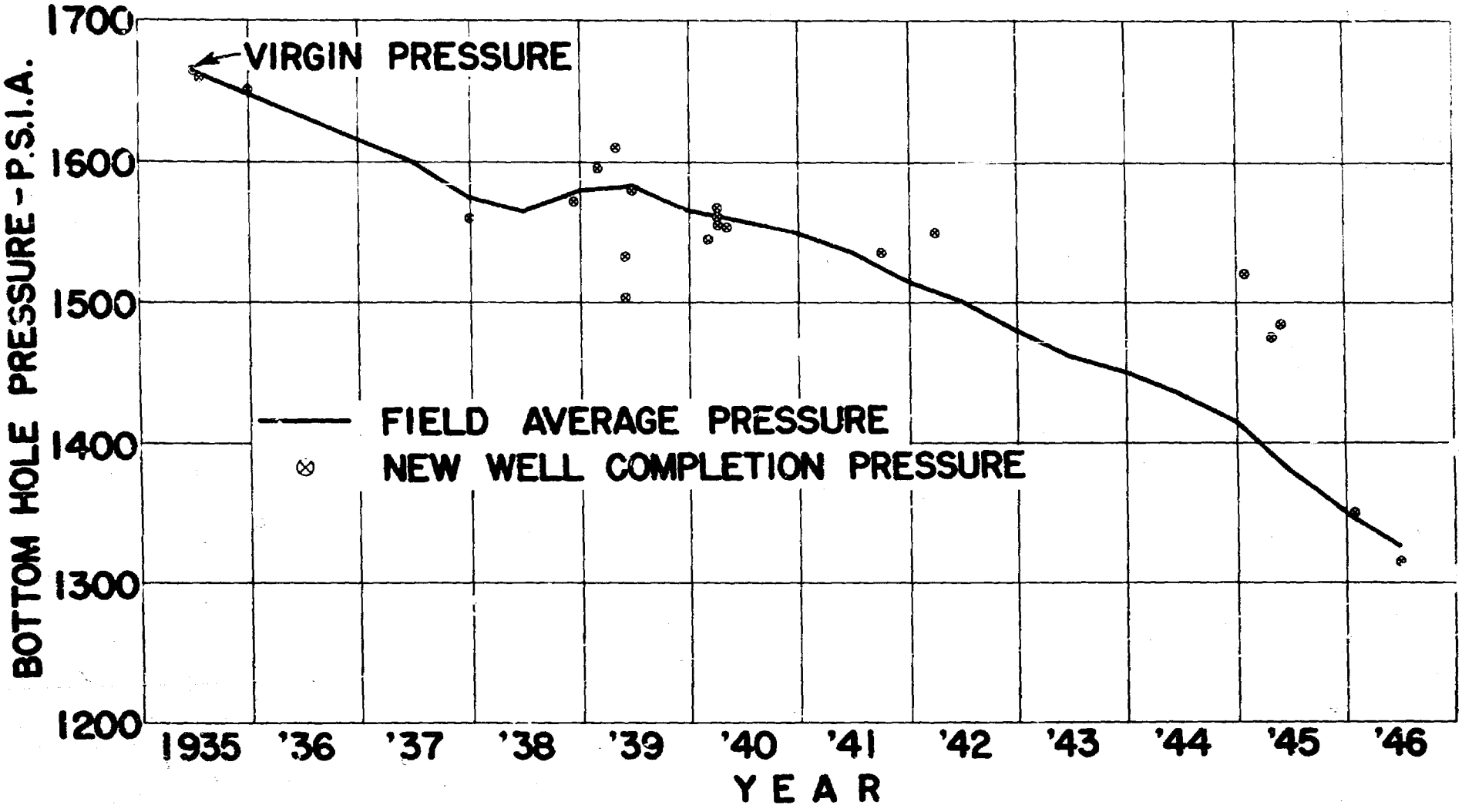
Sitton-Cone #07
June 16-'53

INTERFERENCE TEST DATA
ANTON-IRISH FIELD
LAMB & HALE COUNTIES, TEXAS



Stone - Cline #C
6-16-53

COMPLETION PRESSURE HISTORY
GOLDSMITH FIELD, SOUTH DOME
SAN ANDRES LIME
ECTOR COUNTY, TEXAS



Stan - Case #07
6-16-63

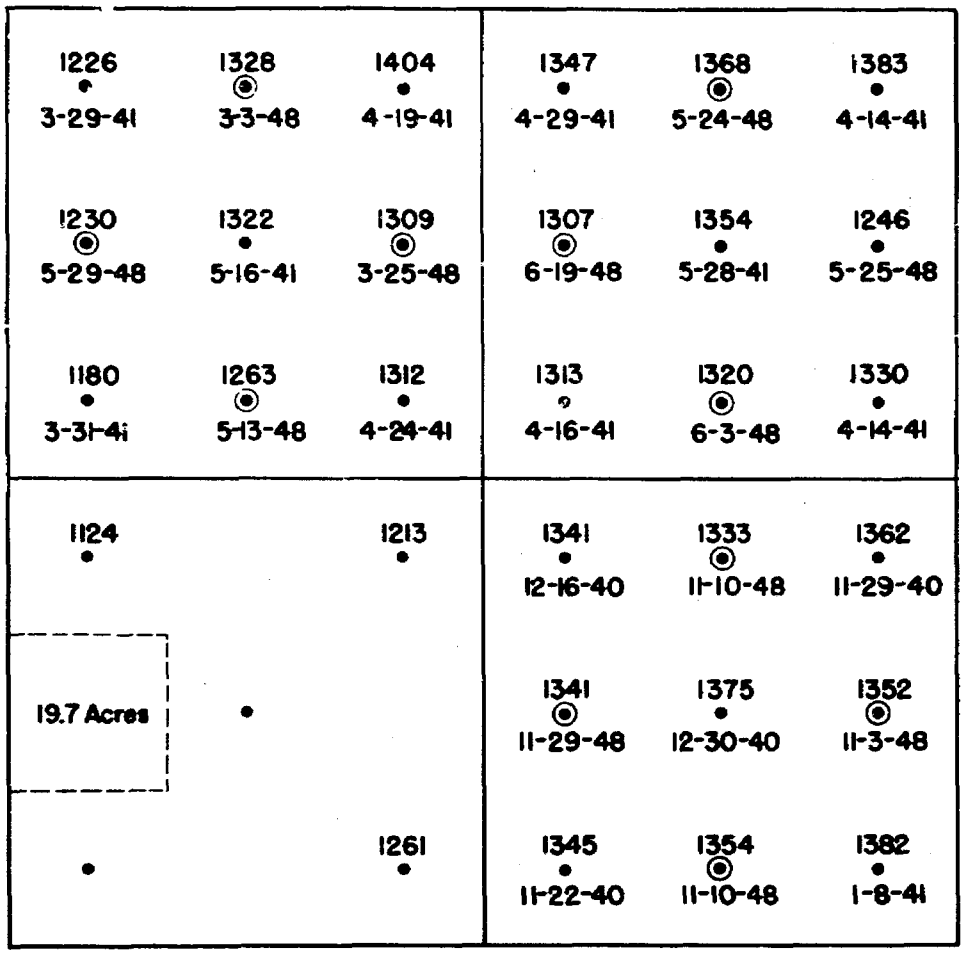
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COCHRAN AND HOCKLEY COUNIES, TEXAS

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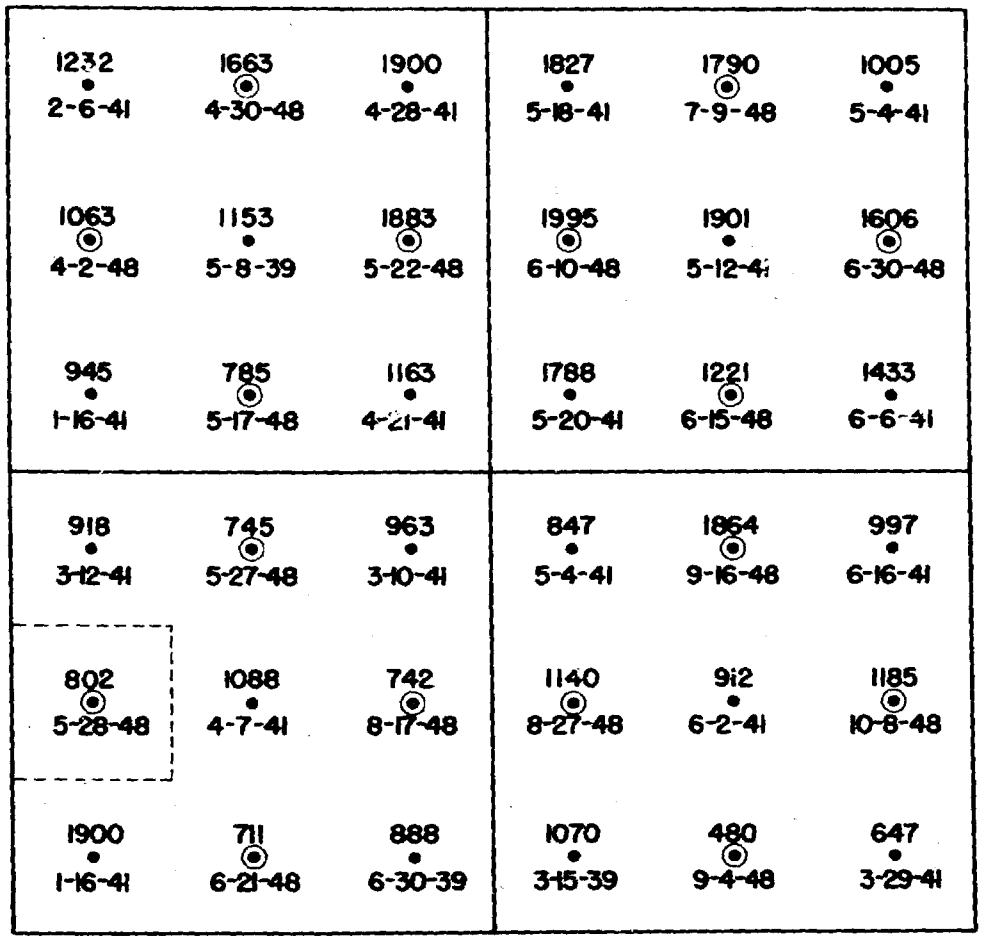
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AVERAGE PRESSURE DECLINE INFILL AREAS DUE TO DRAINAGE TO OLDER WELLS = 458 P.S.I.A.

Stano – Conv. #07
6-16-53

COMPARISON OF COMPLETION GAS-OIL RATIOS OF INFILL WELLS WITH GAS-OIL RATIOS OF OLDER WELLS IN A DEPLETION TYPE RESERVOIR — SLAUGHTER FIELD

COCHRAN AND HOCKLEY COUNTIES, TEXAS



LEGEND:

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• OLDER WELLS

4-11-41 COMPLETION DATE

GOR-4TH. QUARTER SURVEY - 1948

◉ INFILL WELLS

6-10-48 COMPLETION DATE

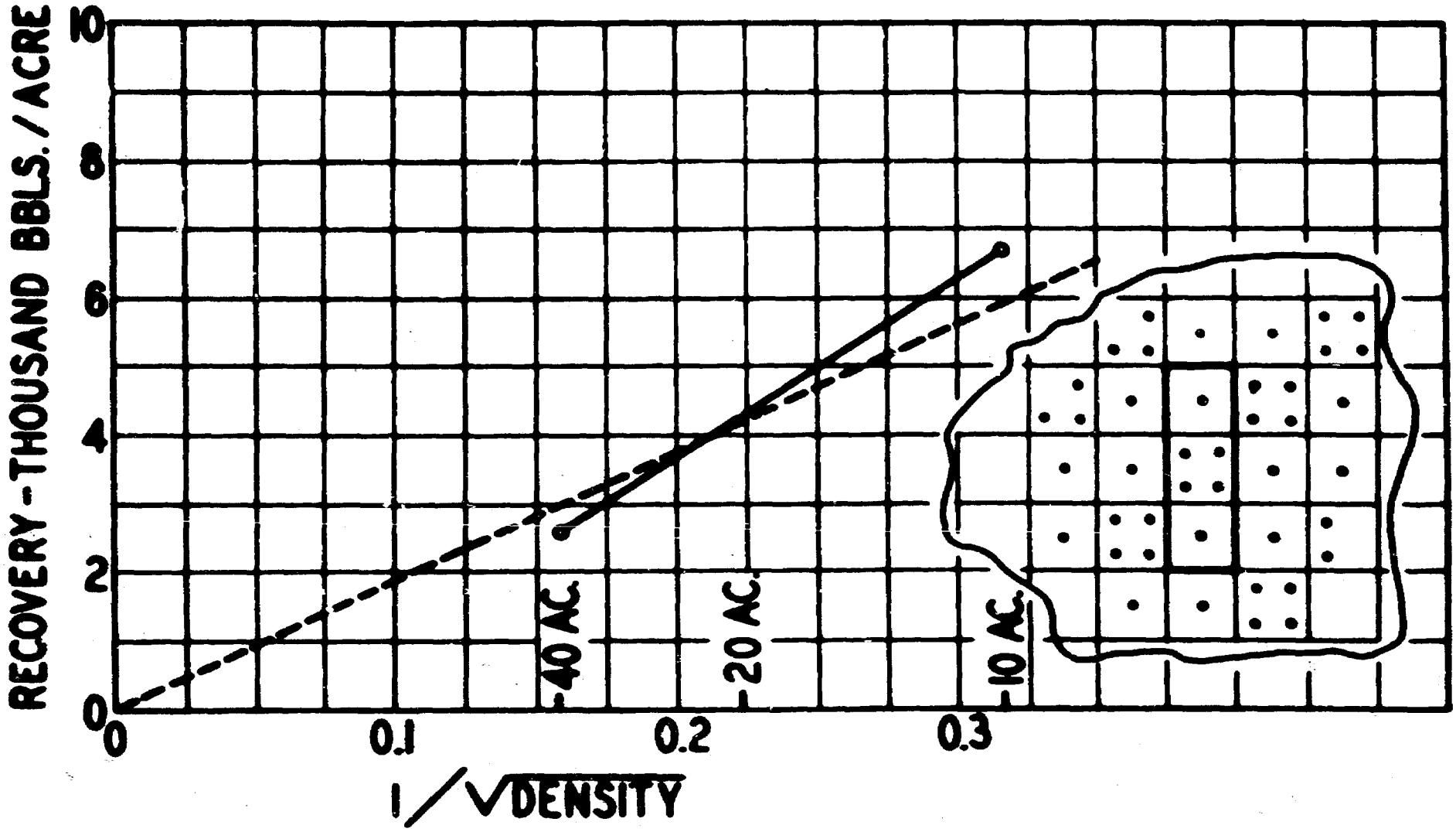
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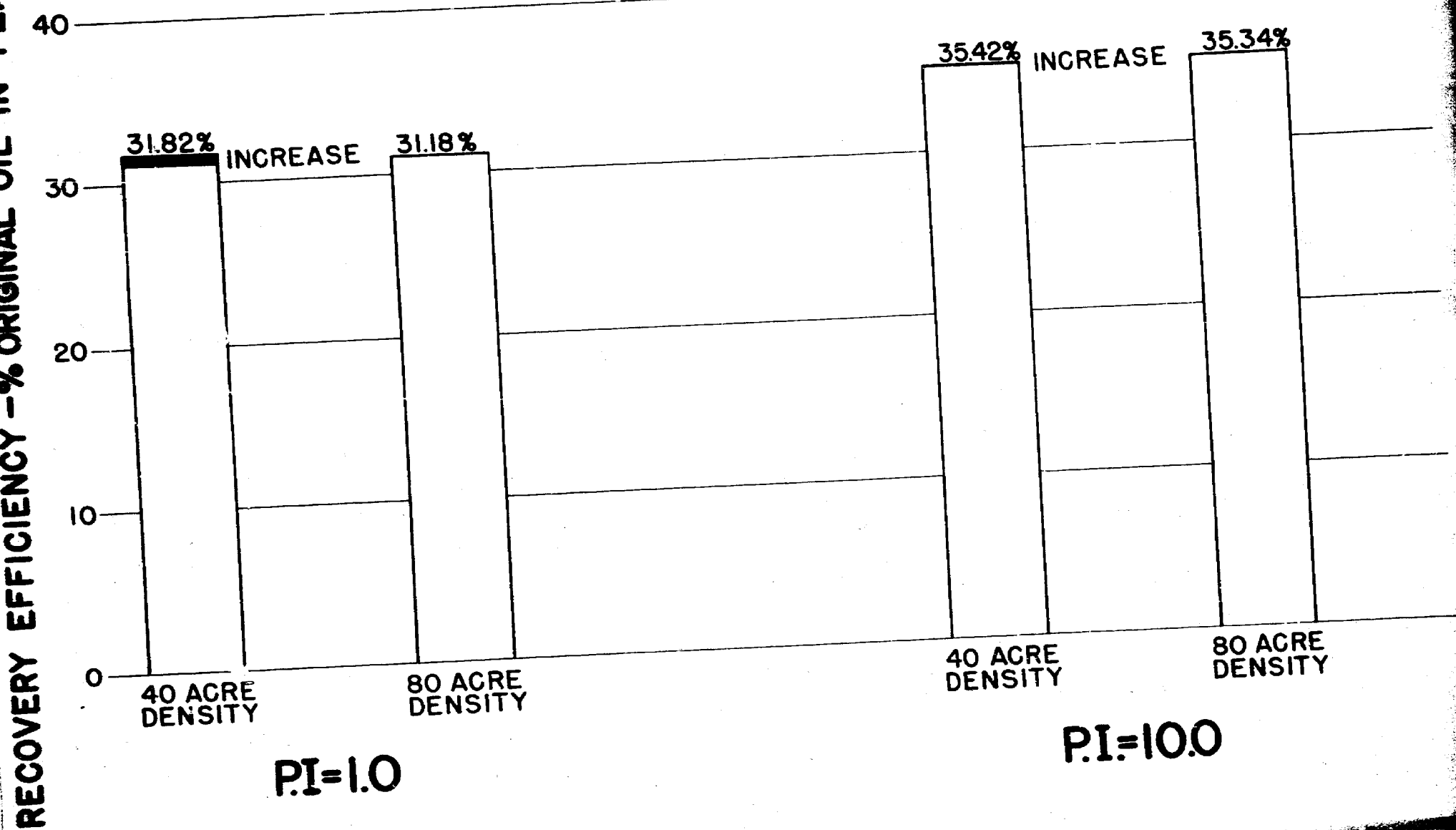
Stano - Case 407
6-16-53

CASE 4



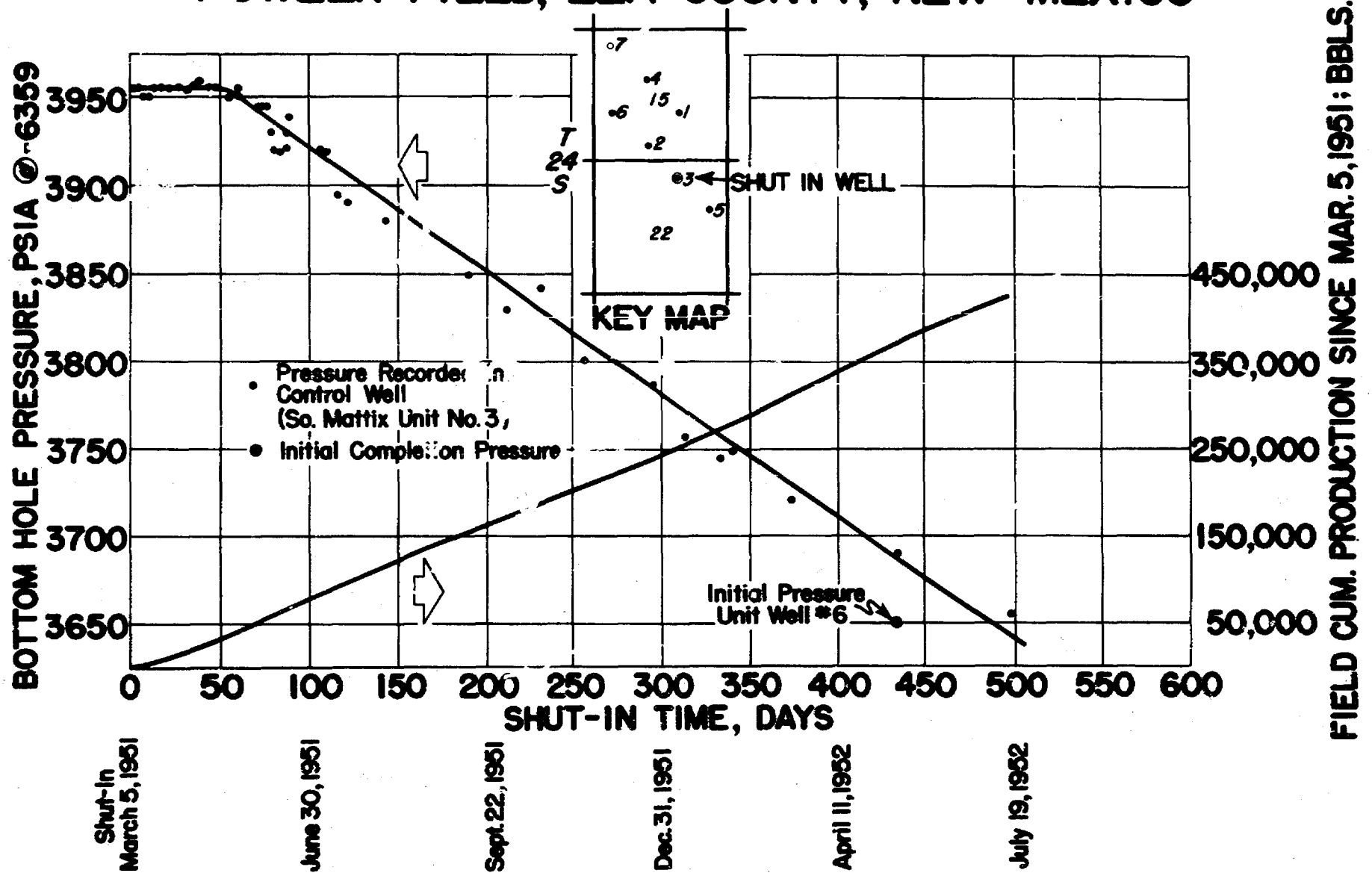
Stone - Case 407
6-16-53

CALCULATED VARIATION IN RECOVERY EFFICIENCY WITH WELL DENSITY AND P.I.



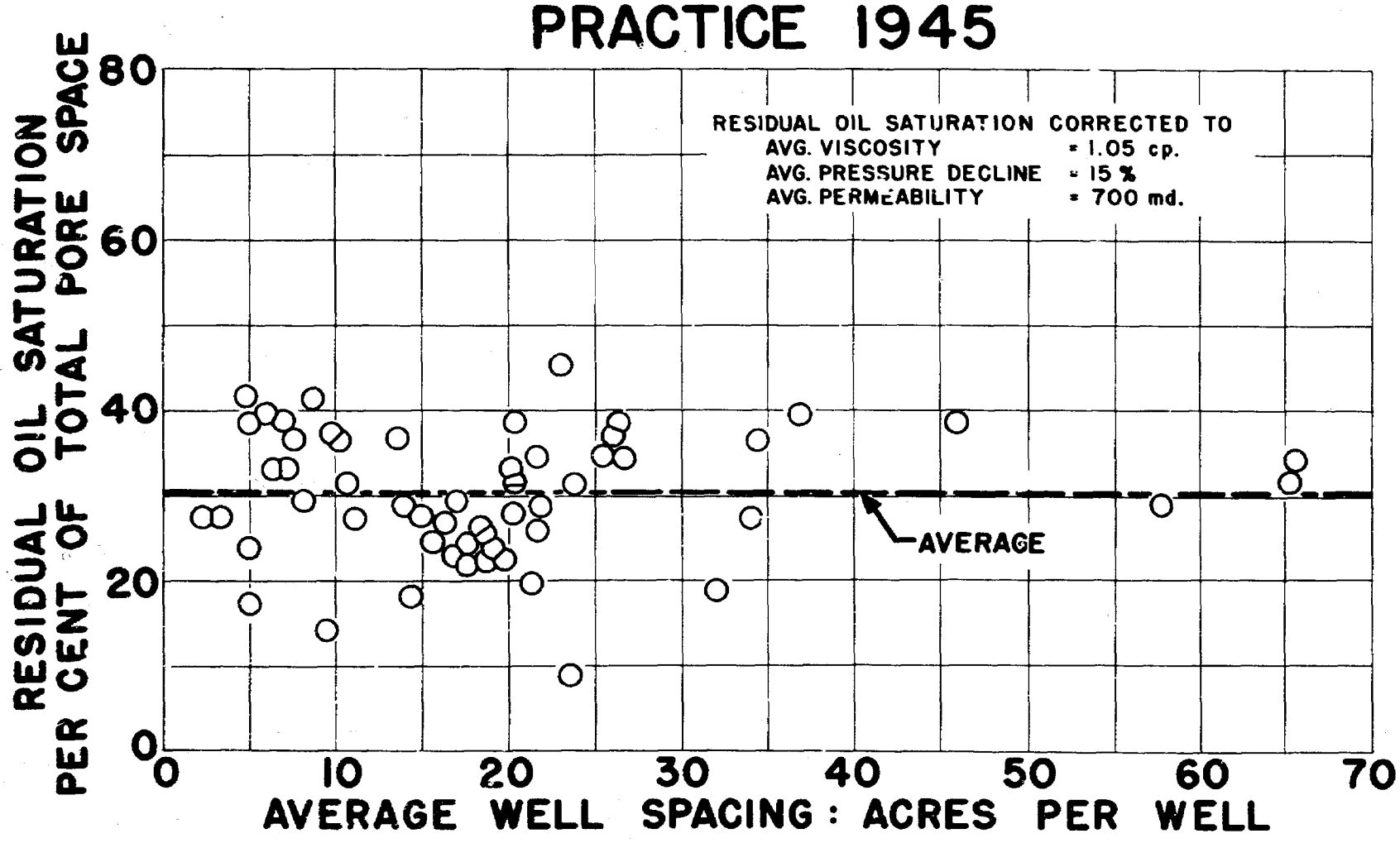
Stano - Ex. 407
6-16-53

INTERFERENCE TEST DATA
FOWLER FIELD, LEA COUNTY, NEW MEXICO



Stano - Case 407
6-15-53

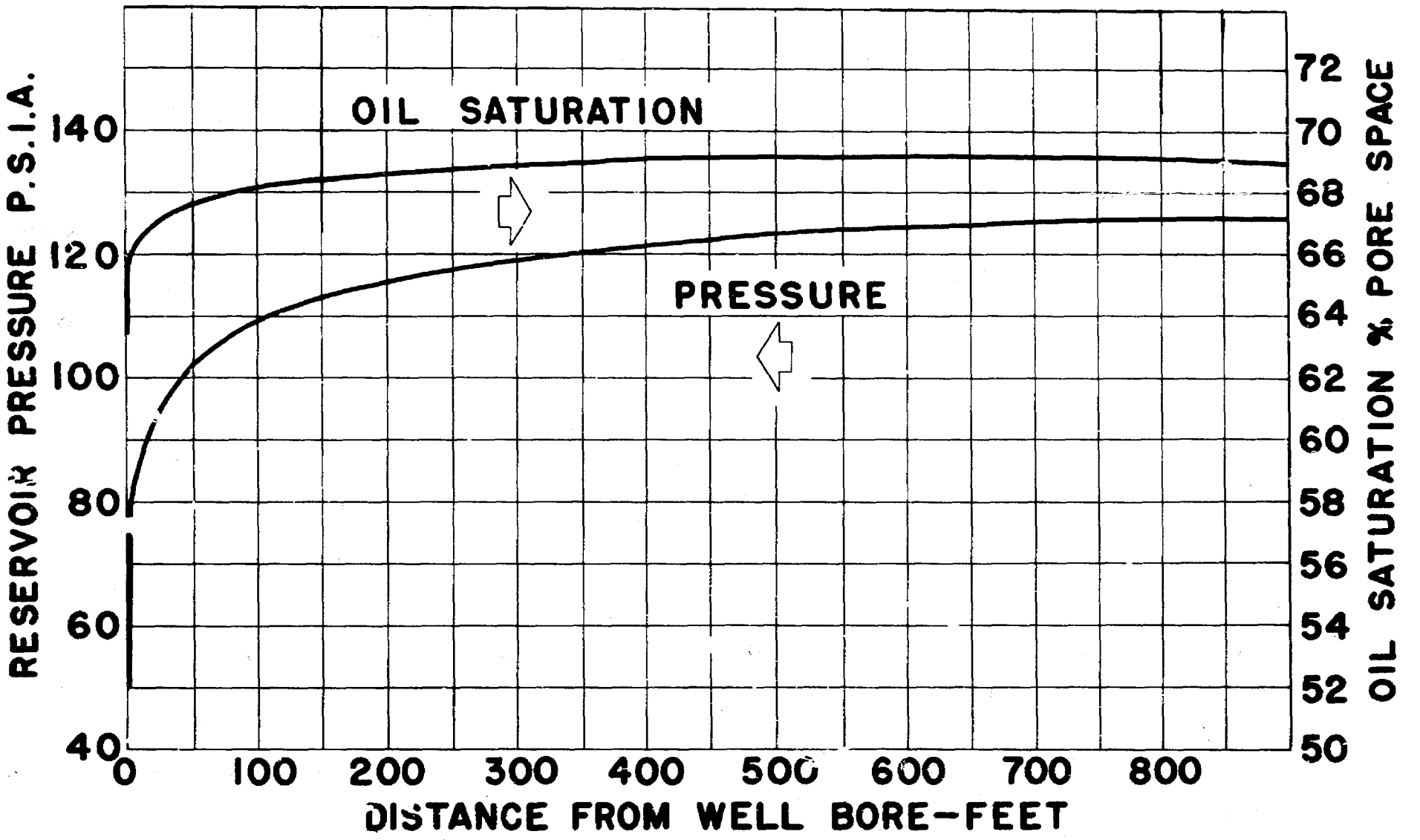
FIGURE 10 FROM "A FACTUAL ANALYSIS OF THE EFFECT OF WELL SPACING ON OIL RECOVERY" BY R.C. CRAZE & S.E. BUCKLEY. A.P.I. DRLG. & PROD. PRACTICE 1945



RELATION BETWEEN CORRECTED RESIDUAL OIL SATURATION AND WELL SPACING—WATER-DRIVE SAND FIELDS

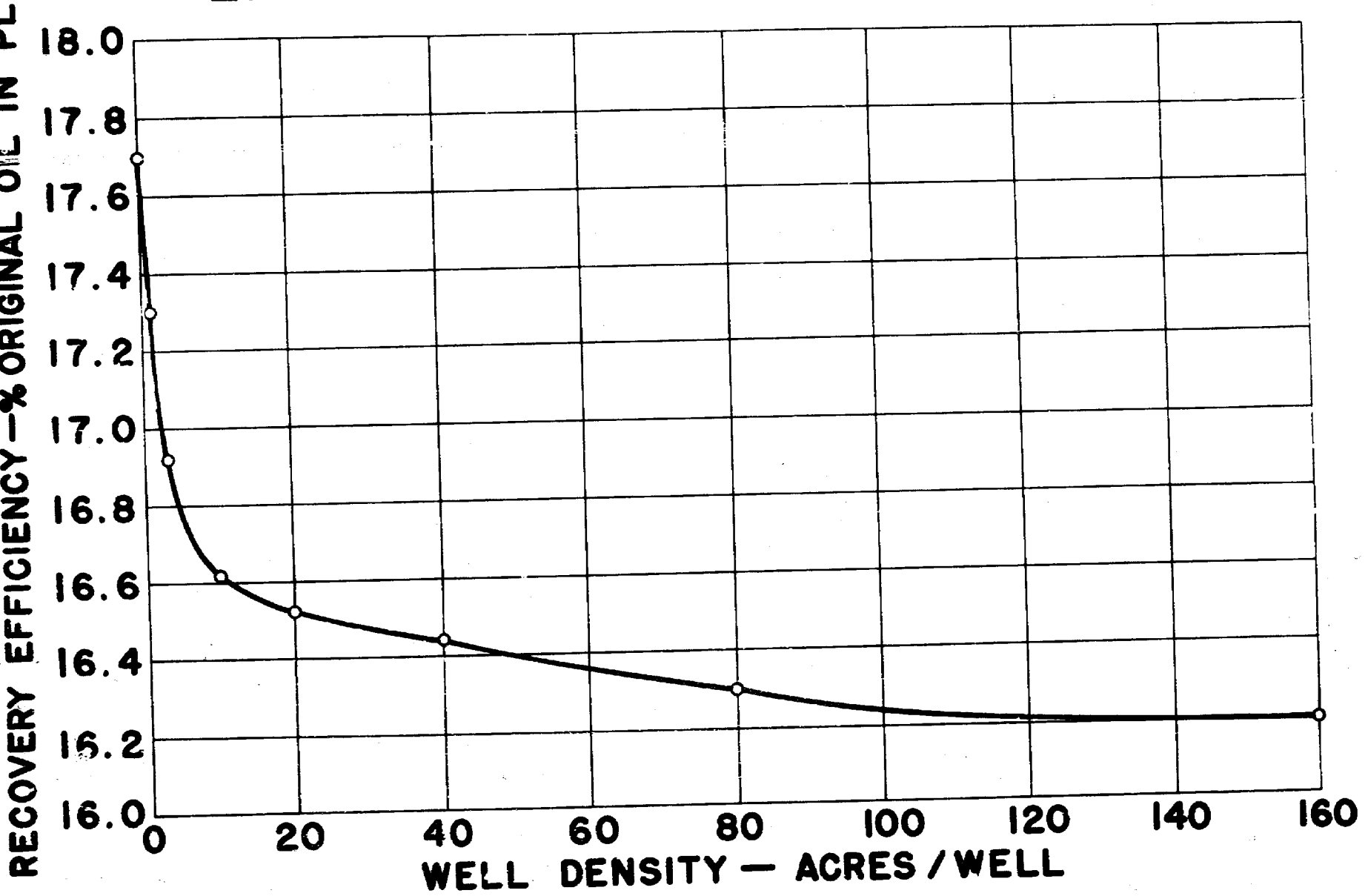
Stano - Case 407
6-16-53

CALCULATED PRESSURE AND OIL SATURATION DISTRIBUTION AT ABANDOMENT



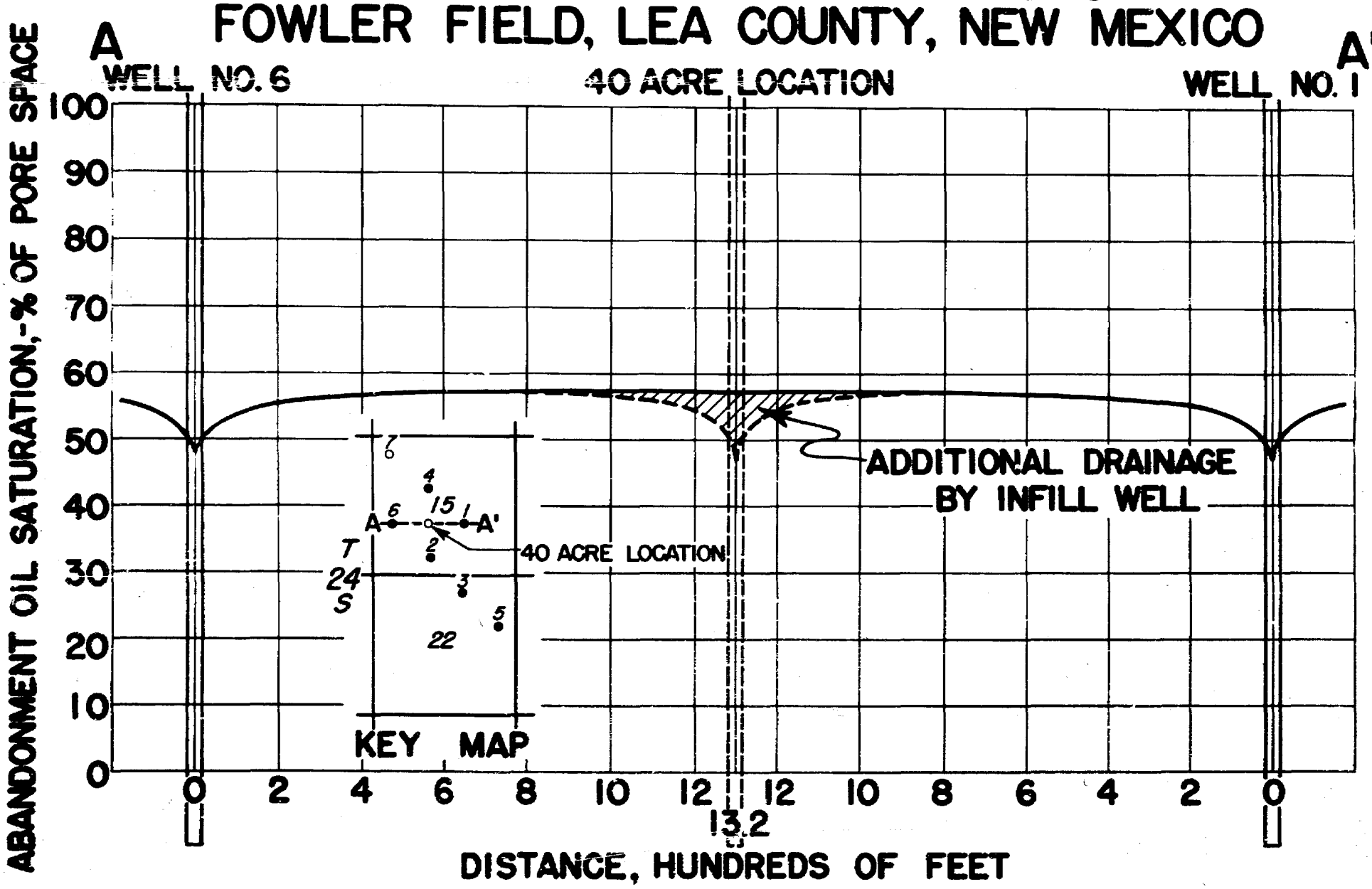
Stano - Case #07
6-16-53

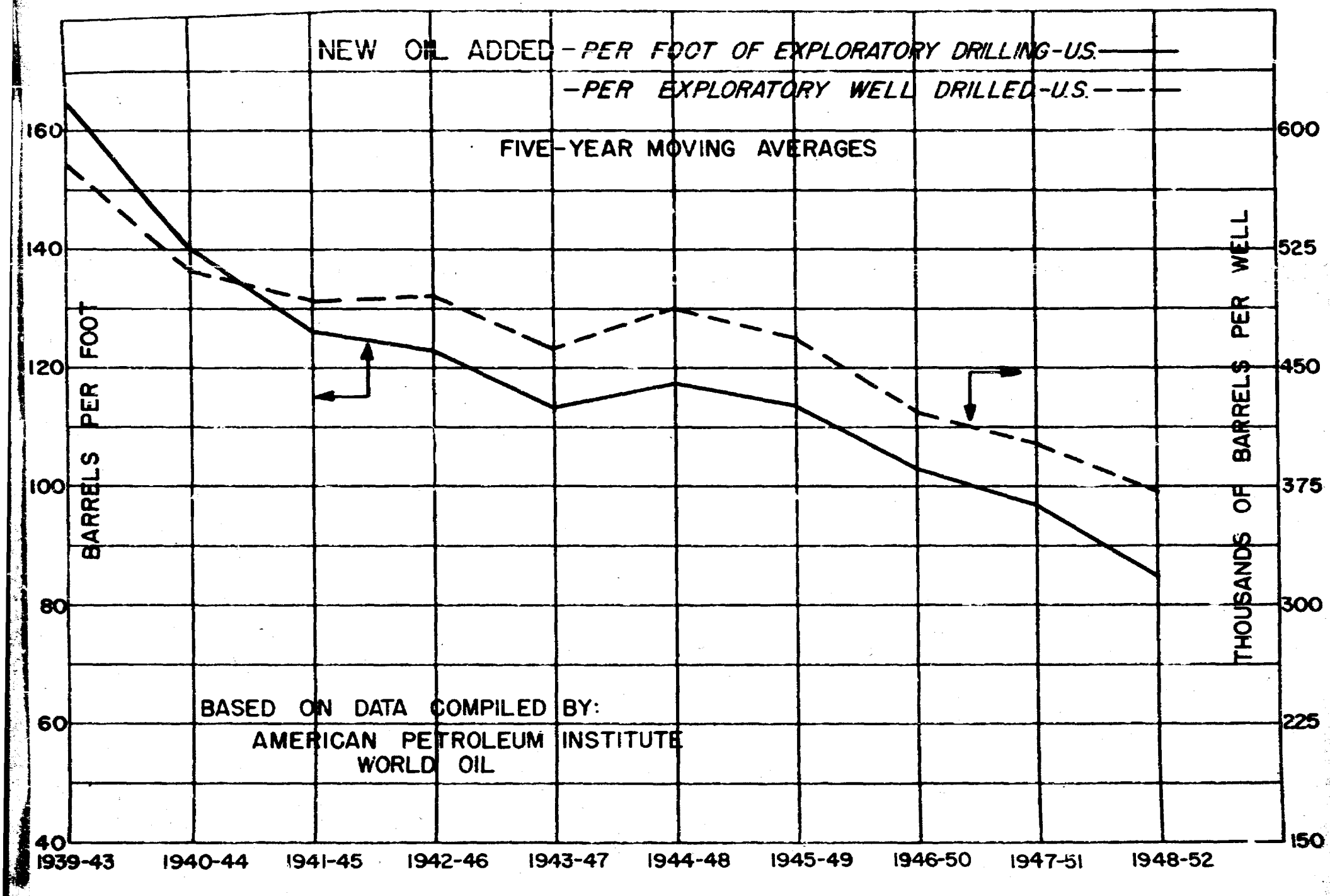
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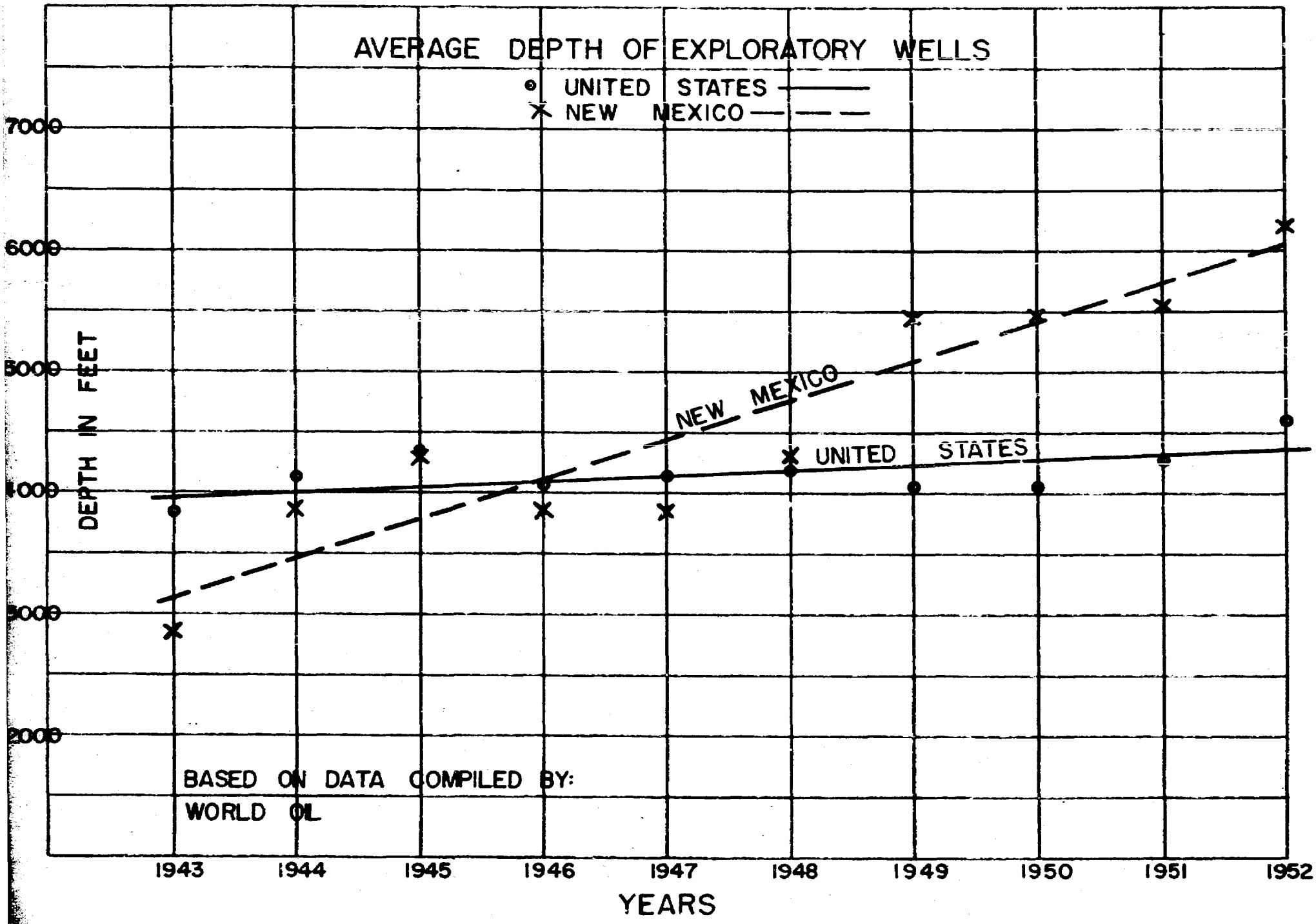


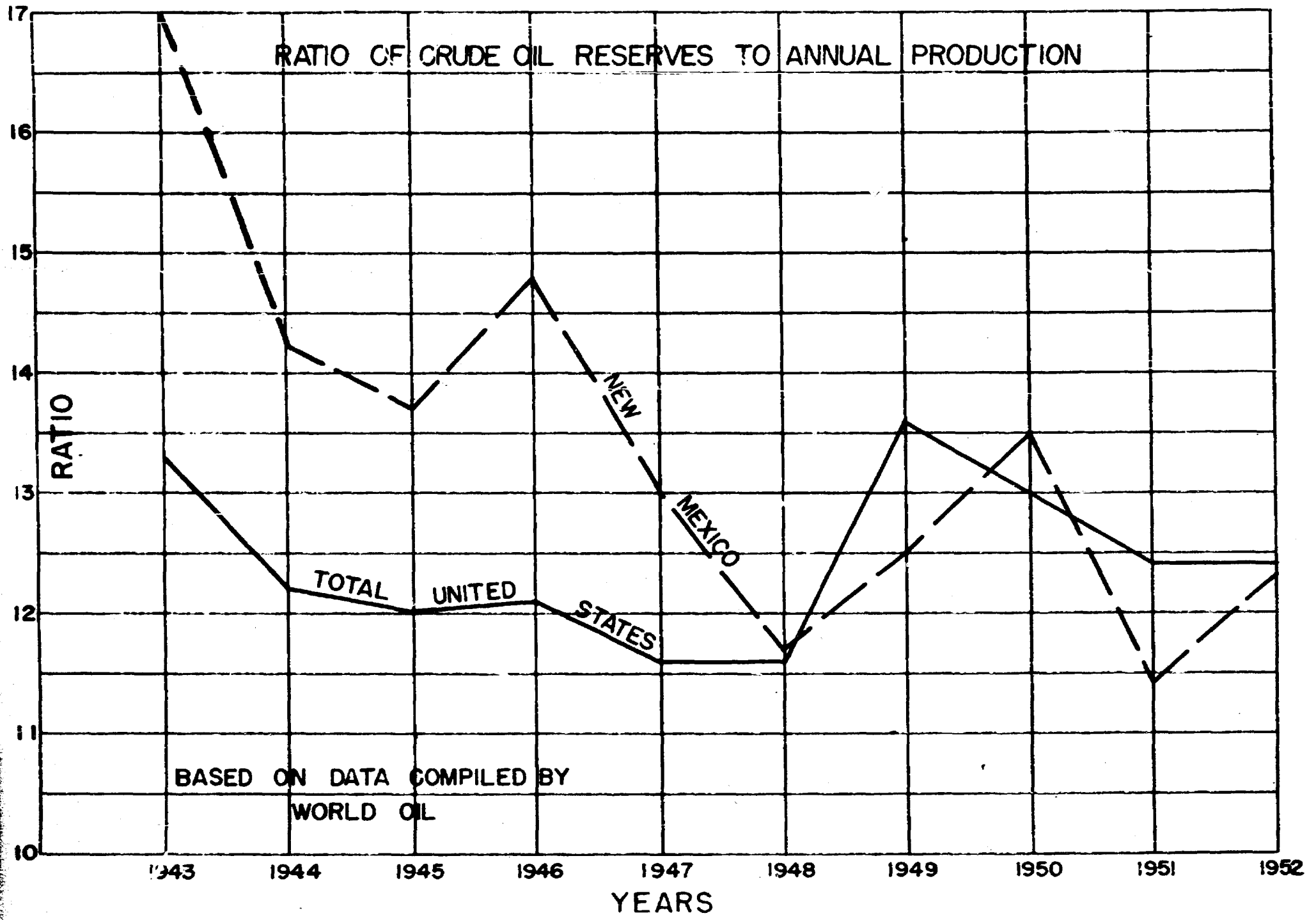
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6-16-53

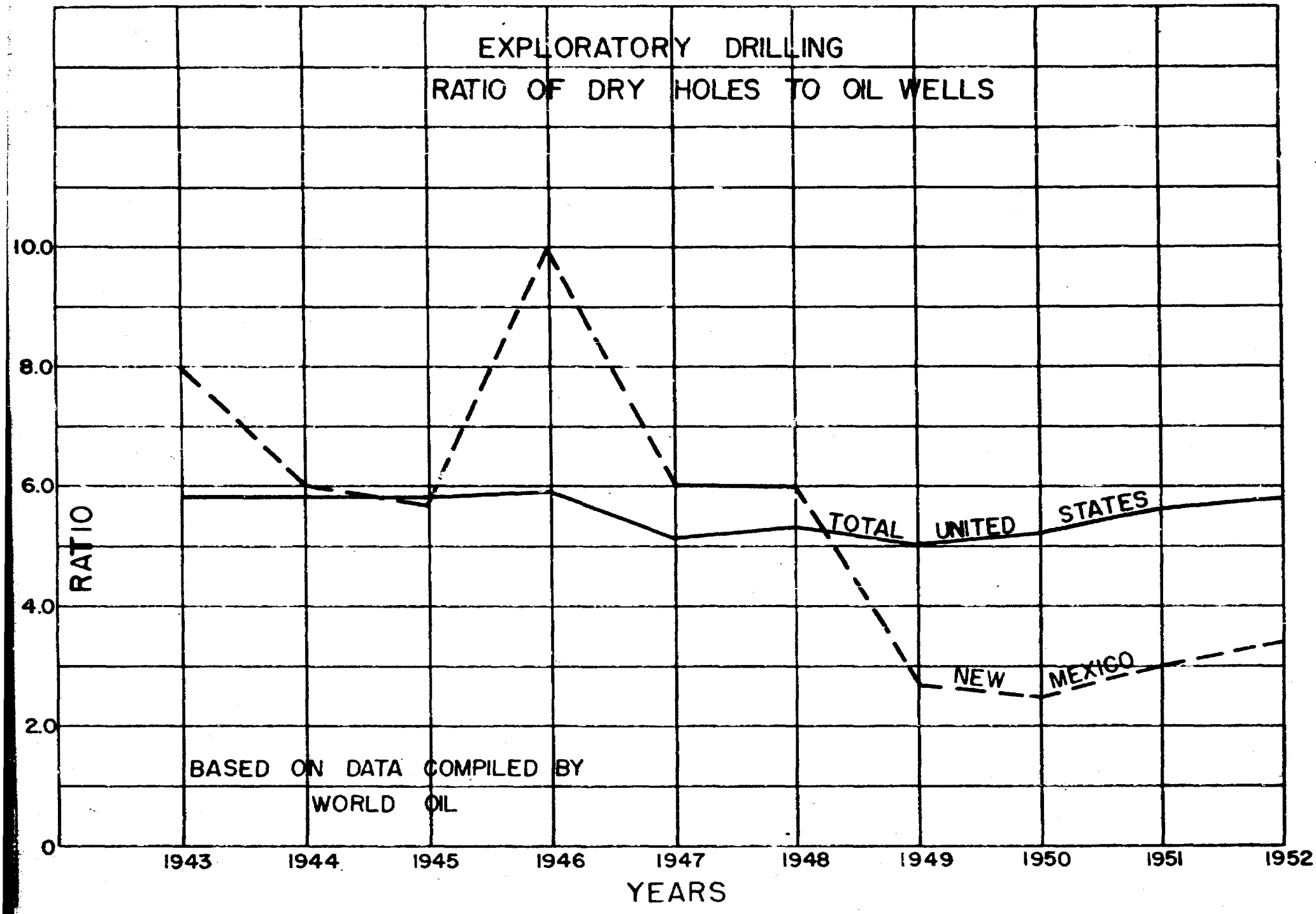
OIL SATURATION DISTRIBUTION AT ABANDONMENT CONDITIONS FOWLER FIELD, LEA COUNTY, NEW MEXICO

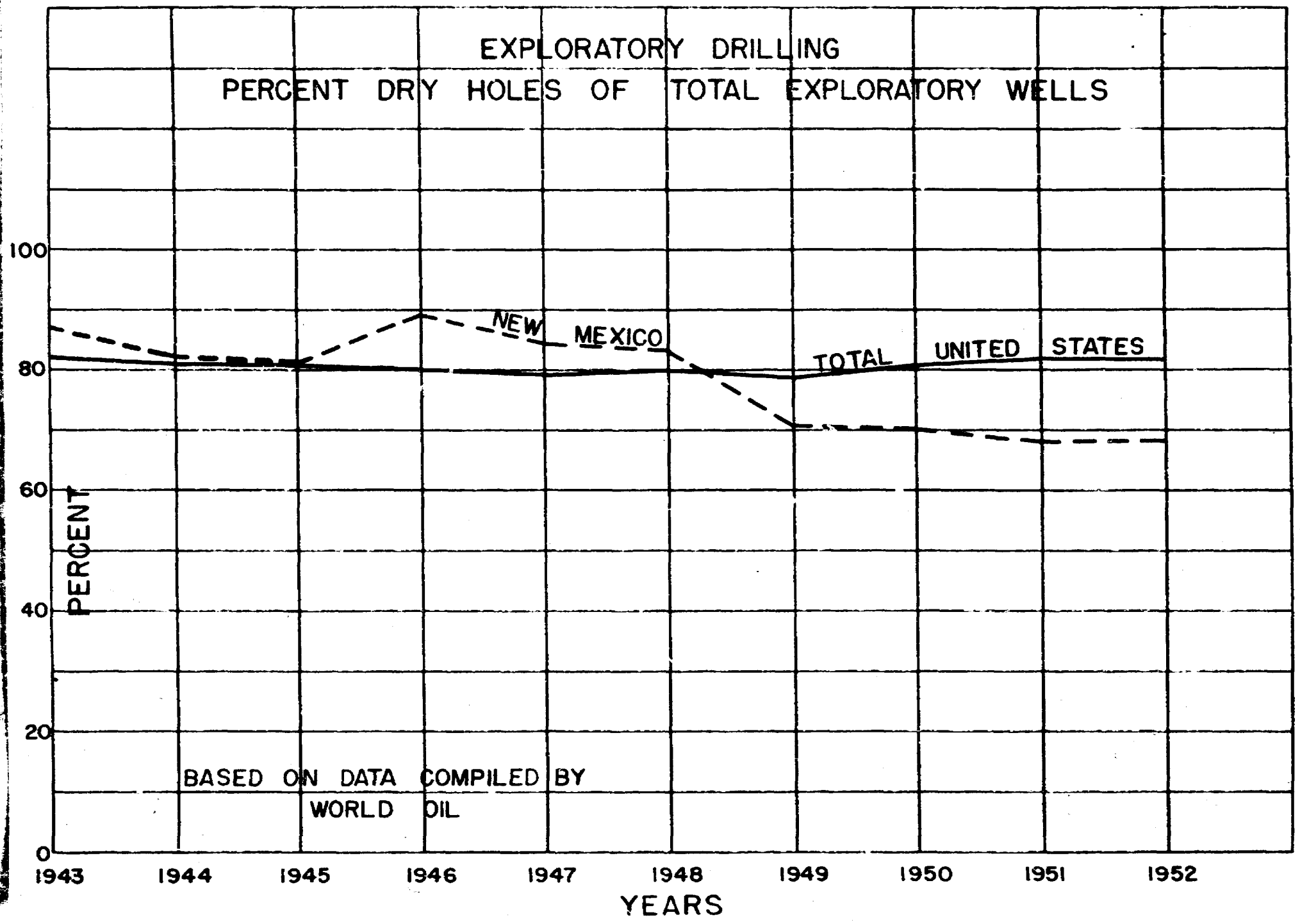



NEW OIL ADDED – PER FOOT OF EXPLORATORY DRILLING – U.S.
– PER EXPLORATORY WELL DRILLED – U.S.
FIVE-YEAR MOVING AVERAGES
BARRELS PER FOOT
THOUSANDS OF BARRELS PER WELL
160
140
120
100
80
60
40
600
525
450
375
300
225
150
BASED ON DATA COMPILED BY:
AMERICAN PETROLEUM INSTITUTE
WORLD OIL
1939-43
1940-44
1941-45
1942-46
1943-47
1944-48
1945-49
1946-50
1947-51
1948-52


AVERAGE DEPTH OF EXPLORATORY WELLS
UNITED STATES
NEW MEXICO
7000
6000
5000
4000
3000
2000
DEPTH IN FEET
NEW MEXICO
UNITED STATES
BASED ON DATA COMPILED BY:
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS

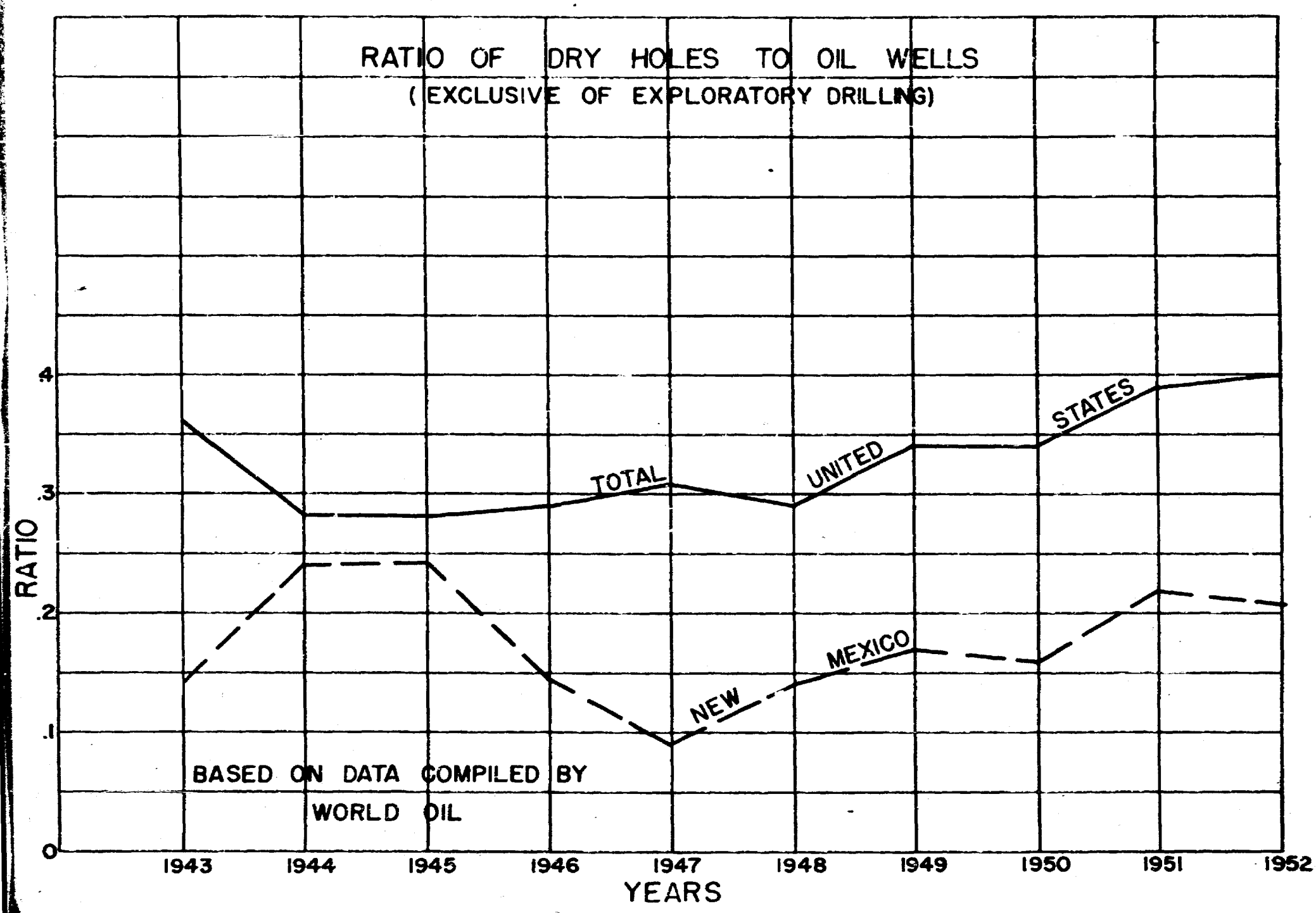

RATIO OF CRUDE OIL RESERVES TO ANNUAL PRODUCTION
RATIO
YEARS
17
16
15
14
13
12
11
10
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
NEW MEXICO
TOTAL UNITED STATES
BASED ON DATA COMPILED BY WORLD OIL


EXPLORATORY DRILLING
RATIO OF DRY HOLES TO OIL WELLS
10.0
8.0
6.0
4.0
2.0
0
RATIO
TOTAL UNITED STATES
NEW MEXICO
BASED ON DATA COMPILED BY
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS

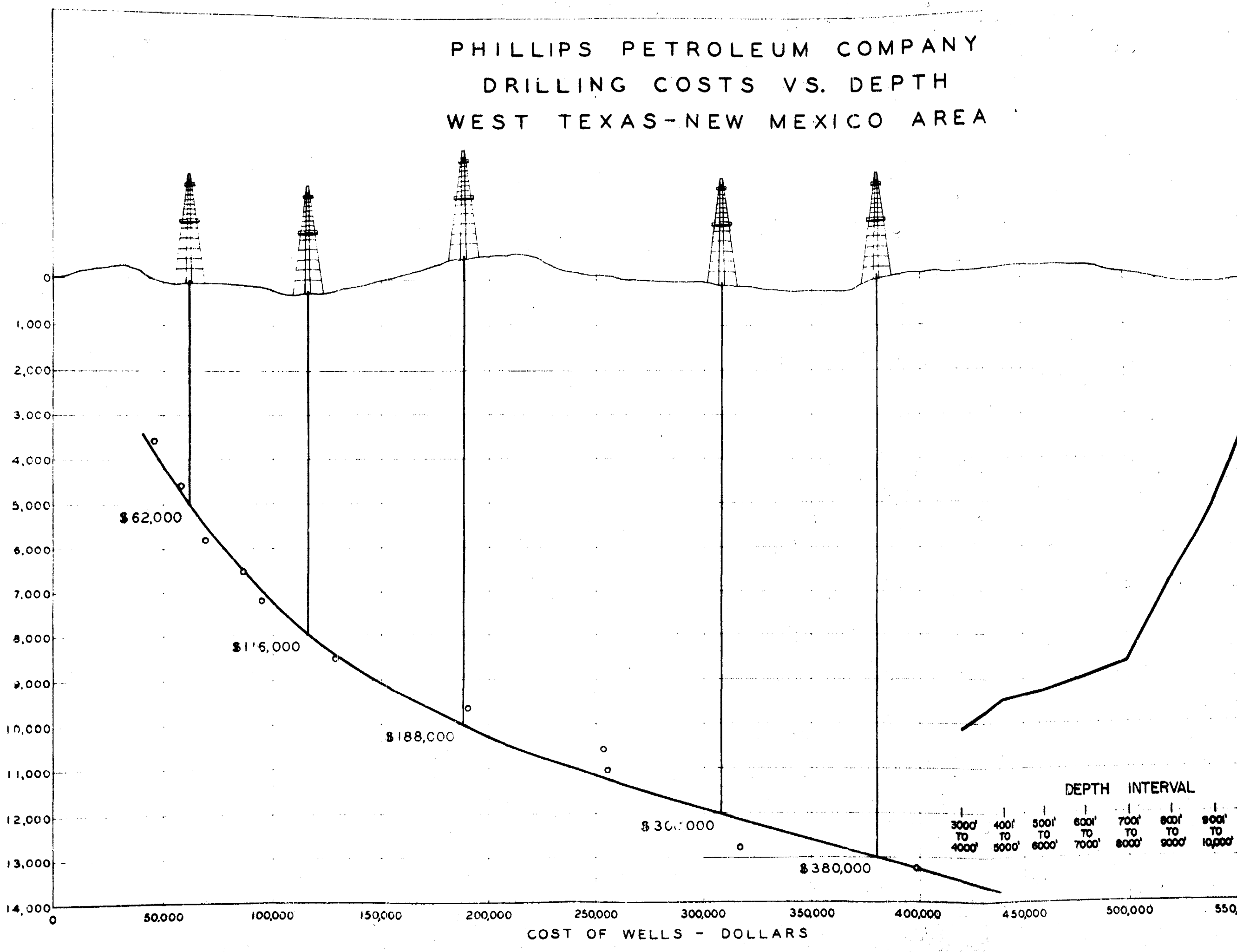

EXPLORATORY DRILLING
PERCENT DRY HOLES OF TOTAL EXPLORATORY WELLS
NEW MEXICO
TOTAL UNITED STATES
PERCENT
100
80
60
40
20
0
BASED ON DATA COMPILED BY
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS

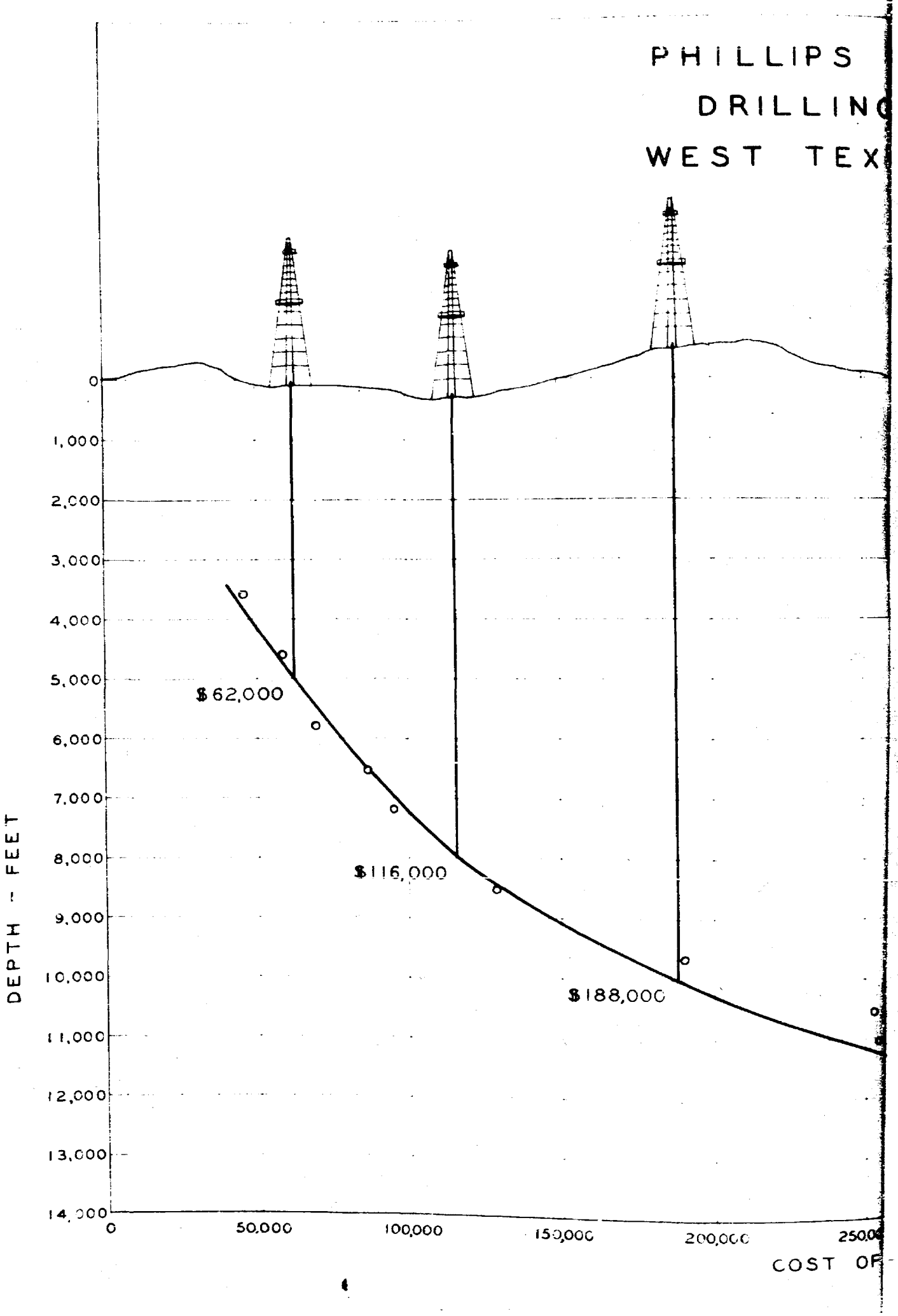
b

RATIO OF DRY HOLES TO OIL WELLS
(EXCLUSIVE OF EXPLORATORY DRILLING)



PHILLIPS PETROLEUM COMPANY
DRILLING COSTS VS. DEPTH
WEST TEXAS-NEW MEXICO AREA



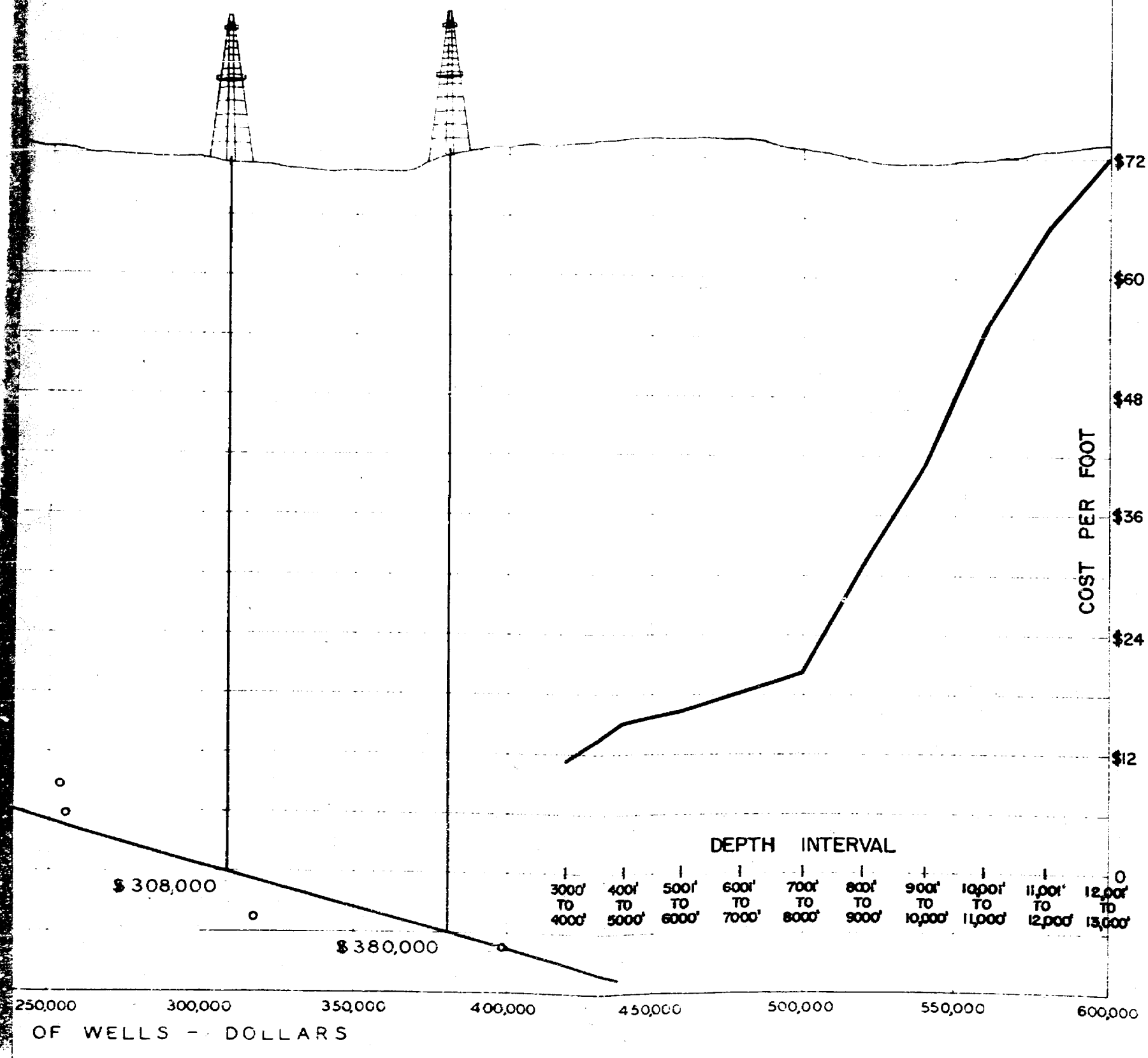

PHILLIPS
DRILLING
WEST TEX
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
$62,000
$116,000
$188,000
DEPTH - FEET
0
50,000
100,000
150,000
200,000
250,00
COST OF

7

PETROLEUM COMPANY

NG COSTS VS. DEPTH

EXAS-NEW MEXICO AREA



Case File
Case 407

STATE OF NEW MEXICO
EXECUTIVE OFFICE
SANTA FE

EDWIN L. MECHEM
GOVERNOR

June 17th, 1953

f: W B Macey

Memo to: Messrs. E. S. Walker
and
R. Spurrier
Oil Conservation Commissioners

From: E. L. Mechem, Governor

The 40/80 has offered nothing new.

We have the same situation we had before. It is cheaper to drill on an 80 pattern than on a 40 pattern. As a matter of fact, we were offered the thinly-veiled threat that if we were too severe, Phillips would pull out. One other company mentioned this also.

Tesch testified that the more wells drilled the more oil recovered; which I believe is the correct situation.

Balancing this is the economic factor which we must also consider and it is important. The only opposition to Tesch's statement was Callaway's explanation of Cutler's Rule or something. In each of his examples the spacing pattern was extremely close and there were more wells clustered in one area than in others. How the hell could anything else happen but a migration of oil to heavily-drilled areas from thinly-drilled areas? This is not our situation - everything is drilled on a uniform pattern. Callaway did testify that close spacing produced more oil per acre and wide spacing produced more oil per well. This should be "hornbook", but where in hell does Cutler's Rule come into the picture? All those b------s ever try to do is to confuse the commission - which ain't hard from my standpoint!

Absolutely no evidence was offered about a comparison of 40/80. What one will do as compared to the others. Buckley said that he had considered 40, 80, and larger, but they did not show us what happened under such circumstances, and not where 40/80 came in.

The only correct statement made from a purely technical standpoint was that each reservoir must relax on its own bottom. However, we must establish and maintain a spacing pattern of some sort. It would be fine to heave spacing to the winds but the commission would then be in session 30 hours a day, 400 days a year. In establishing a pattern we must assume of necessity that we are being arbitrary. There is no other choice, regardless of what the spacing pattern is.

New Mexico has a wide spacing compared to many other states - we have been extremely liberal in many respects; we have given extra allowables for deep wells, etc. As a matter of fact, we are considered by most to be the most liberal of states where regulation of waste is vested in a conservation commission. New Mexico has even been referred to as the Happy Hunting Ground.

We have no evidence - other than economic - to justify a change to 80 acres, unless reservoir structure definitely justifies it. We have to balance between economics as applied to producer and economics as applied to the State and royalty owners. I think we have it now. If we could so proceed that we would not be bothered with requests for 80 acres anymore unless the request was justified and the applicant knew it, we would be doing ourselves and the State a favor.

RS

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
AUG 6 1953

STATE LAND OFFICE

Santa Fe, New Mexico

E. S. WALKER
COMMISSIONER OF PUBLIC LANDS

August 6, 1953

Mr. Richard R. Spurrier
Oil Conservation Commission
Santa Fe, New Mexico

Dear Mr. Spurrier:

In regard to Case No. 407, Order No. R-346, I have received a copy of the petition for re-hearing submitted by Jason W. Kellahin for Phillips Petroleum Company, and Ross Madole for the Magnolia Petroleum Company.

I notice on the transmittal slip attached, you make the statement "I say - what do you say?". I don't know what you say, because you didn't say; but I say "yes". As far as I am concerned, that is part of the duties of the Oil Conservation Commission. I am willing to sit and listen as long as they are willing to stand and talk. I maintain that if we didn't give them a fair hearing and are wrong in our decision, and they request a re-hearing on the basis they have given; then the least we can do is re-hear it. Of course, I realize it is up to you and the Governor, but any way, I vote yes.

Sincerely

E. S. Walker

E. S. WALKER
Commissioner of Public Lands

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
AUG 3 1953

BEFORE THE OIL CONSERVATION COMMISSION

OF NEW MEXICO

IN THE MATTER OF THE APPLICATION OF THE OIL CONSERVATION COMMISSION UPON ITS OWN MOTION FOR AN ORDER EXTENDING SECTION G, OIL PRORATION AND ALLOCATION, TO PROVIDE FOR THE ADDITION OF RULE 508, ESTABLISHMENT OF TEMPORARY 80-ACRE PRORATION UNITS

Case No. 407
Order No. R-346

PETITION FOR RE-HEARING

Come now Phillips Petroleum Company and Magnolia Petroleum Company, and respectfully petition the Oil Conservation Commission of New Mexico for a re-hearing in the above captioned matter, and in support thereof would show:

1. That Petitioners are engaged in the exploration for, development and production of oil and gas, holding interests in the State of New Mexico, and are, and will be in the future, engaged in the drilling of exploratory wells below the depth of 10,000 feet, all as is fully disclosed by records of well locations, well completions, and other data and information on file with the Commission.

2. That Petitioners are affected by the order of the Commission in this cause and make this petition under the provisions of Sec. 69-223, New Mexico Statutes, 1941 Annotated (1949 Supplement).

3. That the Commission erred in entering its order in this cause, the same being Order No. R-346, and that said order is unlawful in that it is unreasonable, arbitrary and capricious in the following respects:

(a). The order is not supported by the evidence offered in this cause, and there is no substantial evidence to support said order.

(b). That the testimony adduced and exhibits offered at the hearings in this cause clearly show that temporary statewide 80-acre proration units for pools 10,000 feet and deeper, on the basis of the proposed order in this cause, would be highly advantageous to the State of New Mexico and its residents, and to operators operating in the State of New Mexico.

(c). That the testimony and exhibits offered at the hearings in this cause clearly show that the temporary 80-acre proration units proposed herein would result in a prevention of waste, as defined by law, and that correlative rights would be protected by such order.

(d). That the order does not recognize the correlative rights of the operators, including the correlative rights of Petitioners herein.

(e). That the order will result in waste as defined by law, as shown by the evidence offered at said hearings.

WHEREFORE, Petitioners respectfully pray that the Commission enter its order granting a re-hearing in this cause, and that upon such rehearing, the Commission rescind its order No. R-346, and enter in lieu thereof its order establishing temporary 80-acre proration units, as proposed in this cause, and as supported by the evidence and testimony herein.

Respectfully submitted.

Jason W. Kellahin

Jason W. Kellahin
Attorney at Law
Laughlin Bldg., Santa Fe, N.M.
For: Phillips Petroleum Company.

Ross Madole

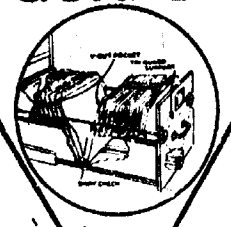
Ross Madole
P. O. Box 900
Dallas, Texas
For: Magnolia Petroleum Company

Case No.

407 File #2

Application, Transcript,
Small Exhibits, Etc.

TRI-GUARD FILE



Globe-Wernicke
CINCINNATI

PATENTED NO. 1,787,410
MADE IN U. S.

BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
JUL 7 1953

CASE 407

The Commission's motion for extension of Section 'G' (Oil Proration and Allocation) to provide for addition of Rule 506, Establishment of Temporary 80-acre Proration Units.

TRANSCRIPT OF HEARING

June 16, 1953
Date

BEFORE: Honorable Ed. L. Mechem, Governor
Honorable E. S. Walker, Land Commissioner
Honorable R. R. Spurrier, Director, OCC

STATE OF NEW MEXICO)
ss
COUNTY OF BERNALILLO)

I HEREBY CERTIFY That the within transcript of proceedings before the Oil Conservation Commission is a true record of the same to the best of my knowledge, skill, and ability.

DONE at Albuquerque, N. M., this 3d day of July 1953.

E. E. Gleason
E. E. Gleason
Notary - Reporter

My Comm. Exp.:
August 4, 1956

COM. SPURRIER: We will move to case 407.

(Mr. Graham reads the advertisement.)

MR. SMITH: May it please the Commission, as I understand the status of this case, it having been continued from the April hearing, I believe that Mr. Tesch -- was he on the stand, or was there additional testimony offered at the conclusion of his testimony?

COM. SPURRIER: As I remember, Tesch was on the stand.

MR. SMITH: I should like to inquire if the Commission has information as to whether or not Mr. Tesch is back for this hearing.

COM. SPURRIER: The two senior members of the Commission tell me Mr. Tesch finished his testimony so that he wouldn't have to return.

MR. SMITH: I had to leave early and I wasn't too sure what the status was.

I presume that the Commission has received no information as to whether or not Mr. Tesch has returned? He indicated he might not be able to return. I presume you have received no information from him?

COM. SPURRIER: No, sir, we haven't.

MR. SMITH: In the interests of saving time, in view of the presentation we wish to make, we divide the presentation off somewhat among the companies, and I believe

Judge Foster is the one who is supposed to proceed.

(Off the record)

MR. SMITH: Is Mr. Hanners here?

COM. SPURRIER: I don't see him, Mr. Smith.

MR. SMITH: Shall we proceed?

COM. SPURRIER: If you wish.

MR. FOSTER: We ask the witnesses be sworn, if it please the Commission.

COM. SPURRIER: Will you ask them to come forward?

(Witnesses sowrn)

MR. FOSTER: May it please the Commission, I am E. H. Foster, representing Phillips Petroleum Company.

The three industry members who were on the Advisory Committee wish to submit a report at this time of the Committee. I have some extra copies here of the report, if the Commission would like them. And I will offer one in evidence. I would just like to read this report of the Committee.

(Reads the report)

MR. FOSTER: Now, I would like to offer that report as part of the record.

COM. SPURRIER: Is there objection?

MR. MACEY: I would like to ask the judge a question. You might have misread. You said unless in 18 months. You meant not more than 18 months?

MR. FOSTER: Yes, I did misread. I did misread.

[illegible] questions, it will be re-

[illegible] I would like the unanimous consent of

[illegible] Mr. Beall, who is our vice-president,

[illegible] testifies so that he may get back to

[illegible] Mr. Beall is very seriously ill, and will under-

[illegible] surgery early in the morning. And Mr. Beall is anxious to return to Bartlesville as soon as he possible can.

COM. SPURRIER: Very well, judge.

MR. FOSTER: And we will call Mr. Beall as the first witness.

K. E. BEALL

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. FOSTER:

Q Will you state your name to the Commission, please?

A K. E. Beall.

Q Where do you reside, Mr. Beall?

A Bartlesville, Oklahoma.

Q Are you employer by Phillips Petroleum Company?

A Yes, sir.

Q What official position do you hold with the company, Mr. Beall?

A Vice-president of the Economics Department.

Q How long have you been in that capacity?

A About six years.

Q Now, Mr. Beall, you have made some studies of the economic implications of well spacing, have you not?

A Yes, sir.

Q And would you say that an economic analysis is important in the oil business?

A Yes, sir, I would say it is very important. As far as I know no company that is going to spend very much money does so without such an analysis. I presume that probably most of the people that appear before this Commission represent the branch of the industry that spends the money. And I would be glad to give you a few slants from the branches that get the money, and determine how it is spent and how.

Q Will you do that, please?

A Yes, sir. I presume most of you realize that the oil industry is one of the four or five major industries of our country. It has gross assets of approximately 40 billion dollars. And it is required this industry each year spend a great deal of money in new capital. For the past five years there has been substantially 15 billion dollars spend in capital expenditures of various branches of the oil industry. And during 1952 the best estimate we can make this early is that approximately thirty billion dollars was spend for capital expenditures. And, inspite of anything anybody

[illegible] oil industry, as well as allother industries, [illegible] when it is satisfied it can make a return; get its money back with a reasonable profit.

In other words, we are part of the capitalistic system, whose purpose is to make money. So that in determining how this staggering amount of three to three and a half billion dollars is spent each year, the various companies who spend it have to make very careful analysis of where to put the money. There is of course competition between the various branches of the oil industry for capital.

We have the refining industry, and the production industry, and the transportation and marketing, and of late years the petro-chemical branch; all clamoring for part of this capital expenditure.

Of recent months you are probably aware of the fact interest rates have increased materially. And I am sure for at least the immediate future it is going to be harder to get capital to spend than it has been in the past. Therefore, the analysis of how to spend this money is even more important in the present and in the immediate future than it has been in the immediate past.

Now, once the company determines what portion of its total capital budget is to be allocated to the producing branch, then it immediately becomes the problem of where to spend the money. In other words, the different states have to

compete with each other to get their proportionate [illegible] the capital funds allocated to the producing [illegible] of course, there is also an allocation as between [illegible] wells and wells to expand the fields already developed.

Now, the industry is faced with the constantly increasing dry hole hazard. If we take an analysis of all the wells that have ever been drilled, there is something over one million four hundred thousand of them. Approximately 25 per cent of these wells have been dry. If we take only the last ten years, something over 300,000 wells, 34 per cent have been dry. If we take just the last year, 44,000 wells, 40 per cent have been dry. So, you see there is a steadily increasing dry hole hazard. And, of course, it is needless to say you don't make money out of dry holes.

Now, in addition to this dry hole hazard, the costs of various kinds affecting the development program have also increased very materially. Going back to the time of our last crude price increase in 1947, labor has increased approximately 40 per cent; steel prices have increased 40 per cent; other materials 20 to 30 per cent. Income taxes are also up, and are very burdensome. So that you can well see that the companies, the departments of companies responsible for the investing of these capital funds, have to make a very close analysis in order to be sure they are going to get their money back, plus an adequate profit.

[illegible] studies of the economics of well spacing, and investment of funds [illegible] as the State of New Mexico, individually.

[illegible]. Among other things, of course, we [illegible] -- we have to determine -- the reserves that [illegible] by development. New Mexico is one of the [illegible] states -- there are many producing states. New [illegible] reserves I think that places it in about seventh place. Texas, first; California, second; Louisiana, third; Oklahoma, fourth; Wyoming, fifth; Kansas, sixth; and New Mexico, seventh.

Now, in general, the industry has had a very good record in uncovering new reserves for the entire country at large. Despite the fact that the production and demand -- crude runs have increased steadily each year. And we find that the amount of new crude reserves which have been developed has increased steadily. At the end of each year we have had a little more reserves of crude oil than we had at the end of the previous year. And at the end of 1952 the crude reserves was the highest it has ever been. Approximately 28 billion bbls. That is in the United States alone. Proven reserves.

Now, the thing that is disturbing about reserves is the fact that it is harder and harder to find them and more costly

to find them. And that, of course, is one of the things that the whole industry is facing.

Now, I have made some curves, which I ask the Judge to distribute to the members of the Commission interested, that show some of the factors that have to be considered by the different oil companies in their determination of what to do with their capital and where to spend it. I have numbered these curves from 1 through 7.

The first curve sheet shows the new oil that is added per foot of exploratory drilling in the United States, and also by the exploratory well.

Now, in the process of determing reserves, the American Petroleum Institute Committee, from which these figures were taken, of which I happen to be a member, has three different categories for new oil that is added. You have, first, the reserves found by wildcat wells which prove productive. Then we have the reserves that are added by finding new pools; deeper pools in most cases in already discovered fields; and the third category of reserves that are added in old pools due to their extension, drilling of the wells that are expanding the proven area in the known pools.

Those three categories of reserves are added together, and averaged for five-year periods, or a five-year average, divided by the feet of exploratory wells drilled, and the number of exploratory wells, which gives the points on these

[illegible] those curves to the Commission.

[illegible] solid lines show -- these figures are [illegible] -- the heavy line shows new oil [illegible] of exploratory drilling. Starting back ten [illegible] for every foot drilled by exploratory [illegible] of new reserves added. That figure [illegible] down with only one slight increase to a [illegible] in the -- in the latest five year period ending in 1972.

The dotted line shows the number of bbls per exploratory well drilled. And it has dropped also steadily from 579,000 ten years ago to 364,000 in the latest five-year period.

Those figures show very conclusively how hard it is to find crude. And that is despite the fact that we are drilling more wells than we ever have before, and drilling deeper and more expensively, and the industry is spending more money than before, and still not finding reserves as rapidly as we did in the past years.

That is one factor that has to be taken into account in the determination of spending of money for production.

Q Mr. Small, I notice on this chart No. 1 that you comment on the statement that it is based on data compiled by the American Petroleum Institute.

A That's right.

Q Are you a member of that [illegible]

A Yes, sir. These figures are taken [illegible] report of the combined two committees. One from the American Petroleum Institute, which studies crude oil [illegible] and the second, the American Gas Association, which studies the reserves of gas and of natural gas liquids included in the gas.

Q I understand in your studies of the economics of the question you have found some economic factors that are unfavorable in New Mexico, and some that are favorable. Is that true?

A Yes, sir, that is true.

Q Would you tell us first what factors you found in New Mexico -- that is, economic factors -- that are unfavorable factors?

A Chart No. 2 shows one of the factors. This has to do with average depth of exploratory wells in the United States and in New Mexico. We found out ten years ago, 1943, the average depth of an exploratory well in New Mexico was 2,834 ft, and in the United States, as a whole, was 3,812 ft. In other words, New Mexico was about 1,000 ft shallower than the United States average.

The trend has been up both for the United States and New Mexico. However, the trend for the United States has been up very gradually. In the ten-year period the average

United States wells has increased only [illegible], which is a relatively small increase [illegible]. On the other hand, with New Mexico start- [illegible] ft., shallower than the United States average in [illegible] increased much more rapidly to 6,293 in 1952; appro- [illegible] ft. deeper than the United States average.

[illegible], as you probably realize, is going to continue, [illegible] as we know from the activity that is currently taking place.

Now, that is one thing that New Mexico has to face that might be considered unfavorable in that it is definitely classed as a deep area. And as most of the deep wells are increasingly costly, it means that whoever wants to develop wells in New Mexico is going to have to be prepared to furnish the capital to drill these deep wells.

Q When you say unfavorable, you mean compared with other states when the company comes to a decision as to where they are going to invest their funds?

A That's right.

Q In developing the oil resources?

A That's right. New Mexico has to compete with the other states. A company has a budget of so many million dollars. It is going to determine where it is going to spend that in the light of possible returns on the investment in the different states, and in the light of producing conditions set up by the regulatory bodies in those states, or in some

few states where there are no regulatory [illegible] have a strike against them to start with.

Q Your testimony is directed at a [illegible] of the industry, isn't it?

A Yes, sir.

Q You are not speaking of any particular company?

A That's right.

Q But this is the over-all composite picture of the economic factors involved in the investment of funds by the oil companies?

A The entire industry, yes, sir. The only chart which I have which is limited strictly to Phillips Petroleum Company figures is the No. 7, which I will get to later.

Q Now, what other unfavorable economic position did you find New Mexico in?

A Well, Chart No. 3 shows the ratio of crude oil reserves to annual production. It shows conclusively that the State of New Mexico has not succeeded in developing reserves in proportion to its production return as rapidly as the remainder of the country.

The dotted line shows reserve picture for New Mexico, and the solid line the total United States. It shows ten years ago New Mexico had 17 years reserves, based on the then rate of production, whereas, the United States had 13.3 years. During the ten-year period the United States

[illegible], but pretty largely level.
[illegible] period, or end of 1952, the United
[illegible] years supply, even at the higher rate
[illegible]. On the other hand, New Mexico has
[illegible] supply ten years ago to 12.3 years sup-
[illegible] words, it was half again as high as the United
[illegible] ten years ago, and now it is below the United
[illegible], and has been consistently for the last four
[illegible]-years. So that shows there hasn't been the reserves
[illegible] in New Mexico in proportion ot the increasing rate
of take that there has in the United States at large.

That also might be deemed to be an unfavorable factor for the State of New Mexico.

Q Now, you have explained these unfavorable economic factors that exist in this state. Did you find some favorable factors ?

A Yes, fortunately I do. I go into Chart No. 4. Charts 4 and 5 pertain to exploratory drilling only. And they show -- Chart No. 4 shows the ratio of dry holes to oil wells among only the exploratory wells. And Chart No. 5 shows the percent of dry holes to total number of exploratory wells.

In both cases, New Mexico has a comparably better average than the United States at large. Ten years ago New Mexico was a little worse than the United States as far as dry hole ratio. It had eight dry holes to each oil well

drilled in its exploratory program, [illegible]
of the year '46 when it had a bad year. [illegible]
age has gone down steadily, and for the [illegible]
years it has been substantially under the [illegible]
age.

And in 1952 the average in New Mexico was [illegible]
for each oil well discovered, as compared to a United States
age of 5.8. A little over half. So, that is very favorable
to New Mexico.

Now, the percentage of dry holes to total exploratory wells is also very similar to the other curve. It shows that ten years ago that the percent was a little higher in New Mexico than the United States average, whereas today it is lower. Sixty-eight per cent of the exploratory wells are dry now as compared to 82 --

Q You are now referring to Chart five?

A Yes, sir, I am now referring to Chart No. 5. That also has taken place for a period of four or five years. And it conclusively proves that the exploratory program in New Mexico is quite as hazardous as elsewhere. And, of course, that is favorable because nobody wants to get into a program of drilling dry holes.

MR. GRAHAM: To what do you attribute that, Mr. Beall?

A To Mother Nature, I would say.

exploration?

methods of exploration

elsewhere. You have

more reserves -- not

better ratio of dry holes to oil

possible faster here -- those two curves

exploratory wells. This next curve applies to

drilled in expanding the production found

exploratory wells, exploratory wells.

Q Right, are those exploratory wells kind of in the

nature of

A They are wildcats.

Q They are wildcats?

A That's right.

Now we are talking about the kind of wells you are talking about applying your factors in the way of your spacing by

Q Yes, sir.

A In other words, expanding the field found by the discovery exploratory well.

This Chart No. 6 shows that exclusive of the exploratory wells, naturally there would be a very much lower percent of dry holes, because you have already proved up the field, and it is a question of expanding it. This average has been

fairly level throughout the ten-year period. It [illegible] in '43, 136 of a dry hole for each oil well in [illegible] expansions; and ended up the ten-year period with [illegible], four-tenths or 40 per cent.

Now, that is the experience for the United States. [illegible] New Mexico is consistently all through the ten-year period has been less than the United States average. And for the last six years it has been approximately half the United States average. In other words, in expanding the production, productive areas, around the discovery wells in New Mexico, the experience has been that only half as many dry holes have been drilled as in the United States at large.

Now, that is a very good point to consider with regard to your spacing [illegible] all through that period -- I think your 40-acre spacing went into effect sometime in the thirties. All during this period you had 40-acre spacing in effect.

Now, many opponents of the wider spacing program have claimed the fact that you had to step out a little further in the 40-acre spacing than you did in the 10 and 20 in effect in other pools would tend to make you drill unnecessary dry holes. That claim isn't borne out at all by these facts. Because here with New Mexico operating under 40-acre spacing throughout this entire period, and the United States as a whole certainly less than 20 acres on an average -- we don't know what the average is because there is no way to compute

[illegible] 40 acres. All [illegible] was about half what [illegible] spacing, which [illegible] earlier part of the period [illegible] an innovation than the expansion from [illegible] that that didn't result in an abnormal [illegible] holes. The only answer that could be given [illegible] would be that it tends to prove once [illegible] fields in New Mexico your geologic formations are more dependable and predictable and extend over a little greater [illegible] pools found elsewhere.

That is distinctly a favorable factor to this state, and indicates the advantage which the state undoubtedly had in the wider spacing, its 40-acre spacing pattern in the earlier days; which, I presume, was put into effect to attract drilling capital in this state, which at that time was very remote from the market. That has worked very satisfactorily and advantageously. And now that your depth has out-distanced the depth in the other areas, it would seem perfectly logical you would maintain that advantage you have had there by stepping out a little favor wider spacing still, if conditions warrant it.

There is no contention you should automatically and arbitrarily extend 40-acre spacing to any other spacing

pattern. Just keep your mind open as to [illegible] pattern should be -- should be given as any [illegible] once the factors have been determined to [illegible] lyze that situation.

Q Have you also compiled some more cost figures in deep drilling, comparable figures?

A Yes, sir.

Q That is illustrated by --

A Chart No. 7.

Q Chart No. 7?

A These figures, first, because it is difficult to compile industry-wide figures on costs of any nature, I have limited the figures shown in this chart to the experience of Phillips Petroleum Company, alone.

Q I want to emphasize again: the figures you have given on the previous charts, 1 through 6, generally, those are industry-wide figures?

A Absolutely.

Q Don't apply to any one company?

A No.

Q To all companies?

A To all companies.

Q Including Phillips Petroleum Company.

A The best figures we can get to apply to the industry as a whole. The reserve figures are taken from the [illegible]

reports, and the figures
drilled and all those
, which has consistently
the years.

state what this petroleum institute is;
is.

Of course, I am sure you are all familiar with the
Petroleum Institute as a whole. It is a body formed
producing elements of the industry; practically
all the big and little companies belong to the American Petro-
leum Institute. And this Reserves Committee, which is a
committee which was appointed many years ago, some 12 or 14
years ago, to analyze the reserve situation of the entire
industry. The Committee is headed up by Dr. Fred Lokey of
the Sun Oil Company at Dallas, and composed of some ten or
fifteen members of the industry who specialize in reserves
calculations; geologists and engineers. And they have hun-
dreds of people serving on sub-committees who make studies
of all the figures and all the wells that are drilled, and
keep abreast of what the reserves situations is, both as to
new wells and old wells.

Q And the information they compile is purely factual?

A That's right. It is published in annual report
form. Here is a copy of the latest report, December 31,
1952. It is published annually by the American Petroleum

Institute. And in the last year or two we have [illegible] cooperation of the American industry with the Canadian industry, and there are figures in here showing in a preliminary way the reserves of crude oil in Canada. And it is the intent and hope as the years progress we will have figures on Canadian reserves which are entirely comparable to figures on American reserves. Which can be added and compiled in statistical analysis just as readily as United States reserves.

Q You regard the figures you get through this Institute as entirely reliable?

A They are the best I know of that can be had.

Q Will you give us comparable figures on well costs at different depths?

A Yes, sir. These figures are composite results on 225 wells, none of which are exploratory wells.

Q No wildcats?

A No wildcats. These are on field expansion wells drilled in the New Mexico and West Texas area by Phillips Petroleum Company in '51 and '52. They are all of such recent nature that the costs are, you might say, up to date; fairly up to date. There have been some increases in costs in the last few months, but they are fairly up to date.

The curve to the left part of the chart under the derrick shows the increasing depth of the wells. The extreme

[illegible] the extreme right
[illegible] 5,000 ft. well -- inci-
[illegible] curve, the little round circles,
[illegible] or wells at different depths.
[illegible] out all best we could at various
[illegible] 5,000 ft. well costs about $[illegible]000. And
[illegible],000. A 10,000 ft. well, $188,000. A
[illegible],000. And a 13,000 ft. well, $381,000.
[illegible] of course, the wildest wells cost far more than this.
[illegible] half million or three-quarters of a million, and
[illegible] dozens of a million. These are pool development wells.
[illegible], the curve on the right-hand side shows the increased
[illegible] in a little different form; increased cost of deeper
drilling. In other words, the fartherest left point shows
the cost per foot at the 3 to 4 thousand foot level. It shows
it costs about $11 per foot at that level. You step the depth
up from 4 to 5 thousand, and the cost is $15 per foot. From
5 to 6 thousand, it costs $16. a foot. From the 6 to 7 thou-
sand foot level, $18 a foot. From the seven to 8 foot --
7 to 8 thousand foot -- $20, a foot.

In that increment between 3 and 8 thousand it isn't
nearly as rapid an increase in the cost per foot of drilling
as thereafter subsequently as you go deeper.

From 8 to 9 thousand the cost jumped to $31 per foot.
From 9 to 10 to $41 per foot. Ten to 11, $55 per foot.
Eleven to 12, $65. And from 12 to 13, $72 per foot.

Obviously every time you add footage below, you don't add costs at the average per foot of the entire depth, but you add it at increments which are very much higher. If you go between 15 and 16 thousand foot wells, as we are getting into, the cost is upward of $100 a foot for those depths. The 13,000 ft. well costs better than six times as much as the 5,000 ft. well. It is obvious if you are going to have the same return on your money and get paid out at the same profit on the 13,000 ft. well that you had on the 5,000 ft. well you have to have about six times as much oil. At least that much.

Well, unfortunately, we have found that as these horizons are developed at the deeper depths they aren't necessarily better in every respect, or in any respect in some cases, than the shallow ones. In fact, to date the best producing horizons are still the shallower ones. If we have a pool that -- a horizon -- that produces at a depth of about 5,000 ft., you might say 2,000 bbls per acre would be the bare minimum at which you could afford to drill the wells. If you found identically that same formation at 13,000 ft., it is quite obvious you couldn't possibly produce those wells. In fact, you would have to have about six times that, or 12,000 bbls per acre to have a bare minimum at 13,000.

Q Is it a sort of popular concept the deeper you

drill these wells, the [illegible]

A Well, I presume there may be [illegible] that concept. I don't believe anyone that is [illegible] the facts has that feeling.

Q That is not true?

A There is no fundamental reason why an [illegible] at a deep depth should be any better or different than one at a shallower depth. It hasn't proven to be the fact. Some of the deepest are very thin and not good in permeability or porosity, and don't produce much per acre. There are some good formations, fortunately.

If you had 20 ft. of pay that gave satisfactory production at 5,000 ft., you would have to have over 100 ft. of pay at 13,000 ft., the other factors being identical.

Q To enjoy the same economic position?

A To enjoy the same return, that's right.

Q You are familiar with the proposal here, Mr. Beall, that a temporary rule be passed by the Commission establishing temporary 80-acre proration units, are you not?

A Yes, sir.

Q And in the light of the economic studies that you have made, and in the light of the particular economic factors that are in play here in New Mexico, would you recommend to the Commission the adoption of such temporary rules?

A Yes, sir, I think, as a temporary rule, I don't

see how there could be any real objection against it. As I pointed out, certainly everyone would have to admit you have to analyze the deeper, more expensive drilling a little differently than the shallower and less expensive drilling. The important thing is that nobody knows how the spacing ought to be when the first well is drilled. You can't tell whether the first well is on top of the structure, and has a maximum of everything, or whether it happened to be an edge well, and has more or less a minimum of everything.

And it seems entirely logical and fair to everybody concerned to have a sort of moratorium period during which you find out the facts which have to be found out in order to intelligently determine what the real permanent spacing ought to be. It is important during that period to have -- in which you are getting these facts -- there shouldn't be any steps taken which will cause the permanent spacing pattern to have to be spaced differently than it ought to be. In other words, if you have close spacing to start with, then you either are faced with numerous exceptions -- and those exceptions are hard to take care of -- and it may result in having a permanent spacing pattern that isn't economic and won't attract the capital that has to be invested in it. Whereas, if you start out with temporary wider spacing, you can always drop back to closer spacing if conditions warrant after you have determined what the factors are. And if the

pool isn't as good as it has to be to have
[illegible] you in position to have wider spac-
[illegible] should be the case on that type of pool.

[illegible] as the man that handles the money, and handles the
[illegible] and cents involved in this problem, would you say
[illegible] proposed temporary wider spacing would be advan-
[illegible] to the State of New Mexico?

A I think it should. If the State of New Mexico is anxious to attract capital to develop its reserves, and to maintain the position which it currently has of having a progressive and well-regulated conservation program. That is a favorable factor, when you go to analyze these various things. And I think it would be a very good step to the state to maintain that position to advocate a temporary order of this nature.

Q Do you see any way that any possible harm -- I am talking about dollars and cents now -- could result to the State of New Mexico and its citizens by the adoption of this so-called temporary order?

A No, sir, I do not.

MR. [illegible]: I believe that is all.

COM. SPURRIER: Does anyone have a question of the witness?

MR. [illegible]: I would like to introduce these seven charts that we have identified here as part of the record.

COM. SPURRIER: Without [illegible]
mitted.

(Off the record)

COM. SPURRIER: If there are no further questions, the witness may be excused.

MR. FOSTER: Excused from the hearing? He wants to get back to Bartlesville.

COM. SPURRIER: That's right.

(Off the record)

COM. SPURRIER: We will recess until one o'clock.

(Noon recess)

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COM. SPURRIER: The meeting will come to order, please. Judge.

MR. FOSTER: I am going to make one more appearance. But Stanolind will take over.

COM. SPURRIER: Mr. Smith.

F. H. CALLAWAY

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. SMITH:

Q Will you state your name, please?

A F. H. Callaway.

Q By whom are you employed, Mr. Callaway?

A Stanolind Oil and Gas Company.

Q How long have you been so employed?

A Six-and-a-half years.

Q What was your educational background prior to employment with Stanolind?

A I received my technical education at the University of Arkansas and the University of Texas; received the degree in petroleum engineering from the University of Texas in 1946.

Q Do you have any other degrees?

A No, I do not.

Q Did you go to work for Stanolind right after you finished your academic training?

A Yes, sir.

Q What position do you occupy with Stanolind?

A I am presently employed as Reservoir Engineering Supervisor by Stanolind in their Tulsa office.

Q How long have you been engaged in reservoir work for Stanolind?

A Approximately six-and-a-half years.

Q Do you belong to any associations or organized groups for study on reservoir behavior or other types of technical background?

A Yes, sir, I am a member of the Petroleum Branch of the American Institute of Mine and Metallurgical Engineers.

Q Aren't you Chairman of some committee that made a study on the question of well spacing?

A I am Chairman of an [illegible] committee, Mid-Continent District, engaged in the [illegible]-spacing problem at this time.

Q And have you attended the meetings of these various groups from time to time during membership in the Association?

A Yes, sir, I have.

Q Are you fully familiar with the so-called controversy that exists between the relative merits of wider and more narrow spacing?

A I have done considerable research in the matter.

Q Are you familiar with the transcript of the proceedings in the hearing involving well spacing as Case 407 on April 16, 1953?

A Yes, sir, I am.

Q Do you recall the statement by Mr. Tesch in the record which reads as follows: "It is generally accepted, regardless whether you are talking about 80-acre, 40-acre, or 20-acre, everything else being equal, that the more wells you drill the more oil that will be recovered from the reservoir."

A Yes, sir, I am familiar with that statement.

Q Do you agree that is a correct statement?

A No, I definitely do not. I believe most of the people that have carefully investigated the problem of well spacing and its relation to the amount of oil that can be recovered from a field are of the opposite opinion.

you personally concur in the concept the more drilling the more oil you recover?

A No, I do not.

Q I assume you are familiar with various argument advanced by various proponentsof differing theories?

A Yes, sir, I am.

Q I wonder if you would give us a brief review of the manner in which this controversy over proper spacing -- that is, whether we should have wider spacing or narrower spacing -- developed?

A Well, there has been a whole lot of water under the bridge in well spacing argument, and I certainly do not want to take the time of all you people to go into a lot of detail on the matter.

However, I do think it is well to point out the place where this well spacing originated, and how it has developed. I think it will throw considerable light on the merits of the various positions taken by the people who believe in close spacing as a means of increasing recovery, and the people who do not believe closer spacing is a method of conservation.

The first formal attention to the well-spacing problem was given in a report prepared by Willard W. Cutler of the Bureau of Mines in 1934. He was studying the decline characteristics of producing leases in a number of oil fields throughout the United States for the purpose of attempting

to compare variations in reserves through use of decline curves. It happened at that time it was necessary for the operator to estimate their oil reserves for the purpose of computation of federal income tax. In connection with this study, he observed -- other conditions being equal -- that under similar leases in the same field he observed the wells drilled on wider spacing recovered more oil than wells on close spacing.

On the other hand, he observed the reverse in regard to separate leases. He observed leases drilled on close spacing did recover more oil per acre than leases drilled on wide spacing.

As a result of this work, Mr. Cutler formulated what has come to be known as Cutler's Rule, which I would like to show as Exhibit 1.

Q As I recall, that was the first formal attention given to it, and is probably the basis for the different contentions that have grown up with regard to this recovery of oil.

A It is the starting point of this controversy on well spacing.

Q Do you have a statement of Cutler's Rule?

A Yes, sir, I do. I don't think we need to read it right now. Let's go on.

Q The Rule I think we might mark for identification

as Exhibit 1. And we have various of these smaller types of exhibits which we will offer to the attention of the Commission, which are duplicates of the ones on the board. The Rule is exhibited on the board?

A Yes, sir, and also on the small sheets.

Q Is there any controversy as to the reliability of the recovery data that was observed by Mr. Cutler?

A No, sir, there isn't. I think it is pretty well established in both advocates of close spacing as a means of increasing recovery and those that do not believe in close spacing as a means of increasing recovery. They all agree under the conditions which Mr. Cutler imposed upon his analysis that closely drilled leases will get more oil than widely spaced leases.

Q The conclusion he came to was correct, but the application of the Rule seems to be a difference of opinion?

A That is correct. The difference of opinion between so-called advocates of close spacing and so-called advocates of wide spacing lies in the interpretation of the facts observed by Mr. Cutler, and subsequently confirmed by other investigators.

Q I understand from your statement that two interpretations can be placed on Cutler's Rule, which lead to diametrically opposite opinions?

A Yes, sir, that is correct.

Q What are the different interpretations?

A I think it can be made plain if you very carefully read Cutler's Rule and remember the assumptions he made.

Cutler's Rule states "The ultimate production for wells, of equal size, in the same pool, where there is interference, seems approximately to vary directly as the square roots of the areas drained by the wells."

Mr. Cutler restricted comparison to leases of approximately the same pay thickness and the same initial productivity and wells in the same pool. Under the circumstances in which he had observed that the new wells drilled in the field did interfere with and reduce recovery from old wells already producing. He restricted it to solution gas-drive reservoirs, and, of course, applied it to production under no production restrictions; all wells produced essentially at capacity.

Q Do you have an exhibit that illustrates the proposition-that you have just stated?

A Yes. I would like to show Exhibit 2, which is purely for illustrative purposes.

Exhibit No. 2 is a portion of the Healdton Field in Carter County, Oklahoma. This is the type of development with which Cutler was concerned when he developed his Rule.

You notice there is no well development pattern on this map. I have indicated in red the average well spacing in acres per well of the various leases. You notice it varies from as little as 1.67 acres per well on a certain lease up

5 acres per well on another lease.

Now, I would like to propose just for a moment and assume one of these leases in the Healdton Field here were developed on different spacing, but had approximately the same pay thickness and the wells were of the same quality, making the same number of barrels per day. It is established from facts that the lease on closer spacing will get greater recovery per acre. There are only two possible reasons for that.

One reason could be that the closely spaced lease did a better job of extracting the oil from the sand underneath it. That is, it had a higher recovery factor, in engineering terms. A larger portion of the oil in place was recovered. That is one possible explanation for the behavior Cutler observed.

The other possible explanation is that the lease on closer spacing benefited by migration of oil across lease lines from the wider spaced lease to the closely spaced lease. In fact, it is possible the increased recovery for the closely drilled lease might be due to the migration of oil across lease lines.

In that case, the widely spaced lease would have sub-normal recovery because it would lose by migration of oil.

Q Do you have any specific illustration on Exhibit 2 to show how that operates, Mr. Callaway?

A Well, for instance here are two 30-acre leases.

work on 5 acres per well on another lease.

Now, I would like to propose just for a moment and assume that of these leases in the Healdton Field here were developed on different spacing, but had approximately the same pay thickness and the wells were of the same quality, making the same number of barrels per day. It is established from facts that the lease on closer spacing will get greater recovery per acre. There are only two possible reasons for that.

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In that case, the widely spaced lease would have subnormal recovery because it would lose by migration of oil.

Q Do you have any specific illustration on Exhibit 2 to show how that operates, Mr. Callaway?

A Well, for instance here are two 30-acre leases.

N, here is a 30-acre lease, an offset to that lease which was drilled to 4.29 acres per well.

Q —You mean that the closely spaced tract could have gotten more oil either by doing a better job of drilling the sands under the lease or by capturing oil from a neighboring lease on a wider spacing basis?

A Yes, sir. I could have been either reason, but there is no way to tell from the physical data itself.

Q Just how do these result in different conclusions regarding well spacing?

A Let's assume for a moment, as Cutler did, that no oil migrated across lease lines. That would mean that the closer spaced lease got greater recovery by virtue of doing a better job of extracting oil from the sand. You could then go in and drill other leases in the field to closer spacing and thereby increase their recovery, thereby increasing recovery in the field as a whole by drilling additional wells.

On the other hand, if the additional recovery had been due to migration across lease lines, the drilling of additional wells on wider spaced leases would simply re-allocate the available oil between leases and not result in increased recovery from the field as a whole.

The people that advocate close spacing have adopted the first attitude and those differing have adopted the second.

Q What is your opinion in this matter?

[redacted] in my opinion, the additional oil recovered by the [redacted] wells -- leases -- under the conditions which [redacted] observed was due primarily to the migration of oil across lease lines.

Q Do you have any support for this opinion?

A Yes. I think that the conditions which Cutler assumed, and which other advocates of close spacing have similarly assumed in obtaining their factual data were such as to be ideal for the migration of oil. Remember Cutler restricted the Rule to the same field where there was an opportunity for migration to occur, and restricted it to cases where he had actually observed leases interfering with each other and were competing for a common source of supply of oil.

Q In other words, his observations have indicated to you definitely his Rule had no application unless there was a reduction in the productivity of the old wells as a result of drilling new additional wells?

A In my opinion, it appears inevitable under the circumstances which were used for developing data of this type that migration to the closely drilled tract at the expense of the widely spaced tract is inevitable.

Q You mean other factors being equal, the closely spaced tract is bound to benefit from that migration?

A That is correct. It would be true under any

circumstances unless you had an allowable, and restricted production per acre the same regardless of spacing.

Q Are there any physical facts to support the conclusion that such migration is inevitable?

A I would like to turn now to Exhibit 3. This is an hypothetical case involving two adjacent leases in the same field, which have been drilled to different well spacing, but on which we may assume for the moment the characteristics of the sand and the productivity of the wells are equal.

Now, assume 16 wells are drilled on Lease No. A, which gives a 2½ acre spacing. And only 8 wells drilled on Lease No. B, to give a five acre spacing. And put those two leases on production. If the productive capacity of the wells average 100 bbls per day, we can say Lease A will produce 1,600 bbls per day, and Lease B only produce 800 bbls per day. What that means is that the pressure on Lease A will decline more rapidly than the pressure on Lease B. Which after a short time will result in a situation in which Lease A will be at a lower pressure than Lease B. This must result inevitably in the migration of oil from Lease B to Lease A.

Q In your opinion, what is the significance of this migration insofar as it may have application to the so-called well spacing controversy?

A Well, what it means is that these combinations of leases of different spacing in the same field are of no real

in tieing down this well spacing question.

You have two unknowns: the possible effect of spacing on the extraction efficiency of the oil, and the migration. There is no way to isolate these two factors to determine how much of the effect is due to which, from the various data which have been used.

Q It is youn opinion that the comparable recovery from different leases in the same field is of little value either way in evaluating the effect of well density on the recovery that may be expected from two respective leases?

A Yes, sir, that is correct, it is for all practical purposes; it is useless.

Q Well, is this the type of data that is still being advanced largely in support of the proponents of more close spacing?

A Unfortunately it is. Most of the factual information which advocates of close spacing as a means of conservation have used and are still using today are examples of this type.

Q Then it does appear that a substantial part of the increased recovery may be attributed to this migration? You stated earlier, in your opinion, most of the increased oil from the densely drilled tract was migratory oil, is that right?

A Yes, sir, that is my opinion. I have undertaken

to calculate what [illegible] of production would [illegible] field of this type, in which you had [illegible] well spacing, to see if it would be of sufficient magnitude to have caused the behavior which Cutler observed.

Q Have you any of the results of your calculations available by way of exhibit?

A Yes, sir, I do. I have several. I don't want to explain each one separately because of the time, but I would like to show Exhibits 4 to 10 at this time.

Q Suppose, Mr. Callaway, that you step over to the board here, and we will flip these through and you might give your explanation at that time.

A All right. I have brought here -- this is from theoretical calculations, now -- the calculated recovery per acre in thousands of barrels.

MR. FOSTER: I don't believe the Commission can see that chart.

MR. SMITH: They have a copy before them.

MR. FOSTER: I know, but they are interested in following him.

(Off the record)

A Plotted on the vertical scale is the recovery per acre in thousands of barrels per acre. Plotted on chart one divided by the square root of the [illegible] concerned. I plotted this thing this [illegible]

[illegible] is a dash

[illegible], as outlined

[illegible], and the eight surround-

ing tracts had one well, and these wells were of equal productivity, and were opened up for capacity production at the same time. We would find that the recovery per acre from the tracts drilled on wide spacing would be approximately 3,200 bbls per acre. On the closely drilled tract in the center the recovery per acre calculates about 9,700 bbls per acre.

Now, you notice that the lines connecting these two points is optically a change in slope than under Cutler's Rule. Which would [illegible] circumstances the degree of the migration would [illegible] degree of recovery.

This [illegible] which I believe is Exhibit 5, is a similar type [illegible] we have two wells drilled on the center tract [illegible]. [illegible] variation in recovery [illegible] is greater than that obtained [illegible].

[illegible] other exhibits, which I [illegible] they have a [illegible] case, but

migration of oil would account for the phenomenon observed by Cutler upon which he based his proposition you get more oil per acre.

A Yes, sir, that is correct.

The results of these calculations are summarized on the next exhibit. I don't have a large chart for this, unfortunately. But I do have a small sheet you can have; Exhibit No. 10. It summarizes the results shown on the six charts which I have just gone over.

You notice on the next to the last line is the recovery ration of closely spaced leases next to wider spaced leases as actually calculated due to migration.

The last line represents the recovery ratio which Cutler would have predicted by his rule.

In each case the difference in recovery between the wider and closer spaced leases as calculated due to migration was as great or greater than that observed by Cutler.

Q Now assuming that these recovery comparisons of different leases in the same field are of little use in solving down the density problem, what can be done to evaluate the effect of well spacing on recovery.

A Well, the ideal way, of course, would be to take an oil field, drill it up, and produce it on one spacing and then by some magic, restore it to its original condition and produce it on another spacing and produce it.

in recovery. Of course, it is impossible
ds. If we could find two fields which were essen-
identical in all other respects, but which had been
developed on different spacing, and depleted those fields
and compared their recoveries, we would have a sound and valid
answer to the effect of well spacing on recovery. That would
be true, of course, because oil could not migrate between
separate fields. It is a tough job, however, to find two oil
fields which are identical, but which have been drilled on
two different spacings. And I personally know of no conclu-
sive examples of this type which have been developed so far.

There has been some rather thorough work done from a statistical standpoint by an API committee. In this API study the recovery factor for a large number of fields was correlated with their well spacing to see if any general trend existed in favor of the closely drilled fields.

The work of this Committee was reported in a technical paper which was printed in the API Drilling and Production Practices for 1945. It was entitled "A Factual Analysis of the Effect of Well Spacing on Oil Recovery", and was authored by R. C. Craze and S. E. Buckley. This work reflected no apparent variation in the recovery efficiency with well spacing. That is, there was no variation observed which was of sufficient magnitude to be noted in the statistical work done by this Committee.

did in regard to water

ing since a very large

the study.

that reflects the findings

A Yes, we have Exhibit No. 11.

Q Which is the one now exhibited on the board?

A Yes, sir, that is the one now exhibited on the board. Plotted on the vertical scale is the estimated oil which will remain in the rock after a field is depleted. On the horizontal scale is the average well spacing for the field involved. You will note there is no apparent trend which would indicate that the closely spaced fields did a better job of getting the oil.

Q Have other authors or students of this subject gone into the matter from any different standpoint?

A Yes, there has been a considerable of effort expended in attempting to evaluate the effect of spacing on recovery from theoretical considerations. This matter has been investigated by Barlow and Berwald, and reported in the API Drilling and Production Practices for 1945; by Loper and Calhoun, as presented at the 1948 meeting of the Petroleum Branch, AIME; [illegible]er, Brownscombe and Kieschnick, which was published [illegible] Transactions for 1950 -- for 1949; by Dr. S. J. [illegible] his textbook "Elements of Oil Reservoir Engineering"

and by Keller and Calloway, as reported in the AIME Transactions for 1950.

Q You are the Calloway that is the author of that particular paper, is that right?

A Yes, sir, that is correct.

Q Now, all of this work was confined to depletion type reservoirs, wasn't it?

A Yes, sir, that is correct.

Q What was the reason for that?

A The reason that the theoretical work has been confined to the depletion drive reservoir is the fact that it is obvious from the physical factors at work that the answer on a water drive field would be no variation in recovery with well spacing.

Q Quite a bit of work on that has been done by Mr. Buckley, hasn't it?

A Yes, sir, there has.

Q I believe he is here today.

A Yes, sir, he is.

Q What [illegible] of the [illegible] depletion

However, the increase is so [illegible] significance.

Q I understand you were one of the engineers to investigate this matter. Are you in a position to show some of the results of the work?

A I will be glad to do that. The technical basis for the calculations themselves is extremely complex, and I certainly don't want to bother you with that at this time. I would like to show you the results of some of these calculations, and attempt to explain in quantative terms the reasons we get the answers we do.

With the depletion type oil field, the oil is driven from the pores of the rock and replaced by gas, which is released from solution. This causes the pressure to decline and more gas is released from the oil until the pressure falls to a low value, and the wells will no longer produce at commercial rates. The oil production is directly related to pressure decline, and the lower the abandonment is -- at the time the wells are abandoned -- the higher will be the recovery factor, other factors being equal. But the depletion drive mechanism for -- recovery is usually only a small fraction of the oil in the rock by this method, usually on the order of 10 to 30 per cent. At the time the wells must be abandoned the pressure throughout the reservoir is [illegible] ever, it will be slightly lower near the [illegible]

will be [illegible] than it
the recovery will be the [illegible] than that
will be out in the central area, and that is the reason for
the slight increase in recovery with close spacing.

Q Do you have an exhibit which represents this pressure and oil saturation when a field is abandoned?

A Yes, sir, I have two or three exhibits which will show how that works.

Exhibit 12 shows the calculated distribution of pressure and unrecovered oil at the time the field is abandoned as a function of the distance from the well bore. You can see that the pressure is somewhat lower close to the well than out 6 or 7 hundred feet away; and also the unrecovered oil is slightly lower near the well bore than at a distance.

Q Do you have a sketch to portray the alteration in underground conditions which results from the drilling of an extra well between two producers; that is, an infill well?

A Yes, sir, I have such an exhibit; Exhibit 13.

Q Will you explain this exhibit, please?

A This exhibit is simply a diagrammatic sketch to show you where extra oil comes from when you drill on closer spacing. Assume that the field were drilled and depleted with only wells on the extreme left and right. The remaining oil underground at the time the field must be abandoned is represented by the solid curve. If an additional well had been

time [illegible] be [illegible]
by the dotted curve, which falls slightly below the [illegible]
curve in the center. The hachured area represents the addi-
tional oil which would be recovered by the infill wells, which
could not have been recovered by the wells spaced on 80 acres.

Q Do you have an additional exhibit reflecting the comparison of recoveries to be expected if a denser drilling is followed?

A Yes, sir. If you convert the type of curve which I have just shown you to its significance in terms of recovery, you have the results shown on the next Exhibit No. 14. On the vertical scale is plotted the recovery efficiency, per cent of oil in place. On the horizontal scale, the well spacing.

I would like to point out on these exhibits that they are peculiar to only one particular set of reservoir conditions. If you worked the same calculations on a different field, you would get answers of a different magnitude, but still have the same relative relation between close and wide spacing.

You note from Exhibit 14 that the recovery factor would [illegible]
figure out in this [illegible] about 16.5 per cent on 40-acre spacing,
about 16.2 per cent on [illegible]

[illegible] by the [illegible] an acre-- an 80-[illegible] about $4,000.

Q Now, do you have an additional exhibit reflecting the calculations for the Fowler Field in New Mexico?

A Yes, sir. Exhibit 15 is a bar graph which shows results of similar calculations on the Fowler Field in New Mexico. I think this chart has previously been placed before the Commission in a hearing on Fowler.

Q These also were theoretical calculations?

A Yes, sir.

Q Now, just what assumptions were made? How do these assumptions affect the reasonableness of the answers you have obtained?

A It is necessary to make assumptions in any calculations on reservoir behavior and mechanics. The only critical assumption it is necessary to make is that the reservoir is continuous throughout. One continuous and common source of supply of fluids and drainage through all parts of the reservoir to the wells which have been drilled.

Q What about the existence of lenticularity in the [illegible]

A [illegible]

[illegible] spacing pattern [illegible] untouched zones [illegible] tap
[illegible] Moreover, the amount of increased oil which you would get
would depend on the number and size of the lenses which you
would happen to tap.

Q That is a condition which could be detected as a field is developed?

A Yes, sir, that is correct. In my opinion, the effect of well spacing on recovery would be very small unless this type of condition exists. It is possible by means of cores and the proper type of engineering and geologic data during the process of developing a field to obtain fairly conclusive evidence as to the presence or absence of [illegible] culerity conditions in the reservoir.

Q In studying a reservoir as the field is developed, it is possible to determine whether or not there is freedom of communication throughout a given oil pool?

A Yes, that is correct. I think the Commission pro-

[redacted]

A. Yes, sir.

[redacted]

A. Yes, sir. Exhibit 16.

Q. All right. Will you [redacted]

A. This exhibits reflects the pressure behavior of a well in the Fowler Field which was shutin for a period of approximately 500 days while other wells in the field were being produced. You will note that the pressure on this well declined continuously during the period it was shutin and not being produced. This means that the oil underneath the shutin well was being drained away by the [redacted] that were at one of which was about 1,867 feet [redacted] location.

Q. During this period of time [redacted] were [redacted] wells were being [redacted]

[redacted]

[illegible] Exhibit [illegible]

[illegible] part on the Anton-Irish [illegible] example of the type data you can get. I don't [illegible] needs any further comment.

Q. Those dots indicate the points in [illegible] tests were taken?

A Each dot represents a separate pressure determination on that well.

Q Do you have an exhibit for the Goldsmith Field?

A Yes, sir. Exhibit 18.

Q Goldsmith is the next one.

A Did you say Slaughter?

Q I said Slaughter, I meant Goldsmith.

A Yes, sir.

Q Will you explain the significance of the curve reflected upon the exhibit for the Goldsmith Field?

A The solid curve represents the field average pressure in the Slaughter Field for the period 1935 -

Q Goldsmith Field, you mean?

A Goldsmith, excuse me.

Q I got you off on the wrong track to start with here.

A From 1935 to 1946, the circles represent the [illegible] completion of infi[illegible]

[illegible] additional wells were drilled.

Q [illegible] you have an exhibit reflecting the gas-oil ratios [illegible] of the infill wells drilled in the Slaughter Field as compared with the wells that had been drilled earlier?

A Yes, sir, I have Exhibit 19 for pressure data on the Slaughter Field rather than gas-oil ratios.

This represents a portion of the Slaughter Field in Texas. The circled wells are infill wells which were drilled in 1948. The un-circled wells are wells which were drilled in 1941. Shown each of them is tabulated the [illegible] that well during [illegible].

You will note that the initial pressure in this reservoir was 1,77[illegible] the average pressure on the old wells in 1948 was 1,2[illegible] pressure upon completion of the [illegible] wells shows that the reservoir [illegible] by the old wells at [illegible] these old

[illegible] on the

[illegible] formation [illegible]

478 cubic [illegible] per barrel, and

initial producing ratio of the wells [illegible]

1948 the average ratio of the [illegible]

1,228 cu. ft. per barrel. The average [illegible] of [illegible]

old wells at the same time was 1,2[illegible]

Since the pressure and the gas-oil ratios are [illegible]

related to the amount of oil which has been produced [illegible]

the locations in a depletion-type reservoir, this data shows

that the entire area was being drained uniformly by the original wells on the wider spacing.

Q I assume you have chosen certain fields by way of illustration, and I assume you know also of many other fields where the same facts have been develop[illegible] theoretical assumptions you have justified.

A Yes, sir. That is correct. I [illegible] Humble Company, and other sources [illegible] data of [illegible] are just showing the [illegible] almost always, the data indicate [illegible] our oil [illegible] which

[illegible] oil produced is replaced by edge water [illegible] oil must migrate over long distances throughout the reservoir. So, if you observe the field has water drive from performance characteristics, you know it is — you know there is sufficient communication.

Q Mr. Calloway, in view of the testimony you have given and your research as indicated by your testimony, I would like to have you say whether or not you consider yourself to be an advocate of wide spacing?

A No, I am not necessarily an advocate of wide spacing. The question of proper well spacing is [illegible] depends upon the circumstances pertaining to the [illegible] at hand. In the absence of [illegible] conditions, which in my experience [illegible] the exception rather than the rule, the problem [illegible] consideration of economics [illegible] should be studied [illegible] to allow the

protect the correlative rights of the various [illegible] in the field. I do not believe in general fields [illegible] drilled on close spacing for the purpose of getting [illegible] recovery or in the expectation of getting greater oil [illegible].

Q Do you have any general opinions as to the proper approach to the well density problem in oil fields?

A Well, it appears to me it is simply good business to drill a field at first on fairly wide spacing insofar as is compatible with ownership and other practical considerations; to obtain some idea as to the extent and quality of the field and accumulate engineering information which will evaluate the need for additional drilling. Infill wells can then be drilled as necessary or desirable.

MR. SMITH: At this time I should like to offer in evidence all the exhibits that have been previously identified by Mr. Callaway.

COM. SPURRIER: Without objection, they will be admitted.

MR. SMITH: I have no further questions of this witness.

COM. SPURRIER: Does anyone have a question of the witness? If not, the witness may be excused.

(Witness excused.)

MR. MADOLE: If the Commission please, we offer this — Ross Madole, on behalf of the Magnolia Petroleum Company — we offer this witness in rebuttal to the impression that was given by Mr. Tesch in his testimony that the Bureau of Mines study of the Healdton Field was an illustration of his theory of more well, more oil. And we wish to introduce evidence to rebut that impression.

BYRON O. SIMMS, JR.

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. MADOLE:

Q Mr. Simms, state your full name, please.

A Byron O. Simms, Jr.

Q By whom are you employed?

A Magnolia Petroleum Company

Q What professional degree do you hold?

A I have the BS degree in petroleum engineering from the University of Texas.

Q In what year were you graduated?

A 1949.

Q Since that time have you been employed as a petroleum engineer?

A That is correct. By Magnolia.

Q At this time you are located in the Healdton Field?

A That is true.

A I have been at Ardmore

Q Since you graduated you have been employed

of Magnolia?

A Yes, sir, that is correct.

Q You had occasion to make a study of the Healdton

Field?

A That is true.

Q Have you previously qualified as a witness in

New Mexico before the Oil Conservation Commission?

A No, I haven't.

MR. MADOLE: Do you think any further qualifications are needed?

(No audible response from the Commission.)

Q Will you state the occasion of the study made by the Bureau of Mines in the Healdton field in Carter County, Oklahoma?

A The Bureau of Mines made a study of the Healdton Field, and it was a petroleum engineering study of the field to determine and evaluate the potentialities of water flooding of the field.

Q In other words, the primary [illegible]

was as to whether or not it [illegible]

[illegible] to prove [illegible]
the Commission the results of their [illegible]
A [illegible] result of their [illegible]ly investigated infill drilling a littlebit. This it made from the water flooding part. The conclusions they reach, and I will read from the report.

"Twenty million barrels of oil over and above that expected by normal production methods was produced as the result of additional drilling, deepening, clean outs, vacuum applications, and gas injection."

And a little farther down they say, "Also 440 new wells have been drilled in the Healdton oil field during the last 25 years. It is interesting to note that at no time since 1920 has the number of producing wells equaled the number of wells" -- 1,971 wells -- "producing at that time; the number of wells abandoned exceeded the number of new wells completed; and in 1950 the number of producing wells was 95 less than in 1920."

I might add here this 20,000,000 bbls which was accumulated from all these factors, such as additional drilling, deepening, vacuum application, and other methods, amounts to a little less than ten per cent of the total recovery from that field [illegible] and of this other ten per cent, your infill drilling [illegible] that.

[illegible] in the evidence the full

[illegible] Healdton Field.

we have no further questions.

COM. SPURRIER: Are there any questions of the witness? If not, the witness may be excused.

(Witness excused)

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MR. MADDOX: Will the exhibit be received?

COM. SPURRIER: The exhibit, without objection, will be received.

(Recess)

E. N. WASHBURN

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. FOSTER:

Q State your name to the Commission, please.

A E. N. Washburn.

Q You are employed by Phillips Petroleum Company?

A Yes, sir.

Q As an engineer?

A Yes, sir.

Q You have testified before the Commission here before and [illegible] your qualifications, have you not?

A [illegible] sir.

[illegible] they accept[illegible]

Yes, [illegible]

Mr. Washburn, at a former hearing of the [illegible], which is now under consideration, testimony was placed in the record to the effect that the matter of the spacing of wells in newly discovered fields should be left to the agreement of the operators in the field. And at that time one member of the Commission here asked the question as to how the pattern of 80 acres got started in those fields. Have you made an investigation for the purpose of determining how that happened?

A Yes, sir.

Q Will you just tell the Commission how it happened.

A There are four fields considered as having 80-acre spacing now: the Fowler Field, which started from a federal unit; the Knowles Pool, and the Hightower, and Crossroads. The latter three fields, one operator owns the larger part of the field, and for that reason it was easier or simpler to get approval from the Commission for 80-acre spacing.

Q But the 80-acre pattern was set before the operators came in and asked for the establishment of the 80-acre pattern?

A That's right.

Q But that pattern was set because the operators in those fields where they drilled the discovery well controlled

most of the acreage?

A Yes, sir.

Q In two of them, I believe, one operator controlled all the acreage?

A That is my understanding.

Q What operator was it-and what field?

A Amerada in the Knowles and Hightower, I understand.

Q In what field was all the land federally owned?

A That was Fowler.

Q And who owned the majority of the acreage in that field?

A I am not familiar with that.

Q You don't know?

A No, sir.

Q Now, at the former hearing of this case there was testimony placed in the record here to the effect that the Commission should deny the establishment of this temporary 80-acre order for the reason that 80 acres was too much of a step out, and that it would result in the drilling of more dry holes if you went to 80 acres than it would if you stayed on the 40-acre pattern. That was expressed as an opinion, I believe, without any facts given to support it. Now, I will ask you if you made any investigation of the fields in this state that are drilled to a depth below 10,000 ft?

A With respect to 80-acre spacing?

Q Yes, sir.

Q Yes, sir, we did.

Q How many fields in this state are producing below 10,000 ft?

A We found 19 fields.

Q Nineteen fields. And did you make an examination of each of those 19 fields to determine whether or not there would have been any more dry holes drilled in those 19 fields if they had been drilled on 80-acre spacing than there would have drilling them on 40-acre spacing?

A Yes, sir.

Q What did you find out?

A We found in 18 of the 19 fields 80-acre spacing would not have contributed to more dry holes than regular 40-acre spacing. The one exception was the Hightower Field where we found four dry holes, and it was drilled on 80 acres. But you can't be definitely sure if it had been on 40 it might not have had dry holes, too.

Q Might havehad the same dry holes on 40 if -- as they had on 80?

A That's right.

Q Is that correct?

A Yes, sir.

MR. FOSTER: That is all.

CON

witness? If not,

MR. SHAVER: Charlie Shaver, repre

Oil and Refining Company.

At this time we would like to call Mr. S.

He was referred to in the April 16th hearing by Mr.

and J. K. Smith, and we would like to present

S. E. BUCKLEY

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. SHAVER:

Q Will you please state your name, and in what capacity you are employed?

A My name is Stuart E. Buckley. I am employed as head of the Production Research Division of Humble Oil and Refining Company.

Q Mr. Buckley, will you state briefly your formal educational qualifications?

A I graduated from the University of Texas in 1932 with a BS and MS degree in chemical engineering.

Q Mr. Buckley, for the benefit of the since you haven't testified here before isn't it?

is correct, [illegible] testified here. Would you summarize [illegible] Commission what activities you have participated in for the past 19 years, in a general way, to inform yourself as to the efficient recovery of oil and gas and related matters?

A The past 19 years has been in the Production Research Division of Humble Oil and Refining Company, for a number of years as research engineer; for the past 11 years as head of that division.

One of the main objectives of that research is to study different methods by which we may increase the efficiency of underground recovery. That is our chief objective. Studies of that sort have included, naturally, a study of the effect of well spacing on recovery as well as all other factors that influence recovery. That research has been the main objective of the Research Division ever since I have been in it.

My work in that capacity has included study not only of the fields in which Humble operates, but I have had access at the same time to data from many other oil fields throughout the world.

Q Mr. Buckley, would you please state what your understanding of the problem before the Commission in this Case 407 is?

A My understanding, Mr. Shaver, is that there are [illegible] two issues before the Commission. One is a proposed

rule [illegible]
spacing during [illegible] development of a new p[illegible]
purpose of allowing it is to determine the proper sp[illegible]
and engineering data on which to arrive at a sound [illegible]
for each individual pool, after a hearing is held for [illegible]
purpose.

I understand that the Commission is concerned with [illegible]
second question; the question of well spacing in gener[illegible]
and its effects on ultimate recovery. The second, not insofar
as it bears directly on the first, but being obviously a
separated topic.

Now, Mr. Buckley, would you please state your views
on the proposed rule? You have studied this rule, haven't
you?

A I have, sir. I have for many years subscribed to
the view that the proper development of new pools would
entail the employment of the widest feasible spacing during
the early development for the purpose of permitting the
operators to determine the nature of the structure and the
underground geology and the other factors that would influence
the ultimate recovery, with the further objective of permit-
ting a determination of what type recovery mechanism is most
apt to be operative. Such a procedure would permit,
in the life of a pool, a proper determination of the
which would be most effective in managing [illegible]

[illegible] suit the p[illegible]
[illegible] perfectly logical to employ wi[illegible]
[illegible] the early development to permit this dete[illegible]
mation early, with a minimum expenditure; and in the ligh[illegible]
of those facts to set the proper spacing for the pool after
the facts are known.

Q You would say, in your opinion, the adoption of this rule would be a forward step in conservation?

A I think it would not only be technically forward from an engineering standpoint, but very definitely serve the public interest from the standpoint of conservation.

Q You mentioned a second question awhile ago. What have you found out on the question of the relationship, if any, between well spacing and ultimate recovery?

A The question of well spacing and its effect on ultimate recovery, as you have probably gathered from the earlier testimony, is quite technically involved. I think it would be impossible to do complete justice to it in a very short time.

What I would attempt to do, if it meets your pleasure, is give a brief digest of what the essence amounts to. I shall state first the fundamental facts generally recognized, [illegible] so far as I know not controverted, which underlie [illegible]
[illegible] the recovery of oil. And I think we

more proper light.

In the first place, oil is inherently incapable of expelling itself from the pores of rock. It has to be expelled by a displacement agent like gas or water, and it has to be acted on by an explodable force. The only forces are pressure and gravity. It is in combination by displacement by gas and water and the proper use of these forces we are able to recover -- influence recovery -- of oil either efficiently or inefficiently.

Secondly, the effectiveness of theseagents differ; gas, in general, being less effective than water,

Thirdly, the efficiency of recovery requires we use these displacements in the most effective possible manner. That is, if displacing with gas, we want to control the displacement throughout the entire extent of the pool in such fashion as to maximize it. If using water, the same thing is true in principle, but the mechanics are somewhat different because of the difference in behavior of gas and water.

So far as I know these basic facts are not controverted. They are generally and universally recognized as underlying the behavior of oil and gas reservoirs by all that have studied that subject.

In logical sequence, when we recognize these facts, the questions of wells comes next. The wells really serve two main pruposes:

[illegible] which [illegible]

[illegible] points through which [illegible] obtained the geologic and engineering data which permit us to determine the nature of a reservoir and how to develop it.

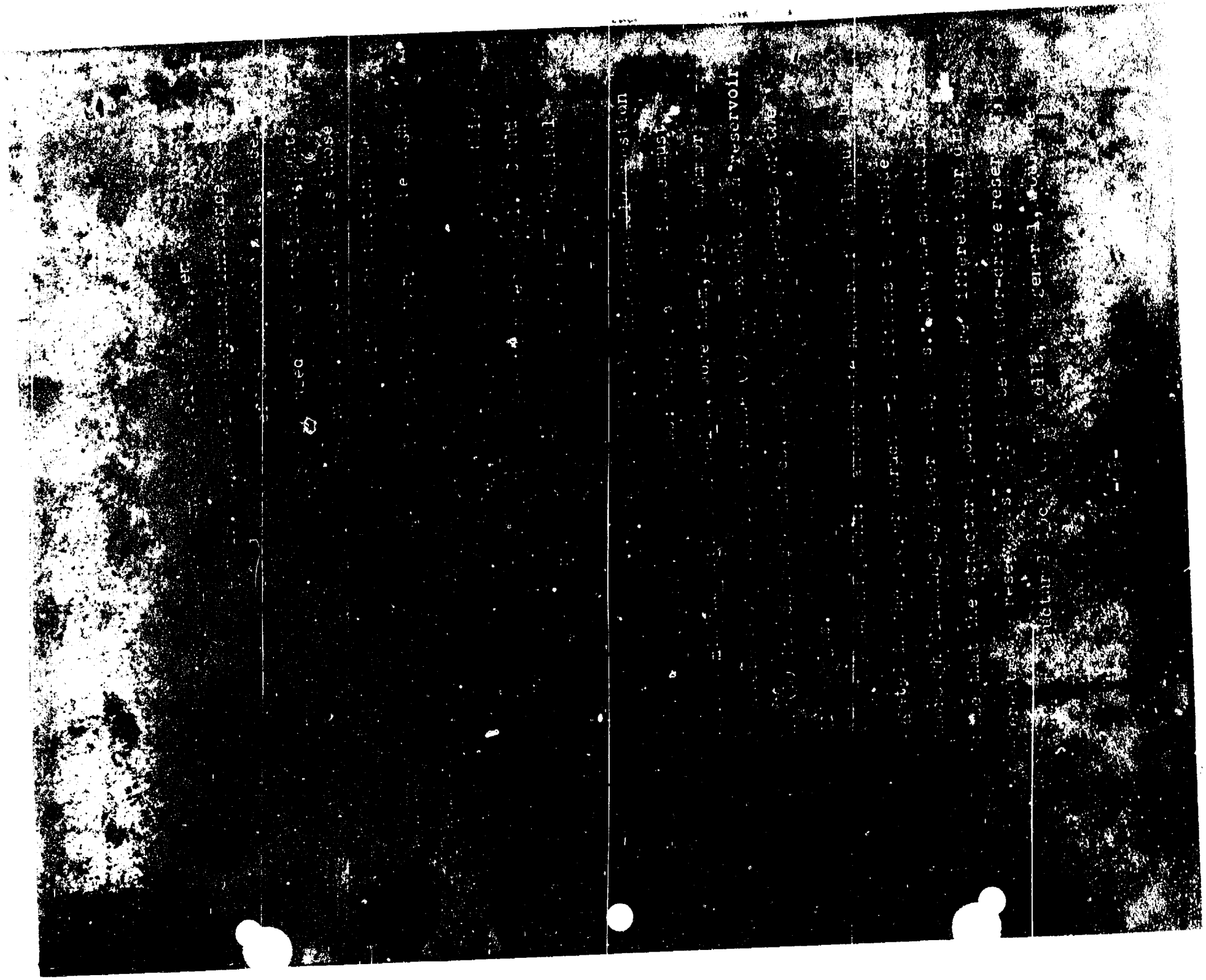
During the development of a new pool it is the observations we are able to make through a well that are, in my opinion, at that time the more important.

Based on my research and that of my associates and others whose work I have studied who have also studied the behavior of oil and gas fields, when we take into account the various characteristics we see the recovery depends on a number of factors.

On the one hand are the inherent characteristics, geology and structure and character of formation and character of the contained fluids. Those, in general, are beyond the control of the operator.

In the second place, there are those factors the operator can control. For example, avoidance of the waste of gas, and the control of the rate of production, and to a substantial extent, control of fluid movements; that is, of water through a reservoir.

Now, when trying to get the utmost in recovery from a reservoir, it is obviously through control of these controllable factors we can bring that effect about. When we properly con-



Q [illegible] Do you advise the Commission [illegible] technical people [illegible] views [illegible]?

A I have, these [illegible] committees, but I am quite convinced these opinions are shared by the overwhelming majority of [illegible] studies of the recovery of oil.

Q Who are some of these people?

A For example, the Special Study Committee on Well Spacing and Allocation of Production of the American Petroleum Institute. That Committee was active in its studies from 1933

until 1950. They have published

to refer to in a moment.

Other groups that have studied this question

views, in general, I think substantiate my

ing Committee of the Interstate Oil Compact Co

such Committee made a report in 1941. Another report

issued in booklet form in the year 1951.

I think the views are also fully supported by a more recent report of the Research and Coordinating Committee of the Interstate Oil Compact Commission.

In substance, I don't think there is any real disagreement on the technical points in the great majority of those that have studied the question in the last 10 to 15 years.

Q You referred to several committees and reports there. Let's go back a little bit and tell the Commission what is this API report of 1941 you referred to a moment ago.

A The API had for many years a Special Study Committee on Well Spacing and Allocation of Production. Since well spacing was obviously related to allocation, the Committee studied all aspects of well spacing and allocation and the protection of correlative rights, and the effects of well spacing on ultimate recovery. Their views were summarized in a progress report published in 1942 entitled "Standards of Allocation of Oil Production Within Pools and Among Pools"

...as I do, the various ...recovery of oil, including the ...location of wells. If I may quote from ...report on page 27, and I quote,

"..... careful studies of the theoretical and practical aspects of well spacing indicate that, under the efficient operating methods made possible by (among other things) restricted production rates, ultimate recovery is in many cases substantially independent of the number of wells."

Q Now, Mr. Buckley, you have also referred to a report of the Engineering Committee of the Interstate Oil Compact Commission of 1941. Would you tell the Commission what that report is?

A That was a report submitted by the Engineering Committee of the Compact Commission at its meeting in New Orleans, La. in April, April 14, 1941. That was a brief report containing, in effect, a number of conclusions arrived at after a study of those factors that influence the ultimate recovery of oil, including the effects of well spacing. That report was issued as a part of the booklet containing the report ...before of the API Special Study Committee on well ... If I may quote from that report to illustrate the ...ews of the Engineering Committee of the Compact Commission ...their Conclusion No. 21, which reads as follows,

"... while spacing is a controlling factor ... the trend

[illegible] well density and that the [illegible] mics. This is the belief of your committee [illegible] of the tendencies toward increasingly wider [illegible] are being shown by the various state regulatory [illegible]

That is particularly pertinent to the proposed rule [illegible] before the Commission.

Their Conclusion No. 22. Remember these are conclusions arrived at in 1941. I quote:

"Your Committee urges that the various regulatory bodies prevent the development of new pools on a pattern of close spacing. Once pools have been drilled with close spacing, the capital invested in unnecessary wells and the limitation of minimum per well allowables established in some states exerts an unfavorable pressure upon the mechanics of conservation and in many cases forces field production to a higher rate than should be permitted under good conservation practice."

Q Now, Mr. Buckley, has the API Well [illegible] you refer to compiled any recent information [illegible]

A The Well Spacing Committee has [illegible] active, as I mentioned before, on [illegible] '40's, recognizing that the information [illegible] as to the theory of fluid [illegible] and pressure [illegible]

there were very little evi-

, and so, they undertook to make as
study of field evidence as was possible to see
whether these views were supported in fact or not supported
by such field evidence.

So they compiled data on some 100 odd oil reservoirs
in the United States as to their ultimate recovery and phy-
sical characteristics, and the geology and the nature of the
contained fluids. And those data were studied in detail,
and published in a separate paper by Mr. R. C. Cross and me
in 1949. That paper and the data have previously been referred
to by Mr. Collins this afternoon. In summary, that data
showed that although the effects of factors such as oil
viscosity and oil pressure decline and other things, the
effects of all those factors could be clearly seen in these
data, that there was no indication of any effect of well spac-
ing on ultimate recovery.

low in spacing of 2½ or 6
to 66 acres per well.

A Dr. C.W. Tomlinson of Ardmore, Oklahoma, has expressed himself quite a few times as to this paper. Mr.Tomlinson undertook some four years after the paper was published to make an analysis of the data, and he arrived at a different conclusion. He reached the conclusion by his method of interpretation, using part of the data, not all of it. And it was by using a peculiar method of averaging that he was able to interpret these data to support his view that more wells do recover more oil.

I think all points were answered particularly and in some detail by Dr. W. V. Vietti, Chairman of the API Well Spacing Committee in a discussion before the Petroleum Branch of the American Institute of Mining and Metallurgical Engineering in San Antonio, Texas in 1949.

Also, in view of the questions raised by Dr.Tomlinson, the API Well Spacing Committee itself undertook a further review of the data and Dr. Tomlinson's interpretation of it and that made by Mr. Craxe and myself.

In a meeting of September 15, 1949, in Dallas, Texas that group issued a statement which I would like to read an excerpt from, if I may.

Q Please.

Q And I quote from minutes of the meeting of the Well Spacing Committee of the API held in Dallas, Texas, September 15, 1949.

Committee has carefully reviewed the method employed by Dr. Tomlinson in his interpretation of the data submitted by the Committee as well as the basis of his conclusions. It was the unanimous conclusion of those members present at the meeting of the Well Spacing Committee in Dallas, Texas, on September 15, 1949, that Dr. Tomlinson's utilization of only a selected portion of the data and method of interpretation was technically faulty, resulting in serious distortion of the facts, and that his conclusions could not be supported from the data in question."

Q Mr. Buckley, I would like to introduce that as Humble Oil and Refining Company's Exhibit 1 at this time.

A For the purpose of the record, I would like to point out at this time the exhibit itself is an excerpt from the minutes rather than a transcript of the entire proceedings.

MR. [illegible]: Will you receive that?

COM. SPURRIER: Without objection, it will be admitted.

Q Mr. Buckley, are you familiar with the fact that the Research and Coordinating Committee of the Interstate Oil Compact Commission has recently reviewed the whole question of well spacing, including your work and that of Dr. Tomlinson?

A I am familiar with the fact that the Research and Coordinating Committee of the Interstate Oil Compact Commission

has recently reviewed the [illegible]
paper I mentioned previously, Dr. [illegible] on
thereof, and a number of other works by other [illegible]

Q What did this Committee have to say about your work and that of Dr. Tomlinson's comments on it?

A This Committee, after its study, issued a report that was adopted at the Fort Worth meeting of the Compact Commission in September 1951. And if I may read from that report, and I quote, on page 47 appears the statement,

" The Craze and Buckley approach to the spacing problem was strictly one of analysis of statistical data. * * * In the present study it is concluded that the work is comprehensive, thorough, and dependable as possible through statistical analysis."

"With reference to Dr. Tomlinson's interpretation of these data, the Committee recognized, as did Mr. Craze and I, that there were certain limitations of the statistical approach. These limitations, I might point out, had been cited by Mr. Tomlinson in criticism. The Committee pointed out, "If the question is justified, then Tomlinson's own analyses of the date loses its value * * *".

The Committee went on further to state, and I quote on page 50, "We find nothing in this latest report to support Tomlinson's advocacy of close wall spacing."

Of this latest report, "they had reference to a [illegible] made by Dr. Tomlinson before [illegible]

-7-

included not only his views as to the date Mr. [illegible] and I had published, but at the same time, his views on the energy relations involved in the recovery of oil..

Q Mr. Buckley, aside from the specific issues you have discussed, what general conclusions did the Committee reach?

A The Committee issued an extensive report based on a study of the entire question. They reached a number of very specific conclusions. In general, I believe they support the views I expressed earlier: that there are a number of factors that influence the recovery of oil, and those that are controllable must be controlled in order to influence the ultimate recovery. But the mere drilling of additional wells solely for the purpose of increasing the well density does not, in general, have any -- add materially to the ultimate recovery.

Now, I have in effect paraphrased what I think to be the substance of their conclusions. If it is important, I would like to read a few --

Q I was wondering if you wouldread those, and also give the page ideptification in the report.

A On page 46 as conclusion No. 7, I quote:

"In either solution gas, water-drive, or combination drive reservoirs, the ultimate production of oil is independent, within reasonable limits, of well density."

Conclusion No. 8,

"Assuming the [illegible] reservoir development and control, the [illegible] density the shorter may be the time in years required to produce all the recoverable oil from a reservoir. This should be qualified on two counts:

"(a) The total oil required from a field to fill market demand might be produced as efficiently from fewer widely spaced as from many closely spaced wells.

"(b) The total oil that could be produced from a reservoir without physical waste might be as efficiently produced from fewer widely spaced as from many closely spaced wells."

On page 54, Conclusion No. 9, and I quote:

"The basic considerations in movement of fluid in oil reservoirs are applicable to either sandstone or limestone-dolomite reservoirs."

On page 54, No. 12:

"If the aim in reservoir control be that of securing the greatest ultimate recovery of oil from the reservoir as a whole, the question of location of wells ceases to be that of density, or spacing on some geometric pattern. Rather, well locations will be chosen to fit structural and reservoir characteristics or peculiarities, including the many possible variations in different sections of the same pool."

With particular reference to the proposed rule before

[illegible] conclusion regarding [illegible] development, I would like to quote Conclusion No. 12 on page 46 of the aforementioned report:

"Where land lease controls permit, new oil fields could be first developed on wide spacing patterns. Final well density and other development and production practices could then be determined in the light of geological, engineering, and economic information developed."

I would like to explain that in this report two sets of conclusions were arrived at. The report was, in effect, preceded by a set of conclusions, and there were a set at the end. These two sets of conclusions were in slightly different language; the second set being, in effect, an amplification and explanation of the first set.

I have selected those I think particularly pertinent to the issues before this Commission. In general, I think the views expressed in all the conclusions are in substantial agreement with the views I have expressed.

Q. Mr. Buckley, After reviewing all these studies, do you believe there is any technical controversy on well spacing?

A. Frankly, I do not. There has been a great to do from time to time about the so-called effect of well spacing on ultimate recovery. In my opinion; there is no real technical controversy and hasn't been for many years. There

[illegible] who
reasons have stated [illegible] be
spacing. I believe their views have
credited and are not subscribed to by
of those whose business it has been to become
med on the technical aspects of recovery and conservation.

I think it is clearly evident those that have clearly studied the question from a technical standpoint are almost in unanimous agreement with the views I have expressed. This was true of the Oil Compact Engineering Committee in its report of '42, and the API Well Spacing Committee in its report of '42. And true again of the Engineering Committee of the Interstate Oil Compact Commission, published in Booklet form in 1951. And I think it was corroborated fully in the September 1951 report I have just quoted from of the Research and Coordinating Committee of the Compact Commission.

I believe that these groups represent, in the aggregate, a substantial cross-section of informed opinion, both in the industry and among the state regulatory bodies.

Q Mr. Buckley, in conclusion, do you have anything further to present to the Commission?

A With regard to the proposed rule [illegible] would like to give one additional [illegible] the recent booklet published by the [illegible] the Interstate Oil Compact Commission.

[illegible] is a different committee from the Research and Coordinating Committee. They published a book entitled "Oil and Gas Production" in 1951, which described in more or less popular terms the behavior of oil and gas fields and those controls necessary to effecient recovery. I quote:

"For proper reservoir control in new fields it is important to determine as promptly as possible the structure, the reservoir-rock characteristics, the extent of the reservoir, the magnitude of reserves, the primary reservoir-energy source, and the type of reservoir control which will permit the greatest recovery. These data can best be determined by drilling new fields on the widest practical spacing pattern. Wide-spacing-development programs afford information that may be used to locate the most advantageous structural position for the drilling of future infill wells, and eliminate the expense of drilling many unnecessary wells. Each reservoir presents a separate problem in the determination of the well-spacing pattern."

Q Do you have anything further in conclusion?

A I have nothing further to add, except to reaffirm my conclusion it is technically sound, and I believe it to be in the public interest, and I believe it to be plain commonsense to develop those pools on a basis which will minimize the drilling of unnecessary wells.

these reports and booklets [illegible] number them 2, 3, 4, 5, and 6. If you would like additional copies, we have them available.

COM. SPURRIER: Without objection, they will be admitted.

THE WITNESS: Mr. SHAVER, you have introduced two I didn't mention, but which I think will be helpful.

MR. SHAVER: One, Mr. Buckley, is "Petroleum Conservation" and the other is "Petroleum Productive Capacity."

THE WITNESS: A report of the National Petroleum Council on the future availability of petroleum in the United States.

MR. SHAVER: I think they are pertinent to the inquiry and would like to introduce them.

(Off the record.)

COM. SPURRIER: Are there any more questions of this witness?

MR. GRAHAM: In the studies in which you participated, were there actually any 80 and 40 acres?

A You mean, I, personally have studied?

MR. GRAHM: Yes, sir.

A Yes, sir, I have studied or had access to data in fields in which spacing has come to [illegible] that. Not necessarily as to [illegible]

[illegible]

MR. GRAHAM: No further questions.

COM. SPURRIER: Are there any other questions? If not, the witness may be excused.

(Witness excused.)

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MR. KELLAHIN: If the Commission please, Jason Kellahin for Phillips Petroleum Company. I would like to call as our concluding witness Mr. Folsom, as an independent operator -- independent observer -- to express his conclusion on the question before the Commission.

In the interests of saving time, Mr. Folsom has prepared a statement which rather than presenting by questions and answers, we would like to have him read into the record, if that is satisfactory.

CLARENCE B. FOLSOM, JR.

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Will you state your name, please?

A Clarence B. Folsom, Jr.

Q By whom are you employed, Mr. Folsom?

A I am employed at the New Mexico School of Mines [illegible] petroleum

engineering and geology?

A I hold the degree of petroleum engineer from the Colorado School of Mines, and the degree of Master of Science in petroleum engineering from the same institution.

Q What year?

A The first degree in '41 and the second in 1952.

Q Have you had any practical experience in the field of petroleum production?

A Yes, sir, employed by Phillips Petroleum Company for the period 1941 to 1946, and in my present capacity from 1947 until the present time.

Q You have been head of the Petroleum Engineering department at the school since 1947?

A That is correct.

Q Have you made a study of the question that is before the Commission in regard to this proposed order, Mr. Folsom?

A I have.

Q Have you prepared a statement on that question?

A I have.

Q Would you read that into the record, please, for the Governor and Members of the Commission that are interested in [illegible]?

A I propose this morning to [illegible] adoption of this motion, [illegible] I am in [illegible] accord with the

and I heartily recommend its adoption. I take this position with certain reservations, however. We must not consider this motion as the final solution to the problems of well-spacing and well patterns. It has certain merit as being indicative of an attitude on the part of the Commission. It indicates to the industry that we are ready to consider each oil and/or gas pool, on its own merits, and will no longer attempt to apply a rigid, unvarying rule to all pools regardless of their physical characteristics, geometry, and type of drainage mechanism.

Our knowledge of the mechanics of reservoir drainage has increased tremendously since the Conservation Act was passed in 1935. We now realize that the ultimate recovery from oil and gas reservoirs depends on many factors, most of them inherent in the reservoir as discovered, and not subject to modification. Among these are the permeability, porosity, and saturation of the reservoir rock, the viscosity, the nature of the reservoir fluids, the pressures on these fluids, and the geometry of the system.

It has been calculated that between two identical reservoirs, having a permeability of 15 millidarcys and developed on 40 and 80 acre spacings, respectively, the difference in per cent of original oil in place, recovered, is less than 0.2 of one per cent and only 0.3 of a per cent in the case of 40 vs. 160 acre spacing. The same reservoirs will produce an addi-

tional 3 per cent if the permeability is increased or 300 md. I mention this to point out that the maximum recovery from an oil or gas pool depends primarily on the inherent physical characteristics of the reservoir and its contained fluids, and only secondarily on the spacing between wells.

With our present knowledge, and sufficient data on the new reservoir, it is now possible to calculate for each new pool, an optimum spacing which will provide the greatest maximum recovery of fluid, at the least cost, with a satisfactory return on the investment.

It might be argued that our concern is limited to the maximum recovery of our reserves, but we must realize that there will be no recovery at all unless we encourage exploration and development by a proper attention to the other factors.

What then is more logical than that we should set a temporary spacing in all new oil and/or gas pools until sufficient reservoir data has been obtained to permit a determination of the optimum spacing?

Our ultimate aim in conservation is the most efficient recovery possible consistent with proper control of the pressure decline, gas-oil and water-oil ratios, and use of the reservoir energy. Therefore, it is recommended that the first wells in a new area be drilled on a wide spacing designed to furnish quickly the [illegible]

[illegible] and physical characteristics of the reser-
[illegible] best, most economical program of develop-
[illegible] particular pool will be based.

[illegible] may turn out to be anything from
[illegible] acres or more. The odds are against it
[illegible] being exactly 40 acres. This, in itself, argues against
the validity of a rigid, arbitrary, state-wide spacing rule.
It is this very flexibility which we must seek. And this
proposed rule is a step, but only a step, toward our goal.

It is entirely possible that the evidence furnished by
the pool itself will support a wider spacing than that which
[illegible] for the initial stage of development. It is also
possible that the optimum spacing may vary from one area within
the pool to another.

If we start with a wide spacing it will be easier to
drill subsequent wells should they be shown to be necessary to
properly recover the oil from the pool, or to meet the market
demand; whereas the use of close spacing in the initial stage
may result in the drilling of unnecessary wells and the con-
sequent economic waste which we are pledged to avoid. Once
[illegible] this waste can never be overcome, even by the most
[illegible] manipulations.

[illegible] that the question of well spacing is
[illegible] to achieve more efficient
[illegible] proper position as a minor

[illegible] In many cases, the close-spacing advocates have prevailed with the result that the excessive expenditures of capital have had to be offset by excessive allowables to prevent premature abandonment. And this has defeated the efforts of engineers to obtain the maximum, ultimate recovery of oil from the reservoir.

Certainly, if we were to mine the reservoir sand, we would achieve complete recovery. Therefore, it is within reason that the per cent of total recovery will increase as the wells are placed closer together. But the increase in recovery, in the region of well spacings within the realm of practical operation, is so small (a fraction of a per cent) that it can be easily overcome by the increased cost of development and production. It is possible that in the case of older shallower fields the small increase in production, due to infill drilling, will exceed the additional investment, and possibly provide a small profit on the operation. But in the case of deep pools requiring investments approaching a million dollars per well, it is doubtful if even a small percentage of the investment can be returned out of the slight additional recovery.

I suspect that many of the advocates of [illegible] who point to their success in shallower areas [illegible] our deeper horizons do not present the same

Unfortunately, perhaps the question [illegible]

[illegible] has been raised here. I do
[illegible] relative to the question before us, but
[illegible] thought we it must be considered in the
[illegible] of the present problem. The question is one of those
academic questions which provide scholars with mental exer-
cise, but which in the end add little to our reserves of
petroleum. Unless we are interested in well spacings of less
than 6 acres per well, the decrease in recovery, as well
spacings increase, is so slight as to be unimportant in com-
pairson to the cost of drilling the additional deep wells neces-
sary to obtain the additional oil.

The day is approaching when the industry will be faced
with the problem of choosing between a number of areas in which
to invest exploratory funds. The past few years have seen
many areas closed to exploration because of legal and other
difficulties but these obstacles have now been removed, and,
as capital funds become more restricted, the industry will be
forced to choose those areas in which, in case of a discovery,
they will be allowed to develop the pool in accordance with the
best engineering practice. If we in New Mexico are willing to
recognize new advances in the field of reservoir technology,
[illegible] our conservation program accordingly, the oil
[illegible] to invest their capital in our state.
[illegible] production and [illegible] with
[illegible] to our

state will far outweigh the slight loss of ultimate recovery, if any. In any case, it will be possible for the original discoverer of the pool or his assigns to carry out infill drilling at a later date if it should prove feasible.

As I pointed out earlier, this is only a first step toward an ultimate goal. After we have had time to observe this new rule in operation, we may wish to remove the depth restriction as well as the provision for a stated, final spacing.

Some further mention should be made of well patters. I am no now, and never have been, convinced that the most efficient recovery is achieved by placing our wells in the center of legal land sub-divisions. This is certainly the case in those fields producing under the influence of an active water drive. I realize that to depart from our present rule at this time would be fraught with legal difficulties; nevertheless, if we would strive for true conservation we must soon consider the advisability of allowing irregular patterns, based on the geometry of the reservoir system and the type of drive in operation on the pool.

In adopting a wider well spacing, we need not alter the proration unit now in use for allocating production. Many of those who argue for close spacing assume that the additional wells will increase the amount of [illegible] the acreage. If allowables are based on the [illegible] than on a per well basis, the [illegible]

[illegible] viewed in its proper economic aspect, and much [illegible] opposition to this proposed motion will disappear.

In the offering of a decision in this matter, we must not [illegible] sight of the obligation we are under to promote exploration, discovery, and development of new reserves in New Mexico; to prevent physical waste through excessive production; to prevent economic waste; to secure the maximum ultimate production of our reserves; and to protect the correlative rights of individuals. These factors complicate the problem, but there is a solution, simple in form but complex in operation, which will accomplish our purpose.

I believe that in the matter of conservation of oil and gas the best interests of the state are identical with those of the oil producers. What is good for either is good for both. We are all interested in obtaining the maximum benefits from our natural resources. And if we continue to work together as we have in the past, we will all prosper; producer, royalty owner, and consumer alike. The proposed motion is in the best interests of all concerned, and I can find no valid, technical reason for opposition to it.

New Mexico has long been a leader in the field of oil and gas conservation. Our operations have served as a model for other commonwealths faced with similar problems. I hope that we will continue to demonstrate our leadership by being [illegible] to abandon the policy of rigid, statewide spacing;

thereby recognizing the individuality of ...

Q Do you have anything you care to add to your prepared statement, Mr. Folsom?

A I thought Mr. Beall submitted some very fine data for the consideration of the Commission; particularly when he pointed out in the case of a 13,000 ft. well you would have to have six times the oil present to pay out the cost of the well as you would have in a 5,000 ft. well. I think it should be further pointed out that this is rather unusual; to find a deep pool with a six-to-one ratio of oil saturation. However, if we cut the number of wells in half, we cut that ratio in half, which would require then a three-to-one ratio, which isn't difficult to picture. I think that should be brought out.

MR. KALLAHIN: That concludes our examination. Any questions?

COM. SPURRIER: Are there any questions of this witness? If not, the witness may be excused.

(Witness excused.)

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COM SPURRIER: Is there anyone else to be heard?

MR. WOODWARD: If there are no other witnesses, we would like to make a statement.

COM. SPURRIER: Very well.

MR. [illegible]: In view of its interest in spacing [illegible] in the last 23 years, Amerada Petroleum Corporation [illegible] to make this additional statement of its position [illegible] the proposed rule.

We recognize oil fields are not identical, and it has always been our contention each pool should be spaced on its facts. The Bagley, Knowles, and Hightower reservoirs indicated and subsequent development confirms one well would efficiently drain 80 acres. Accordingly, we supported 80 acres. We didn't consider conditions in the Saunders Field, and other pools in which we had a similar majority interest, justified 80-acre spacing, and did not ask for an 80-acre spacing in those fields.

We are not advocating 40, 80, or 160-acre spacing in this hearing. In supporting the proposed rule and urging its adoption, we are contending there is a right time to permanently space oil fields; after sufficient facts are in, and before development has progressed to an extent that proper spacing, as a practical matter, is impossible.

COM. SPURRIER: Anyone else?

MR. DAILEY: My name is Homer Dailey, representing the Continental Oil Company.

We wish to make a statement in favor of the proposed rule.

Adoption of the rule would make possible the accumulation of the data necessary to properly evaluate the reservoir. If the factual data supports such a program, this rule will enable

the operators to develop these reservoirs of greater expense and risk on a program of spacing wider than that now possible. Furthermore, the uniformity of spacing protects correlative rights in that allowables may be distributed equally without question of discrimination. And affords flexibility in that the density of wells may be increased without complications in the event that such action is directed by the Commission.

This proposed rule is a sound step toward better conservation of petroleum resources, and should provide additional incentive to drill other deeper horizons.

COM. SPURRIER: Anyone else?

MR. UPCHURCH: Attorney for Gulf Oil Corporation.

At the November hearing Gulf went on record as recommending the adoption of this proposed 80-acre temporary spacing rule. We would like again to re-state our position, and recommend adoption of this temporary 80-acre spacing rule.

COM. SPURRIER: Anyone else?

MR. GAMMON: For the Texas Company.

We would like to concur in the Committee report submitted this morning by Judge Foster, and recommend the proposed rule be adopted.

MR. NASON: R. C. Nason for the Cities Service of Bartlesville, Okla.

Mr. Chairman, I would like to make a brief statement of our position. We concur in the recommendation of the Committee

with the exception of federal acreage to a regular spacing pattern. We would like to call your attention to the evidence as it has developed here. We think that the evidence has been overwhelming in favor of 80-acre development units. We think that the operator that goes out and drills to a depth below 10,000 is entitled rationally and reasonably to consideration.

The evidence of Mr. Beall showed the discovery well, where it is below 10,000 ft., costs between $800,000 and $1,000,000 to drill. We disagree with Mr. Tesch in that I believe that when you analyze his testimony he is opposed to spacing of any kind. If you will go into his testimony, he is opposed to any kind of development units, and he is opposed to the conservation practices that have grown up in the industry. We feel that when a man bets his money and goes in and drills a well to a depth below 10,000 ft, he is entitled to that consideration. Not only that, and it is recognized in every state I know of, the discoverer of a new pool is given consideration. We feel that when -- now, I want to call your attention to Mr. Beall's testimony.

He testified that as far as pools are concerned, when you get below 10,000 ft, they are no more likely to be Golcondas, so to speak, than when they are above 10,000 ft. And we feel that the man that bets his money -- and we agree with Mr. Tesch on this -- he ought not to be compelled to

step out from 1,866 ft. to a half mile to offset his own well. Now, I will admit that you may have something of a cluster there. But all this testimony with reference to infill wells is applicable to the rule if you drill it before with reference to diagonal spacing.

That is our position as we stated it at the commencement of this hearing in April. And that is our position now. And we feel that if that part is stricken from the proposed rule, that it will tend toward the development of the oil reservoirs of new Mexico.

I believe that that states our position fully. Thank you.

COM. SPURRIER: Anyone else?

MR. ELLIS: H. C. Ellis of Artesia, N. M., with Buffalo Oil Company.

I would like to state our position as regards the proposed 80-acre spacing. We are heartily in accord with that spacing.

COM. SPURRIER: Any one else?

MR. BROWN: H. C. Brown, Sun Oil Company.

We have gone on record about four times already as being in favor of this proposal, and I will make it the fifth.

COM. SPURRIER: Anyone else?

MR. SELINGER: George W. Selinger, representing Skelly Oil Company.

[redacted] Company wishes to add its voice to the voices of the vast majority of the industry pleading with the Commission to adopt the rule. In 1935 the Commission of this state was faced with a very difficult problem, and I believe this Commission will meet the problem it is faced with now as courageously as its predecessor. I believe this Commission will not be subject to any criticism in the adoption of this rule for two reasons: one, that this is a temporary spacing rule in which a permanent rule is not adopted until after all information is disclosed and presented to the Commission in very concrete form. Secondly, the rule places a burden upon industry, and the industry welcomes that burden, in proving to this Commission after 18 months of drilling, or drilling of six wells, that 80 acres is necessary.

Now, with those two restrictions, those two defenders from criticism, I believe this Commission can adopt a temporary spacing rule as sought by the industry.

COM. SPURRIER: Anyone else?

MR. JOHNSON: J. P. Johnson with Atlantic Refining Company.

We would like again to state our position in favor of this temporary spacing order.

COM. SPURRIER: Anyone else. If there is no one else to be heard, we will take the case under advisement.

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MADE IN U. S. A.

PATENTED NO. 1,787,410

OIL CONSERVATION COMMISSION
DEC 3 19

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

TRANSCRIPTION OF HEARING

CASE NO. 407

November 20, 1952

E. E. GREESON
ADA DEARNLEY
COURT REPORTERS
BOX 1303
PHONES 5-9422 AND 5-9546
ALBUQUERQUE, NEW MEXICO

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

NOVEMBER 20, 1952

- - - - - - - - - - - - - - - - - - -

In the Matter of:

(Cont'd. from September and October hearings) The Commission's motion for extension of Section "G", Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary 80-Acre Proration Units.

Case No. 407

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(Notice of Publication read by Mr. Graham.)

MR. SPURRIER: The meeting will come to order, please. Before we take up the next case, which is 407, I would like to read an announcement which Judge Foster handed me. "A meeting of Texas oil operators will be held in Dallas, Texas, on Tuesday, November 25", that is next Tuesday, November 25, "at 10:00 o'clock a.m., in rooms 1509 and 1510 of the Magnolia Building, for the purpose of discussing the proposed changes of the Railroad Commission of Texas, of Statewide Rules 24 and 25, pertaining to the production proration and allocation of gas from gas wells which will be considered by the Railroad Commission at a hearing which has been called for nine a.m., December 9th, at the Commodore-Perry Hotel, Austin, Texas". Now, we will proceed with Case 407.

MR. SPURRIER: Mr. McKellar.

MR. MC KELLAR: Mr. Spurrier. As a member of the committee that the Commission has appointed to study this matter the committee held a meeting in Lovington this past Monday which was a most inconvenient date in my - - for me, because I couldn't attend. I didn't see the notice of the meeting until Friday and because of previous arrangements I couldn't be there but I had a representative and there is a misunderstanding between myself and certain others of the committee as to what our mandate from the Commission is. There has been various arguments injected into the committee's 40 acres versus 80 acres and vice versa back and forth and my understanding of the mandate was that we were to adopt a proposed recommendation. The Commission had, on its motion, taken a case under advisement. At least for my personal benefit, if I am to serve as a member of the committee with any value at all, I wish that the Commission would reissue in more detail form the mandate to the committee members. I understand that a wire has been sent to the Commission by the Chairman of this committee to the effect that it was unaminously agreed that the case be continued. My representative had no such authority to agree to any such continuance. He tells me that he did not knowingly agree to any such continuance, so there is obviously a misunderstanding although I am sure it was in good faith between the Chairman of the committee and Magnolia's representative.

This case has been carried on this Docket this is the third

month. Aside from my duties as a committee member and speaking now only on behalf of my client, Magnolia Petroleum Company, we want the case brought before the Commission at the earliest possible date and I am now on my feet here today to make certain recommendations on behalf of my company. We feel it is our opinion that any 80 acre spacing order, temporary 80 acre spacing order, along the lines of that proposed by this Commission should embody certain sections. One of those is that the order should be effective at the depth of 10,000 feet which the Commission proposed. Number two is, if you remember when I was here three months ago to discuss this matter, I was of the firm opinion that no time limit should be placed on this proposed order, that it should, the criterion should be five wells. After going into the matter at some length and discussing it I realize that such a proposal could be abused by operators to the injustice and prejudice of other operators and possibly royalty interest. So I now make my recommendation and would like to recommend to the Commission that this proposed order be for a period of 18 months or five wells, whichever should occur sooner, so that no operator could drill four wells and simply sit back. Of course, realizing that in 18 months if we had only drilled two wells an operator could come in and ask for further continuance of the temporary order and that matter could be heard on its merits but I think in all fairness to the royalty owners and the other operators that an 18 month time limit is reasonable. That is hard work for me to say since I have told George Graham I thought

month. Aside from my duties as a committee member and speaking now only on behalf of my client, Magnolia Petroleum Company, we want the case brought before the Commission at the earliest possible date and I am now on my feet here today to make certain recommendations on behalf of my company. We feel it is our opinion that any 80 acre spacing order, temporary 80 acre spacing order, along the lines of that proposed by this Commission should embody certain sections. One of those is that the order should be effective at the depth of 10,000 feet which the Commission proposed. Number two is, if you remember when I was here three months ago to discuss this matter, I was of the firm opinion that no time limit should be placed on this proposed order, that it should, the criterion should be five wells. After going into the matter at some length and discussing it I realize that such a proposal could be abused by operators to the injustice and prejudice of other operators and possibly royalty interest. So I now make my recommendation and would like to recommend to the Commission that this proposed order be for a period of 18 months or five wells, whichever should occur sooner, so that no operator could drill four wells and simply sit back. Of course, realizing that in 18 months if we had only drilled two wells an operator could come in and ask for further continuance of the temporary order and that matter could be heard on its merits but I think in all fairness to the royalty owners and the other operators that an 18 month time limit is reasonable. That is hard work for me to say since I have told George Graham I thought

it was highly unreasonable. I want to tell you, George, I have come around to your line of thinking. I was wrong about it. The third essential that I think the order should embody is that these wells be placed on a fixed spacing pattern, placed in diagonal quarter sections with possibly the discovery well setting the pattern. Now, I have a proposed temporary 80 Acre spacing rule which is not original with me. I discussed the points that my company thought should be embodied in such a rule with a great many operators who were present here in Santa Fe, practically all I could contact. I discussed this plan with them and we changed it from time to time and I would like to read into the record a suggested Statewide Rule that our company agrees with and then I would like to submit it to the Commission Staff for their study. I will read this, it will just take a moment. First paragraph,"After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres." Second paragraph, "The location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80 acre proration units are in effect. Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of a quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section. Each

quarter section shall be divided into two proration units, running either north and south or east and west." Paragraph three, "Upon the completion of five wells to the same producing formation within a radius of two miles of such wildcat well or within eighteen months after the completion date of the discovery well, whichever shall occur first, a hearing shall be set for the purpose of determining whether or not 80 acre spacing should be continued in effect." Fourth paragraph, "Certified plats of proration units shall be filed with the Commission and such other provisions as may properly be included therein, as supported by proper testimony and evidence adduced at said hearing."

I would like to submit this not for an exhibit but just for the Commission's consideration.

In summing up my remarks, Mr. Chairman, I would like to urge the Commission to, as I say, issue a new mandate to the committee urging upon the Chairman to call the meeting at least a week ahead of the next statewide hearing. We have the Oil and Gas Association coming up in Albuquerque the first of the month. It may be that we can meet in conjunction with that hearing for a short time or at some other time, but at least enough time to where we can meet with the committee and take its recommendations back to our clients. Along with that mandate I think it would be well if the Commission, if their staff have any definite thoughts, which I am sure they have on this matter, to submit a proposal, a proposed rule to the Committee and ask the Committee for their recommendations and considerations of that

proposed rule.

That is all I have to say. If there is any question that anybody has as to what my company's position is in the matter I will be glad to answer them.

MR. SPURRIER: Does anyone have a question of Mr. McKellar? Anyone else to be heard in this case?

MR. HILTZ: R. G. Hiltz, with Stanolind. Our original thoughts on the question were submitted by letter to the Committee. It was our letter from Mr. C. F. Bedford, dated October 20, 1952, filed RGH 5247-175. I would like to request that letter be made a part of the record of this case. Our original thoughts differed very slightly from the rules which were proposed by Mr. McKellar but I would like to state that we have now reviewed the suggested rule and we are in full accord with the suggestion as read into the record. In addition I would like to point out that since the rule would operate in any case on a temporary basis I fail to see how it would adversely affect any of the interested parties. It simply means in the early stages of the development of the field we could be assured of an intelligent, uniform manner of development until sufficient data became available to determine the optimum spacing pattern for the complete field development. Prior to making a decision in this case we could acquire the necessary facts to support the right conclusion. We feel that this is a realistic progressive development in conservation in New Mexico and we strongly urge the Commission to adopt a rule of that sort.

MR. KELLAHIN: Mr. Kellahin, Phillips. Mr. Chairman, I attended the meeting of the Committee that Mr. McKellar referred to,as an alternate member. I would like to second his statement made as a result of that Committee meeting. There was considerable confusion as to the purpose of the Committee and discussion seemed to center around the merits of 80 acre spacing. I would like to second the recommendation that the Commission issue a little - - further clarify its instructions as to what is desired of the Committee if it is to continue to function. Also, Mr. McKellar stated that the telegram that was sent by the Committee Chairman said it was a unaminous request that the hearing be continued or postponed and that was certainly not my understanding of the results of the meeting. The representative of Magnolia certainly did not agree to the postponement, nor did I.

MR. SPURRIER: Thank you. Before we go any further I probably should have read this to begin with. This telegram that is in question or has been mentioned here, sent to the Commission by G. T. Hanners, acting Chairman. "Your Committee on spacing, Case No. 407, met at Lovington Monday morning, 17 of November, with Committee members Leonard Christy, Dan Glidden and Hanners present. Wally J. Ford, Magnolia engineer present in behalf of Committee member McKellar. Mr. Kellahin , attorney, present in behalf of Committee member Foster and W. Glen Staley, of Operators Committee, and DuPont of U.S.G.S. and with representatives of New Mexico Educational Association and other interested

parties present. Importance of the case and complexity of questions will require additional time for preparation and submission of Committee report and recommendations. Your Committee recommends, unaminously, postponement of November 20 hearing and resetting the case for a later convenient date".

There are people here prepared to testify today and although this telegram, the meaning of the telegram, is not quite clear to me. I assume that they mean that the case should be continued rather than the testimony should not be presented today. Therefore, the Commission will take any testimony that you may be ready to present. Are there any other members of the Committee present? Mr. Christy.

MR. CHRISTY: I am also a member of the Committee and attended the meeting as the telegram indicates. I did agree to a continuance, in hopes that the Committee might get together with some kind of a proposal. I might add it would be a hope on the thing. I believe, however, that if the Commission is going to take this under advisement I would concur in the proposed rules as given by Mr. McKellar, and urge their adoption. The Committee was asked - - the Committee charged a few members of the Committee, the engineering members particularly, to propose these rules and I have discussed the rules with two other members of the Committee, the representatives of the Engineer Department, and I am reasonably sure that these are the rules that the Committee would propose. Whether all the members of the Committee will agree to it or not I can not answer that be-

cause they haven't all seen them. I certainly urge the adoption of the rules given by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. FOSTER: Mr. Foster, representing Phillips Petroleum Company. We have already had the report of Mr. Kellahin who attended the Lovington, New Mexico meeting. My representative placed on the Committee. Of course, Phillips Petroleum Company came here prepared to put on some testimony this morning. We have witnesses and we would like the opportunity to do that. I might add that we are very much in accord with the suggested recommendations made by Magnolia on the rule. I believe that these suggested changes in the rules meets with the general approval of all the operators and perhaps before the meeting is over all the operators will have expressed themselves on the matter. When I got the letter appointing me as a member of that Committee I viewed the letter as requiring the Committee to consider the suggested temporary 80 acre proration unit order on the basis that it was assumed that the Committee or that the Commission was considering the adoption of such an order. I did not understand that the Committee would go into any discussions of whether you should or should not have 80 acre proration units established in the State of New Mexico. As far as I am concerned I think it would ba a useless procedure to have the Committee consider the question of whether you are going to have 80 acres or 40 acres. Further I think it would be contrary to what the established policy of this Commission

already is because the Commission has granted 80 acre units; there are four of them in effect in the state now. I take it that the purpose of the Commission in appointing this Committee was simply to find some workable way to implement the policy of the Commission that had already been established by way of the granting of applications for 80 acre proration units. As far as I am concerned I just don't want to get into any argument now, as a member of that Committee, on the question of 40 acres versus 80 acres. The Committee can't decide that. It seems to me that the letter that the Commission sent out, the letter that you, Mr. Spurrier, sent out, was perfectly clear that we were to proceed on the theory that we were to discuss only the proper sort of order that should be made establishing 80 acres. If that isn't clear I want to add my voice to that of the Magnolia representative that it be made clear to this Committee what their functions are, so that if we do have another meeting there won't be that chance or opportunity of argument between members of the Committee as to what they are to do. Now, whenever everybody else gets through expressing themselves about this matter I want to put on a little testimony about this matter.

MR. SPURRIER: I think I might help the status of the record if I would read the proposed Rule 407, as we proposed it some time ago. "One, temporary 80 acre proration units are hereby established for wildcat wells as defined in Rule 104A completed as oil wells with a pool depth range of 10,000 feet or more, determined in accordance with Rule 505A. Two, after the effective

date of this order no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one well to each 80 acres in order to secure his proportionate part of the production. Upon completion of five wells to the same producing formation within a radius of two miles of such wildcat wells the proration units shall be established at 40 acres unless the operator can establish by clear and convincing evidence that one well will efficiently and economically drain the 80 acres assigned to the well. And such other provisions as may properly be included therein as supported by proper testimony and evidence adduced at the said hearing."

I might say that we, the Commission, appointed this Committee. They were appointed to advise the Commission on this proposed rule. The Commission realized that the question of 80 versus 40 acre spacing was a part of the thing at hand but we did not intend that the Committee should report to us whether they recommended 40 or 80 acre spacing. We intended that they report to us or recommend to us on this proposed rule. On matters of depth specifically I set out in my letter at what depths should order be effective, how many wells should be drilled before the hearing is called and should there be a time limit for the date of the hearing.

MR. GRAHAM: Was it not also your idea, Mr. Spurrier, that there probably would be a majority report and a minority report, that we might have both sides?

MR. SPURRIER: I wouldn't say that I thought there probably would be, I thought there was a possibility there would be.

MR. ADAMS: Mr. R. E. Adams, Cities Service Oil Company. As I understand the proposed rule by the Commission, that wouldn't fix the 80 acre spacing pattern for the field. As I understand Mr. McKellar the recommendation of the Committee would. In other words if you drilled a discovery well below 10,000 feet you wouldn't offset that discovery well under the Magnolia recommendation, is that correct?

MR. SPURRIER: That is the way I understand it.

MR. MC KELLAR: That is correct but that is not the recommendation of the Committee. That was entered. That is, I am speaking only for Magnolia Petroleum Company. I said they weren't original with me. I have discussed them with a good many operators. That is not a Committee, that is neither the Majority nor the Minority Committee report. That is something I have entered on behalf of Magnolia. You are correct, you could not, unless because of the data that you received from drilling your discovery well, come in and ask that your discovery well be declared an exemption under the rule and then drill a 40 acre offset and throw your discovery well out for your later deliberation. The attorney put that in because you come up here after locating the proration units and you drill five wells and you have 40 acre wells.

MR. ADAMS: Not necessarily.

MR. MC KELLAR: Not necessarily but it often happens. I realize by having the definite step out and I realize it is highly controversial, it was the thought of my company that it would force an operator if he wanted 80 acres, if that is what he wanted.

MR. ADAMS: An operator might not want 80 acres if he drills a discovery below 10,000 feet. I think that a reasonable operator would offset that well. We have done it down here and we will do it again.

MR. MC KELLAR: That is a point to be considered, the Commission's original proposed rule did not say can not, it said "will not have to", or words to that effect.

MR. ADAMS: That is the way I understood the proposed rule.

MR. MC KELLAR: My proposal on behalf of Magnolia differs from that. That is not a Committee recommendation it is just my --

MR. ADAMS: (Interrupting) Cities Service wishes to go on record as opposing the Magnolia proposal for discovery well on 80 acre spacing. If we go below 10,000 feet we want the permission to offset that well on 40 acres if we so desire.

MR. SPURRIER: Anyone else?

MR. SHAVER: Charles Shaver, representing the Humble Oil and Refining Company. We concur in the proposed rule submitted by Mr. McKellar and also his recommendations. We feel that these rules are not only proposed rules, not only appropriate

but adequate and we would like to urge the Commission to adopt the Statewide Rule along these lines.

MR. SPURRIER: Anyone else?

MR. BALLOU: My name is Ballou, representative from the Sun Oil Company. We went on record in September as favoring the proposal of the Commission. The feeling of the Sun Oil Company that the proposed 80 acre rule suggested by Mr. McKellar would bring about orderly development and also permit a more rapid delineation of a new producing reservoir. We favor the proposal.

MR. SPURRIER: Anyone else?

MR. RAY: Carl Ray, with the Texas Company. We have expressed our views on this proposed order to the members of the Committee. The proposal of the Magnolia Company essentially embodies our proposals in this matter. We are especially desirous of having the fixed spacing provision in that order and we wish to urge the proposal of the Magnolia Company be seriously considered by the Commission in writing such an order.

MR. SPURRIER: Anyone else?

MR. ADAMS: Cities Service is not opposed to 80 acre spacing below 10,000 feet but we do feel that an operator that drills a discovery well should have the option of making the next location as he sees fit. The 80 acre step out, I don't know how many feet that would be, it would be well in excess of 660.

MR. MC KELLAR: 660. No, it would be 1800 and some feet with the next step out, I think. We would like to make a direct

offset to the discovery well.

MR. SPURRIER: Anyone else?

MR. WALKER: Don Walker, with Gulf. We would like to go on record as concurring with the proposed rules as recommended by the Commission and as modified by the statement in the suggested changes as read by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. CROCKER: J. H. Crocker, with Mid Continent Petroleum Corporation. In view of our interpretation of the statutes of New Mexico we think that the Commission is rightfully on its own motion made a suggestion for consideration with respect to this temporary 80 acre proposition. We wholeheartedly support the position as taken by Mr. McKellar with respect to the points made by Mr. Adams. We feel that any operator if he wants to directly offset the wildcat that came in on 40 acre pattern this Commission is always open to applications for exceptions. As I understand this Commission has no authority to require wells to be drilled on a density that is more than necessary for adequate drainage. If one well will adequately drain 80 acres and the Commission agrees with that position it has just one position it can take and that is to authorize a stand back of 80 acre spacing. I think until that question of changed conditions that the pattern that can adequately be drained, the largest pattern is the one that the state should adopt and we agree with the positions that have been taken.

MR. SPURRIER: Anyone else?

MR. HOWARD: R. E. Howard, with Atlantic Refining Company. We would also like to concur with proposal submitted by Mr. Mc Kellar on behalf of Magnolia Petroleum Company. I believe that at the September hearing we went on record at that time as favoring temporary 80 acre spacing for wells below 10,000 feet. We would like to concur with the rules as, the proposed rules as submitted by Mr. McKellar.

MR. SPURRIER: Anyone else?

MR. GRAY: Ralph Gray, of Buffalo Oil Company. Our company would like to see some type of temporary 80 acre spacing program adopted. We ourselves have spent close to half a million dollars drilling one of these deep wells and we don't see how even a major can drill those kind of wells indiscriminately. I would be inclined to with-hold recommendations as to the exact spacing program that should be followed until this Committee has its final say. I think that the Committee should, if they're going to continue to study this problem, should put their stress on determining if it is feasible to have anything other than just a strict diagonal spacing pattern adopted, so maybe they can come out with something that will be a little more satisfactory along that score.

MR. SPURRIER: Anyone else?

MR. SELINGER: If the Commission please I would like to point out a couple of matters in connection with this rule. First I would like to point out that this is the third month this matter has come up. It came up in the September, October

and November hearings. I believe that in the September and October hearings the matter of 40 acre versus 80 acres was at least given an opportunity to all express their views. Secondly I would like to point out that in connection with the suggestion made by Mr. Adams of the Cities Service that the difference between a diagonal and direct 40 acre offset is a difference between 1300 and 2000 feet and 1870 feet. I think comparatively speaking it is an inconsequential footage,you're going to a deep hole test. I would like to say in defense of the Commission, if they need any, I think their letter directed to this Committee was as clear and concise as anything possibly could be because attached to that was a proposed order of 407 which deals exclusively with 80 acres and the three questions propounded to the Committee in the form of instructions propounded by Mr. Spurrier are also definite and clear. I imagine the purpose of the letter of December 24th as compared to the proposed rule heretofore in the September and October hearings was the fact that there was no time element in the original proposed 407 Rule and the Committee was instructed to discuss that time element question. The suggestion of the Statewide Rule as proposed this morning, insofar as Skelly Oil Company is concerned,meets with our approval. There seems to be some question as to whether or not the Commission should go ahead with testimony this morning on this matter or not. It would be, I think, poor judgement to allow a portion of testimony to go in now and leave it hanging, dangling, until a continuation of the hearing and it is our suggestion that after

all the views are expressed that the matter be set over to the December hearings, let the Committee as appointed re-read Mr. Spurrier's directions of September 24th in connection with the Rule 407 as attached to that letter, let the Committee come back at the December hearing, make its suggestion and then the entire matter can be decided with the conclusion of testimony at that hearing.

MR. SPURRIER: Mr. Dailey.

MR. DAILEY: Perhaps some of the members are opposed to 80 acre spacing and that they think that by writing any rule like this it would be favoring something that actually they are opposed to. In other words it would put them in a position where they could present a Committee report that is a workable rule and it would prevent them from testifying against the adoption of such a rule.

MR. SPURRIER: Anyone else?

MR. MC KELLAR: I would like to, in defense of the Committee members that differ with me, that are not here, I would like to point out that it is perfectly feasible for reasonable minds to differ on anything that is written down. If it was not we lawyers would be hard pressed to making a living. We would have to go back to engineering.

MR. SELINGER: That may be the trouble of the oil business today.

MR. MC KELLAR: Those men are conscientious as well as Christy and Foster and myself in wanting to represent the clients

and serve the Commission. We simply disagree among ourselves as to what the instructions were. We read those things more than a casual glance, I am sure. I do want the Commission to give us something else to work on or discharge us as it is we didn't agree on the - - what the mandate is. We read those things.

MR. SPURRIER: Incidentally, I don't know that it is a point that is too serious but the Governor could not be here today because he had a meeting of the Canvassing Board. Does anyone else have a comment in the case? As far as the Commission is concerned anyone that cares to put in testimony in this record may do so, the choice is yours. If you want to take Mr. Selinger's suggestion that is up to you. If you do not we are ready to take the testimony.

MR. FOSTER: This case will be heard in December, will it not?

MR. SPURRIER: The Commission said it will, December 16th we will continue the case to that date for receiving further testimony and/or the recommendations of this Advisory Committee.

MR. FOSTER: I came here, of course, prepared to put on some testimony. I didn't know about this telegram until I got here. I brought a witness here but I don't want to take up the Commission's time to do it when it might not be as effective as if we waited until the December hearing.

MR. SPURRIER: Judge Foster, only as a suggestion I mention the fact that Governor Mechem could not be here.

MR. FOSTER: Yes.

MR. SPURRIER: Perhaps you would like to have a full Commission hear this case.

MR. FOSTER: I would indeed, I would like to have a full Commission because we would just have to repeat it again so that everyone would know what the record is. I realize that some members of the Commission don't have time to read these records.

I believe as far as Phillips is concerned we will just not put on any testimony now if that is really going to be set for hearing on the 16th of December. Is the fact that you're going to set it does that include a statement that in all probability it won't be continued again.

MR. SPURRIER: I don't believe we could rule on that, Judge, it depends upon the testimony and the recommendations of that Committee, I suppose.

MR. FOSTER: Of course it is obvious to me that if the Committee members are going to maintain the attitude that they have about what their directive is from this Commission that you're not going to get any report out of this Committee that is going to be of any help to this Commission or anybody else. So, I just wanted to get that in the record. I like to look at these things realistically, not just be kidding myself here about anything. We are very much in earnest about this temporary 80 acre rule. As far as I am concerned personally and as far as Phillips Petroleum Company is concerned we just can't see how anybody could have any reasonable objection to a temporary rule. Certainly

no one would contend, it seems to me, that if one well will adequately and economically drain 80 acres that you ought to drill two wells on it. I just can't find any basis in my reading or thinking for anybody to be opposed to a temporary order. In view of that it seems to me that the only question to be considered is just what kind of a temporary order you are going to have, not whether you are going to have one or not. That, I thought, was to be the function of the Committee. If the Committee can get together and discuss that thing I am sure, on that basis, I mean, if we could get all the Committee members to approach it on that basis it seems to me we ought to come up with some recommendations. Maybe we will be divided numerically three and three on some matters, four and two on others, and five and one on others. It seems to me that this Commission will now make it clear to all members of this Committee that they are not to consider whether we are going to have 80 acre temporary order or not but what kind of an 80 acre temporary order we are going to have. Maybe three of us here who represent these predatory interests will be able to convince the other members of this Committee that they ought to sit down across the table with us and discuss a problem that is in my opinion and in a lot of the operator's opinions of a very serious nature to the real interest of the State of New Mexico. This isn't any laughing matter. I believe that if you can get a fellow to listen to you long enough you can make a little headway sometimes. Sometimes it seems like you have to get him to listen too long but in any event I believe that with the help

of the Commission now and directing these other members and asking them to call it within a reasonable length of time too -- the matter has dilly dallied along here for nearly 60 days before they called a meeting. They didn't consult with anybody as to what would be their convenience about a date, they just set it down and said "You be there". It just so happened that some of us could not be there because of previous committments. I believe that we should take all these things into consideration and make one more effort here to see if we can get something out of this Committee and maybe it might be of some help to the Commission. On that basis as far as Phillips is concerned we will just forego the presentation of any testimony at this time but I don't want to be understood as agreeing to any more continuances of this thing. We would like to get it heard. It looks like 90 days ought to be long enough.

MR. SPURRIER: Anyone else? I might say, in line with the Judge's suggestion, that I believe the Commission's letter instructing the Committee is pretty clear.

MR. FOSTER: I think it is crystal clear. I don't see how anybody could misconstrue it but apparently they did.

MR. SPURRIER: Anyone else? If not the case will be continued to the definite date of December 16, the next regular hearing.

MR. BALLOU: Before you go on that, Mr. Spurrier, the Sun Oil Company is still in the process of attempting to complete the well we mentioned at the September hearing. We hope sometime to

to be able to complete that well. It would be considerable help to Sun Oil Company to know whether we are going to have a diagonal rule or whether you can offset on the next 40 or what kind of rule you are going to have. We would like to urge that this thing be brought up and decided on at the December 16th hearing, so that we will know how to proceed with development if and when we complete this well. We think that the proposed rules are reasonable and it is something that everyone can abide by,if it is later proven that one well will not drain 80 acres you can go back to 40. Once you drill on 40 you can't undrill and put them on 80's.

MR. SPURRIER: Anyone else?

MR. BROWN: Brown, with Sun Oil. I have come to all these meetings and I have yet to find out who we are arguing about. It seems that everyone that comes says we want the rule. We just keep continuing. Nobody is objecting very seriously to anything. I would like to know if it is the wind we're fighting or what?

MR. SPURRIER: Mr. McKellar, would you like to answer his question?

MR. MC KELLAR: I don't want to seem as Mr. Moderator. I am not representing Mr. Hanners under any circumstances. No, seriously, I think possibly one reason that the opposition is not actively here is because working through their Committee members they are laboring under the impression that the matter will be continued. The Chairman submitted the recommendations

to the Commission and I certainly think in all fairness to those people that the Commission has no alternative other than to continue the matter. The first month we realized that such a controversial problem could not be decided, then the Commission appointed a Committee and the Committee Chairman recommended that the thing be continued to this time. The word went out and so the opposition, if that is the way you want to speak of it, at least the ones that probably are not here because of the fact that the Committee was appointed and their representatives on the Committee probably told them that it was recommended that the matter would be continued. There are some that oppose it.

MR. SPURRIER: Anyone else? We will take a five minute recess.

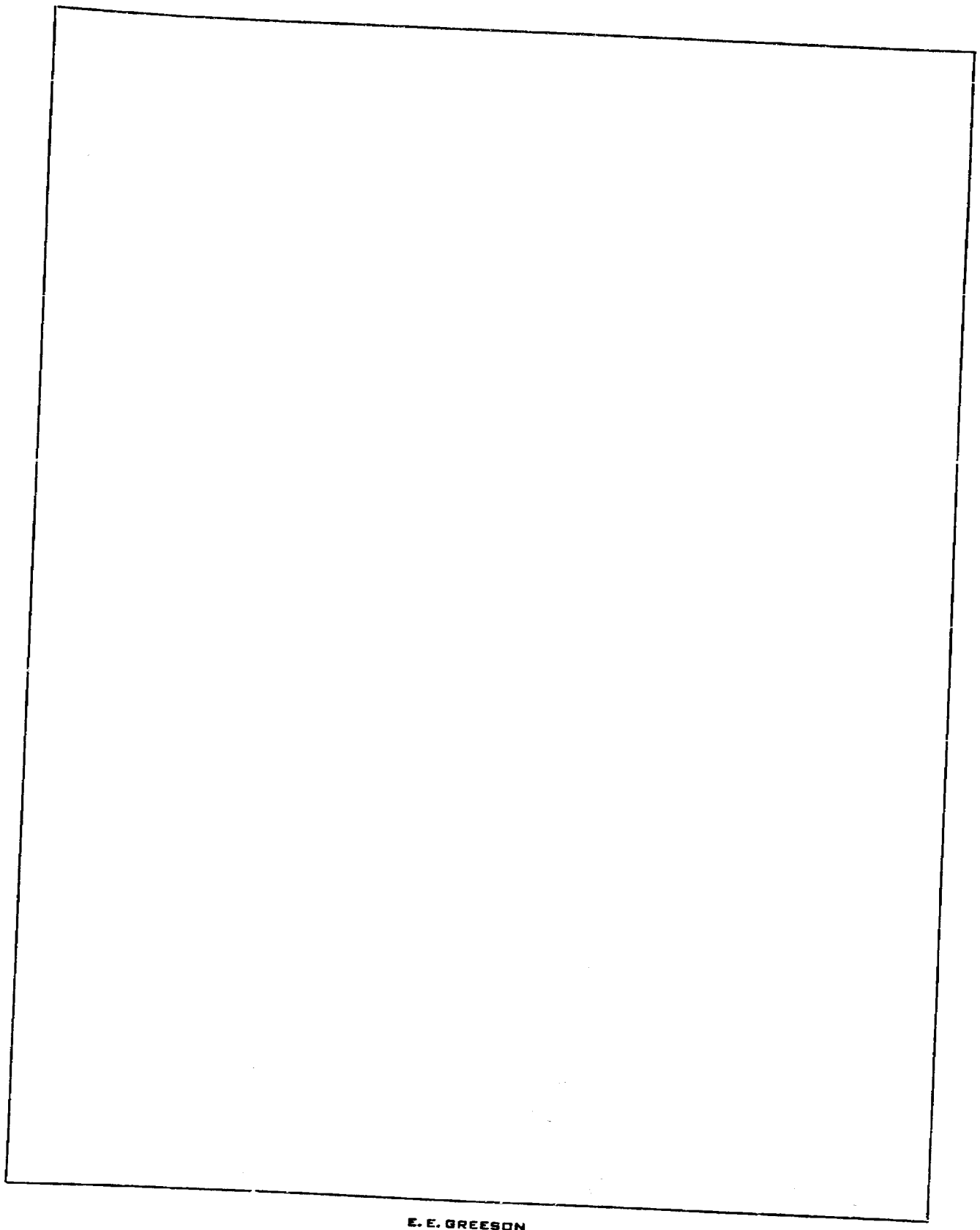
(Recess.)

STATE OF NEW MEXICO)
:
COUNTY OF BERNALILLO)

I HEREBY CERTIFY that the foregoing and attached transcript of hearing in Case No. 407 before the Oil Conservation Commission, State of New Mexico, at Santa Fe, on November 20, 1952, is a true and correct record of the same to the best of my knowledge, skill and ability.

DATED at Albuquerque, New Mexico, this 29th day of November, 1952.

Ada Dearnley
REPORTER



E. E. GREESON
ADA DEARNLEY
COURT REPORTERS
BOX 1393
PHONES 5-9422 AND 5-9546
ALBUQUERQUE, NEW MEXICO

BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

Santa Fe, New Mexico
March 17, 1953

TRANSCRIPT OF HEARING

CASE NO. 407

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
MAR 3 1953

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 12, CROMWELL BLDG
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ALBUQUERQUE, NEW MEXICO

is not here and Mr. Smith has made a motion to continue. Without objection that is what the Commission will do. The case will be continued to the regular April hearing, April the 17th.

REPORTER'S CERTIFICATE

I, ADA DEARNLEY, Court Reporter, hereby certify that the foregoing pages, numbered 1 and 2, constitute a complete and accurate record of the proceedings before the Oil Conservation Commission of New Mexico, in Case No. 407, on March 17, 1953, to the best of my knowledge, skill and ability.

Ada Dearnley
REPORTER

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

March 17, 1953

In the Matter of)
)
Case No. 407.)

TRANSCRIPT OF HEARING

MR. SPURRIER: The next case on the docket is case 407.

(Notice of Publication read by Mr. Graham)

MR. SPURRIER: Is there anyone here in case 407? If not, I guess I will have to dismiss it.

MR. McDOWELL: It was our understanding it was to be continued until the April hearing.

MR. SPURRIER: I don't believe our records show anything to that effect.

MR. SMITH: I make a motion that the case be continued.

MR. SPURRIER: Any objection to Mr. Smith's motion? Mr. Foster, did you wish to say something?

MR. FOSTER: E. H. Foster, representative of Phillips Petroleum Company. I am advised that the Governor couldn't be here for the hearing today and that the case would be continued. I don't know whether my information is wrong or not, but that is a statement for the record for whatever it is worth. I certainly don't want to see the case dismissed.

MR. SPURRIER: Very well, it is apparent that the Governor

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BEFORE THE

OIL CONSERVATION COMMISSION

STATE OF NEW MEXICO

TRANSCRIPT OF PROCEEDINGS

CASE NO. 407

October 15, 1952
Regular Hearing

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
OCT 30 1952

E. E. GREESON
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BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

Santa Fe, New Mexico

October 15, 1952

In the Matter of:

(Continued from September 16 hearing)
The Commission's motion for extension of Section 'G', Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary 80-Acre Proration Units. Case: 407

TRANSCRIPT OF HEARING

(Notice of publication read by Mr. Graham.)

MR. SPURRIER: Anyone to be heard? Judge Foster.

MR. FOSTER: I don't know whether everybody knows it or not, but there was a Committee appointed to study the proposal and make its recommendation at this meeting. I am not the chairman of that Committee, I am just one of the members, but I just want to say there has been no Committee Meeting and I assume that there probably will be, and there will be some sort of report available for action by the Commission at the next hearing. I don't know. You might advise everybody who is on that Committee.

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 105-106, EL CORTEZ BLDG.
PHONES 7-9546 AND 8-9546
ALBUQUERQUE, NEW MEXICO

MR. SPURRIER: I will be glad to. I have a letter here from the Chairman of the Committee, Harry Leonard, dated October 6th. Incidentally, the members of that Committee are Judge Foster, R. S. Christie, Ed McKellar, G. T. Hanners and Jack Danglade. Here is what Mr. Leonard says on October 6th:

(Letter read.)

MR. SPURRIER: Does anyone have a comment on this case, or is there any testimony to be introduced, at this time?

MR. McKELLAR: I don't have any testimony to be introduced, but I would like to request on behalf of Magnolia that the matter be continued until the next hearing, which would be the November 13th hearing.

MR. SPURRIER: November 20th.

MR. McKELLAR: We are very much desirous of finishing this matter up at the earliest possible date. I see, personally, no reason why it should be continued until sometime in the spring. I would like to have the matter continued to the next meeting and be prepared, at that time, to put on some testimony.

MR. SPURRIER: In view of the indefinitness of this letter, the Commission, on its own motion, yesterday moved to continue the case to the November 20th hearing, a definite date.

MR. FOSTER: Will it be considered at that time?

MR. SPURRIER: Yes, sir.

MR. FOSTER: Has the chairman been notified that it will be continued to November?

MR. SPURRIER: No, but he will be notified, so will all the members of the Committee. Obviously the Committee should meet before the next hearing. Is there any further comment?

MR. SPELLMAN: I wonder if I might read into the record a comment I have.

D. K. Spellman. The Ohio Oil Company urges the adoption of the rule proposed by the Oil Conservation Commission for the establishment of temporary 80-acre proration units applicable to new oil pools discovered at depths exceeding 10,000 feet. We believe also that the proposed rule should be so written that it establishes some uniform pattern for the development. That is, it should specify that wells should be drilled in alternate 40-acre locations to the discovery well. For example, assuming that the discovery well is drilled in the northwest quarter of a quarter section, then other wells must be drilled in either northwest quarters or southeast quarters of each quarter section for as long as the 80-acre proration units are maintained within the pool. We believe also that the proposed rule should specifically permit 80-acre units to be so assigned that they may be elongated in a north-south direction or an east-west direction, at the operators discretion.

MR. SPURRIER: Anyone else? If not, we will move on to Case 410.

STATE OF NEW MEXICO)
: SS.
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, hereby certify that the above and foregoing transcript of proceedings in Case No. 407, taken before the Oil Conservation Commission on October 15, 1952, at Santa Fe, New Mexico, is a true and correct record.

Dated in Albuquerque, New Mexico, this 22nd day of October, 1952.

Notary Public

My Commission Expires:
June 19, 1955.

E. E. GREESON
ADA DEARNLEY
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BEFORE THE

OIL CONSERVATION COMMISSION

STATE OF NEW MEXICO

TRANSCRIPT OF PROCEEDINGS

CASE NO. 407

September 16, 1952
Regular Hearing

ADA DEARNLEY & ASSOCIATES
COURT REPORTERS
ROOM 12, CROMWELL BLDG
PHONES 7-9545 AND 5-9546
ALBUQUERQUE, NEW MEXICO

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO.
RECEIVED
OCT 2 - 1952

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

SEPTEMBER 16, 1952

- -

In the Matter of:

The application of the Commission, upon its own motion, for an order extending Section "G", Oil Proration and Allocation, to provide for the addition of Rule 508, Establishment of Temporary 80-Acre Proration Units. In principle, this suggests the establishment of 80-acre proration units for wildcat wells completed as oil wells with a pool depth range of 10,000 feet or more, and includes further stipulations (as legally advertised in all oil-producing counties of New Mexico).

Case No. 407

- -

(Notice of Publication read by Mr. Graham.)

MR. MACEY: I don't think there is any necessity of reading in proposed rules. As far as advertisement, am I right to assume the case is continued?

MR. SPURRIER: Has someone made application for this case to be continued? Is there objection to continuing the case?

MR. HOLLOWAY: In event this is continued, as I am presuming it will be, may the record show that Tide Water recommends the adoption of this rule. We may not have a representative at the next hearing.

MR. C. R. BICKEL: Mr. C. R. Bickel, representing Shell. I would like to make a statement in this connection. Shell Company favors the adoption of the rule. It is our view that the proposed rule would encourage the development of deeper fields and take care of controversial space problems that come before this Commission. Many of the controversies have been more over how to protect the equities of the dry wells drilled on 40 acre spacing and how to work out 80 acre units than over the desirability of 80 acre spacing. The proposed rule should reduce such controversy and it is our hope the Commission will see fit to adopt it.

MR. HOLLOWAY: Due to the fact that interested parties have not had opportunity to review the case I suggest the Commission detain the case to a later date.

MR. A. R. BALLOU: Ballou. Mr. Spurrier, when will this be continued to, the next regular meeting?

MR. SPURRIER: Yes, October 15.

MR. BICKEL: Shell Oil Company would like to go on record at this hearing as favoring the adoption as we understand the rule to be written on the temporary basis and evidence to be presented after a sufficient number of wells have been drilled to determine the spacing pattern.

MR. SPURRIER: Anyone else?

MR. R. S. CHRISTIE: Christie, Amarada. We wish to urge the adoption of the rule as written and in the event we are not present at the meeting as continued we would concur in Mr. Holloway's

suggestion.

MR. M. I. TAYLOR: Taylor, representing Gulf. We would like to go on record as favoring the proposed rule.

MR. J. H. RICHTER: J. H. Richter, representing Atlantic. We approve of the recommended adoption of the proposed rule as it is. We feel it is a very definite step in the exploration, of encouraging the exploration of the deeper pays. There are several advantages we would like to list. It is pretty obvious wider spacing is necessary for quick definition of reservoirs. It would aid in faster development. Such things involved as risk in drilling these wells, precludes closer drilling until reservoirs are defined and the possibility of such wells not paying out. We feel exploration will be encouraged. You can always go to 40 acres from 80 acres but can not enact the reverse. It would also save casing, and other materials vitally needed would be saved for future exploration work and would help the national steel shortage.

That is all I have.

MR. SPURRIER: Anyone else?

MR. W. E. HUBBARD: I would like to go on record as favoring the rule for the reasons given here this morning.

MR. E. H. FOSTER: Mr. Foster, I'd like to go on record as being - - Phillip's Company - - as being in favor of the rule.

MR. SPURRIER: Anyone else, anyone opposed?

MR. CAMPBELL: Are we having the hearing now? I thought it was going to be continued.

MR. SPURRIER: We would like for the people here to be heard now that want to be heard. The Commission would like to know if there is an objection to setting a time limit not only on the number of wells but a time limit on whichever should come first, for example, 18 months.

MR. BALLOU: In that connection I would like to say that we have an expense with a well below 10,000 feet in southeastern New Mexico now, Sun Oil Company does. The time limit, you may not be able to get 5 or 6 wells drilled and you may not be able to accumulate any appreciable engineering data on which to write permanent rules. If you set too short a time limit this well that we are trying to make produce now - - I think the company has been fooling with it five or six months, and somebody else five or six months before we did.

MR. GRAHAM: You favor a reasonable time.

MR. BALLOU: I suppose 18 months may not be unreasonable. After a first well is drilled you can usually get the other well drilled a little faster. I would just like to point out some of

these deep wells require an awful lot of time and should be taken into consideration.

MR. McKELLAR: I didn't intend to make a statement at this time. I wanted to reserve my remarks to the final hearing. Since you are considering the time we strongly support in favor of this recommendation. On the time element, 18 months would be highly unreasonable in that it takes 6 months to drill and complete deep wells and then you have to go over your studies, your logs, geology and all those problems have to be considered and decided where you are going to drill your next location. Three or four months elapsed and another six months, and at the end of 18 months you probably won't have over 2 or 3 wells. Now if you are going to go about this with some system connected with it, which I was led to believe, you have to have pressure surveys and exhibits, the Commission has seen presented in these cases before them. I don't know what the position of Magnolia would be on the time limit, but I think it would be better to leave it open. The companies have to drill in order to maintain their leases and if they don't get 5 wells in it will be probable because they have drilled some unproductive wells and 2 years or so elapses. You can call a hearing and let the company show why they should be granted additional time. I would like to see it left open. You can tell when a company is not going about the job properly, but I would rather see it left open.

MR. SPURRIER: With no number of wells received.

MR. McKELLAR: Put your five wells on, or whatever you decide.

I think five would be sufficient to give you some indication of what you have. You can run your pressure surveys and get an idea of what the structure is and determine how you should proceed from then on. It may be in some cases you may want to do it in less than five.

MR. CAMPBELL: May I ask the Commission if it is the intention to grant to these first five wells an allowable based upon the present 80 acre formula. Is that the thought the Commission has in mind in connection with this proposal?

MR. SPURRIER: That is the thought I had in mind. Anyone else? If not the case will be continued to October 15, and we will circulate a revised rule. In fact, it will be a revision of this proposal you received this morning.

MR. FOSTER: You say you are going to circulate a revised rule. Do you have in mind what the revision will be?

MR. SPURRIER: The proposed rule I don't exactly.

MR. FOSTER: You have in mind what you are going to revise about it? Can you tell us now?

MR. SPURRIER: No, sir.

MR. FOSTER: How do you know you want to revise it?

MR. MACEY: It might be possible we would want to put in a jurisdiction clause.

MR. SPURRIER: We have taken testimony here not sworn but Mr. Campbell has his opinion and a few others. I don't feel that this proposal will necessarily stand. I am not saying it will be changed but I think it will.

MR. FOSTER: I am just asking to be informed in what way this proposal will be changed. I just want to know in what particulars you are going to change it, and what the jurisdiction question is that is involved.

MR. SPURRIER: My answer was I don't know.

MR. FOSTER: Has someone raised a jurisdiction question about this matter? I didn't hear any jurisdiction question raised about it. I just wanted to have something to be thinking about. If you are going to change the thing and know now you are going to change it, it just occurred to me you probably had something in mind you are going to change and if you have I want to hear about it.

MR. SPURRIER: The next case on the docket is Case No. 309.

STATE OF NEW MEXICO)
:
COUNTY OF BERNALILLO)

I HEREBY CERTIFY that the foregoing and attached transcript of hearing in Case No. 407 before the Oil Conservation Commission, State of New Mexico, at Santa Fe, on September 16, 1952, is a true and correct record of the same ot the best of my knowledge, skill and ability.

DATED at Albuquerque, New Mexico, this 25th day of Sept., 1952.

Marianna Meier
REPORTER

PETROLEUM PRODUCTIVE CAPACITY

A Report of

THE

NATIONAL PETROLEUM COUNCIL

1 9 5 2

PETROLEUM PRODUCTIVE

PETROLEUM PRODUCTIVE CAPACITY

A Report on

PRESENT AND FUTURE SUPPLIES OF OIL AND GAS

Presented by the

COMMITTEE ON OIL AND GAS AVAILABILITY

on **JANUARY 29, 1952** *to the*

NATIONAL PETROLEUM COUNCIL

Permission to reprint all or part of this report will be readily granted upon request to the Secretary-Treasurer, National Petroleum Council, 601 Commonwealth Building, Washington 6, D. C.

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NATIONAL PETROLEUM COUNCIL

1625 K STREET, N. W.
WASHINGTON 6, D. C.

January 29, 1952

Honorable Oscar L. Chapman
Secretary of the Interior and
Petroleum Administrator for Defense
Washington, D. C.

My dear Mr. Secretary:

Pursuant to the request of Mr. H. A. Stewart, Director of the Oil and Gas Division, the Department of the Interior, dated December 1, 1950, that the Council make a new and comprehensive study of present and probable future petroleum productive capacity and availability to the United States, I have the honor to transmit to you herewith a report on petroleum productive capacity, a report on present and future supplies of oil and gas, which was prepared by the Committee on Oil and Gas Availability and unanimously approved by the Council on January 29, 1952.

In the preparation of this report the Council has kept actively in mind the importance of the assignment, as expressed in the following quotation from Mr. Stewart's letter of December 1.

> "In view of the present situation and because of the significance of oil and gas to national security and defense, it is a matter of public importance that a new and even more comprehensive study of oil and gas productive capacity and availability be prepared.
>
> "Therefore, I request that the Council make a new and comprehensive study of present and probable future petroleum productive capacity and availability to the United States, including gas as well as liquid petroleum, foreign as well as domestic sources, and that the Council submit the results of this study with such recommendations as it deems appropriate at the earliest possible date."

The major finding of the Council's study as summarized briefly in the report is as follows:

> "Available supplies of oil and gas in the United States and the world are greater than ever before and are still increasing rapidly. Granted continuation of reasonable economic incentives and adequate supplies of materials, crude oil and natural gas may be counted upon to be available in abundance for the foreseeable future."

The results of the committee's comprehensive study and the conclusions which have been approved by the Council are presented to you in the interest of national security and defense and I believe to be a matter of public importance.

Respectfully submitted,

/s/ WALTER S. HALLANAN

Walter S. Hallanan, Chairman
National Petroleum Council

UNITED STATES
DEPARTMENT OF THE INTERIOR
OIL AND GAS DIVISION
WASHINGTON 25, D. C.

December 1, 1950

Mr. Walter S. Hallanan, Chairman
National Petroleum Council
1625 K Street, N.W.
Washington, D. C.

Dear Mr. Hallanan:

In his letter to you of June 14, 1949, the Secretary of the Interior requested the National Petroleum Council to consider the problem of providing a substantial domestic reserve productive capacity to be available in the event of an emergency. The Council appointed a committee which prepared a valuable report, dated January 26, 1950, entitled "U. S. Crude Petroleum Productive Capacity."

In view of the present situation and because of the significance of oil and gas to national security and defense, it is a matter of public importance that a new and even more comprehensive study of oil and gas productive capacity and availability be prepared.

Therefore, I request that the Council make a new and comprehensive study of present and probable future petroleum productive capacity and availability to the United States, including gas as well as liquid petroleum, foreign as well as domestic sources and that the Council submit the results of this study with such recommendations as it deems appropriate at the earliest possible date.

Sincerely yours,
/s/ H. A. STEWART
H. A. Stewart, Director

Houston, Texas
January 29, 1952

Mr. Walter S. Hallanan, Chairman
National Petroleum Council
Washington, D. C.

Dear Mr. Hallanan:

Transmitted herewith is the final report of the Committee on Oil and Gas Availability appointed by the National Petroleum Council. The report has been prepared in response to a request made of the National Petroleum Council by Mr. H. A. Stewart, Director of the Oil and Gas Division of the United States Department of the Interior. Mr. Stewart requested, in his letter of December 1, 1950, that a study be made of "present and probable future petroleum productive capacity and availability to the United States, including gas as well as liquid petroleum, foreign as well as domestic sources."

A section of the study relating to the availability of oil and gas during the period 1951 through 1955 was submitted by this committee to the National Petroleum Council in an interim report dated July 24, 1951. The figures on availability of foreign oil included in that report have been revised to reflect accelerated completion of facilities in the Middle East as a result of the Iranian dispute.

The data contained in this report indicate that availability of all oils in the United States, under maximum efficient rates of production, is expected to rise from 7,300,000 barrels daily in January, 1951, to a figure within a range of 7,789,000 to 8,838,000 barrels daily by 1955. Corresponding figures for all foreign areas, exclusive of Russian-dominated countries, show an expected availability by 1955 within the range of 6,669,000 to 7,427,000 barrels per day, compared to an availability of 4,703,000 barrels per day in January, 1951. These statistics indicate that the total availability of the areas considered in this report was 12,003,000 barrels daily in January, 1951, and that this availability may be expected to range from 14,458,000 to 16,265,000 barrels daily by 1955, assuming maximum efficient rates of production.

The committee's estimates dealing with natural gas show that actual production in 1950 was 6.9 trillion cubic feet and that the range of availability is expected to be between 9.5 and 11.9 trillion cubic feet in 1955. Since the limiting factor on utilization of natural gas is the capacity of transportation facilities, these projections are deliberately conservative.

The foregoing estimates made by this committee are predicated upon a continuation of economic incentives, maintenance of conservation practices, adequate supplies of materials and manpower, and no changes in federal tax provisions and regulations with respect to petroleum production.

The outlook for petroleum supplies in the long-term view is favorable. Analyses and studies made by this committee reveal that, with continuing demand for petroleum products,

reasonable economic incentives, and a favorable climate for private investment, further worldwide increases in availability of petroleum may be expected for many years in the future. This report recognizes the prospects for development of new sources of energy and that the fuel needs of the nation for purposes of national security and economic progress can best be served by competition. With particular reference to petroleum supplies, however, additional large land areas upon which the prospects for future petroleum production are favorable are known and the industry's technology for finding and developing oil which has advanced markedly can reasonably be expected to continue its advancement. These elements of physical existence and improved techniques operating within an economic framework which embraces continued freedom in private competitive enterprise assure ample supplies of petroleum within the foreseeable future.

Respectfully submitted,

/s/ L. F. McCOLLUM
L. F. McCollum, Chairman
NPC Committee on Oil
and Gas Availability

PETROLEUM PRODUCTIVE CAPACITY

A Report on

PRESENT AND FUTURE SUPPLIES OF OIL AND GAS

Presented by the

COMMITTEE ON OIL AND GAS AVAILABILITY

on **JANUARY 29, 1952** *to the*

NATIONAL PETROLEUM COUNCIL

Permission to reprint all or part of this report will be readily granted upon request to the Secretary-Treasurer, National Petroleum Council, 601 Commonwealth Building, Washington 6, D. C.

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1625 K STREET, N. W. WASHINGTON 6, D. C.

THE NATIONAL PETROLEUM COUNCIL

The purpose of the National Petroleum Council is to advise or inform the Secretary of the Interior or the Director of the Oil and Gas Division with respect to any matter relating to petroleum or the petroleum industry submitted to it by or approved by the Secretary or Director. During the existence of the Petroleum Administration for Defense, the Council has an additional purpose of advising or informing the Petroleum Administrator or the Deputy Administrator with respect to any matter relating to petroleum or the petroleum industry submitted to it by or approved by the Administrator or the Deputy Administrator.

NATIONAL PETROLEUM COUNCIL

1625 K STREET, N. W.
WASHINGTON 6, D. C.

January 29, 1952

Honorable Oscar L. Chapman
Secretary of the Interior and
Petroleum Administrator for Defense
Washington, D. C.

My dear Mr. Secretary:

Pursuant to the request of Mr. H. A. Stewart, Director of the Oil and Gas Division, the Department of the Interior, dated December 1, 1950, that the Council make a new and comprehensive study of present and probable future petroleum productive capacity and availability to the United States, I have the honor to transmit to you herewith a report on petroleum productive capacity, a report on present and future supplies of oil and gas, which was prepared by the Committee on Oil and Gas Availability and unanimously approved by the Council on January 29, 1952.

In the preparation of this report the Council has kept actively in mind the importance of the assignment, as expressed in the following quotation from Mr. Stewart's letter of December 1.

> "In view of the present situation and because of the significance of oil and gas to national security and defense, it is a matter of public importance that a new and even more comprehensive study of oil and gas productive capacity and availability be prepared.
>
> "Therefore, I request that the Council make a new and comprehensive study of present and probable future petroleum productive capacity and availability to the United States, including gas as well as liquid petroleum, foreign as well as domestic sources, and that the Council submit the results of this study with such recommendations as it deems appropriate at the earliest possible date."

The major finding of the Council's study as summarized briefly in the report is as follows:

> "Available supplies of oil and gas in the United States and the world are greater than ever before and are still increasing rapidly. Granted continuation of reasonable economic incentives and adequate supplies of materials, crude oil and natural gas may be counted upon to be available in abundance for the foreseeable future."

The results of the committee's comprehensive study and the conclusions which have been approved by the Council are presented to you in the interest of national security and defense and I believe to be a matter of public importance.

Respectfully submitted,

/s/ WALTER S. HALLANAN

Walter S. Hallanan, Chairman
National Petroleum Council

UNITED STATES
DEPARTMENT OF THE INTERIOR
OIL AND GAS DIVISION
WASHINGTON 25, D. C.

December 1, 1950

Mr. Walter S. Hallanan, Chairman
National Petroleum Council
1625 K Street, N.W.
Washington, D. C.

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The foregoing estimates made by this committee are predicated upon a continuation of economic incentives, maintenance of conservation practices, adequate supplies of materials and manpower, and no changes in federal tax provisions and regulations with respect to petroleum production.

The outlook for petroleum supplies in the long-term view is favorable. Analyses and studies made by this committee reveal that, with continuing demand for petroleum products,

reasonable economic incentives, and a favorable climate for private investment, further worldwide increases in availability of petroleum may be expected for many years in the future. This report recognizes the prospects for development of new sources of energy and that the fuel needs of the nation for purposes of national security and economic progress can best be served by competition. With particular reference to petroleum supplies, however, additional large land areas upon which the prospects for future petroleum production are favorable are known and the industry's technology for finding and developing oil which has advanced markedly can reasonably be expected to continue its advancement. These elements of physical existence and improved techniques operating within an economic framework which embraces continued freedom in private competitive enterprise assure ample supplies of petroleum within the foreseeable future.

Respectfully submitted,

/s/ L. F. McCOLLUM

L. F. McCollum, Chairman
NPC Committee on Oil
and Gas Availability

FOREWORD

This report has been prepared at the request of the Oil and Gas Division of the Department of Interior. It summarizes an intensive study by hundreds of experts in the oil industry over a period of a year and represents the best judgment of the industry as to the future.

The report answers recurrent fears that we are running out of oil. It concludes that abundant supplies of crude oil and natural gas may be counted upon for the foreseeable future granted continuation of reasonable economic incentives and adequate supplies of materials. The outlook is for an increasing supply of oil and gas in the United States.

Supplies of oil and gas in the United States in 1950 were nearly three times as much as in 1925. They have accounted for all of the increase in energy used in the United States during this time, while coal has remained at a static level. Oil and gas supplied substantially more energy than coal in 1950 despite the common view that resources of oil and gas are smaller than those of coal.

The report describes large areas favorable for accumulation of oil in the earth in the United States and in foreign countries. About 80 per cent of the surface of the United States is considered favorable for petroleum deposits. This area is about a hundred times as large as the area proved productive by all discoveries to date. Available evidence proves that large additional discoveries of oil and gas may be expected both in presently producing areas and in prospective areas.

The discovery of oil has been related to the amount of exploration and drilling. Currently the industry is devoting more effort than ever before to such work. It is spending several billion dollars a year in exploration and drilling and continuing to achieve large discoveries through this work.

Improved technology has added greatly to the ability of the industry to supply oil and gas. New methods have been devised to locate specific areas in which oil may have accumulated. Drilling equipment has been improved so that wells can now be carried as deep as four miles into the earth. In 1951 the industry was drilling about 475,000 feet a day, equivalent to more than 90 miles into the earth each day. This search for and development of oil is finding substantial new deposits.

The report shows a substantial increase in available supplies based merely on continuing the current rate of drilling. By 1955 supplies are expected to be greater than in January 1951 by not less than 1,324,000 barrels daily in the United States and 2,171,000 barrels daily in foreign areas outside of those dominated by Russia. This minimum expectation is almost equal to the increase in production in the five-year period from 1946 to 1951. Under favorable conditions the increase in available supplies during the next few years will be much larger.

The major conclusion of the report is as follows:

> "The United States and the world can count upon increasing supplies of oil and gas not only for the next few years but for the foreseeable future provided that reasonable economic incentives, adequate materials, and a favorable climate for private investment prevail."

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PETROLEUM PRODUCTIVE CAPACITY

A Report to the National Petroleum Council on Present and Future Supplies of Oil and Gas

Prepared by the Committee on Oil and Gas Availability

SECTION I—INTRODUCTION AND SUMMARY

More than a year has been spent in an intensive study of petroleum supplies. This study reviews present and future supplies, domestic and foreign, but with particular attention to the prospects for the United States. Thousands of hours of work have been spent on it by scores of experts in the industry. Numerous meetings have been held at various stages of the work. Well known experts, qualified by both training and experience, have taken part in the preparation of this report. Many of these men had worked on the report on availability prepared by the American Petroleum Institute in 1948 and the report issued by the National Petroleum Council on "U. S. Crude Petroleum Productive Capacity" in January 1950. As a result, this report reflects the best judgment of oil industry specialists who have studied this subject for years.

The major finding of our studies can be summarized briefly:

> **Available supplies of oil and gas in the United States and the world are greater than ever before and are still increasing rapidly. Granted continuation of reasonable economic incentives and adequate supplies of materials, crude oil and natural gas may be counted upon to be available in abundance for the foreseeable future.**

The facts and analyses which led to this conclusion are summarized in this introduction. The second section of the report deals with supplies expected through 1955. The final section deals with the long-term outlook, based on analysis of the main forces determining oil supplies.

Basis of the Present Report

On December 1, 1950, Mr. H. A. Stewart, Director of the Oil and Gas Division of the Department of the Interior, requested the National

Petroleum Council to make a "comprehensive study of present and probable future petroleum productive capacity and availability to the United States, including gas as well as liquid petroleum, foreign as well as domestic sources."

At a meeting in January 1951, this Committee was appointed by the National Petroleum Council to make a study of petroleum availability. The Committee divided its work into two major phases. The first dealt with supplies available now and the probable range through 1955. The second phase was a study of the long-term outlook.

Intensive studies were made of the range of available domestic and foreign supplies expected from 1951 through 1955. For the United States, the work was done for each of five major areas by groups of specialists. Both oil and natural gas were considered. The results of these area studies were reviewed and combined into national totals.

Foreign supplies were studied by major areas. The estimates have been presented by hemispheres, as the course of development among countries may change as new discoveries are made. Natural gas was not considered in foreign areas, although in time it may be an important source of energy.

Estimates of available domestic and foreign supplies through 1955 are presented in Section II.

The long-term outlook was studied by several different groups of specialists. They considered the natural occurrence of oil in the earth, technology, and economics. Separate reports by these groups were brought together into the composite summary presented in Section III.

Approach to the Problem

The study requested was undertaken as a scientific inquiry. We have worked to assemble, analyze, and evaluate all the data bearing on the problem. We have sought to give as full an answer as possible. Some questions, such as how much oil remains to be found, involve speculations about unknowns which make numerical estimates of questionable value, if not dangerously misleading. Consequently, the evidence available on this subject has been presented as an analysis of future prospects in order to avoid the dangers of speculative estimates.

Our study has been approached with full realization of its difficulties. We do not believe that in 1900 or 1925 the best informed opinion of the industry would have considered probable the actual developments which have taken place in petroleum. We know that as recently as 1946 industry experts were presenting to Government committees estimates of demand and supply which have already proved to be conservative. We know that a similar projection of available supplies made in 1948 by the American Petroleum Institute has been exceeded. These facts are

cited as a reminder of the difficulties of predicting what a dynamic industry can accomplish.

A consistent underestimating of the future is apparent in past estimates about the oil industry. It is natural that we should tend to be conservative in looking forward into an unknown future. Many of the forces that will shape that future are still to be determined by individuals and governments. A cautious view seems wise under such circumstances. We have tried in this study to be as realistic as possible. Still, the future may prove that we have been conservative in projecting how far and how fast we may move ahead.

Any estimate for the future must consider past experience. Future estimates are largely a projection of what we have learned in the past and what we know now. One fact stands out clearly from the oil industry's past; namely, the remarkable rate at which supplies have been increased. A backward glance at 1925 and 1900 shows the following changes in the production of mineral fuels in the United States. (See Table 1.)

The heat value of oil and gas produced in the United States more than tripled between 1925 and 1950. Domestic oil and gas supplies now exceed those of coal substantially in heat value. Thus, despite past fears that we had very little oil, a dynamic petroleum industry has been able to serve consumers well by a great increase in supplies in direct competition with other energy resources. If this change seems strange in terms of the common view that our resources of coal are much greater than those of oil, it is only because there has been confusion between potential resources and their actual economic availability.

The Meaning of Availability

An inquiry as to available supplies requires an answer in economic rather than physical terms. It must deal with the ability to supply a commodity at a price which makes it of value. The mere existence of a mineral in a natural state does not mean that it is available. Even known valuable minerals may be worthless because the cost of making them available is greater than their value.

A simple example proves that material existence is not the same as economic availability. A cubic mile of sea water has about $93,000,000 in gold and $8,500,000 in silver. These precious metals in the oceans are enough to make every person in the world a millionaire. They have not made us rich for a simple reason. The cost of extracting them exceeds their value. Thus, gold in the ocean is not available to us even though we know it exists. It might as well not exist unless technology develops enough so that we can recover it at a cost that makes it of real value.

TABLE 1

Mineral Energy Production in the United States*

	Coal Million Tons	Crude Oil Million Barrels	Gas‡ Billion Cu. Ft.	British Thermal Units—Trillions				Per Cent of Total		
				Coal	Oil	Gas	Total	Coal	Oil	Gas
1900.....	270	64	128	7,020	369	254	7,643	91.9	4.8	3.3
1925.....	582	764†	1,189	15,195	4,430	1,278	20,903	72.7	21.2	6.1
1950P.....	560	1,972†	6,124	14,542	11,438	6,583	32,563	44.7	35.1	20.2

* Bureau of Mines, Preprint from Minerals Yearbook 1950, *Coal—Bituminous and Lignite*, page 59. In this tabulation the Bureau of Mines has used revised values for heat content as follows: 26,200,000 B. t. u. per ton of bituminous coal and lignite, 25,400,000 B. t. u. per ton of anthracite coal, 5,800,000 B. t. u. per barrel of crude oil, and 1,075 B. t. u. per cubic foot of natural gas.

† Excludes production of natural gasoline in 1925 of 27 million barrels and of natural gas liquids in 1950 of 181 million barrels.

‡ Marketed production of natural gas.

P Preliminary.

Future available supplies of fuels have not been viewed generally in economic terms. In comparing future fuel resources of the United States, estimates of the total amount of coal and lignite underlying the surface of the United States have usually been compared with proved reserves of oil and natural gas. Such comparisons are meaningless. They fail to consider (1) whether the solid fuels are economically available and (2) potential petroleum resources that may be found in the future. The difference between estimates of coal reserves and those commercially available is expressed in the following statement:

> "One conclusion should be crystal-clear from this estimate of the coal reserves in the United States: Unless truly fantastic improvements in the state of the arts are achieved, our descendants will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc., that only unheard-of ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be." *

The petroleum industry almost always deals with known, recoverable reserves. Estimates of proved reserves are limited to that part of discovered oil which can be recovered by known methods and at present levels of costs and prices. None of the large quantities of oil known to exist in proved fields but not expected to be recovered by prevailing methods of production or at prevailing prices are counted as reserves. Reserve estimates are modified as development indicates more oil in place or more productive acreage, or experience demonstrates that improved technology, lower costs, or higher prices will permit greater recovery than previously expected. They are made field by field and are not approximations for large areas, as in the case of estimates of coal.

Failure to take into account economics has caused considerable confusion in thinking about available fuel resources. Coal and lignite have been stressed as far outweighing oil and gas, without any consideration of the costs of making them available to fuel-consuming areas. Potential supplies of oil and gas have been underestimated by considering only the presently proved reserves or conservative estimates, amounting to minimum figures of the lowest possible order of magnitude, of what may be found in the future.

Consideration of the fuel resources of the United States must face economic realities. In spite of past comparisons indicating much more coal available than oil and gas, the fact remains that oil and gas have been the source of all the increase in mineral energy produced in the

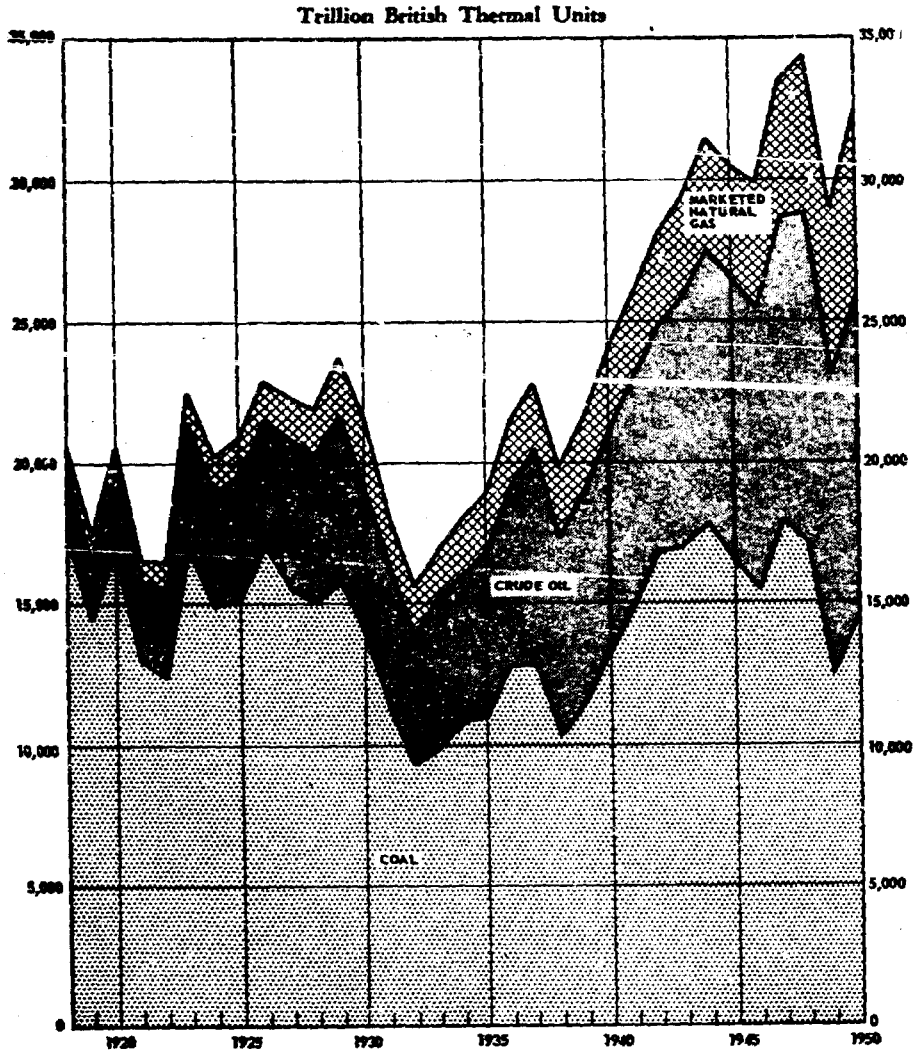
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* Zimmermann, Erich W., *World Resources and Industries*, Rev. Edition, page 462.

CHART I

U. S. Mineral Energy Production

Trillion British Thermal Units



United States since 1920 (See Chart 1). While proved reserves of petroleum have increased greatly, estimates of probable ultimate coal reserves have been reduced substantially. Such changes mean that the oil industry has been able to discover, develop, and deliver increased petroleum resources at attractive prices by comparison with competitive fuels. Thus, an inquiry as to future fuel supplies must concentrate on

the significant question of economic availability, not the theoretical question of potential resources. This study centers, therefore, on the prospects for continuing to find and develop new petroleum supplies at a cost that will permit or encourage their use.

The Record of Fuel Availability, 1900-1950

The rapid increase in availability of oil and gas relative to coal is evident from the record. In 1900 the availability of oil and gas was only 10 per cent as much as that of coal. By 1925, petroleum availability had increased ninefold and was nearly 30 per cent that of coal. During the past twenty-five years, coal availability has shown practically no increase while oil and gas more than quadrupled. As a result, petroleum now exceeds coal substantially in availability as well as in actual consumption. The figures on the availability of these fuels in volume and heat value are compared below:

TABLE 2

Availability of Coal, Oil, and Gas in the U. S.

	Coal and Lignite Capacity at 280 Days (Million Tons) *	Liquid Petroleum † (Million Barrels)	Natural Gas** (Billion cu. ft.)	Trillion B.t.u.‡	
				Coal & Lignite	Oil & Gas
1900.....	312	64	236	8,129	623
1925.....	810	791	1,189	21,173	5,857
1950.....	824	2,665	8,805	21,554	24,860

* Basic Data Relating to Energy Resources, Senate Committee on Interior and Insular Affairs, 1951, page 73, for bituminous coal and lignite. The latest capacity shown was for 1949 and that figure has been used for 1950. Capacity on anthracite coal was assumed to be the same as production shown on page 78.

† Production of crude oil in 1900 and crude oil and natural gasoline in 1925 considered to be at capacity; 1950 availability based on estimates for January 1951.

** Production of natural gas in 1900 and 1925 considered to be at capacity; 1950 availability represents the average of the upper and lower ranges of 1951 availability.

‡ Based on 26,200,000 B.t.u. per ton of bituminous coal and lignite, 25,400,000 B.t.u. per ton of anthracite coal, 5,800,000 B.t.u. per barrel of crude oil, 5,500,000 B.t.u. per barrel of natural gas liquids, and 1,075 B.t.u. per cubic foot of natural gas.

The great increase in availability of oil and gas has been achieved despite the low estimates of proved reserves. In September 1926, the Federal Oil Conservation Board reported that proved reserves were estimated at about 4.5 billion barrels or only about six times as much

as the annual rate of production at that time. Nevertheless, the United States did not run out of oil in six years. Recoverable proved reserves of crude oil and natural gas liquids at the end of 1950 were 29.5 billion barrels. The production of oil in the United States in the period 1926-1950 was 34 billion barrels. In other words, the 59 billion barrels of oil produced and added to reserves since 1926 are thirteen times as much as the estimate of proved reserves in 1926.

Forces Determining Availability

How has it happened that the availability of oil and gas has increased rapidly while that of coal lagged behind? The trend might have been expected to be the other way on the basis of views as to the potential resources of these fuels. The answer to this apparent paradox is simple. Availability of any mineral is determined more by economics and technology than by mere physical existence.

Supplies of a resource are determined by three factors: (1) natural existence, (2) technology, and (3) economic incentives.

If a material does not exist in nature, it cannot be made available. Even if a material exists in nature, its availability depends upon a technology capable of locating and supplying it at a price that causes it to be in demand. Finally, economic incentives are necessary to develop availability even after deposits, technology, and markets are established. Without adequate economic incentives, no new capital will be risked to locate or develop new deposits needed to supply future demands.

These three factors have been considered at length in the studies of this Committee and in the preparation of this report. In the final analysis, it is economics which makes an available resource out of natural deposits. The petroleum industry has been able to develop supplies of oil and gas in proportion to the demand. When economic depressions have brought about a decrease in demand, there has been a slowing down of the search for more oil. When the demand for oil and gas has advanced rapidly, the search for and development of petroleum resources has been increased. To date, development of new supplies has been closely related to the rate of drilling.

Despite increasing difficulty and expense of finding oil, the industry has been able to continue supplying its products at reasonable prices by means of improved techniques. The price of crude oil today is less than it was in 1920, although commodity prices generally are higher now than then. Whether such relation can continue will depend on the balance of forces at work on costs. Thus far technical progress has been a major factor in keeping the cost of oil low. Such progress may well continue to affect the long-term trend.

The Existence of Petroleum Deposits

Large areas are favorable for accumulation of oil in the earth, both in the United States and in foreign countries. The sedimentary area considered favorable for petroleum deposits covers about 50 per cent of the surface of the United States. Early in 1951 a symposium on the possible future oil provinces of North America conducted by the American Association of Petroleum Geologists showed that 1,660,000 square miles in the United States are considered to have prospects for future production. Part of the prospective area overlaps some parts of producing provinces, but the producing provinces have 200,000 square miles in addition to the 1,660,000 square miles included in the future prospective areas. The prospective area amounts to one billion acres, or about one hundred times as much as the area proved productive by all discoveries to date.

Some measure of the potentialities of the prospective petroleum provinces is indicated by the following:

1. Of the 34 provinces considered to have possibilities in 1941, 20 have already proved to have production during the past ten years.
2. In 43 of the 60 provinces listed in the 1951 symposium there are positive evidences of the existence of oil and gas, such as seepages, good showings in the wells drilled to date, or some actual production.
3. About 15 per cent of the area in the 60 provinces listed in the latest symposium is already under lease.

It should be noted that a long time is required to explore a province even after initial discovery of production. In Texas, major discoveries continue to be made regularly more than fifty years after the first impressive discovery at Spindletop. Many of the large fields in Texas, including the huge East Texas field, have been found since 1929. It was 1949 before the Spraberry Trend in West Texas began to be developed commercially, although it will probably prove to have the largest productive area of any field yet found in the United States. A few additional examples from many possible illustrations show that important discoveries continue to be made in old areas for a long time. The recently discovered gas field in Leidy township, Pennsylvania, is only about fifty miles away from the famous Bradford field discovered about 1875. A major field was found in 1950 at Castaic Junction, California, within four miles of the first commercial production in that state at Pico Canyon in 1876. The North Snyder Reef field in Scurry County, West Texas, was discovered in 1948 quite close to the Sharon Ridge discovery of

twenty-five years earlier. In Canada it was thirty-three years after the first major discovery at Turner Valley in 1914 before the full possibilities of the area became apparent with the discovery of Leduc, some 190 miles northeast of Turner Valley.

Future availability of oil is frequently approached on the assumption that each new field reduces the possibilities of further discovery. A discovery may mean one less field to be found, but it may also mean that (1) remaining fields will be found more rapidly or (2) that it will lead to discovery of fields that might not be found otherwise. The discovery of a new producing field provides additional information as to formations and structures in which more oil may be found. The discovery of production in reef formations in Scurry County, for example, suggested the search for oil in places where other new oil fields have been found in West Texas. The discovery of the Leduc field in Alberta, Canada, led to numerous additional important discoveries in the same area. The recent discoveries in the Williston Basin in North Dakota and Montana suggest possibilities for locating oil fields in a vast new province. These examples illustrate the manner in which new discoveries add to the knowledge by which the petroleum industry finds additional fields. Discoveries of new fields frequently improve, rather than decrease, the possibilities of finding more oil.

Most of the drilling to date has been to the relatively shallow formations. As a rule the wells drilled in the search for oil have been stopped at the first important producing horizon reached. Only subsequently has the search been carried deeper in some of these fields, frequently with the discovery of additional producing horizons. To date, by far the major part of the oil discovered has been at depths less than 5,000 feet. Up to January 1, 1950 only about 600 exploratory wells had been drilled below 12,000 feet, although in a large part of the prospective area the sediments in which petroleum deposits may occur extend deeper than 15,000 feet. As technology has improved and made deeper drilling feasible, a great new volume of prospective area has opened up for testing in the future. Important discoveries have been made in recent years at depths that would have been beyond the technical or economic limit prior to 1940.

Available evidence proves that large additional discoveries of oil and gas may be expected. They will occur in both present major producing areas and prospective areas and at depths ranging from shallow to very deep. The amount of oil and gas deposits remaining underneath the surface of the United States may be many times the quantity discovered to date. There is no satisfactory way of estimating the oil and gas reserves underlying the surface or what part of that volume will be found and developed commercially. It would require the drilling of an

enormous number of wells through the entire sedimentary column all over the United States to make such an estimate. It would take literally hundreds of years to drill just one exploratory well per square mile in the prospective area of the United States at the 1950 rate of over 5,000 wildcats drilled in the search for new fields.

The conditions and circumstances described lead to the conclusion that it is impossible to make a satisfactory estimate of the amount of oil to be discovered in the United States in the future. The United States Geological Survey in 1951 stated this conclusion as follows: "The time has not yet arrived when a definitely accurate estimate of ultimate potential production can be made." * The United States Geological Survey added the following positive statement on the future outlook:

> "If the future can be judged by the past, oil and gas will be found in sufficient quantities for many years to come. In the United States adequate production has been a direct function of economic incentive. Until the unpredictable date at which that incentive fails to provide the needed supplies, there will be no convincing evidence that we have reached the limits of our ability to expand the potential ultimately recoverable reserves of petroleum." *

Existing conditions and expert opinions indicate that we may continue to count on ample supplies of oil for a long time. It may well be that other sources of energy, such as solar heat or nuclear fission, will decrease the economic importance and need for petroleum before the industry has time to locate or test all the deposits that exist.

In the opinion of this Committee there is reason to believe that the quantity of oil remaining to be discovered is of a large order of magnitude. It will take a very long time at current or accelerated exploration rates to test the prospective area thoroughly.

With respect to foreign resources, it is only necessary to mention briefly that vast deposits have already been located in the Middle East, Latin America, and Canada, principally by American companies. These resources have been found with a fraction as much exploratory effort as in the United States. Since the sedimentary area in foreign countries is very large, there is still much exploration to be done abroad. The excellent results of the early stages of foreign exploration indicate that tremendous foreign oil deposits remain to be found.

Technical Factors Affecting Availability

The technology to discover and develop petroleum resources is extensive and constantly improving. The industry has been finding

* United States Geological Survey, *Fuel Reserves of the United States*, 1951, pages 30, 35. (A statement prepared for the Senate Committee on Interior and Insular Affairs.)

and developing oil at an accelerated rate, roughly in proportion to the amount of drilling. There has been a steady expansion of production and proved reserves. In other words, the rate of development of new oil has increased with demand. This achievement results from better ways of locating and producing petroleum. Evidence on this point is presented in Section III. It is mentioned briefly here because it is the basis of our conclusion that availability of oil and gas can continue to increase.

The technology for locating oil has improved dramatically through the years. The widespread use of geology dates from about 1915 and is still increasing. The application of geology to surface evidence and subsurface conditions has been supplemented within the past quarter century by geophysical methods. Refinements in geophysical methods, plus the accumulation of additional knowledge through drilling, result in the location of many prospects and fields which could not have been found by earlier techniques. Aerial reconnaissance and the use of helicopters hasten the search for oil in areas previously inaccessible. Various methods of testing formations have been devised and improved to locate productive horizons. Improvements in all phases of exploration are constantly being made, with the result that new fields are being located at record rates.

Production technology also has advanced tremendously. Drilling methods make it possible to carry wells to depths unheard of twenty-five years ago. Now we can produce horizons that would have been overlooked or dismissed as non-commercial in earlier days. Understanding of the behavior of fluids in a reservoir and the adoption of conservation practices have increased the amount recoverable from many fields. Wider spacing of wells makes it possible to develop economically fields with a small recovery per acre. Such fields might not have been commercially productive in the days of close spacing. Longer life for wells and other methods of reducing costs have added to the recovery of oil. These and other methods by which improved technology has added to availability in the past and will add to it in the future are discussed in Section III.

Economic Factors Affecting Availability

Technology is important but economics is controlling in determining availability of oil and gas. It is the hope of realizing a profit which spurs operators to search for oil and to improve technology. A change in the price of crude oil relative to costs automatically affects incentive. It may thereby influence future availability apart from changes in technology and prospects. Economic factors affect both demand and supply. They influence not only how much oil is available but how that oil will be used in meeting fuel requirements.

The effect of economics on the ability of available oil supplies to satisfy requirements can be illustrated by the experience with respect to gasoline. The yield of gasoline from a barrel of crude oil in 1950 was 43 per cent, or twice as much as in 1917. One barrel of crude oil in 1950, therefore, was worth as much as two barrels in 1917 in terms of gasoline supplies. In addition, a gallon of gasoline of the quality supplied today provides 50 per cent more power than that supplied twenty-five years ago. Whether we use the extra power to get more mileage per gallon or to drive heavier, more powerful cars with the same mileage per gallon as before is a matter of economics and individual choice.

If we were really faced with a problem of limited oil supplies, it would be extremely simple to increase automotive mileage per gallon of gasoline by using from among engines now in production those with the lowest gasoline consumption. It would also be quite simple to increase the yield of gasoline substantially above present levels at some increase in costs. Such changes could extend greatly the period of years for which a specific quantity of reserves would suffice to meet demands. Consumers have not chosen to use technical progress to cut down on consumption of petroleum because the favorable combination of quality and low price achieved by the oil industry has made attractive the consumption of its products.

There must be reasonable opportunity for development of resources as well as economic incentives in order to bring about availability. Any government actions which interfere with the opportunity to search for oil will handicap future supplies. Nationalization, expropriation, or failure to permit exploration can retard drastically the development of supplies. Artificial controls of price or materials may do the same.

The experience of the United States demonstrates that a system of private, competitive enterprise results in a more active search for oil than one of government ownership or control. Although the United States has only a relatively small portion of the world's area favorable for the production of petroleum, the amount of oil discovered in the United States to date nearly equals total discoveries in the rest of the world. Such a significant difference is clearly related to the competitive search for oil in this country. Petroleum technology has been improved by American ingenuity under the stimulus of competition, and has then been carried to the far corners of the world.

The competitive search for oil by thousands of operators finds many fields that would be missed under a system of exploration by a government bureau or by a monopoly enterprise. There are countless examples of fields which have been discovered after numerous failures in the same area by other operators.

Tax policies are among the economic factors affecting availability of petroleum. Income taxes, particularly at high rates, have an adverse effect on availability by their influence on incentive and on funds available for further development.

Income tax provisions with respect to natural resources involve peculiar problems in that production of such resources represents the liquidation of the basic capital. Since income taxes are expected to apply only to ordinary income, special provisions are needed in order to protect producers of oil and gas against unfair and excessive taxation as they produce their capital assets (oil and gas). The capital in a petroleum-producing property cannot be considered merely the amount of money invested in it. Such a narrow view overlooks the large amounts of capital risked and lost on unsuccessful ventures. Unusual measures are required to deal with these special circumstances. Congress has had to devise special tax provisions to provide fair tax treatment and to encourage continuance in the business by oil and gas producers. During the past twenty-five years these provisions have been in the form of percentage depletion.

Congress recognized the peculiarities of oil production in the early application of income taxes by providing that a producer should be allowed to recover as capital the value of his property after oil was discovered on it. Subsequently, percentage depletion was substituted in 1926 as a simple, equitable method of allowing for discovery value. Existing provisions of the income tax laws have encouraged discovery and development of petroleum in the past. That has meant larger available supplies. Unfavorable changes in these provisions would decrease future discovery and availability, while liberalization would serve to stimulate exploration and increase availability.

Closely related to the economic factors affecting availability are state conservation laws. The passage of laws regulating the drilling of wells and the withdrawal of oil as a means of preventing waste and assuring equity among operators has added immeasurably to the recovery of oil. Additional recovery has meant more oil and reasonable prices. The regulation of production to market demand in order to prevent waste has increased long-term availability by checking the wastes involved in rapid dissipation of flush production.

Regulation of production to prevent waste (by the use of restrictions to maximum efficient rates and to market demand) reduces the violent fluctuations in the price of oil but does not fix the price. The effect of conservation is to give customers more oil at a lower average price than would prevail in the absence of conservation because of the lower investment and operating costs under orderly development.

The actions of government with respect to taxes, conservation, price controls, and other matters can affect materially the search for and availability of petroleum. Government attitudes toward business enterprise can offset or reverse normal economic forces. Regulations which prevent or discourage further search for oil, whether in the form of nationalization, excessive taxes, interference with the development of new areas, or price controls, seriously decrease the availability of petroleum as compared with what would be achieved under normal economic forces. It is through the avoidance of restraints and handicaps to the search for oil and the maintenance of a favorable climate for investment of risk capital that government policy can contribute effectively to promoting greater availability of petroleum for the future.

The economics of price and cost is basic in determining availability of a resource. The availability of oil and gas has increased because the industry has been able to develop new resources at costs which permitted attractive prices for these fuels. Because of these attractive prices, the demand for oil and gas has increased nearly fourfold in the past twenty-five years.

The industry's achievements have been remarkable in controlling costs and keeping prices low despite the impact of inflation, the necessity of drilling deeper, and of other forces working toward higher costs. The great area available for exploration, improved technology, and wider spacing of wells have been the major factors back of this achievement. Costs have increased, frequently very sharply, for drilling and carrying on each operation, but the industry has worked diligently to overcome such trends with economical investment and better methods. Competition has spurred such efforts. Consequently, costs have been controlled and prices have remained at levels that are attractive in terms of other fuels, of commodity prices generally, or of the hours of work required by the average worker to buy a gallon of petroleum products.

Increasing Availability for 1951-1955

Granted continued adequacy of economic incentives and adequate supplies of steel, the availability of oil and gas in the United States and foreign countries will increase steadily during the next five years. Careful studies have been made of the probable range of available supplies. The details of these studies appear in Section II for 1951-1955.

Under the conditions set forth in Section II, it is estimated that the availability of petroleum liquids in 1955 will be higher than production in January 1951 by not less than 1,324,000 barrels daily in the U. S. and 2,171,000 barrels daily in foreign areas outside of those dominated by Russia. This minimum expectation is almost equal to the increase

in production from 1946 to January 1951. Under favorable conditions, availability in 1955 may exceed production in January 1951 by more than 5,300,000 barrels daily.

TABLE 3

Changes in Production 1946-1951,
and Projected Availability, 1951-1955,
For All Petroleum Liquids—Thousand Barrels Daily

	U. S.	Excluding Russian Dominated Areas	
		Foreign	Total
1946 Production	5,074	2,243	7,317
January 1951			
Production	6,465	4,498	10,963
Availability	7,300	4,703	12,003
1955 Availability Range			
Lower	7,789	6,669	14,458
Upper	8,838	7,427	16,265
1955 Increase Over January 1951 Production			
Lower	1,324	2,171	3,495
Upper	2,373	2,929	5,302

Part of the domestic reserve productive capacity in 1951 resulted because imports of crude oil and products, particularly residual fuel oil, amounting to 825,000 barrels daily exceeded exports by about 420,000 barrels daily.

Available supplies of natural gas in the United States will also increase. By 1955 it is expected that they will be 9.5 to 11.9 trillion cubic feet annually, compared with production of about 6.9 trillion cubic feet in 1950 and 4.9 trillion cubic feet in 1946. No estimates have been prepared on foreign natural gas because of the relatively limited use of such gas for fuel.

Past experience indicates that even the upper range of supplies projected in these studies may be exceeded under favorable conditions. By January 1951, availability exceeded by 7.8 to 14.3 per cent the range which had been estimated for that time in 1948 by the American Petroleum Institute's Committee on Long-Term Availability. The rate of drilling exceeded the expectations of the industry as a result of high demand and improved economic incentives. Consequently, available

supplies outran the upper range projected in 1948. The present projection for 1951-1955 assumes a continuation of drilling at about the 1951 rate throughout the period. It may prove to be conservative if drilling increases to higher levels under the stimulus of rising demand or greater economic incentives.

The Long-Term Outlook

In 1900, petroleum production in the world was 400,000 barrels daily, half of which was in Russia. By January 1951, production of all petroleum liquids outside of Russian dominated areas had increased to nearly 11,000,000 barrels daily, whereas production of Russian dominated areas was estimated to be less than one million barrels daily. Clearly, petroleum availability increased rapidly in the first half of the twentieth century. The rate of discovery and development during this period has been upward and the proved reserves at the end of 1950 were the highest in the experience of the industry.

The outlook for development of petroleum resources during the last half of the twentieth century is favorable. Demand, reasonable economic incentives, and a favorable climate for private investment may bring about a further increase in availability of petroleum for many years to come. A study of potential resources suggests ample opportunity for still further development in the United States and worldwide. New sources of power may prove limiting factors on availability of petroleum before completed development of natural petroleum resources is approached. As usual in a free economy, economics will govern our choice and use of fuels.

The prospects for development of new sources of energy are real. Only recently authorizations have been made for the construction of the first submarine and airplane to be powered by plants using nuclear fission as a source of energy. At the end of 1951 the Atomic Energy Commission announced that useful electric power had been produced in Idaho for the first time by atomic energy. These developments suggest that it may not be long before atomic energy may provide a commercial source of power. In that case, petroleum and coal would be faced with major new competition.

Nuclear fission is not the only feasible form of energy that may be developed to compete with petroleum and coal. We may learn to harness the heat of the sun as an effective and economical source of power. Such a development might also foretell revolutionary developments in the field of energy which would be of economic benefit to all in the long run.

The role of different forms of energy in supplying power is constantly changing as a result of technology and economics. Such changes will continue to take place in any dynamic, free economy. As tech-

nology makes new forms of energy available at reasonable cost, other competitive fuels tend to lose position. Within the first half of the twentieth century coal has lost position to oil and gas. That change occurred not because of any lack of coal resources but for economic reasons.

No one can be sure what changes will occur in energy supplies in the next fifty years. Oil and gas may continue to gain position in the energy market, to hold their own in an expanding market, or lose position. The latter prospect, if it should occur, is more likely to be the result of economic competition from other forms of energy than from a lack of potential resources.

Our fuel needs for national security and economic progress are best served by competition. Abundant fuel supplies at low cost, which have meant so much in our economic progress, have been the result of competition. Any fuels policy interfering with that competition will be a threat to our future supplies of energy and will mean increased costs to consumers.

Summary

The present study of petroleum availability leads to the following conclusions:

1. Available supplies of oil and gas will continue to increase rapidly for the near future.
2. Large quantities of oil and gas remain to be found in the United States and foreign countries.
3. Techniques for finding and producing oil have improved greatly, are currently being improved, and will continue to improve.
4. Increasing availability of petroleum can be counted on in the United States and worldwide provided reasonable economic incentives and a favorable climate for private investment are maintained.
5. Energy from other sources at attractive prices may finally bring about a decrease in petroleum demand before any lack of prospects causes a decrease of available supplies.
6. Competition among fuels is the best way to supply our needs for energy at the lowest cost.

In short, the United States and the world can count upon increasing supplies of oil and gas not only for the next few years but for the foreseeable future provided that reasonable economic incentives, adequate materials, and a favorable climate for private investment prevail.

SECTION II—THE IMMEDIATE OUTLOOK FOR OIL SUPPLIES

Crude oil production has increased at a remarkable rate since 1900. (See Chart 2.) The rate of increase continues to be rapid. Analysis of the immediate outlook through 1955 indicates still larger supplies provided that several major conditions are realized. These conditions include continuation of reasonable opportunity and economic incentive to develop new oil, a legal and political climate which will not discourage the investment of private capital, and materials and manpower in amounts at least equal to those available in 1951.

Estimates have been made of the anticipated range of available oil supplies for the United States and foreign countries outside of Russian-dominated areas. The estimates indicate supplies available under efficient production practices. They are not a forecast of production, as demand may be less than the amount available. It is normal for the expanding oil industry to operate with some margin of spare capacity. A substantial reserve capacity exists now and probably will continue to exist for the near future in the absence of emergency conditions.

Projected development will mean an increase in available oil supplies through 1955 at a rate comparable with the rapid expansion of 1946-1951. (See Table 4.)

Except for upward revisions in foreign availability, the estimates in this report are the same as in the Interim Report presented to the National Petroleum Council on July 24, 1951. Revisions of the foreign estimates reflect accelerated completion of facilities in the Middle East following the loss of Iranian supplies. The earlier estimates had been made prior to the interruption of production in Iran.

The report on availability for the United States includes estimates of natural gas. Available supplies of natural gas are expected to increase substantially by 1955 even though the estimates are deliberately conservative because the limiting factor on the use of natural gas is still the capacity of pipe line facilities rather than the maximum efficient rate of production. It is estimated that by 1955 the range of available domestic supplies of natural gas will be 9.5 to 11.9 trillion cubic feet, compared with the actual production in 1950 of 6.9 trillion cubic feet. It is apparent from these figures that there is room for substantial growth in production and demand for natural gas.

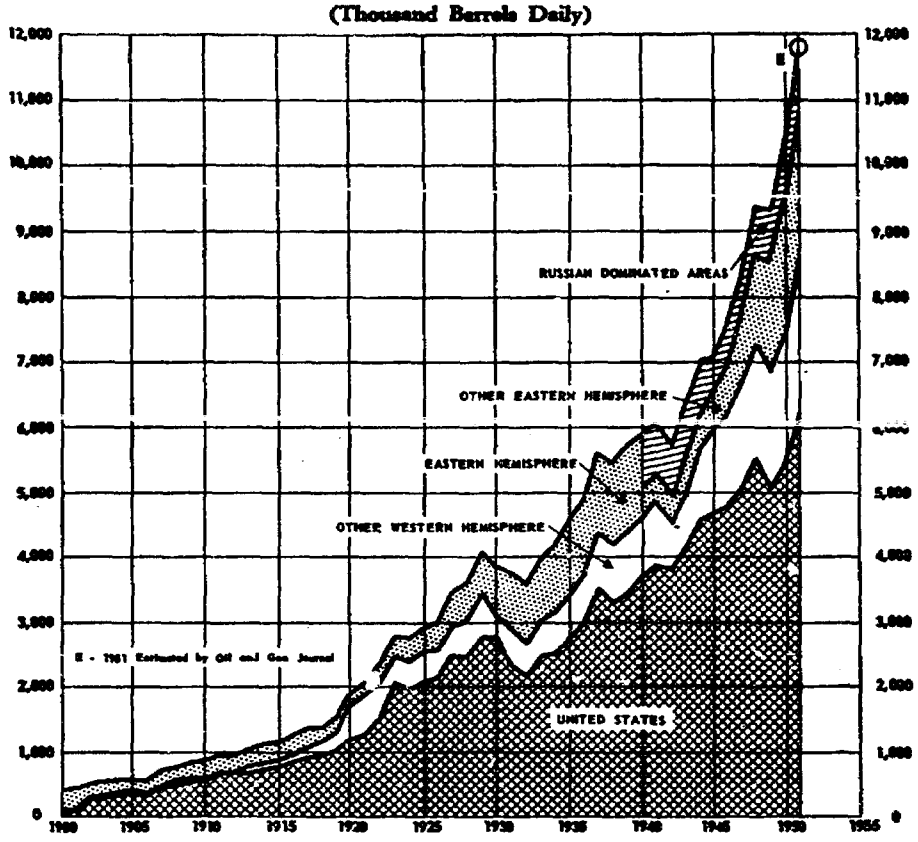
TABLE 4

Changes in Production and Availability of Petroleum Liquids, Thousand Barrels Daily

	United States	Other Western Hemisphere	Total Western Hemisphere	Eastern Hemisphere (Exclusive of Russian-Dominated Areas)	World (Exclusive of Russian-Dominated Areas)	Estimated Russian-Dominated Areas*
Production						
1946	5,074	1,446	6,520	797	7,317	572
Jan. 1951	6,465	2,245	8,710	2,253	10,963	880
Increase	1,391	799	2,190	1,456	3,646	308
Availability						
Jan. 1951	7,300	2,319	9,619	2,384	12,003	
1955—Upper	8,838	3,279	12,117	4,148	16,265	
1955—Lower	7,789	2,903	10,692	3,766	14,458	
Increase 1951-55						
Upper	1,538	960	2,498	1,764	4,262	
Lower	489	584	1,073	1,382	2,455	

* Crude oil production only, based on reports of *World Oil*, February 15, 1951 and Bureau of Mines World Petroleum Statistics, January, 1951.

CHART 2
World Crude Oil Production
(Thousand Barrels Daily)



The following sections summarize the reports prepared as a result of careful study of domestic and foreign prospects for petroleum development.

U. S. Availability of Oil and Gas, 1951-1955

(Report submitted to National Petroleum Council, July 24, 1951)

The availability of domestic petroleum continues to increase at a substantial rate. As of January 1951 the available production from the United States at maximum efficient rates was 7,300,000 barrels daily of crude oil and natural gas liquids, or 835,000 barrels daily more than actual production. Availability will increase still further during 1951 and the next four years, provided that steel supplies are not reduced below the levels requested for 1951 and economic incentives remain unchanged.

Availability of domestic petroleum in January 1951 exceeded the peak production attained during World War II (in the second quarter of 1945) by 2,130,000 barrels daily. The increase in availability since 1945 of more than 41 per cent results from the drilling of new wells and reflects the additions to proved reserves of crude oil and natural gas liquids. In the six years 1945-1950 there were drilled in the United States 211,000 wells, including 146,000 oil and gas producers and service wells. The increase in estimated proved reserves of petroleum during this period is shown in the following tabulation:

TABLE 5

Proved Reserves of Petroleum Liquids Estimated by the American Petroleum Institute

(Million Barrels)

	Crude Oil	Condensate	Natural Gas Liquids (Incl. Condensate)	All Liquids
Jan. 1, 1945.....	19,784.5	668.7	2,970.0-Est.*	22,754.5*
Jan. 1, 1946.....	19,941.8	885.0	2,990.0-Est.*	22,931.8*
Jan. 1, 1951.....	25,268.4		4,267.7	29,536.1

* Up to the end of 1945 the American Petroleum Institute estimated reserves of crude oil and condensate but not other natural gas liquids. After 1945 the reserve estimates were for crude oil and all natural gas liquids, including condensate. For the years 1946 through 1949 the reserves of natural gas liquids were 15.13 to 15.21 per cent of the estimated crude oil reserves. To arrive at 1945-1946 reserve figures comparable with that for January 1, 1951, reserves of natural gas liquids were taken at 15 per cent of the crude oil reserves.

The availability of domestic petroleum and the reserve productive capacity over production in January 1951 are set forth below by districts for the United States. (See Table 6.)

By January 1951 availability exceeded by 525,000 to 915,000 barrels daily, or a margin of 7.8 to 14.3 per cent, the range of availability which the American Petroleum Institute report on Long-Term Availability* in 1948 had estimated would be developed by that time. The availability developed by January 1951 was nearly as high as that anticipated under favorable conditions for 1953 by the API report three years ago. These comparisons show that the upper availability projected in 1948 on the basis of favorable developments has been achieved more than two years ahead of schedule. Availability has increased more rapidly

* Report on the Long-Term Availability of Petroleum by the National Oil Policy Committee of the American Petroleum Institute, November 1948.

TABLE 6

U. S. Availability and Production of Petroleum, January 1951

(Thousand Barrels Daily)

District	Availability			Production			Reserve Productive Capacity		
	Crude Oil	Nat. Gas Liquids	All Oils	Crude Oil	Nat. Gas Liquids	All Oils	Crude Oil	Nat. Gas Liquids	All Oils
1—East Coast	54	19	73	54	19	73	0	0	0
2—Mid-Continent	1,088	72	1,155	1,077	72	1,149	6	0	6
3—Southwest	4,161	383	4,544	3,525	377	3,902	636	6	642
4—Rocky Mountains	350	9	359	292	7	299	58	2	60
5—California*	1,079	90	1,169	959	83	1,042	120	7	127
U. S.	6,727	573	7,300	5,907	558	6,465	820	15	835

* Including Elk Hills.

than projected by the American Petroleum Institute Subcommittee on Long-Term Availability principally because well completions have been greater than anticipated. This development emphasizes the fact that changes in availability are directly related to drilling.

The rapid increase in availability since 1945 has been due to additional drilling in recent years as more steel became available. During World War II drilling was curtailed drastically to save steel. Consequently, an average of only 12,000 oil wells was completed annually in the war years 1942-1945. Nearly twice as many oil wells were completed annually in 1948-1950, when the industry drilled about 23,000 oil wells annually. The number of wells drilled during the war years 1942-1945 was slightly less than adequate to maintain available production, as the availability from new wells did not quite offset the normal decline of old wells. The more rapid rate of drilling after 1945 had a great impact on availability because every additional well above the number required to offset decline increases availability by the full amount of its efficient productive capacity.

The increase in availability since 1945 was brought about by the expenditure during the past five years of about ten billion dollars for exploration and development. In the early part of the postwar period demand increased as fast as availability. By 1948, however, availability was increasing more rapidly than demand. A high level of activity continued through 1949 even though crude oil production and income decreased and demand remained relatively constant. In 1950 drilling increased to record levels as demand and production again moved upward. The large expenditures and high level of development activity in 1946-1950 served to provide the productive capacity which made it possible to meet record demands in 1950 and still have a margin of reserve capacity.

The factors which have developed new capacity and created reserve productive capacity have already been reviewed in a report submitted January 26, 1950 to the National Petroleum Council by a Committee on Crude Petroleum Reserve Productive Capacity.* These factors have been: aggressive competition in the search for oil, a market providing adequate economic incentives through reflection of changes in supply and demand, and conservation practices developed by the industry and state conservation agencies. The same factors will continue to be of major importance in the development of productive capacity, and any estimates of what such productive capacity may be in the future must take these conditions into account.

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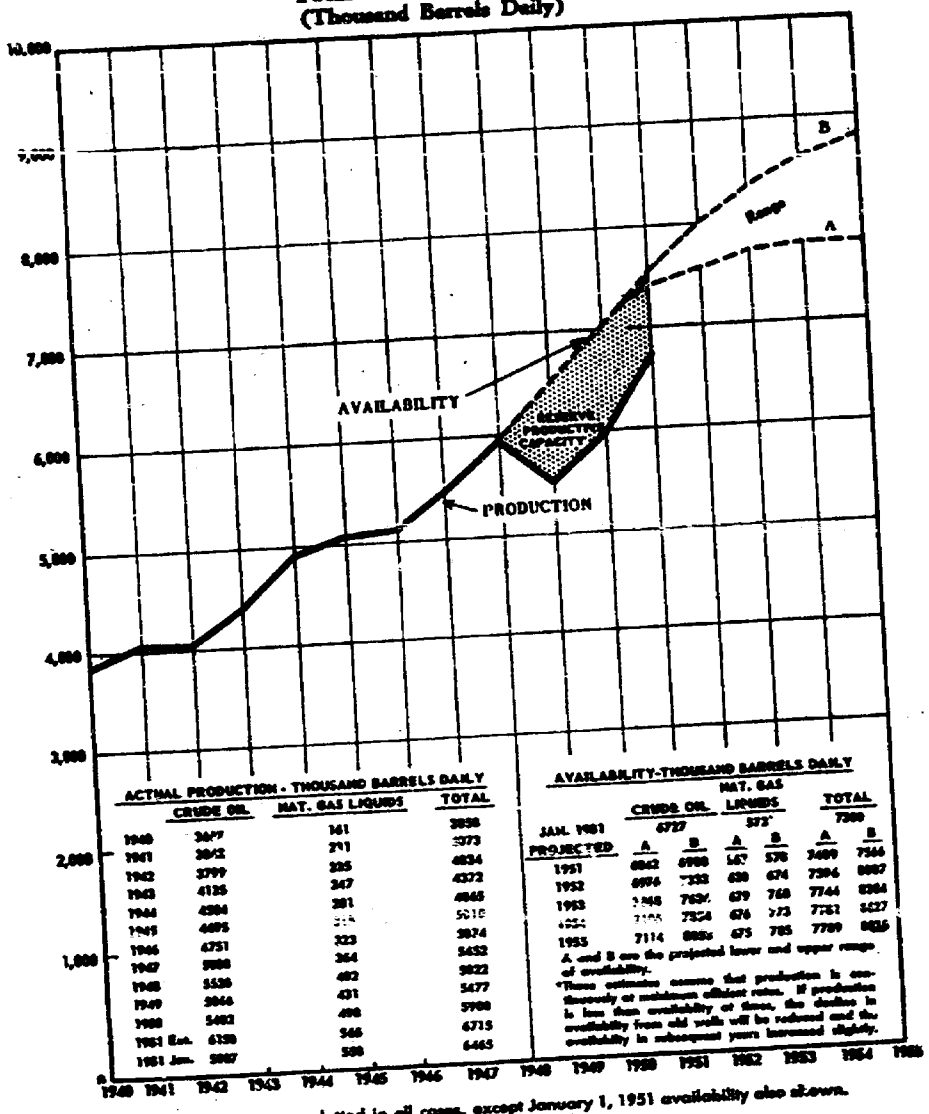
* "U. S. Crude Petroleum Reserve Capacity," January 26, 1950, National Petroleum Council.

CHART 3

U. S. Production 1940-1951, and Availability, 1948-1955

Total Petroleum Liquids

(Thousand Barrels Daily)



ACTUAL PRODUCTION - THOUSAND BARRELS DAILY

	CRUDE OIL	NAT. GAS LIQUIDS	TOTAL
1940	3677	161	3838
1941	3852	211	4073
1942	3799	235	4034
1943	4135	247	4372
1944	4584	281	4865
1945	4695	[illegible]	5018
1946	4751	323	5074
1947	5088	364	5452
1948	5530	402	5922
1949	5046	431	5477
1950	5402	498	5900
1951 Est.	6130	585	6715
1951 Jan.	5907	558	6465

AVAILABILITY-THOUSAND BARRELS DAILY

	CRUDE OIL		NAT. GAS LIQUIDS		TOTAL	
JAN. 1951	6727		573*		7300	
PROJECTED	A	B	A	B	A	B
1951	6862	6988	567	578	7429	7566
1952	6976	7332	630	674	7606	8007
1953	7068	7634	679	768	7747	8384
[illegible]	7155	7924	676	773	7781	8427
1955	7114	8086	675	785	7789	8855

A and B are the projected lower and upper ranges of availability.

*These estimates assume that production is economically or maximum efficient rates. If production is less than availability or flows, the decline in availability from old wells will be reduced and the availability in subsequent years increased slightly.

Annual averages plotted in all cases, except January 1, 1951 availability also shown.

Future Domestic Availability, 1951-1955

The Subcommittee created research groups for each of the five major districts in the United States to make careful studies of the prospects for drilling and development over the period 1951-1955. This

report represents the combined views of the members of these groups for their areas and of this Subcommittee.

The studies of future prospects indicate that substantial amounts of reserves and additional productive capacity will be developed in the next five years if present economic incentives are maintained and the industry can secure sufficient steel and manpower to continue at about the current level of operations, which includes the drilling of more than 48,000 wells a year. If additional steel were available, more wells would be drilled by the industry and greater availability would be developed to the extent warranted by demand and economic incentives. The estimates contained herein take into account existing limitations on steel, since these limitations currently determine the rate of drilling and the development of new petroleum availability. In addition, any substantial loss of key technical men to military service will make it difficult for the industry to carry on the exploration and development activities projected.

The Subcommittee has projected a range of availability which will result from the anticipated drilling. The lower figure of that range is one that can easily be attained with steel supplies continued at the rate allocated for 1951, while the upper figure may be attained with success in new discovery and development comparable with that realized during the past five years. It is estimated that by 1955 availability will be 7,789,000 to 8,838,000 barrels daily, a gain of 32 to 50 per cent in five years over the actual production of 5,900,000 barrels daily of all petroleum liquids in 1950. The estimated availability in 1955 exceeds the availability in January 1951 by an amount ranging from 489,000 to 1,538,000 barrels daily for the lower and upper cases. For the projected availability of all petroleum liquids see Table 7.

These estimates assume that there will be no reduction of the incentive to search for and develop new resources, that sufficient steel and manpower will be available, and that the development of the Continental Shelf will be permitted. Artificial price controls or large increases in taxes which affect the economic incentives for further development can upset the amount of development activity carried on by the industry and reduce availability. Interference with present or prospective markets for petroleum by arbitrary action limiting the uses which might be made of petroleum would also change the outlook for availability. Lack of steel to drill the number of wells projected or of personnel to carry out the program would affect directly the development of new productive capacity. Failure to permit and encourage development of the Continental Shelf may also result in less availability than anticipated in this report.

TABLE 7

U. S. Availability of Petroleum

(Thousand Barrels Daily)

Average For Year	Crude Oil Projected Range*		Nat. Gas Liquids Projected Range		Total Liquids Projected Range	
	Lower	Upper	Lower	Upper	Lower	Upper
1951	6,842	6,988	567	578	7,409	7,566
1952	6,976	7,333	620	674	7,596	8,007
1953	7,065	7,624	679	760	7,744	8,384
1954	7,105	7,854	676	773	7,781	8,627
1955	7,114	8,053	675	785	7,789	8,838

* These estimates assume that production is continuously at the maximum efficient rate. If production is less than availability at times the decline in availability from old wells will be reduced and the availability in subsequent years will be increased slightly.

It is estimated that the availability of crude oil production from the Continental Shelf is now about 18,000 barrels daily, or much less than had been projected in the 1948 report of the American Petroleum Institute. Major factors responsible for this unfavorable development have been the controversy raised by the Federal Government over the title to these lands, which had been considered to be owned by the states adjoining the Continental Shelf, and the high costs experienced in offshore operations. The uncertainty with respect to title has virtually halted exploration and development, and will affect activity on the Continental Shelf so long as it continues. In preparation of this report the Subcommittee has assumed that the controversy over title to these lands will be settled promptly and that the industry will then be permitted to proceed immediately with normal development. Assuming that drilling is encouraged by prompt settlement and reasonable leasing, it is estimated that about one thousand wells will be drilled on the Continental Shelf over the next five years. These wells are estimated to increase availability from this area in the order of magnitude of 100,000 to 200,000 barrels daily, depending on the need for oil. Any delay in development will necessarily reduce availability within the five years below the estimate included in this report.

Natural Gas Availability

The Subcommittee has also made studies of natural gas availability. These studies considered separately gas associated with oil, including dissolved gas, and gas not associated with oil (non-associated gas) for each of the five districts in the United States. These studies merely indicate the magnitude of availability of natural gas, since the rate of withdrawal without waste from non-associated gas reserves is subject to considerable range. The Subcommittee has deliberately used conservative estimates of availability of non-associated gas because the limiting factor on utilization of natural gas at the present time is still the pipe line facilities for transporting gas. The current availability of natural gas substantially exceeds the combined total of local consumption plus the capacity of existing large pipe lines.

Availability of associated gas was determined in relation to the availability of oil with which it would be produced. Generally, the production of gas associated with oil is expected to maintain about the same relation to available oil production as at present. The estimated availability of associated gas in 1951 from wells existing at the beginning of the year represents 5.8 per cent of the proved reserves of associated and dissolved gas of 54.6 trillion cubic feet as of January 1. This rate of availability of associated gas is lower than the rate of depletion that the estimated availability of crude oil would be on the proved reserves

of crude oil. Depletion for associated and dissolved gas at a slower rate than crude oil takes into account the fact that production from gas caps overlying oil reservoirs may be delayed for conservation reasons until the oil is substantially depleted and that oil reserves from stripper wells which have little remaining associated gas reserves are generally depleted more rapidly than the oil reserves of other fields with substantial amounts of remaining associated gas.

The availability of non-associated gas from wells existing January 1, 1951 was estimated to be at most 4.3 per cent of the proved reserves of non-associated gas of 130.6 trillion cubic feet. In the lower case, the rate of withdrawal from proved reserves of non-associated gas would be only 3.3 per cent in 1951. These rates of withdrawal are less than would occur in case of depletion over a 20-year life contemplated in many long-term contracts for large interstate transmission lines.

The estimates of natural gas availability arrived at by the Subcommittee range from 8.1 to 9.5 trillion cubic feet in 1951 to 9.5-11.9 trillion cubic feet in 1955. The upper availability estimate for 1951 is 39 per cent more than the production in 1950. By 1955, the estimated availability is 58-72 per cent more than the production in 1950. The following tabulation shows the estimated range of availability of natural gas:

TABLE 8

Projected Availability of Natural Gas

(Billion Cubic Feet Annually)

Year	Non-Associated Gas		Associated Gas		Total Gas	
	Lower	Upper	Lower	Upper	Lower	Upper
1951	4,738	6,149	3,326	3,398	8,064	9,547
1952	5,085	6,619	3,403	3,593	8,488	10,212
1953	5,398	7,055	3,462	3,760	8,860	10,815
1954	5,690	7,467	3,501	3,891	9,191	11,358
1955	5,966	7,860	3,523	4,003	9,489	11,863

Summary

The petroleum industry of the United States has accomplished the following in the past five-year period 1946-1950:

For Petroleum Liquids

1. Produced 10.2 billion barrels of crude oil and natural gas liquids.

2. Increased proved reserves of all petroleum liquids by more than 6.5 billion barrels, after replacing with new reserves the 10.2 billion barrels produced during the period.
3. Increased availability of all petroleum liquids to 7,300,000 barrels daily in January 1951 and to an estimated range of 7,409,000-7,566,000 barrels daily for the year 1951, compared with production in 1946 of 5,074,000 barrels daily, which was then about the availability at maximum efficient rates.

For Natural Gas

1. Produced 29.7 trillion cubic feet of natural gas.
2. Increased proved reserves by 37.8 trillion cubic feet, after replacing with new reserves the 29.7 trillion cubic feet produced during the period.
3. Increased net production of natural gas from 4.9 trillion cubic feet in 1946 to 6.9 trillion cubic feet in 1950.
4. Increased availability to an estimated 8.1-9.5 trillion cubic feet annually in 1951.

These achievements of increasing reserves and availability have been realized even though demand was at a high level at the end of World War II and continued to increase sharply thereafter. They are the result of an active program of exploration and development and of large capital expenditures.

Careful study of the prospects for future discoveries and development indicates that the present situation is about as promising as it was at the beginning of 1946. The higher rate of production now does mean that there is a larger volume of normal decline which must be offset before drilling can increase availability, but on the other hand, drilling is now at a much higher rate than in 1946.

Granted continuation of sufficient materials and manpower and the same incentives prevailing in recent years, the petroleum industry can increase still further availability of both oil and natural gas over the next five years. Careful studies show that by 1955 availability in the United States can be increased to the range of 7,800,000-8,800,000 barrels daily for crude oil and natural gas liquids compared with production of 5,900,000 barrels daily in 1950. Similarly, the availability of natural gas can be increased by 1955 to the range of 9.5 to 11.9 trillion cubic feet as against actual production in 1950 of 6.9 trillion cubic feet. Consequently, the petroleum industry will be in a position to meet increased demands for oil and gas during the five-year period 1951 through 1955.

The Immediate Outlook for Foreign Oil Supplies

The prospects for rapid development of foreign oil supplies are excellent for countries outside of Russian-dominated areas. (This report excludes throughout the following Russian-dominated areas: Albania, Austria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, Russia, Sakhalin, and Yugoslavia.)

Foreign areas have very great prospects for future discoveries. There has been relatively little exploration and drilling in these areas by comparison with the United States. With reasonable opportunity, there is no question that foreign oil supplies can be increased rapidly in the future. In fact, the adequacy of transportation facilities is likely to be the controlling factor on the amount of oil supplies that can be made available from foreign areas, rather than the productive capacity of the wells.

It must be noted, however, that large investments of private capital have been the basis of increasing oil supplies in foreign countries. Large additional amounts of private capital will have to be risked in order to continue this expansion. Such risks can and will be taken only if economic and political conditions remain favorable to private investment. This report assumes that conditions will continue to be favorable for private investment in foreign countries, that markets will warrant further rapid development, and that supplies of materials and manpower will be no less than in 1951.

From 1946 to January 1951 foreign oil production doubled, with an increase of 2,255,000 barrels daily outside of Russian-dominated areas. The average increase in availability anticipated in foreign countries from January 1951 to 1955 under the conditions set forth above exceeds the increase in production in the past five years. A particularly rapid development is projected for the Middle East.

Prior to World War II, foreign areas did not produce enough oil to meet foreign demand. Exports from the United States in excess of its imports helped to make up the deficit. Important developments in foreign production took place in the years 1939-1945. As a result, foreign areas emerged from the war with production approximately equal to their demand. At the end of the war the excess of supply over demand in the Western Hemisphere outside of the United States was about equal to the deficit of the Eastern Hemisphere. Since 1947 foreign areas have had an increasing margin of supply over demand and become net exporters of oil to the United States. Demand in these areas increased at a compound rate of over 13 per cent annually, but supply has increased even faster. (See Table 9.)

TABLE 9

Foreign Petroleum Production and Demand Excluding Russian-Dominated Areas
(Thousand Barrels Daily)

	Production‡			Demand			Balance		
	Western Hemis.•	Eastern Hemis.†	Total Foreign†	Western Hemis.•	Eastern Hemis.†	Total Foreign†	Western Hemis.•	Eastern Hemis.†	Total Foreign†
1938	859	606	1,465	488	1,297	1,785	371	−691	−320
••									
1946	1,446	797	2,243	826	1,351	2,177	620	−554	66
1947	1,606	975	2,581	933	1,666	2,599	673	−691	−18
1948	1,779	1,368	3,147	1,049	1,799	2,848	730	−431	299
1949	1,815	1,700	3,515	1,093	2,040	3,133	722	−340	382
1950	2,056	2,102	4,158	1,237	2,346	3,583	819	−244	575

• Outside of the United States.
•• War years omitted.
† Exclusive of Russian-dominated areas.
‡ Crude oil and natural gas liquids.

As a starting point for projecting future availability an estimate was made of productive capacity as of January 1951. At the time the estimate was made there had been no disruption of Iranian supplies. This estimate is presented in Table 10.

The loss of Iranian supplies about the middle of 1951 brought about accelerated completion of facilities in other Middle East countries. By July 1951, available foreign supplies had increased by 630,000 barrels daily over the level of January 1951, principally in the Middle East. This increase was realized through advanced completion of oil-handling facilities in Middle East countries other than Iran under the necessity of offsetting the decrease in Iranian production. Since Iranian supplies are potentially available and may again enter world markets in case of satisfactory conclusion of the dispute, it was necessary to increase estimates of available oil for 1951. For subsequent years the present estimates of availability are about 500,000 barrels daily higher than in the earlier *Interim Report*, reflecting the acceleration in availability of supplies from other Middle East countries.

Continued increases in productive capacity of foreign areas are expected over the next five years. The principal gains, as in the past, will probably be in the Middle East and Latin America. Important discoveries in Canada in recent years indicate that this area will have a more rapid development of supplies ahead than in the past. It is difficult, however, to predict the course of development by individual countries. Therefore, the estimates of available oil supplies have been projected in this report only for the Western Hemisphere and the Eastern Hemisphere, exclusive of Russian-dominated areas. These estimates have been made in terms of a range believed to indicate the probable developments. Separate estimates are presented of supplies of gas liquids available along with crude oil. Since these supplies are comparatively unimportant, a single estimate is presented rather than a range. The combined results of these estimates are shown in Table 11.

Available foreign supplies were estimated to be 4,703,000 barrels daily in January 1951 and 5,335,000 barrels daily in July 1951. Because of the sharp increase about the middle of the year, the estimate for July is higher than the average availability for the year 1951. By 1955, in the absence of interference with normal developments anticipated, availability in foreign countries exclusive of Russian-dominated areas is expected to be in the range of 6,669,000-7,427,000 barrels daily. (See Chart 4.) In all probability, the expansion of supplies from January 1951 to the year 1955 will equal or exceed the increase in production of 2,255,000 barrels daily from 1946 to January 1951. Supplies available

TABLE 10

Comparison of Productive Capacity and Oil Production for Foreign Countries Excluding Russian-Dominated Areas, January 1951

(Thousand Barrels Daily)

	Productive Capacity			Production			Reserve Productive Capacity		
	Crude Oil	Nat. Gas Liquids	All Oils	Crude Oil	Nat. Gas Liquids	All Oils	Crude Oil	Nat. Gas Liquids	All Oils
Canada	165	2	167	95	2	97	70	—	70
Latin America	2,130	22	2,152	2,126	22	2,148	4	—	4
Total	2,295	24	2,319	2,221	24	2,245	74	—	74
Europe and Africa	86	24	110	86	24	110	—	—	—
Middle East	2,000	—	2,000	1,874	—	1,874	126	—	126
Far East	270	4	274	265	4	269	5	—	5
Total	2,356	28	2,384	2,225	28	2,253	131	—	131
Total Area	4,651	52	4,703	4,446	52	4,498	205	—	205

for the world will advance even more because of the gains in the United States. (See Chart 5.)

Unfavorable political or economic developments may affect the rate or location of development of availability. The Iranian dispute, for example, accelerated expansion in other countries of the Middle East and the Western Hemisphere.

Where and at what rate foreign supplies will be developed will depend on conditions that prevail with respect to encouragement of investment of private capital.

TABLE 11

Projected Foreign Availability of Petroleum Excluding Russian-Dominated Areas

(Thousand Barrels Daily)

Annual Average	Crude Oil				Natural Gas Liquids		Total Petroleum	
	Western Hemis.		Eastern Hemis.		Western Hemis.	Eastern Hemis.		
	Lower	Upper	Lower	Upper			Lower	Upper
1951	2,413		2,756		24	28	5,221	
1952	2,550	2,668	2,980	3,202	25	28	5,892	6,109
1953	2,680	2,873	3,571	3,870	26	30	6,307	6,799
1954	2,799	3,085	3,662	3,962	27	30	6,518	7,104
1955	2,875	3,251	3,734	4,116	28	32	6,669	7,427

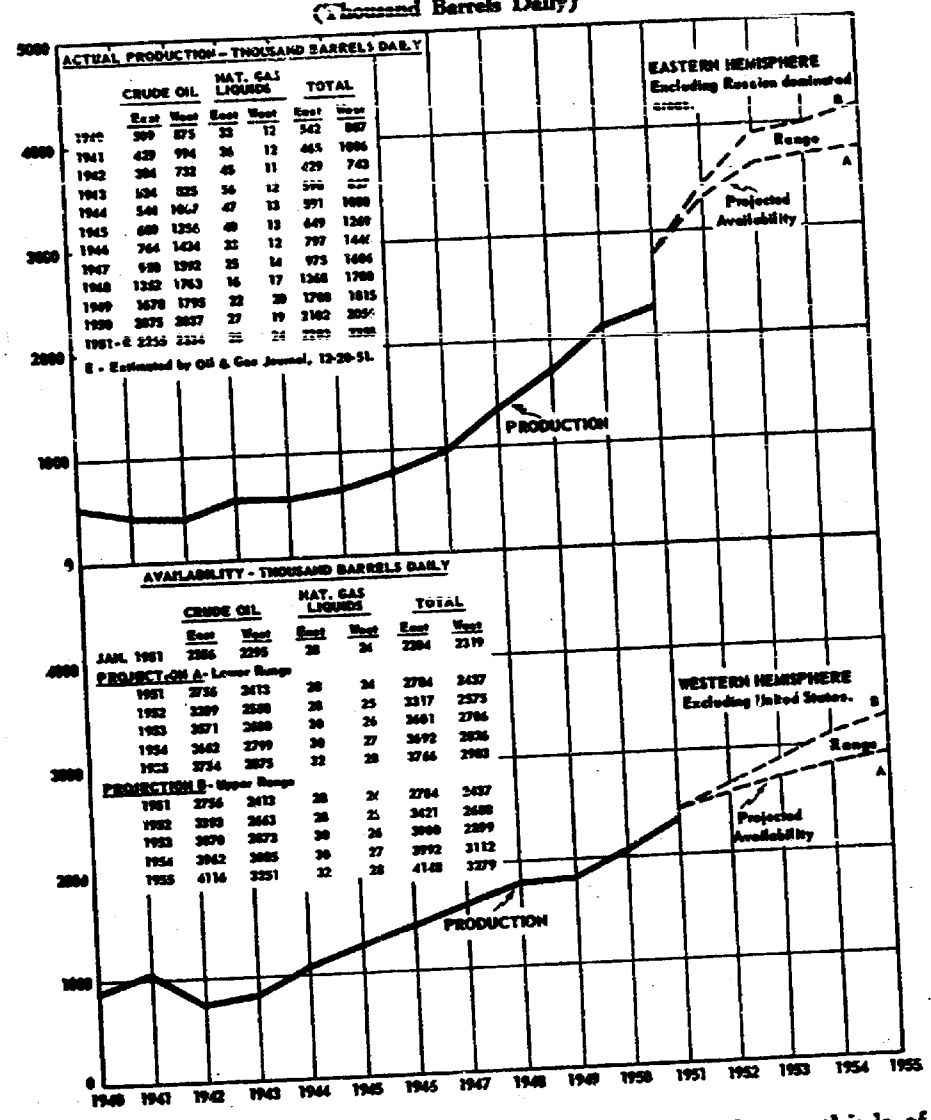
The rate at which crude oil productive capacity will be expanded in foreign areas will depend not only on the drilling of oil wells but also on the completion of many other facilities. Among the factors taken into account in these estimates are the facilities for handling oil in the field, the transportation facilities for moving crude oil to tide water, the installations required for the welfare of personnel, and the requirements for maintenance of plant and equipment. It is possible that such facilities may be completed even faster than projected in this report. Particularly in the Middle East, developments are underway which will add rapidly to availability in 1952 and 1953.

As recently as 1949, foreign oil production in the Western Hemisphere was greater than that in the Eastern Hemisphere outside of areas dominated by Russia. It is anticipated that future developments will bring about a much more rapid increase in supplies in the Eastern

CHART 4

Foreign Production and Availability of Total Petroleum Liquids Excluding Russian-Dominated Areas

(Thousand Barrels Daily)

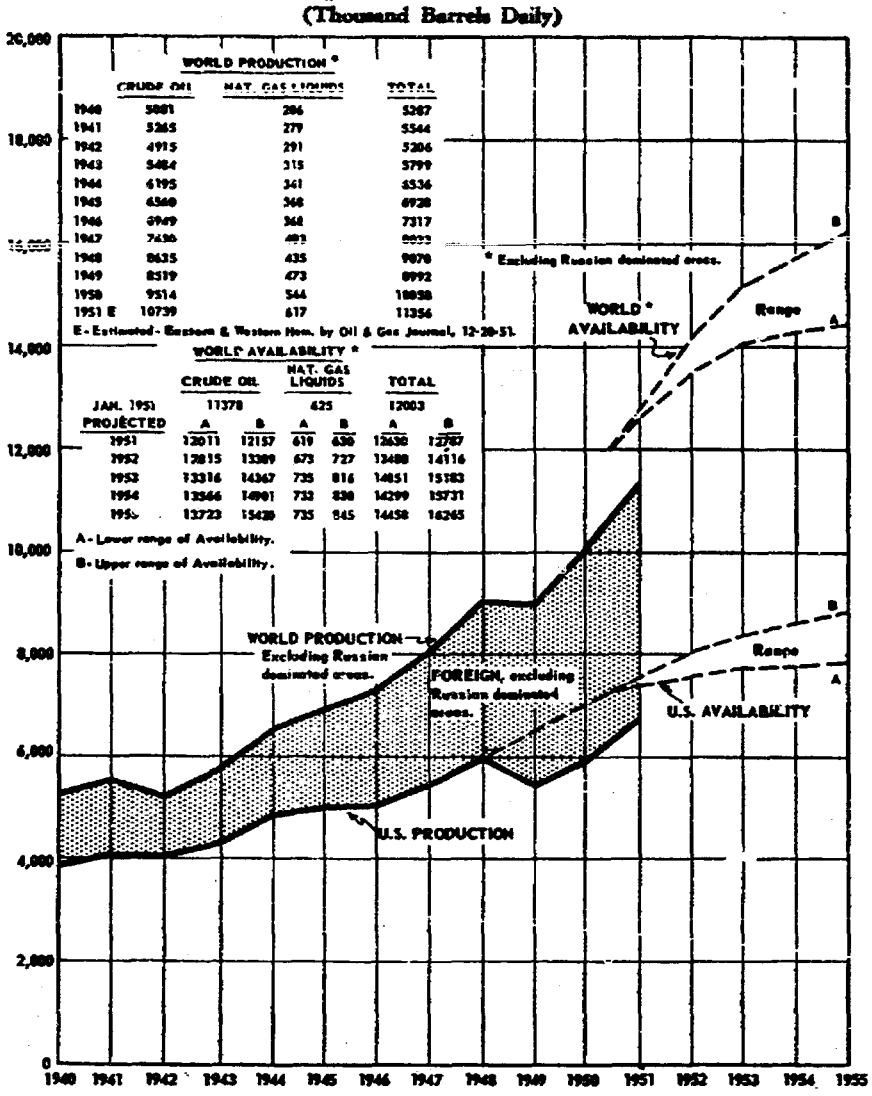


Hemisphere than in the Western Hemisphere. Roughly two thirds of the increase in foreign oil availability anticipated for 1951-1955 is estimated to be in the Middle East and Far East. The limiting factor in developing availability in these areas probably will continue to be

CHART 5

World Production and Availability of Total Petroleum Liquids, Excluding Russian-Dominated Areas

(Thousand Barrels Daily)



transportation facilities, as the proved and prospective reserves capable of further development by drilling are large.

Careful studies indicate increasing supplies of foreign oil in the future, provided that favorable conditions exist for continued investment of private capital.

SECTION III—LONG-TERM PROSPECTS FOR PETROLEUM SUPPLIES

In the next few years, for which prospects can be judged by present knowledge, the outlook is for increasing supplies of petroleum. In terms of national needs we must consider the prospects beyond the next few years. Where do we stand today with respect to petroleum supplies for the long term? The world's oil and gas production is now closing a hundred years of commercial significance. In that century petroleum fuels have become a major factor in economic progress. They have changed our transportation, agriculture, industry, and our whole way of life. Particularly in the United States, our standard of living depends largely upon abundant supplies of mineral fuels. Can we count on ample supplies of petroleum and all fuels for the foreseeable future of twenty-five to fifty years?

Several facts bear on our future prospects. Our technology for finding and producing oil is better than ever before. The effort being spent on the search for oil is also at a high level. The areas remaining to be explored for oil in the United States and foreign countries are very extensive. These facts have an important bearing on prospects for future petroleum supplies.

Today the production of oil and gas far exceeds the most optimistic views of even ten years ago. World oil production has doubled in ten years. This year it will be greater than in 1925 by four times for the world and three times for the United States. Proved reserves are far greater than ever before and are still increasing rapidly. Such achievements could hardly have been anticipated in 1925. They have been made possible by progress in technology and a more intensive search for oil. They represent the high potential of a dynamic industry. The industry is doing more now than ever before to develop new supplies for our future needs. It is impossible to foretell how much may be achieved in the next fifty years. It would not be surprising, however, for supplies in the next fifty years to exceed those of the past half century.

In foreign countries, discoveries and production have been amazing relative to the small amount of exploration and drilling done. The Middle East alone already has known reserves about twice as large as those of the United States. It is producing only one third as much oil as the United States. Under favorable economic and political conditions it may in time supply more oil than the United States. Latin America is producing as much as the Middle East and is still in the early stages

of development. Canada is just starting to develop its vast oil possibilities. There are other large provinces, such as Alaska, which may provide additional future supplies. Their development still lies ahead.

Foreign countries have an area favorable for oil finding ten times as large as that of the United States. Granted reasonable opportunity and conditions the oil industry may develop in these areas much more oil than in this country. Foreign countries are now producing less oil than the United States, but their rate of expansion since World War II has been greater. The continued rapid growth in foreign production anticipated through 1955 is only part of what may be expected for the long run if favorable conditions prevail. Judging by what we know today, the potential future world supplies of oil are very great. It might almost be said that we have just begun to scratch the surface of the world in the search for oil.

There seems little room for difference of opinion about the great amount of oil available in the world in the long run. Prospects must be measured in generations, and perhaps in centuries, rather than in decades. In case of peace and uninterrupted world trade, it might be expected that oil would move freely between countries. Exports and imports would normally balance oil supply and demand among countries as in the past. In an uncertain world, however, petroleum is of strategic importance. Dangers are involved in relying too much on imports of oil which might be cut off in an emergency. For that reason, we must consider with care the future supplies available to the United States.

A survey of prospects for oil in the United States is useful for several reasons. It will indicate the future outlook for an area in which there has been much exploration. It will indicate the forces which determine future supplies. Finally, it will deal directly with fears sometimes heard that we are running out of oil in this country.

The following sections will be limited largely to the United States, and particularly to its oil supplies. Natural gas will be dealt with only incidentally, as it is located and developed by the same processes as oil. Conclusions with respect to future prospects of oil will apply equally to natural gas. The analysis in the following sections will consider the forces determining oil supplies, the exploration process that makes oil available, the size of the prospective oil area, progress in development and recovery, economic factors, and the way in which fuel requirements can be met from different sources.

What Determines Oil Supplies?

Existence of oil in the earth does not alone determine available supplies. If mere physical occurrence governed supplies we would have

had the largest amount available upon initial discovery and a constantly declining available supply since then. Actually, the trend has been exactly opposite. Available supplies have increased steadily since the discovery of oil.

Oil supplies are made available by a process of exploration, drilling, and recovery. In exploration we must first find oil in the earth. After we find oil we must drill enough wells to recover it. Finally, we must produce those wells for twenty to forty or more years in order to deplete a field. This process obviously takes a long time. The wells producing today will continue to produce for many years. The prospects already discovered by past exploration will continue to provide discoveries for many years. The exploration now being done will mean still more prospects to be tested and developed in the future. The combination of these forces will govern future supplies.

Future supplies are not determined by the reserves known today. The estimates of proved reserves prepared annually by the American Petroleum Institute are limited strictly to the oil which will be recovered from areas already proved and largely through wells already in production. These estimates represent only that part of the oil in place underneath the earth which is known to be recoverable under current operating practices and economic conditions. Revisions of these estimates are made as drilling provides additional information on the proved area in a field and as evidence develops that the recovery may be more or less than previously anticipated. Further drilling may extend the proved area of a field materially. Improved operating conditions may mean a larger recovery per well. Economies in production or an increase in price may extend the productive life and increase the recoverable reserves.

The estimates of proved reserves do not include any allowance for oil that may be found in the future. They are minimum figures which are subject to further revision, as development drilling extends the limits of known fields. These estimates deal with the industry's immediate underground inventory. The size of the proved reserves largely determines the rate at which supplies can be made available currently, but not the amount of future supplies. The industry is constantly drawing from its underground proved reserves by production, but it is also constantly engaged in exploration and drilling which add new proved reserves. Over the fourteen years for which estimates of proved reserves have been prepared annually by the American Petroleum Institute, the new oil developed through discoveries, extensions, and revisions has been 1.59 times as much as the oil produced. It is the development of proved reserves at a more rapid rate than production that

increases available supplies. Clearly, proved reserves are not the measure of future supplies.

A common mistake made in discussing future oil supplies is to consider only proved reserves. Frequently these proved reserves are compared with the current annual production to arrive at the number of years that supplies will last. By such calculation it would have seemed almost any time in the past that supplies could last only ten to twenty years. On this basis there have been many predictions that we are running out of oil. Such predictions have been false in the past. They are nonsense today because they fail to consider the rate of oil finding and development. It is future discoveries, not presently known reserves, that will determine available supplies for the long run.

Statistics on proved reserves and production are set forth in Table 12 and shown on Chart 6. They provide proof that proved reserves are only part of the supplies available over a period of years. Two examples will illustrate this point: (1) In September 1926, the Federal Oil Conservation Board reported that known oil reserves in the United States were about 4.5 billion barrels. That much oil was produced in the next five years, but by then proved reserves had increased greatly. (2) At the end of 1937, known reserves were estimated to be 15.5 billion barrels. That much oil was produced in the next ten years. Still, at the end of 1947 the estimate of proved crude oil reserves was 21.5 billion barrels, or nearly 40 per cent higher than a decade earlier.

These examples show that the proved reserves at any time are only part of the supplies that will become available for the future. The total proved reserves become available over a period of years at the efficient rate of production from those reserves as they are depleted. In addition, large new supplies become available from the discovery and development of other reserves. The sum of the supplies available from wells producing today and from wells drilled in the future determines the long-term prospects for petroleum supplies. Available supplies really depend on the rate at which we search for and develop new oil. If we stop that process, the available supplies will decline, because the amount which wells can produce will decrease as they are depleted. If we carry on enough development to offset depletion caused by production, available supplies can be maintained at a constant rate. If the development of new reserves is at a rate exceeding production, available supplies will increase. To determine the prospects for future petroleum supplies, therefore, we must study with care the exploration process.

The rate at which we discover oil in the earth is a function of (1) knowledge and technology and (2) the effort spent on exploration and drilling. Both of these factors change with time. It is because of this

TABLE 12

U. S. CRUDE OIL PRODUCTION AND PROVED RESERVES

	Crude Oil Production* (Thousand Barrels)	Proved Crude Oil Reserves Million Barrels January 1	Ratio of Reserves on January 1 to Annual Production
1918	355,928		
1919	378,367		
1920	442,929		
1921	472,183		
1922	557,531		
1923	732,407		
1924	713,940		
1925	763,743		
1926	770,874	4,500.0†	
1927	901,129		
1928	901,474		
1929	1,007,323		
1930	898,011		
1931	851,081		
1932	785,159		
1933	905,656		
1934	908,065		
1935	936,596		
1936	1,009,687		
1937	1,279,160	13,063.4**	10.2
1938	1,214,355	15,507.3	12.8
1939	1,264,962	17,348.1	13.7
1940	1,353,214	18,483.0	13.7
1941	1,402,228	19,024.5	13.6
1942	1,386,645	19,589.3	14.1
1943	1,505,613	20,082.8	13.3
1944	1,677,904	20,064.2	12.0
1945	1,713,655	20,453.2	11.9
1946	1,733,939	19,941.8	11.5
1947	1,856,987	20,873.6	11.2
1948	2,020,185	21,487.7	10.6
1949	1,841,940	23,280.4	12.6
1950	1,971,845	24,649.5	12.5
1951	2,250,000 P	25,268.4	11.3

P—Preliminary.

* Bureau of Mines.

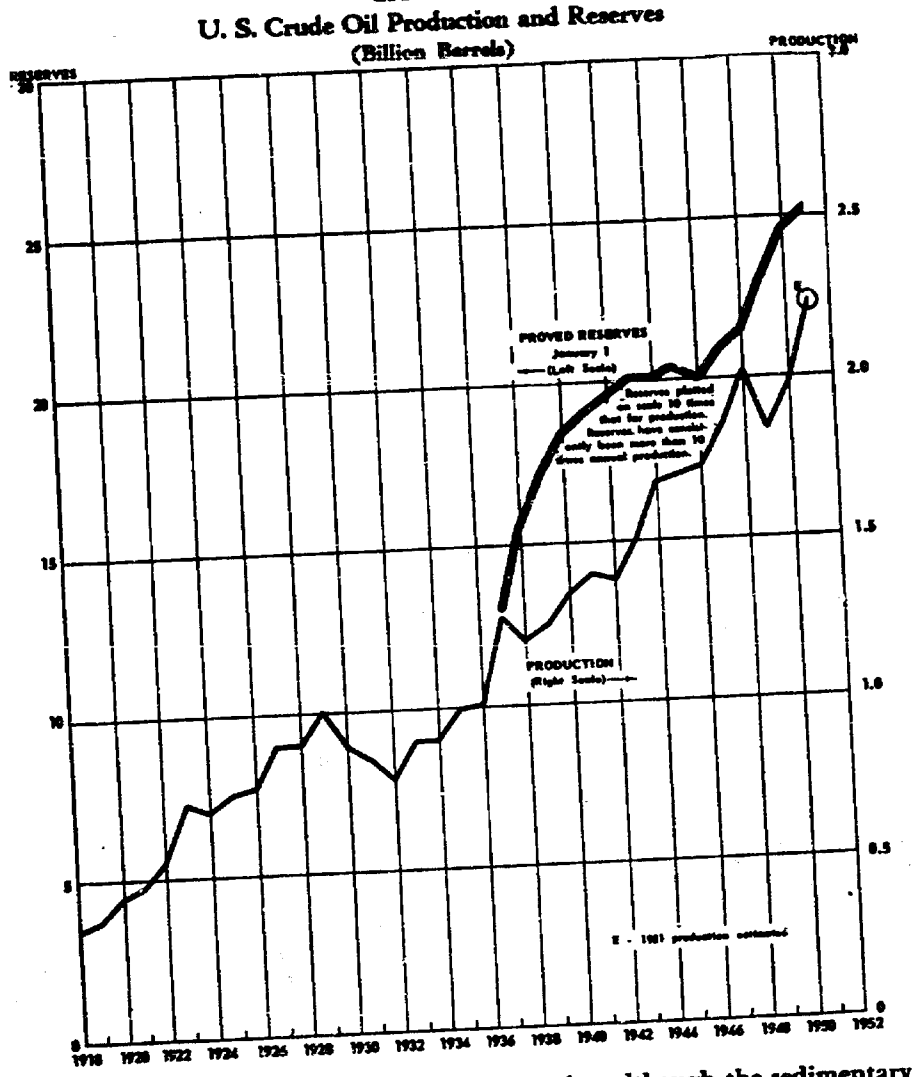
† Report of the Federal Oil Conservation Board to the President of the United States, September 1926, Part I, Page 8.

** American Petroleum Institute, 1937-1951, exclusive of natural gas liquid reserves reported at 4,267.7 million barrels on January 1, 1951.

CHART 6

U. S. Crude Oil Production and Reserves

(Billion Barrels)



change that the rate of discovery of oil varies, although the sedimentary area in which oil may be found remains constant.

Our knowledge of where we may find oil in the earth has progressed steadily. Initially, the search for oil was associated with surface showings in seeps. Later, a geologic theory was developed that oil might be found where there were anticlines in the structure of the earth. With the passing of time, other geologic conditions have been connected with the occurrence of oil. Faults, salt domes, stratigraphic traps, and reefs

have been found to indicate possible accumulation of oil underground. Each new idea as to the conditions under which oil occurs opens up possibilities in old and new areas.

Our knowledge of subsurface geology grows by the hour with the drilling of more wells. In 1951 the industry drilled about 475,000 feet a day. About one fourth of this drilling is in exploratory wells that are being studied deliberately to find out where oil may occur. The information provided by these wells adds steadily to our knowledge of where we may find still more oil.

Technology also improves steadily. We have made great strides in the tools to hunt for oil, to reach it, and to locate its exact position in the earth. Similarly, progress has been made in equipment and techniques for increasing the recovery of oil after it is found. Thus, technology combined with knowledge adds to our ability to find oil.

The effort spent on the search for oil also changes. As more supplies are needed, we carry on additional exploration and drill more wells. The results of exploration with a specific technology have generally been about in proportion to the effort spent on the search for areas of similar geologic conditions. Available supplies for the future will be influenced by increases or decreases in the rate of search for oil. The rate of exploration and drilling may be influenced by economic forces independent of changes in prospects or technology.

Changing conditions with respect to knowledge and technology make it futile to predict how much oil remains to be found in the United States. The sedimentary areas in which oil may be found do not change, but our ideas of where oil may be found in that vast area constantly expand. Speculations as to how much oil will ultimately be found are necessarily limited by what we know today, as any allowance for future progress is only a guess. Past speculations on this point have proved conservative. They have had to be revised upward consistently as further experience and progress made it necessary to raise our sights. These speculations cannot even give us an approximate range, for they are subject to great change within a short time. Two illustrations show how conservative these predictions can be and how rapidly they may change.

In 1920 the United States Geological Survey estimated the oil remaining in the ground at 7 billion barrels and made the following statement about future supplies in its annual report:

"Fortunately, it is simply impossible to discover and take out the oil remaining in the ground in the United States, 7 billion barrels, in so short a period as eighteen years. Instead of mining our petroleum so rapidly we must either depend more and more on oil from other sources or get along with less oil. Our children will doubtless do both."

Since 1920 there have been produced in the United States about 38 billion barrels of crude oil. At the end of 1951 the proved reserves of crude oil and natural gas liquids in the United States will exceed 30 billion barrels. We have already found about ten times as much oil as the U. S. Geological Survey estimated remained in the ground in 1920, and are still finding oil at a rapid rate.

In the case of natural gas, one estimate of future supplies was revised upward by 70 per cent in a period of six years. This estimate of future production was changed from 300 trillion cubic feet or more in 1944 to 510 trillion cubic feet or more in 1950.* The later estimate was related to figures on the probable ultimate recovery of oil. Consequently, it would have to be revised upward as future experience causes a revision of the estimates of oil remaining to be discovered.

The preceding illustrations show the limitations of speculation about oil and gas reserves remaining to be found. It would have been foolish to base national policy with respect to fuels in 1920 on the assumption that only 7 billion barrels of oil remained in the ground. The speculations at that time were proved to be wrong by later evidence. Current speculations, which range widely in themselves and change rapidly, will probably prove to be incorrect. The error lies in trying to determine future discoveries on the basis of present knowledge, when all experience shows that these discoveries will be determined by the developments still ahead in the operations of a dynamic industry.

A fuller appreciation of the forces which will determine future oil supplies can be gained by an analysis of the exploration process. Consequently, the following section describes this process and the manner in which it will contribute to future supplies.

The Exploration Process

Oil in the earth is only a potential resource. Effort is required on our part to find it and make it available. Supplies are determined by the rate at which we develop new resources, not by the amount of the resources which may exist in the earth.

In the search for oil we are guided by the knowledge that petroleum may have accumulated in any sedimentary deposits, particularly those of marine origin. Wherever the subsurface contains sand, lime, or shale, there may be petroleum.

Of the three million square miles of area in the continental United States approximately 80 per cent consists of sedimentary formations considered favorable for petroleum deposits.† The oil and gas dis-

* Terry, Lyon F., "The Future Supply of Natural Gas" presented at the annual meeting of the American Gas Association, October 2, 1950.

† *World Geography of Petroleum*, page 21, American Geological Society, special publication No. 31, 1950.

covered to date has been developed on about one per cent of the prospective area. Future supplies will depend upon the rate at which we find oil in some 2,400,000 square miles of sedimentary area.

The sediments under the surface of the United States range in thickness from a few feet to 50,000 feet or more. Oil has been found at depths of less than 100 feet and greater than 15,000 feet. One well in Mississippi is reported to have encountered gas at a depth in excess of 20,000 feet.

There is no direct method of telling where oil exists in the vast sedimentary area. Through experience the industry has come to associate the occurrence of oil with certain typical geologic conditions beneath the surface. These conditions provide a situation in which deposits of oil and gas may have accumulated in some sedimentary formations and been sealed off or trapped, so that the accumulation is of commercial significance. Exploration is designed to find locations underneath which the geology may be favorable for the accumulation of oil. These locations are termed prospects. The prospects must be tested by drilling to determine whether the geologic interpretation is correct and whether petroleum actually exists. Only about one exploratory well out of nine drilled in non-producing areas finds oil or gas. Many of the discoveries are small and provide little return on the capital risked even though they add to reserves.

Geology and Geophysics

The chief tools used in locating specific areas under which oil and gas may lie are geology and geophysics. Geology is the study of the earth. Petroleum geology interprets surface and subsurface data. In many areas the manner in which formations outcrop at the surface provides clues as to subsurface conditions. In other areas, such as the plains, information on subsurface geology may be inferred from data provided by geophysics or by actual drilling of wells. Surface and subsurface geology are combined with geophysics as a rule in the scientific search for oil.

Around 1920 the principle of physics that sound travels at different rates in hard and soft formations was applied by what is known as geophysics. Small explosions of dynamite set off sound waves, and equipment located at various points around the explosion measured the time required by the shock to be reflected by formations underground. These measurements permitted interpretation of subsurface conditions even before wells were drilled. Subsequently, many refinements have been made in geophysics. The refinements permit better measurement, more accurate interpretation, and greater speed. Different geophysical methods may be used to supplement each other. They are used with other geologic information to select locations to be tested by drilling.

Exploratory Drilling

The drill is the final exploration tool, as geology and geophysics cannot indicate whether oil and gas actually exist. Sometimes wells are drilled without scientific evidence in what is termed random exploration. Some of these wells drilled on a hunch find oil, but the odds are much better for the scientific methods. Of the exploratory wells searching for new fields in 1950, 13 per cent of those drilled on scientific evidence resulted in discoveries but only 3 per cent of those drilled without a technical basis found oil or gas.

The drill serves not only to determine whether oil exists but also to provide geologic information. By inspection of the fossils in some of the materials penetrated by the drill it is possible to identify the formation and relate its position to that in other wells. Occasionally, wells are drilled strictly for geologic information to find how formations occur beneath the surface rather than to test for the actual location of oil.

On the average, eight out of nine exploratory wells drilled away from producing areas are dry holes. Even the dry holes may help to find oil, however, by providing additional information on subsurface conditions. Such information may indicate the possible existence of oil at another location.

Improvement in Drilling

Progress in drilling has been a major factor in the development of large oil supplies. After a prospect which may have oil is located, it is necessary to drill wells to reach the prospective formation, to identify any formations that have oil and gas, and to complete wells as successful producers.

The first commercial oil well in the United States was less than 70 feet deep. Early drilling methods consisted of raising and dropping a heavy bit which penetrated the earth. This process, known as the cable tool method, was limited as to depth and required a good deal of time. Most wells are now drilled by the rotary method. In this method a drill pipe is rotated from the surface to make the bit cut deeper into the earth. The material cut by the bit is removed continuously by a drilling mud pumped down inside the drill pipe and back up to the surface between the drill pipe and the wall of the hole.

The deepest well drilled up to 1900 was only about 3,000 feet. In the next twenty-five years the maximum depth reached was increased to nearly 8,000 feet. By 1951 drilling had been carried deeper than 20,000 feet. Chart 7 shows the history of the record depths attained from 1900 to 1950, and the average depth of all wells since 1925. As technology changes the limits that are physically possible and economically feasible, the trend is toward deeper wells. The high cost of deep wells means

The intensive use of scientific exploration methods is relatively new. It was not until about 1915 that geology began to be applied generally to the search for oil. The application of geophysics came even later. The number of persons engaged in the scientific search for oil has increased steadily. In 1951 there were in operation in the United States some 600 geophysical crews and thousands of geologists.

The progress made in knowledge and techniques of petroleum exploration has been tremendous. Geologic concepts have advanced from simple principles to the recognition of many types of subsurface oil traps. Each new concept adds to the area in which we look for oil and helps find more oil.

The effectiveness of subsurface geology has been improved in several ways. Study of the wells drilled, whether productive or dry, has provided more pieces to fill in gaps in our knowledge of underground geology. New methods have been devised for obtaining precise subsurface information. Techniques for securing cores of the section being penetrated by a well permit careful study of the fossils and correlation with similar studies on other wells. Readings of conditions throughout the depth of a well by means of techniques known as electric loggings and radioactive logging provide detailed information not available otherwise. Recently a dipmeter has been developed which measures the angle of inclination of the sediments penetrated by a well. This information about the area surrounding the well may be valuable in finding or developing oil.

Many new inventions are adapted to the search for oil by the industry. Aerial mapping has provided a quick method of surveying large areas which might be difficult or take a long time to cover by conventional methods. Special aerial photographs when viewed with a stereopticon permit measurement of topographic features in three dimensional relief. Airplanes have also been used for rapid application of some geophysical techniques to large areas.

Geophysical methods have undergone marked improvement. The equipment has been made more reliable and sensitive. By the use of helicopters and special vehicles for swamps, geophysics has been applied to areas that could not ordinarily be reached. New techniques were devised for geophysical exploration of the shallow waters of the Continental Shelf. Radio surveying techniques were used in this work and have been adapted to exploration on some land areas. Electronic developments have been applied to provide more precise geophysical information. In short, the apparatus, the method, and the interpretation in geophysics have improved vastly. These improvements make it possible to detect many prospects previously missed in old areas and to carry the search into new areas at a high level of efficiency.

ance of various formations to electric currents, and other factors. Mud logging is also used to detect minute traces of oil and gas in the drilling fluid as it returns from the bottom of the well to the surface. The material cut by the bit is also analyzed for information. Special equipment is used to take a core of the section being penetrated by the drill, so that this section may be studied for fossils and other indications as to geologic age and probable oil content. The combination of these various methods makes it possible to locate even thin sections containing oil and gas. In some fields a well may penetrate twenty or thirty separate formations which have oil and gas.

Control over the direction of drilling has made it possible to reach oil that might not otherwise be economically available. Techniques for directional drilling permit completion of a well at a predetermined distance and depth from the surface point at which the drilling takes place. Wells drilled on the shore of California by this method reach out underneath the Pacific Ocean to produce oil lying beneath the water. Directionally drilled wells have also been used from the expensive platforms built in the Gulf of Mexico, in order to test formations within an extensive radius and reduce the cost of developing the oil.

After the presence of petroleum is indicated, the production possibilities of the formation are determined. These possibilities are tested either while the well is still being drilled or after the final depth has been reached and the well is completed. The production tests measure the amount of oil or gas recovered in a period of time. They indicate whether the production is of commercial significance, and the rate at which the well may produce.

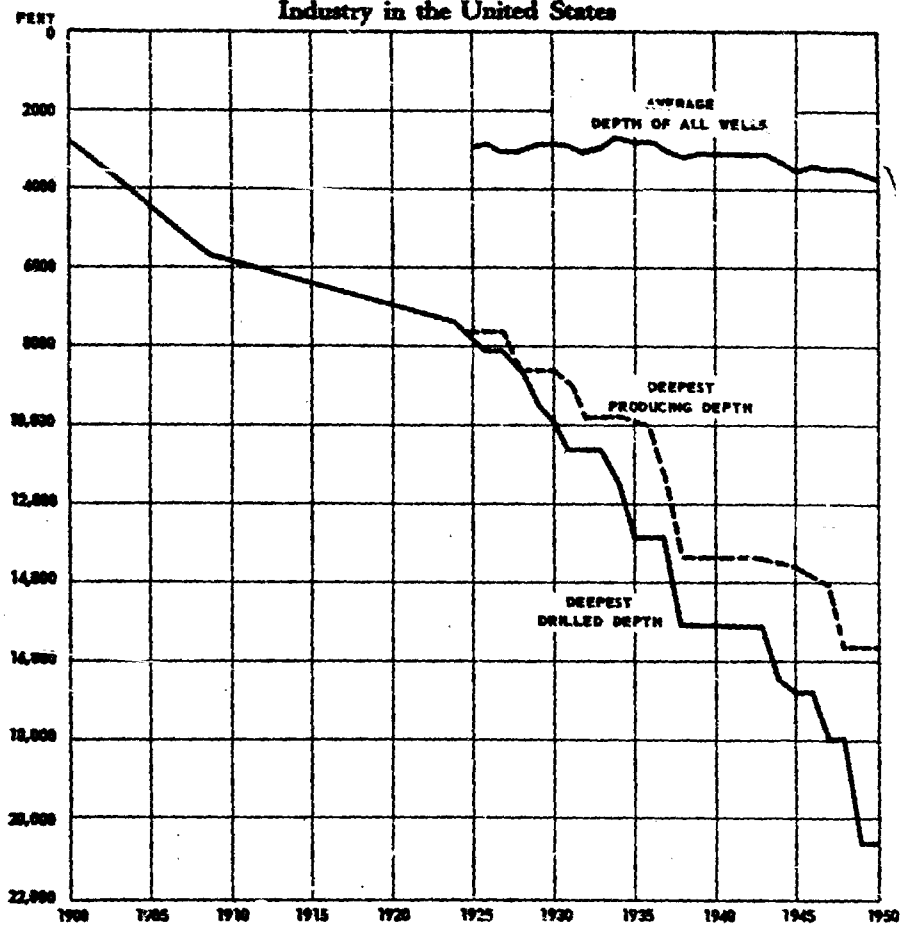
The actual completion of the well also contributes to the successful recovery of oil. Before techniques were perfected for controlling pressure, many discoveries would blow out and waste a great deal of oil. This seldom happens now because of the careful controls maintained in drilling a well.

Some wells have relatively small initial production. Under ordinary circumstances they might not be worth operating. Special means are used to increase the flow of oil to the well. These include treatment with acid, fracturing by the application of high pressure, and shooting with nitroglycerine. All of these methods help open new channels of flow for the oil through the formations to the well.

The design of drilling equipment has been improved to reduce costs and permit access to difficult locations. The modern unitized drilling rig can be set up quickly and moved with little loss of time to another location after a well is completed. Drilling barges have been designed for use in swamps. These barges are floated to the location, sunk in the water to provide a foundation while drilling proceeds, and

CHART 7

Depth of Wells Drilled by the Petroleum Industry in the United States



that fewer wells can be drilled to recover a specific quantity of oil from deep fields than from shallow ones.

Rotary drilling is much faster than cable tool drilling. It presents problems of identifying formations that may have oil and gas, however, for without special techniques this drilling method might hide the contents of the formation. The industry has developed instruments that can be run down into the hole as the well is drilled to measure different properties which provide clues as to the possible location of oil. These tools provide a log of information related to depth. Various logging methods are used, such as thermal, electric, radioactive, and neutron logging. These methods measure the temperature, the resist-

then refloated to other locations. Drilling equipment has been placed on boats for some of the operations in the Gulf of Mexico.

The speed of drilling has been increased by various methods. Improved types of bit at the bottom of the drill are used to penetrate rock and other formations more rapidly. A recent development has been of the "jet bit" which uses high velocity circulation of the drilling fluid at the bit in order to increase the rate of penetration. With these methods new drilling records have been set of the penetration of over 2,500 feet in eight hours.

The preceding review does not exhaust the list of improvements made in exploration and drilling. The information presented has been designed to illustrate progress and the way in which supplies are made available that previously could not have been counted upon. It shows that supplies are a function of exploration and drilling rather than of oil in the earth. Consequently, it emphasizes the importance of an active search and dynamic technology in any consideration of future long-term prospects.

Achievements of Exploration

The combination of information secured by geology, geophysics, and drilling is adding constantly to our knowledge about where to hunt for oil. Improved knowledge and techniques, taken together with a more active search, explain the remarkable progress that has occurred in the development of new oil resources.

The accomplishments of the exploration processes in the past are evident from development of increasing supplies of oil. As there is available an official estimate of reserves, prepared by the Federal Oil Conservation Board in 1926, it is interesting to measure the accomplishments before and after that year.

In the years 1859-1925, 700,000 wells were drilled by the oil industry in the United States. Some 8.7 billion barrels of oil were produced during those years and the proved reserves were estimated to be 4.5 billion barrels in 1926. Therefore, the wells drilled in the period developed a total of about 13 billion barrels. In the period 1926-1951 about 696,000 wells were drilled and 34.5 billion barrels of oil were produced. Proved reserves of crude oil at the end of 1951 will be at least 21.5 billion barrels more than in 1926. Consequently, the oil developed in the past 26 years has been at least 56 billion barrels, or more than four times as much as in the preceding 67 years, although the number of wells drilled was approximately the same in both periods.

In the latest decade for which final figures are available, 1941-1950, the industry drilled 306,000 wells and developed 23 billion barrels of oil. The rate of development for the past ten years is comparable with

or slightly greater than that for the longer period, 1926-1951. In other words, the rate of development of reserves has been in proportion to drilling during the past quarter century of scientific exploration, without any downward trend. The search is more expensive now than in the past, and frequently it is necessary to drill to much deeper depths. The trend toward higher costs has been partially offset by improved technology and the wider spacing of wells.

In 1951 there were drilled nearly 45,000 wells in the search for and development of oil and gas in the United States. Of these wells, about 37.5 per cent were dry holes. The other wells, nearly 28,000 in number, added to our ability to produce oil and gas. At recent drilling rates the industry would complete another 700,000 wells in about fifteen years to equal the total drilled in 1859-1925 and in 1926-1951. How much oil these wells will develop will depend on the success of the exploration process as it is applied to the large prospective area. Since ingenuity and technology continues to progress, we may expect reasonable success in the development of supplies for the future provided there is a sufficiently large favorable area in which to continue the search. The evidence on the magnitude of the area still prospective for oil is encouraging.

Size of the Prospective Oil Area

The prospective area in which the industry thinks oil and gas may be found is about one hundred times as large as the area of all the oil and gas fields discovered in the United States during the past 92 years of exploration. Our ideas as to the size of the prospective oil area have increased as a result of additional knowledge.

The search for oil was concentrated largely in Pennsylvania, New York, and Ohio until about 1890. By 1900, West Virginia, Indiana, and California also had attained substantial oil production. Until this time Texas and other states which subsequently have proved very productive were hardly considered prospective areas. By 1910, Illinois, Kansas, Oklahoma, Texas, and Louisiana had been added to the list of states producing over a million barrels a year. In the next decade substantial production was developed in Wyoming and Kentucky. Between 1920 and 1930, Arkansas, New Mexico, Colorado, Kentucky, Michigan, and Montana were added to the list of states in which substantial production had been developed. Mississippi was added to the list in the following decade, and Nebraska and Utah during the past ten years. Other states, such as North Dakota, Florida, and Alabama, may in time be added to the list with substantial production. The growth in the number of states with crude oil production in excess of a million barrels annually from one in 1870 and eleven in 1910 to twenty-one in 1950 is shown in Table 13.

TABLE 13

STATES WITH ANNUAL CRUDE OIL PRODUCTION IN EXCESS OF ONE MILLION BARRELS

States by Rank and Production in Million Barrels

Rank	1870	1880	1890	1900	1910	1920	1930	1940	1950†
1	Pa. 5	Pa. 25	Pa. 27	Ohio 22	Cal. 73	Okla. 106	Texas 290	Texas 493	Texas 829
2		N.Y.* 1	Ohio* 16	W.Va.* 16	Okla.* 52	Cal. 103	Cal. 227	Cal. 224	Cal. 328
3			N.Y. 2	Pa. 13	Ill.* 33	Texas 97	Okla. 216	Okla. 156	La. 209
4				Ind.* 5	W.Va. 12	Kan. 39	Kan. 42	Ill. 148	Okla. 165
5				Cal.* 4	Ohio 10	La. 36	La. 23	La. 104	Kan. 108
6				N.Y. 1	Texas* 9	Wyo.* 17	Ark.* 20	Kan. 66	Ill. 62
7					Pa. 9	Ill. 11	Wyo. 18	N.M. 39	Wyo. 60
8					La.* 7	Ky.* 9	Pa. 13	Ark. 26	N.M. 48
9					Ind. 2	W.Va. 8	N.M.* 10	Wyo. 26	Miss. 38
10					Kan.* 1	Pa. 7	Ky. 7	Mich. 20	Ark. 31
11					N.Y. 1	Ohio 7	Ohio 6	Pa. 17	Colo. 23
12							Ill. 6	Mont. 7	Mich. 16
13							W.Va. 5	Ky. 5	Pa. 12
14							Mich.* 4	N.Y. 5	Ky. 10
15							N.Y.* 4	Ind.* 5	Ind. 10
16							Mont.* 3	Miss.* 4	Mont. 8
17							Colo.* 2	W.Va. 3	N.Y. 4
18								Ohio 3	Ohio 3
19								Colo. 2	W.Va. 3
20									Nebr.* 2
21									Utah* 1
Total	1	2	3	6	11	11	17	19	21

Source: Bureau of Mines.

* Passed one million barrels annual production during preceding decade.

† Other states which had production of less than one million barrels in 1950 were: Alabama, Florida, Missouri, Tennessee, and Virginia.

The sedimentary area of the continental United States prospective for oil is about 2,490,000 square miles or approximately 80 per cent of the land area. About two thirds of this sedimentary area is included in the possible future oil provinces classified by the American Association of Petroleum Geologists in a symposium published in February 1951. The prospective future oil provinces described in this study contain 1,660,000 square miles, including certain portions of the Continental Shelf to a water depth of 120 feet. Another 200,000 square miles in presently producing areas not included in the classification of "future oil provinces" must be added to arrive at a total of 1,860,000 square miles with favorable prospects for future discoveries.

Future Oil Provinces

The study published by the American Association of Petroleum Geologists in 1951 on possible future oil provinces was similar to one published in 1941. These studies were made by local geological societies, representatives of geological surveys, and individual geologists familiar with specific provinces. These specialists considered all available evidence in classifying geologic provinces from the standpoint of future oil prospects. Each study was limited by the technology and geologic concepts prevailing at the time. In 1941 it was not considered feasible to include in the possible future oil provinces the offshore Continental Shelf or the sediments deeper than 15,000 feet. Progress by 1951 resulted in the inclusion as possible oil provinces of the offshore Continental Shelf and sediments as deep as 20,000 feet.

The 1941 report on future oil provinces by the American Association of Petroleum Geologists described 34 provinces. By 1951 oil and gas fields had been proved to exist in 20 out of the 34 provinces listed ten years earlier. The names of these 20 provinces listed in the 1941 study and some of the fields discovered in them since 1941 are shown in Table 14.

In about 100,000 square miles of the 1,860,000 square miles in the producing and prospective provinces, oil possibilities are considered to be only remote at this time, but this opinion may be changed with later developments. In forty-three of the sixty prospective provinces there are some evidences of oil and gas. About one fifth of the prospective area has sediments extending below 15,000 feet. It is estimated that some 15 per cent of the area included in the future oil provinces is already under lease by oil companies. Such lease operations indicate active consideration of the prospects by oil companies. The prospective provinces discussed by the American Association of Petroleum Geologists are shown on a map and described briefly in Exhibit A.

The size of the prospective oil area is impressive. It is large in relation to the area in which oil has been found. It is also very large in relation to the rate at which exploratory work is being carried on. Although an estimated 140,000 exploratory wells have been drilled in the United States through 1950, huge areas remain in which very little exploration has been done. For example, only about 150 exploratory

TABLE 14

Geological Areas Listed in the 1941 Study of Future Oil Provinces by the American Association of Petroleum Geologists in which Discoveries had been made by 1951

Name of Province	No. on Map	Fields Discovered
1. Sacramento Basin (Incl. San Joaquin Valley)	8	Helm, several in Coalinga area
2. Calif. Coastal Embayments	9	Cuyama Valley, Russell Ranch, San Ardo
3. South Central Montana	19	Elk Basin
4. Powder River Basin	20	Mush Creek, Sussex
5. Big Horn	21	Worland, Elk Basin
6. Green River Basin	23	Church Buttes
7. Wind River Basin	22	Big Sand Draw, Steamboat Butte
8. Unita Basin	25	Roosevelt
9. Eastern Colorado	30	Sterling Area
10. N. and S. Dakota	31	Williston Basin
11. W. Nebraska	32	Gurley
12. Salina & Forest City Basins	33 & 34	Borada and 15 other small pools Falls City area
13. S. E. Okla., N. W. Ark.	35	60 producing gas fields, little oil
14. Anadarka-Panhandle	36	Elk City, Apache, Ringwood
15. Northern Llano Estacado	37	Anton Irish
16. Trans-Pecos	38	13 oil and 2 gas fields
17. Mississippi	45	Baxterville, Cranfield, Heidelberg, Gwinville, others
18. South Alabama		Gilbertown
19. Florida	46	Sunniland
20. Appalachian Basin	55, 56 57, 58, 59	Canton (Ohio), Rose Hill (Va.), Leidy (Pa.).

wells were drilled in 1950 in the vast prospective area included in the following fifteen states: Arizona, Florida, Georgia, Idaho, Maryland, Missouri, Nebraska, Nevada, North Carolina, North Dakota, Oregon, South Dakota, Utah, Virginia, and Washington.

The volume of sediments remaining to be tested is as impressive as the area. The average depth of all wells drilled to date is less than 4,000 feet. Even in producing areas prospects remain to be explored at greater depths. There are already hundreds of examples of fields in

which deeper production has been found long after oil was initially discovered. In early years it was customary to stop drilling with the first substantial production encountered. Later drilling to greater depths in such old fields is constantly finding additional production.

The size of the prospective oil area is so large that it would take many years and a great deal of capital to complete an intensive search. Recently the oil industry has been spending several billion dollars annually in exploration and drilling. It has been completing more than 10,000 exploratory wells a year. Even at this rate the exploratory wells drilled in fifty years would be less than one to three square miles. Many areas have required even more intensive exploratory drilling than this in the process of testing prospects, for it is not unusual to drill several dry holes in a small area before finally locating oil production.

The question may be raised whether the area remaining to be explored is likely to result in much less discovery of oil relatively than the area already explored. At first glance it might seem that the prospects most likely to contain abundant oil would have been tested first. Such an assumption is not true because of the nature of the exploration process. We are unable to tell at any time where the most prolific fields may occur. Prior to 1900, Texas was not considered a good prospective oil area, but it has since been proved to contain a great deal of oil. It was not until nearly 1925 that West Texas, which is now considered to be one of the great oil provinces, was considered to be a good prospective area. The East Texas field, with the largest proved reserves discovered in this country, was not found until 1930. The Spraberry trend, which seems to cover the largest producing area of any field yet found in the United States, was brought into production in 1949. There probably are still to be found very good producing areas which have not in the past been considered as favorable as those presently producing. The recent discoveries in North Dakota and Montana, for example, may open up an area which the future may prove to have been very favorable for oil production.

Time Required to Explore Prospective Areas

There are several reasons why much of the prospective oil area has not already been explored. In the first place, the sedimentary area is so large that there has not been sufficient time in which to carry out a thorough exploration of all of it. In the second place, exploratory drilling has been concentrated in relatively small regions where oil was being found. Furthermore, some of the prospective area has only been brought into the picture as progress made it possible to carry the search into more difficult and deeper areas. Finally, the search is not likely to be carried into new areas until there is an economic prospect for suc-

cess in case of discovery. Initially the cost of transportation of oil was quite high and discoveries in areas remote from markets would have been of no commercial value. Even within the past fifteen years there are examples of fields known to exist which were not worth commercial development because of economic circumstances. One of these fields was Rangely in Colorado. For another economic reason the development of the Spraberry trend in West Texas, now underway, would not have been feasible at the price of crude oil that prevailed in the period 1930-1945.

It takes a long time to explore a new province thoroughly and develop its oil possibilities. Two examples will illustrate this point. The first discovery of oil along the Gulf Coast was made at Spindletop, Texas, in 1901. The entire coastal strip from the Mexican border to Florida has numerous geologic similarities. It is characterized by thick sediments that dip toward the coast and out under the Continental Shelf. Active exploration in Texas and Louisiana developed substantial production along the Gulf Coast. It was not until the 1930's, however, that many of the large oil fields of the Gulf Coastal area were found. It was 1933 before oil was discovered in Mississippi, 1943 when it was discovered in Florida, and 1944 when it was discovered in Alabama. Alabama and Florida produce less than a million barrels of oil a year and their prospects still remain to be tested in the future. Thus, the Gulf Coastal province has large areas remaining to be tested more than fifty years after the initial discovery of oil. Available supplies from the area are at a level greater than ever before and may well increase in the future.

Another example of the time required to explore an area is evident in Canada. The first well in the province of Alberta was drilled in August 1894. The first major discovery was made in 1914 at Turner Valley. Through the year 1947 a total of 775 dry holes had been drilled in the province of Alberta, but there was little success in finding oil. In 1947, an important discovery was made at Leduc, 190 miles northeast of Turner Valley. Increased exploration followed rapidly. Within a few years discoveries have amounted to about 1.5 billion barrels. By the end of 1950 over 100 million acres had been leased by oil companies in the provinces of Alberta and Saskatchewan. More than a hundred geologic crews were operating in the area and 140 rigs were engaged in drilling wells. In this case it was thirty-three years from the initial discovery of a major field to the subsequent sharp expansion of exploration and production. Several decades may pass before the oil prospects of this large region are reasonably tested and production approaches its maximum rate.

Progress in exploration frequently provides the key required to extend the search into new areas. As geophysical techniques are im-

proved, for example, the areas in which good interpretations can be made increase. Thus, it becomes possible to apply such methods where they were not previously effective. Improvements in the method of applying a process also extend the limits in which the search can be made. This was true in the case of the application of geophysics to the Continental Shelf. In other cases improvements in drilling techniques make it possible to enter a new area. The Continental Shelf and the swamps of Louisiana both illustrate this point.

Evaluation of Future Prospects

The prospects for finding oil in the future may be analyzed separately for the areas in which substantial production has already been achieved and those in which little production has been developed to date.

The reasons why the older producing provinces remain prospective are as follows: (1) improvements in exploration reveal new prospects not evident by earlier methods; (2) the ability to drill deeper opens up prospects below the shallow producing fields; and (3) the accumulation of information through exploration and drilling suggests possibilities of production elsewhere in the same formations that have proved productive in the past.

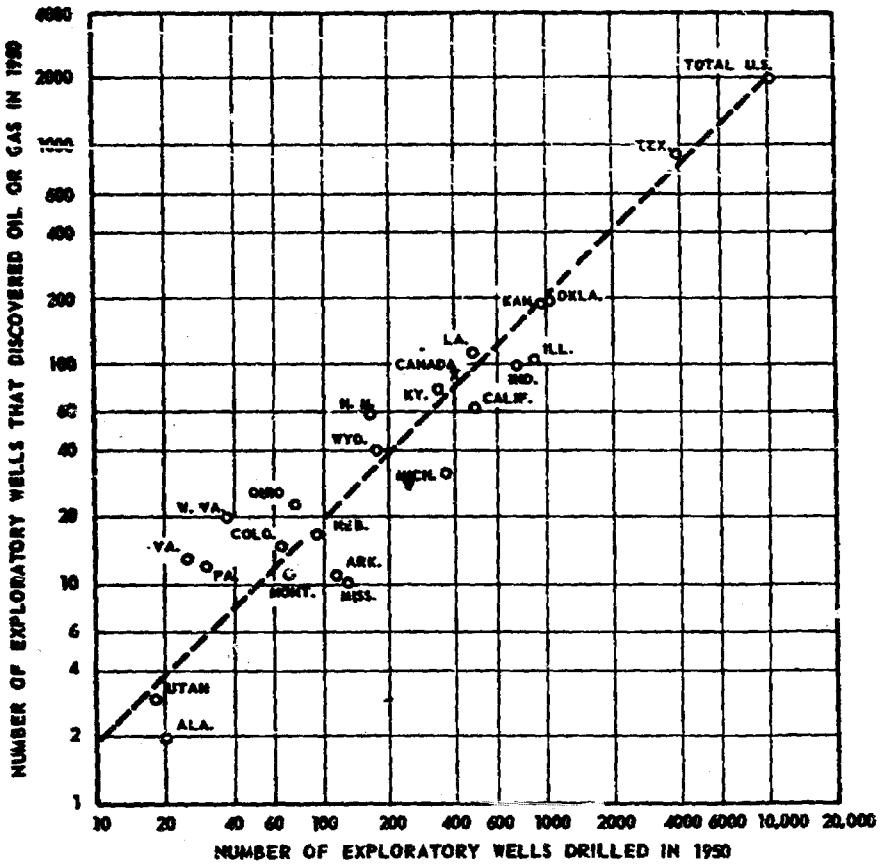
The prospects for finding substantial oil in areas which have had little exploration in the past may be considered good for the following reasons: (1) the geologic conditions of these prospective areas are generally similar to those of areas already producing; (2) there are already indications of the existence of oil and gas in some of the prospective areas, although very little exploration has been done; and (3) large sums of money are being risked by oil companies on exploration and leasing in prospective areas.

The best evidence of the continued discovery of oil is in the experience that discovery is in proportion to the exploratory effort and in the current high level of exploration. In the states in which extensive drilling was carried on during 1950 the number of oil and gas discoveries was directly proportional to the number of exploratory wells. Of the exploratory wells drilled in non-producing areas about one in nine resulted in a discovery. Of all exploratory wells drilled, including extensions and deeper tests in producing areas, about one in five discovered new oil. The relation between the total number of exploratory wells drilled and the number of discoveries is shown on Chart 8.

The amount of new oil realized through discoveries, extensions, and revisions also proves to be in proportion to exploratory drilling. In the ten states which had discoveries, extensions, and revisions in excess of 100 million barrels for the three-year period 1948-1950 the volume of

CHART 8

Exploratory Wells Drilled and Oil and Gas Discoveries in 1950—United States and Canada

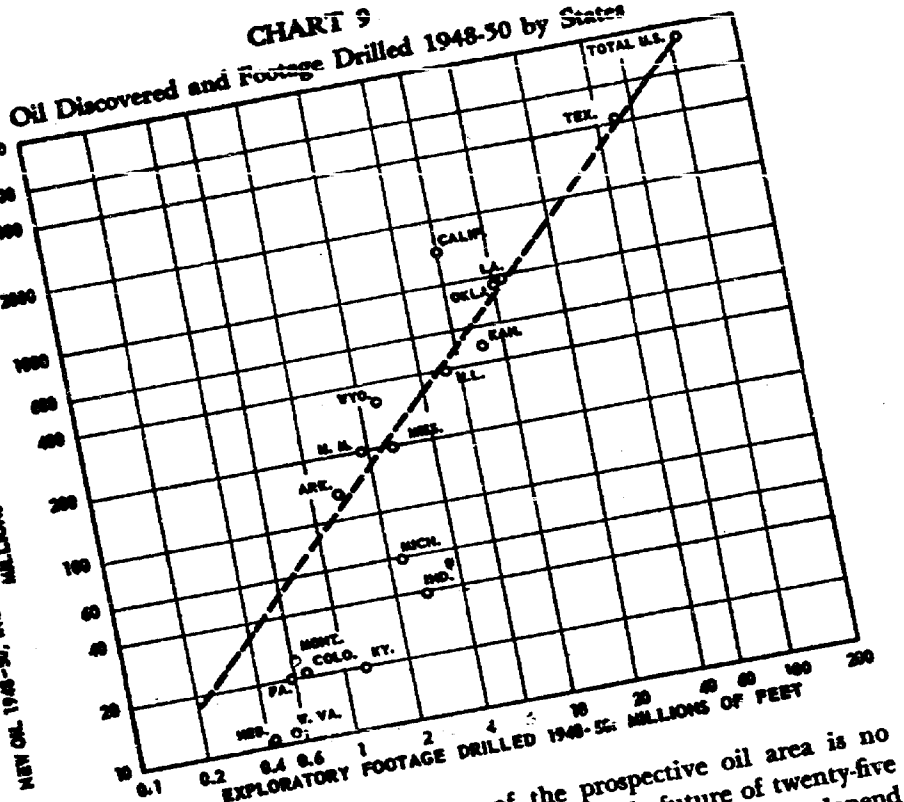


new oil was directly proportional to the exploratory footage drilled. The relationship is shown in Chart 9.

The size of the prospective oil area is so large that exploration will have to be carried on for scores of years to test the possibilities thoroughly by present methods and at present rates. There is no lack of places in which the search for oil may be successful. As our technology improves steadily the search is being extended successfully to additional areas not previously considered prospective. A major new device for finding oil may accelerate the discovery in the prospective area, but it is not essential to future supplies. The progress made by the industry in the discovery of oil has been largely in the improvement of processes known for a long time.

CHART 9

Oil Discovered and Footage Drilled 1948-50 by States



In these circumstances, the size of the prospective oil area is no limitation on the supplies of oil for the foreseeable future of twenty-five to fifty years. The rate at which supplies will be developed will depend upon the influence of economic forces on exploration and drilling.

Greater knowledge, improved technology, and increased exploratory work can continue to operate for a long time to come in a vast prospective area that gives promise of large supplies of oil for the foreseeable future.

Progress in Development and Recovery

The amount of oil supplies is affected by the recovery from the fields discovered as well as by the amount of oil in the earth. Oil exists in the porous spaces of sand, lime, and shale formations. It is frequently associated with gas and water. The method of occurrence prevents complete recovery of the oil in place underground. The amount of oil recovered from a particular field may vary substantially, depending on conditions in the reservoir and on producing practices. Great progress

has been made in increasing recovery through improvements which add to efficiency and reduce costs. Such progress means larger supplies of oil.

Many of the improvements in drilling exploratory wells, already described, are equally important in the more numerous development wells that make discovered oil available. Methods of completing wells in producing formations have been improved. These methods increase the flow of oil to the well. Careful completion of wells can reduce the amount of gas produced with oil and control the amount of water produced with the oil. The ratio of gas to oil produced from a well affects the pressure in the producing formation and thereby influences the recovery of oil. Generally, maintenance of pressure in the producing formation is a means of helping assure the fullest recovery of oil. The loss of gas can be minimized simultaneously with an increase in the recovery of oil by keeping the gas-oil ratio low.

Conservation of Oil

Great progress has been made in understanding and controlling the flow of fluids in an oil reservoir, particularly since about 1925. In many early operations wells were completed in such manner that gas was lost in tremendous quantities and much oil was trapped in the reservoir by irregular encroachment of water. During the period 1916 through 1929, there gradually developed an awareness that these methods of production resulted in waste and a loss of oil that could be recovered. The industry began to devote increasing attention to reservoir engineering. As a result, new conservation methods were evolved. Most of the important producing states adopted conservation laws providing for control of the drilling of wells, the gas-oil ratio, the rate of production, and other factors which affect the efficient recovery of oil. These conservation measures have increased the recovery of oil in place, prolonged the life of many wells, and helped to reduce costs so that more oil was economically recoverable.

Conservation of oil and gas is based on scientific knowledge accumulated through the years. The manner in which oil, gas, and water in a reservoir operate has been studied by careful observation. Mathematical techniques have been applied to the analysis of available data. Models have been devised in which the effects of different rates of production upon recovery can be studied. Electronic calculating machines are sometimes used to handle the many variable factors involved in connection with the production of a field. All this work has served to prove that too rapid production from a reservoir decreases the amount of oil recovered and involves physical waste both underneath and above ground. Actual field experience has demonstrated the value of new production practices.

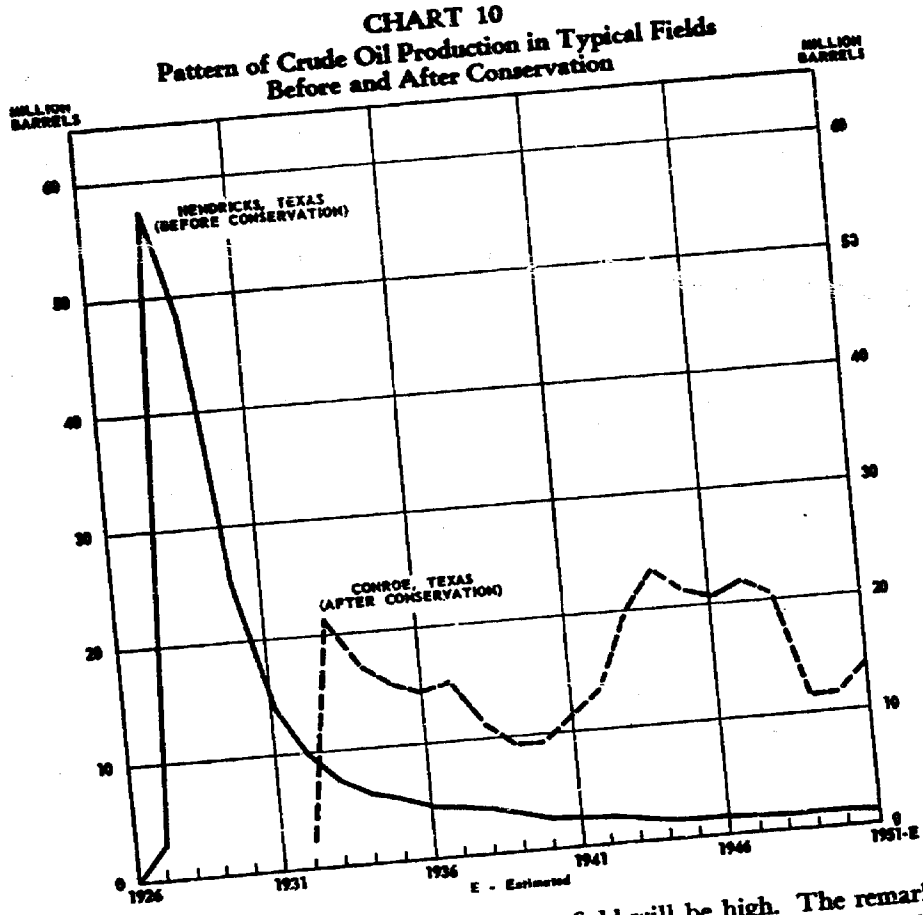
Engineering studies have established that for each reservoir there is a rather closely definable maximum rate at which oil can be produced efficiently. If production exceeds this rate, physical waste occurs and the amount of oil recovered from the field decreases. Conservation laws of the producing states take into account this principle and provide for regulation of production in order to prevent waste. Experience has shown that when physical factors alone are considered without respect to market outlets, waste may occur because of uneven withdrawals by different operators whose market outlets vary. If adjoining wells produce at different rates, there may be irregular encroachment of water and other developments which cause physical waste, in addition to the inequity resulting among the operators from the different rates of production per well. Consequently, many states take into account market demand as well as physical factors in the conservation measures used to prevent physical waste.

The understanding of efficient methods of production and the adoption of conservation laws have brought about an entirely different pattern of production from fields. Now the pattern is generally for a sustained level of production over a long period of years. Prior to about 1925 new fields generally were developed very rapidly and produced at excessive rates in the earlier years, after which there was a very sharp decline in production. The difference in the production pattern before and after the effective application of conservation principles could be illustrated by the history of many fields. (See Chart 10.) In Table 15 there is a comparison of three fields with uncontrolled production prior to conservation and four fields developed later under conservation. The uncontrolled fields declined to 10 per cent of their peak annual production within four to nine years. The controlled fields, on the other hand, were still producing at 50 to 63 per cent of their peak annual rate from twelve to twenty years after they were discovered.

Another example of sustained productivity under conservation is the East Texas field. This field has been the largest discovered in the United States to date, in terms of amount of reserves that will be recovered. At the end of 1950 it was twenty years old, but had produced only about half of the oil that will be recovered. In 1951 the field produced about 273,000 barrels daily, or 50 per cent as much as the peak annual rate in 1933. The pressure in the field has been maintained at a substantially constant level since 1942 despite the production of about a billion barrels of oil. Efficiency of recovery has been increased not only by controlling the rate of production but also by returning to the producing formations a large amount of the salt water that comes up with the oil. Maintaining the pressure in the reservoir has kept gas in solution in the oil and preserved the fluidity of the oil. As a result,

CHART 10

Pattern of Crude Oil Production in Typical Fields
Before and After Conservation



the recovery of oil from the East Texas field will be high. The remarkable performance of this great field under conservation is shown by Charts 11 and 12.

Conservation of Natural Gas and Associated Liquids

Conservation has made possible many other measures that increase supplies of oil and gas. The stable rate of production over a long period of years, instead of a high peak for a short time followed by a long decline, has made it possible to install equipment for the conservation of gas produced with oil and for the recovery of the liquids contained in that gas. Such operations would not have been economically feasible in the days of wide-open, inefficient production. The significance of this progress is evident from the fact that the production of natural gas liquids in 1951 of about 565,000 barrels daily was almost

10 per cent as large as the total production of crude oil, and exceeded the combined production from New Mexico, Mississippi, and Kansas. Chart 13 shows the growth in production of natural gas liquids.

Tremendous advances have been made in the conservation of natural gas. Throughout much of the industry's history, gas produced with oil has generally been flared because it was not economically feasible to utilize it. Today, the majority of the gas produced with oil is captured and put to further use. Only in isolated cases where costs are prohibitive to economic use does natural gas continue to be flared in any large

TABLE 15

Comparison Controlled and Uncontrolled Fields

Field	Year of Discovery	Peak Annual Production As Per Cent of Estimated Ultimate Production	1950 Production As Per Cent of Peak Annual Production	Years After Discovery For Production to Decline to 10% of Peak Annual Rate
Uncontrolled Fields				
Seminole City, Okla....	1926	26.6	2.6	4
Powell, Texas	1923	26.4	1.1	6
Hendricks, Texas	1926	24.5	2.1	9
Controlled Fields				
Conroe, Texas	1931	3.9	51.7	—
Hastings, Texas	1934	4.4	60.2	—
Tom O'Connor, Texas.	1934	4.1	61.7	—
Magnolia, Ark.	1938	6.7	63.0	—

Source: U. S. Bureau of Mines, American Institute of Mining and Metallurgical Engineers, and Oil and Gas Journal Reviews for 1950.

amounts. Careful completion of wells and controlled methods of production reduce the amount of gas produced with oil and help preserve any gas cap or pressure needed for the recovery of oil.

The conservation of gas produced with oil is an economic problem which requires for its solution an adequate market to create a value for the gas that will pay for the cost of saving it. Improved methods of transporting natural gas over long distances at relatively low costs have created large new markets for natural gas. These markets have meant better prices for gas, and better prices have naturally stimulated conservation.

CHART 11

Crude Oil Production in the East Texas Field

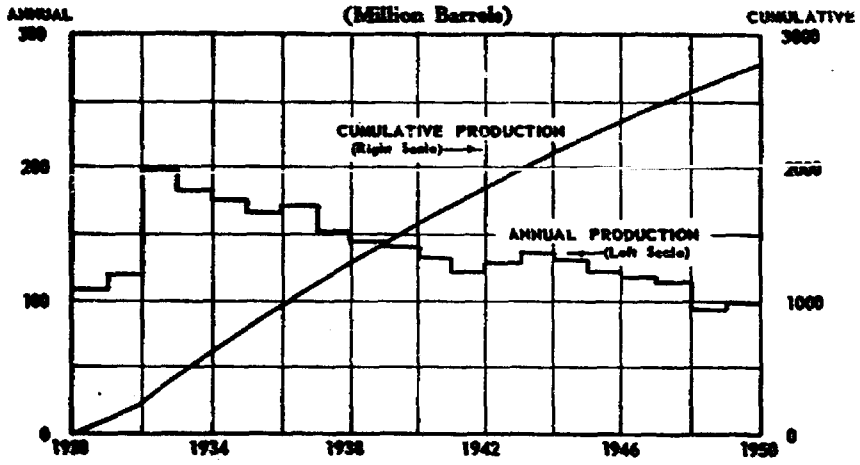
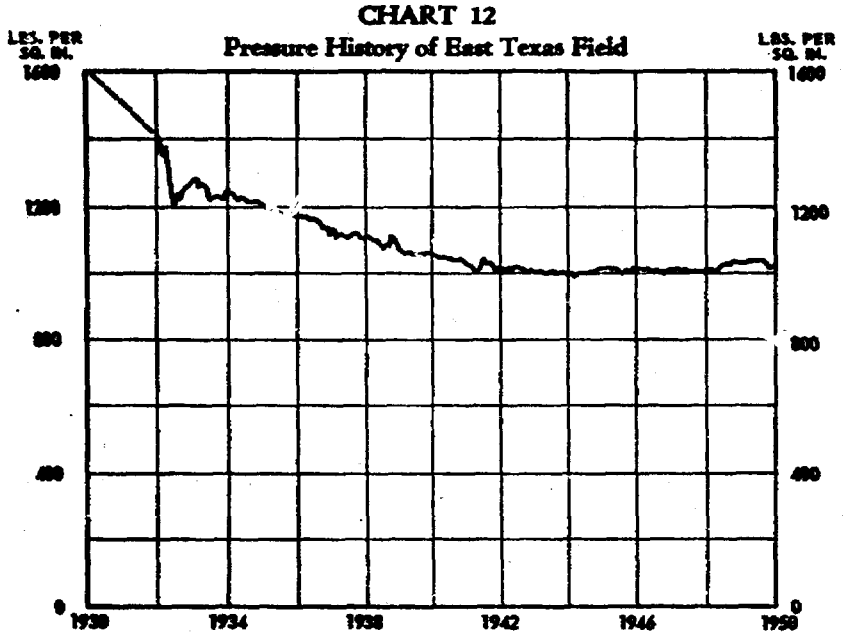


CHART 12

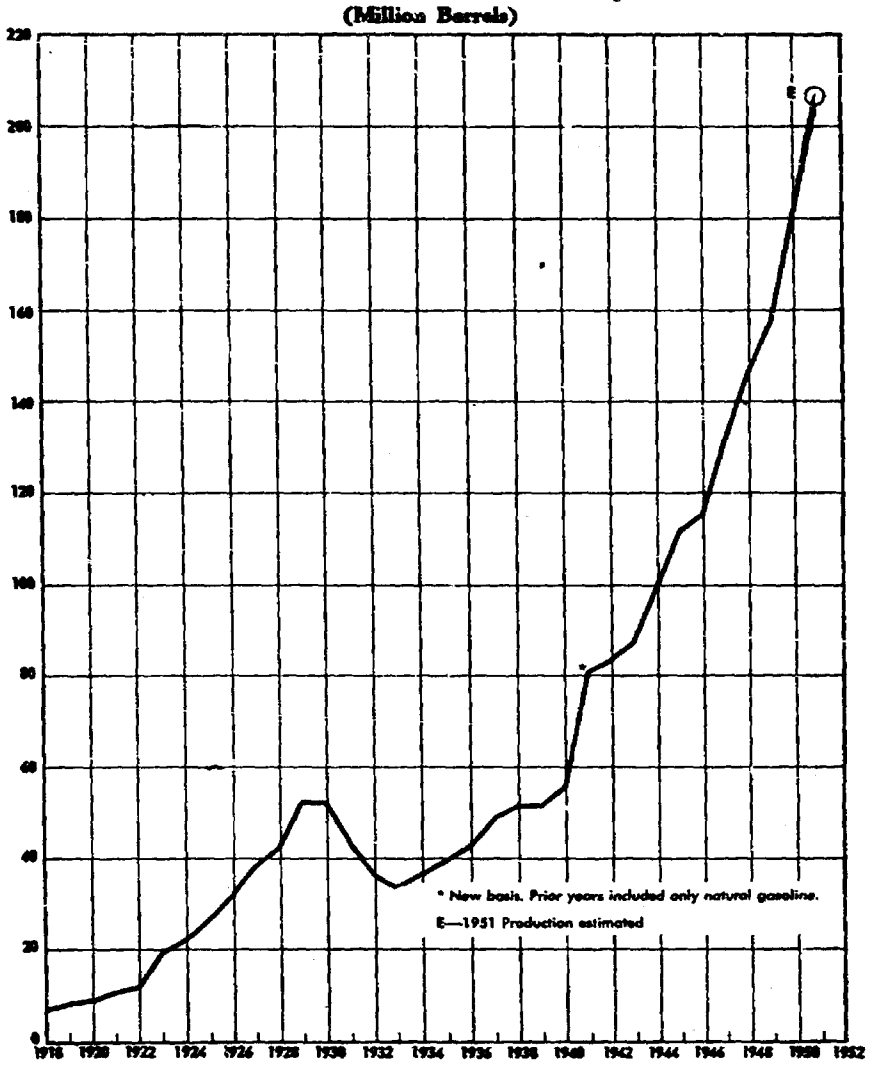
Pressure History of East Texas Field



Benefits of Conservation

Conservation has meant larger supplies and lower development costs for crude oil. The fact that conservation increases the recovery of oil adds to supply and thereby acts to bring about a balance with demand

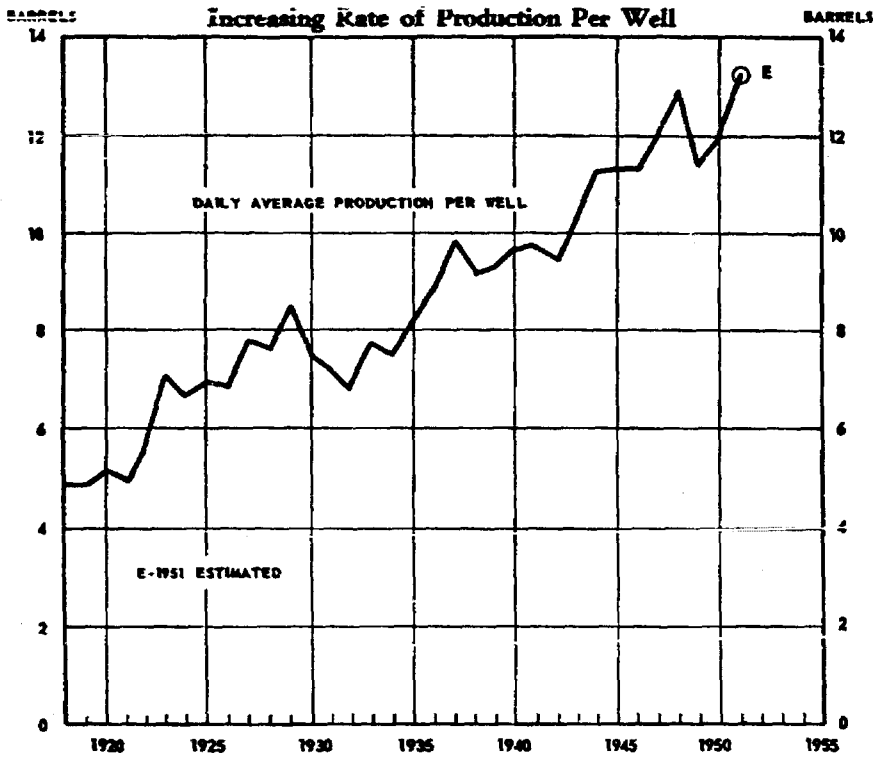
CHART 13
U. S. Production of Natural Gas Liquids
(Million Barrels)



at a lower level of price than would prevail if supplies were smaller. Conservation has also made a great contribution to lower prices through its help in reducing costs. Under unregulated competition without conservation measures, wells were drilled very closely. Such close development meant a high cost for drilling, in addition to the loss of recoverable oil that followed when production was too rapid.

CHART 14

Increasing Rate of Production Per Well



Conservation practices have permitted new fields in the past twenty years to be developed with many less wells. It is now generally the practice in the industry to drill only one oil well to each 10 to 80 acres, depending on the field, because that spacing pattern will drain the recoverable oil from such areas when production is controlled at efficient rates. In earlier days fields were developed with such close spacing that wells were frequently drilled on an acre or a fraction of an acre. Such extravagant methods of development meant a relatively high cost for oil. Efficient methods of development under conservation practices reduce costs and make it possible to recover oil that would not have been economically available under the old practices.

The favorable effect of conservation on production is evident in the upward trend of production per well. Chart 14 and Table 16 show this trend. The average daily production per well in 1951 was nearly twice as much as in 1925 and about three times as much as in 1918. In 1918 there were about 200,000 wells producing an average of 975,000 barrels daily or less than 5 barrels a day. In 1951 there were about

TABLE 16

TREND OF CRUDE OIL PRODUCTION PER WELL

	Annual Crude Oil Production* Thousand Barrels Daily	Producing Oil Wells at End of Year*	Daily Average Production Per Well
1918	975.2	208,875	4.8
1919	1,036.6	227,000	4.6
1920	1,210.2	251,000	5.1
1921	1,293.7	274,500	4.9
1922	1,527.5	284,880	5.5
1923	2,006.6	290,100	7.0
1924	1,950.7	299,100	6.6
1925	2,092.5	306,100	6.9
1926	2,112.0	318,600	6.8
1927	2,468.8	323,300	7.7
1928	2,463.0	327,800	7.6
1929	2,759.8	328,200	8.4
1930	2,460.3	331,070	7.5
1931	2,331.7	315,850	7.2
1932	2,145.2	321,500	5.7
1933	2,481.2	326,850	7.7
1934	2,487.8	333,070	7.5
1935	2,730.4	340,990	8.1
1936	3,004.6	349,450	8.7
1937	3,504.5	363,030	9.8
1938	3,527.0	369,640	9.1
1939	3,465.6	380,390	9.2
1940	3,697.3	389,010	9.6
1941	3,841.7	399,960	9.7
1942	3,799.0	404,840	9.4
1943	4,125.0	407,170	10.2
1944	4,584.5	412,220	11.2
1945	4,695.1	415,750	11.3
1946	4,750.5	421,460	11.3
1947	5,087.8	426,280	12.0
1948	5,519.8	437,880	12.8
1949	5,046.5	448,680	11.4
1950	5,402.5	461,130P	11.9P
1951	6,164.4P	472,389P	13.2P

* Bureau of Mines.
P—Preliminary estimates.

475,000 oil wells which produced 6,164,000 barrels daily and could have produced efficiently about 6,900,000 barrels per day. Clearly, the cost of oil would have been much greater in 1951 if the production per well had been only as much as it was in 1918. In that case, it would have taken several times as many wells to produce the oil we used in 1951. The investment and operating costs of the larger number of wells would have meant a much higher cost for oil.

Secondary Recovery

Additional oil supplies have been realized through secondary methods of recovery as well as by the methods already described for increasing the primary recovery from a field. Knowledge about proper methods of recovery indicated that substantial quantities of recoverable oil had been left in some fields that appeared to be depleted. This knowledge suggested that further production might be realized from these fields by the development of methods for additional or "secondary" recovery. Secondary recovery methods consist principally of injecting gas or water into an oil-producing formation in order to stimulate production. It is reported that gas was injected into a producing oil sand in Venango County, Pennsylvania, as early as 1890-1891 to stimulate oil production. Air was injected for this purpose into a producing formation in Ohio in 1911. Water injection was used in the Bradford field in Pennsylvania beginning about 1925 and resulted in a great increase in production.

The Bradford, Pennsylvania field reached its peak of primary production in 1881. Production declined rapidly, as usual at that time. By 1890 it was less than one-fourth as much as in 1881, and by 1905 it was down to 10 per cent of the peak annual rate. Intensive water flooding increased the annual rate of production in the field sharply from 1925 through 1937. At that time production was about three-fourths as much as it had been in the peak year of 1881. By the end of 1950 the total oil production from the Bradford field had reached about 534 million barrels, of which it is estimated more than half had resulted from secondary recovery. (See Chart 15.) The field still has substantial reserves remaining to be produced by secondary recovery.

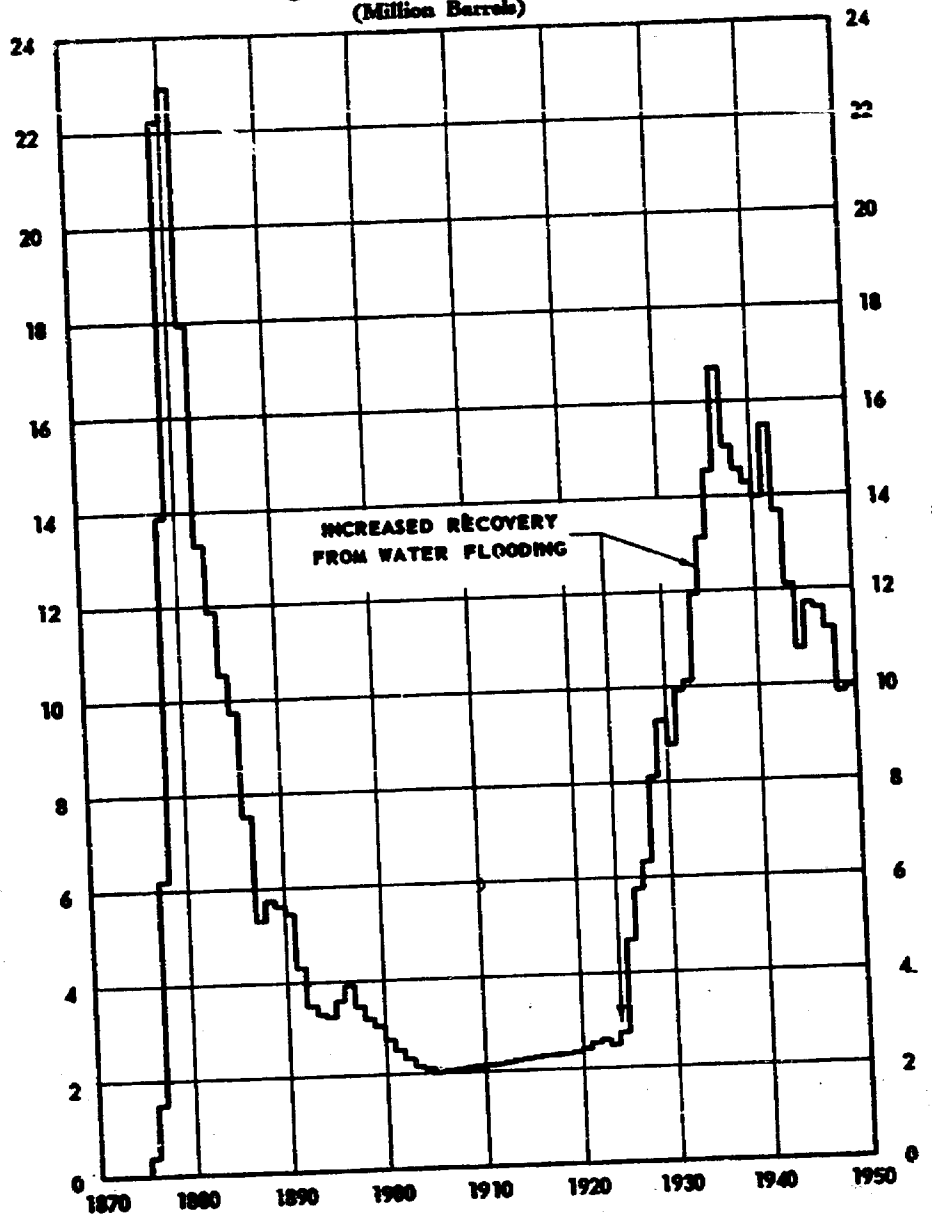
Secondary recovery has been applied principally in shallow fields in the older producing regions of the East. It is being extended rapidly to the Mid-Continent area, particularly North Texas, Oklahoma, Kansas, and Illinois. In many cases a substantial increase in production has resulted. Secondary recovery methods will increase supplies of oil from many old fields if the economic incentive exists for the investment in the process.

Rate of Progress in Production Technique

The progress in knowledge about development and production techniques has been remarkable. It has occurred under a system of

CHART 15

Production History of Bradford, Pa., Field
Showing Results of Secondary Recovery



freedom of opportunity and competition. Thousands of individuals and companies have been engaged in exploration, development, and production. They have devised innumerable improvements which add to our supplies of oil at reasonable costs. Technical information has been widely distributed and freely discussed throughout the industry. There are no barriers to the exchange of such information. Patented improvements are free to all users in many cases or generally available under licenses. Professional societies, trade associations, and industry publications have contributed to the spread of information which helps to find and develop oil. The Interstate Oil Compact and the producing states have had a part in the broad conservation movement and in improving the distribution of knowledge essential to technological progress by the industry.

The knowledge and technology of the petroleum industry in 1951 must be rated as remarkable by the standards as recent as 1925. The continuous rate of progress in these fields is impressive. We can only speculate about the extent of such progress for the future. There is no way of guessing what inventions, improvements, and advances in knowledge may be made in the next twenty-five or fifty years. We can say, however, that there is every reason to expect a continuation of our past progress, granted reasonable economic climate and incentives. Each invention and addition to our knowledge has a cumulative effect on our ability to progress in the future. History shows an accelerated rate of technological progress. Granted conditions reasonably similar to those under which past progress has been made, there should be no question that the oil industry can and will make further substantial progress in its knowledge and technology.

Economic Forces Determine Fuel Supplies

The existence of oil and adequate technology are necessary, but they are not enough to make supplies available. Economics is the final force determining oil supplies. That is to say, there must be the economic incentive to develop production. Also, oil products must be available at prices that will attract buyers.

We have already noted that it takes an intensive search and a lot of drilling to find oil. That effort takes a great deal of money. The amount of money which will be risked on the effort depends on the prospects of making a return in keeping with the risks. Unless an adequate return is expected, the development of oil will not be undertaken.

In the United States billions of dollars are spent annually in the search for and development of new oil. Without that continuous effort supplies would soon begin to decline. The investment in development of new resources depends on the prospects for profitable return. Under

normal economic conditions it is the relation between costs and prices which determines whether it is attractive to carry on an intensive search for oil. Changes in profit margin can affect development of oil supplies apart from any changes in prospects or technology, as illustrated by the experience during the depression.

There was a sharp decline in exploration and drilling in the United States in the years 1931-1933. This change occurred as a result of lower crude oil prices. The chances of finding oil and the technology of exploration and development remained the same, but the economic incentive to carry on the search for oil decreased. The average price of crude oil in the years 1931-1933 was 73 cents a barrel, a decrease of 40 per cent from the average price of $1.21 a barrel in the preceding three-year period. As a result of reduced effort in the search for oil, substantially less oil was added to reserves in 1931-1933 than in the preceding three-year period. In the following three years the price of crude oil improved to an average of $1.02 a barrel. Exploration and drilling also increased, reflecting the improved economic incentive.

It requires great sums of money to search for oil in old and new areas. In some ventures, such as the Continental Shelf and foreign countries, several hundred million dollars may be spent initially before any substantial production or income is developed. The production and income in case of success is realized slowly over a long period of years. Whether the initial investment is recovered and any profit made depends on prices and costs over a long period. In making the initial investment it is necessary to consider the time required to recover the capital as well as the risk of losing it on unsuccessful ventures.

Much effort and capital have been spent in developing oil in the United States. Producers have been free to search for oil wherever they wished, and to sell their oil at the market prices determined by supply and demand in competition with other fuels. There have been no restraints on the markets which might be reached. The risks have been great, and many operators have been unsuccessful. In addition, even the successful operators have experienced numerous failures and losses of investment. Still, the freedom for individual initiative and the expectation of being allowed to enjoy the rewards of any unusual success have brought about the venture of large sums of money in the search for oil. The willingness of operators to risk their capital in the hazardous search for oil has developed a great availability of oil products in the United States.

Competition

Oil supplies in this nation have been developed under a competitive system with thousands of individuals and firms engaged in the business.

Different individuals and companies frequently explore the same area again and again. There are many cases of discoveries in areas of repeated failures by others. It is this competitive search which results in the continuing discovery of oil even in old areas already intensively explored by many operators. Freedom of enterprise and reasonable economic incentives have found great supplies of oil in the United States.

The economic rewards to an industry depend upon its ability to produce at a price that makes the product attractive to buyers. There is competition not only within an industry but among industries. Oil producers compete with each other and also with the producers of other forms of energy, such as coal. It has been the efficiency of the oil industry in supplying its products that has enabled it to build a great market in competition with coal. The oil industry has developed efficient, low-cost methods of drilling, producing, refining, and transporting liquid fuels. By supplying its products at attractive prices, it has built up large markets in direct competition with coal for home heating and industrial heating. In these fields its important advantage, in addition to a reasonable price, has been convenience and cleanliness.

Competition among fuels is keen and continuous. The coal industry is making progress in mechanization as a means of reducing costs. Experiments are being conducted on the transportation of coal in small particles together with liquids in a pipe line as a means of reducing the cost of moving coal to market. Such progress is spurred by the competition from oil. Similarly, progress in reducing costs for oil products is spurred by competition from coal. Consumers benefit greatly from this free competition among fuels. They would stand to lose from any decrease in that competition. Therefore, it would be contrary to the interest of consumers to permit any artificial restraints on the competition among fuels.

Dangers of Artificial Government Controls

The idea of artificial controls by government over the use of fuels recurs from time to time. It usually takes the form of proposals to prohibit the use of oil or gas for certain purposes. The argument for such controls is generally based on the theory that supplies of oil or gas are so short that they should be "saved" for future generations. The effect of the proposals would be to give coal a monopoly in certain markets. The very restriction on the use of oil and gas would interfere with the development of new supplies for the future. The report of the National Petroleum Council on "U. S. Crude Petroleum Reserve Productive Capacity," dated January 26, 1950, brought out the fact that crude oil discoveries and reserves are affected by the volume of production as well as price. Limitations on the market for petroleum.

therefore, would reduce the incentives for future discoveries in the same way as restrictions on price.

To insist that coal should be used instead of oil or gas because of fears of shortages in the future would mean that consumers would be deprived of the right to use available oil and gas which they prefer to buy because of their low price and other advantages. The imposition of such a penalty on consumers is not justified by present or future prospects for oil and gas supplies. Any government controls over the use of fuels would involve political considerations as to which areas and individuals should be forced to use the higher priced fuels. The economic power of such political controls over the progress of an area and the costs of individual firms would be very great. Such controls would violate the basic principle of reliance on competition which is at the root of American economic progress. Furthermore, it would make the erroneous assumption that technology is static. The truth is, of course, that our technical progress is so rapid that new and cheaper methods of securing fuel may be devised while oil and gas supplies are still very abundant.

Interrelation of Demand and Supply

Economic forces not only determine supplies but also demand. When supplies are abundant it is natural that demand should keep pace. Similarly, if demand tends to outrun supplies, price changes in a free market quickly work to restore a balance. In a free market demand and supply are inseparably related through price.

In the United States we use petroleum supplies very freely. Our consumption of petroleum per capita is about twenty times as much as that of the rest of the world, although our consumption of all forms of mineral energy per capita is about ten times as much as that in the rest of the world. We use powerful, heavy cars which realize much less mileage per gallon than the light cars generally used in Europe. The reason for this difference is the low price of gasoline in the United States. The gasoline produced now is 50 per cent more powerful than that supplied twenty-five years ago and its price, exclusive of tax, is almost exactly the same as in 1925. With the pay for one hour, the average manufacturing worker could buy more than twice as many gallons of gasoline, including higher taxes, in 1951 as in 1925. (Average hourly earnings in all manufacturing industries were $0.547 in 1925 and $1.59 in 1951. The average retail price of a gallon of gasoline, exclusive of tax, was 20.09 cents in 1925 and 20.27 cents in 1951. Including tax, the average retail price of a gallon of gasoline was 22.20 cents in 1925 and 27.01 cents in 1951. Therefore, with an hour's pay the average

worker in manufacturing industries could buy 5.88 gallons in 1951 compared with 2.46 gallons in 1925.)

If at some distant future date we were really faced with a problem of limited oil supplies, many changes would occur in demand to bring about a balance with supply. There would then be an economic incentive and reason for using lighter cars with motors which would secure much greater mileage per gallon of gasoline. If such circumstances developed, the price of gasoline would increase and the industry would find it attractive to make more gasoline and less fuel oil out of a barrel of crude oil. As a result of such changes other forms of energy might be used in place of fuel oil and a larger proportion of the oil supplies might be used for automotive transportation. It is through such adjustments that a free economy provides users with the best and cheapest form of fuel available at any time. That freedom of choice on the part of consumers may seem extravagant to some, but it is the very key to the great economic progress of the United States and its abundance of fuels. Without such freedom of choice the mainspring of progress through competition would be removed to our great loss.

Confusion About Coal Supplies

Proposals for restrictions on the use of oil and gas are generally based on the theory that at best the supplies of these fuels are so small relative to the reserves of coal that greater use of coal should be forced upon consumers despite their wishes in the matter or the higher costs involved. These proposals have confused physical existence with economic availability. Coal is available only after it is mined, not when it is still in the earth. Whether it is economically useful depends on the costs of mining, transportation, and distribution in competition with other fuels. More coal is not used because at prevailing prices many consumers find it cheaper or more convenient to use oil or gas instead of coal.

The costs of making available much of the coal in the earth would be prohibitive. Some of the estimated reserves are buried so deep that they are of questionable significance. Others are in thin seams, and some are so remote from markets that high transportation costs would make them very expensive regardless of the cost of mining. The doubtful economic value of large parts of the estimated coal reserves has been expressed as follows by a distinguished authority:

"One conclusion should be crystal-clear from this estimate of the coal reserves in the United States: Unless truly fantastic improvements in the state of the arts are achieved, our descendants will have to pay far more for coal than the prices paid both in the past and at present. Large portions of the coal reserves listed by Campbell are of such poor quality, are

> located in such out-of-the-way corners, are so unfavorable as to thickness of vein, depth, etc., that only unheard-of ingenuity or desperate need will render them available for use. In other words, they are not commercial reserves now, and they may never be." *

The basic question in a discussion of available energy resources is how much can be supplied at prices that are attractive to consumers. The question of how much energy resources exists is entirely secondary to that of costs in any discussion of availability of energy resources.

Governmental Actions Affect Oil Supply

Economic forces in the modern world are subject to great influence by government action. There are many government measures which affect the supply of oil. Several immediate examples of such influence can be noted in the United States:

1. Price and Material Controls

In the years 1942-1946 and again beginning with 1950, the government has imposed controls over prices and materials which have affected the entire economy. The experience of World War II shows how such controls influence oil supplies. During the years 1942-1945 drilling decreased because of controls over materials and price ceilings which tended to result in lower profit margins as wages and other costs increased. As a result, the new oil reserves developed through discoveries, extensions, and revisions were less in this period than in the preceding or succeeding four-year periods of time. In the years 1938-1941 when the average price of crude oil was $1.08 a barrel, discoveries, extensions, and revisions of proved reserves were estimated to be 9.5 billion barrels by the American Petroleum Institute. During the next four-year period of war controls, similar estimates amounted to only 7.5 billion barrels. In the first four postwar years, following removal of government controls, the estimates of new discoveries, extensions, and revisions, were 13 billion barrels. The average price of crude oil in 1946-1949 was $2.12 a barrel, which amounted to $1.34 a barrel in terms of dollars of the same purchasing power as in 1938-1941. This example shows the adverse effects of government control and the stimulus to development provided by economic incentives.

2. Tax Policies

Tax policies also have an important effect on development of resources, particularly as tax rates reach high levels. A natural resource industry presents unique and difficult taxation problems because it is

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* Zimmermann, Erich W., *World Resources and Industries*, Rev. Edition, page 462.

engaged in using up its basic capital as it produces the resources. It is necessary in this case to distinguish between capital and current income properly subject to the usual income tax rates. The capital in a producing property cannot be viewed merely as the money invested in that property, for large amounts of additional capital were risked and lost in related unsuccessful ventures. When Congress first applied income taxes it recognized that some special provisions were required for oil production in order to protect operators against unfair taxation compared with other industries. Several types of allowances were tried before Congress finally decided in 1926 on a simple method of percentage depletion as a means of distinguishing between capital and income properly subject to regular income tax rates.

The percentage depletion provisions of the income tax laws and the option to recover drilling costs immediately instead of over a period of time have become a part of the industry's basic economic structure. Adverse changes in these provisions would reduce the economic incentive for further search. Liberalization of the provisions on the other hand could stimulate the search and development of new oil. Governmental tax policies in this field can and will have an important bearing on future availability of oil supplies. Increasing tax rates in themselves tend to reduce the economic incentive for investment of risk capital. Any additional tax burdens due to changes in percentage depletion or the option to expense intangible drilling costs could have a prompt and serious effect on future oil supplies.

3. Artificial Regulations

Another example of the impact of artificial regulations on available supplies is provided by the efforts of the Federal Power Commission to regulate the price of natural gas on a cost basis as though the production of natural gas were a utility business rather than a hazardous resource development business. The Federal Power Commission has actually asserted control in some cases over the price of gas produced at the well and has set prices which are far below the market level determined by supply and demand under free competition. The threat that such regulations might be applied generally to gas producers definitely affects the economic incentive to develop natural gas supplies. To the extent that the economic incentive is reduced, there is a tendency for the effort devoted to the development of future supplies to decrease.

4. Delay in Development of the Tidelands

Another influence of government on future supplies in the United States has developed from the action of the Federal Government in seeking to assert its control over the Continental Shelf. Previously the

states had exercised control over oil producing, fishing, dredging, and other activities on the Continental Shelf. When technological progress and the need for oil led to the willingness of oil companies to risk capital in exploring for the potential resources in this submerged area, it was the state which granted oil leases. Subsequently, the Federal Government brought suits against the states claiming control over the Continental Shelf. The controversy over control has delayed substantially the testing of the potential resources of this area and the development of new oil supplies.

The impact of government action on oil supplies is even more apparent in foreign countries than it is in the United States. The willingness of a country to grant concessions and permit exploration is essential if its potential resources are to be explored and tested. Furthermore, there must be assurance that in case of discovery and development, the investors who have taken the risks will be allowed to enjoy the results of any success. Unreasonable taxes, expropriation, or nationalization all constitute a serious threat to future supplies, not only in the countries where they occur but in other countries as well, because of their effect on willingness to risk capital in foreign areas.

Failure to permit private enterprise in the search for oil is a grave threat to the development of future oil supplies in an area, as evidenced by the backward position of Russia in oil production, despite its great potential resources. Russia's large area should have potential oil resources greater than those of the United States. At present Russia's oil production is only about 10 per cent as much as that of the United States; however, whereas in 1900 it was actually greater than in the United States. Similarly, the expropriated oil industry in Mexico has failed to keep progress with the developments in the rest of the Western Hemisphere, although prospects in that country are considered good.

It has been the extraordinary ability of the petroleum industry to supply liquid fuels at reasonable prices that has created the huge market for oil products and thereby provided the incentive for the risk of further capital in the search for still more supplies. These developments have taken place under the stimulus of keen competition within the industry and with other industries supplying fuels. They have proved of great benefit to us in terms of our economic progress and national security. It is essential that we realize, therefore, the basic forces which have provided us with an abundant supply of reasonably priced fuels in the past in order that we may benefit in formulating fuel policies for the future. It is competitive enterprise and economic incentive for the risking of venture capital which has provided us with abundant supplies of oil. Government planning and control has not been the basis of our fuel supplies. On the contrary, the experience

of foreign countries shows that government planning and control is a handicap rather than a help to the development of large oil supplies. We must realize, therefore, that our future oil supplies depend upon keeping in effect active competition and reasonable economic incentives, and not upon the adoption of any other government plans or policies.

Alternate Sources of Liquid Fuels

The concern over future oil supplies comes down to the question of continuing to have liquid fuels at attractive prices which will permit us to maintain or increase our consumption in this form. We know that the United States could supply its needs for energy with much less liquid fuel than it uses today if that were economically necessary. We also know that if we are willing to pay higher prices, liquid fuels in large quantities can be made from oil shale, from natural gas, from coal, and from tar sands. At much higher prices for liquid fuels, however, the demand would be considerably less for fuel in this form and greater for alternate fuels in the form of gas or coal. The form in which we use energy is largely a matter of relative cost and convenience.

Liquid fuels are particularly convenient and economical for transportation. The automobile, airplane, steamship, and diesel engine provide low-cost transportation by virtue of the large amount of energy available in compact form from liquid fuel. As we have noted before, however, the amount of liquid fuel we use for transportation could be modified greatly if the cost of that fuel were higher. It should also be noted that other forms of fuels may be used in place of liquid fuels for transportation. Coal can be used for railroad locomotives and steamships at a higher cost than that currently paid for oil. Automobile engines could be run by gas from the burning of coal or wood. Contracts have been let for submarines and airplanes to use atomic energy. Technical progress may in time make atomic energy for commercial transportation quite attractive. It is possible that coal burning turbines may be developed for railroad and other forms of transportation. New methods may be devised for converting heat from the sun into cheap power for use in many different ways. The possibilities for the interchange of fuels through technology and economic adjustment are tremendous.

About one-fourth of the energy used in the United States at the present time serves to run mobile equipment, while the other three-fourths is for stationary units. In supplying heat for stationary units, price and convenience determine whether coal, oil, or gas will be used. Such abundant supplies of oil have been developed in the United States that we find it attractive and cheap to use large quantities of heating oil and residual fuel oil in stationary equipment. Roughly half of the

oil used in the United States is for automobiles, airplanes, steamships, and diesel locomotives. Most of the remaining oil is used in stationary units, with a small part being made into lubricants and special products.

There is no economic hurdle other than the attractive price of oil, considering its convenience, to keep coal from capturing the markets for fuel used in stationary units. The increasing importance of oil and gas relative to coal has occurred simply because consumers have found it attractive to use liquid fuel and gas instead of coal and because the petroleum industry has made available large supplies.

Flexibility in Products Made from Crude Oil

If future developments should make oil seem less abundant relative to demand than it is today, and therefore higher in price by comparison with other fuels, many adjustments could take place among fuels. The amounts of different products made from a barrel of crude could, at some additional cost, be changed greatly. Much more gasoline might be made at the expense of distillate and residual fuel oil, but the cost of the gasoline would then be higher than it is now. In that case, gas and coal would first be used as a direct replacement for heating oil and fuel oil rather than as a source of synthetic gasoline. Such change would provide the cheapest solution of our energy requirements, for there is a considerable loss of heat and a high cost involved in converting coal from its solid state to liquid fuels. Since we use large quantities of fuel in solid, liquid, and gaseous forms, the natural development in case of any tendency toward a shortage of crude oil would be to use it for the liquid fuels which would be most expensive to supply from other sources.

Currently, the industry converts about 43 per cent of a barrel of crude oil into gasoline. Equipment is now in use which can secure a larger yield of gasoline from a barrel of crude oil, but it is not economically attractive to do so in terms of the relative prices and costs of making the various products. It would require only a few cents increase in the price of gasoline relative to heating and fuel oils to bring about larger production of gasoline from a barrel of crude. Processes are also known by which almost all of a barrel of crude oil could be changed into gasoline, but the cost of gasoline made by these processes would be considerably higher. The important point about petroleum refining technology is the great flexibility which can be attained in the output of products, depending upon economic incentives.

Liquid fuels can be made if necessary from materials other than crude oil. In terms of cost, the substitutes most closely approaching a competitive basis seem to be shale oil and gasoline from natural gas. The latter possibility seems limited because natural gas is such a convenient fuel in the form in which it exists in nature. It is easier and

cheaper to make more gasoline from crude and to use natural gas directly in place of fuel oils than it is to convert natural gas into gasoline.

Oil from Shale

The ultimate prospects for production of liquid fuels from oil shales are good, even though costs are not yet competitive. A pilot plant is now in operation at Rifle, Colorado, using this process. The cost of gasoline from shale is still substantially higher today than the cost from crude oil. Improved technology and any tendency toward a scarcity of crude oil, however, might make gasoline from shale oil competitive ultimately. There are technical problems involved in the development of large supplies of oil from shale, however, particularly with respect to sufficient water for the plants and a low cost for disposing of the large amount of shale left after the extraction of the oil.

Shale oil may not be commercially attractive unless crude oil proves to be much more difficult and expensive to find than it is currently. The investments in shale oil plants are tremendous and the risks in competition with crude oil from domestic and foreign sources are consequently quite serious. Ultimately, however, if the need for liquid fuels should prove to be greater than can be supplied from natural petroleum, the development of oil from shale might prove commercially attractive and would be undertaken by private capital. In the meantime, the wise course seems to be to continue research on the production of shale oil and to let economic forces determine the natural development of this supply under competitive conditions.

It has been estimated that there may be more than 100 billion barrels of oil that can be recovered from shale in the Rocky Mountain area. Whether this oil can or will be recovered will depend on economics. Cheaper supplies of energy from other sources may be available in such quantities that the use of shale oil will be very limited. Technological progress might make liquid fuels obsolete while supplies of oil are still abundant and before the commercial development of oil shales is feasible. We cannot say that oil shale will ever be developed commercially, but it may be an alternate source of gasoline at a cost only a few cents more than that from crude oil.

Liquid Fuel from Coal

The potential supplies of liquid fuels from coal are even greater than those from oil shale. If economic costs are completely ignored, theoretically the coal reserves of the United States could be used to make several hundred billion barrels of liquid fuels. As a matter of practical economics, however, the cost of liquid fuels in this form would be prohibitive under present technology and competitive conditions.

The cost of gasoline from coal would be a great deal more than that from oil shale and, of course, than the current price of gasoline.

The capital investment required for development of gasoline from coal would be enormous. Government estimates indicate a plant investment of about $10,000 for the capacity to produce one barrel daily of liquid products from coal. The increase in demand for petroleum products in the United States in 1951 was more than 500,000 barrels daily. It would take an investment of five billion dollars to supply from coal merely the increase in demand for liquid fuels between 1950 and 1951. The cost of operation and the price of liquid fuels from coal would have to be so much higher than current prices for oil products that the demand inevitably would be only a fraction of what it is now.

Liquid fuels can be made from coal and have been made by that means in foreign countries, by both hydrogenation and synthesis. It is possible, although not economically feasible, to make liquid fuels from coal in this country. We know that liquid fuels can be made by several different processes from shale, coal, and gas if the need or desirability of doing so arises.

There are some who propose that the United States government should immediately undertake to build large plants for the manufacture of oil from shale or coal. Even small quantities of oil by these processes would require tremendous investments by the government and subsidies to permit production, as the products could not compete commercially with those made from crude oil. Construction of such plants obviously could be undertaken only if the government would guarantee markets for the products at a higher price than it needs to pay for products made from crude oil. The danger and fallacy of such proposals, in addition to their tremendous cost to the taxpayers, is that they would automatically interfere with the market for natural petroleum and act to reduce the economic incentives for the development of new crude oil. There is no real need for the government to undertake these expensive and uneconomical projects when private capital is available to supply all of the liquid fuels required.

Reserve Petroleum Productive Capacity

The petroleum industry of the United States has a substantial reserve capacity currently, and available supplies continue to increase at a rapid rate. It is the existence of adequate capacity to meet normal needs which provides the greatest assurance of supplies in case of any national emergency. Such was the experience in World War II when enormous military requirements were met without government investments in oil production. The small naval reserves owned by the government in Elk Hills made very little contribution to the supplies of oil

for war, because they were not developed and ready when the emergency came. There is substantial leeway for cutting the civilian use of petroleum products in case an emergency requires supplies for military use greater than the reserve capacity of the industry, and additional capacity can be developed if the industry is given enough steel for drilling new wells.

The principal risk which may lie ahead for the United States in continuing to rely on crude oil supplies is in becoming unduly dependent upon foreign sources that might be cut off suddenly. It is for that reason that the National Petroleum Council has stressed the importance of adequate supplies of domestic production and the desirability of keeping imports in the position of supplementing domestic supplies. The degree of accessibility of foreign oil in case of an emergency will be of paramount importance. Oil from Canada might be almost as accessible as that from the United States. On the other hand, oil from the Middle East might be quite inaccessible in case of an emergency. Consequently, the United States must look primarily to supplies in the Western Hemisphere which it must count upon protecting and having available in any emergency. So long as its imports come primarily from such Western Hemisphere sources, the principal concern need be only with keeping the proportion of imports to domestic supplies in reasonable relation, so that domestic supplies still continue to be our primary source.

The advantages to the nation and consumers of using the cheapest available fuels is quite clear from our own history. That policy takes advantage of competition among fuels and within each fuel industry to provide us with abundant supplies of energy at the lowest cost. That policy has served to make the United States the leading nation in the production of oil, gas, and coal, and in the development of technology for producing these fuels which are still the indispensable sources of power for economic progress. Technology permits such great flexibility in the use of fuels that economics becomes the determining force at any time in deciding how much of the different forms of fuels we will use.

The economic outlook is that we will continue to have abundant supplies of oil and of all forms of energy for a long time to come.

Conclusion

This study of the long-term prospects for petroleum supplies has dealt with two major issues:

1. The forces which have made and will continue to make oil available.
2. The prospects for oil supplies for the foreseeable future.

The following conclusions result from this study:

We have today in the United States and the world larger supplies and larger proved reserves of oil and gas than ever before.

Our tools and techniques for finding and developing petroleum have improved greatly and continue to improve rapidly.

Competition has proved an extremely effective device for stimulating development of new resources and new processes which serve to supply us with fuels.

The economic forces of a free market continue to be the best method of developing abundant fuel supplies at low cost for consumers.

Fuel supplies needed for national security as well as economic progress are provided best by relying upon competition.

There still exist excellent prospects for the development of ample new reserves of oil and gas in the United States and in foreign countries.

We have the potential resources, the technology, and the economic framework for continuing to enjoy large supplies of fuels.

The major threat to future oil supplies would be any interference with economic incentives which might act to prevent the normal developments that would otherwise occur.

Our prospects are good for the discovery of petroleum and for ample supplies of fuels generally for the foreseeable future.

EXHIBIT A

POSSIBLE FUTURE PETROLEUM PROVINCES

The symposium on "Possible Future Oil Provinces of North America," published in the bulletin of the American Association of Petroleum Geologists, Volume 35, February 1951, is the basis for this summary. Decisions as to the possible future oil provinces were made by local geological societies, members of geologic surveys, and other specialists particularly well informed on the geology of various areas. The symposium thus presents the general views of the industry because of the manner in which it was prepared.

The present symposium brings up to date a similar study of the United States and Canada made by the American Association of Petroleum Geologists in 1941. The 1941 symposium described 34 provinces considered to have possibilities for future discoveries. By 1951 discoveries of oil and gas had been made in 20 of the 34 provinces. The 1951 study lists 60 provinces with future oil prospects. Technological progress has led to inclusion in the more recent study of the Continental Shelf and sediments as deep as 20,000 feet.

The location of the possible future petroleum provinces in the United States is shown on Figure 1. The areas of these provinces have been computed by planimeter. Including that part of the Continental Shelf to 120 feet water depth contour, the area of the 60 provinces is 1,660,000 square miles. The Continental Shelf area included in this total is 77,000 square miles. The symposium gives a figure of 235,000 square miles, but 100,000 square miles covered by water 120 to 656 feet deep, and 58,000 square miles off the shores of Mexico have not been included in the present estimate. No mention was made in the symposium of the Continental Shelf of the southeastern United States which has an area of about 30,000 square miles to a water depth of 120 feet. This area is not included in the preceding total of 1,660,000 square miles.

Some of the prospective areas relate to deeper producing possibilities in provinces that already have shallow production. This is true, for example, of the western Gulf Coast shown as No. 41 on the map. The area of presently producing provinces not duplicated by that of future oil provinces is 200,000 square miles. The sum of the areas in presently producing provinces and possible future petroleum provinces, excluding duplications, is 1,860,000 square miles.

A brief description of the 60 possible future petroleum provinces listed by the American Association of Petroleum Geologists follows.

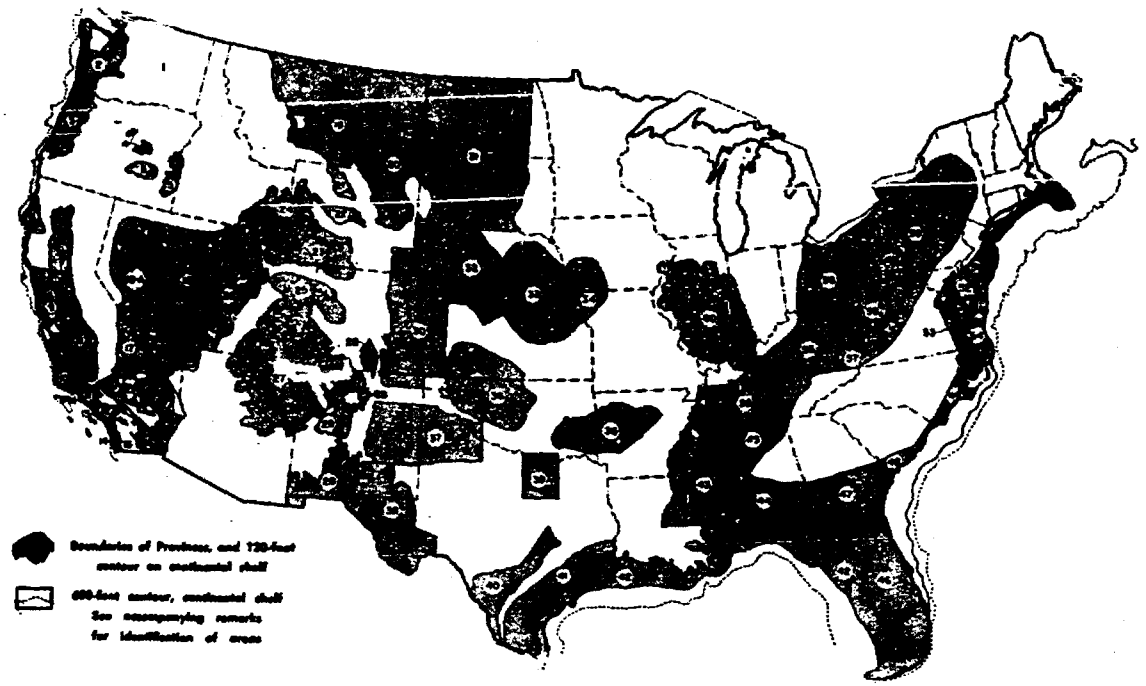


FIGURE 1

FIGURE 1. SOME POSSIBLE FUTURE PETROLEUM PROVINCES OF THE UNITED STATES IN ADDITION TO PRESENTLY PRODUCING AREAS THAT ALSO HAVE PROSPECTS FOR FUTURE PRODUCTION*

Based on a symposium on "Possible Future Petroleum Provinces of North America" conducted by the American Association of Petroleum Geologists and published, February, 1951

*The Symposium from which this summary was prepared dealt with geologic provinces or areas considered to have possibilities for future discoveries. Some of the geologic provinces, such as No. 41, are deeper formations underlying present production. Some presently producing areas, such as the State of Mississippi, were included on the basis that they still are at an early stage of development. Some other producing areas, such as the Permian Basin of West Texas, were considered to belong more in the category of proved provinces than prospective, although they may still have substantial prospects for future discoveries. The bounding of certain provinces by state boundaries or certain latitude or longitude apparently resulted from the manner in which assignments were divided between local geologic groups for study.

SUMMARY DESCRIPTION OF POSSIBLE FUTURE PETROLEUM PROVINCES SHOWN ON FIGURE 1

1. **Eastern Washington**

   This area of 54,000 sq. mi. receives only brief mention and is not considered prospective at present. Most of the area is covered by Miocene volcanics. There is a non-commercial gas field in Benton County.

2. **Western Washington**

   An area of 15,000 sq. mi. having a section of interbedded sediments and volcanics up to 11,000 feet or more. There are at least 13 authentic oil and gas seeps, 35 small gas wells, and showings of light oil in several wells.

3. **Oregon Coast Range**

   An area of 14,000 sq. mi. having a 20,000 to 25,000-foot section, about half of which is volcanic. Three-fourths of the sediments present are marine. There are no authentic seeps, but some asphaltic residue associated with volcanics and some siltstone having a kerosene odor.

4. **Central Oregon**

   1,400 sq. mi. having a 35,000 ft. predominantly marine section. No seeps are present, but there are Mesozoic black shales, asphaltic residues, fetid limestones and calcareous sandstones, fossil shells containing a volatile amber oil. Remotely prospective.

5. **Southeastern Oregon**

   An area of 6,000 sq. mi. in part covered by Tertiary volcanics. Thickness and nature of section is largely unknown, but contains appreciable sediments and volcanics. Section has been penetrated by one well to 6,500 feet. Strong showings of gas at very shallow depth. Remotely prospective.

6. **Northern Coast Ranges of California**

   Includes an area of 2,000 sq. mi. which is considered to have fair prospects. One minor gas field in the Eel River Basin, many oil and gas seeps and tar sands. In places, the section is in excess of 12,000 feet.

7. **Sacramento Valley**

   An area of 14,000 sq. mi. In part, the section is in excess of 20,000 feet. 28 commercial gas fields have been discovered. One major gas field. Excellent prospects.

8. **San Joaquin Valley**

   An area of 14,000 sq. mi. Maximum depth to basement is in excess of 30,000 feet. Major oil discoveries in the Helm and Coalinga areas. Excellent future prospects.

9. **Central Coast Ranges**

   Includes 4,500 sq. mi. of sediments considered to have good prospects. Major oil discoveries at San Ardo, Russell Ranch and South Cuyama. Many oil seeps and outcropping tar sands.

10. **Santa Maria**

    Area of 2,000 sq. mi. Maximum depth to basement 16,000 feet. 16 producing areas discovered.

11. **Ventura Basin**

    Area of 5,000 sq. mi. Maximum depth to basement estimated to be 60,000 feet. 53 oil fields and 2 gas fields discovered.

12. **Los Angeles Region**

    Prospective area of 2,000 sq. mi. Long the most productive California area. Much possible vertical and lateral extension. Estimated maximum thickness of sediments, 25,000 feet. 41 oil fields and 1 gas field discovered.

13. **Continental Shelf, Southern California**

    Lithologic character and structure similar to adjoining Ventura and Los Angeles Basins, and should have similar oil content. Area 2,000 sq. mi.

14. **Southern Coastal Region**

    Area of 1,000 sq. mi. Remotely prospective. Only 30 wildcats drilled. Several wells to basement without showings. Maximum depth to basement, 6,000 ft. Seeps and other evidence of oil lacking.

15. **Southern Mountain Region**

    Area of 6,000 sq. mi. Remotely prospective. 70 exploratory wells. Evidence of oil and gas scant. Some production in two wells, abundant showings near Placerita.

16. **Imperial Valley**

Area of 4,000 sq. mi. Remotely prospective. Possibly 25,000 feet of sediments, mostly non-marine. No good evidence of oil or gas.

17. **Eastern Desert and Mountain**

Central subprovince, 12,800 sq. mi., is the most prospective, containing thick normal marine sediments in the eastern part. One known oil seep, associated with volcanic thermal activity. Some showings of oil. Northern subprovince, 41,000 sq. mi., not considered prospective.

17A. **Southern subprovince of 17**

13,700 sq. mi. not considered particularly prospective because of complex structure, metamorphic areas, and predominantly terrestrial sediments. Not sufficiently explored.

18. **Nevada**

Paleozoic Basin, comprising an area of 65,000 sq. mi., is considered prospective. Large area and thickness of sedimentary rock, containing all types of reservoir rock. Poorly explored. One known oil seep, oil stains in Paleozoic limestones, some free oil associated with fossils. At least 30,000 feet of sediments in part of the area.

18A. **Nevada-Permo-Trias Basin**

19,000 sq. mi., considered not prospective chiefly because of lack of exploration, considerable metamorphism. Minor evidences of oil in fossils. Some oil shale.

19. **Central Montana**

An area of 84,000 sq. mi., largely unexplored. Great thickness of sediments. 16 small oil fields and 2 gas fields. One major oil field. Many showings in Devonian and Mississippian.

20. **Powder River Basin**

Area of 35,000 sq. mi. Oil and gas fields and seepages surround the basin. Deep exploration only begun. Good possibilities for stratigraphic traps and reef production. At least 16,000 feet of sediments in deeper parts. Mush Creek and Sussex are major discoveries.

21. **Big Horn Basin**

Area of 3,500 sq. mi., with 17,000-foot section. Many oil and gas fields surround the basin. Major production from Embar formation at 10,000 feet in Worland field and at 8,000 feet at Badger Basin.

22. **Wind River and Jackson Hole Basins**
Area of 6,500 sq. mi., 20,000 feet in deepest parts. Numerous oil seeps. 14 oil and gas fields border area on three sides.

23. **Green River Basin**
Area of 20,000 sq. mi. Section at margin of basin exceeds 30,000 feet. Contains all kinds of structures and suitable reservoir rocks. Numerous evidences and some production of oil and gas. Church Buttes, major gas production.

24. **Overthrust Belt**
Area of 13,000 sq. mi. 60,000 feet of sediments in southern part. Several fields produce oil and gas along the southeastern border of the area.

25. **Uinta Basin**
Area of 14,000 sq. mi. with maximum section of at least 20,000 feet. Roosevelt field is a major producer. Production also at Ashley Creek. Many other indications of oil and gas.

26. **Great Basin**
Area of 38,000 sq. mi. Maximum section of 40,000 feet. Both oil and gas seepages present.

27. **Four Corners Region**
Area of 85,000 sq. mi. Up to 15,000 feet of sediments. Minor Cretaceous, Permian and Pennsylvanian production; many seeps and strong showings of oil and gas.

28. **Rio Grande Basins**
Area includes some 23,000 sq. mi., with sediments ranging from 1,000 to 15,000 feet in thickness. Surface indications of oil and gas lacking.

29. **West Central and Southwestern Basins**
Area of 4,000 sq. mi. (Zuni Basin is included in the Four Corners region on the map.) Average thickness of strata, 8,000 feet. Remotely prospective.

30. **Eastern Colorado and vicinity**
Area of 54,000 sq. mi. Several minor oil discoveries and oil seeps.

31. **North and South Dakota**
Area of 117,000 sq. mi. Maximum of 12,000 feet of sediments. Recent oil discovery in the Williston Basin. Several showings of oil and gas.

32. **Western Nebraska**
Area of 44,000 sq. mi. Average thickness of sediments about 4,000 feet. Minor production and numerous showings.

33. **Salina Basin**
Area of 40,000 sq. mi. Maximum depth of sediments somewhat less than 5,000 feet. Minor production.

34. **Forest City Basin**
Area of 19,000 sq. mi. Maximum depth of sediments about 4,000 feet. Minor production.

35. **Southeastern Oklahoma and Northwestern Arkansas**
Area of 21,000 sq. mi. with sediments ranging from 2,000 to 40,000 feet. Small amounts of oil, 60 producing gas fields.

36. **Anadarko Basin**
Area of 41,000 sq. mi. Maximum depth of sediments in excess of 20,000 feet. Important production on three sides of the area. Elk City a major discovery. Two others, Apache and Ringwood.

37. **Plainview Basin**
Area of 46,000 sq. mi. Maximum thickness of 11,000 feet. Major production in Anton Irish field. Three fields produce from Pennsylvanian reef limestone. Many oil showings.

38. **Trans-Pecos**
Area of 40,000 sq. mi. More than 15,000 feet of sediments. Minor production in 15 oil and gas fields. Prolific production northeast of area. Numerous showings in Delaware Basin.

39. **Fort Worth Basin and Muenster Arch**
Area of 11,000 sq. mi. Maximum depth of sediments, 17,000 feet. 90 sq. mi. already productive. Deeper drilling should result in many discoveries.

40. **Downdip Mesozoic Rocks of South Texas**
Area of 19,000 sq. mi. 4,000 to 15,000 feet of Cretaceous rocks and about 1,300 feet of Jurassic rocks below present production. Present Cretaceous production in Pearsall, Jourdanton and Imogene fields.

41. **Western Gulf Coast**
Area of 26,000 sq. mi. Wilcox, Yegua-Cockfield, and Frio, below 10,000 feet. Important gas-distillate production below 10,000 feet in Wilcox in Central Gulf Coast area and major proved reserve in the Frio at Old Ocean field.

42. **Continental Shelf, Gulf of Mexico**
Area of 77,000 sq. mi. to 120-foot water depth contour. Sediments similar to those of adjoining land area. Shelf off Louisiana might be considered as already proved. (The symposium gives a figure of 235,000 sq. mi., but this includes that part of the shelf off Mexico and assumes the entire shelf out to water depths of 656 feet.)

43. **Mississippi**
Area of 49,000 sq. mi. Already a proved oil province. 3 major oil fields and 2 major gas fields already discovered. Up to 50,000 feet of sediments in southwestern part.

44. **South Alabama**
Area of 26,000 sq. mi. Maximum of 25,000 feet of sediments. One producing field and good showings in other wells.

45. **Northwest Alabama**
Area of 14,000 sq. mi. Numerous showings of oil and gas.

46. **Florida**
Area of 58,000 sq. mi. Estimated maximum of 20,000 feet of sediment in places. One producing field. Excellent possibilities for structural and stratigraphic traps.

47. **Georgia**
Area of 20,000 sq. mi. No commercial production. Several oil seeps and showings.

48. **South Carolina**
Area of 5,000 sq. mi., insufficiently explored. No production, unconfirmed oil seeps.

49. **North Carolina**
Area of 8,000 sq. mi. Section is about 10,000 feet thick in vicinity of Cape Hatteras. Unconfirmed showings of oil and gas in some wells.

50. **Tenneasee**
Area of 32,000 sq. mi., poorly explored. Has all requisites of an oil province, source beds, reservoir rocks, and structures. Minor production and good showings. Adjacent areas are productive.

51. **New Jersey and Long Island**
Area of 3,000 sq. mi. of sediments thicker than 1,000 feet. Conditions favorable for stratigraphic traps. No seeps or other indications of oil and gas.

52. **Maryland and Delaware**
Area of 7,000 sq. mi. Like New Jersey and other Atlantic States, the area is insufficiently explored. Possible stratigraphic traps. Beds are thin and lenticular, a fact which discourages development in all these Atlantic coast areas.

53. **Virginia**
Favorable area of 3,000 sq. mi. Same comments apply as to areas 51 and 52.

54. **Continental Shelf, N.E. United States**
Area of 27,000 sq. mi. to the 120-foot depth contour. If geophysical evidence is correct, the dip on land continues out to sea and there should be 13,000 to 16,000 feet of sediments favorable for the accumulation of oil and gas.

55. **Kentucky, east of crest of Cincinnati Arch**
Area of 27,000 sq. mi. in which deeper Paleozoic possibilities remain to be explored. There are many showings and several wells now produce from greater depths.

56. **Ohio, east of crest of Cincinnati Arch**
Area of 33,000 sq. mi. with deep possibilities. One major discovery, Canton gas field, producing from the Silurian.

57. **Southern Basin Area**
Area of 11,000 sq. mi. having excellent deep possibilities. Rose Hill represents first commercial production east of the Appalachian structural front and opens a large area for further exploration. Numerous oil seeps.

58. **Central Basin Area**
Area of 30,000 sq. mi. with excellent deep prospects. Some commercial production developed. Major gas production in deeper part of the basin. Many encouraging showings in the Ordovician.

59. **Northern Basin Area**
Area of 75,000 sq. mi., with good prospects for deep drilling. New discovery in the Devonian has caused increased exploration activity. Many showings of gas and oil below present production.

60. **Eastern Interior Basin**
Area of 52,000 sq. mi. having deep prospects. Within the basin, no wells penetrate more than two-thirds of the probable section, which in places may reach 13,000 feet. Many neglected areas even of formations known to be the best reservoirs in present production.

EXHIBIT B

MEMBERSHIP OF THE COMMITTEE AND ITS SUBCOMMITTEES

COMMITTEE ON OIL AND GAS AVAILABILITY

Chairman: L. F. McCollum, Continental Oil Company

Editors:

Max W. Ball, Oil and Gas Consultant

Stuart Buckley, Research Engineer

Richard J. Gonzalez, Economist

Secretary: Stanley G. Olson, Continental Oil Company

K. S. Adams
Phillips Petroleum Company

Hines H. Baker
Humble Oil & Refining Company

Max W. Ball
Oil and Gas Consultant

H. S. M. Burns
Shell Oil Company

Howard A. Cowden
Consumers Cooperative Association

E. DeGolyer
DeGolyer and MacNaughton

J. C. Donnell, II
The Ohio Oil Company

R. G. Follis
Standard Oil Company of California

Robert L. Foree
Texas Independent Producers and Royalty Owners Association

B. I. Graves
Tide Water Associated Oil Company

Jake L. Hamon
Mid-Continent Oil & Gas Association

B. A. Hardey
Petroleum Producer

D. A. Hulcy
Lone Star Gas Company

A. Jacobsen
Amerada Petroleum Corporation

B. Brewster Jennings
Socony-Vacuum Oil Company

J. P. Jones
National Stripper Well Association

John M. Lovejoy
Seaboard Oil Company of Delaware

A. C. Mattei
Honolulu Oil Corporation

N. C. McGowen
United Gas Corporation

E. E. Pyles
Jergins Oil Company

Ralph O. Rhoades
Gulf Oil Corporation

R. S. Shannon
Pioneer Oil Corporation

P. C. Spencer
Sinclair Oil Corporation

Stewart M. Vockel
The Waverly Oil Works Company

J. E. Warren
Independent Petroleum Association of America

W. K. Warren
Warren Petroleum Corporation

L. S. Wescoat
The Pure Oil Company

Robert E. Wilson
Standard Oil Company (Indiana)

NEAR-TERM SUBCOMMITTEES OF THE COMMITTEE ON OIL AND GAS AVAILABILITY

FOREIGN PETROLEUM AVAILABILITY

Chairman: JOHN R. SUMAN, Standard Oil Company (N. J.)

H. S. M. Burns
Shell Oil Company

R. G. Follis
Standard Oil Company of California

B. Brewster Jennings
Socony-Vacuum Oil Company

H. T. Klein
The Texas Company

S. B. Mosher
Signal Oil and Gas Company

S. A. Swenstrud
Gulf Oil Corporation

DOMESTIC OIL AND GAS AVAILABILITY

Chairman: HINES H. BAKER, Humble Oil & Refining Company

Vice Chairman: D. A. HULCY, Lone Star Gas Company

E. Buddrus
Panhandle Eastern Pipe Line Company

E. F. Bullard
Stanolind Oil & Gas Company

J. C. Donnell, II
The Ohio Oil Company

Robert L. Foree
Texas Independent Producers & Royalty Owners Association

J. P. Jones
National Stripper Well Association

A. C. Mattei
Honolulu Oil Corporation

N. C. McGowen
United Gas Corporation

Henry Phillips
Sinclair Oil Corporation

E. E. Pyles
Jergins Oil Company

R. S. Shannon
Pioneer Oil Corporation

L. S. Wescoat
The Pure Oil Company

DISTRICT SUBCOMMITTEE OF THE DOMESTIC OIL AND GAS AVAILABILITY

District 1

Chairman: J. P. JONES, National Stripper Well Association

George J. Hanks
South Penn Oil Company

J. P. Healy
Quaker State Oil Refining Corporation

George W. Holbrook
Bradley Producing Company

Harvey Lowe
The Pure Oil Company

G. Allan Reid
South Penn Natural Gas Company

J. French Robinson
The East Ohio Gas Company

E. E. Roth
The Columbia Gas System, Inc.

Stewart M. Vockel
The Waverly Oil Works Company

DISTRICT SUBCOMMITTEE OF THE DOMESTIC OIL AND GAS AVAILABILITY

District 2

Chairman: E. F. BULLARD, Stanolind Oil & Gas Company

Secretary: E. F. SHEA, Stanolind Oil & Gas Company

Glenn F. Bish
The Ohio Oil Company

E. Buddrus
Panhandle Eastern Pipe Line Company

A. R. Denison
Amerada Petroleum Corporation

A. B. Gibson
Magnolia Petroleum Company

Harry A. Glover
The Texas Company

Charles C. Hoffman
Cities Service Gas Company

H. F. Moses
Carter Oil Company

R. R. Porterfield
Gulf Oil Corporation

C. E. Turner
Phillips Petroleum Company

District 3

Chairman: B. C. BELT, Gulf Oil Corporation

R. W. Bond
Shell Oil Company

E. A. Brown
Lone Star Gas Company

D. V. Carter
Magnolia Petroleum Company

J. P. Coleman
McCarty & Coleman

Morgan J. Davis
Humble Oil & Refining Company

Alexander Deussen
Consulting Geologist

E. P. Hayes
The Texas Company

J. E. Hill
Richardson Oil, Inc.

John Ivy
Consulting Geologist

R. B. Kelly
The Pure Oil Company

E. W. Owen
Consulting Geologist

F. J. Schempf
Stanolind Oil & Gas Company

J. T. Scopes
Union Producing Company

W. C. Spooner
Consulting Geologist

District 4

Chairman: R. S. SHANNON, Pioneer Oil Corporation

Al Barrett
General Petroleum Corporation

A. E. Brainerd
Continental Oil Company

H. E. Christensen
The Texas Company

T. S. Harrison
Argo Oil Corporation

W. S. McCabe
Stanolind Oil & Gas Company

Rolland McCanne
Ohio Oil Company

Robert Seilaff
Sinclair Oil & Gas Company

R. S. Shannon, Jr.
Pioneer Oil Corporation

Ray Sloan
The Carter Oil Company

R. W. White
The California Company

District 5

Chairman: A. C. MATTEI, Honolulu Oil Corporation

R. M. Bauer
Southern California Gas Company

Gage Lund
Standard Oil Company (Calif.)

R. L. Minckler
General Petroleum Corporation

Frank A. Morgan
Richfield Oil Corporation

A. C. Rubel
Union Oil Company of California

C. P. Watson
Seaboard Oil Company of Delaware

Torrey H. Webb
The Texas Company

District 5 Working Subcommittee

Chairman: G. B. MOODY, Standard Oil Company (Calif.)

R. M. Bauer
Southern California Gas Company

J. C. Burtt
Shell Oil Company

L. W. Chasteen
Union Oil Company of California

D. M. Johnston
Tide Water Associated Oil Company

F. E. Minshall
Continental Oil Company

L. E. Porter
Richfield Oil Corporation

John P. Wallace, Jr.
The Texas Company

M. T. Whitaker
General Petroleum Corporation

LONG-TERM SUBCOMMITTEES OF THE COMMITTEE ON OIL AND GAS AVAILABILITY

DOMESTIC OIL AND GAS AVAILABILITY

Chairman: MAX W. BALL, Oil and Gas Consultant

Secretary: GUY H. WOODWARD, Noble Drilling Company

F. A. Bush
Sinclair Oil Corporation

M. G. Cheney
Anzac Oil Corporation

Stewart F. Coleman
Standard Oil Company (N. J.)

Ira H. Cram
Continental Oil Company

E. DeGolyer
DeGolyer & MacNaughton

W. H. Garbade
Deep Rock Oil Corporation

Jake L. Hamon
Mid-Continent Oil & Gas Association

B. A. Hardey
Petroleum Producer

Serge Jurenev
Continental Oil Company

Paul Kayser
El Paso Natural Gas Company

Frederic H. Lahee
Sun Oil Company

A. I. Levorsen
Stanford University

John M. Lovejoy
Seaboard Oil Company of Delaware

Joseph E. Pogue
The Chase National Bank

Wallace E. Pratt
Petroleum Geologist

Carl E. Reistle, Jr.
Humble Oil & Refining Company

George A. Wilson
Interstate Natural Gas Company, Inc.

J. French Robinson
The East Ohio Gas Company

A. C. Rubel
Union Oil Company of California

A. L. Solliday
Stanolind Oil & Gas Company

Clarendon E. Streeter
Carter, Bradley and Streeter

Henry N. Toler
Southern Natural Gas Company

J. Ed Warren
Independent Petroleum Association of America

W. K. Warren
Warren Petroleum Corporation

PANEL ON FUTURE DISCOVERY PROSPECTS

Chairman: IRA H. CRAM, Continental Oil Company

Raymond F. Baker
The Texas Company

George S. Buchanan
Sohio Petroleum Company

Monroe G. Cheney
Amac Oil Corporation

E. DeGolyer
DeGolyer & MacNaughton

A. Rodger Denison
Amerada Petroleum Corporation

G. Clark Gester
Consulting Geologist

K. C. Heald
Gulf Oil Corporation

Serge B. Jurenev
Continental Oil Company

Paul Kayser
El Paso Natural Gas Company

Frederic H. Lahee
Sun Oil Company

A. I. Levorsen
Stanford University

William S. McCabe
Stanolind Oil & Gas Company

Clarence L. Moody
The Ohio Oil Company

Frank A. Morgan
Richfield Oil Corporation

Wallace E. Pratt
Petroleum Geologist

Henry N. Toler
Southern Natural Gas Company

Paul Weaver
Gulf Oil Corporation

Gerald H. Westby
Seismograph Service Corporation

Fred H. Wilcox
Socony-Vacuum Oil Company

PANEL ON IMPROVED DEVELOPMENT AND RECOVERY TECHNIQUES

Chairman: J. Ed Warren, Independent Petroleum Ass'n. of America

Secretary: Stuart Buckley, Humble Oil & Refining Company

D. V. Carter
Magnolia Petroleum Company

H. E. Chiles, Jr.
Western Company of Midland

Richard W. French
Sohio Petroleum Company

Jake L. Hamon
Mid-Continent Oil & Gas Association

H. H. Kaveler
Phillips Petroleum Company

Hallan N. Marsh
General Petroleum Corporation

C. V. Millikan
Amerada Petroleum Corporation

Carl E. Reistle, Jr.
Humble Oil & Refining Company

Ivan Salinkov
Standard Oil Company (N. J.)

Clarendon E. Streeter
Carter, Bradley and Streeter

Paul D. Torrey
Lynes, Inc.

W. K. Warren
Warren Petroleum Corporation

PANEL ON ECONOMIC AND POLITICAL FACTORS

Chairman: Stewart P. Coleman, Standard Oil Company (N. J.)

W. G. Donley
Standard Oil Company of California

Robert G. Dunlop
Sun Oil Company

William H. Garbade
Deep Rock Oil Corporation

Richard J. Gonzalez
Humble Oil & Refining Company

B. A. Hardey
Petroleum Producer

Robert E. Hardwicke
Attorney, Fort Worth

Serge B. Jurenev
Continental Oil Company

Walter J. Levy
Petroleum Consultant

John M. Lovejoy
Seaboard Oil Company of Delaware

Eugene McElvaney
First National Bank, Dallas

Robert L. Minckler
General Petroleum Corporation

Joseph E. Pogue
The Chase National Bank

J. French Robinson
The East Ohio Gas Company

J. Melville Sands
Phillips Petroleum Company

Henri Schwall
Shell Oil Company

George A. Wilson
Interstate Natural Gas Co., Inc.

PANEL ON FUTURE DEVELOPMENT OF SUPPLIES FROM SYNTHETIC SOURCES

Chairman: A. C. Rubel, Union Oil Company of California

P. C. Keith
Hydrocarbon Research, Inc.

L. C. Kemp, Jr.
The Texas Company

Eger V. Murphree
Standard Oil Development Company
(Alternate, E. J. Gohr)

A. L. Solliday
Stanolind Oil & Gas Company

EXHIBIT C

NATIONAL PETROLEUM COUNCIL
MEMBERS

January 29, 1952

R. B. Anderson, General Manager
W. T. Waggoner Estate

Robert O. Anderson, President
Malco Refineries, Inc.

C. H. Arnold, Vice-President and General Manager
Haggart's Service, Inc.

Hines H. Baker, President
Humble Oil & Refining Company

Max W. Ball
Oil and Gas Consultant

Munger T. Ball, President
Sabine Transportation Co., Inc.

T. H. Barton, Chairman of the Board
Lion Oil Company

Fred E. Bergfors, President and Treasurer
The Quincy Oil Company

Jacob Blaustein, President
American Trading & Production Corporation

Paul G. Blazer, Chairman of the Board
Ashland Oil & Refining Company

Rush Maxwell Blodgett, Executive Vice-President
Oil Producers Agency of California

William R. Boyd, Jr., Managing Partner
Boyd, Hardey & Wheelock

Reid Brazell, President and General Manager
Leonard Refineries, Inc.

J. S. Bridwell
Bridwell Oil Company

Russell B. Brown, General Counsel
Independent Petroleum Association of America

H. S. M. Burns, President
Shell Oil Company

Robert H. Colley, President
The Atlantic Refining Company

Howard A. Cowden, President and General Manager
Consumers Cooperative Association

Earle M. Craig, President
National Petroleum Association

Stuart M. Crocker, Chairman of the Board
The Columbia Gas System, Inc.

John F. Cummins, President
Cumberland Oil Company

Horace E. Davenport, President
Independent Oil Men's Association of New England, Incorporated

E. DeGolyer
DeGolyer & MacNaughton

J. C. Donnell, II, President
The Ohio Oil Company

Fayette B. Dow, General Counsel
National Petroleum Association

Warwick M. Downing
Independent Oil Producer

J. Frank Drake, Chairman of the Board
Gulf Oil Corporation

John Dressler, President and Executive Secretary
New Jersey Gasoline Retailers Association and Allied Trades, Inc.

Gordon Duke
Oil Marketer

J. L. Nolan, Manager, Oil Department
Farmers Union Central Exchange, Inc.

J. R. Parten, President
Woodley Petroleum Company

Bryan W. Payne, President
Texas Independent Producers and Royalty Owners Association

Wm. T. Payne, President
Mid-Continent Oil & Gas Association

Joseph E. Pogue
Petroleum Consultant

Frank M. Porter, President
American Petroleum Institute

E. E. Pyles, Vice-President
Jergins Oil Company

Walter R. Reitz, Vice-President
Quaker State Oil Refining Corporation

Sid W. Richardson, President
Sid W. Richardson, Inc.

A. S. Ritchie
Independent Producer

M. H. Robineau, President
The Frontier Refining Company

W. S. S. Rodgers, Chairman of the Board
The Texas Company

Roland V. Rodman, President
Anderson-Prichard Oil Corporation

A. H. Rowan, President
Rowan Oil Company

R. S. Shannon, Director
Pioneer Oil Corporation

W. G. Skelly, President
Skelly Oil Company

P. C. Spencer, President
Sinclair Oil Corporation

Clarendon E. Streeter, President
Pennsylvania Grade Crude Oil Association

Reese H. Taylor, President
Union Oil Company of California

A. W. Thompson, President
American Association of Oilwell Drilling Contractors

R. L. Tollett, President
Western Petroleum Refiners Association

W. W. Vandeveer
Oil Producer

S. M. Vockel, President
The Waverly Oil Works Company

J. Ed Warren
% King, Warren & Dye

Wm. K. Warren, Chairman of the Board
Warren Petroleum Corporation

L. S. Wescoat, President
The Pure Oil Company

John H. White, Vice-President and General Manager
Hewitt Oil Company

Russel S. Williams
Individually Branded Petroleum Association

Robert E. Wilson, Chairman of the Board
Standard Oil Company (Indiana)

John Wrather
Independent Oil Operator

C. H. Wright, President
Sunray Oil Corporation

James P. Dunnigan, President
Producers Refining, Inc.

Paul Endacott, President
Phillips Petroleum Company

Max M. Fisher, Executive Vice-President
Aurora Gasoline Company

R. G. Follis, Chairman of the Board
Standard Oil Company of California

Clyde T. Foster, President
The Standard Oil Company (Ohio)

Harry K. Franklin
Oil Marketer

B. C. Graves, President
Union Tank Car Company

B. I. Graves, Vice-President
Tide Water Associated Oil Company

Walter S. Hallanan, President
Plymouth Oil Company

B. A. Hardey
Independent Producer

R. H. Hargrove, President
Texas Eastern Transmission Corp.

John Harper, Chairman
National Oil Jobbers Council

I. W. Hartman
Oil Producer

Fred W. Herlihy, President
National Oil Marketers Association

Charles S. Hill
Oil Producer

Harry B. Hilts, Secretary
Atlantic Coast Oil Conference, Inc.

Eugene Holman, President
Standard Oil Company (N. J.)

D. A. Hulcy, President
Lone Star Gas Company

A. Jacobsen, President
Amerada Petroleum Corporation

B. Brewster Jennings, President
Socony-Vacuum Oil Company, Inc.

Carl A. Johnson, President
Independent Refiners Association of California

Charles S. Jones, President
Richfield Oil Corporation

J. P. Jones, President
National Stripper Well Association

W. Alton Jones, President
Cities Service Company

William M. Keck, Jr., President
The Superior Oil Company

Richard Gray Lawton, President
Lawton Oil Corporation

F. H. Lerch, Jr., Chairman of the Board
Consolidated Natural Gas Company

John M. Lovejoy, President
Seaboard Oil Company of Delaware

John F. Lynch, President
Natural Gasoline Association of America

Charlton H. Lyons, President
Independent Petroleum Association of America

William G. Maguire, Chairman of the Board
Panhandle Eastern Pipe Line Company

B. L. Majewski, President
Great American Oil Company

J. Howard Marshall
Ashland, Kentucky

A. C. Mattei, President
Honolulu Oil Corporation

Frederick M. Mayer, President
Petroleum Equipment Suppliers Association

Nelson Maynard, President
National Congress of Petroleum Retailers, Inc.

L. F. McCollum, President
Continental Oil Company

N. C. McGowen, President
United Gas Corporation

S. B. Mosher, President and General Manager
Signal Oil and Gas Company

Glenn E. Nielson, President
Husky Oil Company

S. F. Niness
National Tank Truck Carriers, Inc.

BEFORE THE

OIL CONSERVATION COMMISSION

STATE OF NEW MEXICO

CASE 1071 (Continued successively since September 16) The Commission's motion for extension of Section '6', Oil Proration and Allocation, to provide for addition to Rule 506, Establishment of Temporary 80-acre Proration Units.

TRANSCRIPT OF HEARING

December 16, 1952

BEFORE: Hon. Ed. Mechem, Governor and Chairman
Hon. Guy Shepard, Land Commissioner and Member
Hon. R. R. Spurrier, Director and Member

STATE OF NEW MEXICO

ss

COUNTY OF BERNALILLO

I HEREBY CERTIFY That the within transcript of hearing in the above styled case before the Oil Conservation Commission of the State of New Mexico is a true record of the same to the best of my knowledge, skill and ability.

DONE at Albuquerque, New Mexico, December 20, 1952.

E. E. Gleason

E. E. Gleason
Reporter

MR. SPURRIER: We will move on to Case 407.

(Mr. Graham reads the notice of publication.)

MR. SMITH: May it please the Commission, I am J. K. Smith of the Stanolind Oil & Gas Company.

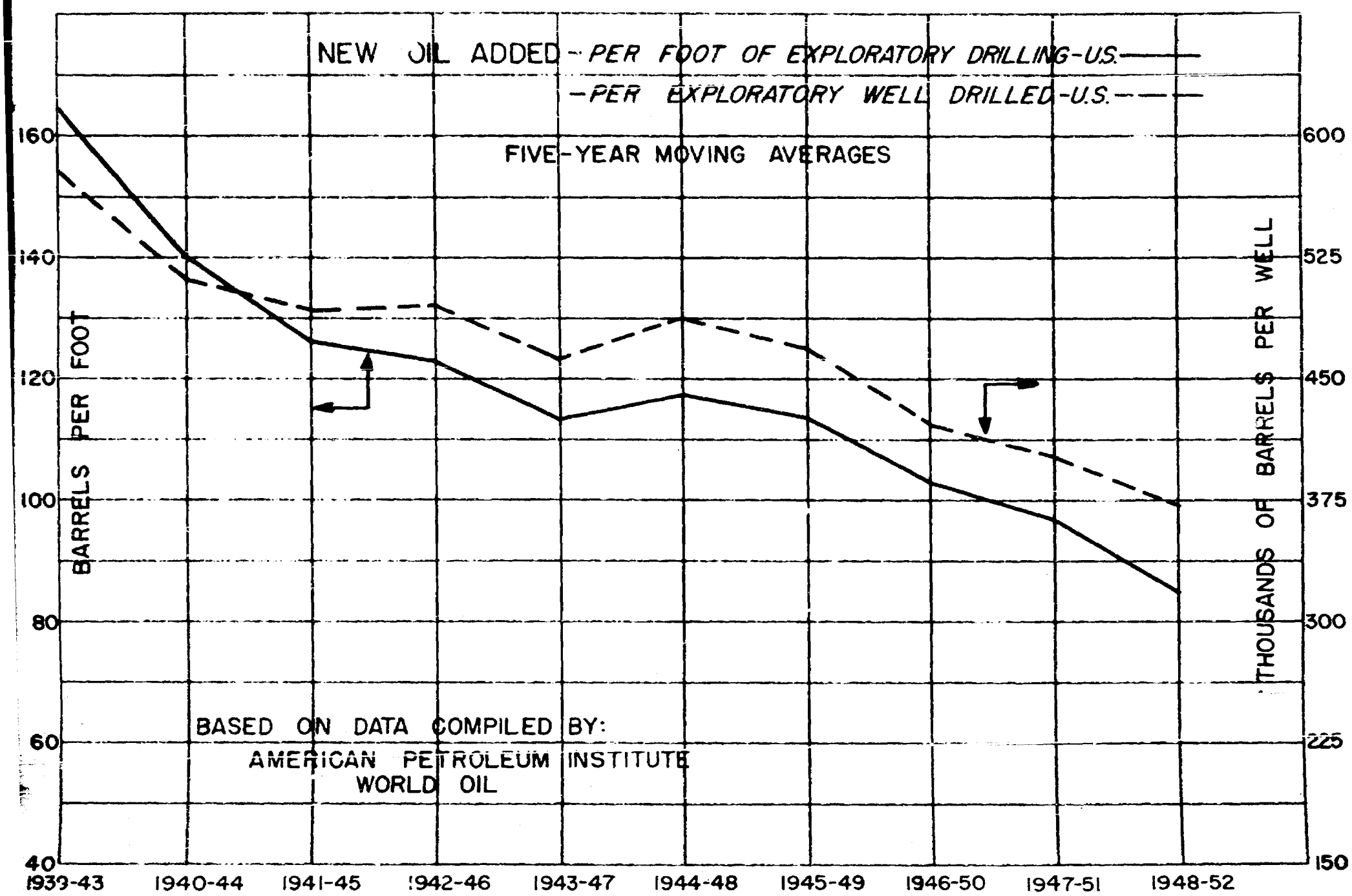
I would like to suggest to the Commission this matter be continued for ninety days or to the March hearing. It has occurred to me that the most significant type of data to get with respect to the feasibility of 80-acre spacing or 40-acre or 20 or whatever it may be is reservoir performance. And perhaps the Commission might like to give some consideration to any interference tests which may be run during the interim period before March to determine whether or not the evidice is consistent with that which was developed at the Fowler Pool hearing which we put on. We would like to make that suggestion and ask that the hearing be postponed until the March hearing.

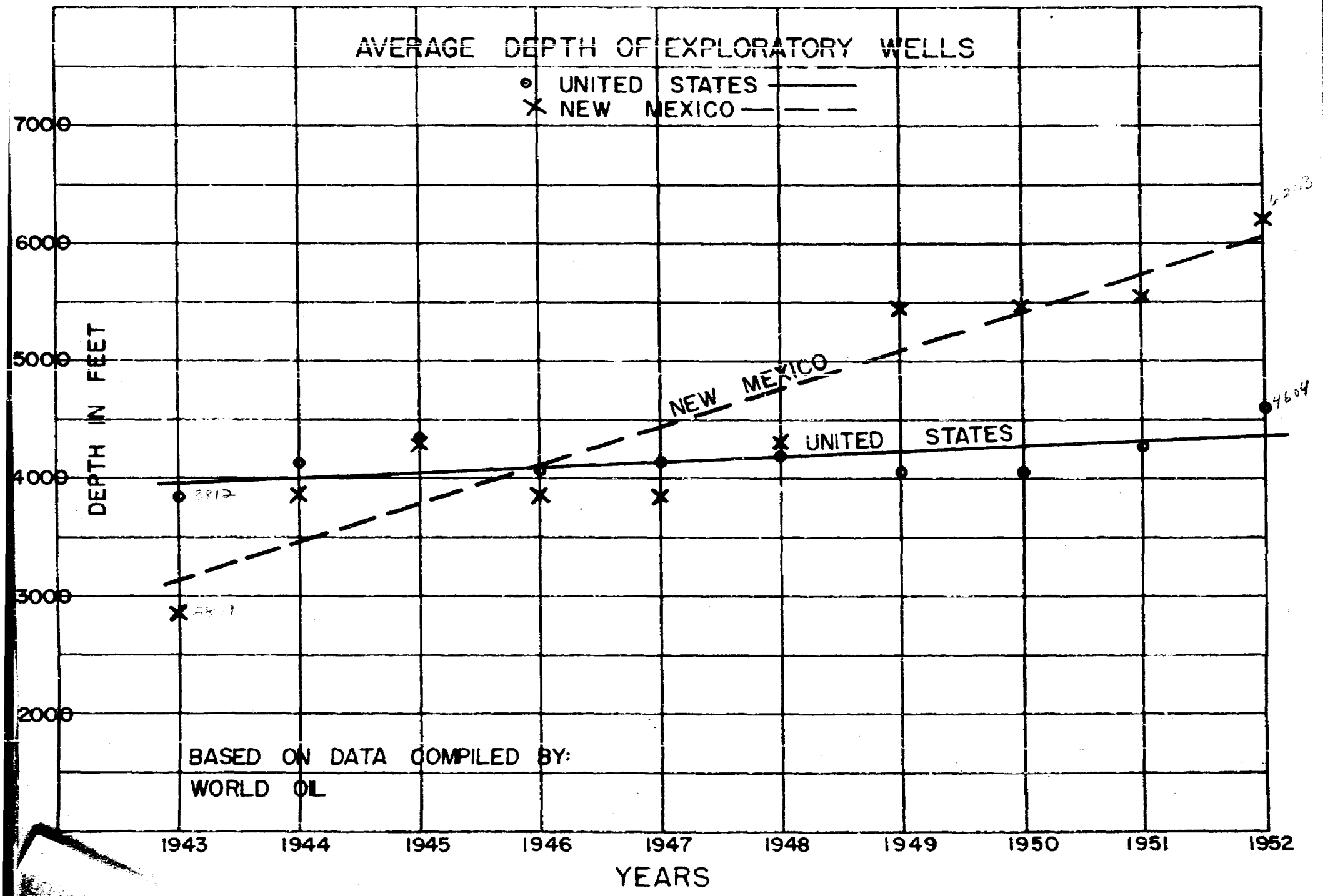
MR. SPURRIER: That is your motion?

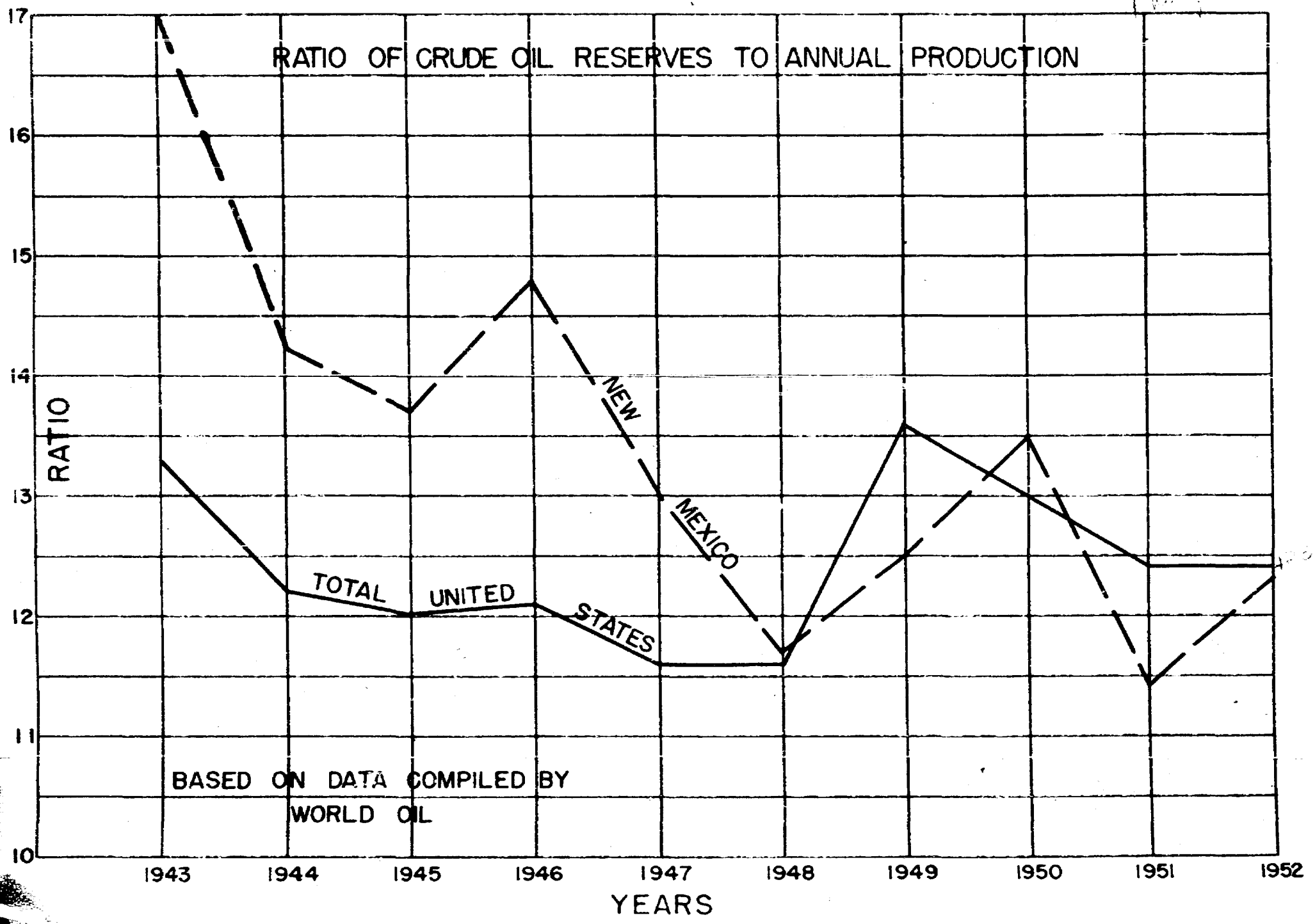
MR. SMITH: Yes, sir.

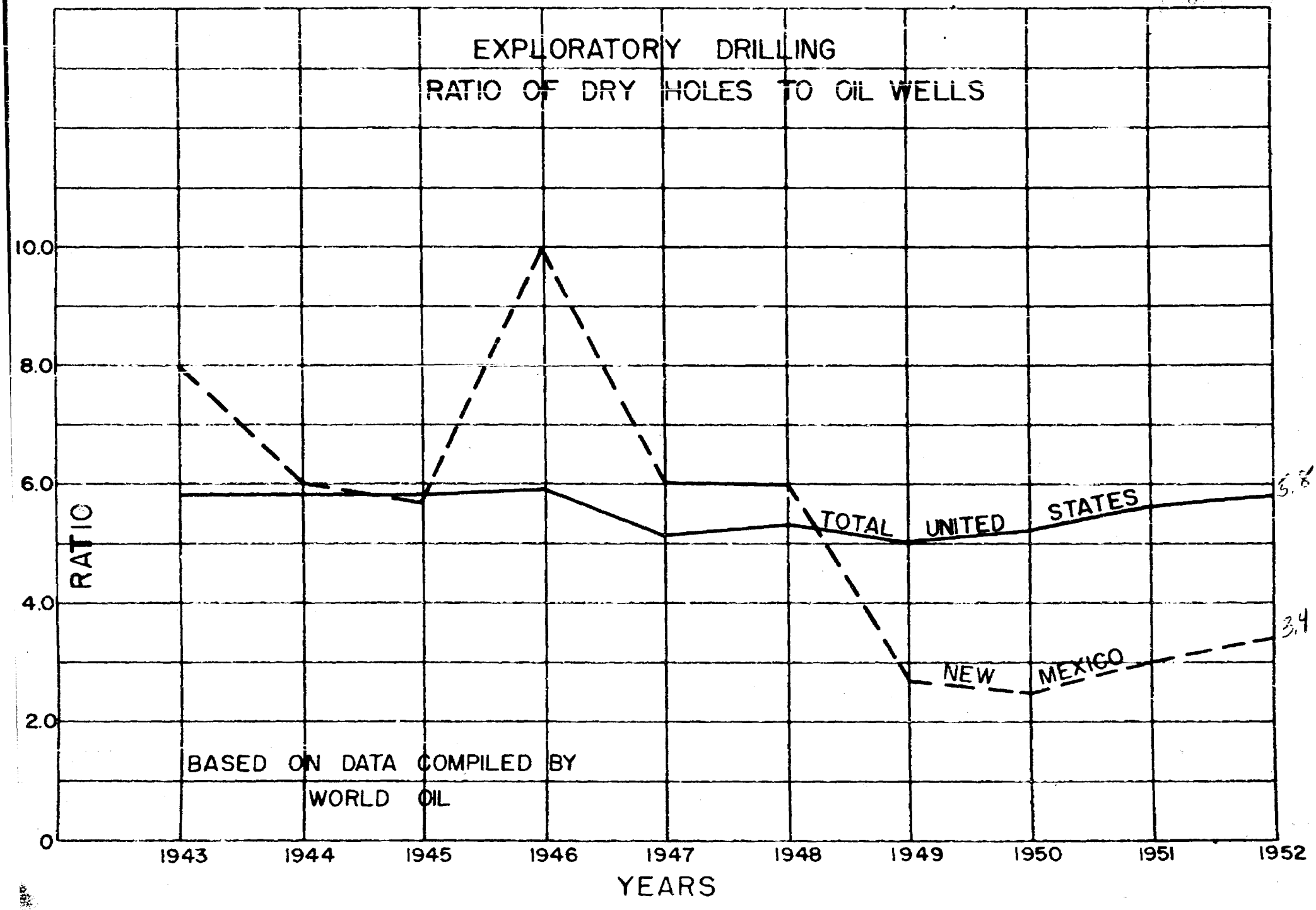
MR. SPURRIER: Anyone else have a comment? Does anyone have an objection to counsel's motion for a continuance to March? Without objection, the case will be continued until the regular March hearing.

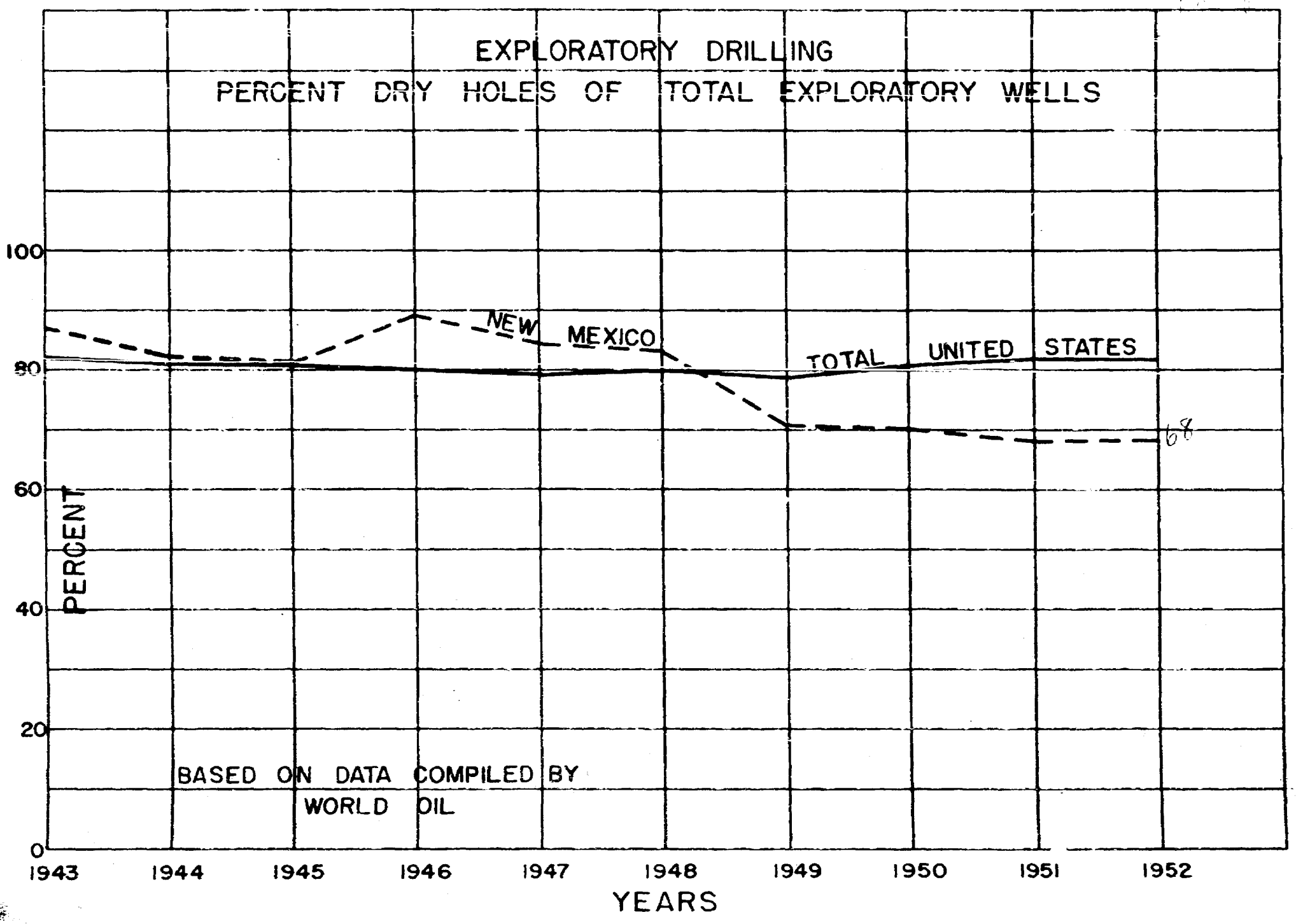
———o———


NEW OIL ADDED - PER FOOT OF EXPLORATORY DRILLING-U.S.
- PER EXPLORATORY WELL DRILLED-U.S.
FIVE-YEAR MOVING AVERAGES
BARRELS PER FOOT
THOUSANDS OF BARRELS PER WELL
160
140
120
100
80
60
40
600
525
450
375
300
225
150
1939-43
1940-44
1941-45
1942-46
1943-47
1944-48
1945-49
1946-50
1947-51
1948-52
BASED ON DATA COMPILED BY:
AMERICAN PETROLEUM INSTITUTE
WORLD OIL

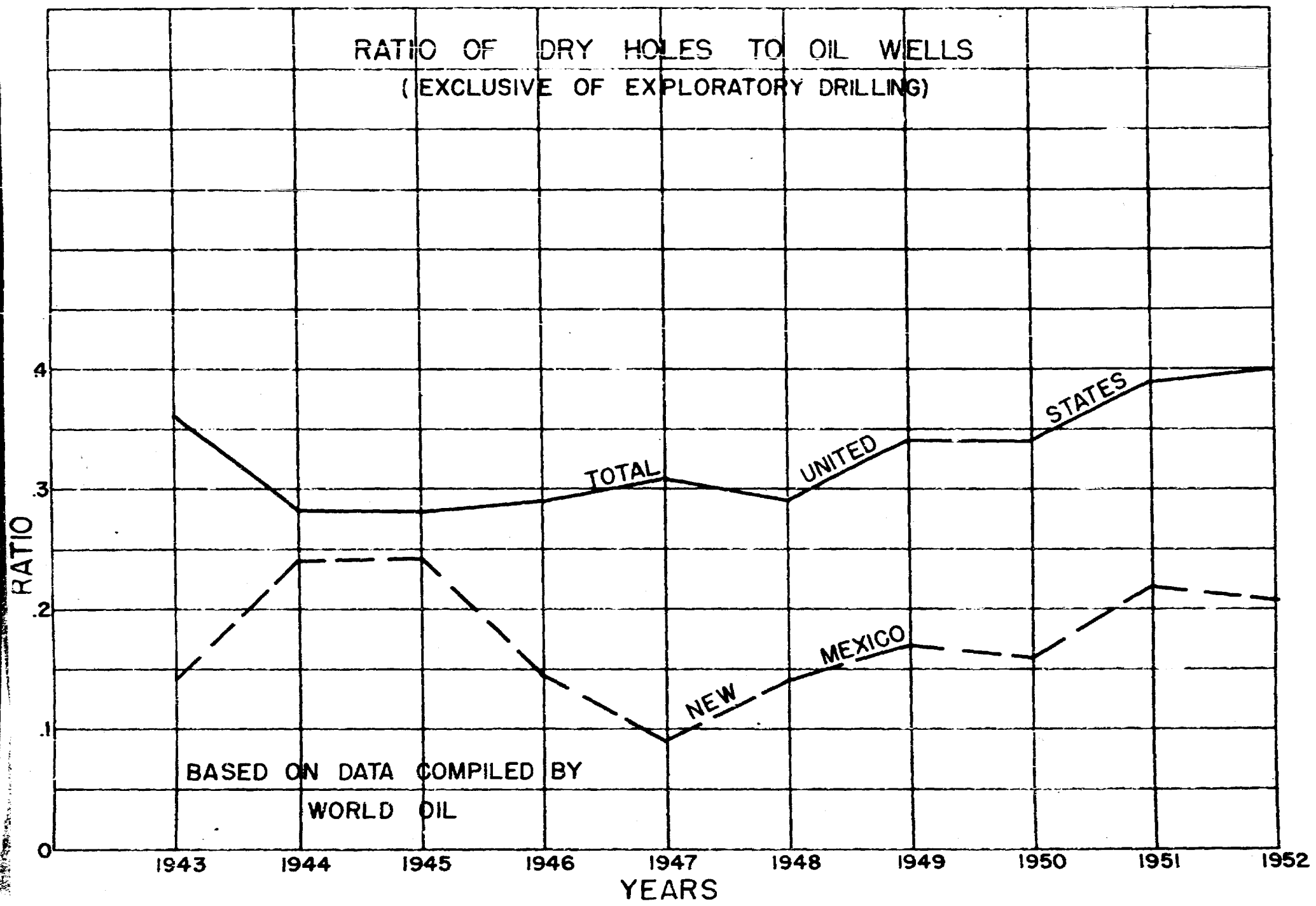

AVERAGE DEPTH OF EXPLORATORY WELLS
UNITED STATES
NEW MEXICO
7000
6000
5000
4000
3000
2000
DEPTH IN FEET
NEW MEXICO
UNITED STATES
4604
BASED ON DATA COMPILED BY:
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS


RATIO OF CRUDE OIL RESERVES TO ANNUAL PRODUCTION
RATIO
17
16
15
14
13
12
11
10
NEW MEXICO
TOTAL UNITED STATES
BASED ON DATA COMPILED BY WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS

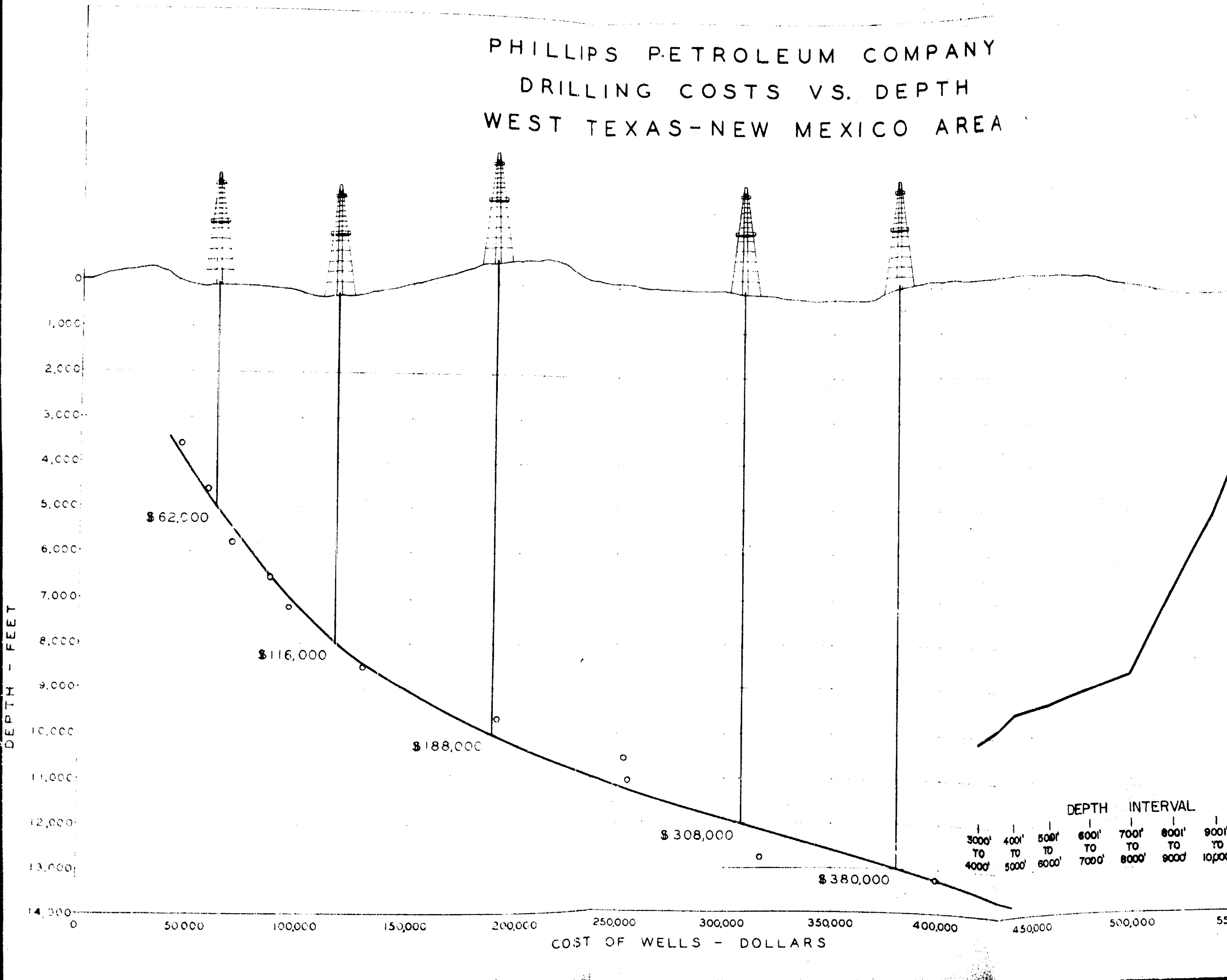

EXPLORATORY DRILLING
RATIO OF DRY HOLES TO OIL WELLS
10.0
8.0
6.0
4.0
2.0
0
RATIO
TOTAL UNITED STATES
5.8
NEW MEXICO
3.4
BASED ON DATA COMPILED BY
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS


EXPLORATORY DRILLING
PERCENT DRY HOLES OF TOTAL EXPLORATORY WELLS
NEW MEXICO
TOTAL UNITED STATES
68
PERCENT
100
80
60
40
20
0
BASED ON DATA COMPILED BY
WORLD OIL
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
YEARS

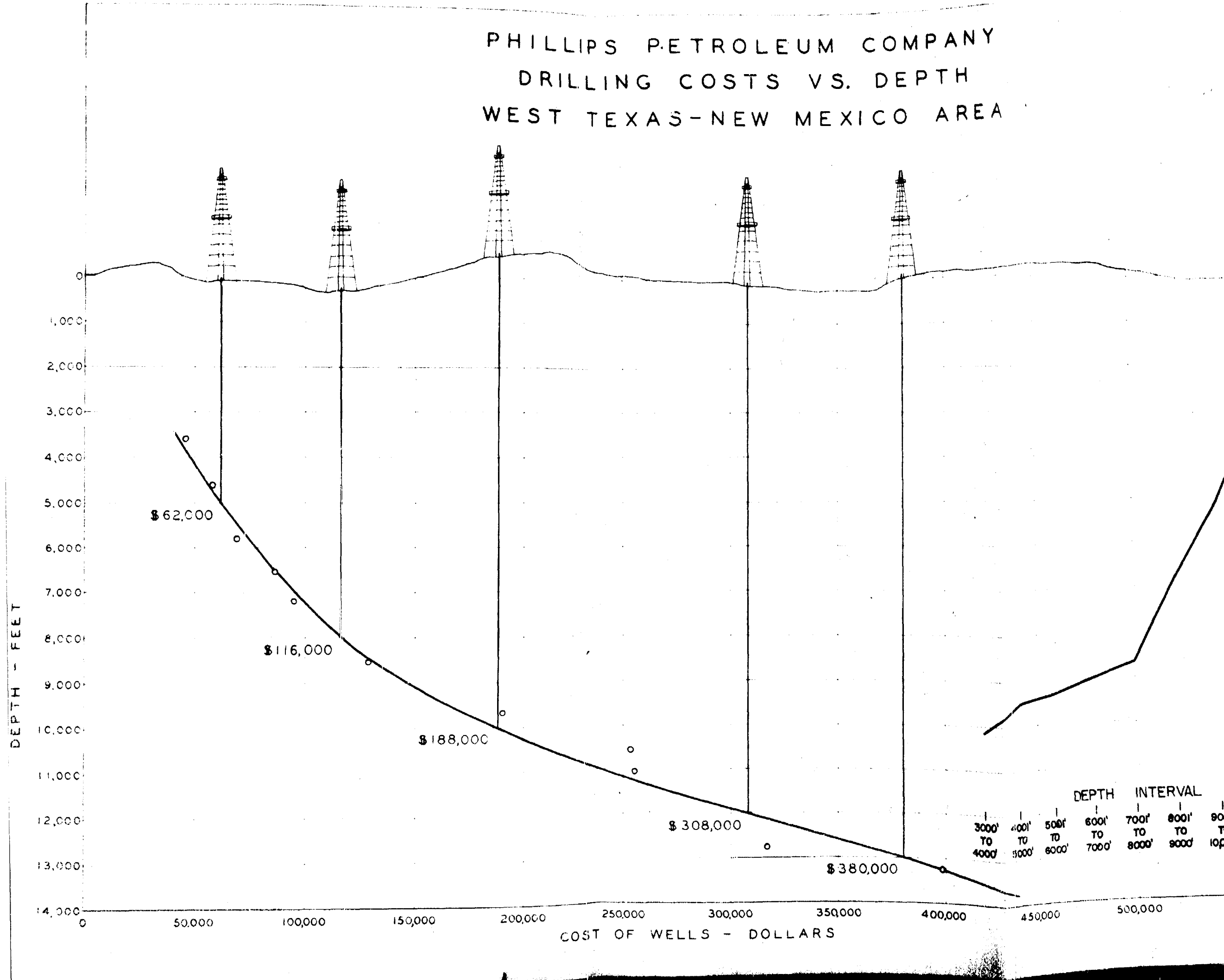
RATIO OF DRY HOLES TO OIL WELLS
(EXCLUSIVE OF EXPLORATORY DRILLING)



PHILLIPS PETROLEUM COMPANY
DRILLING COSTS VS. DEPTH
WEST TEXAS - NEW MEXICO AREA



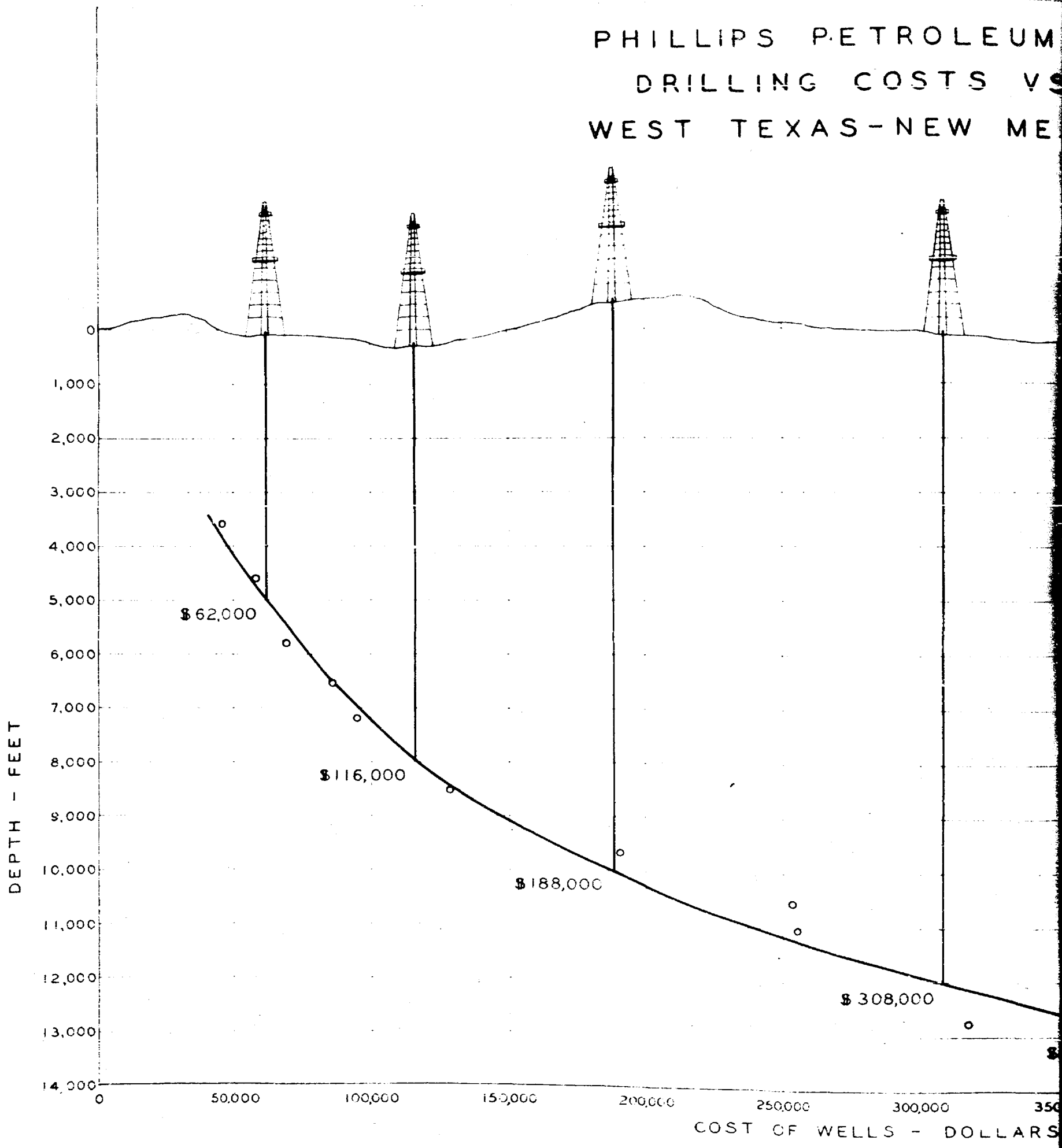
PHILLIPS PETROLEUM COMPANY
DRILLING COSTS VS. DEPTH
WEST TEXAS - NEW MEXICO AREA



PHILLIPS PETROLEUM

DRILLING COSTS VS

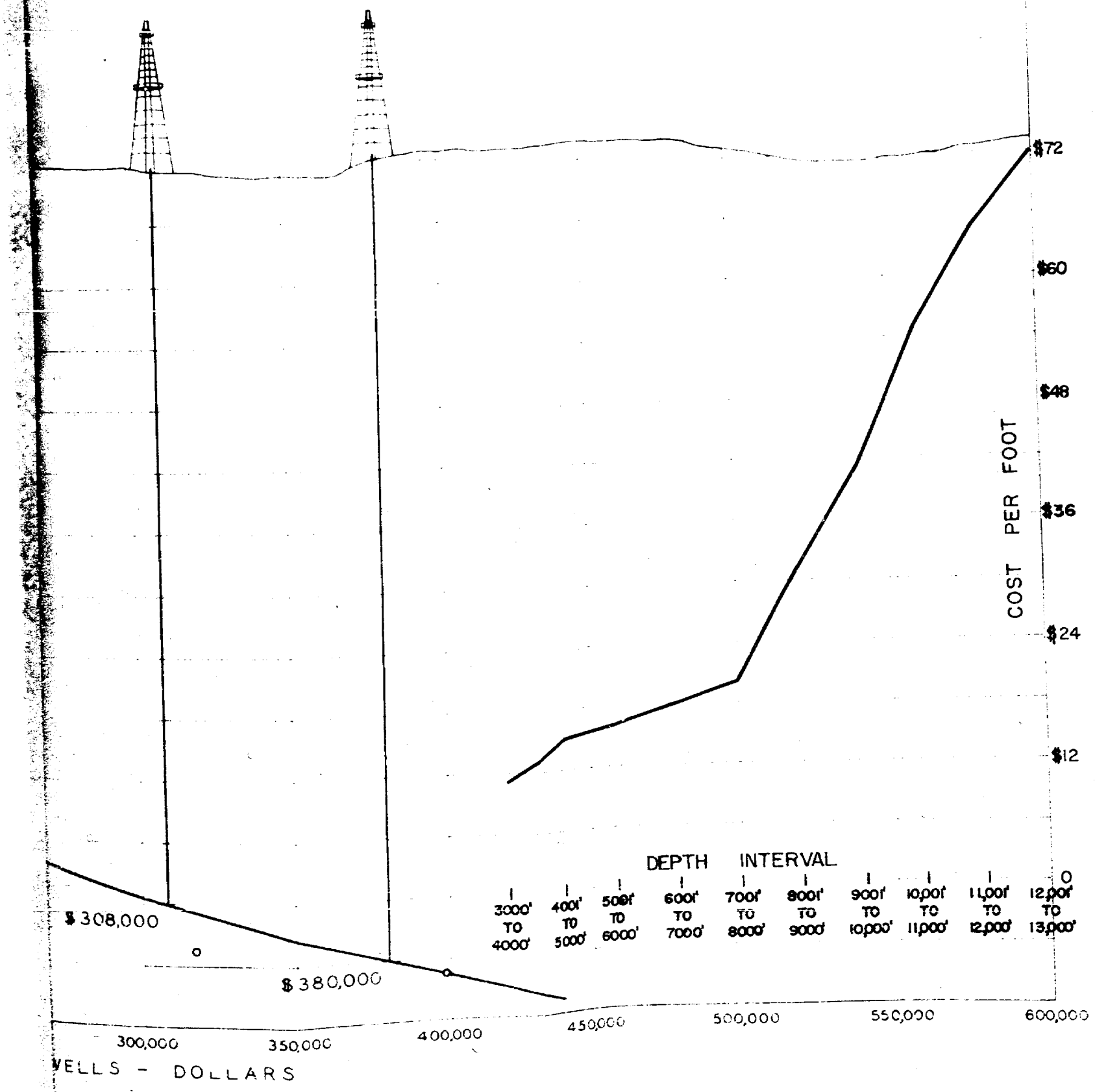
WEST TEXAS-NEW ME



ETROLEUM COMPANY

COSTS VS. DEPTH

S-NEW MEXICO AREA



BEFORE THE
OIL CONSERVATION COMMISSION
STATE OF NEW MEXICO

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
RECEIVED
JUL 7 1953

CASE 407

The Commission's motion for extension of Section 'G' (Oil Proration and Allocation) to provide for addition of Rule 508, Establishment of Temporary 80-acre Proration Units.

TRANSCRIPT OF HEARING

June 16, 1953
Date

BEFORE: Honorable Ed. L. Mechem, Governor
Honorable E. S. Walker, Land Commissioner
Honorable R. R. Spurrier, Director, OCC

STATE OF NEW MEXICO)
ss
COUNTY OF BERNALILLO)

I HEREBY CERTIFY That the within transcript of proceedings before the Oil Conservation Commission is a true record of the same to the best of my knowledge, skill, and ability.

DONE at Albuquerque, N. M., this 3d day of July 1953.

E. E. Gresson

My Comm. Ex.:
August 4, 1956

E. E. Gresson
Notary - Reporter

COM. SPURRIER: We will move to case 407.

(Mr. Graham reads the advertisement.)

MR. SMITH: May it please the Commission, as I understand the status of this case, it having been continued from the April hearing, I believe that Mr. Tesch -- was he on the stand or was there additional testimony offered at the conclusion of his testimony?

COM. SPURRIER: As I remember, Tesch was on the stand.

MR. SMITH: I should like to inquire if the Commission has information as to whether or not Mr. Tesch is back for this hearing.

COM. SPURRIER: The two senior members of the Commission tell me Mr. Tesch finished his testimony so that he wouldn't have to return.

MR. SMITH: I had to leave early and I wasn't too sure what the status was.

I presume that the Commission has received no information as to whether or not Mr. Tesch has returned? He indicated he might not be able to return. I presume you have received no information from him?

COM. SPURRIER: No, sir, we haven't.

MR. SMITH: In the interests of saving time, in view of the presentation we wish to make, we divide the presentation off somewhat among the companies, and I believe

Judge Foster is the one who is supposed to proceed.

(Off the record)

MR. SMITH: Is Mr. Hanners here?

COM. SPURRIER: I don't see him, Mr. Smith.

MR. SMITH: Shall we proceed?

COM. SPURRIER: If you wish.

MR. FOSTER: We ask the witnesses be sworn, if it please the Commission.

COM. SPURRIER: Will you ask them to come forward?

(Witnesses sowrn)

MR. FOSTER: May it please the Commission, I am E. H. Foster, representing Phillips Petroleum Company.

The three industry members who were on the Advisory Committee wish to submit a report at this time of the Committee. I have some extra copies here of the report, if the Commission would like them. And I will offer one in evidence. I would just like to read this report of the Committee.

(Reads the report)

MR. FOSTER: Now, I would like to offer that report as part of the record.

COM. SPURRIER: Is there objection?

MR. MACEY: I would like to ask the judge a question. You might have misread. You said unless in 18 months. You meant not more than 18 months?

MR. FOSTER: Yes, I did misread. I did misread.

Thank you.

COM. SPURRIER: Without objection, it will be received.

MR. FOSTER: I would like the unanimous consent of the Commission to excuse Mr. Beall, who is our vice-president, immediately after he testifies so that he may get back to Bartlesville. Mrs. Beall is very seriously ill, and will undergo major surgery early in the morning. And Mr. Beall is anxious to return to Bartlesville as soon as he possible can.

COM. SPURRIER: Very well, judge.

MR. FOSTER: And we will call Mr. Beall as the first witness.

K. E. BEALL

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. FOSTER:

Q Will you state your name to the Commission, please?

A K. E. Beall.

Q Where do you reside, Mr. Beall?

A Bartlesville, Oklahoma.

Q Are you employer by Phillips Petroleum Company?

A Yes, sir.

Q What official position do you hold with the company, Mr. Beall?

A Fice-president of the Economics Department.

Q How long have you been in that capacity?

A About six years.

Q Now, Mr. Beall, you have made some studies of the economic implications of well spacing, have you not?

A Yes, sir.

Q And would you say that an economic analysis is important in the oil business?

A Yes, sir, I would say it is very important. As far as I know no company that is going to spend very much money does so without such an analysis. I presume that probably most of the people that appear before this Commission represent the branch of the industry that spends the money. And I would be glad to give you a few slants from the branches that get the money, and determine how it is spent and how.

Q Will you do that, please?

A Yes, sir. I presume most of you realize that the oil industry is one of the four or five major industries of our country. It has gross assets of approximately 40 billion dollars. And it is required this industry each year spend a great deal of money in new capital. For the past five years there has been substantially 15 billion dollars spend in capital expenditures of various branches of the oil industry. And during 1952 the best estimate we can make this early is that approximately thirty billion dollars was spend for capital expenditures. And, inspite of anything anybody

may say the oil industry, as well as allother industries, spends only when it is satisfied it can make a return; get its money back with a reasonable profit.

In other words, we are part of the capitalistic sy.tem, whose purpose is to make money. So that in determining how this staggering amount of three to three and a half billion dollars is spent each year, the various companies who spend it have to make very careful analysis of where to put the money. There is of course competition between the various branches of the oil industry for capital.

We have the refining industry, and the production industry, and the transportation and marketing, and of late years the petro-chemical branch; all clamoring for part of this capital expenditure.

Of recent months you are probably aware of the fact interest rates have increased materially. And I am sure for at least the immediate future it is going to be harder to get capital to spend than it has been in the past. Therefore, the analysis of how to spend this money is even more important in the present and in the immediate future than it has been in the immediate past.

Now, once the company determines what portion of its total capital budget is to be allocated to the producing branch, then it immediately becomes the problem of where to spend the money. In other words, the different states have to

compete with each other to get their proportionate part of the capital funds allocated to the producing branch. And, of course, there is also an allocation as between exploratory wells and wells to expand the fields already developed.

Now, the industry is faced with the constantly increasing dry hole hazard. If we take an analysis of all the wells that have ever been drilled, there is something over one million four hundred thousand of them. Approximately 25 per cent of these wells have been dry. If we take only the last ten years, something over 300,000 wells, 34 per cent have been dry. If we take just the last year, 44,000 wells, 40 per cent have been dry. So, you see there is a steadily increasing dry hole hazard. And, of course, it is needless to say you don't make money out of dry holes.

Now, in addition to this dry hole hazard, the costs of various kinds affecting the development program have also increased very materially. Going back to the time of our last crude price increase in 1947, labor has increased approximately 40 per cent; steel prices have increased 40 per cent; other materials 20 to 30 per cent. Income taxes are also up, and are very burdensome. So that you can well see that the companies, the departments of companies responsible for the investing of these capital funds, have to make a very close analysis in order to be sure they are going to get their money back, plus an adequate profit.

Q Have you made some particular studies of the economic implications of well spacing, and investment of funds by oil companies insofar as the State of New Mexico, individually, isnconcerned?

A Well, yes. Among other things, of course, we have determined -- we have to determine -- the reserves that are uncovered by development. New Mexico is one of the various states -- there are many producing states. New Mexico has reserves I think that place it in about seventh place. Texas, first; California, second; Louisiana, third; Oklahoma, fourth; Wyoming, fifth; Kansas, sixth; and New Mexico, seventh.

Now, in general, the industry has had a very good record in uncovering new reserves for the entire country at large. Despite the fact that the production and demand -- crude runs have increased steadily each year. And we find that the amount of new crude reserves which have been developed has increased steadily. At the end of each year we have had a little more reserves of crude oil than we had at the end of the previous year. And at the end of 1952 the crude reserves was the highest it has ever been. Approximately 28 billion bbls. That is in the United States alone. Proven reserves.

Now, the thing that is disturbing about reserves is the fact that it is harder and harder to find them and more costly

to find them. And that, of course, is one of the things that the whole industry is facing.

Now, I have made some curves, which I ask the Judge to distribute to the members of the Commission interested, that show some of the factors that have to be considered by the different oil companies in their determination of what to do with their capital and where to spend it. I have numbered these curves from 1 through 7.

The first curve sheet shows the new oil that is added per foot of exploratory drilling in the United States, and also by the exploratory well.

Now, in the process of determing reserves, the American Petroleum Institute Committee, from which these figures were taken, of which I happen to be a member, has three different categories for new oil that is added. You have, first, the reserves found by wildcat wells which prove productive. Then we have the reserves that are added by finding new pools; deeper pools in most cases in already discovered fields; and the third category of reserves that are added in old pools due to their extension, drilling of the wells that are expanding the proven area in the known pools.

Those three categories of reserves are added together, and averaged for five-year periods, or a five-year average, divided by the feet of exploratory wells drilled, and the number of exploratory wells, which gives the points on these

curves.

Q Will you explain those curves to the Commission.

A The heavy, solid lines show -- these figures are for entire United States -- the heavy line shows new oil added per foot of exploratory drilling. Starting back ten years ago we found that for every foot drilled by exploratory wells there was 164 bbls of new reserves added. That figure has steadily gone down with only one slight increase to a figure of 85 bbls at the -- in the latest five year period ending in 1952.

The dotted line shows the number of bbls per exploratory well drilled. And it has dropped also steadily from 579,000 ten years ago to 364,000 in the latest five-year period.

Those figures show very conclusively how hard it is to find crude. And that is despite the fact that we are drilling more wells than we ever have before, and drilling deeper and more expensively, and the industry is spending more money than before, and still not finding reserves as rapidly as we did in the past years.

That is one factor that has to be taken into account in the determination of spending of money for production.

Q Mr. Beall, I notice on this chart No. 1 that you comment on the statement that it is based on data compiled by the American Petroleum Institute.

A That's right.

Q Are you a member of that Institute?

A Yes, sir. These figures are taken from the annual report of the combined two committees. One from the American Petroleum Institute, which studies crude oil reserves; and the second, the American Gas Association, which studies the reserves of gas and of natural gas liquids included in the gas.

Q I understand in your studies of the economics of this question you have found some economic factors that are unfavorable in New Mexico, and some that are favorable. Is that true?

A Yes, sir, that is true.

Q Would you tell us first what factors you found in New Mexico -- that is, economic factors -- that are unfavorable factors?

A Chart No. 2 shows one of the factors. This has to do with average depth of exploratory wells in the United States and in New Mexico. We found out ten years ago, 1943, the average depth of an exploratory well in New Mexico was 2,834 ft, and in the United States, as a whole, was 3,812 ft. In other words, New Mexico was about 1,000 ft shallower than the United States average.

The trend has been up both for the United States and New Mexico. However, the trend for the United States has been up very gradually. In the ten-year period the average

depth of the total United States wells has increased only from 3,812 to 4,604, which is a relatively small increase for a ten-year period. On the other hand, with New Mexico starting out 1,000 ft. shallower than the United States average in 1943, it has increased much more rapidly to 6,203 in 1952; approximately 1,600 ft. deeper than the United States average. And the trend, as you probably realize, is going to continue, as we know from the activity that is currently taking place.

Now, that is one thing that New Mexico has to face that might be considered unfavorable in that it is definitely classed as a deep area. And as most of the deep wells are increasingly costly, it means that whoever wants to develop wells in New Mexico is going to have to be prepared to furnish the capital to drill these deep wells.

Q When you say unfavorable, you mean compared with other states when the company comes to a decision as to where they are going to invest their funds?

A That's right.

Q In developing the oil resources?

A That's right. New Mexico has to compete with the other states. A company has a budget of so many million dollars. It is going to determine where it is going to spend that in the light of possible returns on the investment in the different states, and in the light of producing conditions set up by the regulatory bodies in those states, or in some

few states where there are no regulatory bodies those states have a strike against them to start with.

Q Your testimony is directed at a composite picture of the industry, isn't it?

A Yes, sir.

Q You are not speaking of any particular company?

A That's right.

Q But this is the over-all composite picture of the economic factors involved in the investment of funds by the oil companies?

A The entire industry, yes, sir. The only chart which I have which is limited strictly to Phillips Petroleum Company figures is the No. 7, which I will get to later.

Q Now, what other unfavorable economic position did you find New Mexico in?

A Well, Chart No. 3 shows the ratio of crude oil reserves to annual production. It shows conclusively that the State of New Mexico has not succeeded in developing reserves in proportion to its production return as rapidly as the remainder of the country.

The dotted line shows reserve picture for New Mexico, and the solid line the total United States. It shows ten years ago New Mexico had 17 years reserves, based on the then rate of production, whereas, the United States had 13.3 years. During the ten-year period the United States

as a whole has fluctuated up and down, but pretty largely level. At the end of the ten-year period, or end of 1952, the United States still had 12.4 years supply, even at the higher rate of production in '52. On the other hand, New Mexico has dropped from 17 years supply ten years ago to 12.3 years supply. In other words, it was half again as high as the United States average ten years ago, and now it is below the United States average, and has been consistently for the last four or five years. So that shows there hasn't been the reserves opened up in New Mexico in proportion ot the increasing rate of take that there has in the United States at large.

That also might be deemed to be an unfavorable factor for the State of New Mexico.

Q Now, you have explained these unfavorable economic factors that exist in this state. Did you find some favorable factors ?

A Yes, fortunately I do. I go into Chart No. 4. Charts 4 and 5 pertain to exploratory drilling only. And they show -- Chart No. 4 shows the ratio of dry holes to oil wells among only the exploratory wells. And Chart No. 5 shows the percent of dry holes to total number of exploratory wells.

In both cases, New Mexico has a comparably better average than the United States at large. Ten years ago New Mexico was a little worse than the United States as far as dry hole ratio. It had eight dry holes to each oil well

drilled in its exploratory program, with the single exception of the year '46 when it had a bad year. The New Mexico average has gone down steadily, and for the past four or five years it has been substantially under the United States average.

And in 1952 the average in New Mexico was 3.4 dry holes for each oil well discovered, as compared to a United States average of 5.8. A little over half. So, that is very favorable to New Mexico.

Now, the percentage of dry holes to total exploratory wells is also very similar to the other curve. It shows that ten years ago that the percent was a little higher in New Mexico than the United States average, whereas today it is lower. Sixty-eight per cent of the exploratory wells are dry now as compared to 82 --

Q You are now referring to Chart five?

A Yes, sir, I am now referring to Chart No. 5. That also has taken place for a period of four or five years. And it conclusively proves that the exploratory program in New Mexico is quite as hazardous as else where. And, of course, that is favorable because nobody wants to get into a program of drilling dry holes.

MR. GRAHAM: To what do you attribute that, Mr. Beall?

A To Mother Nature, I would say.

MR. GRAHAM: Better methods of exploration?

A No, sir, I wouldn't say the methods of exploration have been any better in New Mexico than elsewhere. You have more productive area and have proved up more reserves -- not more reserves, but found a better ratio of dry holes to oil wells.

Another very favorable factor here -- those two curves applies only to exploratory wells. This next curve applies to the wells which are drilled in expanding the production found in these discovery wells, exploratory wells.

Q First, are these exploratory wells kind of in the wildcat class?

A They are wildcats.

Q They are wildcats?

A That's right.

Now we are talking about the kind of wells you are talking about applying your factors in the way of your spacing to.

Q Yes, sir.

A In other words, expanding the field found by the discovery exploratory well.

This Chart No. 6 shows that exclusive of the exploratory wells, naturally there would be a very much lower percent of dry holes, because you have already proved up the field, and it is a question of expanding it. This average has been

fairly level throughout the ten-year period. It started out in '43, 136 of a dry hole for each oil well in these pool expansions; and ended up the ten-year period with .40, or four-tenths or 40 per cent.

Now, that is the experience for the United States. Now, New Mexico is consistently all through the ten-year period -- has been less than the United States average. And for the last six years it has been approximately half the United States average. In other words, in expanding the production, productive areas, around the discovery wells in New Mexico, the experience has been that only half as many dry holes have been drilled as in the United States at large.

Now, that is a very good point to consider with regard to your spacing here. All through that period -- I think your 40-acre spacing went into effect sometime in the thirties. All during this period you had 40-acre spacing in effect.

Now, many opponents of the wider spacing program have claimed the fact that you had to step out a little further in the 40-acre spacing than you did in the 10 and 20 in effect in other pools would tend to make you drill unnecessary dry holes. That claim isn't borne out at all by these facts. Because here with New Mexico operating under 40-acre spacing throughout this entire period, and the United States as a whole certainly less than 20 acres on an average -- we don't know what the average is because there is no way to compute

it, but we do know it is substantially under 40 acres. All during that period the dry hole per cent was about half what the United States average is.

That would indicate that the 40-acre spacing, which through this period, certainly the earlier part of the period anyway, was far more of an innovation than the expansion from 40 to 80 is today, that that didn't result in an abnormal increase in dry holes. The only answer that could be given to that, I would say, would be that it tends to prove once you find a field in New Mexico your geologic formations are more dependable and predictable and extend over a little greater area than the rank and file of the pools found elsewhere.

That is distinctly a favorable factor to this state, and indicates the advantage which the state undoubtedly had in the wider spacing, its 40-acre spacing pattern in the earlier days; which, I presume, was put into effect to attract drilling capital in this state, which at that time was very remote from the market. That has worked very satisfactorily and advantageously. And now that your depth has out-distanced the depth in the other areas, it would seem perfectly logical you would maintain that advantage you have had there by stretching out a little favor wider spacing still, if conditions warrant it.

There is no contention you should automatically and arbitrarily extend 40-acre spacing to any other spacing

pattern. Just keep your minds open as to what the spacing pattern should be -- should be given to any particular field once the factors have been determined to intelligently analyze that situation.

Q Have you also compiled some more cost figures in deep drilling, comparable figures?

A Yes, sir.

Q That is illustrated by --

A Chart No. 7.

Q Chart No. 7?

A These figures, first, because it is difficult to compile industry-wide figures on costs of any nature, I have limited the figures shown in this chart to the experience of Phillips Petroleum Company, alone.

Q I want to emphasize again: the figures you have given on the previous charts, 1 through 6, generally, those are industry-wide figures?

A Absolutely.

Q Don't apply to any one company?

A No.

Q To all companies?

A To all companies.

Q Including Phillips Petroleum Company.

A The best figures we can get to apply to the industry as a whole. The reserve figures are taken from the American

Petroleum Institute Reserves Committee reports, and the figures on the number of wells and the footage drilled and all those statistics are taken from "World Oil ", which has consistently compiled those type figures over the years.

Q You might state what this petroleum institute is; what its purpose is.

A Of course, I am sure you are all familiar with the American Petroleum Institute as a whole. It is a body formed of all the producing elements of the industry; practically all the big and little companies belong to the American Petroleum Institute. And this Reserves Committee, which is a committee which was appointed many years ago, some 12 or 14 years ago, to analyze the reserve situation of the entire industry. The Committee is headed up by Dr. Fred Lokey of the Sun Oil Company at Dallas, and composed of some ten or fifteen members of the industry who specialize in reserves calculations; geologists and engineers. And they have hundreds of people serving on sub-committees who make studies of all the figures and all the wells that are drilled, and keep abreast of what the reserves situations is, both as to new wells and old wells.

Q And the information they compile is purely factual?

A That's right. It is published in annual report form. Here is a copy of the latest report, December 31, 1952. It is published annually by the American Petroleum

Institute. And in the last year or two we have expanded the cooperation of the American industry with the Canadian industry, and there are figures in here showing in a preliminary way the reserves of crude oil in Canada. And it is the intent and hope as the years progress we will have figures on Canadian reserves which are entirely comparable to figures on American reserves. Which can be added and compiled in statistical analysis just as readily as United States reserves.

Q You regard the figures you get through this Institute as entirely reliable?

A They are the best I know of that can be had.

Q Will you give us comparable figures on well costs at different depths?

A Yes, sir. These figures are composite results on 225 wells, none of which are exploratory wells.

Q No wildcats?

A No wildcats. These are on field expansion wells drilled in the New Mexico and West Texas area by Phillips Petroelum Company in '51 and '52. They are all of such recent nature that the costs are, you might say, up to date; fairly up to date. There have been some increases in costs in the last few months, but they are fairly up to date.

The curve to the left part of the chart under the derrick shows the increasing depth of the wells. The extreme

left side shows the shallow wells. And the extreme right side shows deep wells. It shows a 5,000 ft. well -- incidentally, the points on the curve, the little round circles, are the individual groups of wells at different depths. And the curve is averaged out as best we could at various points. It shows a 5,000 ft. well costs about $62,000. And 8,000 ft. well, $116,000. A 10,000 ft. well, $188,000. A 12,000 ft. well, $318,000. And a 13,000 ft. well, $381,000.

Now, of course, the wildcat wells cost far more than this. Many cost a half million or three-quarters of a million, and some in excess of a million. These are pool development wells.

Now, the curve on the right-hand side shows the increased cost in a little different form; increased cost of deeper drilling. In other words, the fartherest left point shows the cost per foot at the 3 to 4 thousand foot level. It shows it costs about $11 per foot at that level. You step the depth up from 4 to 5 thousand, and the cost is $15 per foot. From 5 to 6 thousand, it costs $16. a foot. From the 6 to 7 thousand foot level, $18 a foot. From the seven to 8 foot -- 7 to 8 thousand foot -- $20, a foot.

In that increment between 3 and 8 thousand it isn't nearly as rapid an increase in the cost per foot of drilling as there is subsequently as you go deeper.

From 8 to 9 thousand the cost jumped to $31 per foot. From 9 to 10 to $41 per foot. Ten to 11, $55 per foot. Eleven to 12, $65. And from 12 to 13, $72 per foot.

Well, that means obviously every time you add footage to these deep wells, you don't add costs at the average over-all cost per foot of the entire depth, but you add it at these increments which are very much higher. If you go down to the 15 and 16 thousand foot wells, as we are getting into, the cost is upward of $100 a foot for those depths. The 13,000 ft. well costs better than six times as much as the 5,000 ft. well. It is obvious if you are going to have the same return on your money and get paid out at the same profit on the 13,000 ft. well that you had on the 5,000 ft. well you have to have about six times as much oil. At least that much.

Well, unfortunately, we have found that as these horizons are developed at the deeper depths they aren't necessarily better in every respect, or in any respect in some cases, than the shallow ones. In fact, to date the best producing horizons are still the shallower ones. If we have a pool that -- a horizon -- that produces at a depth of about 5,000 ft, you might say 2,000 bbls per acre would be the bare minimum at which you could afford to drill the wells. If you found identically that same formation at 13,000 ft., it is quite obvious you couldn't possibly produce those wells. In fact, you would have to have about six times that, or 12,000 bbls per acre to have a bare minimum at 13,000.

Q Is it a sort of popular concept the deeper you

drill these wells, the better wells you are going to get?

A Well, I presume there may be people that have that concept. I don't believe anyone that is familiar with the facts has that feeling.

Q That is not true?

A There is no fundamental reason why an horizon at a deep depth should be any better or different than one at a shallower depth. It hasn't proven to be the fact. Some of the deepest are very thin and not good in permeability or porosity, and don't produce much per acre. There are some good formations, fortunately.

If you had 20 ft. of pay that gave satisfactory production at 5,000 ft., you would have to have over 100 ft. of pay at 13,000 ft., the other factors being identical.

Q To enjoy the same economic position?

A To enjoy the same return, that's right.

Q You are familiar with the proposal here, Mr. Beall, that a temporary rule be passed by the Commission establishing temporary 80-acre proration units, are you not?

A Yes, sir.

Q And in the light of the economic studies that you have made, and in the light of the particular economic factors that are in play here in New Mexico, would you recommend to the Commission the adoption of such temporary rules?

A Yes, sir, I think, as a temporary rule, I don't

see how there could be any real objection against it. As I pointed out, certainly everyone would have to admit you have to analyze the deeper, more expensive drilling a little differently than the shallower and less expensive drilling. The important thing is that nobody knows how the spacing ought to be when the first well is drilled. You can't tell whether the first well is on top of the structure, and has a maximum of everything, or whether it happened to be an edge well, and has more or less a minimum of everything.

And it seems entirely logical and fair to everybody concerned to have a sort of moratorium period during which you find out the facts which have to be found out in order to intelligently determine what the real permanent spacing ought to be. It is important during that period to have -- in which you are getting these facts -- there shouldn't be any steps taken which will cause the permanent spacing pattern to have to be spaced differently than it ought to be. In other words, if you have close spacing to start with, then you either are faced with numerous exceptions -- and those exceptions are hard to take care of -- and it may result in having a permanent spacing pattern that isn't economic and won't attract the capital that has to be invested in it. Whereas, if you start out with temporary wider spacing, you can always drop back to closer spacing if conditions warrant after you have determined what the factors are. And if the

horizon and the pool isn't as good as it has to be to have close spacing, then you are in position to have wider spacing, which should be the case on that type of pool.

Q As the man that handles the money, and handles the dollars and cents involved in this problem, would you say that the porposed temporary wider spacing would be advantagious to the State of New Mexico?

A I think it should. If the State of New Mexico is anxious to attract capital to develop its reserves, and to maintain the position which it currently has of having a progressive and well-regulated conservation program. That is a favorable factor, when you go to analyze these various things. And I think it would be a very good step to the state to maintain that position to advocate a temporary order of this nature.

Q Do you see any way that any possible harm -- I am talking about dollars and cents now -- could result to the State of New Mexico and its citizens by the adoption of this so-called temporary order?

A No, sir, I do not.

MR. FOSTER: I believe that is all.

COM. SPURRIER: Does anyone have a question of the witness?

MR. FOSTER: I would like to introduce these seven charts that we have identified here as part of the record.

COM. SPURRIER: Without objection, they will be admitted.

(Off the record)

COM. SPURRIER: If there are no further questions, the witness may be excused.

MR. FOSTER: Excused from the hearing? He wants to get back to Bartlesville.

COM. SPURRIER: That's right.

(Off the record)

COM. SPURRIER: We will recess until one o'clock.

(Noon recess)

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COM. SPURRIER: The meeting will come to order, please. Judge.

MR. FOSTER: I am going to make one more appearance. But Stanolind will take over.

COM. SPURRIER: Mr. Smith.

F. H. CALLAWAY

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. SMITH:

Q Will you state your name, please?

A F. H. Callaway.

Q By whom are you employed, Mr. Callaway?

A Stanolind Oil and Gas Company.

Q How long have you been so employed?

A Six-and-a-half years.

Q What was your educational background prior to employment with Stanolind?

A I received my technical education at the University of Arkansas and the University of Texas; received the degree in petroleum engineering from the University of Texas in 1946.

Q Do you have any other degrees?

A No, I do not.

Q Did you go to work for Stanolind right after you finished your academic training?

A Yes, sir.

Q What position do you occupy with Stanolind?

A I am presently employed as Reservoir Engineering Supervisor by Stanolind in their Tulsa office.

Q How long have you been engaged in reservoir work for Stanolind?

A Approximately six-and-a-half years.

Q Do you belong to any associations or organized groups for study on reservoir behavior or other types of technical background?

A Yes, sir, I am a member of the Petroleum Branch of the American Institute of Mine and Metallurgical Engineers.

Q Aren't you Chairman of some committee that made a study on the question of well spacing?

A I am Chairman of an API study committee, Mid-Continent District, engaged in the well-spacing problem at this time.

Q And have you attended the meetings of these various groups from time to time during membership in the Association?

A Yes, sir, I have.

Q Are you fully familiar with the so-called controversy that exists between the relative merits of wider and more narrow spacing?

A I have done considerable research in the matter.

Q Are you familiar with the transcript of the proceedings in the hearing involving well spacing as Case 407 on April 16, 1953?

A Yes, sir, I am.

Q Do you recall the statement by Mr. Tesch in the record which reads as follows: "It is generally accepted, regardless whether you are talking about 80-acre, 40-acre, or 20-acre, everything else being equal, that the more wells you drill the more oil that will be recovered from the reservoir."

A Yes, sir, I am familiar with that statement.

Q Do you agree that is a correct statement?

A No, I definitely do not. I believe most of the people that have carefully investigated the problem of well spacing and its relation to the amount of oil that can be recovered from a field are of the opposite opinion.

Q Do you personally concur in the concept the more wells drilled the more oil you recover?

A No, I do not.

Q I assume you are familiar with various argument advanced by various proponentsof differing theories?

A Yes, sir, I am.

Q I wonder if you would give us a brief review of the manner in which this controversy over proper spacing -- that is, whether we should have wider spacing or narrower spacing -- developed?

A Well, there has been a whole lot of water under the bridge in well spacing argument, and I certainly do not want to take the time of all you people to go into a lot of detail on the matter.

However, I do think it is well to point out the place where this well spacing originated, and how it has developed. I think it will throw considerable light on the merits of the various positions taken by the people who believe in close spacing as a means of increasing recovery, and the people who do not believe closer spacing is a method of conservation.

The first formal attention to the well-spacing problem was given in a report prepared by Willard W. Cutler of the Bureau of Mines in 1934. He was studying the decline characteristics of producing leases in a number of oil fields throughout the United States for the purpose of attempting

to compare variations in reserves through use of decline curves. It happened at that time it was necessary for the operator to estimate their oil reserves for the purpose of computation of federal income tax. In connection with this study, he observed -- other conditions being equal -- that under similar leases in the same field he observed the wells drilled on wider spacing recovered more oil than wells on close spacing.

On the other hand, he observed the reverse in regard to separate leases. He observed leases drilled on close spacing did recover more oil per acre than leases drilled on wide spacing.

As a result of this work, Mr. Cutler formulated what has come to be known as Cutler's Rule, which I would like to show as Exhibit 1.

Q As I recall, that was the first formal attention given to it, and is probably the basis for the different contentions that have grown up with regard to this recovery of oil.

A It is the starting point of this controversy on well spacing.

Q Do you have a statement of Cutler's Rule?

A Yes, sir, I do. I don't think we need to read it right now. Let's go on.

Q The Rule I think we might mark for identification

as Exhibit 1. And we have various of these smaller types of exhibits which we will offer to the attention of the Commission, which are duplicates of the ones on the board. The Rule is exhibited on the board?

A Yes, sir, and also on the small sheets.

Q Is there any controversy as to the reliability of the recovery data that was observed by Mr. Cutler?

A No, sir, there isn't. I think it is pretty well established in both advocates of close spacing as a means of increasing recovery and those that do not believe in close spacing as a means of increasing recovery. They all agree under the conditions which Mr. Cutler imposed upon his analysis that closely drilled leases will get more oil than widely spaced leases.

Q The conclusion he came to was correct, but the application of the Rule seems to be a difference of opinion?

A That is correct. The difference of opinion between so-called advocates of close spacing and so-called advocates of wide spacing lies in the interpretation of the facts observed by Mr. Cutler, and subsequently confirmed by other investigators.

Q I understand from your statement that two interpretations can be placed on Cutler's Rule, which lead to diametrically opposite opinions?

A Yes, sir, that is correct.

Q What are the different interpretations?

A I think it can be made plain if you very carefully read Cutler's Rule and remember the assumptions he made.

Cutler's Rule states "The ultimate production for wells, of equal size, in the same pool, where there is interference, seems approximately to vary directly as the square roots of the areas drained by the wells."

Mr. Cutler restricted comparison to leases of approximately the same pay thickness and the same initial productivity and wells in the same pool. Under the circumstances in which he had observed that the new wells drilled in the field did interfere with and reduce recovery from old wells already producing. He restricted it to solution gas-drive reservoirs, and, of course, applied it to production under no production restrictions; all wells produced essentially at capacity.

Q Do you have an exhibit that illustrates the proposition that you have just stated?

A Yes. I would like to show Exhibit 2, which is purely for illustrative purposes.

Exhibit No. 2 is a portion of the Healdton Field in Carter County, Oklahoma. This is the type of development with which Cutler was concerned when he developed his Rule.

You notice there is no well development pattern on this map. I have indicated in red the average well spacing in acres per well of the various leases. You notice it varies from as little as 1.67 acres per well on a certain lease up

to 4 or 5 acres per well on another lease.

Now, I would like to propose just for a moment and assume two of these leases in the Healdton Field here were developed on different spacing, but had approximately the same pay thickness and the wells were of the same quality, making the same number of barrels per day. It is established from facts that the lease on closer spacing will get greater recovery per acre. There are only two possible reasons for that.

One reason could be that the closely spaced lease did a better job of extracting the oil from the sand underneath it. That is, it had a higher recovery factor, in engineering terms. A larger portion of the oil in place was recovered. That is one possible explanation for the behavior Cutler observed.

The other possible explanation is that the lease on closer spacing benefited by migration of oil across lease lines from the wider spaced lease to the closely spaced lease. In fact, it is possible the increased recovery for the closely drilled lease might be due to the migration of oil across lease lines.

In that case, the widely spaced lease would have subnormal recovery because it would lose by migration of oil.

Q Do you have any specific illustration on Exhibit 2 to show how that operates, Mr. Callaway?

A Well, for instance here are two 30-acre leases.

N, here is a 30-acre lease, an offset to that lease which was drilled to 4.29 acres per well.

Q You mean that the closely spaced tract could have gotten more oil either by doing a better job of drilling the sands under the lease or by capturing oil from a neighboring lease on a wider spacing basis?

A Yes, sir. I could have been either reason, but there is no way to tell from the physical data itself.

Q Just how do these result in different conclusions regarding well spacing?

A Let's assume for a moment, as Cutler did, that no oil migrated across lease lines. That would mean that the closer spaced lease got greater recovery by virtue of doing a better job of extracting oil from the sand. You could then go in and drill other leases in the field to closer spacing and thereby increase their recovery, thereby increasing recovery in the field as a whole by drilling additional wells.

On the other hand, if the additional recovery had been due to migration across lease lines, the drilling of additional wells on wider spaced leases would simply re-allocate the available oil between leases and not result in increased recovery from the field as a whole.

The people that advocate close spacing have adopted the first attitude and those differing have adopted the second.

Q What is your opinion in this matter?

A In my opinion, the additional oil recovered by the closely spaced wells -- leases -- under the conditions which Cutler observed was due primarily to the migration of oil across lease lines.

Q Do you have any support for this opinion?

A Yes. I think that the conditions which Cutler assumed, and which other advocates of close spacing have similarly assumed in obtaining their factual data were such as to be ideal for the migration of oil. Remember Cutler restricted the Rule to the same field where there was an opportunity for migration to occur, and restricted it to cases where he had actually observed leases interfering with each other and were competing for a common source of supply of oil.

Q In other words, his observations have indicated to you definitely his Rule had no application unless there was a reduction in the productivity of the old wells as a result of drilling new additional wells?

A In my opinion, it appears inevitable under the circumstances which were used for developing data of this type that migration to the closely drilled tract at the expense of the widely spaced tract is inevitable.

Q You mean other factors being equal, the closely spaced tract is bound to benefit from that migration?

A That is correct. It would be true under any

circumstances unless you had an allowable, and restricted production per acre the same regardless of spacing.

Q Are there any physical facts to support the conclusion that such migration is inevitable?

A I would like to turn now to Exhibit 3. This is an hypothetical case involving two adjacent leases in the same field, which have been drilled to different well spacing, but on which we may assume for the moment the characteristics of the sand and the productivity of the wells are equal.

Now, assume 16 wells are drilled on Lease No. A, which gives a 2½ acre spacing. And only 8 wells drilled on Lease No. B, to give a five acre spacing. And put those two leases on production. If the productive capacity of the wells average 100 bbls per day, we can say Lease A will produce 1,600 bbls per day, and Lease B only produce 800 bbls per day. What that means is that the pressure on Lease A will decline more rapidly than the pressure on Lease B. Which after a short time will result in a situation in which Lease A will be at a lower pressure than Lease B. This must result inevitably in the migration of oil from Lease B to Lease A.

Q In your opinion, what is the significance of this migration insofar as it may have application to the so-called well spacing controversy?

A Well, what it means is that these combinations of leases of different spacing in the same field are of no real

value in tieing down this well spacing question.

You have two unknowns: the possible effect of spacing on the extraction efficiency of the oil, and the migration. There is no way to isolate these two factors to determine how much of the effect is due to which, from the various data which have been used.

Q It is your opinion that the comparable recovery from different leases in the same field is of little value either way in evaluating the effect of well density on the recovery that may be expected from two respective leases?

A Yes, sir, that is correct, it is for all practical purposes; it is useless.

Q Well, is this the type of data that is still being advanced largely in support of the proponents of more close spacing?

A Unfortunately it is. Most of the factual information which advocates of close spacing as a means of conservation have used and are still using today are examples of this type.

Q Then it does appear that a substantial part of the increased recovery may be attributed to this migration? You stated earlier, in your opinion, most of the increased oil from the densely drilled tract was migratory oil, is that right?

A Yes, sir, that is my opinion. I have undertaken

to calculate what the magnitude of migration would be in a field of this type, in which you had unequal well spacing, to see if it would be of sufficient magnitude to have caused the behavior which Cutler observed.

Q Have you any of the results of your calculations available by way of exhibit?

A Yes, sir, I do. I have several. I don't want to explain each one separately because of the time, but I would like to show Exhibits 4 to 10 at this time.

Q Suppose, Mr. Callaway, that you step over to the board here, and we will flip these through and you might give your explanation at that time.

A All right. I have brought here -- this is from theoretical calculations, now -- the calculated recovery per acre in thousands of barrels.

MR. FOSTER: I don't believe the Commission can see that chart.

MR. SMITH: They have a copy before them.

MR. FOSTER: I know, but they are interested in following him.

(Off the record)

A Plotted on the vertical scale is the recovery per acre in thousands of barrels per acre. Plotted against one divided by the square root of the acres per well on the lease concerned. I plotted this thing this way so that Cutler's

Rule could be plotted as a straight line, which is a dash line on this curve.

Assuming we had a segment of a reservoir, as outlined here, and the center lease had 4 wells, and the eight surrounding tracts had one well, and those wells were of equal productivity, and were operned up for capacity production at the same time. We would find that the recovery per acre from the tracts drilled on wide spacing would be approximately 3,200 bbls per acre. On the closely drilled tract in the center the recovery per acre calculates about 9,700 bbls per acre.

Now, you notice that the lines connecting these two points is actually steeper in slope than under Cutler's Rule. Which means under these circumstances the degree of the migration would cause a larger degree of recovery.

This next exhibit, which I believe is Exhibit 5, is a similar type of data except we had two wells drilled on the center tract instead of one. Once again the variation in recovery with spacing due to migration alone is greater than that observed by Cutler.

The same thing is shown by these other exhibits, which I won't comment on except to show them to you. They have a little different geometrical configuration in each case, but the plot gives the same type of results in each instance.

Q These all show support for the proposition that

the migration of oil would account for the phenomenon observed by Cutler upon which he based his proposition you get more oil per acre.

A Yes, sir, that is correct.

The results of these calculations are summarized on the next exhibit. I don't have a large chart for this, unfortunately. But I do have a small sheet you can have; Exhibit No. 10. It summarizes the results shown on the six charts which I have just gone over.

You notice on the next to the last line is the recovery ration of closely spaced leases next to wider spaced leases as actually calculated due to migration.

The last line represents the recovery ratio which Cutler would have predicted by his rule.

In each case the difference in recovery between the wider and closer spaced leases as calculated due to migration was as great or greater than that observed by Cutler.

Q Now assuming that these recovery comparisons of different leases in the same field are of little use in tieing down the density problem, what can be done to evaluate the effect of well spacing on recovery.

A Well, the ideal way, of course, would be to take an oil field, drill it up, and produce it on one spacing, and then, by some magic, restore it to initial conditions, and drill on another spacing and produce it again, and see

how much you get in recovery. Of course, it is impossible to do this. If we could find two fields which were essentially identical in all other respects, but which had been developed on different spacing, and depleted those fields and compared their recoveries, we would have a sound and valid answer to the effect of well spacing on recovery. That would be true, of course, because oil could not migrate between separate fields. It is a tough job, however, to find two oil fields which are identical, but which have been drilled on two different spacings. And I personally know of no conclusive examples of this type which have been developed so far.

There has been some rather thorough work done from a statistical standpoint by an API committee. In this API study the recovery factor for a large number of fields was correlated with their well spacing to see if any general trend existed in favor of the closely drilled fields.

The work of this Committee was reported in a technical paper which was printed in the API Drilling and Production Practices for 1945. It was entitled "A Factual Analysis of the Effect of Well Spacing on Oil Recovery", and was authored by R. C. Craze and S. E. Buckley. This work reflected no apparent variation in the recovery efficiency with well spacing. That is, there was no variation observed which was of sufficient magnitude to be noted in the statistical work done by this Committee.

The analysis which this Committee did in regard to water drive fields was particularly convincing since a very large number of fields were used for making the study.

Q Now, is there an exhibit that reflects the findings of that Committee?

A Yes, we have Exhibit No. 11.

Q Which is the one now exhibited on the board?

A Yes, sir, that is the one now exhibited on the board. Plotted on the vertical scale is the estimated oil which will remain in the rock after a field is depleted. On the horizontal scale is the average well spacing for the field involved. You will note there is no apparent trend which would indicate that the closely spaced fields did a better job of getting the oil.

Q Have other authors or students of this subject gone into the matter from any different standpoint?

A Yes, there has been a considerable of effort expended in attempting to evaluate the effect of spacing on recovery from theoretical considerations. This matter has been investigated by Barlow and Berwald, and reported in the API Drilling and Production Practices for 1945; by Loper and Calhoun, as reported at the 1948 meeting of the Petroleum Branch, AIME; by Miller, Browscombe and Kieschnick, which was published in the AIME Transactions for 1950 -- for 1949; by Dr. S. J. Pierson in his textbook "Elements of Oil Reservoir Engineering";

and by Keller and Callaway, as reported in the AIME Transactions for 1950.

Q You are the Callaway that is the author of that particular paper, is that right?

A Yes, sir, that is correct.

Q Now, all of this work was confined to depletion type reservoirs, wasn't it?

A Yes, sir, that is correct.

Q What was the reason for that?

A The reason that the theoretical work has been confined to the depletion drive reservoir is the fact that it is obvious from the physical factors at work that the answer on a water drive field would be no variation in recovery with well spacing.

Q Quite a bit of work on that has been done by Mr. Buckley, hasn't it?

A Yes, sir, there has.

Q I believe he is here today.

A Yes, sir, he is.

Q What were the results of these various depletion type reservoir studies?

A All these calculations -- which, incidentally, are each approached from a little bit different angle -- they all resulted in the conclusion that the recovery of oil should not be appreciably influenced by well spacing. The calculations

show a very slightly larger recovery of oil on closer spacing. However, the increase is so small as to be of no real practical significance.

Q I understand you were one of the engineers to investigate this matter. Are you in a position to show some of the results of the work?

A I will be glad to do that. The technical basis for the calculations themselves is extremely complex, and I certainly don't want to bother you with that at this time. I would like to show you the results of some of these calculations, and attempt to explain in quantative terms the reasons we get the answers we do.

With the depletion type oil field, the oil is driven from the pores of the rock and replaced by gas, which is released from solution. This causes the pressure to decline and more gas is released from the oil until the pressure falls to a low value, and the wells will no longer produce at commercial rates. The oil production is directly related to pressure decline, and the lower the abandonment is -- at the time the wells are abandoned -- the higher will be the recovery factor, other factors being equal. But the depletion drive mechanism for -- recovery is usually only a small fraction of the oil in the rock by this method, usually on the order of 10 to 30 per cent. At the time the wells must be abandoned, the pressure throughout the reservoir is generally low. However, it will be slightly lower near the well bores than it

will be out in the area between the wells. This means that the recovery will be slightly better near the wells than it will be out in the central area, and that is the reason for the slight increase in recovery with close spacing.

Q Do you have an exhibit which represents this pressure and oil saturation when a field is abandoned?

A Yes, sir, I have two or three exhibits which will show how that works.

Exhibit 12 shows the calculated distribution of pressure and unrecovered oil at the time the field is abandoned as a function of the distance from the well bore. You can see that the pressure is somewhat lower close to the well than out 6 or 7 hundred feet away; and also the unrecovered oil is slightly lower near the well bore than at a distance.

Q Do you have a sketch to portray the alteration in underground conditions which results from the drilling of an extra well between two producers; that is, an infill well?

A Yes, sir, I have such an exhibit; Exhibit 13.

Q Will you explain this exhibit, please?

A This exhibit is simply a diagrammatic sketch to show you where extra oil comes from when you drill on closer spacing. Assume that the field were drilled and depleted with only wells on the extreme left and right. The remaining oil underground at the time the field must be abandoned is represented by the solid curve. If an additional well had been

drilled between the wells on 80-acre spacing, as indicated by the dotted well in the center, the conditions in the reservoir at the time the wells must be abandoned would be represented by the dotted curve, which falls slightly below the other curve in the center. The hachured area represents the additional oil which would be recovered by the infill well, which could not have been recovered by the wells spaced on 80 acres.

Q Do you have an additional exhibit reflecting the comparison of recoveries to be expected if a denser drilling is followed?

A Yes, sir. If you convert the type of curve which I have just shown you to its significance in terms of recovery, you have the results shown on the next Exhibit No. 14. On the vertical scale is plotted the recovery efficiency, per cent of oil in place. On the horizontal scale, the well spacing.

I would like to point out on these exhibits that they are peculiar to only one particular set of reservoir conditions. If you worked the same calculations on a different field, you would get answers of a different magnitude, but still have the same relative relation between close and wide spacing.

You note from Exhibit 14 that the recovery factor would figure out in this field at 16.45 per cent on 40-acre spacing; about 16.3 per cent on 80-acre spacing. Assuming this figure

would make 5,000 bbls per acre on 40 acre spacing, the recovery on 80-acre spacing would be 4,950 bbls per acre. The additional oil recovered by the second well on an acre -- an 80 acre tract would be about 4,000 bbls.

Q Now, do you have an additional exhibit reflecting the calculations for the Fowler Field in New Mexico?

A Yes, sir. Exhibit 15 is a bar graph which shows results of similar calculations on the Fowler Field in New Mexico. I think this chart has previously been placed before the Commission in a hearing on Fowler.

Q These also were theoretical calculations?

A Yes, sir.

Q Now, just what assumptions were made? How do these assumptions affect the reasonableness of the answers you have obtained?

A It is necessary to make assumptions in any calculations on reservoir behavior and mechanics. The only critical assumption it is necessary to make is that the reservoir is continuous throughout. One continuous and common source of supply of fluids and drainage through all parts of the reservoir to the wells which have been drilled.

Q What about the existence of lenticularity in the producing zone.

A It is obvious if you have isolated segments of the reservoir due to lenses or faulting conditions which are not

in communication and cannot be drained by the wells on the existing spacing pattern, that closer spacing then would tap these previously untouched zones and increase recovery of oil. However, the amount of increased oil which you would get would depend on the number and size of the lenses which you would happen to tap.

Q That is a condition which could be detected as a field is developed?

A Yes, sir, that is correct. In my opinion, the effect of well spacing on recovery would be very small unless this type of condition exists. It is possible by means of cores and the proper type of engineering and geologic data during the process of developing a field to obtain fairly conclusive evidence as to the presence or absence of lenticularity conditions in the reservoir.

Q In studying a reservoir as the field is developed, it is possible to determine whether or not there is freedom of communication throughout a given oil pool?

A Yes, that is correct. I think the Commission probably is familiar with engineering information of this type from previous hearings. I would like to show a few examples of the type of data which can be obtained to determine whether or not we have communication throughout a reservoir.

Q These are some results of physical studies?

A These are results of physical studies.

Q They support theoretical assumptions made in your earlier testimony?

A Yes, sir.

Q Do you have one -- an exhibit showing the results of physical tests in the Fowler Field?

A Yes, sir. Exhibit 16.

Q All right. Will you please explain this exhibit?

A This exhibits reflects the pressure behavior of a well in the Fowler Field which was shutin for a period of approximately 500 days while other wells in the field were being produced. You will note that the pressure on the shut-in well declined continuously during the period in which it wasn't being produced. This means that the oil underneath the shutin well was being drained upon by the offset wells. The nearest one of which was about 1,867 ft., a diagonal 80-acre location.

Q During this period of time that the well was shutin additional wells were being drilled in the field?

A That is correct.

Q And what was the observation with regard to the bottomhole pressures of these additional wells being drilled, as compared with the pressure in the key well?

A The pressure on all wells, including the new wells and the shutin well and the wells being produced, went right along together; declined at the same rate.

Q Now, do you have a similar exhibit for the Anton-Irish Field?

A Yes, sir. Exhibit 17 is the results of a similar interference test on the Anton-Irish Field. Just another example of the type data you can get. I don't think it needs any further comment.

Q Those dots indicate the points in time when various tests were taken?

A Each dot represents a separate pressure determination on that well.

Q Do you have an exhibit for the Goldsmith Field?

A Yes, sir. Exhibit 18.

Q Goldsmith is the next one.

A Did you say Slaughter?

Q I said Slaughter, I meant Goldsmith.

A Yes, sir.

Q Will you explain the significance of the curve reflected upon the exhibit for the Goldsmith Field?

A The solid curve represents the field average pressure in the Slaughter Field for the period 1935 --

Q Goldsmith Field, you mean?

A Goldsmith, excuse me.

Q I got you off on the wrong track to start with here.

A From 1935 to 1946. The circles represent the pressures upon completion of infill wells or field extensions

drilled subsequently.

You will note the pressure on all of the wells drilled at a later date was substantially below the initial pressure, and the same order of magnitude as the field average pressure; which means that the undrilled locations had been draining prior to the time those additional wells were drilled.

Q Do you have an exhibit reflecting the gas-oil ratios of the infill wells drilled in the Slaughter Field as compared with the wells that had been drilled earlier?

A Yes, sir, I have Exhibit 19 for pressure data on the Slaughter Field rather than gas-oil ratios.

This represents a portion of the Slaughter Field in Texas. The circled wells are infill wells which were drilled in 1948. The un-circled wells are wells which were drilled in 1941. Above each of them is tabulated the pressure on that well during 1948.

You will note that the initial pressure in this reservoir was 1771 lbs. The average pressure of the old wells in 1948 was 1,332 lbs. The average pressure upon completion of the new wells in 1948 was 1,313 lbs. This shows that the reservoir tapped by the new wells was being depleted by the old wells at the same rate as the locations immediately around those old wells.

Exhibit 20 is a comparison of gas-oil ratio data on the same field, the Slaughter Field. Here again, the gas-oil

ratios of the old wells drilled in 1941 are compared to the gas-oil ratios of the new wells at the time they were completed. The solution gas-oil ratio in the Slaughter Field was 470 cubic feet per barrel. And that was approximately the initial producing ratio of the wells drilled in 1941. In 1948 the average ratio of the new wells upon completion was 1,228 cu. ft. per barrel. The average gas-oil ratio of the old wells at the same time was 1,229 cu. ft. per barrel.

Since the pressure and the gas-oil ratios are both related to the amount of oil which has been produced from the locations in a depletion-type reservoir, this data shows that the entire area was being drained uniformly by the original wells on the wider spacing.

Q I assume you have chosen certain fields by way of illustration, and I assume you know also of many other fields where the same facts have been developed to support the theoretical assumptions you have testified to earlier?

A Yes, sir. That is correct. I have had access through my own company, and other sources too, to a large amount of data of the type just shown. My observation has been that almost always the data indicate good communication throughout most of our oil fields. The assumptions which I have put on today are simply to illustrate the type of data which can be gathered to prove this point.

Q The information you have cited up to now has applied

to gas-drive fields. What can be done to establish continuity of communication in water-drive fields?

A Well, the establishment of communication in water-drive fields is no problem at all. If you have a water drive, you automatically know you have communication. In a water drive most of the oil produced is replaced by edge water encroachment, which means oil must migrate over long distances throughout the reservoir. So, if you observe the field has water drive from performance characteristics, you know it is -- you know there is sufficient communication.

Q Mr. Callaway, in view of the testimony you have given and your research as indicated by your testimony, I would like to have you say whether or not you consider yourself to be an advocate of wide spacing?

A No, I am not necessarily an advocate of wide spacing. The question of proper well spacing is one which depends upon the circumstances peculiar to the individual field at hand. In the absence of lenticular conditions, which in my experience is the exception rather than the rule, the problem is one of economics and the protection of correlative rights. Certainly a reasonable number of wells must be drilled in every oil field. Enough wells must be drilled to allow the field to be developed and depleted at a reasonable rate, to obtain adequate sub-surface information to determine the proper production methods, and to evaulate the field, and to

protect the correlative rights of the various property owners in the field. I do not believe in general fields should be drilled on close spacing for the purpose of getting greater oil recovery or in the expectation of getting greater oil recovery.

Q Do you have any general opinions as to the proper approach to the well density problem in oil fields?

A Well, it appears to me it is simply good business to drill a field at first on fairly wide spacing insofar as is compatible with ownership and other practical considerations; to obtain some idea as to the extent and quality of the field and accumulate engineering information which will evaluate the need for additional drilling. Infill wells can then be drilled as necessary or desirable.

MR. SMITH: At this time I should like to offer in evidence all the exhibits that have been previously identified by Mr. Callaway.

COM. SPURRIER: Without objection, they will be admitted.

MR. SMITH: I have no further questions of this witness.

COM. SPURRIER: Does anyone have a question of the witness? If not, the witness may be excused.

(Witness excused.)

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MR. MADOLE: If the Commission please, we offer this -- Ross Madole, on behalf of the Magnolia Petroleum Company -- we offer this witness in rebuttal to the impression that was given by Mr. Tesch in his testimony that the Bureau of Mines study of the Healdton Field was an illustration of his theory of more well, more oil. And we wish to introduce evidence to rebut that impression.

BYRON O. SIMMS, JR.

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. MADOLE:

Q Mr. Simms, state your full name, please.

A Byron O. Simms, Jr.

Q By whom are you employed?

A Magnolia Petroleum Company

Q What professional degree do you hold?

A I have the BS degree in petroleum engineering from the University of Texas.

Q In what year were you graduated?

A 1949.

Q Since that time have you been employed as a petroleum engineer?

A That is correct. By Magnolia.

Q At this time you are located in the Healdton Field?

A That is true.

Q How long have you been in that location?

A I have been at Healdton three years, now.

Q Since you graduated you have been in the employment of Magnolia?

A Yes, sir, that is correct.

Q You had occasion to make a study of the Healdton Field?

A That is true.

Q Have you previously qualified as a witness in New Mexico before the Oil Conservation Commission?

A No, I haven't.

MR. MADOLE: Do you think any further qualifications are needed?

(No audible response from the Commission.)

Q Will you state the occasion of the study made by the Bureau of Mines in the Healdton field in Carter County, Oklahoma?

A The Bureau of Mines made a study of the Healdton Field, and it was a petroleum enginering study of the field to determine and evaluate the potentialities of water flooding of the field.

Q In other words, the primary function of the study was as to whether or not it lent itself to secondary recovery by water flooding?

A That is correct.

Q Will you turn to page 44 of this report, and give the Commission the results of that study?

A The result of their -- they investigated infill drilling a littlebit. This is aside from the water flooding part. The conclusions they reach, and I will read from the report.

"Twenty million barrels of oil over and above that expected by normal production methods was produced as the result of additional drilling, deepening, clean outs, vacuum applications, and gas injection."

And a little farther down they say, "Also 440 new wells have been drilled in the Healdton oil field during the last 25 years. It is interesting to note that at no time since 1920 has the number of producing wells equaled the number of wells" -- 1,971 wells -- "producing at that time; the number of wells abandoned exceeded the number of new wells completed; and in 1950 the number of producing wells was 95 less than in 1920."

I might add here this 20,000,000 bbls which was accumulated from all these factors, such as additional drilling, deepening, vacuum application, and other methods, amounts to a little less than ten per cent of the total recovery from that field to date. And of this other ten per cent, your infill drilling is an insignificant portion of that.

MR. MADOLE: We offer in the evidence the full

report of the petroleum study committee of the Bureau of Mines on the Healdton Field.

We have no further questions.

COM. SPURRIER: Are there any questions of the witness? If not, the witness may be excused.

(Witness excused)

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MR. MADDOX: Will the exhibit be received?

COM. SPURRIER: The exhibit, without objection, will be received.

(Recess)

E. N. WASHBURN

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. FOSTER:

Q State your name to the Commission, please.

A E. N. Washburn.

Q You are employed by Phillips Petroleum Company?

A Yes, sir.

Q As an engineer?

A Yes, sir.

Q You have testified before the Commission here before and stated your qualifications, have you not?

A Yes, sir.

MR. FOSTER: Are they accepted?

COM. SPURRIER: Yes, sir.

Q Mr. Washburn, at a former hearing of this matter, which is now under consideration, testimony was placed in the record to the effect that the matter of the spacing of wells in newly discovered fields should be left to the agreement of the operators in the field. And at that time one member of the Commission here asked the question as to how the pattern of 80 acres got started in those fields. Have you made an investigation for the purpose of determining how that happened?

A Yes, sir.

Q Will you just tell the Commission how it happened.

A There are four fields considered as having 80-acre spacing now: the Fowler Field, which started from a federal unit; the Knowles Pool, and the Hightower,,and Cross-roads. The latter three fields, one operator owns the larger part of the field, and for that reason it was easier or simpler to get approval from the Commission for 80-acre spacing.

Q But the 80-acre pattern was set before the operators came in and asked for the establishment of the 80-acre pattern?

A That's right.

Q But that pattern was set because the operators in those fields where they drilled the discovery well controlled

most of the acreage?

A Yes, sir.

Q In two of them, I believe, one operator controlled all the acreage?

A That is my understanding.

Q What operator was it and what field?

A Amerada in the Knowles and Hightower, I understand.

Q In what field was all the land federally owned?

A That was Fowler.

Q And who owned the majority of the acreage in that field?

A I am not familiar with that.

Q You don't know?

A No, sir.

Q Now, at the former hearing of this case there was testimony placed in the record here to the effect that the Commission should deny the establishment of this temporary 80-acre order for the reason that 80 acres was too much of a step out, and that it would result in the drilling of more dry holes if you went to 80 acres than it would if you stayed on the 40-acre pattern. That was expressed as an opinion, I believe, without any facts given to support it. Now, I will ask you if you made any investigation of the fields in this state that are drilled to a depth below 10,000 ft?

A With respect to 80-acre spacing?

Q Yes, sir.

Q Yes, sir, we did.

Q How many fields in this state are producing below 10,000 ft?

A We found 19 fields.

Q Nineteen fields. And did you make an examination of each of those 19 fields to determine whether or not there would have been any more dry holes drilled in those 19 fields if they had been drilled on 80-acre spacing than there would have drilling them on 40-acre spacing?

A Yes, sir.

Q What did you find out?

A We found in 18 of the 19 fields 80-acre spacing would not have contributed to more dry holes than regular 40-acre spacing. The one exception was the Hightower Field where we found four dry holes, and it was drilled on 80 acres. But you can't be definitely sure if it had been on 40 it might not have had dry holes, too.

Q Might havehad the same dry holes on 40 if -- as they had on 80?

A That's right.

Q Is that correct?

A Yes, sir.

MR. FOSTER: That is all.

COM. SPURRIER: Anyone have a question of the witness? If not, the witness may be excused.

(Witness excused)

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MR. SHAVER: Charlie Shaver, representing Humble Oil and Refining Company.

At this time we would like to call Mr. S. E. Buckley. He was referred to in the April 16th hearing by Mr. Tesch and J. K. Smith, and we would like to present some testimony.

S. E. BUCKLEY

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. SHAVER:

Q Will you please state your name, and in what capacity you are employed?

A My name is Stuart E. Buckley. I am employed as head of the Production Research Division of Humble Oil and Refining Company.

Q Mr. Buckley, will you state briefly your formal educational qualifications?

A I graduated from the University of Texas in 1932 with a BS and MS degree in chemical engineering.

Q Mr. Buckley, for the benefit of the Commission since you haven't testified here before -- that is correct, isn't it?

A That is correct, I have never testified here.

Q Would you summarize for the Commission what activities you have participated in for the past 19 years, in a general way, to inform yourself as to the efficient recovery of oil and gas and related matters?

A The past 19 years has been in the Production Research Division of Humble Oil and Refining Company; for a number of years as research engineer; for the past 11 years as head of that division.

One of the main objectives of that research is to study different methods by which we may increase the efficiency of underground recovery. That is our chief objective. Studies of that sort have included, naturally, a study of the effect of well spacing on recovery as well as all other factors that influence recovery. That research has been the main objective of the Research Division ever since I have been in it.

My work in that capacity has included study not only of the fields in which Humble operates, but I have had access at the same time to data from many other oil fields throughout the world.

Q Mr. Buckley, would you please state what your understanding of the problem before the Commission in this Case 407 is?

A My understanding, Mr. Shaver, is that there are really two issues before the Commission. One is a proposed

rule which would permit temporary employment of 80-acre spacing during the development of a new pool. The principal purpose of allowing it is to determine the proper geologic and engineering data on which to arrive at a sound spacing for each individual pool, after a hearing is held for that purpose.

I understand that the Commission is concerned with a second question, the question of well spacing in general, and its effects on ultimate recovery. The second, not insofar as it bears directly on the first, but being obviously a related topic.

Q Now, Mr. Buckley, would you please state your views on the proposed rule? You have studied this rule, haven't you?

A I have, sir. I have for many years subscribed to the view that the proper development of new pools would entail the employment of the widest feasible spacing during the early development for the purpose of permitting the operators to determine the nature of the structure and the underground geology and the other factors that would influence the ultimate recovery, with the further objective of permitting a determination of what type recovery mechanism is most apt to be operative. Such a procedure would permit, early in the life of a pool, a proper determination of the method that would be most effective in bringing about the recovery,

and at the same time the spacing and location of wells that in relation to the type recovery would best suit the purpose. It would, therefore, seem perfectly logical to employ wide spacing during the early development to permit this determination early, with a minimum expenditure; and in the light of those facts to set the proper spacing for the pool after the facts are known.

Q You would say, in your opinion, the adoption of this rule would be a forward step in conservation?

A I think it would not only be technically forward from an engineering standpoint, but very definitely serve the public interest from the standpoint of conservation.

Q You mentioned a second question awhile ago. What have you found out on the question of the relationship, if any, between well spacing and ultimate recovery?

A The question of well spacing and its effect on ultimate recovery, as you have probably gathered from the earlier testimony, is quite technically involved. I think it would be impossible to do complete justice to it in a very short time.

What I would attempt to do, if it meets your pleasure, is give a brief digest of what the essence amounts to. I might state first the fundamental facts generally recognized, and so far as I know not controverted, which underlie the basic principles of the recovery of oil. And I think we

might then be able to see the effect of well spacing in its more proper light.

In the first place, oil is inherently incapable of expelling itself from the pores of rock. It has to be ejected by a displacement agent like gas or water, and it has to b e acted on by an explodable force. The only forces are pressure and gravity. It is in combination by displacement by gas and water and the proper use of these forces we are able to recover -- influence recovery -- of oil either efficiently or inefficiently.

Secondly, the effectiveness of theseagents differ; gas, in general, being less effective than water.

Thirdly, the efficiency of recovery requires we use these displacements in the most effective possible manner. That is, if displacing with gas, we want to control the displacement throughout the entire extent of the pool in such fashion as to maximize it. If using water, the same thing is true in principle, but the mechanics are somewhat different because of the difference in behavior of gas and water.

So far as I know these basic facts are not controverted. They are generally and universally recognized as underlying the behavior of oil and gas reservoirs by all that have studied that subject.

In logical sequence, when we recognize these facts, the questions of wells comes next. The wells really serve two main pruposes:

First, they are the focal points through which oil escapes from the reservoir, and

Second, provide the observation points through which are obtained the geologic and engineering data which permit us to determine the nature of a reservoir and how to develop it.

During the development of a new pool it is the observations we are able to make through a well that are, in my opinion, at that time the more important.

Based on my research and that of my associates and others whose work I have studied who have also studied the behavior of oil and gas fields, when we take into account the various characteristics we see the recovery depends on a number of factors.

On the one hand are the inherent characteristics, geology and structure and character of formation and character of the contained fluids. Those, in general, are beyond the control of the operator.

In the second place, there are those factors the operator can control. For example, avoidance of the waste of gas, and the control of the rate of production, and to a substantial extent, control of fluid movements; that is, of water through a reservoir.

Now, when trying to get the utmost in recovery from a reservoir, it is obviously through control of these controllable factors we can bring that effect about. When we properly con-

trol these factors -- those are the things that are important, rather than the mere number of wells we happen to have drilled into the reservoir. The wells exert an influence only insofar as they can effect the efficiency of the displacement process; that is, if they can be used to control movements of gas and water through a reservoir. Because it is those movements and displacements that go with them that in the long run determine that the ultimate recovery will be high or low.

Q Now, Mr. Buckley, what you have said here on this question of well spacing has been rather technical. Could you kind of summarize what you have said in less technical terms for the Commission?

A I think so. In effect, I think the whole question might be summarized as follows: In any reservoir we must drill a minimum number of wells, core them, log them or otherwise test them to determine (a) the extent of a reservoir and (b) its characteristics, and all the properties of the oil and gas.

The second point: an adequate number of wells must be located in the proper structural positions to provide for thorough flushing by water or by gas. Now, we should recognize that the structural positions are different for different type reservoirs. If it be a water-drive reservoir, proper structural location of wells, in general, would be

different from that of a reservoir in which the primary displacement agent would be gas.

The third point: the total number of wells and proper structural locations obviously must be adequate to permit the desired total rate of withdrawal from the reservoir without cuasing local unfavorable conditions through excessive rates of production from an individual well.

Now, those are requirements. How many wells do we need as a minimum to properly determine information on the reservoir, to properly develop it, and to set the ground work through which we can efficiently recover the oil. After we have met these requirements, the mere drilling of additional wells would, in my opinion, serve no useful purpose. It would have no material effect on ultimate recovery, and obviously constitute economic waste.

Q Mr. Buckley, you have made these statements, now. Can you advise the Commission as to whether or not other technical people share your views on well spacing?

A I have stated these as my personal convictions, but I am quite convinced these opinions are concurred in by an overwhelming majority of those who have made technical studies of the recovery of oil.

Q Who are some of these people?

A For example, The Special Study Committee on Well Spacing and Allocation of Production of the American Petroleum Institute. That Committee was active in its studies from 1933

until 1950. They have published various reports I would like to refer to in a moment.

Other groups that have studied this question and whose views, in general, I think substantiate my own are the Engineering Committee of the Interstate Oil Compact Commission. One such Committee made a report in 1941. Another report was issued in booklet form in the year 1951.

I think the views are also fully supported by a more recent report of the Research and Coordinating Committee of the Interstate Oil Compact Commission.

In substance, I don't think there is any real disagreement on the technical points in the great majority of those that have studied the question in the last 10 to 15 years.

Q You referred to several committees and reports there. Let's go back a little bit and tell the Commission what is this API report of 1941 you referred to a moment ago.

A The API had for many years a Special Study Committee on Well Spacing and Allocation of Production. Since well spacing was obviously related to allocation, the Committee studied all aspects of well spacing and allocation and the protection of correlative rights, and the effects of well spacing on ultimate recovery. Their views were summarized in a progress report published in '42 entitled "Standards of Allocation of Oil Production Within Pools and Among Pools."

I think this Committee recognized, as I do, the various factors that do influence recovery of oil, including the proper structural location of wells. If I may quote from that report on page 27, and I quote,

" ..... careful studies of the theoretical and practical aspects of well spacing indicate that, under the efficient operating methods made possible by (among other things) restricted production rates, ultimate recovery is in many cases substantially independent of the number of wells."

Q Now, Mr. Buckley, you have also referred to a report of the Engineering Committee of the Interstate Oil Compact Commission of 1941. Would you tell the Commission what that report is?

A That was a report submitted by the Engineering Committee of the Compact Commission at its meeting in New Orleans, La. in April, April 14, 1941. That was a brief report containing, in effect, a number of conclusions arrived at after a study of those factors that influence the ultimate recovery of oil, including the effects of well spacing. That report was issued as a part of the booklet containing the report mentioned before of the API Special Study Committee on Well Spacing. If I may quote from that report to illustrate the views of the Engineering Committee of the Compact Commission their Conclusion No. 21, which reads as follows,

"Well spacing is a controversial matter but the trend

of best considered thought seems to be that from a strictly physical viewpoint, recovery does not depend materially upon well density and that the problem is largely one of economics. This is the belief of your committee and it approves of the tendencies toward increasingly wider spacing which are being shown by the various state regulatory bodies."

That is particularly pertinent to the proposed rule before the Commission.

Their Conclusion No. 22. Remember these are conclusions arrived at in 1941. I quote:

"Your Committee urges that the various regulatory bodies prevent the development of new pools on a pattern of close spacing. Once pools have been drilled with close spacing, the capital invested in unnecessary wells and the limitation of minimum per well allowables established in some states exerts an unfavorable pressure upon the mechanics of proration and in many cases forces field production to a higher rate than should be permitted under good conservation practice."

Q Now, Mr. Buckley, has the API Well Spacing Committee you refer to compiled any recent information since 1941?

A The Well Spacing Committee has continued to be active, as I mentioned before, up until 1950. During the '40's, recognizing that the information they had developed as to the theory of fluid mechanics, laboratory experiments and research in general all pointed toward the conclusion

that additional wells beyond the required minimum do not increase recovery of oil, they, nevertheless, recognized that some people believed that there were very little evidences to the contrary; and so, they undertook to make as exhaustive a study of field evidence as was possible to see whether their views were supported in fact or not supported by such field evidence.

Sc they compiled data on some 100 odd oil reservoirs in the United States as to their ultimate recovery and physical characteristics, and the geology and the nature of the contained fluids. And those data were studied in detail, and published in a separate paper by Mr. R. C. Craze and me in 1945. That paper and the data have previously been referred to by Mr. Callaway this afternoon. In summary, that data showed that although the effects of factors such as oil viscosity and oil pressure decline and other things, the effects of all those factors could be clearly seen in these data, but there was no indication of any effect of well spacing itself on ultimate recovery.

These figures varied from a low in spacing of 2.5 or 6 acres per well to a maximum of from 65 to 66 acres per well.

Q Mr. Buckley, In the April 16th hearing Mr. Tesch referred to Dr. Tomlinsom and his theory. I would like you to tell the Commission whether Dr. Tomlinson has expressed himself in regard to the API study you have just discussed.

A Dr. C.W. Tomlinson of Ardmore, Oklahoma, has expressed himself quite a few times as to this paper. Mr.Tomlinson undertook some four years after the paper was published to make an analysis of the data, and he arrived at a different conclusion. He reached the conclusion by his method of interpretation, using part of the data, not all of it. And it was by using a peculiar method of averaging that he was able to interpret these data to support his view that more wells do recover more oil.

I think his points were answered particularly and in some detail by Dr. W. V. Vietti, Chairman of the API Well Spacing Committee in a discussion before the Petroleum Branch of the American Institute of Mining and Metallurgical Engineering in San Antonio, Texas in 1949.

Also, in view of the questions raised by Dr.Tomlinson, the API Well Spacing Committee itself undertook a further review of the data and Dr. Tomlinson's interpretation of it and that made by Mr. Craxe and myself.

In a meeting of September 15, 1949, in Dallas, Texas that group issued a statement which I would like to read an excerpt from, if I may.

Q Please.

Q And I quote from minutes of the meeting of the Well Spacing Committee of the API Held in Dallas, Texas, September 15, 1949.

"This Committee has carefully reviewed the method employed by Dr. Tomlinson in his interpretation of the data assembled by the Committee as well as the basis of his conclusions. It was the unanimous conclusion of those members present at the meeting of the Well Spacing Committee in Dallas, Texas, on September 15, 1949, that Dr. Tomlinson's utilization of only a selected portion of the data and method of interpretation was technically faulty, resulting in serious distortion of the facts, and that his conclusions could not be supported from the data in question."

Q Mr. Buckley, I would like to introduce that as Humble Oil and Refining Company's Exhibit 1 at this time.

A For the purpose of the record, I would like to point out at this time the exhibit itself is an excerpt from the minutes rather than a transcript of the entire proceedings.

MR. SHAVER: Will you receive that?

COM. SPURRIER: Without objection, it will be admitted.

Q Mr. Buckley, are you familiar with the fact that the Research and Coordinating Committee of the Interstate Oil Compact Commission has recently reviewed the whole question of well spacing, including your work and that of Dr. Tomlinson?

A I am familiar with the fact that the Research and Coordinating Committee of the Interstate Oil Compact Commission

has recently reviewed the whole question, including the paper I mentioned previously, Dr. Tomlinson's interpretation thereof, and a number of other works by other authors.

Q What did this Committee have to say about your work and that of Dr. Tomlinson's comments on it?

A This Committee, after its study, issued a report that was adopted at the Fort Worth meeting of the Compact Commission in September 1951. And if I may read from that report, and I quote, on page 47 appears the statement,

" The Craze and Buckley approach to the spacing problem was strictly one of analysis of statistical data. * * * In the present study it is concluded that the work is comprehensive, thorough, and dependable as possible through statistical analysis."

With reference to Dr. Tomlinson's interpretation of these data, the Committee recognized, as did Mr. Craze and I, that there were certain limitations of the statistical approach. These limitations, I might point out, had been cited by Mr. Tomlinson in criticism. The Committee pointed out, "If the question is justified, then Tomlinson's own analyses of the date loses its value * *".

The Committee went on further to state, and I quote on page 50, "We find nothing in this latest report to support Tomlinson's advocacy of close well spacing."

Of this latest report, they had reference to a statement made by Dr. Tomlinson before this Engineering Committee in

which he included not only his views as to the date Mr. Craze and I had published, but at the same time, his views on the energy relations involved in the recovery of oil..

Q Mr. Buckley, aside from the specific issues you have discussed, what general conclusions did the Committee reach?

A The Committee issued an extensive report based on a study of the entire question. They reached a number of very specific conclusions. In general, I believe they support the views I expressed earlier: that there are a number of factors that influence the recovery of oil, and those that are controllable must be controlled in order to influence the ultimate recovery. But the mere drilling of additional wells solely for the purpose of increasing the well density does not, in general, have any -- add materially to the ultimate recovery.

Now, I have in effect paraphrased what I think to be the substance of their conclusions. If it is important, I would like to read a few --

Q I was wondering if you wouldread those, and also give the page identification in the report.

A On page 46 as conclusion No. 7, I quote:

"In either solution gas, water-drive, or combination drive reservoirs, the ultimate production of oil is independent, within reasonable limits, of well density."

Conclusion No. 8, and I quote:

"Assuming the same efficiency in other features of reservoir development and control, the greater the well density the shorter may be the time in years required to produce all the recoverable oil from a reservoir. This should be qualified on two counts:

"(a) The total oil required from a field to fill market demand might be produced as efficiently from fewer widely spaced as from many closely spaced wells.

"(b) The total oil that could be produced from a reservoir without physical waste might be as efficiently produced from fewer widely spaced as from many closely spaced Wells."

On page 54, Conclusion No. 9, and I quote:

"The basic considerations in movement of fluid in oil reservoirs are applicable to either sandstone or limestone-dolomite reservoirs."

On page 54, No. 12:

"If the aim in reservoir control be that of securing the greatest ultimate recovery of oil from the reservoir as a whole, the question of location of wells ceases to be that of density, or spacing on some geometric pattern. Rather, well locations will be chosen to fit structural and reservoir characteristics or peculiarities, including the many possible variations in different sections of the same pool."

With particular reference to the proposed rule before

this Commission regarding spacing during the early development, I would like to quote Conclusion No. 12 on page 46 of the aforementioned report:

"Where land lease controls permit, new oil fields could be first developed on wide spacing patterns. Final well density and other development and production practices could then be determined in the light of geological, engineering, and economic information developed."

I would like to explain that in this report two sets of conclusions were arrived at. The report was, in effect, preceded by a set of conclusions, and there were a set at the end. These two sets of conclusions were in slightly different language; the second set being, in effect, an amplification and explanation of the first set.

I have selected those I think particularly pertinent to the issues before this Commission. In general, I think the views expressed in all the conclusions are in substantial agreement with the views I have expressed.

Q Mr. Buckley, After reviewing all these studies, do you believe there is any technical controversy on well spacing?

A Frankly, I do not. There has been a great to do from time to time about the so-called effect of well spacing on ultimate recovery. In my opinion, there is no real technical controversy and hasn't been for many years. There

have been a few individuals whose local experiences or other reasons have caused them to be outspoken in advocacy of close spacing. I believe their views have been thoroughly discredited and are not subscribed to by any important segment of those whose business it has been to become really informed on the technical aspects of recovery and conservation. I think it is clearly evident those that have clearly studied the question from a technical standpoint are almost in unanimous agreement with the views I have expressed. This was true of the Oil Compact Engineering Committee in its report of '42, and the API Well Spacing Committee in its report of '42. And true again of the Engineering Committee of the Interstate Oil Compact Commission, published in Booklet form in 1951. And I think it was corroborated fully in the September 1951 report I have just quoted from of the Research and Coordinating Committee of the Compact Commission.

I believe that these groups represent, in the aggregate, a substantial cross-section of informed opinion, both in the industry and among the state regulatory bodies.

Q Mr. Buckley, in conclusion, do you have anything further to present to the Commission?

A With regard to the proposed rule itself, I would like to give one additional brief quotation, if I may, from the recent booklet published by the Engineering Committee of the Interstate Oil Compact Commission. The Engineering

Committee is a different committee from the Research and Coordinating Committee. They published a book entitled "Oil and Gas Production" in 1951, which described in more or less popular terms the behavior of oil and gas fields and those controls necessary to effecient recovery. I quote:

"For proper reservoir control in new fields it is important to determine as promptly as possible the structure, the reservoir-rock characteristics, the extent of the reservoir, the magnitude of reserves, the primary reservoir-energy source, and the type of reservoir control which will permit the greatest recovery. These data can best be determined by drilling new fields on the widest practical spacing pattern. Wide-spacing-development programs afford information that may be used to locate the most advantageous structural position for the drilling of future infill wells, and eliminate the expense of drilling many unnecessary wells. Each reservoir presents a separate problem in the determination of the well-spacing pattern."

Q Do you have anything further in conclusion?

A I have nothing further to add, except to reaffirm my conclusion it is technically sound, and I believe it to be in the public interest, and I believe it to be plain commonsense to develop those pools on a basis which will minimize the drilling of unnecessary wells.

MR. SHAVER: We would like at this time to introduce these reports and booklets he has referred to. We will number them 2, 3, 4, 5, and 6. If you would like additional copies, we have them available.

COM. SPURRIER: Without objection, they will be admitted.

THE WITNESS: Mr. SHAVER, you have introduced two I didn't mention, but which I think will be helpful.

MR. SHAVER: One, Mr. Buckley, is "Petroleum Conservation" and the other is "Petroleum Productive Capacity."

THE WITNESS: A report of the National Petroleum Council on the future availability of petroleum in the United States.

MR. SHAVER: I think they are pertinent to the inquiry and would like to introduce them.

(Off the record.)

COM. SPURRIER: Are there any more questions of this witness?

MR. GRAHAM: In the studies in which you participated, were there actually any 80 and 40 acres?

A You mean, I, personally have studied?

MR. GRAHM: Yes, sir.

A Yes, sir, I have studied or had access to data in fields in which spacing has gone to much wider spacing than that. Not necessarily as to whole pools, but as to substantial

portions thereof.

MR. GRAHAM: No further questions.

COM. SPURRIER: Are there any other questions? If not, the witness may be excused.

(Witness excused.)

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MR. KELLAHIN: If the Commission please, Jason Kellahin for Phillips Petroleum Company. I would like to call as our concluding witness Mr. Folsom, as an independent operator -- independent observer -- to express his conclusion on the question before the Commission.

In the interests of saving time, Mr. Folsom has prepared a statement which rather than presenting by questions and answers, we would like to have him read into the record, if that is satisfactory.

CLARENCE B. FOLSOM, JR.

having been first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. KELLAHIN:

Q Will you state your name, please?

A Clarence B. Folsom, Jr.

Q By whom are you employed, Mr. Folsom?

A I am employed at the New Mexico School of Mines as head of the Petroleum Engineering department.

Q What is your education in the field of petroleum

engineering and geology?

A I hold the degree of petroleum engineer from the Colorado School of Mines, and the degree of Master of Science in petroleum engineering from the same institution.

Q What year?

A The first degree in '41 and the second in 1952.

Q Have you had any practical experience in the field of petroleum production?

A Yes, sir, employed by Phillips Petroleum Company for the period 1941 to 1946, and in my present capacity from 1947 until the present time.

Q You have been head of the Petroleum Engineering Department at the school since 1947?

A That is correct.

Q Have you made a study of the question that is before the Commission in regard to this proposed order, Mr. Folsom?

A I have.

Q Have you prepared a statement on that question?

A I have.

Q Would you read that into the record, please, sir?

A Governor and Members of the Commission and interested spectators:

I appear this morning to add my voice to those who advocate the adoption of the motion, pending before this Commission. I am in full accord with the aims and purposes of the motion,

and I heartily recommend its adoption. I take this position with certain reservations, however. We must not consider this motion as the final solution to the problems of well-spacing and well patterns. It has certain merit as being indicative of an attitude on the part of the Commission. It indicates to the industry that we are ready to consider each oil and/or gas pool, on its own merits, and will no longer attempt to apply a rigid, unvarying rule to all pools regardless of their physical characteristics, geometry, and type of drainage mechanism.

Our knowledge of the mechanics of reservoir drainage has increased tremendously since the Conservation Act was passed in 1935. We now realize that the ultimate recovery from oil and gas reservoirs depends on many factors, most of them inherent in the reservoir as discovered, and not subject to modification. Among these are the permeability, porosity, and saturation of the reservoir rock, the viscosity, the nature of the reservoir fluids, the pressures on these fluids, and the geometry of the system.

It has been calculated that between two identical reservoirs, having a permeability of 15 millidarcys and developed on 40 and 80 acre spacings, respectively, the difference in per cent of original oil in place, recovered, is less than 0.2 of a per cent; and only 0.3 of a per cent in the case of 40 vs. 160-acre spacings. The same reservoirs will produce an addi-

tional 3 per cent if the permeability is increased of 300 md. I mention this to point out that the maximum recovery from an oil or gas pool depends primarily on the inherent physical characteristics of the reservoir and its contained fluids, and only secondarily on the spacing between wells.

With our present knowledge, and sufficient data on the new reservoir, it is now possible to calculate for each new pool, an optimum spacing which will provide the greatest maximum recovery of fluid, at the least cost, with a satisfactory return on theinvestment.

It might be argued that our concern is limited to the maximum recovery of our reserves, but we must realize that there will be no recovery at all unless we encourage exploration and development by a proper attention to the other factors.

What then is more logical than that we should set a temporary spacing in all new oil and/or gas pools until sufficient reservoir data has been obtained to permit a determination of the optimum spacing?

Our ultimate aim in conservation is the most efficient recovery possible consistent with proper control of the pressure decline, gas-oil and water-oil ratios, and use of the reservoir energy. Therefore, it is recommended that the first wells in a new area be drilled on a wide spacing designed to furnish quickly that information regarding the

geology, geometry, and physical characteristics of the reservoir upon which the best, most economical program of development for that particular pool will be based.

This optimum spacing may turn out to be anything from one acre to 500 acres or more. The odds are against it ever being exactly 40 acres. This, in itself, argues against the validity of a rigid, arbitrary, state-wide spacing rule. It is this very flexibility which we must seek. And this proposed rule is a step, but only a step, toward our goal.

It is entirely possible that the evidence furnished by the pool itself will support a wider spacing than that which we propose for the initial stage of development. It is also possible that the optimum spacing may vary from one area within the pool to another.

If we start with a wide spacing it will be easier to drill subsequent wells should they be shown to be necessary to properly recover the oil from the pool, or to meet the market demand; whereas the use of close spacing in the initial stage may result in the drilling of unnecessary wells and the consequent economic waste which we are pledged to avoid. Once started, this waste can never be overcome, even by the most efficient reservoir manipulation.

It is my opinion that the question of well spacing is hampering the efforts of engineers to achieve more efficient recovery, instead of assuming its proper position as a minor

factor. In many cases, the close-spacing advocates have prevailed with the result that the excessive expenditures of capital have had to be offset by excessive allowables to prevent premature abandonment. And this has defeated the efforts of engineers to obtain the maximum, ultimate recovery of oil from the reservoir.

Certainly, if we were to mine the reservoir sand, we would achieve complete recovery. Therefore, it is within reason that the per cent of total recovery will increase as the wells are placed closer together. But the increase in recovery, in the region of well spacings within the realm of practical operation, is so small (a fraction of a per cent) that it can be easily overcome by the increased cost of development and production. It is possible that in the case of older shallower fields the small increase in production, due to infill drilling, will exceed the additional investment, and possibly provide a small profit on the operation. But in the case of deep pools requiring investments approaching a million dollars per well, it is doubtful if even a small percentage of the investment can be returned out of the slight additional recovery.

I suspect that many of the advocates of infill drilling who point to their success in shallower areas will find that our deeper horizons do not present the same rosy picture.

Unfortunately, perhaps the question of the relative

merits of 40 vs. 80-acre spacing has been raised here. I do not consider it to be relative to the question before us, but since it has been brought up it must be considered in the light of our present problem. The question is one of those academic questions which provide scholars with mental exercise, but which in the end add little to our reserves of petroleum. Unless we are interested in well spacings of less than 6 acres per well, the decrease in recovery, as well spacings increase, is so slight as to be unimportant in compairson to the cost of drilling the additional deep wells necessary to obtain the additional oil.

The day is approaching when the industry will be faced with the problem of choosing between a number of areas in which to invest exploratory funds. The past few years have seen many areas closed to exploration because of legal and other difficulties but these obstacles have now been removed, and, as capital funds become more restricted, the industry will be forced to choose those areas in which, in case of a discovery, they will be allowed to develop the pool in accordance with the best engineering practice. If we in New Mexico are willing to recognize new advances in the field of reservoir technology, and carry out our conservation program accordingly, the oil industry will be willing to invest their capital in our state. The result will be increased production and reserves, with increased tax revenues for the state. The advantages to our

state will far outweigh the slight loss of ultimate recovery, if any. In any case, it will be possible for the original discoverer of the pool or his assigns to carry out infill drilling at a later date if it should prove feasible.

As I pointed out earlier, this is only a first step toward an ultimate goal. After we have had time to observe this new rule in operation, we may wish to remove the depth restriction as well as the provision for a stated, final spacing.

Some further mention should be made of well patters. I am no now, and never have been, convinced that the most efficient recovery is achieved by placing our wells in the center of legal land sub-divisions. This is certainly the case in those fields producing under the influence of an active water drive. I realize that to depart from our present rule at this time would be fraught with legal difficulties; nevertheless, if we would strive for true conservation we must soon consider the advisability of allowing irregular patterns, based on the geometry of the reservoir system and the type of drive in operation on the pool.

In adopting a wider well spacing, we need not alter the proration unit now in use for allocating production. Many of those who argue for close spacing assume that the additional wells will increase the amount of production allocated to the acreage. If allowables are based on the proration unit, rather than on a per well basis, the number of wells on a proration

unit can be viewed in its proper economic aspect, and much of the opposition to this proposed motion will disappear.

In arriving at a decision in this matter, we must not lost sight of the obligation we are under to promote exploration, discovery, and development of new reserves in New Mexico; to prevent physical waste through excessive production; to prevent economic waste; to secure the maximum ultimate production of our reserves; and to protect the correlative rights of individuals. These factors complicate the problem, but there is a solution, simple in form but complex in operation, which will accomplish our purpose.

I believe that in the matter of conservation of oil and gas the best interests of the state are identical with those of the oil producers. What is good for either is good for both. We are all interested in obtaining the maximum benefits from our natural resources. And if we continue to work together as we have in the past, we will all prosper; producer, royalty owner, and consumer alike. The proposed motion is in the best interests of all concerned, and I can find no valid, technical reason for opposition to it.

New Mexico has long been a leader in the field of oil and gas conservation. Our operations have served as a model for other commonwealths faced with similar problems. I hope that we will continue to demonstrate our leadership by being the first to abrogate the policy of rigid, statewide spacing;

thereby recognizing the individuality of oil and/or gas pools.

Q Do you have anything you care to add to your prepared statement, Mr. Folsom?

A I thought Mr. Beall submitted some very fine data for the consideration of the Commission; particularly when he pointed out in the case of a 13,000 ft. well you would have to have six times the oil present to pay out the cost of the well as you would have in a 5,000 ft. well. I think it should be further pointed out that this is rather unusual; to find a deep pool with a six-to-one ratio of oil saturation. However, if we cut the number of wells in half, we cut that ratio in half, which would require then a three-to-one ratio, which isn't difficult to picture. I think that should be brought out.

MR. KALLAHIN: That concludes our examination. Any questions?

COM. SPURRIER: Are there any questions of this witness? If not, the witness may be excused.

(Witness excused.)

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COM SPURRIER: Is there anyone else to be heard?

MR. WOODWARD: If there are no other witnesses, we would like to make a statement.

COM. SPURRIER: Very well.

MR. WOODWARD: In view of its interest in spacing in this state in the last 23 years, Amerada Petroleum Corporation would like to make this additional statement of its position with regard to the proposed rule.

We recognize oil fields are not identical, and it has always been our contention each pool should be spaced on its facts. The Bagley, Knowles, and Hightower reservoirs indicated and subsequent development confirms one well would efficiently drain 80 acres. Accordingly, we supported 80 acres. We didn't consider conditions in the Saunders Field, and other pools in which we had a similar majority interest, justified 80-acre spacing, and did not ask for an 80-acre spacing in those fields.

We are not advocating 40, 80, or 160-acre spacing in this hearing. In supporting the proposed rule and urging its adoption, we are contending there is a right time to permanently space oil fields; after sufficient facts are in, and before development has progressed to an extent that proper spacing, as a practical matter, is impossible.

COM. SPURRIER: Anyone else?

MR. DAILEY: My name is Homer Dailey, representing the Continental Oil Company.

We wish to make a statement in favor of the proposed rule.

Adoption of the rule would make possible the accumulation of the data necessary to properly evaluate the reservoir. If the factual data supports such a program, this rule will enable

the operators to develop these reservoirs of greater expense and risk on a program of spacing wider than that now possible. Furthermore, the uniformity of spacing protects correlative rights in that allowables may be distributed equally without question of discrimination. And affords flexibility in that the density of wells may be increased without complications in the event that such action is directed by the Commission.

This proposed rule is a sound step toward better conservation of petroleum resources, and should provide additional incentive to drill other deeper horizons.

COM. SPURRIER: Anyone else?

MR. UPCHRUCH: Attorney for Gulf Oil Corporation.

At the November hearing Gulf went on record as recommending the adoption of this proposed 80-acre temporary spacing rule. We would like again to re-state our position, and recommend adoption of this temporary 80-acre spacing rule.

COM. SPURRIER: Anyone else?

MR. GANNON: For the Texas Company.

We would like to concur in the Committee report submitted this morning by Judge Foster, and recommend the proposed rule be adopted.

MR. NASON: R. O. Nason for the Cities Service of Bartlesville, Okla.

Mr. Chairman, I would like to make a brief statement of our position. We concur in the recommendation of the Committee

with the exception of federal acreage to a regular spacing pattern. We would like to call your attention to the evidence as it has developed here. We think that the evidence has been overwhelming in favor of 80-acre development units. We think that the operator that goes out and drills to a depth below 10,000 is entitled rationally and reasonably to consideration.

The evidence of Mr. Beall showed the discovery well, where it is below 10,000 ft., costs between $300,000 and $1,000,000 to drill. We disagree with Mr. Tesch in that I believe that when you analyze his testimony he is opposed to spacing of any kind. If you will go into his testimony, he is opposed to any kind of development units, and he is opposed to the conservation practices that have grown up in the industry. We feel that when a man bets his money and goes in and drills a well to a depth below 10,000 ft, he is entitled to that consideration. Not only that, and it is recognized in every state I know of, the discoverer of a new pool is given consideration. We feel that when -- now, I want to call your attention to Mr. Beall's testimony.

He testified that as far as pools are concerned, when you get below 10,000 ft, they are no more likely to be Golcondas, so to speak, than when they are above 10,000 ft. And we feel that the man that bets his money -- and we agree with Mr. Tesch on this -- he ought not to be compelled to

step out from 1,866 ft. to a half mile to offset his own well. Now, I will admit that you may have something of a cluster there. But all this testimony with reference to infill wells is applicable to the rule if you drill it before with reference to diagonal spacing.

That is our position as we stated it at the commencement of this hearing in April. And that is our position now. And we feel that if that part is stricken from the proposed rule, that it will tend toward the development of the oil reservoirs of new Mexico.

I believe that that states our position fully. Thank you.

COM. SPURRIER: Anyone else?

MR. ELLIS: H. C. Ellis of Artesia, N. M., with Buffalo Oil Company.

I would like to state our position as regards the proposed 80-acre spacing. We are heartily in accord with that spacing.

COM. SPURRIER: Any one else?

MR. BROWN: D. C. Brown, Sun Oil Company.

We have gone on record about four times already as being in favor of this proposal, and I will make it the fifth.

COM. SPURRIER: Anyone else?

MR. SELINGER: George W. Selinger, representing Skelly Oil Company.

Skelly Oil Company wishes to add its voice to the voices of the vast majority of the industry pleading with the Commission to adopt the rule. In 1935 the Commission of this state was faced with a very difficult problem, and I believe this Commission will meet the problem it is faced with now as courageously as its predecessor. I believe this Commission will not be subject to any criticism in the adoption of this rule for two reasons: one, that this is a temporary spacing rule in which a permanent rule is not adopted until after all information is disclosed and presented to the Commission in very concrete form. Secondly, the rule places a burden upon industry, and the industry welcomes that burden, in proving to this Commission after 18 months of drilling, or drilling of six wells, that 80 acres is necessary.

Now, with those two restrictions, those two defenders from criticism, I believe this Commission can adopt a temporary spacing rule as sought by the industry.

COM. SPURRIER: Anyone else?

MR. JOHNSON: J. P. Johnson with Atlantic Refining Company.

We would like again to state our position in favor of this temporary spacing order.

COM. SPURRIER: Anyone else. If there is no one else to be heard, we will take the case under advisement.

---------o---------

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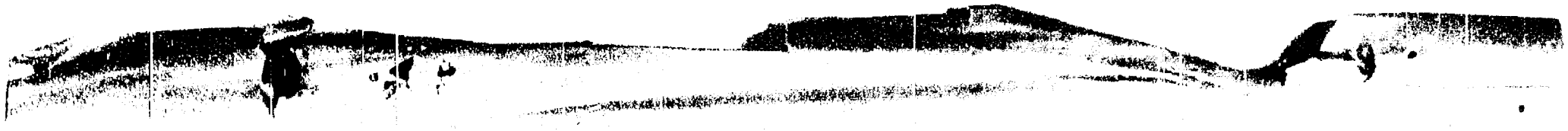
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MAGNOLIA PETROLEUM CORP EXHIBIT #1 CASE 407

PRESENTED AT HEARING JUNE 16 1953

PRODUCTION RESEARCH MAR 1953

Bureau of Mines
Report of Investigations 4917

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PETROLEUM-ENGINEERING STUDY OF HEALDTON OIL FIELD, CARTER COUNTY, OKLA.

BY C. H. RIGGS, JOHN E. WEY, EDWARD SANABRIA, JR., PAUL MEADOWS, WILLIAM C. SMITH, AND JAMES A. WEST

United States Department of the Interior—February 1953

Ex. 1 Magnolia

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Report of Investigations 4917

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary
BUREAU OF MINES
J. J. Forbes, Director

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February 1953

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by

C. H. Riggs,[1] John E. Wey,[1] Edward Sanabria, Jr.,[1] Paul Meadows,[2]
William C. Smith,[3] and James A. West[3]

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INTRODUCTION AND SUMMARY

This petroleum-engineering study of the Healdton oil field in Carter County, Okla., describes the geology and production history of that field and estimates the oil reserves that could be produced by efficient secondary-recovery methods.

The Healdton field, in western Carter County approximately 20 miles west of Ardmore, Okla., was discovered in 1913 and was one of the early important oil-producing areas in the State. Although the volume of oil recovered from the Healdton sands has been comparatively high, studies show that a large reserve remains in the pressure-depleted sand, which can be recovered by efficient water-flood operations.

In making this study of the Healdton-sand reservoir, the writers utilized many data already available in company and Government offices. Most of the fluid samples were collected by Bureau of Mines personnel and analyzed in the Bureau's laboratories at Bartlesville, Okla.; but other data, including logs, core analyses, and production records, were obtained from outside sources. These data were examined critically but were not verified, and possible errors in the original data may be reflected in the conclusions.

In this study, attempts were made to consider only those aspects of the available information that would contribute to a clear and concise engineering report on the Healdton-sand reservoir. Other phases of the data, as well as those concerning associated reservoirs, were eliminated from consideration as being irrelevant to the particular problem. Cores and drill cuttings of the Healdton sands were analyzed and studied to determine the nature of the reservoir rocks. Analyses of samples of produced oil, water, and gas were studied to fix the different types, the limits of their occurrence, and the suitability of different waters for injection into the Healdton sands. Records of oil, gas, and water produced and of gas and water injected were studied to interpret the production behavior of the field and of certain individual leases. Theoretical calculations were made to predict the probable water-flood behavior and oil recovery, at constant water-injection rates, for individual sands on two leases.

Table 1 summarizes data pertinent to the Healdton field.

Oil is produced from discontinuous and lenticular Healdton sands of late Pennsylvanian age, which range in depth between 700 and 1,400 feet. Apparently these sands were deposited unconformably around and over a topographic high of the eroded Ordovician surface. During Mesozoic time, the area was folded and faulted to form a modified anticlinal structure.

TABLE 1. - Field and reservoir data, Healdton sands, Healdton oil field, Carter County, Okla.

GENERAL	
Date of discovery	Aug. 14, 1913
Depth of wells, ft.	700 to 1,400
Total productive area, acres	7,142
Total wells drilled to Nov. 1, 1951	2,590
Wells producing as of Nov. 1, 1951	1,863
Stock tank gravity of oil, A.P.I.°	26 to 35
Viscosity of typical stock-tank oil of 31° A.P.I., at 80° F., Cps.	13.3
RESERVOIR DATA	
Average effective thickness, ft.	72
Average porosity, percent	21.6
Average permeability, md.	330
Average connate water content, percent	18.2
Average original reservoir pressure (est.), p.s.i.g.	270
Average formation temperature (est.), °F.	80
Gas in solution in reservoir oil per barrel of stock tank oil (est.), cu. ft.	85
Formation volume factor, (est.)	1.044
Original mobile oil reserves, bbl.	422,000,000
Total stock tank oil originally in reservoir, do.	674,195,000
PRODUCTION DATA	
Average initial oil production between 1913 and 1917, per well per day, bbl.	270
Maximum yearly oil production, 1917, do.	22,036,000
Yearly oil production, 1950, do.	2,263,000
Average daily oil production, 1950, do.	6,200
Average daily water production, 1950, do.	14,600
Average specific gravity of produced gas (est.)	0.88
Gasoline content of produced gas as of Jan. 1, 1951, per M c.f., gal.	0.31 to 3.95
RECOVERY	
Cumulative oil production to Jan. 1, 1951, bbl.	211,179,000
Oil recovery to Jan. 1, 1951, field average per acre, do.	29,570
Oil recovery to Jan. 1, 1951, field average, barrels per acre foot	410

In this study the Healdton sands are considered to belong to four zones, the uppermost of which is termed the "first-sand zone" and the lowermost, the "fourth-sand zone." The first sand, the most nearly depleted, is the thickest and most extensive and should lend itself best to water-flood development. The character of this sand and the proposed methods of water-flood development are described in the sections on Reservoir Conditions and Water Flooding. The second and third sands are extremely lenticular, with alternating beds of sand and limestone of high and low permeability. The fourth sand covers a relatively smaller area and is more uniform in character, but it differs from the other sands in that natural water drive is the important production mechanism. The history of the natural water drive in the fourth sand for the field and for certain representative leases is discussed under Production Mechanisms.

Approximately 2,600 wells have been drilled in the Healdton field, as shown on the development map (fig. 1.), and over 211 million barrels of oil have been recovered from the several Healdton sands underlying the 7,142 oil-productive acres in the field. The comparatively high oil production obtained from "infill" wells drilled between old producers substantially raised the rate of oil production following three infill-drilling periods during the life of the field. The increased recovery from the field as a whole and from three leases in particular is given careful attention in the report under Infill Drilling.

Air and gas injection to increase oil production or to store gas for future use has been tried on a limited scale but with comparatively little success. The results obtained on several projects are discussed in detail both as to the accompanying increases in oil recovery and as to the indications they give of the continuity of the oil sands.

The study indicates that, in the Healdton sands, many millions of barrels of oil will not be recovered by present operating methods. Much of this oil can be flushed from the sands and forced to producing wells by water injected through specially equipped and properly spaced input wells. Introducing water into the several sands and controlling its movements through the oil-bearing pore spaces between the sand grains will present many problems to the water-flood engineer, but possible recovery of millions of barrels of oil will be an adequate reward. Methods of water-flood development and associated problems are discussed under Water Flooding.

ACKNOWLEDGMENTS

This engineering study of the Healdton oil field, Carter County, Okla., was conducted by the Bureau of Mines under a cooperative agreement with the State of Oklahoma. The investigation was carried on under the general supervision of R. A. Cattell, chief, Petroleum and Natural Gas Branch, Bureau of Mines, Washington, D. C., and H. C. Fowler, superintendent, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Okla., and under the direct supervision of D. B. Taliaferro, chief, Secondary Recovery Branch, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Okla.

The writers wish to extend their sincere appreciation to the following companies, who by furnishing production data and other pertinent information regarding their properties in the Healdton oil field have made this report possible:

Shell Oil Co., Inc., Oklahoma City, Okla.
Sinclair Oil & Gas Co., Tulsa, Okla.
The Pure Oil Co., Tulsa, Okla.
Magnolia Petroleum Co., Oklahoma City and Healdton, Okla.
Schermerhorn Oil Co., Tulsa, Okla.
Kewanee Oil Co., Tulsa, Okla.
The Texas Co., Tulsa, Okla.
Harry Ells, Inc., Tulsa, Okla.

Cities Service Oil Co., Bartlesville, Okla., and Shell Oil Co., Inc., Oklahoma City, made available early reports of oil purchased in the field. The completeness of oil-production data for many individual leases largely is due to their cooperation. Recent data concerning pipeline runs from individual leases made available by Bell Oil & Gas Co., Tulsa, Okla., and Shell Pipe Line Co., Tulsa, Okla., helped immeasurably.

Sincere thanks are extended to C. W. Tomlinson, Ardmore, Okla.; S. W. Hamner, Schermerhorn Oil Co., Healdton, Okla.; I. B. Stitt, Magnolia Petroleum Co., Healdton, Okla.; and S. H. Rockwood, Shell Oil Co., Inc., Oklahoma City, Okla., for their aid in many phases of this study. The cooperation and assistance of the personnel of operating companies in the field is gratefully acknowledged also.

Samples of drill cutting were obtained for study through the cooperation of Elbert King, Ardmore Sample Cut, Ardmore, Okla.

Data from unpublished reports on the Healdton oil field by Bureau of Mines personnel, A. A. Hammer, R. A. Cattell (1),4/ C. F. McCarroll (2), and C. R. Bopp were especially helpful.

GENERAL GEOLOGY

Location and Topography

The Healdton oil field is located in the western part of Carter County, Okla., about 20 miles west of Ardmore and 30 miles southeast of Duncan, Okla. (see fig. 2). The major portion of the field lies in T. 4 S., R. 3 W. (Indian meridian), although portions of the field extend into T. 3 S., Rs. 3 and 4 W., and T. 4 S., Rs. 2 and 4 W. The communities of Healdton, Wirt, and Dundee (McMan) are wholely or partly within the field limits.

The land is flat or gently rolling, with elevations ranging from about 885 to 1,070 feet above sea level. The topsoil consists of red and yellow clay and sand. Blackjack oak and low bushes comprise the natural vegetation, and very little of the land in the field is now cultivated. The area is drained by Whiskey and Walnut Creeks, small tributaries flowing southeast to the Red River.

In the immediate area the principal industries are associated with producing, transporting, and refining petroleum; a few cattle are grazed along the edges of the field. A branch of the Gulf, Colorado, & Santa Fe Railroad runs from Ardmore to Ringling, with a spur to Healdton. U. S. Highway 70 from Ardmore to Waurika passes south of the field. State Highway 76 passes through Healdton along the east side of the field.

Regional Geology

Stratigraphy

Figure 2 shows the geography, areal geology, and principal structural features in southern Oklahoma. In Carter County surface formations range in age from Ordovician, which outcrops on the Criner Hills, to Cretaceous beds in the Marietta syncline. Tomlinson (3) gives the following general section for Carter County, Okla.:

Recent	Alluvium and gravel
Cretaceous	Goodland limestone Trinity sand
Permian	Red Beds
Pennsylvanian	Pontotoc series Hoxbar formation Deese formation (Healdton sands?) Dornich Hills formation (Hewitt sands?) Springer formation

4/ Underlined numbers in parentheses refer to references at end of this report.

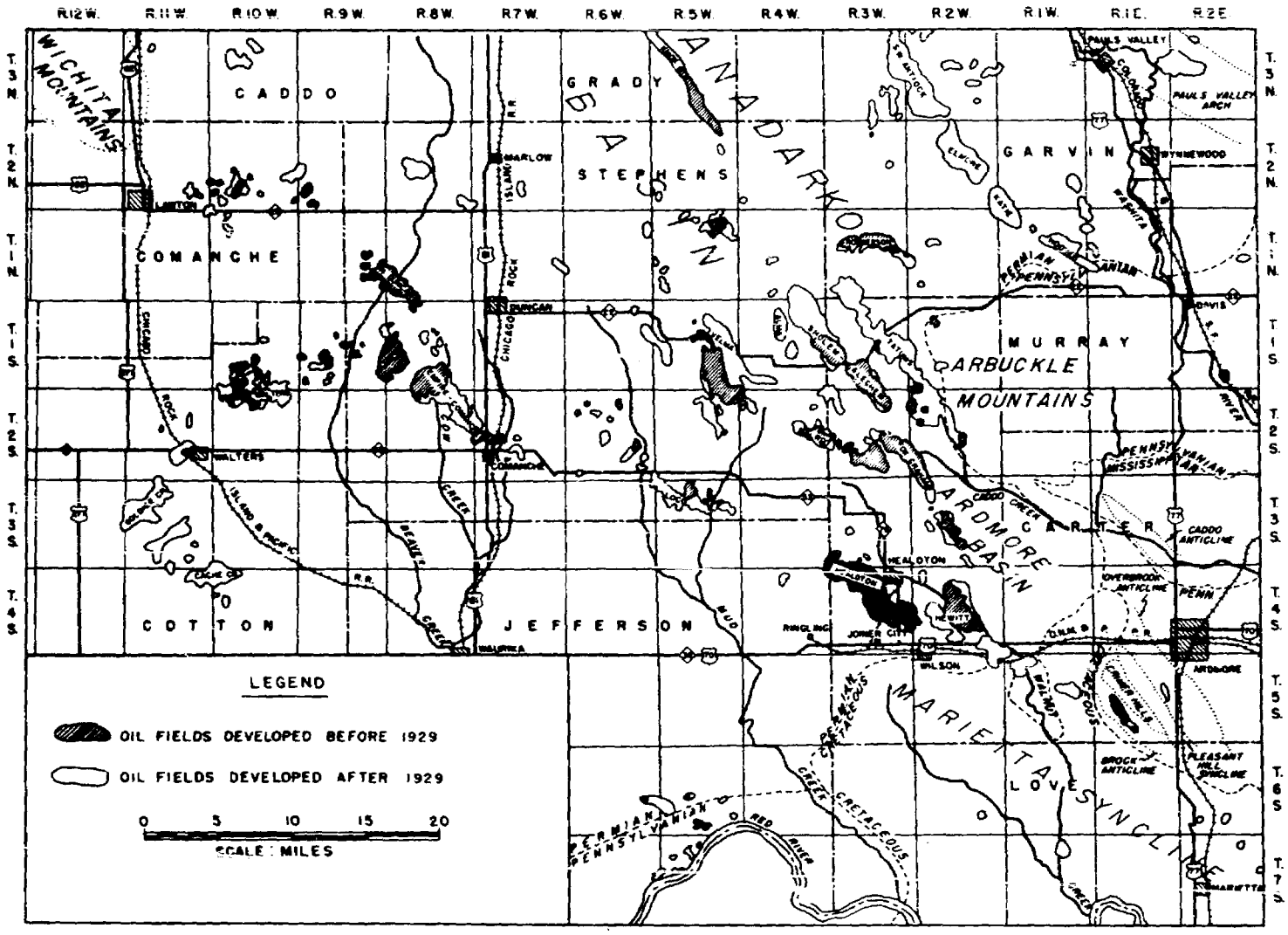


Figure 2. - Location of Healdton oil field in relation to other oil fields and structural features in Southern Oklahoma.

Mississippian	Caney shale Sycamore limestone Woodford chert	
Devonian	Hunton formation	Bois d'Arc limestone Haragan shale
Silurian	Hunton formation	Henryhouse shale Chimney Hill limestone
Ordovician	Sylvan shale Viola limestone Simpson formation Arbuckle limestone	

Many of these formations are exposed in the highly folded area immediately southwest of Ardmore, which includes the Criner Hills and the Overbrook anticline. Permian "Red Beds" cover most of the county west of the Indian meridian, including the area of the Healdton field.

Geological History of Structure

The known structural history of this area begins in late Pennsylvanian time with deposition of the Dornick Hills formation (4). A major diastropic movement, which formed the Wichita, Arbuckle, and Ouachita Mountains, also formed smaller parallel folds running northwest and southeast. Many of these smaller folds influenced oil accumulations in the Healdton, Velma, Loco, Fox-Graham, Sholem-Alechem, and Tatums fields. In the erosion period that followed this diastrophism, the lower Pennsylvanian and older formations were removed from the crest of the Healdton and Criner Hills. Gradual subsidence followed, beginning in the Marietta syncline and Ardmore Basin and progressing northwest. During the early stages of this subsidence and deposition the Healdton and Criner Hills stood out as islands with steep limestone cliffs facing the sea (5). Sand bars and shale beds were deposited, reworked, and redeposited around the base of the Healdton Island. As the land continued to subside, lenticular sand and shale beds were deposited over the top of the Healdton Island. In the Healdton area there is little apparent break between these Healdton sands and the overlying Permian Red Beds, although further to the east a discomformity is apparent (6).

Following Hoxbar deposition the area was again folded and faulted along the former trends and raised above sea level. In early Cretaceous time Gulf seas again invaded the continent, spreading over Oklahoma and Kansas. Probably Cretaceous sediments originally were deposited over the entire area, although a small patch in the Marietta syncline is all that remains in Carter County of the sediments deposited by these seas. After Cretaceous time the area was again uplifted, and the seas receded to form the off-lap deposits of the coastal areas of Texas and Louisiana. During the present emergence, all of the Cretaceous and much of the Permian sediments have been removed from the Healdton Hills by erosion (7) (8).

DEVELOPMENT

Discovery

Early in the 1890's a prospector named Palmer used a springpole rig to drill a well near an oil seep on what was Indian land and is now the Shell Oil Co., Inc., C. L. McClure lease in sec. 5, T. 4 S., R. 3 W. (9). At 425 feet in depth oil "oozed and slopped" over the top of the hole. Palmer capped the well, hoping to obtain the necessary leases before the news spread about the oil strike. However, before the Atoka Agreement in 1897, a Federal treaty with the Chickasaw and Choctaw Indians prohibited development of Indian lands for oil, and Palmer died without profiting from his discovery.

Substantial "oil shows" were found in water wells drilled several years later on the Apple, Franklin, and Smith properties in secs. 5 and 8, T. 4 S., R. 3 W. These indications, together with the fact that oil was still oozing from the capped Palmer well, prompted Roy Johnson, Edward Galt, Wirt Franklin, and Lon Apple to lease 4,000 acres of land in the Healdton area and organize the Plains Development Co. and the Red River Oil Co.

The first commercial oil well in the field was drilled by the Red River Oil Co. and was completed August 4, 1913, on what is now the Shell Oil Co., Inc., Wirt Franklin lease, NE1/4 sec. 8, T. 4 S., R. 3 W. Oil was found at a depth of approximately 900 feet, and the initial production was 80 barrels daily, from a sand about 20 feet thick. The second well, drilled on what is now the Shell Oil Co., Inc., C. L McClure lease northwest of the discovery well, initially produced 300 barrels of oil per day.

Development of other leases followed, and by the end of the year 15 oil wells had been drilled (10). Originally, independent operators held 90 percent of the leases. By November 1, 1913, 14 oil companies were operating in the field. The Sun Oil Co. obtained 1,000 acres from the Crystal Oil Co. (formerly the Plains Development Co.) in October 1913.

Intensive drilling in a southeast extension, including all or parts of secs. 13, 14, 15, 22, 23, 24, and 25, T. 4 S., R. 3 W. and secs. 18 and 19, T. 4 S., R. 2 W., was begun in 1916 and continued through 1917. Table 2 shows a summary of the development history during the first 3 years.

TABLE 2. - Early development history, Healdton oil field, Carter County, Okla.

Year	Completed wells				Oil production, bbl.			Gas production, M c.f.	
					Initial daily		(Yearly)	Initial daily	
	Total	Oil	Gas	Dry	Total	Average	total	Total	Average
1913.....	23	15	3	5	844	56	36,250	50,000	17,000
1914.....	392	340	9	43	106,171	312	7,784,000	150,000	16,000
1915.....	335	290	14	31	86,010	297	6,412,500	191,000	13,600

Figure 3 shows the oil-production history, average price paid for crude oil, and number of producing wells in the Healdton oil field from 1913 through 1950.

Transportation and Oil Sales

During the early development of the field, equipment and supplies were hauled from Ardmore by mule teams over poor, muddy roads. Construction of the Ringling Railroad (now Gulf, Colorado & Santa Fe) was begun in May 1913, and by December of that year the railroad had reached a point 3 miles south of the field. Wilson and Joiner City became transportation headquarters for hauling supplies to the field and oil to the railroad by mule teams. Later, a spur track (Oil Field Railroad) was laid into Healdton, and oil was shipped out in tank cars.

By January 1914 oil production averaged 1,600 barrels daily. In February 1914 Magnolia Pipe Line Co., the principal purchaser of crude oil in the Healdton field, announced an increase in the price for crude oil from $1.00 to $1.03 per barrel. A 55,000-barrel storage tank was completed that month, and shortly thereafter the first oil was run through a newly laid 6-inch line to Addington, Okla., and thence through the main pipeline to the Magnolia Petroleum Co. refinery at Fort Worth, Tex.

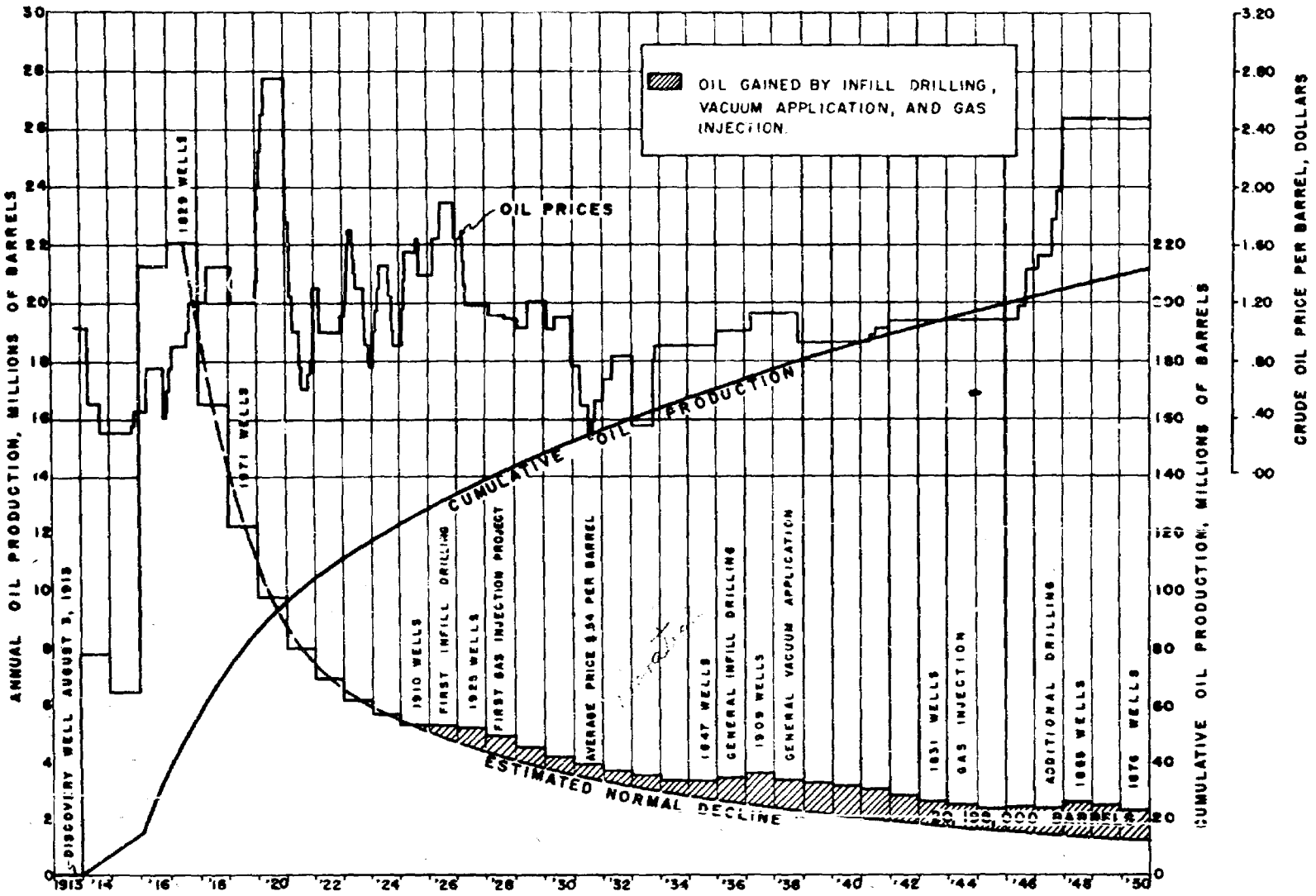


Figure 3. - Oil production history and crude oil prices (Healdton sand zone only), Healdton oil field, Carter County, Okla.

Comparatively low drilling costs and high initial-production rates (100 to 1,000 barrels daily (9)), contributed to rapid development of the field early in 1914. Fear of underground drainage led to competitive production, which soon filled all available storage.

Earthen pits were hastily constructed to store the oil, but heavy rains and fire started by electrical storms caused much loss and damage. McPhail & Corbett constructed a small dam across a creek and skimmed much lost oil off the top of the water. Oil prices dropped to 70 cents.

By August 1914, after 1 year of operation, 208 wells on 74 leases were producing over 50,000 barrels of oil daily. Oklahoma Corporation Commission Order 846 restricted oil production from wells to the amount that could be sold for 65 cents or more per barrel. In October the Magnolia Pipe Line Co. reduced the price to 40 cents per barrel, and the Oklahoma Corporation Commission (Order 847) prohibited production of any oil that could not be sold for 50 cents or more per barrel. Oil stored in earthen pits became unsalable at quoted market prices because of included water and the decrease in gravity, so the Oklahoma Corporation Commission (Order 878, issued November 10, 1914) permitted sale of this oil below the market price, provided that the amount sold was charged against the prorated allowable on the basis of the value received therefor. The Oklahoma Corporation Commission Order 920 (issued June 5, 1915) prohibited storage of oil in earthen pits.

Late in 1914 the Ardmore Refining Co. completed the first 1,000-barrel refining unit at Ardmore, and the Producers Refining Co. began to construct an 8-inch line to Gainesville, Tex.

Because of inadequate markets and low prices for crude, development was virtually at a standstill during late 1914 and early 1915. Oil prices dropped to 30 cents per barrel, and the pipeline companies purchased only currently produced oil and would accept none from storage. Activity increased late in 1915, and in October of that year the Producers Refining Co. 8-inch line to Gainesville, Tex., was completed. The independent operators in the Healdton field contracted to furnish 15,000 barrels of oil daily to the pipeline at 30 cents a barrel. By the end of 1915 750 wells had been drilled, and daily oil production averaged 75,000 barrels.

Oil prices gradually increased from 35 cents per barrel in October 1915 to 75 cents per barrel in December 1916. (See fig. 3.)

By February 1917, six pipelines with a daily handling capacity of 73,000 barrels of oil had been constructed. Since then oil-transportation facilities have been adequate. By December 1917, 1,825 oil wells had been completed, and yearly oil production (as illustrated in figure 3) reached a peak of 22 million barrels in 1917 (11). During 1918 and 1919, 150 wells were drilled, but their comparatively low rates of production could not stay the sharply declining field rate of production. The initial drilling campaign in the Healdton field came to a close in 1919, and since that time there has been little change in the productive limits of the field. In 1919 and 1920, 1,971 oil wells were producing in the field. At no time since have there been as many.

Table 3 lists the 11 pipelines that, in the early 1920's, transported oil from the field to refineries in cities as near as Wilson, Okla., and as far away as Wood River, Ill.

TABLE 3. - Pipeline companies and refineries serving Healdton oil field in the early 1920's, Healdton oil field, Carter County, Okla.

Pipeline company	Size of line	Connected leases	Refinery name	Refinery location	Refinery capacity, bbl.
Pure Pipe Line Co.	6-inch	18	Pure Oil Co.	Ardmore, Okla.	7,000
Magnolia Pipe Line Co.	Two 6-inch	34	Magnolia Refining Co.	Fort Worth, Tex.	20,000
Sinclair Pipe Line Co.	8-inch	20	Sinclair Refining Co.	do.	10,000
Chickasaw Pipe Line Co. (Coline Oil Co.)	4-inch	8	Chickasaw Refining Co.	Ardmore, Okla.	5,000
Cameron Pipe Line Co. (Ardmore Refining Co.)	6-inch	5	Cameron Refining Co.	do.	3,500
Empire Pipe Line Co. (Producers Refining Co.)	8-inch	16	Producers Refining Co.	Gainesville, Tex.	6,000
Imperial Refining Co.	4-inch	7	Imperial Refining Co.	Ardmore, Okla.	7,000
Nyanza Refining Co. (J. Howard Pugh)	3-inch	1	Nyanza Refining Co.	Wilson, Okla.	3,000
Yarhola Pipe Line Co.	6-inch	13	Shell Oil Co.	Wood River, Ill.	Unknown
Texas Pipe Line Co. of Okla.	8-inch	10	Unknown	Unknown	Do.
Pierce Pipe Line Co.	do.		Pierce Refining Co.	Fort Worth, Tex.	8,000

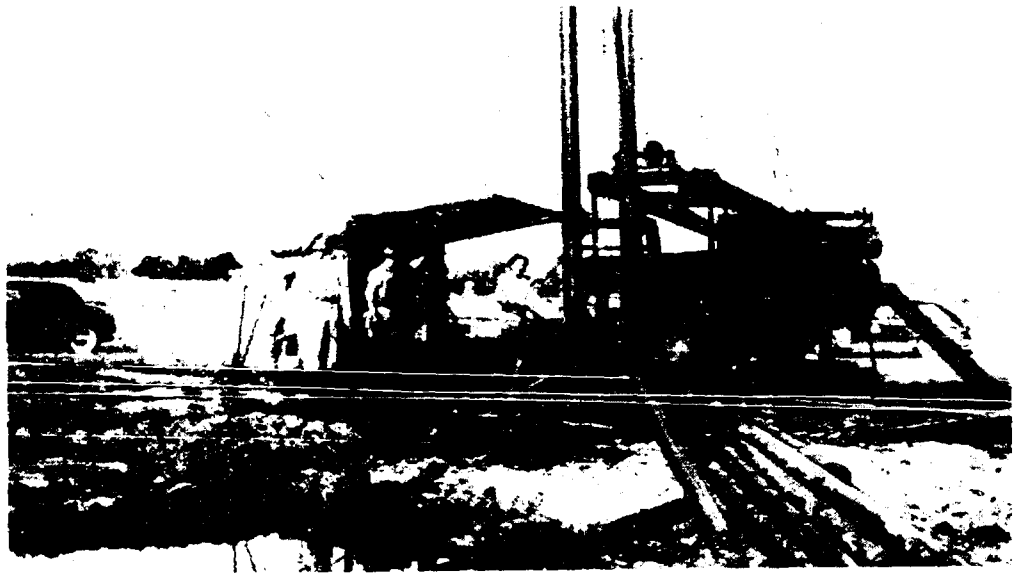
In 1920 the demand for crude oil increased sharply, and the price increased steadily to a peak of $2.75 per barrel in March of that year. Shortly thereafter, imports of foreign crude, chiefly from Mexico, decreased the price to a low of 60 cents per barrel. After 1922 most oil was sold on a gravity basis, but until 1925 the price paid for Healdton crude was 20 cents per barrel less than for other crudes of comparable gravity.

In 1926 the first infill-drilling program began, and during the next few years 38 new wells were drilled. Oil prices for 31° A.P.I. gravity oil declined from a high of $1.89 per barrel in 1926 to a low of 25 cents per barrel in 1931.

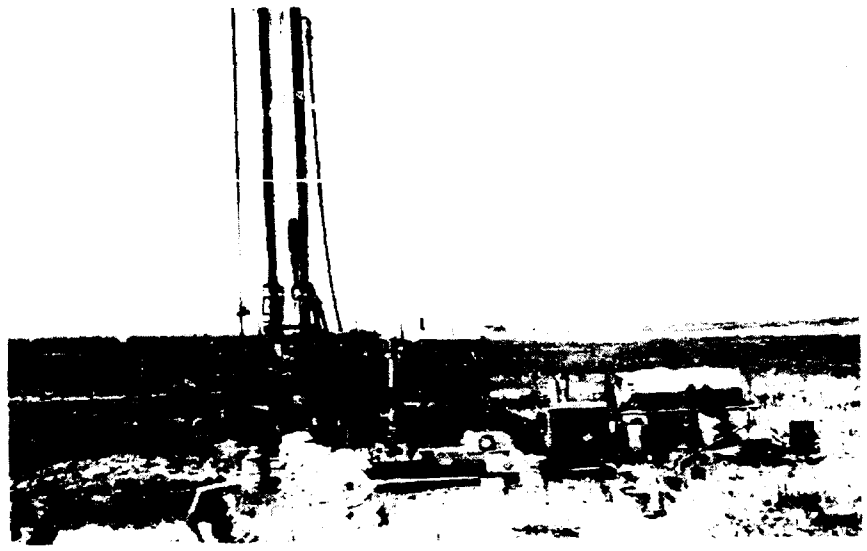
In November 1930 State-wide proration limited oil production to 5 barrels of oil per well per day, plus 50 percent of the difference between this and the potential daily oil production of the well. The proration base was raised to 10 barrels per well per day in January 1931 and to 20 barrels in May 1931.

By 1933 the economic depression forced many small refineries in the Healdton area to discontinue operations, and the plants were shut down or dismantled. However, two refineries still were operating in Ardmore and processing Healdton crude oil, and Shell Pipe Line Co., Magnolia Pipe Line Co., and Pierce Pipe Line Co. were transporting oil to refineries in Wood River, Ill., and Fort Worth, Tex. The average daily oil production from the fields was approximately 9,500 barrels.

The second infill-drilling campaign, beginning in 1935, and general application of vacuum, beginning in 1938, increased and maintained the yearly oil production at 3 to 3 1/2 million barrels per year until 1941.



Cable tool drilling rig



Rotary drilling rig

Figure 4. - Portable cable tool and rotary drilling rigs used in the Healdton oil field, Carter County, Okla. (1951).

Healdton crude-oil prices were stabilized at $1.07 per barrel during World War II (1941-45). After price restrictions were removed, the price for oils of gravities between 31 and 31.9° A.P.I. rose steadily to $2.47 per barrel in 1948.

A third infill-drilling and extension program began in 1946 and continued through 1950, with the drilling of 114 new wells.

In 1950 oil from the Healdton field was purchased at $2.47 per barrel by the Bell Oil & Gas Co. for refining in Ardmore, Okla., and by the Shell Pipe Line Co. and the Magnolia Pipe Line Co. for refining at Wood River, Ill., and Fort Worth, Tex. During this year, 1,876 wells produced 2,260,000 barrels of oil, or about 6,200 barrels daily.

Drilling and Completion Practices

Most of the wells in the Healdton field were drilled with cable tools (see fig. 4), probably because of the lower cost during development. Drilling time for these cable-tool wells was 10 to 20 days, and costs averaged $3,000 to $4,000 per well. During early development, rotary tools were used to drill a few wells to oil-productive formations below the Healdton sands.

The only logs for wells drilled before the late 1930's were those kept by the drillers. During the infill-drilling period beginning in 1935, several electric logs were made, and cores of the formation were cut. More recently, radioactivity logs have been made in several of the old wells, as well as in some recently drilled.

When the field was being developed, the usual practice was to use three strings of casing - 10-inch at about 300 feet, 8-1/4-inch at 400 to 600 feet, and 6-5/8-inch at about 800 feet. In some instances the 10-inch casing was pulled. A 5-3/16-inch slotted liner was set on bottom extending approximately 20 feet up into the 6-5/8-inch casing. This casing program usually was adequate; but, in some instances, more strings of casing were used to exclude upper formation waters.

Many of the earlier wells were shot with 1 quart of nitroglycerin per foot of oil sand. Today the same practice is followed on some new wells, but others are completed without shooting. Indiscriminate shooting sometimes damaged the casing seat for the producing string and permitted an influx of water from the upper water sands. Several instances where this occurred in wells drilled in 1917 in the southeast extension have been recorded by Bureau of Mines engineers, who studied water production in that area of the Healdton field (1).

Because of the caving nature of the Healdton sands, work-over and clean-out jobs were necessary on many early wells to sustain the rate of production. Drillers' logs show that many of the old wells drilled originally to the first Healdton sand were deepened later to produce oil from the lower Healdton sands. When these wells were deepened, it was necessary to pull and reset the liner. Often a new string of casing had to be run inside the original production string, or the production string was pulled and reset at a lower depth. Many wells were plugged back with lead wool, rocks, or limit plugs to exclude bottom water, but some of these plug backs were not successful.

A majority of the recent wells have been drilled with a combination of rotary and cable tools. A portable rotary rig (fig. 4) is used to drill to the top of the oil sand where the production string is set and cemented with about 250 sacks of cement, and then a cable-tool rig is used to drill into the producing sand. If

rotary tools were used to complete the wells, the water-base mud might penetrate and seal off the pressure-depleted Healdton oil sands, which would result in poor or non-productive wells. A few recent wells were completed with rotary, using oil-base mud.

Table 4 shows the estimated cost of drilling and completing a well in the Healdton field in 1951, using the combination rotary- and cable-tool methods described above.

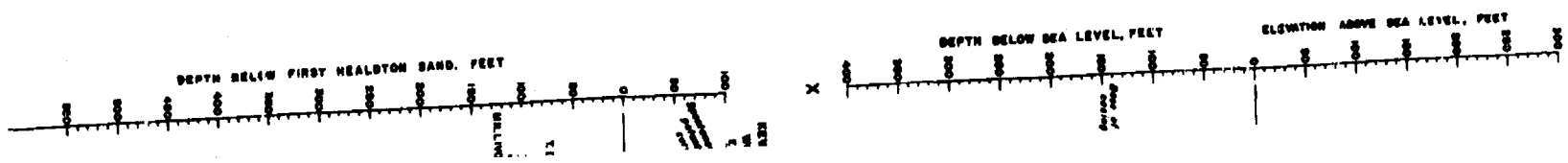
TABLE 4. - Estimated cost of completing a well in the Healdton sand, 1951, Healdton oil field, Carter County, Okla.

	Item	Total
Drilling - Depth 1,200 feet		
Cost per foot includes fuel, water, rigging up, pits, etc.		
900 ft. drilled with rotary tools at $2.00 per ft.	$1,800	
300 ft. drilled with cable tools at $3.00 per ft.	900	
Total cost of drilling		$2,700
Casing and tubing		
80 ft. of 10-3/4-in. o.d., 32-3/4 lb. per ft.	208	
900 ft. of 7-in. o.d., 24 lb. per ft.	1,746	
320 ft. of 5-3/16-in. o.d. liner	352	
1,190 ft. of 2-3/8-in. o.d. tubing	488	
Total cost of casing and tubing		2,794
Equipment		
Rods, 1,200 ft.	125	
Pump (includes pumping jack)	300	
Flow line, 500 ft.	350	
Miscellaneous	75	
Total cost of equipment		850
Material		
Cement, 300 sacks	180	
Mud	270	
Total cost of material		450
Completion costs		
Services of cable tool rig for completion (2 days at $175 per day)	350	
Cementing service		
10-3/4-in. casing with 50 sacks and 7-in. casing with 250 sacks	296	
Trucking, labor, miscellaneous	100	
Total cost for completion		846
Total cost for drilling and completing well		$7,640

RESERVOIR CONDITIONS

Structure and Stratigraphy

Most authorities agree that Healdton sands of Pennsylvanian age were unconformably deposited around and over folded and eroded Ordovician hills. Subsurface studies made in preparation for this report support this concept of Healdton-sand deposition on an irregular Ordovician surface. The irregularity of this depositional surface affected the thickness and extent of the Healdton sands.


DEPTH BELOW FIRST HEALDTON SAND, FEET
DEPTH BELOW SEA LEVEL, FEET
ELEVATION ABOVE SEA LEVEL, FEET

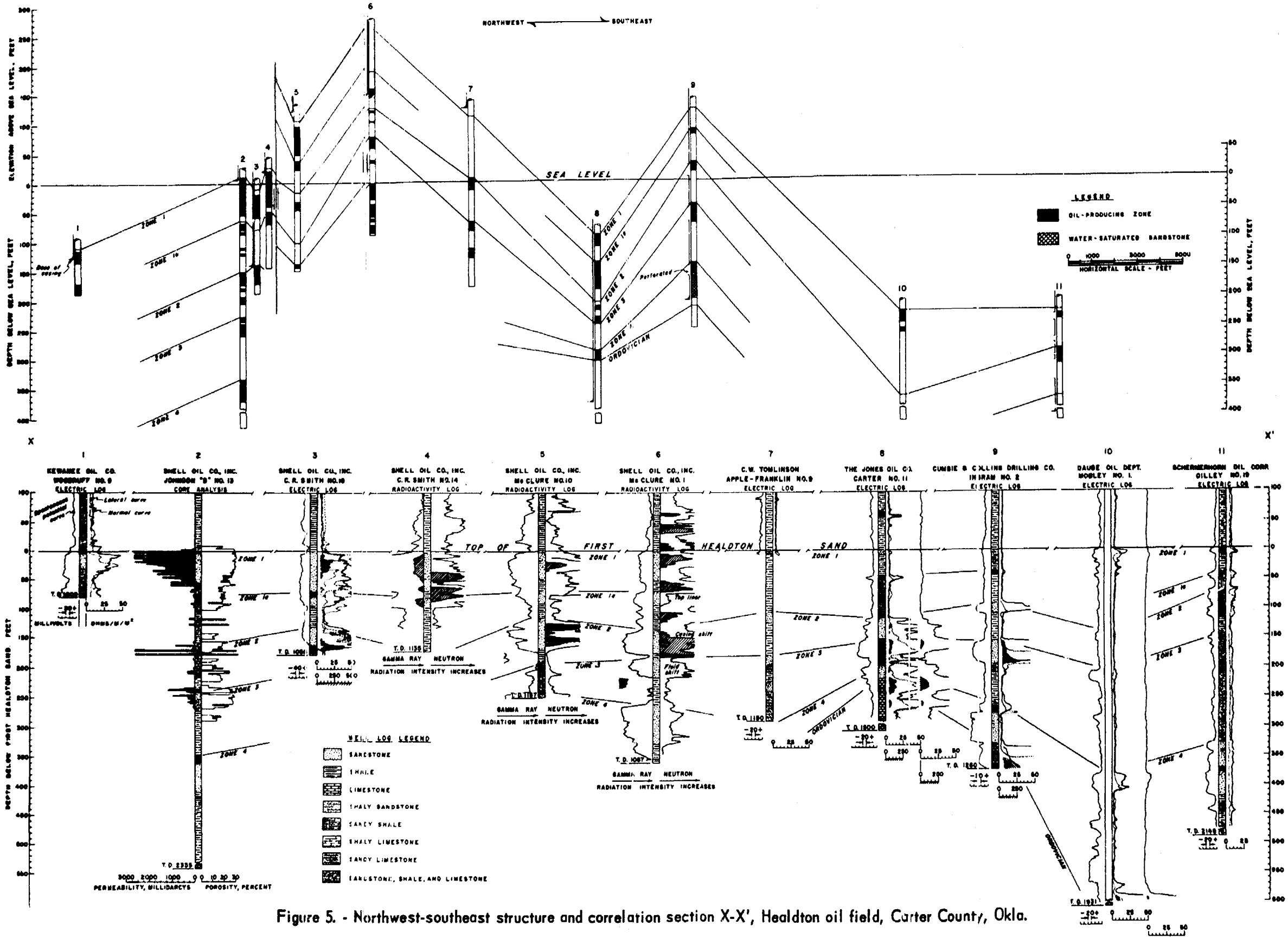


Figure 5. - Northwest-southeast structure and correlation section X-X', Healdton oil field, Carter County, Okla.

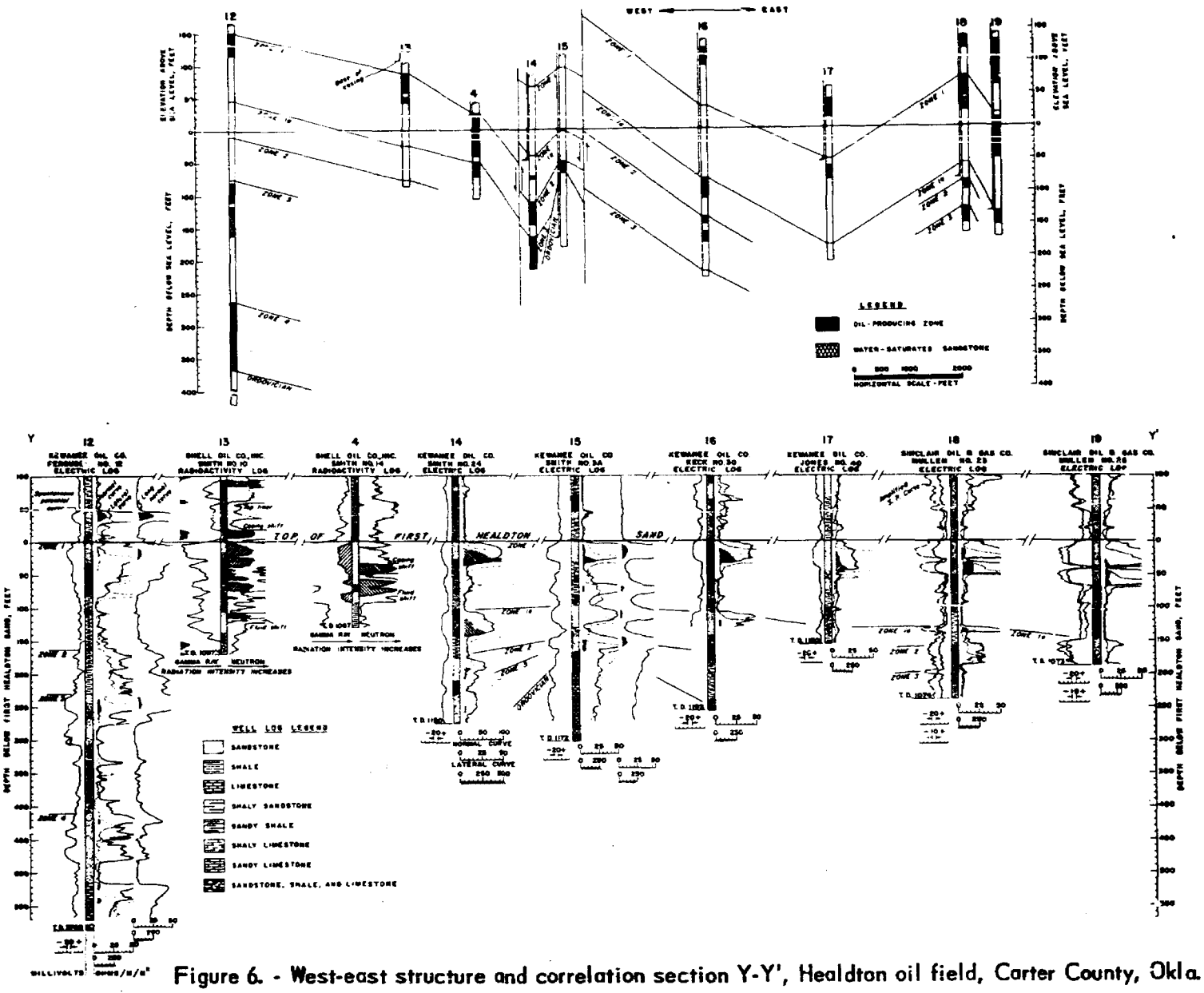


Figure 6. - West-east structure and correlation section Y-Y', Healdton oil field, Carter County, Okla.

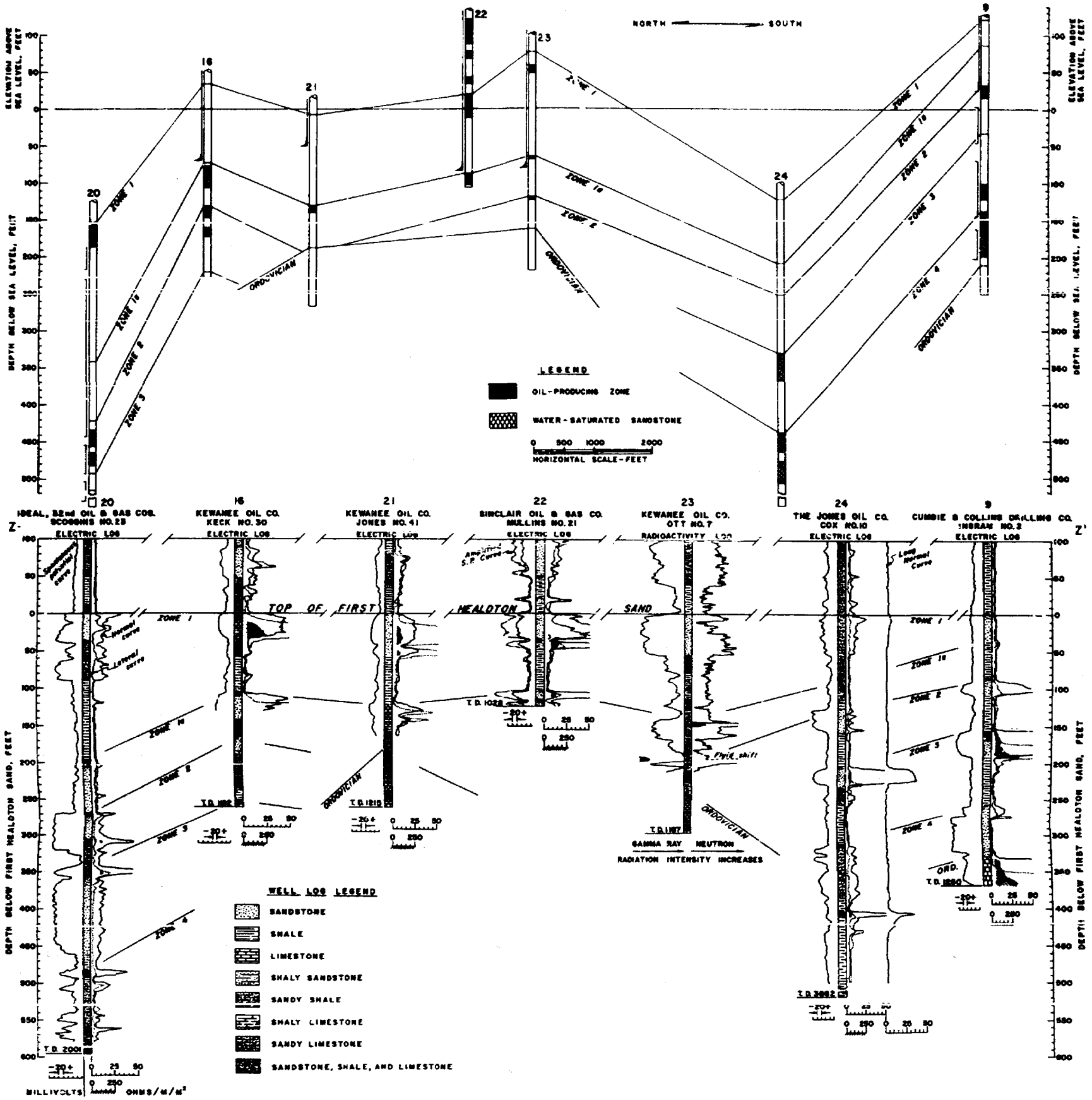


Figure 7. - North-south structure and correlation section Z-Z', Healdton oil field, Carter County, Okla.

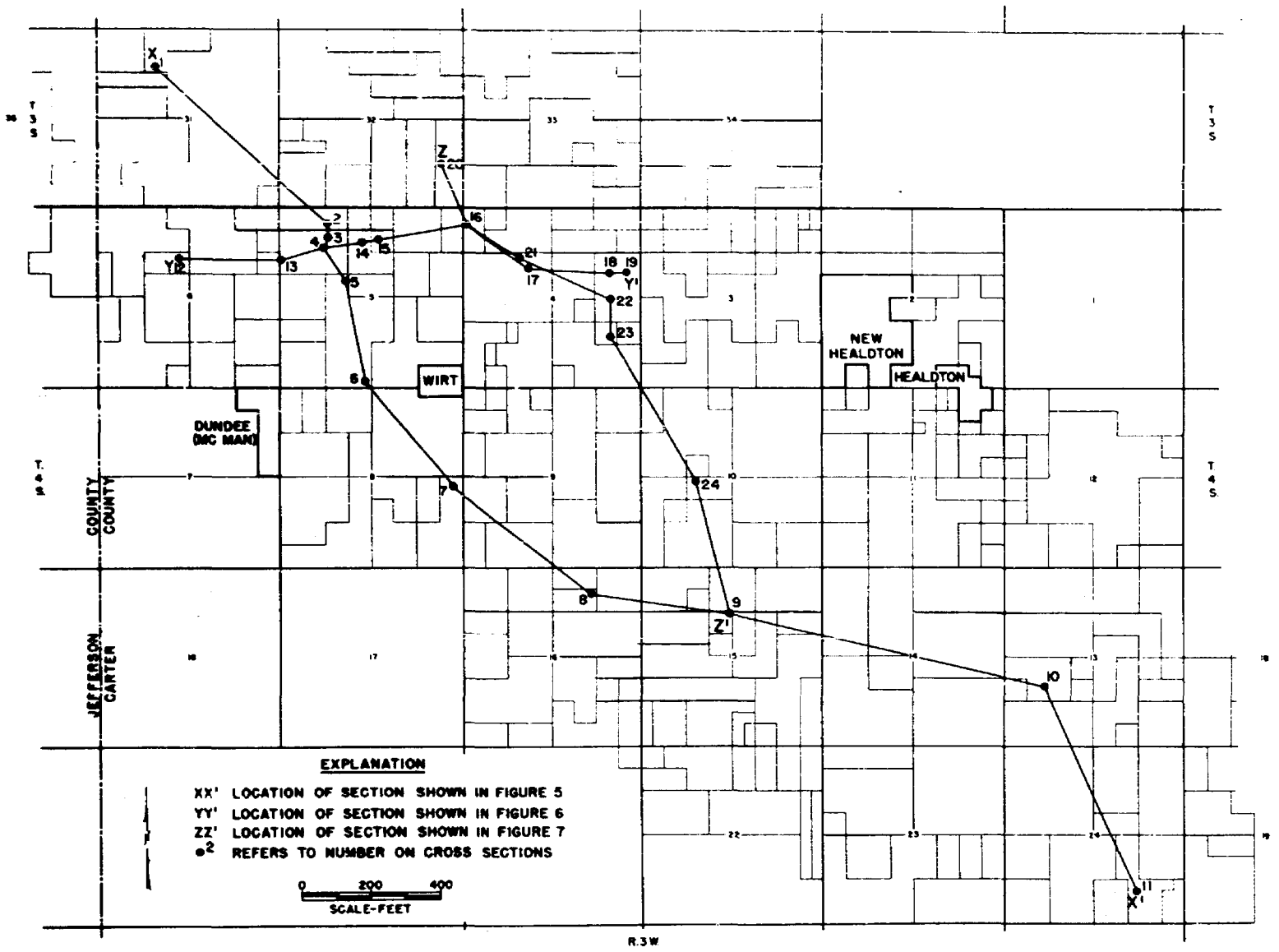


Figure 8. - Location of structure and correlation sections, Healdton oil field, Carter County, Okla.

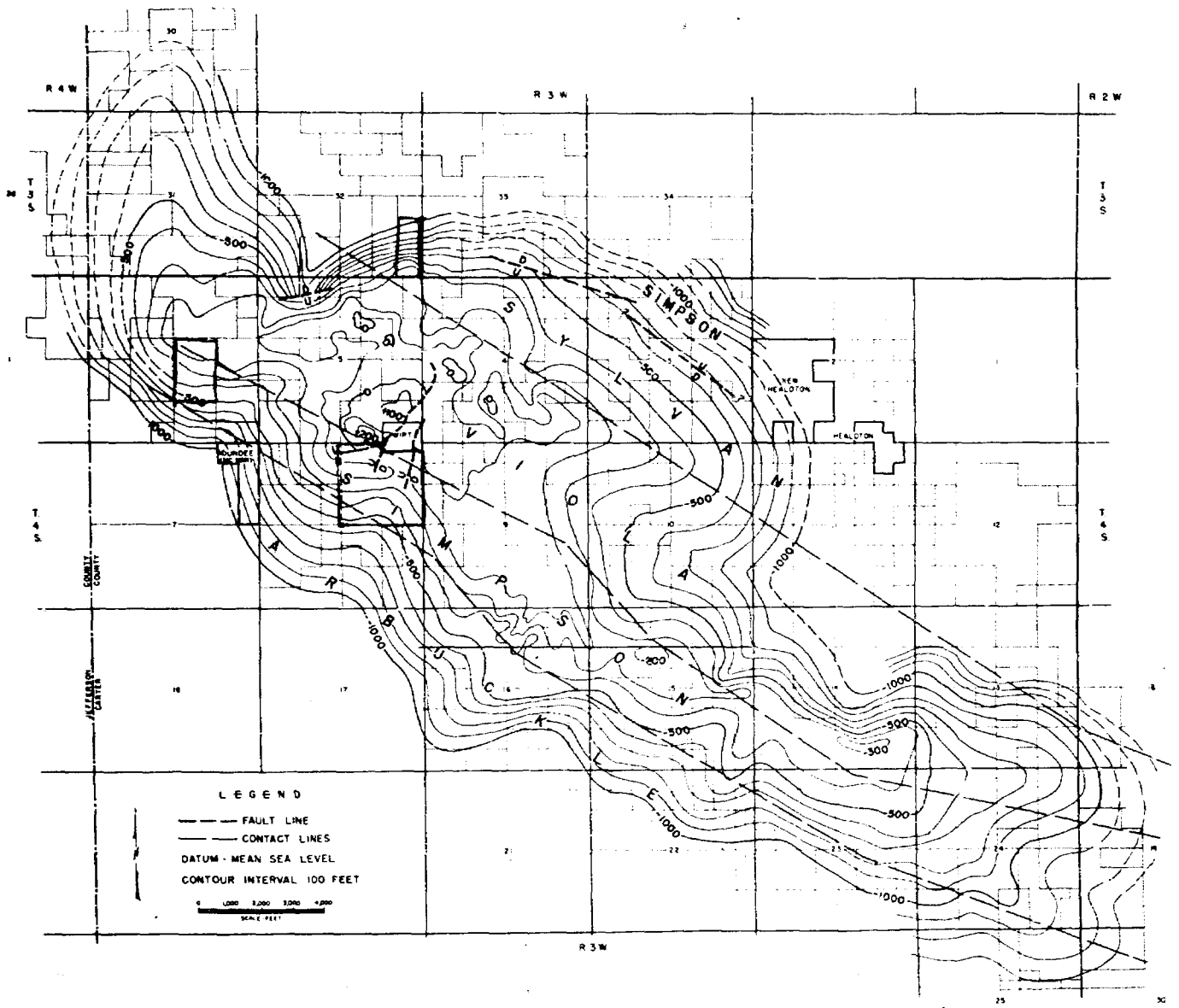


Figure 9. - Structure and geologic map of pre-Pennsylvanian surface, Healdton oil field, Carter County, Okla.

By 1950 about 2,600 wells had been drilled in the Healdton field, and drillers' logs, many of questionable accuracy, of approximately 2,500 of these wells were available for study. Complete or partial electric logs of 132 wells and radioactivity logs of 32 wells were studied. Drill cuttings from 33 wells and analyses of cores from 49 wells were used to interpret reservoir conditions in the Healdton sands. Most of these data were concentrated in the north and central areas of the field, although electric logs and drill cuttings were available for several wells in the eastern and southeastern areas. More data were available for the first than for lower sands, although several wells were electrically logged and cored through all Healdton sands.

The structure and extent of the fourth and other Healdton sands has been studied in 57 cross sections. Figures 5, 6, and 7 are structure and correlation sections across the field northwest to southeast, west to east, and north to south, based upon electric and radioactivity log studies. The locations of cross sections (figs. 5, 6, and 7) are shown on figure 8. Zones 1, 1-A, 2, 3, and 4 have been identified and correlated as separate members, but these correlations picture a simplicity that actually does not exist in the reservoir. Individual sands are lenticular and grade laterally and vertically into shale. In the north-central and northwestern part of the field, several oil-productive stray sands lie stratigraphically above the first Healdton sand.

A core-analysis profile of a well in sec. 5, T. 4 S., R. 3 W., is shown as well 2 in figure 5. The porosities of the sands range between 10 and 33 percent, and the permeabilities between 0 and 3,800 millidarcys.

Figure 9, a structure map with contours drawn on top of the Ordovician, shows the present attitude of the pre-Pennsylvanian surface. Many irregularities shown were present at the time of the Healdton-sand deposition, but others result from post-Hoxbar folding and faulting. This figure also shows, in a general way, the areal geology of the pre-Pennsylvanian surface. Cuttings from deep wells in this area show that the Arbuckle limestone immediately underlies the Pennsylvanian sands in a belt parallel to and southwest of the field. Progressing northeast across the structure, successively younger Ordovician sediments (Simpson, Viola, and Sylvan) are directly overlain by the Pennsylvanian formations. Subsurface investigation in the Healdton area did not include a study of the structure of the Ordovician sediments, except that truncated sections of successively older beds to the southwest indicate that the axis of any such structure would lie considerably southwest of the anticline, as indicated in figure 9. Presumably, the Viola limestone was the resistand member that capped the Healdton hills during the late Pennsylvanian time.

Deep wells on C. W. Tomlinson's Bell and Schermerhorn leases in sec. 3, T. 4 S., R. 3 W., penetrated Simpson formations and not Sylvan shale immediately under the Healdton sands. Apparently a pre-Pennsylvanian fault in this area lifted the older sediments and permitted erosion of the Sylvan and Viola formations before Healdton-sand deposition.

A series of oil-bearing sands overlies the Ordovician beds at the southeast end of the field at depths between 1,200 and 2,000 feet but is not present over the main part of the field. These sands include the "Jackson" sand in sec. 15, T. 4 S., R. 3 W., the "Pugh" sand in sec. 18, T. 4 S., R. 2 W., and the "Westheimer" sands in secs. 24 and 25, T. 4 S., R. 3 W. These sands, which represent a separate oil reservoir, are not included in this study of the Healdton sands.

Fourth Sand

Above the Pugh and Westheimer sands in the southeast extension, and immediately overlying the Ordovician throughout the central part of the field, is a Healdton sand and sandy lime zone, usually separated from the Healdton sands above by 10 to 30 feet of waxy shale. This zone, which is included with the "Simpson" Sand in some localities, can be identified and traced throughout much of the field. In this report it is considered to be the fourth Healdton-sand zone. Usually the top of the zone is marked by thin sandy limestone beds, often glauconitic with small calcareous oolites 0.3 to 5 mm. in diameter, which were formed around subangular quartz grains. A representative section of this fourth sand, penetrated in the Shell Oil Co., Inc., C. L. McClure well 38, sec. 5, T. 4 S., R. 3 W., is described as follows:

	Thickness, feet	Top depth, feet
Limestone, light-gray, sandy, and oolitic	4	1,010
Sand, gray grains 0.2 to 0.4 mm. in diameter, rounded and subangular	14	1,014
Sand, as above, with thin streaks of dark-gray shale	34	1,028
Sand, gray, as above with little white chert	4	1,062
Shale, gray sandy, with many crinoid stem fragments and pelecypod shells	11	1,066
Limestone, gray and light-buff, sandy	18	1,077
Sand, very fine, light-buff	11	1,095
Limestone, gray, sandy	5	1,106
Sandstone, fine-grained, calcareous	6	1,111
Sand, gray, calcareous and fossiliferous	27	1,117
Sand, very fine	7	1,144
Limestone, light-gray with some gray shale	15	1,151
Shale, light-gray, calcareous	17	1,166
Limestone, light-gray, sandy and shaly	2	1,183
----------(Unconformity)----------		
Limestone, white, dense (Ordovician)	-	1,185

For the purposes of this report, the fourth Healdton zone is considered as a separate reservoir, differing from the upper Healdton sands above in that it is under the influence of a rather definite water drive. The extent and effect of this water drive on oil production is discussed under Production.

The top of the fourth Healdton sand ranges from 150 feet above sea level in the northwestern part of the field to 600 feet below sea level at the southeastern edge.

Logs of early wells record water in the fourth sand at depths ranging from 470 feet below sea level in the southeast extension to 180 feet below sea level along the northeast and southwest edges in the main part of the field. Only those wells drilled before 1920 were used to establish the original oil-water contact in the different areas of the field.

Figure 10, an isopachous map of the effective oil-productive thickness of the fourth Healdton sand above the water level, was constructed using the oil-water contact levels in various parts of the field and a structure map of the top of the fourth sand. In general, the thickness of oil-productive beds in the fourth sand zone, as recorded in drillers' logs, compared closely with those shown by electric logs through the section. The fourth sand is absent in large areas (including 750 acres) of secs. 4, 5, 6, and 9, T. 4 S., R. 3 W., where the top of the Ordovician surface is structurally high.

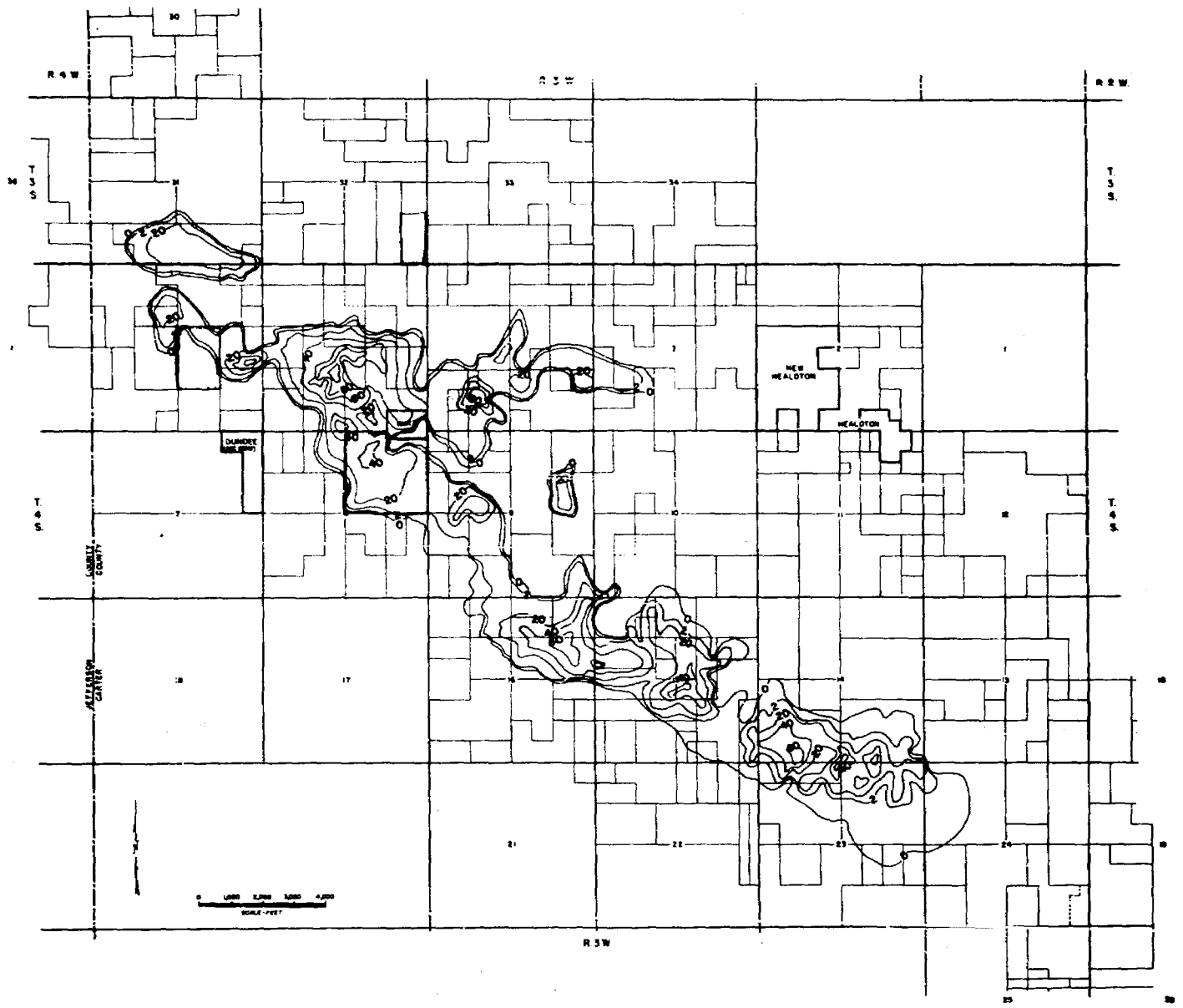


Figure 10. - Effective thickness of fourth Healdton sand, Healdton oil field, Carter County, Okla., 1951.

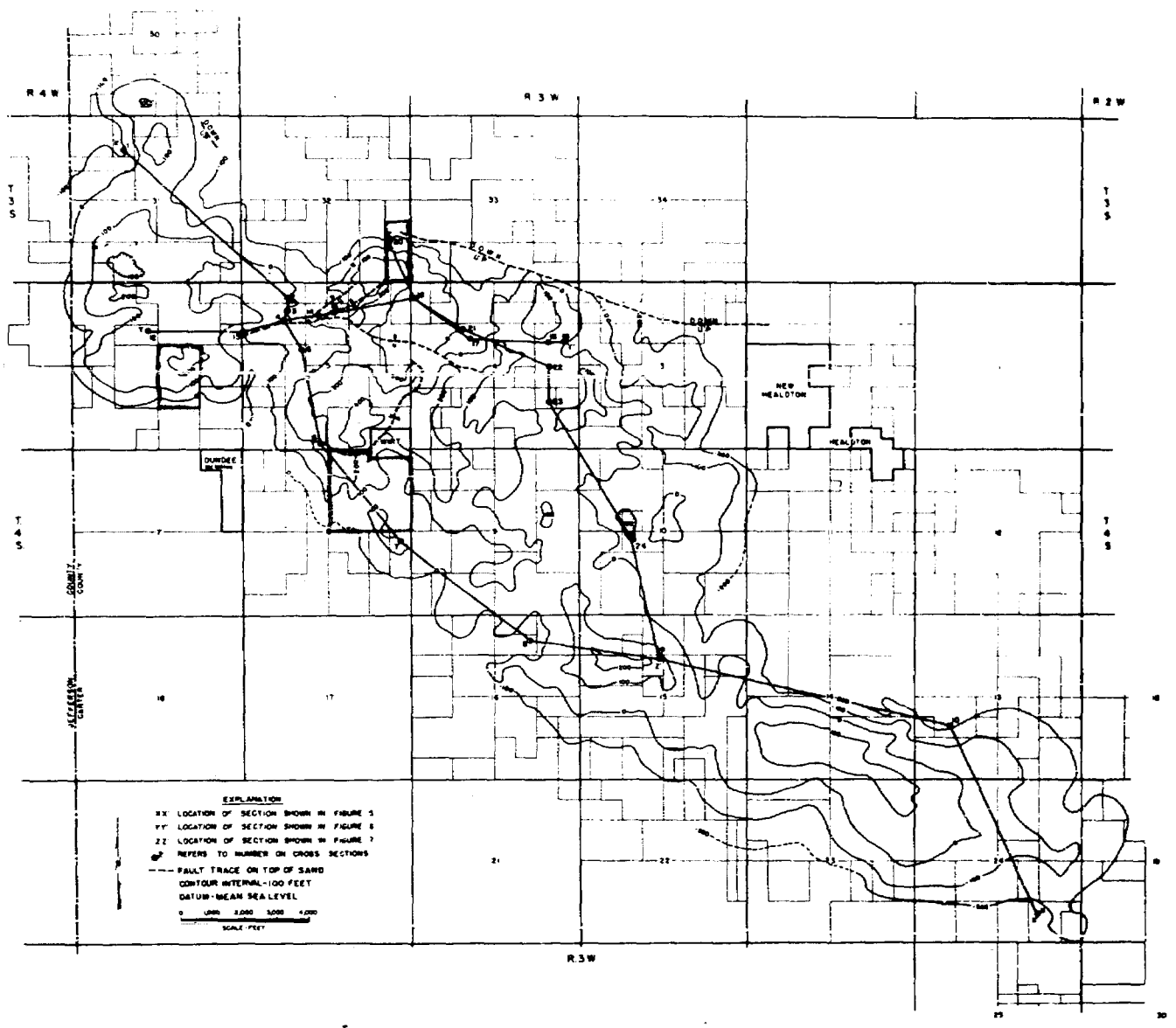


Figure 11. - Structure of the top of first Healdton sand, Healdton oil field, Carter County, Okla., 1951.

The study of well logs and oil-production history of the fourth sand indicates that the actual economically oil-productive area of the fourth sand is substantially less, particularly at the southeast end of the field, than that within the designated oil-water contact line. Actually the oil-water contact is not horizontal but, to a large extent, follows the structure, so that, in an area along the edge of the structure, the water level is close to, although not at the top of, the sand zone. Wells drilled in these areas recorded a thin oil sand, not economically productive, above bottom-hole water. In figure 10 a 2-foot contour line has been drawn inside the oil-water contact line to illustrate the large area where the oil-water contact is near the top of the sand. For practical purposes, only those areas within this 2-foot contour line have been considered as economically oil-productive in estimating reserves in the fourth sand.

The original oil-productive area of the fourth sand covered 1,960 acres. Total thickness ranged from 50 to 75 feet, and the total volume of oil-productive sand was 45,080 acre-feet.

Upper Sands

A contour map (fig. 11) was prepared, with the aid of cross sections, to show the structural attitude of the top of the first Healdton-sand zone. The structure is an anticline 8 miles long and 1 to 3 miles wide, with several local high areas throughout the field and with steep dips on the northwest flank. The total closure is about 500 feet. A study of records of wells in sec. 33, T. 3 S., R. 3 W., and sec. 3, T. 4 S., R. 3 W., indicates a major normal fault along the northeast edge of the field, with a displacement on the north side of approximately 300 feet. In sec. 5, T. 4 S., R. 3 W., a series of faults surround a central upthrown block. Some of these faults may have been caused by differential settling owing to compaction of sediments around topographic highs of the Ordovician surface, but others are the results of deep-seated faulting, which cut the Ordovician limestone. (See figs. 9 and 11.)

Because identification and correlation of individual sand members in wells have been very difficult, all beds above the fourth sand, except for some stray sands in the northwestern part of the field, have been treated as belonging to a common reservoir. Results of infill drilling and gas injection have proved that often shaly zones with little horizontal or vertical permeability separate the productive beds, so that this treatment as a common reservoir, although practical, does not represent all the actual conditions.

The total oil-productive area of the upper sands, as determined from a study of well logs and production records, includes 7,016 of the 7,142 productive acres in the Healdton field. In several structurally high areas of the field upper sands are barren, and oil production was obtained from the fourth sand only.

Throughout most of the field, the top of the fourth sand was taken as the base of the upper sand section, but where the fourth sand was absent the top of the Ordovician limestone was used as the lower limit. A few structurally low wells penetrated bottom water at depths ranging from 142 to 440 feet below sea level and in these areas the water-saturated sand was used as the base of the productive upper sand section.

The upper oil-productive sands were studied in a series of 50-foot zones, beginning at the top of the sand, as indicated in figure 11. All wells penetrated the

first 50-foot zone, fewer wells the second, and progressively fewer each succeeding zone. It is assumed that sands not penetrated in one well yielded gas and some oil to adjacent wells in the immediate vicinity, and, as such, the sand should be considered as a part of the entire reservoir. Many of the wells, particularly the early wells, did not penetrate the complete section. The relatively lower initial production rates of most of the later wells, which penetrated the full section, leads to the general conclusion that most of these unpenetrated sands were depleted of pressure and some oil by the earlier wells. Notable exceptions are those later wells with initial-production rates higher than those of the original wells on the lease.

Six deep wells in the northwestern part of the field penetrated seven 50-foot zones, whereas, in the southeastern part of the field, there were oil-productive sands in only two or three such zones.

Several wells were cored and electrically logged through the upper sands, and comparisons between core analyses and electric logs showed that indentations in the SP and normal resistivity curves represented thin shale beds in the sand section, which should be eliminated from the net oil-productive thickness. Comparison between drillers' logs and electric logs on the same wells showed that beds reported by the drillers as oil sands often contained such shale partings and nonproductive tight streaks. By comparing the electric and drillers' logs, a correction factor of 0.841 was developed, which was applied to the thickness of oil sands recorded in the drillers' logs to estimate the net effective thickness of oil-producing sands in the main part of the field. In the southeastern part of the field, fewer electric logs of wells were available, but drill cuttings were examined microscopically, and the results were used with these electric logs to develop a correction factor of 0.816, which was applied to the thickness of the oil sand in the drillers' logs to estimate the net productive thickness.

Using the net effective thickness of oil sands in those wells that were drilled through each 50-foot zone, net isopachous maps were prepared for each of seven 50-foot zones. From these maps the probable net thickness of unpenetrated sand at each well was read and tabulated. The total net oil-productive thickness at each well was then plotted on a map and contoured.

The total thickness of the upper Healdton beds, which included the oil-productive sands above the fourth sand, ranges from 120 feet on top of the structure to over 500 feet along the flanks of the north end of the field. The total volume of oil-productive upper sands in the entire field is approximately 454,000 acre-feet.

Stray Sands

In certain areas of the Healdton field, oil sands were penetrated at depths above those that generally have been designated as the first Healdton sand. In the northwestern part of the field, it appears from correlation studies that these oil-productive sands are continuous, but in other areas they are discontinuous or absent entirely. During the early development many of these stray sands were cased off by a producing string run to the more productive Healdton sands at greater depths. When a stray sand did appear to be commercially oil-productive, it was left open to production. Studies show that the productive area of the stray sands included approximately 1,420 acres.

The original reserves in two of these productive sands were calculated. Electric and radioactivity logs of the sands showed that what the drillers described as a solid section of productive oil sand, actually contained a large number of shale and limestone partings. From these comparisons the correction factor of 0.841, as described

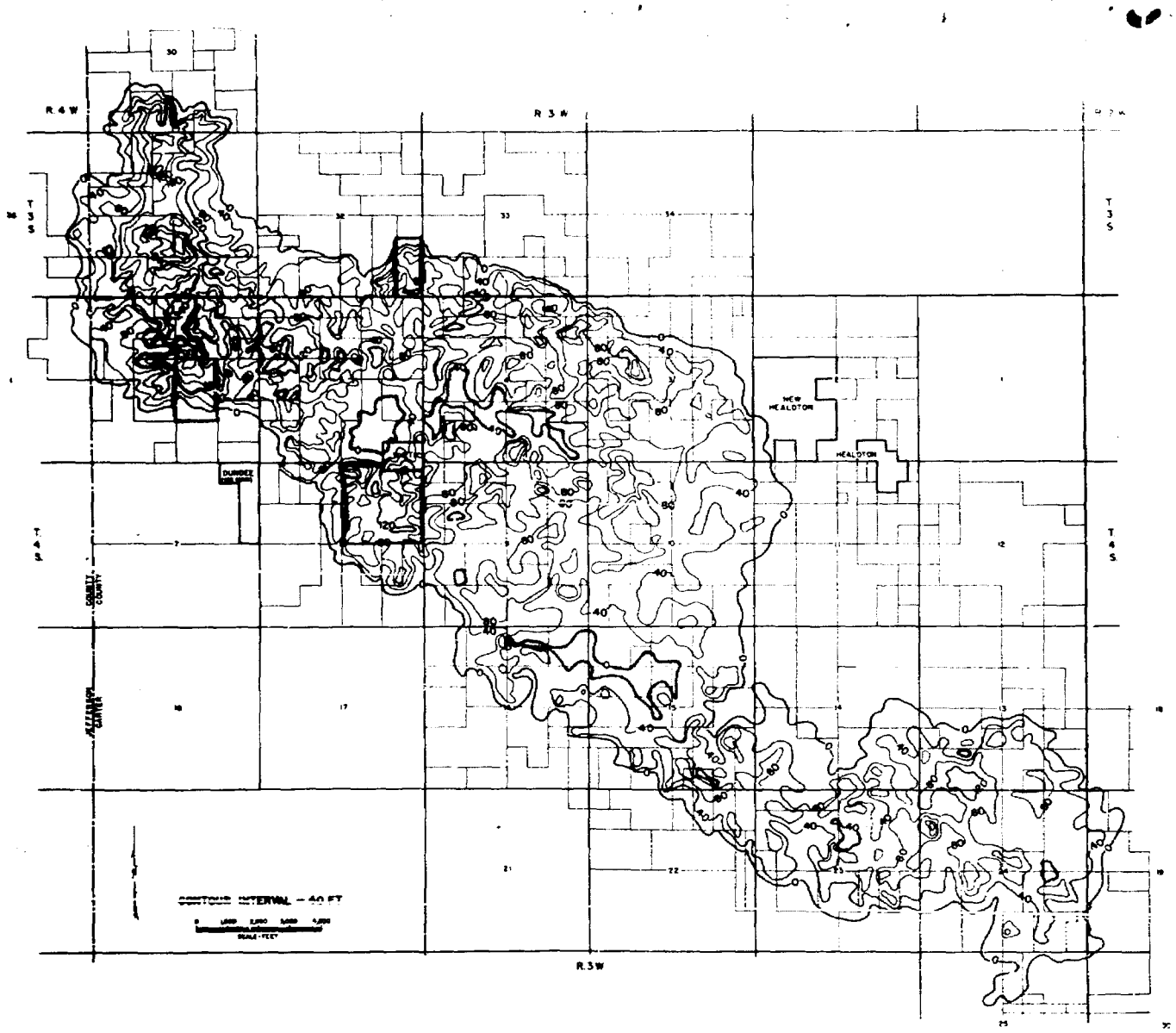
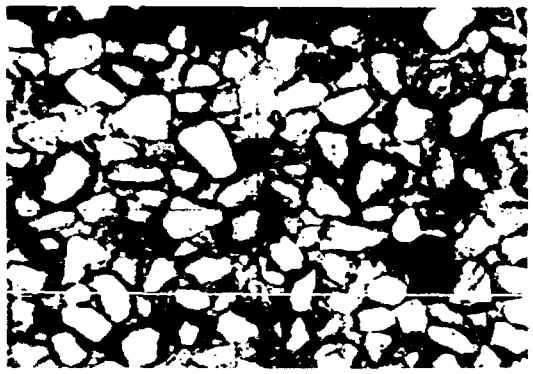
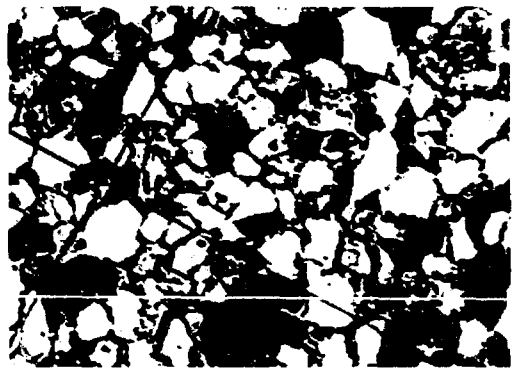


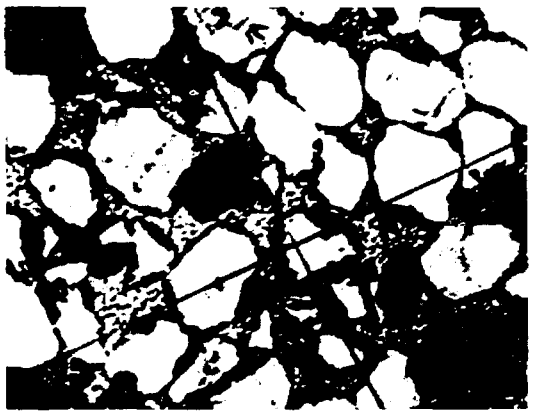
Figure 12. - Effective thickness of oil-productive sands above the fourth Healdton sand, Healdton oil field, Carter County, Okla., 1951.



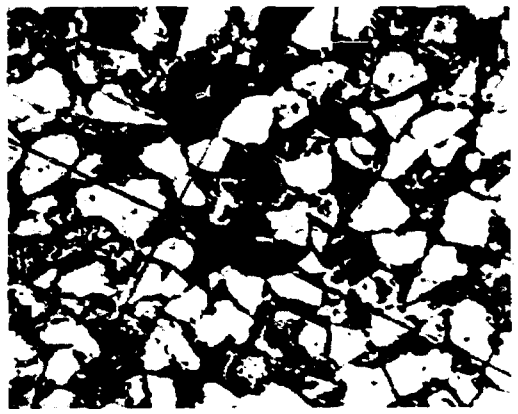
No. 12. Porosity 6.9 pct., Perm. 110 Md. Limestone 34.2 pct., Clay 5.5 pct. Average grain size .241 mm.



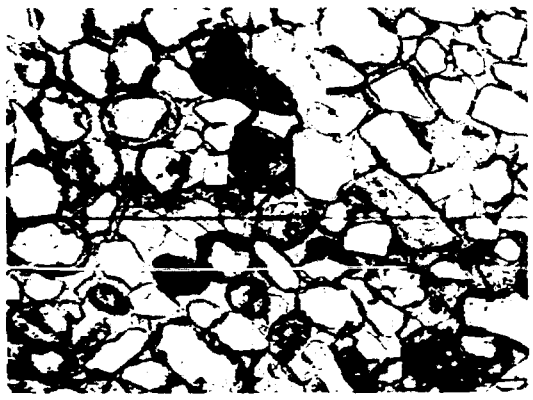
No. 7. Porosity 27.0 pct., Perm. 530 Md. Limestone 3.6 pct., Clay 13.4 pct. Average grain size .151 mm.



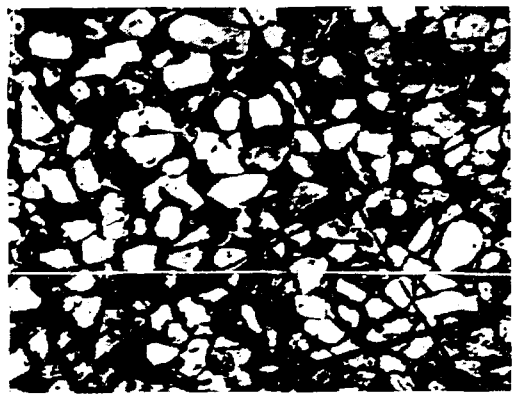
No. 41. Porosity 10.5 pct., Perm. 14 Md. Limestone 33.2 pct., Clay 4.5 pct.



No. 40. Porosity 30.1 pct., Perm. 2900 Md. Limestone Trace, Clay 16.5 pct. Average grain size .255 mm.



No. 34. Porosity 8.7 pct., Perm. 7.1 Md. Limestone 37.1 pct., Clay 4.1 pct. Average grain size .181 mm.



No. 31. Porosity 29.1 pct., Perm. 740 Md. Limestone 7.6 pct., Clay 2.2 pct. Average grain size .166 mm.

Figure 13. - Plastic-impregnated core samples of Healdton sands.

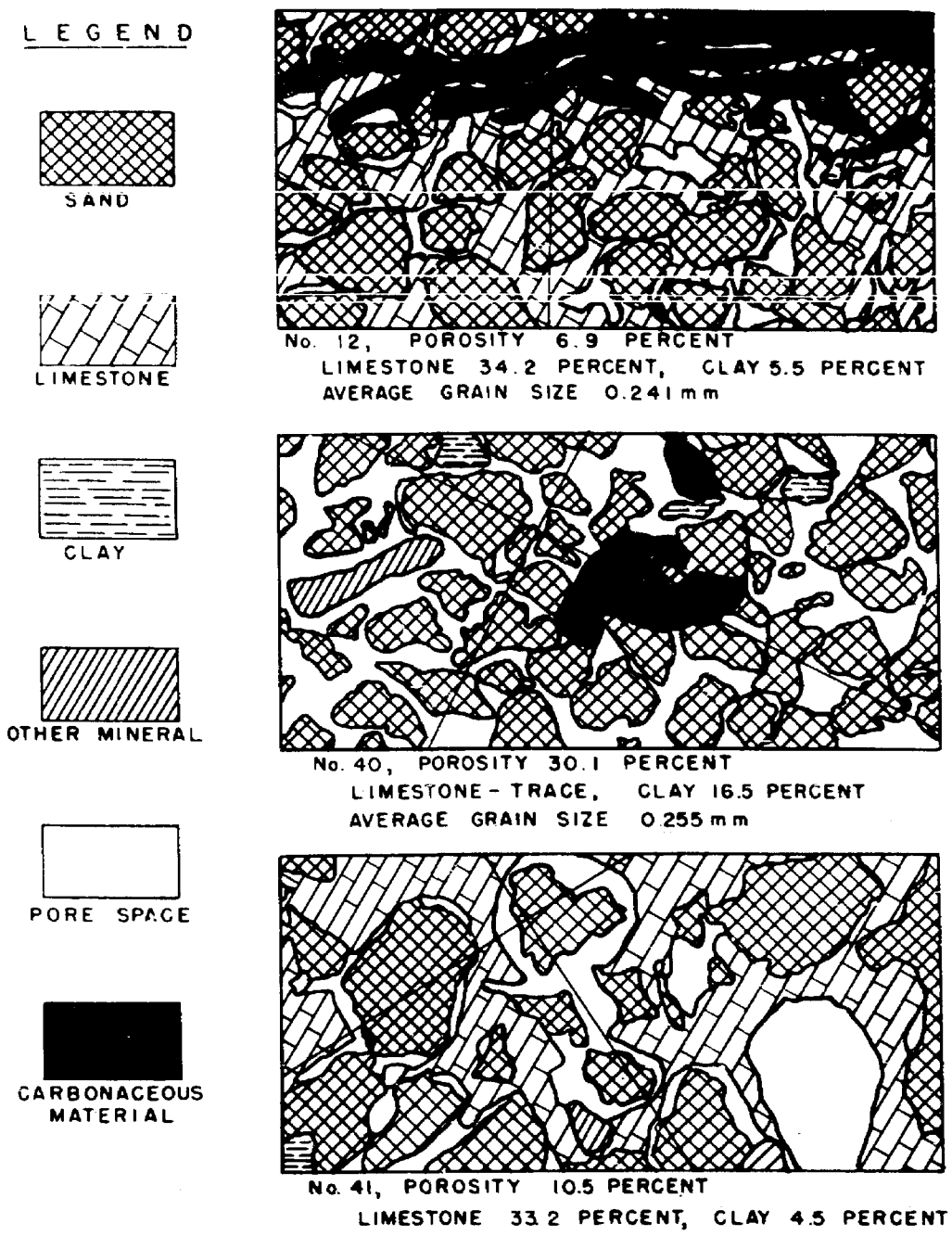


Figure 13A. - Arrangement of mineral grains and pore spaces in Healdton oil sands, Carter County, Okla.

earlier, was applied to recorded thicknesses in the drillers' logs. Total thickness of stray sands ranged up to 70 feet. Calculations indicate that the total oil-productive portion of the stray sands is about 18,900 acre-feet.

Figure 12 is an isopachous map, which shows the total net effective thickness of all oil-productive sands above the fourth sand, including upper sands and stray sands, which range in thickness up to 320 feet. The thicker sands occur throughout the north-central part of the field, and the thinner sands lie along the edges and in the southeast extension. For individual leases, the net average effective thickness of all oil-productive sands above the fourth sand ranged from 4 to 177 feet.

Lithology

In general, the first sand zone includes fine-grained, loosely cemented sand and shaly sand, whereas the lower sand zones contain more limestone. Several core samples from these sands were analyzed in the Bureau of Mines laboratories, and the results of measurements on these cores are summarized in table 5. Clean cores were saturated under vacuum with formation brine, but in most instances the cores could not be saturated to 100 percent of the pore volume as determined by gas expansion. The fraction of the total pore volume thus saturated with brine ranged from 0.57 to 1.0 and appears in column 4 of the table. The resistivity of the brine-saturated core to the flow of an electrical current of approximately 30 milliamperes was determined, and the ratio between this resistivity and that of the brine alone at the same temperature (about 78° F.) is shown in column 5 as Formation factor. The saturating brine was displaced (restored-state method) from the cores with nitrogen at pressures up to 50 p.s.i., and the water remaining in the core is assumed to be representative of the connate water.5/ The percentage of the pore volume, ranging from 4.3 to 71.7, that remained filled with this connate water is shown in column 6. The clay and limestone content of the core samples, as shown in columns 7 and 8, was determined by sodium peroxide and acid separation; and the average size of the remaining sand grains, as shown in column 9, was determined by sieve analysis and microscopic measurements. A lithologic description of the core is shown in column 10.

In addition to the routine laboratory measurements on consolidated core samples, the sedimentation method was used to determine the porosities of unconsolidated, or loosely consolidated sands, which make up a large percent of the Healdton sands. In this method, described by Rockwood (12), clay and limestone are removed from the sample, and the clean sand is sedimented in water. Corrections of the observed porosity are then made, depending on the percentage of clay and limestone. The "sedimented porosity" of five samples ranged between 26 and 30 percent and is related to grain-size distribution and clay and limestone content.

Fifteen core samples were impregnatad with plastic by a method outlined by Lockwood (13), and thin sections were prepared for microscopic study. Photomicrographs of six of these plastic-impregnated core samples are shown in figure 13. Figure 13a is a drawing of three enlarged photomicrographs, cores 12, 40, and 41, showing the composition and the relation of pore spaces to sand grains and cementing material.

5/ As used in this report the term "connate water" is defined as minimum water saturation; that quantity of water coexisting with oil in a water-wet reservoir rock at initiation of exploitation and maintained by capillary forces that equal or exceed displacing gravitational forces.

TABLE 5.--Laboratory measurements on Healdton sand core samples, Healdton field, Carter County, Okla.

Core No.	Porosity, percent	Permeability, millidarcys	Maximum brine saturation,[1] fraction of pore space	Formation factor[2]	Connate water, percent of pore space[3]	Clay, volume percent	Limestone, volume percent	Average grain size, mm.	Core description
1	2	3	4	5	6	7	8	9	10
						First sand			
1	27.6	260	0.86	8.93	27.8	14.3	5.0	-	Fine, hd. sd. - sh. stk. - mod. to well-cem.
2	20.1	210	.74	11.07	36.7	13.3	8.9	-	Very shy. sd. - mod. to well-cem.
3	17.1	73	.78	14.55	38.4	14.8	11.8	-	-
4	18.5	-	-	15.16	-	-	-	-	-
5	29.0	4,200	.76	6.24	11.3	8.4	3.2	0.326	Fine sd. - loosely cem.
6	27.6	-	.92	5.77	24.7	-	-	.176	Do.
7	27.0	530	.77	8.53	15.4	13.4	3.6	.151	Fine sd. - mod. to well cem.
8	21.6	-	.80	6.37	28.1	24.8	6.6	.159	Fine sd. - sh. stk., - fri., loosely cem.
9	27.8	1,300	.67	11.44	16.8	9.9	4.3	.184	Fine sd. - sh. stk., mod. cem.
10	20.8	-	.78	9.45	43.6	29.8	6.5	-	Laminated sh. and sd.
11	19.1	21	.00	13.10	18.6	20.1	4.2	.134	Shy. sd. - mod. cem.
12	6.9	110	.94	45.41	34.3	5.5	34.2	.241	Hd. sd. - (limestone?) very dense.
13	2.3	.1	.61	192.25	71.7	3.2	42.9	-	hd. limestone.
14	30.5	-	.89	6.24	10.2	5.0	1.8	-	Sd. - loosely cem.
15	27.2	770	.81	9.47	14.2	10.5	10.7	-	Fine sd. - mod. cem.
16	29.5	-	.88	6.54	11.9	8.3	5.6	-	Fine sd. - little sh. stk. - very loosely cem.
17	30.3	-	.91	9.56	10.4	6.5	2.9	-	Fine sd. - loosely cem.
18	30.1	3,500	.87	6.26	12.9	7.1	3.2	-	Fine sd. - very fri. - loosely cem.
19	30.6	1,100	.91	6.64	11.3	5.7	3.7	-	Fine sd. - few sh. inclusions - loosely cem.
20	28.3	3,200	.96	6.53	10.9	5.3	3.5	-	Fine sd. - thin sh. stks. - loosely cem.
21	29.9	-	.86	5.47	11.7	6.0	3.7	-	Fine sd. - very fri., - very loosely cem.
22	29.8	1,700	.91	6.52	11.9	7.4	3.7	-	Fine sd. - fri., - loosely cem.
23	29.2	-	.83	8.72	11.7	8.7	5.4	-	Fine sd. - very loosely cem.
24	25.7	-	.90	7.28	9.7	7.1	4.3	-	Fine sd. - loosely cem.
25	28.4	1,900	.93	4.98	11.3	7.6	4.7	-	Fine sd. - very loosely cem.
26	25.3	600	.76	8.10	13.6	9.8	10.0	-	Sdy. sh. - stk. of sd. in sh. - loosely cem.
27	13.2	18	.95	34.94	5.7	-	-	-	Fine to med. sd. - mod. to well-cem.
28	26.3	1,600	.93	7.77	11.5	-	-	-	-
						Second sand			
29	24.9	760	1.00	7.71	15.2	4.2	7.6	-	Hd., fine sd. - mod. to well-cem.
30	28.8	270	.73	12.50	14.4	11.3	2.4	-	Fine sd. - well-cem.
31	29.1	740	.72	11.52	7.1	2.2	7.6	0.166	Fine sd. - mod. to well-cem.
32	11.9	3.7	.95	34.63	23.6	3.5	31.2	-	Sd., - dense , - well cem.
33	20.7	170	.79	9.55	6.1	4.6	21.2	.153	-
34	8.7	7.1	.97	45.72	24.2	4.1	37.1	.181	Hd., dense, fine sd. - well cem.
35	14.0	-	.63	14.46	16.5	3.4	66.8	-	Fine sd. - very loosely cem.
36	8.8	.3	.57	106.53	54.4	17.4	67.3	-	Fine sd. - well cem.
						Third sand			
37	27.1	450	0.77	10.09	14.8	8.8	2.5	-	Fine to med. sd. - mod. to well-cem.
38	27.4	-	.77	9.07	12.3	12.5	2.6	-	Fine to med. sd. - thin sh stk. - mod. cem.
39	27.1	2,600	.89	6.81	13.2	6.9	21.3	0.246	-
40	30.1	2,900	.94	6.27	8.1	16.5	0	.255	Med. sd. - loosely cem.
						Fourth sand			
41	10.5	0.4	0.62	71.40	56.2	4.5	33.2	-	Tight cal. ss.
42	27.3	870	.81	7.00	11.9	9.2	6.5	0.200	Fine to med. sd. - mod. to well cem.
43	30.1	620	.83	12.60	7.0	-	-	-	-
44	27.7	525	.87	9.90	7.8	-	-	-	Coarse sd. - sh. laminations.
45	25.8	630	.91	10.16	16.3	-	-	-	Coarse sd.
46	28.7	1,200	.96	8.10	10.0	-	-	-	Med. sd. - very little sh. - some mica.
47	27.9	520	.89	6.90	14.4	-	-	-	Fine to med. sd. - some limestone.
48	8.5	2	1.00	65.60	32.4	-	-	-	Dense ss. with included limestone.
49	9.8	9	.96	56.30	34.3	-	-	-	Dense ss. - many cal. fossil fragments.
50	15.1	12	.94	35.90	21.0	-	-	-	Coarse cal. ss. - some oolites.
51	25.7	500	.89	11.20	15.2	-	-	-	Hard, cal., fine to med. ss. - some mica.
52	29.5	1,350	.84	8.60	4.3	-	-	-	-
53	32.5	1,450	.79	8.10	11.9	-	-	-	-
54	31.8	640	.86	8.90	11.0	-	-	-	Very fri. ss.
55	26.8	640	.87	12.30	11.0	-	-	-	Cal. ss., coarse.
56	27.9	1,050	.88	10.00	8.3	-	-	-	Fine rounded ss. - very little sh. or mica.
57	28.2	700	.90	12.50	13.6	-	-	-	Med. to coarse sd. - fri., loosely cem.
58	26.6	350	.84	12.80	16.3	-	-	-	Dark, fine grained sh. ss. - micaceous, loosely cem.

1/ Saturated in laboratory under vacuum.

2/ Formation Factor = $\frac{\text{Resistivity of core at maximum brine saturation}}{\text{Resistivity of brine}}$

3/ By Restored State method, displacement at 50 p.s.i.

Explanation of abbreviations

cal. - calcareous; cem. - cemented; dn. - dense; fri.- friable; hd. - hard; med.- medium; mod. - moderate; sd. - sand; sdy. - sandy; sh. - shale; shy. - shaly; ss. - sandstone; stk. - streaks

Core 12, taken from the first Healdton sand, shows streaks of carbonaceous material in the oil sand that was not removed by toluene extraction of the core. The core contains a large percentage of limestone, which surrounds the sand grains and appears in the photograph as dark areas or lines surrounding the individual sand grains. Most of the interstitial spaces are filled with limestone cementing material. A few scattered particles of clay are present, but almost no clay cementing material.

Core 7 shows a more porous and permeable sandstone containing comparatively little limestone. Although the grains vary considerably in size, average grain size is somewhat less than in the former core. Core 7 contains a large percentage of clay, which appears brown under the microscope but black in the photograph. Pore spaces between the sand grains appear as speckled areas.

Core 41 shows large sand grains with considerable limestone cementing material between the grains. In the photograph the pore spaces appear as dark areas, whereas the mottled area between the grains is limestone cementing material. The pore spaces are almost entirely in areas surrounding individual grains. In the lower right corner is a large pore space that may have been the result of the removal of a sand grain during grinding.

Little cementing material is present in core 40, and most of the space between the grains is filled with plastic. One of the dark areas near the center of the photograph is carbonaceous material; the other is an unidentified dark mineral. Shale appears as dark spots scattered throughout the photograph. Core 34 is a dense, calcareous sand with a few isolated pore spaces surrounding the sand grains. Some oolites are present. Core 31 is a fine-grained sand with angular, well-sorted grains and large, interconnected pore spaces.

These thin sections and the physical measurements shown in table 5 illustrate the wide range in character of the Healdton sands. Core 40 has large, open pore spaces, permitting a comparatively low connate-water saturation, whereas, in core 41, the pore spaces surrounding the individual grains are small and disconnected, resulting in a much higher connate-water saturation.

Porosity

Cores from 49 wells in several areas of the Healdton oil field have been analyzed. These core analyses show that the porosity of the oil sand ranges from 12 to 35 percent. Many of the later wells have been electrically logged. For a few wells, core analyses and electric logs through the same producing sands were available, so that the electrical properties of the sands could be compared with laboratory measurements on the cores. Attempts to calculate porosity from log resistivity by Archie's formulas (14) proved unsatisfactory. (See Appendix.) However, electric logs did give some qualitative idea as to the nature of the producing sand and, with certain limitations, were used for porosity estimates.

From many indications the porosity of the fourth sand is more consistent than that of the upper sands. Core analyses through this sand in three wells show average porosities between 20.8 and 25.5 percent. Porosities estimated with the aid of electric logs range from 20 to 24 percent. From these data a weighted average porosity of 21.3 percent was taken as representative of the oil-productive section of the fourth sand and was used in reserve calculations for this sand throughout the field.

It is more difficult to estimate the porosity of the upper sands underlying the leases throughout the field. Cores and electric logs were taken on only 27 leases in

the more prolific parts of the field, and these do not provide enough data to construct a porosity map of the upper sands throughout the field. Likewise a field-wide average porosity based upon analyzed cores and estimations from electric logs would give a value too high for much of the field and too low for a few prolific leases. Drillers' logs and production records indicate that the porosity of the sands does vary greatly, so that reserve estimates for individual leases based upon a field-wide average porosity would be inaccurate. To obtain reasonable reserve estimates, some indirect method was needed for estimating the porosity of the sands underlying each individual lease.

To some extent, the initial daily oil production per foot of penetrated sand reflects the character of that sand; and, with certain limitations, the initial production can be used to estimate the relative porosity of the sand surrounding that well. In estimating porosity, a method similar to that described by Fox, Thigpen, Ginter, and Alden (15) was followed. The initial potentials of the first few wells on each lease were studied, considering drainage area and probable interference of other wells. An average porosity value was calculated for each of the 27 leases mentioned above on which some reliable porosity data were available. These average porosities were plotted on semilogrithmic paper against the square root of the average initial oil production per foot of penetrated sand (fig. 14). Although the points are widely scattered because cored wells may not be representative of the entire lease, a general relationship is apparent. Average initial production is higher for those leases with more porous sands. This graph was used with initial-oil-production data to estimate probable porosity of the upper oil sands on 180 other leases in the field. Based on the study of many upper Healdton-sand cores, which rarely showed porosity values greater than 32 percent, an estimated porosity of 32 percent was fixed as the highest average value likely to be representative of the best leases. Estimated lease porosities read from this graph ranged from 31.8 percent for an average initial oil production of 11 barrels per day per foot of open sand to 12 percent for 1/2 barrel per day per foot of open sand.

No porosity measurements were made on stray sands; and, in the absence of suitable core data, the following rough method was used to approximate the average porosity of the stray sands underlying each lease. Drillers' logs describe "good oil sand," "oil sand," "fair oil sand," "oil sand tight," and "poor oil sand" in these stray sand zones. By comparing drillers' log descriptions of other sands with the core analyses on the same sand, a quantitative porosity value was assigned to each descriptive term. Using this comparison as a basis, the porosity of the stray sands in each well was estimated and averaged for the lease.

Reservoir Fluids

Water

Nearly all sands in structurally low areas along the flanks of the field were water-saturated originally. In the fourth sand, the oil-water contact has been drawn from well data and is shown as the limiting line in figure 10. This oil-water contact in the fourth sand ranges from about 180 feet below sea level in the north end of the field to 470 feet below sea level along the southwest flank in the southeast extension. This original oil-water contact in the fourth sand has been fairly well established, and the advance of water as the oil was produced has been traced and will be discussed later in the section under Production.

In the main part of the field, no definite oil-water contact has been established in the upper Healdton sands above the fourth sand. Along the edges of the field, upper

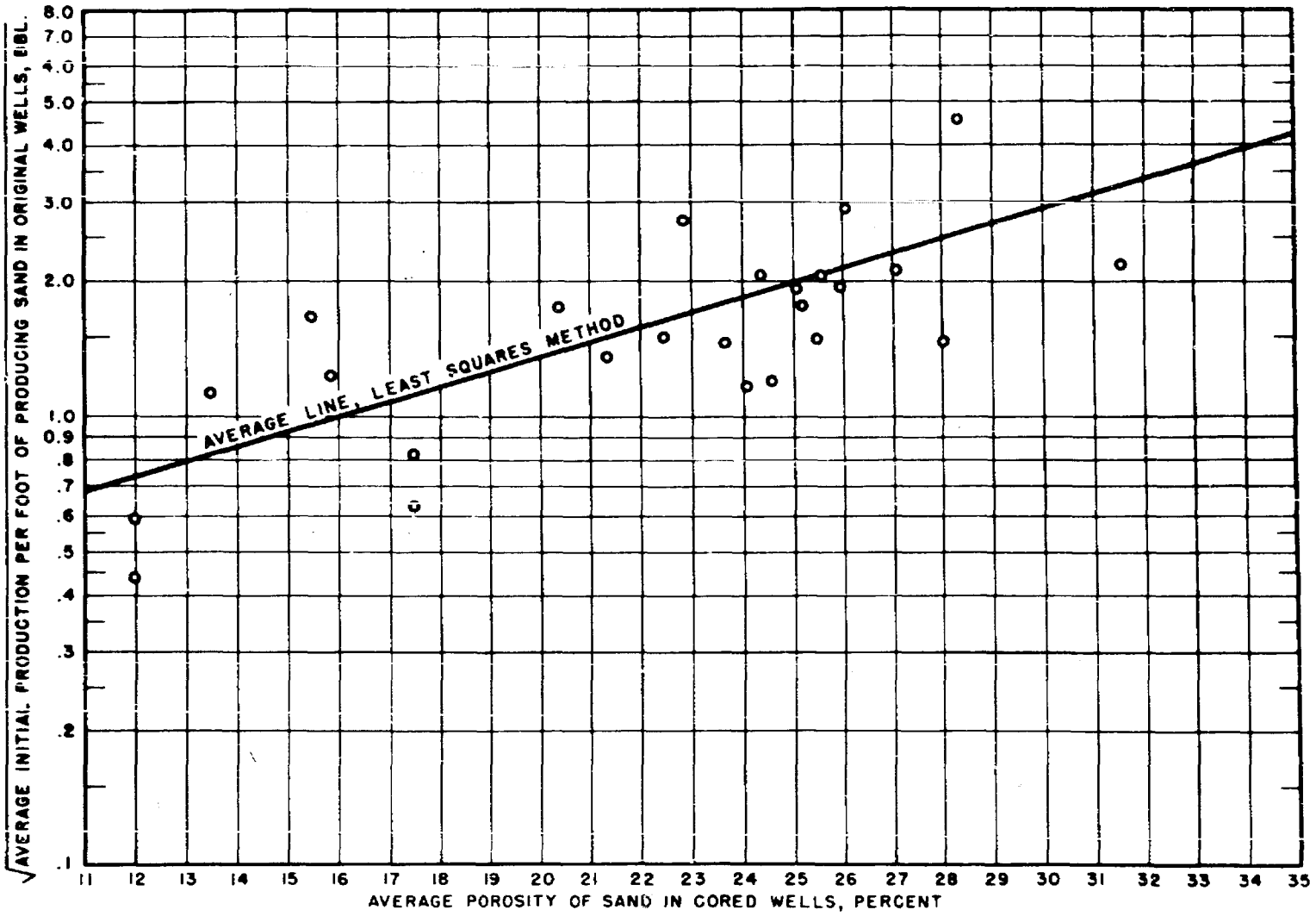


Figure 14. - Relationship between average porosity of sand in cored wells and the average initial production per foot of producing sand in original wells on the lease.

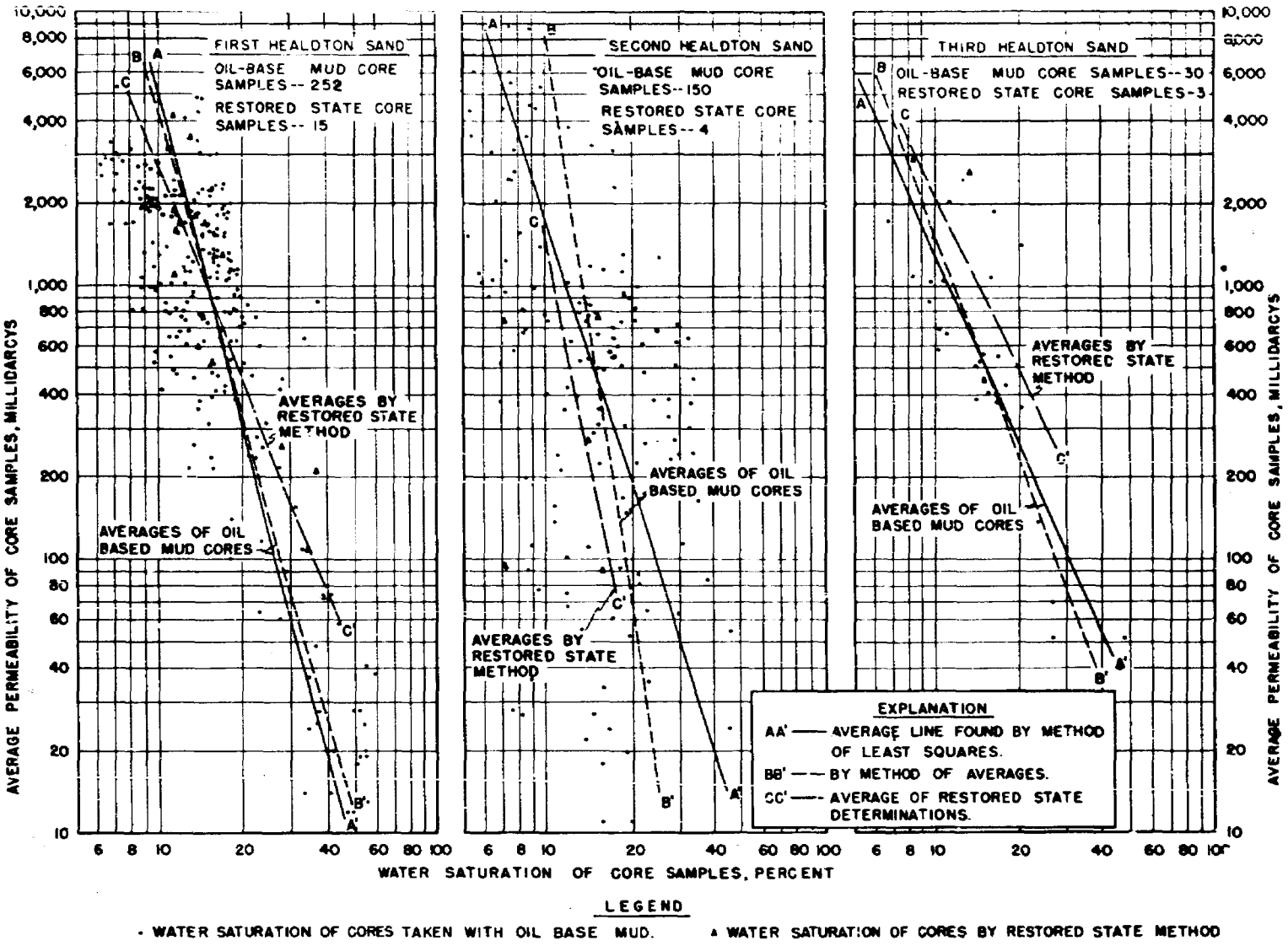


Figure 15. - Relationship between connate-water saturation and permeability in the first, second, and third Healdton sands, Healdton oil field, Carter County, Okla.

Healdton sands that were penetrated in early wells were water saturated at depths ranging from 110 to 430 feet below sea level. A study of these data shows that the water level follows in general the structural pattern but exhibits less relief. However, the water level was not consistent in depth locally, and many wells produced water-free oil from sands at depths below those of the water-producing sands in adjacent wells. After continued production, the water has become depleted. Water production from the upper sands will be more fully discussed under Production.

Above the oil-water contact and above a transition zone of indefinite thickness, the water in the sand is connate water as defined on page 12. To estimate the amount of oil originally in place in the several sands, it was necessary to calculate the percent of the pore space originally filled with connate water. In the Healdton oil field nine wells were cored with oil-base mud, and the connate-water saturation was determined by the operators on a total of 502 core samples from the several sands. The connate-water saturation of 57 core samples was measured in the Bureau of Mines laboratory by the restored-state method. These data have been used to construct figure 15, which shows the relationship between permeability and connate-water saturation.

Of 317 core samples obtained by coring the first Healdton sand, several showed abnormally high or low water saturation and were eliminated from consideration. In all, 252 determinations of the connate-water saturation of first sand cores cut with oil-base mud have been plotted against the corresponding permeability in the left section of figure 15. The scattering of points is at once apparent. Two lines, A and B, have been drawn by two mathematical methods to represent the locus of the average connate-water saturation of these oil-base mud cores. These lines show fairly close agreement and indicate the decrease in connate-water content with increasing permeability. Line C represents the locus of average connate-water saturation, as determined on 15 cores by the restored-state method.

Permeability is only one of several factors that control the connate-water saturation in the pendant zone above the oil-water contact. As discussed earlier, the size, shape, and interconnection of the individual pore spaces are important factors. Measurements of grain size and clay and limestone content were compared with the measured connate-water saturation to determine the possible effect of these variables upon the connate-water saturation, as determined by the restored-state method, but no conclusions could be drawn from the available data.

Permeability and connate-water data for the second and third Healdton sands were assembled and plotted in the center and right section of figure 15. Although fewer data were available for the second sand, it is apparent from lines A, B, and C that somewhat less connate-water saturation can be expected in the second than in the first Healdton sand. The sparse data available for the third Healdton sand indicate a somewhat greater variation in connate-water saturation with different permeability than for the first or second Healdton sands. No data were available as to the permeability-connate-water relationships for the fourth sand. Comparison of the three graphs shows that, with a permeability of 1,000 millidarcys, the first sand would have an average connate-water saturation of 15 percent, the second sand 11 percent, and the third sand 12 percent.

Cores used to construct figure 15 were obtained from a few wells on several leases in the western part of the field, but definite data regarding the connate-water content of the upper sands underlying most of the leases are not available. In the absence of connate water-saturation values for each lease, data from figure 15 were

considered applicable to upper sands throughout the field. These data show that connate water is related to permeability and porosity, although it differs slightly for the several sand zones. Based upon the relative percentages of first, second, and third sands underlying the several leases and upon an average permeability estimated from the assigned porosity, a weighted average connate-water saturation was assigned to each lease and used in calculations of the oil originally in place in the upper sands for each lease.

No connate-water data were available for the fourth sand, so a round figure of 20 percent of the pore space was assumed for the average connate-water saturation of that sand.

Apparently the stray sands resemble the first Healdton sand in character; and, since no data as to connate water in the strays were available, a connate-water content of 19 percent, corresponding to a permeability of 500 millidarcys, from first-sand data, was assigned to all oil-productive stray sands in calculating the volume of oil originally in place.

Reservoir Oil

Above the oil-water contact in the several sands, that portion of the pore spaces not filled with connate water is assumed originally to have been saturated with reservoir oil. As far as can be ascertained, a bottom-hole sample of oil from the Healdton sands has never been obtained, and definite data are not available as to the original reservoir pressure and temperature and the quantity of gas dissolved in the reservoir oil. Free dry gas originally was present above the oil in gas-cap areas throughout the field, indicating that probably the reservoir oil originally was saturated with gas at the initial reservoir pressure and temperature. Early records of gasoline plants showed that the gasoline content of the produced wet gas ranged from 0.28 to 3.3 gallons per thousand cubic feet.

Assuming a pressure gradient of 0.4 p.s.i. per foot of depth, the initial reservoir pressures in the Healdton oil field would have ranged from 260 p.s.i. at 650 feet to 480 p.s.i. at 1,200 feet. Reservoir temperatures at these depths, as determined in several wells, would range from 73° to 85° F.

In October 1950 measurements showed that the specific gravity of gas in relation to air ranged from 0.83 to 1.3. Katz (16) has shown that, for the average gas gravity of 0.88 and oil gravity of 31.9° A.P.I., 70 cubic feet of gas per barrel of stock-tank oil would be dissolved in the reservoir oil. Data published by Standing (17) indicates that at 260 p.s.i. pressure and at a reservoir temperature of 73° F., reservoir oil with gravity of 31.9° A.P I. would contain about 70 cubic feet of gas in solution per barrel of oil, as measured at stock-tank conditions. In the deeper zones of the Healdton reservoir with oils of higher specific gravity, it is estimated that approximately 110 cubic feet of gas per barrel of oil was in solution at about 480 p.s.i. pressure and at a temperature of 85° F. Assuming an average for the field of 90 cubic feet of gas per barrel of oil, it has been calculated that reservoir oil would shrink approximately 4.2 percent, as measured at stock-tank conditions, indicating a formation volume factor of 1.044. This average formation volume factor was used to calculate the volume of oil in place, as measured under stock-tank conditions, in the sands throughout the field.

After deduction for connate water and shrinkage, the original saturation of the pores in the upper Healdton sands with stock-tank oil would range from 87.5 percent of the pore space at 32.0 percent porosity and 3,000 millidarcys permeability to 36.8 percent at 12.0 percent porosity and 18 millidarcys permeability.

Reservoir Calculations

Nonrecoverable Oil Saturations

Little is known definitely regarding the percent of oil that is left in the pore spaces and termed nonrecoverable. In general, it is recognized that oil displacement by water, either in a natural water drive or by artificial water flooding, is more efficient in reducing the oil saturation to a minimum than is solution-gas drive, gas-cap drive, or gravity drainage. Cores with oil saturations ranging from 28 to 84 percent of the pore space were subjected to flooding tests in the laboratory under controlled conditions, and the data available on 19 cores so tested showed that the residual-oil saturation, after continued flooding with several thousand pore volumes of water, ranged from 9 to 29 percent and averaged 19 percent. No relationship was apparent between residual-oil saturation and other measured properties of the core. In actual practice such high water-oil ratios and complete flooding of the sand would not be economically feasible. In the Healdton field most oil wells are abandoned when oil constitute less than 1 percent of the total produced liquid. Assuming 1 percent as an economic limit, when the throughput fluid in laboratory tests reached the ratio of 1 volume of oil to 99 volumes of water, the residual-oil saturation of cores ranged from 18 to 45 percent and averaged 29 percent. The mobility ratio of water to oil increases disproportionately with increased water saturation and decreased oil saturation, so that at an average oil saturation of 29 percent, the water-oil mobility ratio and production is about 99:1. At this saturation, the remaining oil may be considered as economically immobile or fixed, whereas that oil saturation greater than 29 percent of the pore space can be considered as mobile and recoverable under the most favorable conditions. Inasmuch as the porosity and permeability of these 19 core samples covered the complete range of values measured on Healdton oil-producing sands, this figure of 29 percent was adopted as a reasonable average residual-oil saturation. Original mobile-oil saturation ranged from 58.5 percent of the pore volume for an average sand of 30.0 percent porosity to 7.8 percent for the average sand of 12.0 percent porosity cited earlier.

Original Mobile Oil

The volume of mobile oil originally present in the Healdton reservoirs was calculated for individual leases by the following formula:

$$O.M.O. = 7{,}758 \times A \times T \times P \left[\frac{(1 - C_w)}{FVF}\right] - N.R.O. \quad ;$$

where:

O.M.O. = original mobile oil, measured at stock-tank conditions, bbl.;

7,758 = conversion factor, acre-feet to barrels;

A = area of sand, acres;

T = effective thickness of sand, feet;

P = average porosity of sand, decimal fraction of total volume;

C_w = average connate-water saturation, decimal fraction of pore space;

F.V.F. = formation-volume factor;

N.R.O. = nonrecoverable-oil saturation, decimal fraction of pore space.

Average data for the Healdton reservoirs based upon a summation of lease totals are listed below:

	Fourth Healdton	Upper sands (first, second, and third Healdton)	Stray sands (above first Healdton)
A.	1,960	7,016	1,420
T.	23.00	64.71	13.31
P.	0.213	0.216	0.234
C.	0.200	0.190	0.187
F.V.F.	1.044	1.044	1.044
N.R.O.	0.29	0.29	0.29
O.M.O.	35,455,000	369,765,000	16,780,000

The original stock-tank oil for the Healdton reservoir was calculated to be as follows:

	Bbl.
Fourth Healdton	57,026,000
Upper sands	590,448,000
Stray sands	26,721,000
Total	674,195,000

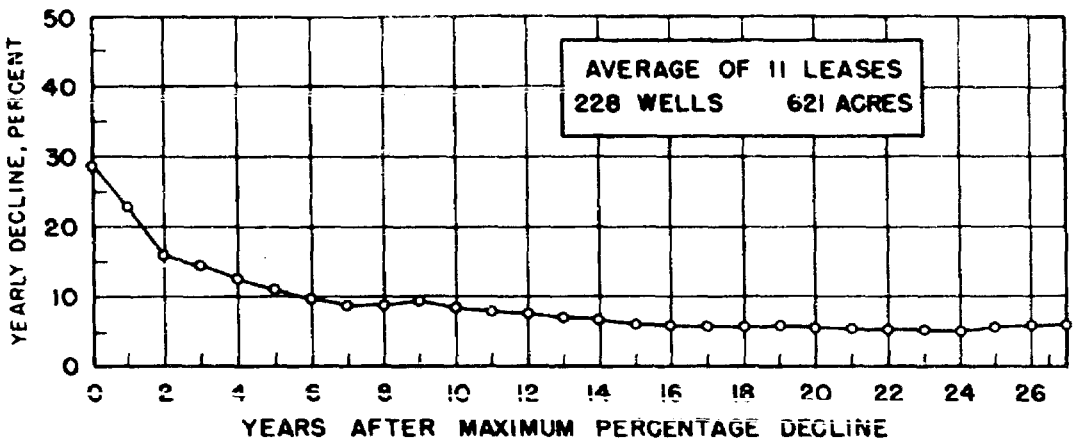
PRODUCTION

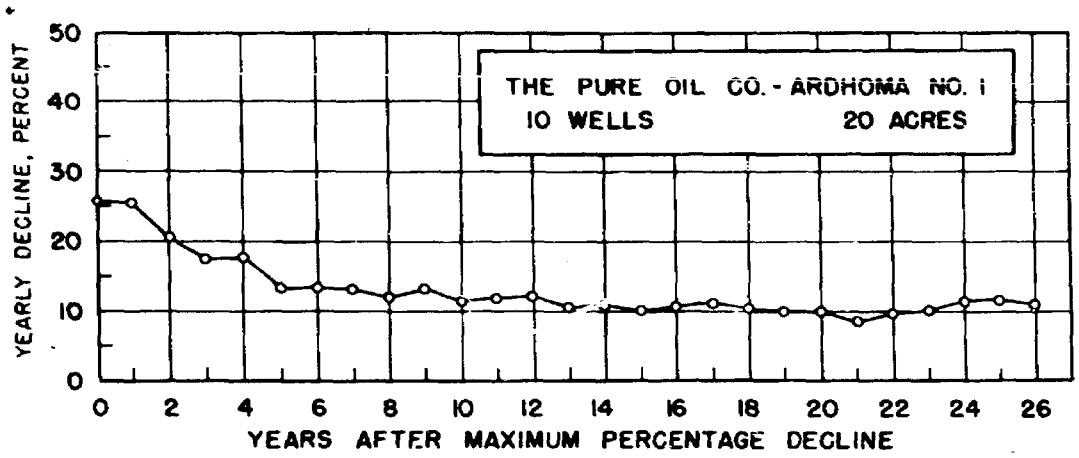
The Healdton oil field has been one of the most prolific oil-producing areas in Oklahoma. Cumulative oil production to January 1, 1951, from 7,142 productive acres of Healdton sand exceeds 211 million barrels, averaging 29,570 barrels of oil per acre and 410 barrels per acre-foot. Oil recovery from several leases exceeds 120,000 barrels per acre. With few exceptions, to be discussed later, this oil has been recovered by primary production methods utilizing the natural energy of the reservoir fluids.

Production Mechanism

Although all four natural-energy sources - dissolved gas, water drive, gas-cap expansion, and gravity drainage - undoubtedly have contributed to the oil production, dissolved gas primarily and water drive secondarily have been the principal natural-energy sources active in the Healdton field.

Expansion of dissolved gas has been most important in producing oil from the upper Healdton sands, whereas natural water drive has been effective in recovering oil from edge leases producing principally from the fourth Healdton sand. Gravity drainage has been an important recovery factor in some structurally low areas. During the life of the field, no particular effort was made to conserve gas energy or to utilize it most effectively to recover oil. The result was a rapid decline in pressure and oil production between 1917 and 1925 (see fig. 3). Vacuum, applied





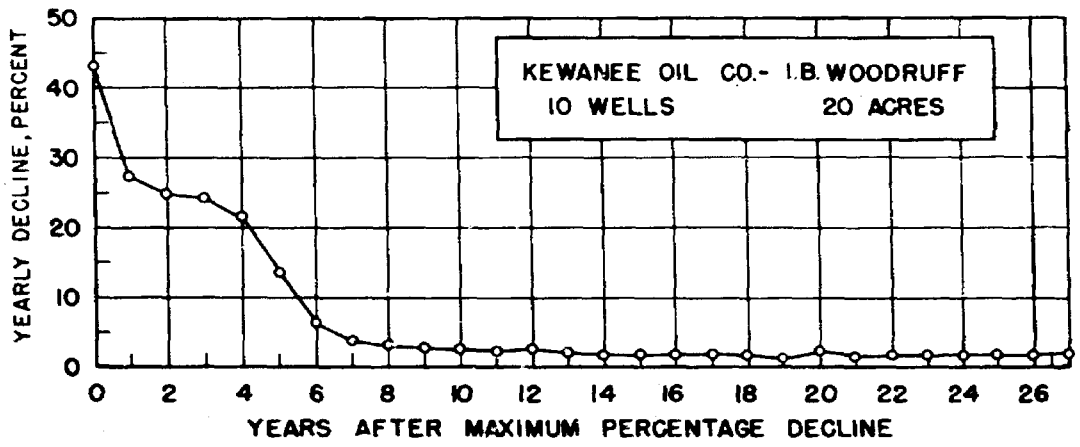


Figure 16. - Percent yearly decline in the rates of oil production from representative leases with no secondary development, Healdton oil field, Carter County, Okla.

intermittently since 1918 and consistently since 1938, reduced the pressure further, so by 1950 the reservoir pressure was very near atmospheric throughout most of the field. In the southeast extension, where vacuum has not been as generally applied and where edge water may be slowly encroaching into some of the upper Healdton sands, fluid levels in idle wells indicate reservoir pressures in some sands greater than 100 p.s.i.

Representative Decline Curves

To illustrate the effects of natural energy on the rate of oil production, the percentage decline of several leases with long uninterrupted production histories is shown in figure 16.

To construct these curves the actual annual oil production, in barrels, was plotted against time for each lease. Normal yearly oil production was read from a smooth curve through the points. The percentage decline then was calculated by taking the difference in normal yearly oil production between 2 successive years and dividing this difference by the normal production in the earlier year. Annual percentage decline was plotted for yearly intervals, beginning with the year of the maximum percentage decline. The upper graph shows the yearly average percentage decline of 11 leases that have not had infill drilling or other interruption of the normal production decline. Declines for the first two periods were 29 and 23 percent respectively, but thereafter the percentage decline decreased slowly until it became more or less stable at 6 percent per year. Twenty-five years after the maximum percentage decline a slight increase to 6-1/2 percent per year is noted. This increase in percentage decline reflects an actual marked decrease in the oil-production rates, probably attributable to wearing-out of production equipment on the leases.

The graph of The Pure Oil Co. Ardhoma 1 lease shows the highest percentage decline of the 11 leases considered. During the early life of the lease the decline in oil production was 33.5 percent per year, and from this peak the rate of decline dropped rather sharply until the oil production was decreasing at the rate of about 13 percent per year. From this point, in the sixth year after the maximum percentage decline, the rate of decline decreases slowly and appears to become more or less constant at about 10 percent per year.

On this lease in the NW1/4 sec. 9, T. 4 S., R. 3 W., where the fourth Healdton sand is thin or entirely absent, oil is produced from upper Healdton sands, and water encroachment has little, if any, effect on oil production.

The graph for the Kewanee Oil Co. I. B. Woodruff lease illustrates the oil-production history of a lease, which after the tenth year showed the lowest percentage decline of any of the 11 leases considered. After the peak decline of 43.5 percent, the rate of decline dropped sharply to about 27 percent and then dropped less sharply for about 4 years. Ten years after the year of highest percentage decline the yearly percentage decline continued more or less constant for 17 years at 2 to 2-1/2 percent per year. This extremely low percentage decline reflects a nearly constant production rate.

Wells on this lease, in sec. 31, T. 3 S., R. 3 W. at the northwestern edge of the field, have been producing increasingly larger volumes of water since 1920. Several down-structure wells in this area already have been abandoned or plugged back because of high water production. Apparently, advancing edgewater has sustained the oil production at a nearly constant rate.

The percentage-decline curves for 17 leases with long, uninterrupted production histories were used as typical curves to calculate the normal expected decline in yearly production of other leases in the field. Where it was important to calculate the increased oil production resulting from infill drilling or secondary recovery or where an extrapolation of the rate of future oil production was necessary, the typical curve that best fitted the available data was used.

Water Production from Upper Healdton Sands

Water production from wells that did not penetrate to the fourth Healdton sand has been reported by operators since early in the life of the field. Several drillers' logs recorded water in the upper Healdton sands at the time of drilling, and tests on some of the wells indicate that water was produced during the early productive life of the field.

Information from well test records, plug-backs, and abandonments indicates that the water is produced primarily from the third sand. However, along the edges of the field, water is present in all of the upper Healdton sands, including some of the oil-productive stray sands above the main Healdton sands.

Figure 17 shows areas in which the water produced from the upper Healdton sands exceeded 50 percent of the total fluid production from these areas in 1950. Areas where the water production ranges from 2 to 10 barrels daily and other areas where it exceeds 10 barrels daily are shown by different types of cross hatching. A few individual wells with high water-production rates are not shown on the map. Areas in which the daily water production exceeds 10 barrels per well are not related to structural position or to any particular location in the field. Areas bounded by the dashed heavy line include wells from which the water is believed to be produced from the first sand.

There is no evidence of an extensive water drive in any of the upper Healdton sands, although in a localized area a limited water drive may exist. Figure 18 shows graphs of the average daily oil and water production per well and the percentage of water in the total fluid for wells producing from upper Healdton sands for 1920, 1930, 1935, 1940, 1945, and 1950. The number of well tests considered in calculating these average daily volumes is shown along the average daily-oil production curve. The average daily oil production decreased from 20.5 to 6.1 barrels per well between 1920 and 1930. During this interval, water production decreased from approximately 7.5 to 6.3 barrels per well; but, because of the greater decrease in oil production, the percentage of water in total fluid produced increased from 27 to 51 percent. In 1935 the average daily oil production increased to approximately 7.5 barrels per well, probably because of infill drilling, whereas the average daily water production remained approximately the same. Since 1935 the average daily rate of oil and water production has decreased steadily, and by 1950 it was approximately 3.8 and 4.5 barrels per well, respectively. Between 1935 and 1945 the percentage of water in total fluid produced increased from 46 to 54 percent, but since 1945 it has remained constant.

From these data and from a study of the oil- and water-production history of 100 other wells, it is concluded that both oil and water in the upper Healdton sands are being depleted and that in these sands there is no appreciable water drive.

Natural Water Drive

Natural water drive has been more important in producing oil from the fourth sand than from the upper Healdton sands. The fourth sand originally was oil-productive

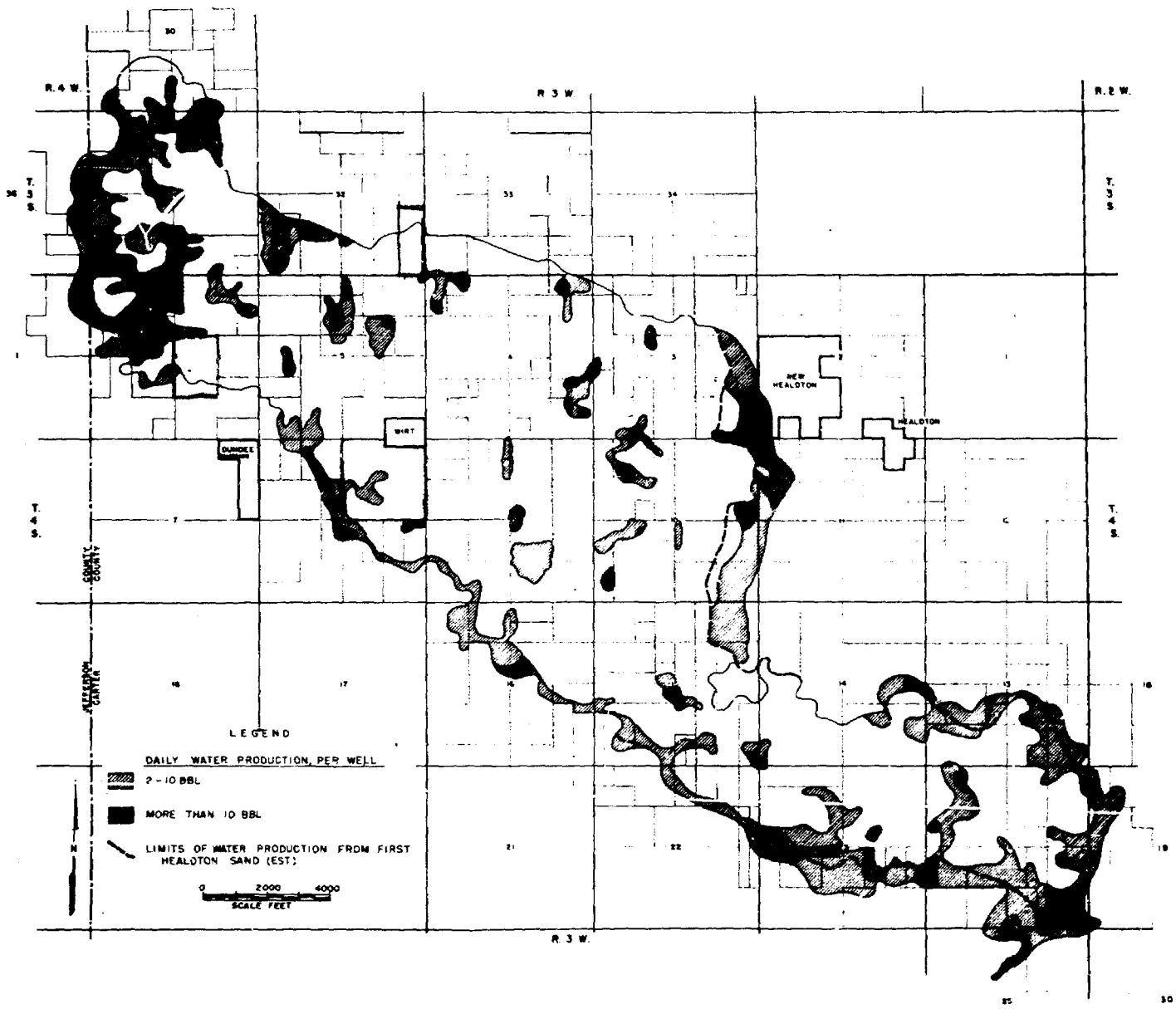


Figure 17. - Areas in which production from upper Healdton sands is more than 50 percent water, Healdton oil field, Carter County, Okla.

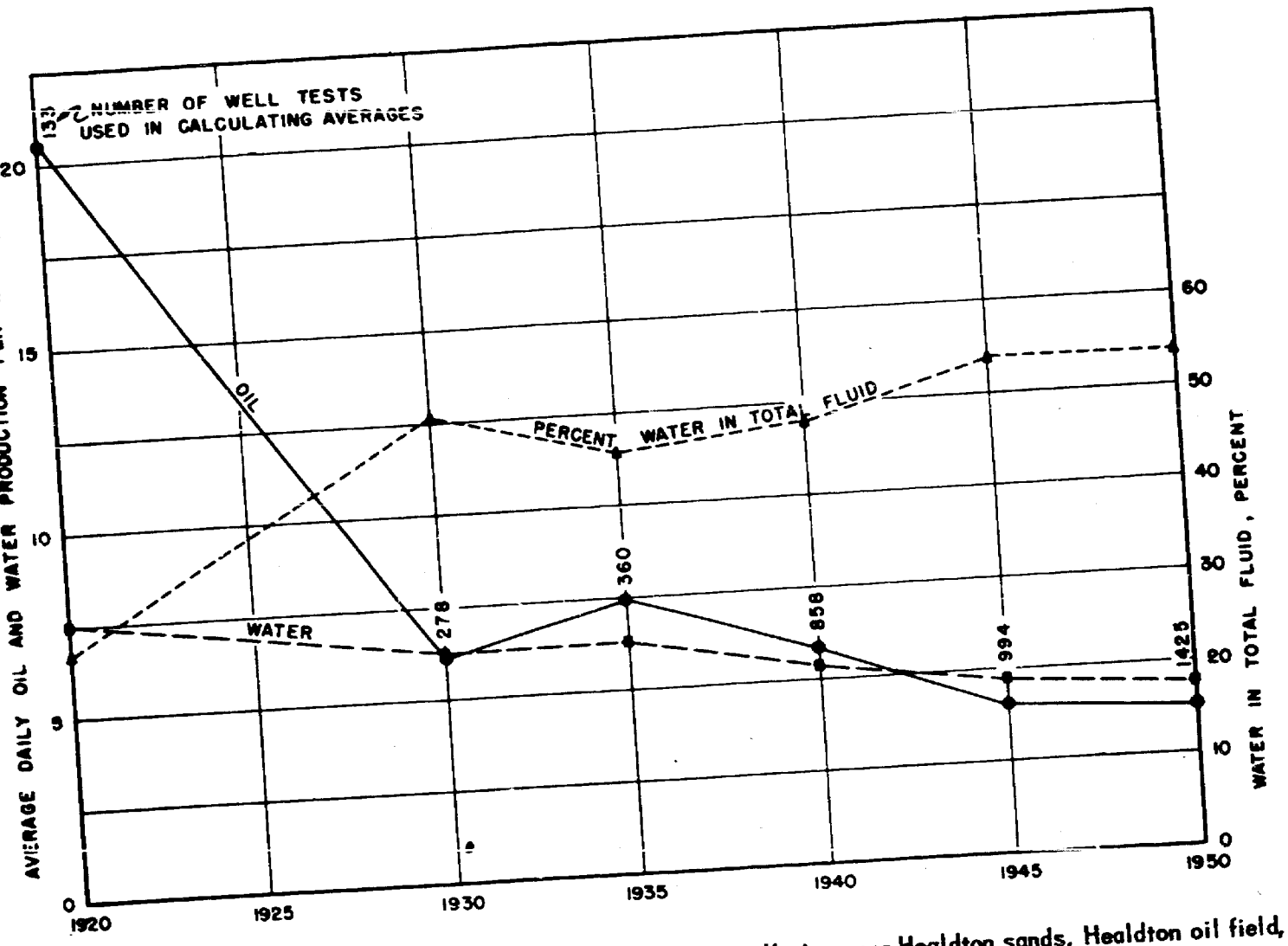


Figure 18. - Average daily oil and water production history of wells in upper Healdton sands, Healdton oil field, Carter County, Okla.

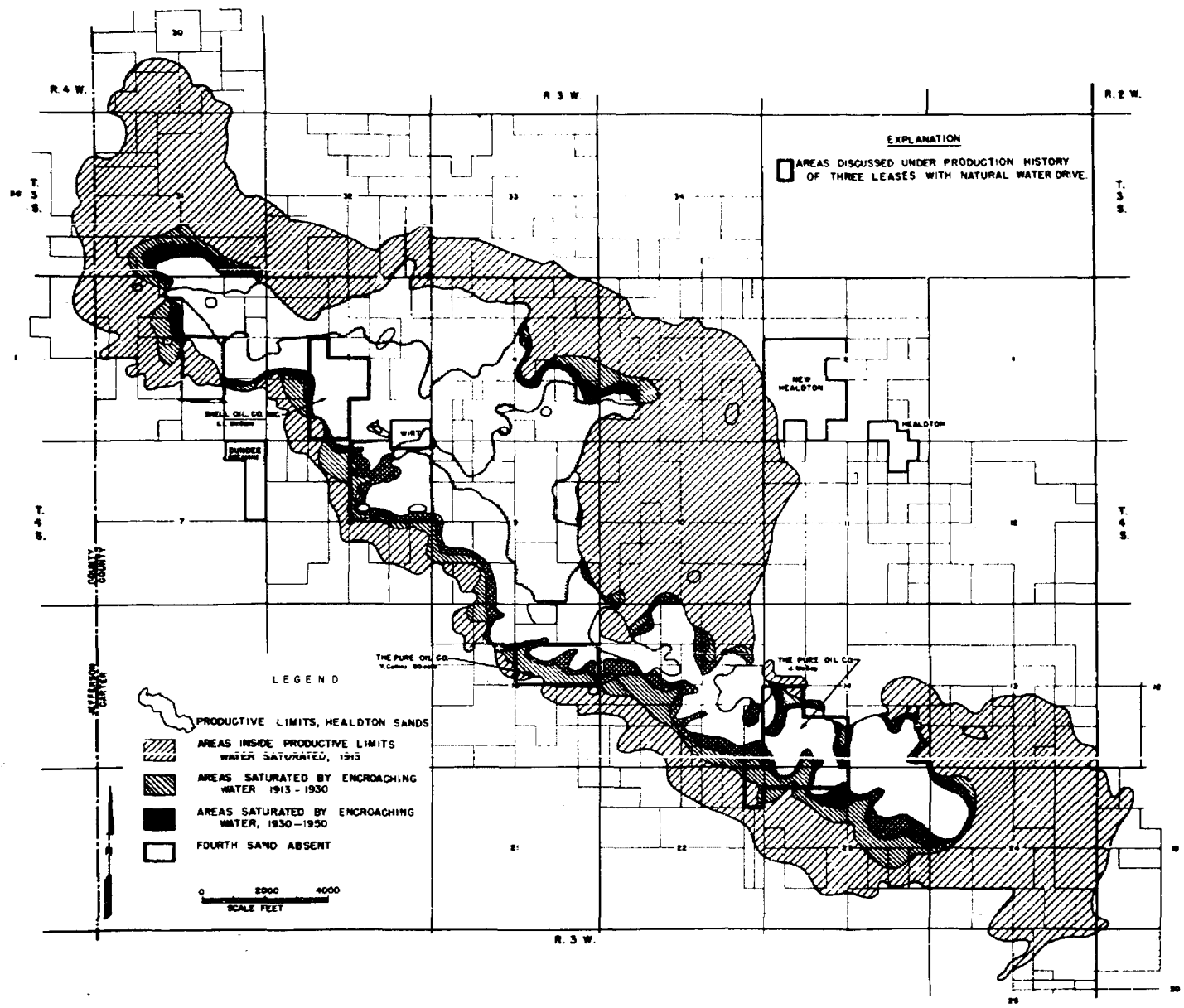


Figure 19. - Progressive advance of water in fourth Healdton sand, Healdton oil field, Carter County, Okla.

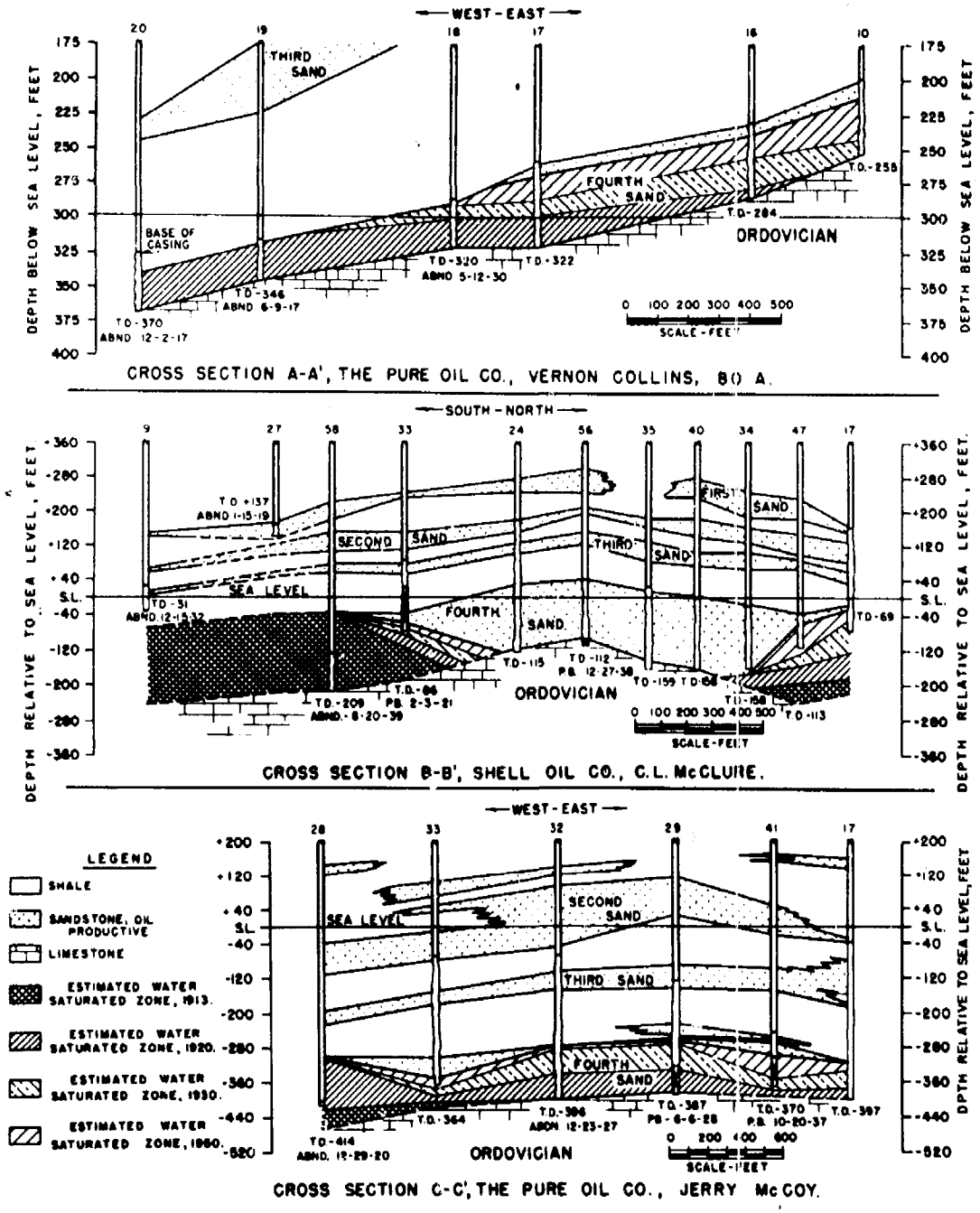


Figure 20. - Structure sections through three leases showing water encroachment in the fourth Healdton sand, Healdton oil field, Carter County, Okla.

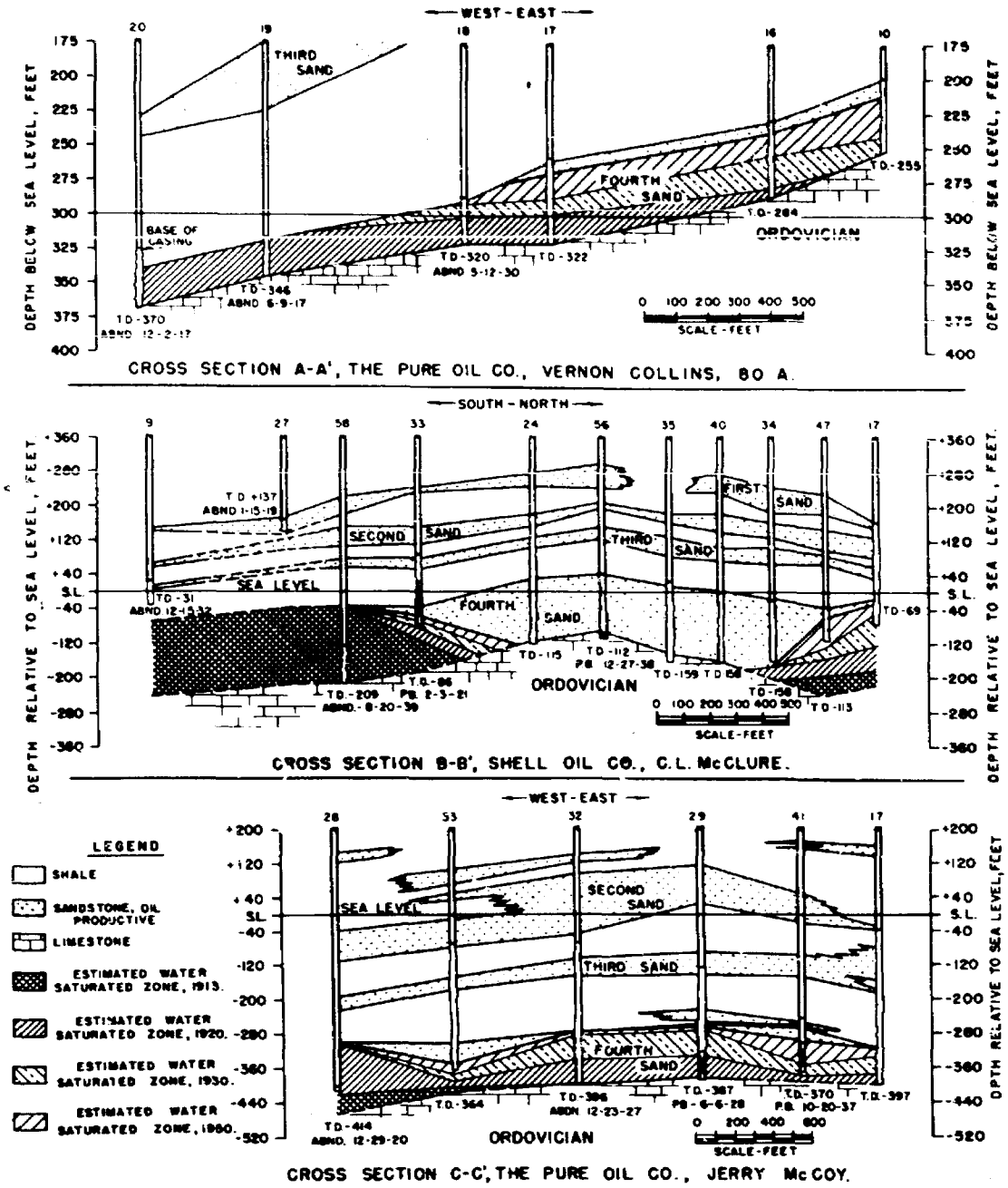


Figure 20. - Structure sections through three leases showing water encroachment in the fourth Healdton sand, Healdton oil field, Carter County, Okla.

under a comparatively limited area in the field. As discussed earlier, the fourth sand was not deposited over the topographically high areas in the north-central part of the field, and much of the structurally lower areas were water-saturated when the field was developed. Figure 19 shows the progressive advance of edgewater in this sand. It shows that between 1913 and 1930, wells in an area of 470 acres, principally along the southwestern edge of the field, were abandoned because of excessive water production. Between 1930 and 1950, inclusive, an additional area of 420 acres of the fourth sand was similarly flooded.

Production History of Three Leases with Natural Water Drive

To show in more detail the progress of advancing water, three leases, The Pure Oil Co. Vernon Collins 80-acre, The Pure Oil Co. Jerry McCoy, and the Shell Oil Co., Inc., C. L. McClure, where the water advance in the fourth sand is quite apparent and a long oil- and water-production history is available, were selected for study.

The Pure Oil Co. Vernon Collins 80 Acre.- The production data on this lease, in sec. 16, T. 4 S., R. 3 W., along the southwest flank of the structure near the south edge of the main part of the field, indicate that the fourth sand alone has an effective water drive. The strata in this area dip to the southwest about 800 feet per mile, the northeast corner of the lease being near the crest of the field structure, whereas the southwest corner is at the productive limit of the field. West-east cross section A-A' (fig. 20) from well 20 to well 10 shows the thickness and attitude of the fourth sand zone. Wells on this lease were not cored or electrically logged, and the cross section was made from the interpretation of drillers' logs. The cross section shows the top of the fourth sand at 341 feet below sea level in well 20 near the west edge of the lease and at 197 feet below sea level in well 10 near the east edge of the lease. The thickness of the fourth sand varies according to locations, 113 feet being penetrated in well 8 along the north edge of the lease, as compared to an estimated thickness of 70 feet along the south edge of the lease.

The initial production of the wells ranged from 2 to 850 barrels of oil per day with an average of about 165 barrels per day. Generally the wells along the north and east edges of the lease where the sand is thicker had higher initial oil-production rates, although the highest initial production of 850 barrels per day was recorded from a well along the south edge of the lease.

Well 1 near the southeast corner of the lease was completed in the upper Healdton sands in November 1915, and the initial production was only 5 barrels of oil per day. The lease was developed slowly, and by December 1917, 27 wells had been drilled. During this interval of development six of the wells were abandoned, presumably because of low oil production or because of encroaching water. By January 1921, 7 additional wells had been abandoned making a total of 13 abandonments during the first 5 years of operation of the lease. Since then 1 well has been abandoned, and in 1950 only 13 wells were producing oil; 9 of these were producing from the fourth sand. There has been no secondary development or drilling of new wells on this lease, although there have been several deepenings and plug-backs since the primary development.

When wells 22 and 24, in the southwest corner of the Vernon Collins 80-acre lease, were completed in 1917, water, but no oil, was reported in the fourth sand. Operation of wells 14 and 15 along the south edge of the lease was discontinued by 1919 because of high water production. Twenty barrels of salt water and no oil were pumped from well 14 soon after completion in 1917. The depths of these wells indicate that the original oil-water contact was approximately 380 feet below sea level

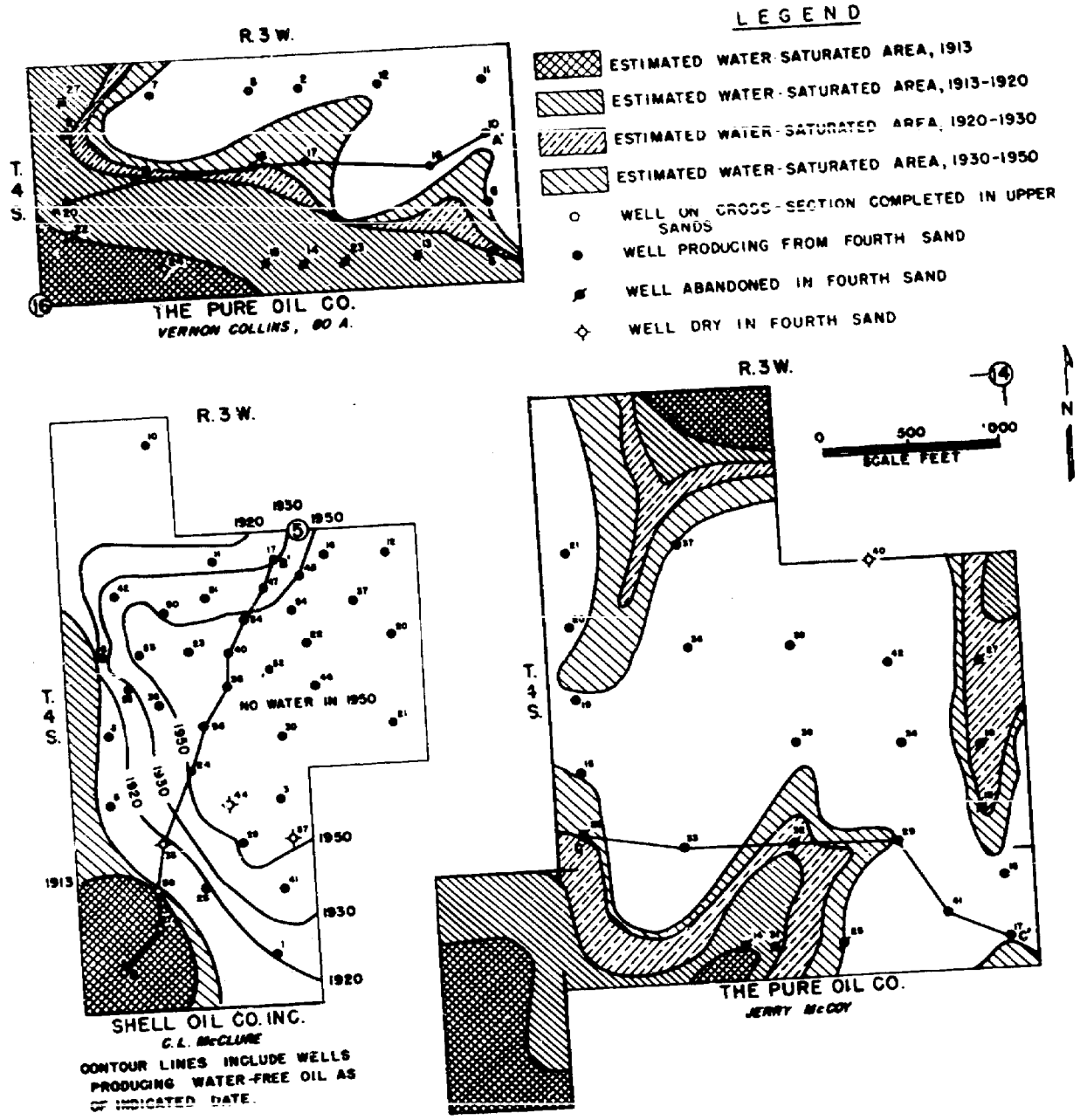


Figure 21. - Progressive advance of water in fourth Healdton sand underlying three leases, Healdton oil field, Carter County, Okla.

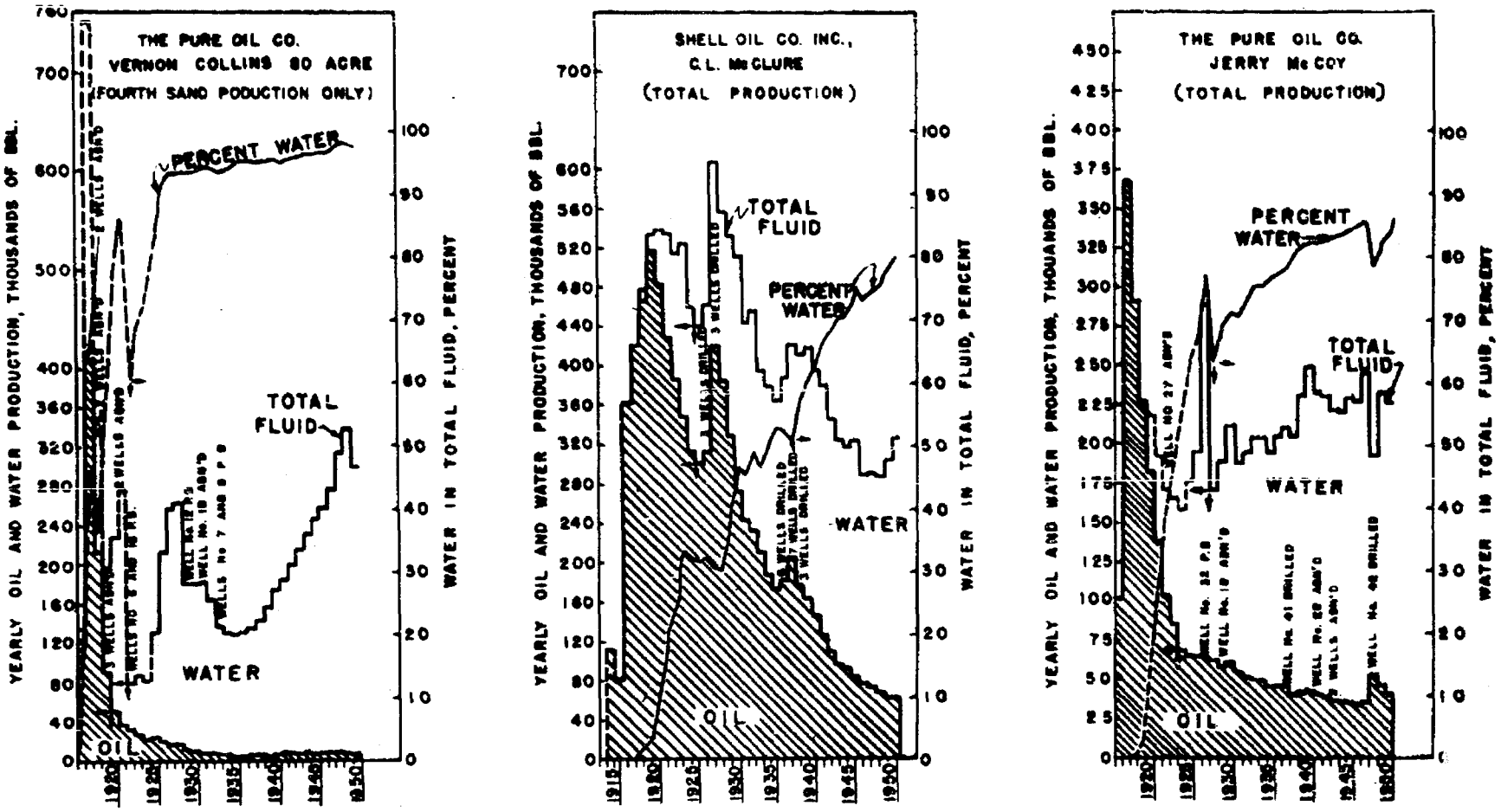


Figure 22. - Production histories of three leases with active water drive in fourth Healdton sand, Healdton oil field, Carter County, Okla.

As computed from drillers' logs, 2,629 acre-feet of the fourth sand on the Vernon Collins 80-acre lease originally contained mobile oil. The comparative wealth of fourth-sand data available permitted calculations of porosity and connate water for this lease that differed from the average porosity and connate water values used for the fourth sand throughout the rest of the field. Porosity ranges from 12 percent to 27.5, according to location and sand conditions, and the weighted average porosity of the sand is 17.8 percent. Using the formation volume factor of 1.044 and estimating the connate water at 27.5 percent, the oil originally in place was calculated to be approximately 2,519,500 barrels. As discussed earlier the residual-oil saturation could be reduced to an average of about 29 percent by efficient flooding. After deducting this 29 percent residual-oil saturation, the volume of mobile oil would be approximately 1,466,700 barrels. The efficiency of the water drive would be the total oil recovered at abandonment date (1,227,000 barrels) divided by the total mobile oil (1,466,700 barrels), an efficiency of 83.7 percent.

Shell Oil Co., Inc., C. L. McClure. - The second lease studied is a 110-acre lease, located in sec. 5, T. 4 S., R. 3 W. near the crest of the field structure, but the southwest corner is near the outer productive limit of the field. Drillers' logs of wells near the center of the lease record the first Healdton sand at approximately 300 feet above sea level (fig. 11). From this high the strata dip southwest at about 440 feet per mile and northwest at approximately 480 feet per mile.

South to north cross section B-B' (fig. 20) from well 9, completed in the upper Healdton sands, to well 17, completed in the fourth sand, shows the thickness and attitude of the several sand zones. Production data indicate that the fourth sand zone had an effective water drive and that on the southern edge of the lease the third sand zone may have had a limited water drive. Wells on this lease were neither cored nor electrically logged, although radioactivity well logs were available for five wells to help correlate the sands. Within the last 15 years, 19 new wells have been drilled and several old wells have been deepened, so that more reliable and complete data as to sand conditions are available for this lease than for The Pure Oil Co. Vernon Collins 80-acre lease described above. Cross section B-B' shows the top of the first sand to be at 144 feet above sea level in well 9, and the top of the Ordovician strata is estimated to be 240 feet below sea level, giving a thickness of 384 feet for the total Healdton-sand section. In well 56 the top of the first sand is 299 feet above sea level and the top of the Ordovician strata 89 feet below sea level, indicating a thickness of the total Healdton-sand section of 388 feet. In well 17 at the north end of the cross section, the top of the first sand is 158 feet above sea level and the estimated top of the Ordovician strata is 220 feet below sea level, showing a thickness of 378 feet. The total Healdton-sand section does not vary much with structure, but the individual sands are not consistent in thickness.

The initial oil production of the original wells ranged from 25 barrels per day to a high of 436 barrels per day and averaged about 140 barrels daily. Infill wells drilled later in the life of the lease had lower initial production rates.

Well 1 in the southeast corner of the lease was completed in the fourth sand in September 1913, and all producing sands above were open for production. The lease was developed slowly, and it was not until February 1921 that the last well in the original drilling campaign was completed. During this development period two dry holes were drilled, and wells 27 and 28 were abandoned soon after completion because of high water production. Water was produced from other wells on the lease as early as 1917. From 1921 to 1926 one well was abandoned, presumably because of low oil production. In July 1926 an infill-drilling campaign was begun, and by August 1927 six additional wells were completed as oil producers. In 1932 structurally low wells 7 and 9 along the south line of the lease were abandoned because of high water

production. Drilling of well 40 in February 1936 initiated the second infill-drilling campaign, during which 16 producing wells were drilled and several of the older wells were deepened to lower sands. The last productive infill well was completed in December 1938, but since then, some wells have been either deepened to lower sands or plugged back to upper sands.

Although water was not reported in any early wells that penetrated the fourth sand, the probable oil-water contact in the fourth sand was established by interpreting drillers' logs on adjacent leases. From all the data available, it appears that, had wells been drilled deep enough during primary development, water would have been encountered in the fourth sand in the southwest corner of the C. L. McClure lease between 50 and 60 feet below sea level and in the northeast corner of the lease between 180 and 200 feet below sea level. Figure 21 shows a map of the Shell Oil Co., Inc., C. L. McClure lease, with the original water-saturated area in the fourth sand in the southwest corner of the lease. It is estimated that approximately 9 acres of the fourth sand originally was water-saturated.

By 1920 the water had advanced up-structure to the position shown on the map (fig. 21), and some water was being produced from four fourth-sand wells. During this period of primary development and flush production, 2,457,000 barrels of oil was produced from all sands on the lease. From the data available, it appears that the water advanced up-structure from the southwest and northwest corners and along the west edge of the lease. Individual monthly oil- and water-production records were available for all producing wells, and the advance of edgewater during a period of time could be discerned readily. By 1930 varying amounts of water was being produced with the oil in all wells included within the contour line for that year. By 1950 water was being produced from 15 wells in the fourth sand in the western part of the lease, and that sand underlying an area represented by the cross-hatching was estimated to be entirely water-saturated.

Figure 22 shows the production history for all sands on the Shell Oil Co., Inc., C. L. McClure lease. Because many early wells were open to all sands, it was impossible to separate the fourth-sand production from that produced from the other sands. Most of the water produced on the lease was definitely from the fourth sand, and, if available, a graph of the fourth-sand oil and water production alone would show the natural water drive more clearly. The graph shows that the maximum yearly oil production from all sands was not reached until 1919, almost 6 years after primary development was begun. One year before this peak oil production, a small amount of water was produced and this volume is shown on the graph as the difference between the oil and the total fluid production. The two peaks in 1927 and 1937 on the oil-production and the total-fluid curves are primarily the results of infill drilling. Except for these two peaks the oil and water production has declined steadily since 1919. In 1950 the oil production was 65,000 barrels and the water production was 328,000 barrels. The curve showing the percentage of water in total produced fluid illustrates the natural water drive on this lease more decisively. Since 1917 the percentage of water in the total produced fluid has increased almost steadily, being about 80 percent by 1950.

The Pure Oil Co. Jerry McCoy. - The third lease considered is in secs. 14, 22, 23, T. 4 S., R. 3 W., near the west edge of the southeast extension. The axis of the main anticlinal structure passes northwest to southeast across this lease, and there is a small dome near the east edge of the lease. The rock strata dip north, west, and south from this dome.

West to east cross section C-C' (fig. 20) from well 28 to well 17 shows the thickness and attitude of all the sands. Only one core analysis of the fourth sand was available on this lease. Electric logs were not made in any of the wells, and subsurface structure was interpreted almost entirely from drillers' logs. In this area the first sand is discontinuous, and most of the wells are completed in lower sands. The tops of the sands are higher structurally in wells 29 and 32 than in well 28 on the west edge or in well 17 on the east edge of the cross section. The sands vary in thickness according to location and are thicker near the center or structurally high part of the lease.

The initial oil production from the individual wells ranged from 5 to 400 barrels per day, with an average of about 130 barrels per day. Logs of wells drilled nearer the crest of the structure recorded higher initial-production rates than did logs of wells drilled near the productive limits of the reservoir.

Well 1, drilled in July 1914, near the center line along the west edge of sec. 14, T. 4 S., R. 3 W., was a dry hole. Well 2, completed in April 1916, in the northeast corner of sec. 22, T. 4 S., R. 3 W., initially produced 100 barrels of oil per day. By October 1918, 37 additional wells had been completed. In May 1922 well 27 was abandoned, presumably because of low oil production. Since 1922 two additional wells have been drilled - well 41 in October 1937 and well 42 in September 1948. Several wells were abandoned because of high water production, and some of the earlier wells were deepened to lower sands.

The logs of some wells, drilled on the south side of the anticlinal structure, recorded water in the fourth sand. Using these logs and those of wells on adjacent leases, the original oil-water contact in the fourth sand zone was established at approximately 400 to 430 feet below sea level. On the north side of the anticlinal structure, the original oil-water contact was established at approximately 350 feet below sea level. Figure 21 shows that approximately 12 acres of the fourth sand zone in the southwest part of the lease and 20 acres in the north part of the lease were water-saturated originally.

From all data available it appears that the water drive was confined to the fourth sand. Between 1913 and 1920 the water had advanced in the fourth sand, underlying an area shown in figure 20. By 1930 the water had advanced up-structure, four wells had been abandoned, and considerable amounts of water were being produced from all wells in the fourth sand. By 1950 three more wells had been abandoned, and the fourth sand underlying approximately 40 percent of the lease had been flooded. Although the advance of water was influenced by structure, it appears that "coning and fingering" occurred in the southern and western parts of the lease where the water advance was more rapid. This irregular advance could have been caused by variance in permeability or by different methods of operation of the individual wells.

Figure 22 shows the oil- and water-production history of The Pure Oil Co. Jerry McCoy lease and the percentage of water in the total produced fluid. As it was impossible to separate the fourth-sand production from the total, the indicated oil production is from all the sands, whereas the major portion of the produced water is from the fourth sand. Yearly oil production was at a maximum in 1917 and from this peak of 367,750 barrels per year declined sharply, with the result than by 1925 yearly oil production was 65,550 barrels. Small quantities of water were produced from the wells in 1919, but the total fluid production decreased until 1924, when well 32 began to yield large volumes of water. This well was plugged back in 1927, and the volume of total produced fluid decreased sharply at this time, but the proportion of water to

total produced fluid remained approximately 68 percent. In 1929 well 18 was abandoned, resulting in a sharp drop in total produced fluids, as shown by the curve. From 1930 to 1940 the rate of oil production decreased steadily, whereas water production increased. The abandonment of well 28 in 1941 and wells 8, 14, and 26 in 1943 caused yearly water production to decrease. Deepening of several wells and the drilling of well 42 in 1948 caused a slight increase in both oil and water production.

Between 1929 (when well 18 was abandoned) and 1948 the percentage of water in the total produced fluid increased from 64 to 85 percent. Following the deepening and drilling in 1948 the water percentage dropped sharply to 79 percent, but by 1950 produced water constituted about 86 percent of the total fluid production.

On the three leases studied, a natural water drive in the fourth sand is apparent in that increasingly larger areas are being flooded, the oil-production rates are being sustained, and the percentage of water in total produced fluid has steadily increased. Other areas where natural water drive may be active should be carefully studied before secondary-recovery methods are applied.

Gas Production

In addition to a large production of oil, substantial quantities of gas also have been produced from the Healdton field.

The first big gas well, with an estimated initial production of 33 million cubic feet daily, was completed in December 1913 by the Crystal Oil Co. on what is now the Sinclair Oil & Gas Co. Million and Thomas lease in sec. 5, T. 4 S., R. 3 W. As many as three gas sands, including stray sands and the first Healdton sand, were penetrated at depths of 500 to 900 feet in wells on this lease. Pressures up to 600 p.s.i. were reported. A few wells completed in 1915 and 1916 in sec. 4, T. 4 S., R 3 W., produced gas from Healdton sands ranging in depth from 800 to 1,100 feet. The initial daily volumes from these wells were not recorded. Several gas wells with capacities of 20 to 40 million cubic feet daily were completed in sec. 15, T. 4 S., R. 3 W. during the same years. These wells penetrated dry-gas sands in the Healdton sand section at depths ranging from 900 to 1,200 feet.

During these early years dry gas was piped to Ardmore, Ringling, and Wilson by local gas companies (10).

Table 2, page 6, shows that only 26 gas wells were completed in the Healdton field during the first 3 years of development; many oil wells penetrated gas-producing zones in the first sand or in the stray sands above the Healdton series.

Approximately 50 wells originally were completed as dry-gas producers, but none of these were producing gas by 1950. Some were abandoned as early as 1919, and most of the remaining ones were shut in during the 1930's. These wells produced dry gas in the beginning, but many "went to oil" and were "put on the pump" a few years after completion. Some wells, however, remained dry after the gas was exhausted and were abandoned.

Figure 23 shows the approximate extent and thickness of the original gas-productive sands in the first sand and the stray sands above.

Gas was produced from the first sand in several scattered, structurally high areas throughout the field; the largest area, in secs. 4, 5, 8, and 9, T. 4 S., R. 3 W., along the crest of the anticline includes 335 acres. Smaller areas are

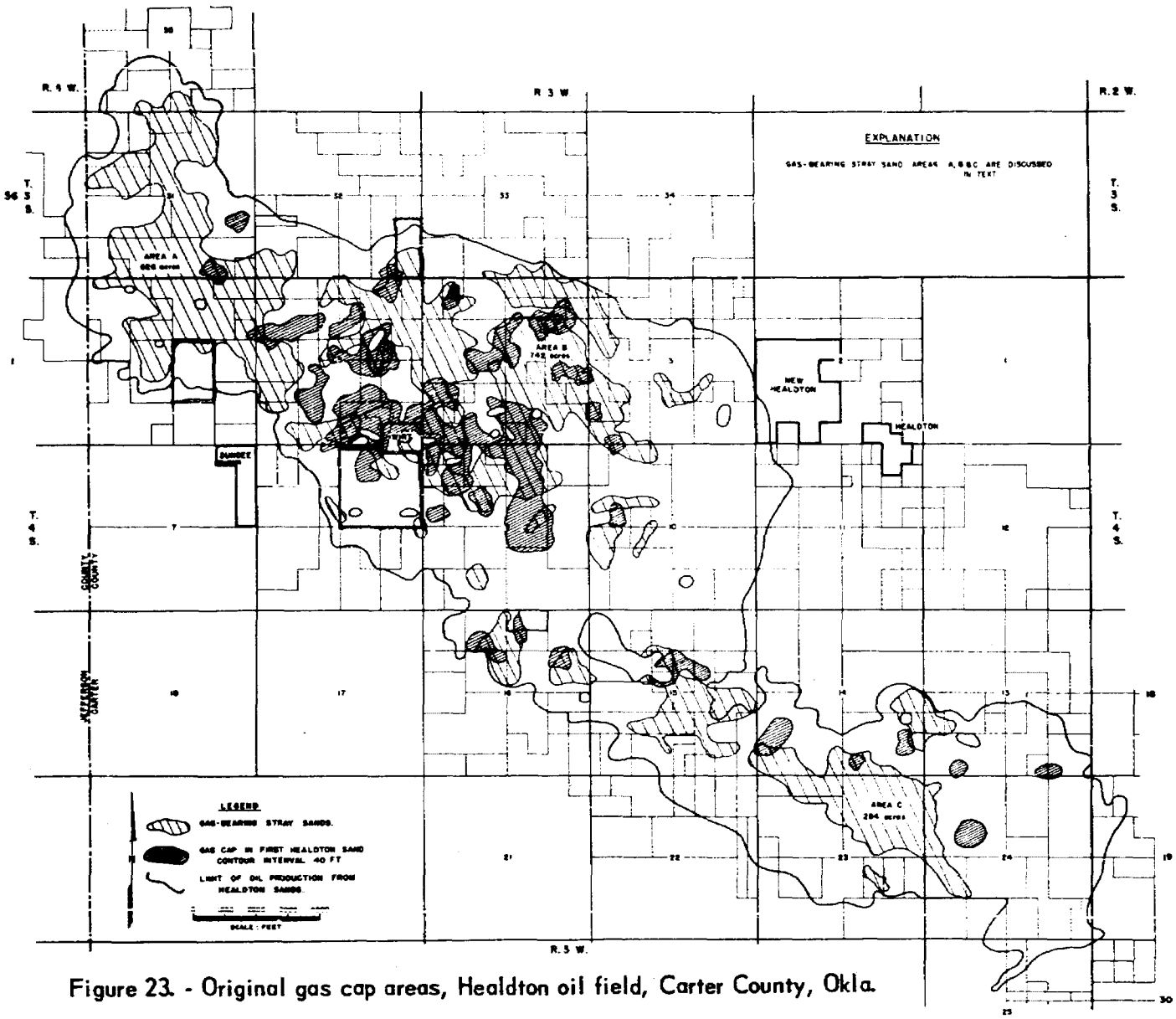


Figure 23. - Original gas cap areas, Healdton oil field, Carter County, Okla.

scattered throughout the field on local structural highs. Thickness of the gas-productive first sand ranges from less than 1 to 120 feet. with an average of 25 feet. Apparently the gas-oil contact was not horizontal but varied in elevation from 150 to 350 feet above sea level on the highest part of the structure and from 50 feet above sea level to as low as 50 feet below sea level in scattered areas on the flank.

Although stray sands are highly lenticular and discontinuous, figure 22 shows three principal areas, designated as areas A, B, and C, where the stray sands produced gas.

Area A in the northwestern part of the field covers 626 acres, in which gas sands range in thickness from less than 1 foot to 50 feet. In this area the elevation of the gas-oil contact ranges from 202 to 239 feet above sea level.

Area B includes 742 acres in the north-central part of the field where gas sands range in thickness from a mere parting to a maximum of 50 feet. Average thickness is about 22 feet. Gas was found above the oil at elevations between 129 and 202 feet above sea level.

Stray gas-cap area C in the southeastern part of the field includes 284 acres and averages 20 feet in thickness. The original gas-oil contact ranges from 130 to 200 feet above sea level.

Figure 22 also shows many small stray gas areas scattered throughout the field, ranging in size from 5 to 146 acres and totaling 509 acres.

In general, the thickness of stray sands containing gas averages 19 feet over a total area of 2,161 acres. Although the elevation of this gas-oil contact varies considerably, depending on local conditions, dry gas was not found in sands at elevations less than 129 feet above sea level, and oil was not found at elevations greater than 239 feet above sea level.

Non-Healdton wells in the field have yielded large quantities of gas, some from shallow sands and some from deeper sands. Two wells penetrated gas sands at depths greater than 2,000 feet. The first of these, in sec. 4, T 4 S., R. 3 W., was completed in 1924, with an initial rate of 50,000 cubic feet of gas daily. The second well was completed in 1948 in sec. 3, T. 4 S., R. 3 W., at a depth of 2,258 feet. The drill pipe and bit were cemented in this well to control the gas, which "blew out" and caught fire. No initial production test was made, but the capacity was estimated to be 500,000 cubic feet of gas daily. In 1951 mud in the drill pipe was bailed out; and, after a small shot, shut-in pressure measured 1,500 p.s.i., but open-flow capacity was only 6,500 cubic feet daily.

The volume of casinghead gas produced during the early life of the field was undoubtedly quite large, although before 1928 no substantiating records of gas production are available.

Table 6 lists the known gas-compressor plants in the Healdton field. A number of natural-gasoline compression plants began operation in 1916 and 1917, and in 1918 the Humble Oil Co. began operating a natural-gasoline refrigeration plant on the Lucy Tubbee lease in sec. 24, T. 4 S., R. 3 W. The amount of gasoline recovered by these early plants is not known.

TABLE 6--Gas compressor plants, Healdton oil field, Carter County, Okla.

Name	Location: Lease	Q.	S.	T.	R.	Leases connected	Type operation	Date operation begun	Date operation discontinued	Units	Type prime mover	Capacity, M c.f. daily	Pressure: Intake	Pressure: Exhaust, p.s.i.
Shell Oil Co. Barco plant	Wirt Franklin do.	NE NE	8 8	4S 4S	3W 3W	51 63	Gasoline comp. Gasoline absorp.	1918 1940	1940 1946	1-Aux. Miller 3-Laidlaw compressors 1-Cooper-Bessemer 18x24" Compressor	3-110 hp. Millers do. 170 hp. combination	2,000	13" vac.	48
Shell Oil Co. (Merry Elfe, Inc., lessee)	do.	NE	8	4S	3W	67 leases	do.	1946	Operating	(Same as above)	(Same as above)	2,000	13" vac.	40
The Pure Oil Co.	Westheimer & Daube 6C acre	NE	9	4S	3S	11 Pure leases-9 others	Vacuum and compression	Gaso. plant-1916 Vacuum-1935	Discontinued 1935 Operating			212	10" vac.	3-7
Sinclair Oil & Gas Co.	J.S.Mullen	NE	4	4S	3W	J.S.Mullen and Ardworth (after 1945)	Vacuum and repressuring	October 1943	do.	3-14x20" Ingersoll-Rand 180 r.p.m. -	3-80 hp. Cooper -	- -	- 10" vac.	- 250
Shell Oil Co.	L.Tubbee	NW	24	4S	3W	L.Tubbee, M.Tubbee, and Rhodes	do.	1928	do.	2-17x12" single stage 1-2 stage 4x10", 9½x10" Ingersoll-Rand	Superior 35 hp.	-	-	-
Gates Oil Co. (now Cox & Hamon)	Jackson	SE	15	4S	3W	Cox & Hamon-L.Watkins, Carnes, Ward, Ingram, E. Watkins, Wesley, Simpson	Gasoline compression	1916	1932	3-vacuum pumps	4-110 hp. Millers 3- 70 hp. Millers	2,000	-	75 low 250 high
Do.	Wesley	SW	3	4S	3W	Wesley	Vacuum and compression	1916	1940(?)	1-Blaisdell combination 16x20"(180 r.p.m.)	180 hp. Blaisdell	-	-	-
Magnolia Petroleum Co.	Hamon	NW	15	4S	3W	J.L.Hamon, R.Johnson,	Gasoline compression	1916-17	1935	3-Cooper-Bessemer compressors	3-90 hp. Cooper-Bessemer	-	-	-
Do.	C.Richards	NE	31	3S	3W	C. Richards, E. T. Richards, Woodruff	Gassoline compression and vacuum	1916	1924-25	9-Cooper-Bessemer compressors	90 hp. Cooper-Bessemer	-	6" vac.	Atmos.
Do.	J.B.Rose	NW	23	4S	3W	Rose, Daniels, Watkins, Tubbee	Gasoline compression	1916-17	1926-27	5-Cooper-Bessemer compressors	5-90 hp. Cooper-Bessemer	-	-	-
McGraw Oil Co.	Stewart & Hawk	SW	33	3S	3W	Stewart & Hawk	Vacuum repressuring	1939	1941	1-Twin 20x12" Ingersoll-Rand	-	-	-	-
Do.	do.	SW	33	3S	3W	do.	do.	1946	Oct. 1948	1-9x8" Ingersoll-Rand 130 r.p.m.	25 hp. Superior	-	-	-
Humble Oil Co.(now Shell)	L.Tubbee	NW	24	4S	3W	L. Tubbee	Gasoline refrigeration	1918	1922	5-14x20" Gaso. (belted to engine)	Bruce McBeth	-	2" vac.	-
Carter Oil Co.(now Shell)	C.R.Smith	NW	5	4S	3S	Schermerhorn-Smith, Shell-Willis	Vacuum and gasoline compression	1918	1920	Ingersoll-Rand 6-units-V-type-2-stages	-	3,000	20" vac.	350
Shell Oil Co.	H.Z.Ward	NW	6	4S	3W	Ward	Vacuum and compression	-	1942	Ingersoll-Rand Twin-cyl. 180 r.p.m. 12x10"	35-hp.Superior-4 cycle gas	200	6" vac.	Atmos.
Do.	C.R.Smith	NW	5	4S	3W	Smith, Johnson "B", Koskie	Vacuum	Before 1939	1942	18x10" Twin cyl.-150 r.p.m. Ingersoll-Rand 2-stages	Superior 35 hp.	200	-	-
Merrick Gasoline Co. (now Schermerhorn Oil Co.)	Fee 40 acre	CW½	5	4S	3W	Fee 20 and 40, Merrick	Gasoline compression	July 1918	May 1922	2x10" 2 stage Ingersoll-Rand, High-350 p.s.i., Low-70 p.s.i.	2-200 hp. engines	1,000	Atmos.	350
Schermerhorn Oil Co.	do.	CW½	5	4S	3W	Fee 40	Vacuum repressuring	Mar. 1935	Nov. 1935	2-National compressors	100 hp. combination	450	Atmos.	50-150
Kewanee Oil Co.	Jones	CW½	4	4S	3W	Jones	do.	Nov. 1937	1940	9x18" Ingersoll-Rand 180 r.p.m.	4 cyl. Waukesha	250	-	-



Figure 24. - Shell Oil Co. Barco gasoline plant (Harry Ells operator), Healdton oil field, Carter County, Okla.

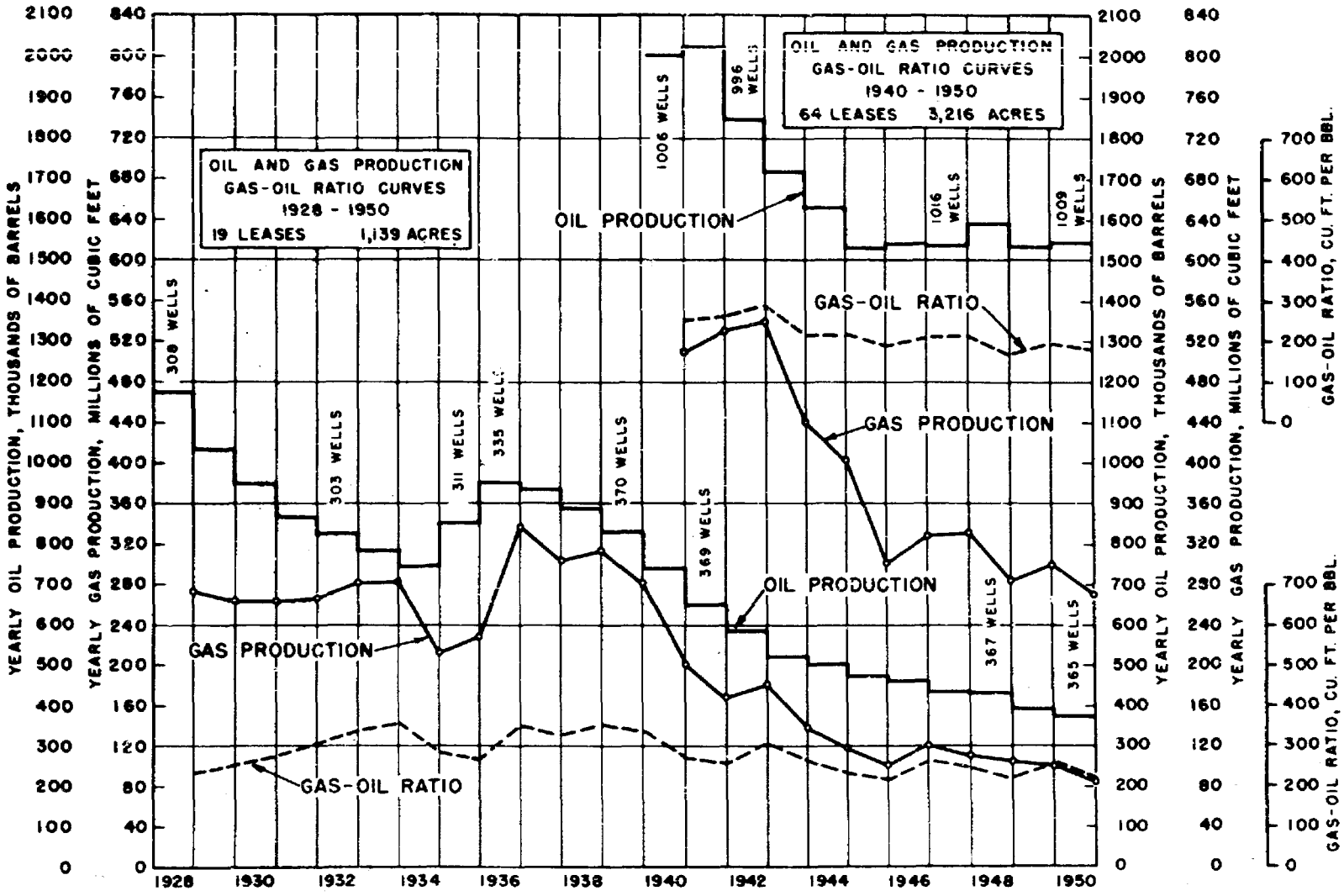


Figure 25. - Oil- and gas-production history of representative leases, Healdton field, Carter County, Okla.

Vacuum, which has been applied intermittently since 1917, has aided production of casinghead gas (2). In 1917 the Oklahoma Corporation Commission ruled against the use of vacuum in any field in oklahoma unless permission was obtained from the Commission. However, a limited use of vacuum at the casinghead for gathering gas to be used for lease operations and delivery to gasoline plants was condoned. A few plants, which were operating at a vacuum of almost 20 inches of mercury, were shut down by the Commission.

Some operators continued to apply vacuum in varying amounts until 1935, when a controversy arose over its use in the field. The Oklahoma Corporation Commission issued another order prohibiting the application of vacuum in the Healdton field. After an appeal to the State Supreme Court by the Gilmer Oil Co., a temporary order was issued by the Court on October 8, 1937, limiting the use of vacuum to 6 inches of mercury. Consequently, a final Order by the Commission (No. 12429) was issued on July 22, 1938, permitting the use of vacuum up to 6 inches of mercury at the casinghead in producing oil in the Healdton oil field. Also, each lease was required to be equipped with a back-pressure vacuum regulator and chart-recording meter of an adequate type to control and record the amount of vacuum applied.

During recent years the Shell Barco plant at Wirt, Okla., in sec. 8, T. 4 S., R. 3 W., operated by Harry Ells, Inc. (fig. 24), has been the only gasoline plant in operation in the field. This plant, built by Jake Hamon early in the life of the field, was operated as the Shell Oil Co., Inc., Barco gasoline plant between 1916 and 1947, when Harry Ells, Inc., took over the operation on a farm out. First built and operated as a compression plant, it was converted to an absorption plant in 1940, when gathering lines were extended to include several additional leases. During 1950 the plant processed an average of 1.7 million cubic feet of gas daily, gathered at 6 inches of mercury vacuum from 67 leases in the Healdton field and from 9 leases in the nearby Hewitt field.

Three other plants are operated to apply vacuum to the casingheads of the wells. Largest of these is The Pure Oil Co. booster plant on the Westheimer and Daube 60-acre lease in sec. 9, T. 4 S., R. 3 W. Operated as a compression gasoline plant between 1916 and 1935, the plant now gathers gas from 11 leases of The Pure Oil Co., and 9 other leases, at vacuum equivalent to 6 inches of mercury, and delivers it to the Harry Ells, Inc., gasoline plant at a pressure of 3 to 7 p.s.i. A smaller plant on the Sinclair Oil & Gas Co. J. S. Mullen lease in sec. 4, T. 4 S., R. 3 W., gathers gas from the Mullen and Ardworth leases for injection into wells on the Mullen lease. A plant on the Shell Oil Co., Inc., L. Tubbee lease in sec. 24, T. 4 S., R. 3 W., originally was used for gas injection but now is used to apply vacuum to wells on three Shell Oil Co., Inc., leases in the area. On several edge leases not served by compressor plants vacuum is applied to the wells by rodline pumps operated from the central power.

Natural Gasoline Association of America contracts between the operators and the Harry Ells, Inc., plant provide for the purchase of casinghead gas from each lease at a price depending upon the periodically tested gasoline content of the incoming gas and the market price of natural gasoline. Denuded residue gas not required for plant operation is returned to the several leases. Additional dry gas may be purchased from Harry Ells, Inc., when the volume of gas returned is not adequate for lease requirements.

Figure 25 shows the oil- and gas-production history of several representative leases in the Healdton oil field. Oil- and gas-production data since 1928 were available for 19 leases covering 1,139 acres and including more than 300 producing oil wells.

Both the oil- and gas-production rates increased in 1936 with the drilling of additional wells but have declined steadily since that date. The indicated gas production is that volume sold to the gasoline plant less included air (see table 10, p. 43) and is not necessarily the total volume of gas produced on the leases. The gas-oil ratio for all 19 leases based upon total oil and gas sales, less included air, has varied somewhat from year to year with a marked increase between 1936 and 1939 following the infill drilling. For most of this period gas was being injected through wells on one or two of these leases, but the total volume of gas thus injected constituted only 6 to 18 percent of the total gas production.

Since 1940 gas-sales data are available for 64 leases, including the 19 mentioned above. These 64 leases, with approximately 1,000 producing oil wells, cover 3,216 acres of the most productive areas of the field. The gas-oil ratio, after deduction for air content, declined from a high of 290 cubic feet per barrel in 1942 to 185 cubic feet per barrel in 1950. Gas production declined from 530 million cubic feet per year in 1942 to 270 million cubic feet per year in 1950. During part of this period gas was being injected into wells of five leases, but the total volume of gas injected constituted 8 percent or less of total gas production.

If these gas-oil ratios are representative of Healdton-sand production in the field, they indicate that about 16 billion cubic feet of gas has been produced since 1929 compared to a total injected volume of about 1 billion cubic feet during the same period.

When it is considered that the original solution gas-oil ratios were about 90 cubic feet per barrel, it is surprising that so much gas is available after 20 years of vacuum application. The conclusion is obvious that a large volume of unproduced oil in the reservoir is contributing to the gas production from the leases; but, because definite data are not available regarding the solubility of the gas in the reservoir oil and the reservoir pressure history, it would be impossible to make any quantitative estimates of this volume.

Character of Produced Fluids

Produced Oil

Thirteen samples of Healdton crude oils were analyzed by the Bureau of Mines routine method, and a study of these analyses has brought forth the conclusion that two and possibly three distinctly different types of oil are being produced from the Healdton sands. For convenience the oils will be referred to as types A, B, and C.

The 3 crude-oil analyses in table 7 are representative of 13 samples studied; sample A-8 is a typical type-A oil, sample B-3 is a typical type -B oil, and sample C-1 is a typical type -C oil.

Table 8 shows the distinguishing characteristics (gravity, sulfur content, and viscosity) of 23 samples of crude oil separated into types A, B, and C. From a detailed study of the 13 complete analyses available it was possible to determine the type of oil for the remaining samples by checking their A.P.I. gravities and percentages of sulfur. The type A oils have higher gravity, definitely lower sulfur content, and lower viscosity than the other two types. The type C oils differ from the type B in having slightly lower gravity and higher viscosity, sulfur content, and carbon residue.

TABLE 7. - Chemical and physical properties of three crude oils, Healdton oil field, Carter County, Okla.

Typical A-type crude oil
Magnolia Petroleum Co.
E. T. Richards well 93

Sample A-8, table 8
1,102-1,142 feet
Sec. 31, T. 4 S., R. 3 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.868 A.P.I. gravity, 31.5° Pour point, °F. below 5
Sulfur, percent, 0.72 Color, dark green
Saybolt Universal viscosity at 77° F., 87 sec.; at 100° F., 66 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1. - Distillation at atmospheric pressure, 736 mm. Hg
First drop, 33° C. (91° F.)

Fraction No.	Cut at- °C.	°F.	Percent	Sum, percent	Sp. gr., 60/60 °F.	°A.P.I., 60 °F.	C.I.	Aniline point, °C.	S.U. visc., 100 °F.	Cloud test, °F.
1	50	122	0.1	0.1)						
2	75	167	.7	.8)						
3	100	212	2.8	3.6)	0.723	64.2	-	50.2		
4	125	257	4.1	7.7	.757	55.4	30	48.6		
5	150	302	3.9	11.6	.778	50.4	32	48.4		
6	175	347	4.4	16.0	.800	45.4	36	48.6		
7	200	392	4.2	20.2	.816	41.9	37	52.9		
8	225	437	3.6	23.8	.825	40.0	36	60.0		
9	250	482	5.3	29.1	.831	38.8	33	64.4		
10	275	527	7.2	36.3	.836	37.8	31	69.8		

STAGE 2. - Distillation continued at 40 mm. Hg

11	200	392	2.9	39.2	0.843	36.4	30	74.4	42	10
12	225	437	6.7	45.9	.852	34.6	31	77.6	46	25
13	250	482	6.3	52.2	.865	32.1	34		57	40
14	275	527	5.1	57.3	.878	29.7	37		82	55
15	300	572	8.0	65.3	.887	28.0	38		155	70
Residuum			32.5	97.8	.951	17.3				

Carbon residue of residuum, 7.0 percent; carbon residue of crude, 2.5 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	3.6	0.723	64.2	
Total gasoline and naphtha	20.2	.777	50.6	
Kerosine distillate	3.6	.825	40.0	
Gas oil	21.1	.840	37.0	
Nonviscous lubricating distillate	11.5	.857-.880	33.6-29.3	50-100
Medium lubricating distillate	8.9	.880-.893	29.3-27.0	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	32.5	.951	17.3	
Distillation loss	2.2			

TABLE 7. - Chemical and physical properties of three crude oils, Healdton oil field, Carter County, Okla. (Cont.)

Typical B - type crude oil
Cox & Hamon
L. Carnes well 9B

Sample No. B-3, table 8
845 - 1,189 feet
Sec. 15, T. 4 S., R. 3 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.876 A.P.I. gravity, 30.0 Pour point, °F. 20
Sulfur, percent, 0.93 Color, dark green
Saybolt Universal viscosity at 77 °F., 140 sec.; at 100 °F., 87 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1. - Distillation at atmospheric pressure, 755 mm. Hg
First drop, 27 °C. (81 °F.)

Fraction No.	Cut at- °C.	°F.	Percent	Sum, percent	Sp. gr., 60/60 °F.	°A.P.I., 60 °F.	C.I.	Aniline point, °C.	S.U. visc., 100°F.	Cloud test, °F.
1	50	122	0.4	0.4)						
2	75	167	.7	1.1)						
3	100	212	1.5	2.6)	0.683	75.7	-	-		
4	125	257	2.8	5.4	.731	62.1	18	56.0		
5	150	302	3.9	9.3	.760	54.7	24	55.0		
6	175	347	3.7	13.0	.783	49.2	28	53.0		
7	200	392	3.4	16.4	.801	45.2	30	53.9		
8	225	437	4.0	20.4	.815	42.1	31	57.0		
9	250	482	5.2	25.6	.827	39.6	31	62.4		
10	275	527	7.0	32.6	.834	38.2	30	68.6		

STAGE 2. - Distillation continued at 40 mm. Hg

11	200	392	3.3	35.9	0.844	36.2	31	73.2	40	10
12	225	437	6.6	42.5	.853	34.4	31	76.4	45	30
13	250	482	6.8	49.3	.866	31.9	34		56	45
14	275	527	5.7	55.0	.881	29.1	38		82	65
15	300	572	7.2	62.2	.891	27.3	40		150	80
Residuum			36.3	98.5	.970	14.4				

Carbon residue of residuum, 7.6 percent; carbon residue of crude, 3.1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	2.6	0.683	75.7	
Total gasoline and naphtha	16.4	.757	55.4	
Kerosine distillate	4.0	.815	42.1	
Gas oil	22.0	.839	37.2	50-100
Nonviscous lubricating distillate	11.5	.859-.883	33.2-28.8	50-100
Medium lubricating distillate	8.3	.883-.897	28.8-26.3	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	36.3	.970	14.4	
Distillation loss	1.5			

TABLE 7. - Chemical and physical properties of three crude oils, Healdton oil field, Carter County, Okla. (Cont.)

Typical C - type crude oil
The Pure Oil Co.
V. Collins 80-A well 21

Sample No. C-1, table 8
1,068-1,091 feet
Sec. 16, T. 4 S., R. 3 W.

GENERAL CHARACTERISTICS

Specific gravity, 0.888 A.P.I. gravity, 27.9° Pour point, °F. below 5
Sulfur, percent, 1.40 Color, dark green
Saybolt Universal viscosity at 100° F., 130 sec.; at 130° F., 95 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1. - Distillation at atmospheric pressure, 736 mm. Hg
First drop, 27° C. (81° F.)

Fraction No.	Cut at- °C.	°F.	Percent	Sum, percent	Sp. gr., 60/60 °F.	°A.P.I., 60 °F.	C.I.	Aniline point, °C.	S.U. visc., 100 °F.	Cloud test, °F.
1	50	122	1.2	1.2)						
2	75	167	.7	1.9)						
3	100	212	1.5	3.4)	0.681	76.3	-	58.0		
4	125	257	2.4	5.8	.734	61.3	19	55.9		
5	150	302	3.1	8.9	.761	54.4	24	55.5		
6	175	347	3.1	12.0	.782	49.5	27	55.0		
7	200	392	2.9	14.9	.800	45.4	30	55.4		
8	225	437	3.5	18.4	.817	41.7	32	58.0		
9	250	482	4.2	22.6	.829	39.2	32	62.8		
10 1/	275	527	7.7	30.3	.838	37.4	-	66.9		

STAGE 2. - Distillation continued at 40 mm. Hg

11	200	392	1.8	32.1	0.849	35.2	33	-	42	15
12	225	437	6.1	38.2	.859	33.2	34	72.4	46	30
13	250	482	6.3	44.5	.873	30.6	37		60	50
14	275	527	5.6	50.1	.888	27.9	41		85	65
15	300	572	7.5	57.6	.896	26.4	42		170	80
Residuum			40.3	97.9	.974	13.8				

Carbon residue of residuum, 11.0 percent; carbon residue of crude, 4.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	°A.P.I.	Viscosity
Light gasoline	3.4	0.681	76.3	
Total gasoline and naphtha	14.9	.750	57.2	
Kerosine distillate	3.5	.817	41.7	
Gas oil	18.5	.842	36.6	
Nonviscous lubricating distillate	11.6	.863-.889	32.5-27.7	50-100
Medium lubricating distillate	7.7	.889-.899	27.7-25.9	100-200
Viscous lubricating distillate	1.4	.899-.901	25.9-25.6	Above 200
Residuum	40.3	.974	13.8	
Distillation loss	2.1			

1/ Distillation discontinued at 273 °C. (523 °F.)

TABLE 8.--Comparison of properties of crude oil samples from the Healdton oil field, Carter County, Okla.

Sample No.	Company	Lease	Well No.	Location	Producing sands	Gravity °A.P.I.	Sulfur, percent	Viscosity, 80°F., cp.	Year analyzed
A-1*	Shell Oil Co., Inc.	Wirt Franklin	46	NE NE sec. 8, T. 4 S., R. 3 W.	1,2,3,3a	34.6	0.72	8.7	1939
A-2*	Do.	A. D. Horton	11	NW SE sec. 6, T. 4 S., R. 3 W.	1	32.5	.75	14.0	1950
A-3*	The Pure Oil Co.	V. Collins, 80 acre	11	SE NE sec. 16, T. 4 S., R. 3 W.	4	32.3	.75	10.9	1950
A-4	Texas-Gulf Producing Co.	Apple & Franklin	2	SW NE sec. 9, T. 4 S., R. 3 W.	No log	32.3	.80		1951
A-5*	Shell Oil Co., Inc.	A. D. Horton	7	NW SE sec. 6, T. 4 S., R. 3 W.	1,2,3	31.9	.72	13.0	1939
A-6*	Do.	C. L. McClure	41	SE SW sec. 5, T. 4 S., R. 3 W.	4	31.9	.74	11.8	1949
A-7*	Magnolia Petroleum Co.	C. Richards	8	SE NW sec. 31, T. 3 S., R. 3 W.	2,3(?)	31.9	.70	15.0	1949
A-8*	Do.	E. T. Richards	93	SW SE sec. 31, T. 3 S., R. 3 W.	2,3(?)	31.5	.72	14.0	1950
A-9	Do.	K. W. Dawson	3	NW NE sec. 4, T. 4 S., R. 3 W.	1	31.5	.80	-	1951
A-10*	Magnolia Pipeline		-	-	-	31.1	.72	13.5	1920
A-11	Shell Oil Co., Inc.	K. N. Hapgood	14	NE SW sec. 3, T. 4 S., R. 3 W.	1,2	31.0	.87	-	1951
B-1	Do.	L. Tubbee	6	NE NW sec. 24, T. 4 S., R. 3 W.	1,2	30.8	1.22	-	1951
B-2*	Rockland Oil Co.	Sarasota	49	SE NE sec. 23, T. 4 S., R. 3 W.	1,2,3,(?)	30.6	1.00	18.3	1949
B-3*	Cox & Hamon	L. Carnes	98	SE SE sec. 15, T. 4 S., R. 3 W.	4	30.0	.93	23.9	1950
B-4	Shell Oil Co., Inc.	L. Tubbee	9	SE NW sec. 24, T. 4 S., R. 3 W.	1	29.7	.98	-	1951
B-5	Magnolia Petroleum Co.	J. A. Smalley	33	SW NE sec. 10, T. 4 S., R. 3 W.	1,2,3	29.1	.99	-	1951
B-6*	Gray Oil Co.	Pugh	1	SW SW sec. 18, T. 4 S., R. 2 W.	Pugh	28.9	.92	31.3	1949
B-7	The Pure Oil Co.	J. McCoy	16	NE NW sec. 23, T. 4 S., R. 3 W.	1,2,3,4	28.7	.95	-	1951
B-8	Magnolia Petroleum Co.	J. Hamon	12	NE NW sec. 15, T. 4 S., R. 3 W.	No log	28.2	1.02	-	1951
C-1*	The Pure Oil Co.	V. Collins, 80 acre	21	SW NE sec. 16, T. 4 S., R. 3 W.	2	27.9	1.40	31.7	1950
C-2	Engelbrecht	Mobley	5	SE SE sec. 13, T. 4 S., R. 3 W.	No log	27.1	1.10	-	1951
C-3	Ring & Trachenburg	J. McCoy	1,2	NE SW sec. 14, T. 4 S., R. 3 W.	3	26.8	1.10	-	1951
C-4*	Magnolia Petroleum	F. E. Watkins	5	SW SE sec. 24, T. 4 S., R. 3 W.	No log	26.1	1.21	58.9	1949

* Distillation, Bureau of Mines routine method.

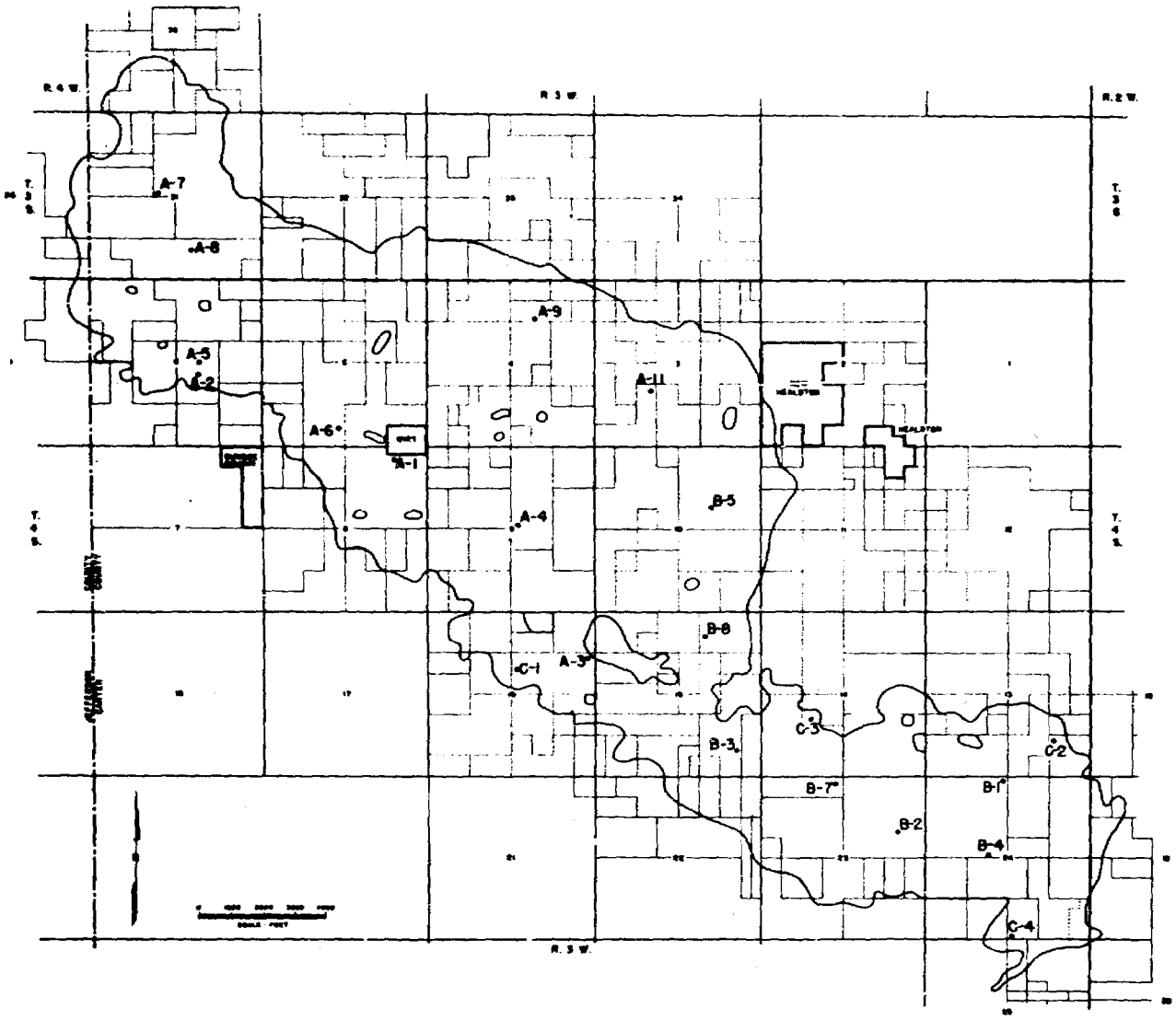


Figure 26. - Location of oil sample analyses shown in table 8.

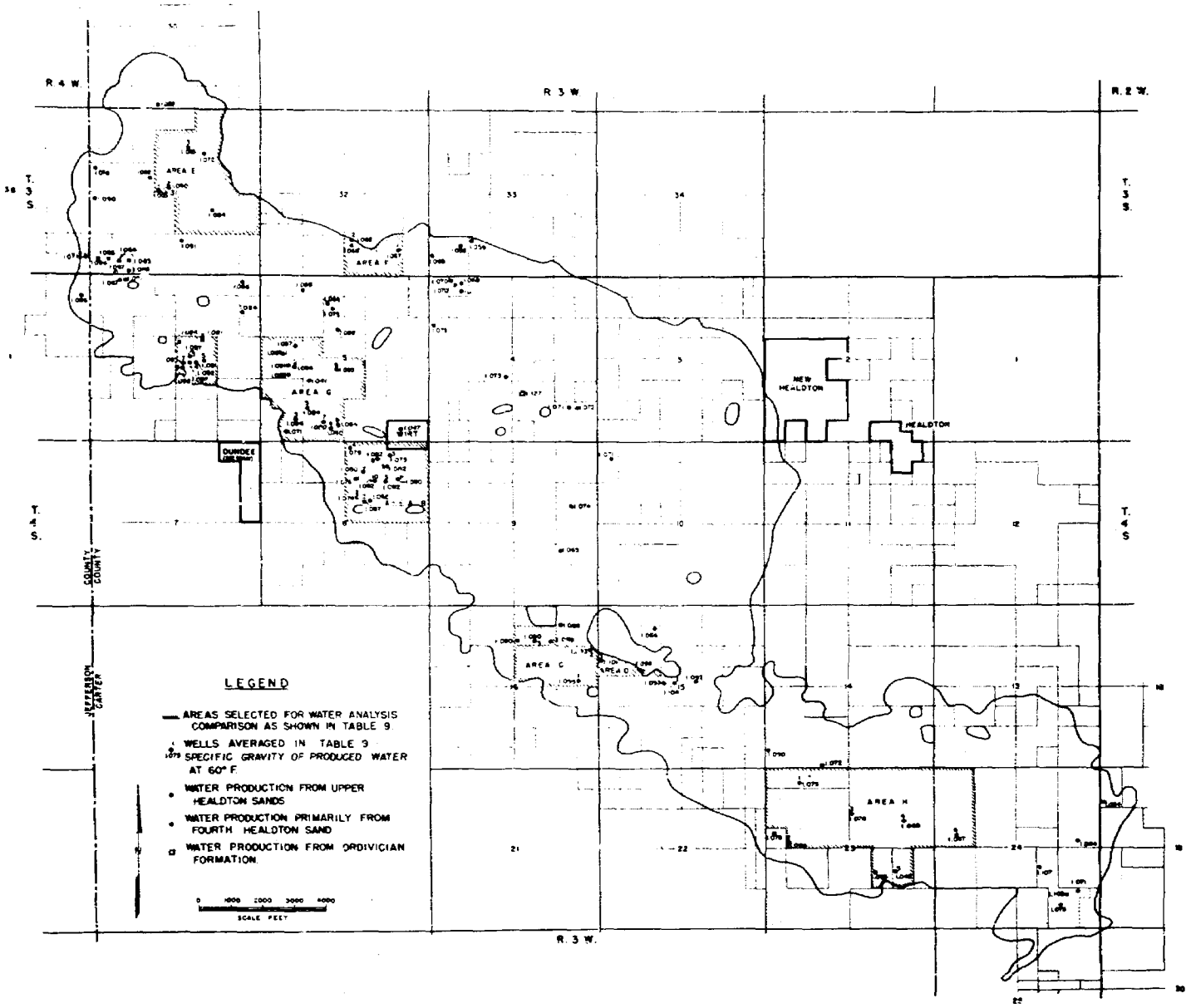


Figure 27. - Areas and wells considered in a study of produced water samples, Healdton oil field, Carter County, Okla.

No satisfactory explanation can be advanced as to the reasons for the different oils produced from the Healdton sands. Differences do not depend upon the sand or age of the well but do seem to show a relationship to their areal distribution in the field. Figure 26 shows the location of wells from which samples were obtained. The A-type oils are found in secs. 30, 31, 32, and 33, T. 3 S., R. 3 W., and secs. 3, 4, 5, 6, 8, 9, and part of 16, T. 4 S., R. 3 W., whereas the B- and C-type oils are found in secs. 10, 15, and part of 16, T. 4 S., R. 3 W., and in the entire southeast extension of the field.

Produced Waters

In an attempt to differentiate between waters produced from several stratigraphic horizons, as well as to identify and trace the sources of produced water in individual wells, a detailed study was made of produced water throughout the field.

Figure 27 is a map of areas and wells from which samples of produced water were collected and analyzed. The well symbol denotes whether water is being produced from upper Healdton sands or the fourth sand. The specific gravity of the produced water at 60° F. is below the well symbol. The numbered wells are those from which sample analyses were averaged and presented in table 9. In general, the specific gravity of waters from upper Healdton sands is lower than that of water from the fourth sand. In some wells water is produced from both the upper Healdton sands and fourth sand, and the mixture of these waters results in an intermediate specific gravity.

Included in table 9 are averages of 47 mineral analyses of waters, which have been grouped according to areas (see fig. 27) in which the water is being produced. This grouping by areas was advisable because of the difficulty of comparing waters from widely separated parts of the field.

Because of difficulty in determining the exact sources of the water, no attempt has been made to differentiate between waters produced from the first, second, or third Healdton sands. Analyses of waters from these upper Healdton sands have been grouped and called upper-sand waters. Waters collected from wells that penetrated the fourth sand and where water production is believed to be primarily from the fourth sand are included in another group as fourth-sand waters.

The principal ions in all of the produced waters are calcium, magnesium, sodium, and chloride, with very little bicarbonate and sulfate. The total solids content and the specific gravity of the waters analyzed vary, depending primarily upon the water-producing formation. The difference in the relative proportion of ions in upper-sand waters and fourth-sand waters can be seen when the average reacting values, in percentage, are compared.

In the Healdton field the reacting values of calcium appear to increase with depth, and the reacting values of sodium and magnesium appear to decrease with depth. For instance, water produced from the Ordovician formation has reacting values of 12.2, 4.6, and 33.2 percent for calcium, magnesium, and sodium, respectively, as compared to reacting values of approximately 11.5, 4.7, and 34.0 percent for those ions in fourth-sand waters.

TABLE 9.--Analyses of water produced with oil, Healdton oil field, Carter County, Okla.

Area	No. of analyses averaged	Calcium(Ca),		Magnesium(Mg),		Sodium(Na),		Bicarbonate(HCO_3),		Sulfate(SO_4),		Chloride(Cl),		Total solids,		Specific gravity, 60°F.
		p.p.m. 1/	r.v. 2/	p.p.m.	r.v.	p.p.m.	r.v.	p.p.m.	r.v.	p.p.m.	r.v.	p.p.m.	r.v.	p.p.m.	r.v.	
A																
Average Upper sand waters	5	7,790	9.49	2,595	5.21	33,233	35.30	150	0.06	1	0.0	72,513	49.93	116,302	100.00	1.063
Average Fourth sand waters	2	11,165	11.58	2,739	4.69	37,251	33.74	119	.04	2	0	85,102	49.95	136,361	100.00	1.097
B																
Average Upper sand waters	3	6,538	8.66	2,621	5.74	30,741	35.59	245	.11	5	0	66,486	49.89	106,634	100.00	1.076
Average Fourth sand waters	8	8,445	10.42	2,435	4.96	32,311	34.81	141	.06	61	.03	71,169	49.84	114,562	100.00	1.082
C																
Average Fourth sand waters	3	10,705	11.42	2,836	4.99	36,141	33.59	370	.13	6	0.	82,736	49.87	132,791	100.00	1.093
D																
Average Fourth sand waters	3	11,513	11.47	3,002	4.93	38,657	33.60	160	.06	58	.01	88,646	49.94	141,997	100.00	1.101
E																
Average Upper sand waters	5	7,148	8.75	2,536	5.14	33,721	36.11	276	.11	0	0.	71,890	49.89	115,571	100.00	1.083
F																
Average Upper sand waters	2	4,829	7.11	2,149	5.22	29,355	37.66	107	.05	22	.01	60,011	49.94	96,468	100.00	1.069
G																
Average Upper sand waters	4	8,500	10.73	2,459	5.15	30,742	34.12	127	.05	45	.01	69,542	49.94	111,381	100.00	1.081
Average Fourth sand waters	6	8,470	10.12	2,621	5.19	33,174	34.70	109	.04	11	.01	73,724	49.95	118,107	100.00	1.085
H																
Average Upper sand waters	5	7,414	10.80	2,028	4.87	27,004	34.34	22	.01	0	0.	60,661	49.99	97,129	100.00	1.070
Average Fourth sand waters	1	9,083	10.47	2,822	5.36	34,023	34.17	106	.04	541	.26	76,295	49.70	122,869	100.00	1.083

1/ p.p.m. - parts per million.

2/ r.v. - reacting value in percentage (Palmer)

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Table 9 shows that, for water samples from five upper-sand wells in area A, the average reacting value of calcium was 9.49 percent compared with an average of 11.58 percent for the average reacting value of calcium in waters from two fourth-sand wells. The average reacting value of magnesium in water from upper sands was 5.21 percent, whereas the average reacting value of magnesium in water from the fourth sand was 4.69 percent. The average reacting value of sodium was 35.30 percent in upper-sand waters and 33.74 percent in fourth-sand waters. This comparison of water analyses indicates that, for upper-sand waters in area A, the specific gravity and reacting value of calcium were lower and reacting values of magnesium and sodium higher than those in fourth-sand waters.

In area B analyses were made of water from three wells producing from upper sands and of water from eight wells producing from the fourth sand. In comparing the average reacting values of ions in upper-sand waters with those of fourth-sand waters, it can be seen that, for the upper sands, the average reacting value of calcium is low and the average reacting values of magnesium and sodium high. The reacting value of calcium in upper-sand waters is 8.66 percent, whereas in fourth-sand water it is 14.42 percent. The average reacting value of magnesium in upper-sand waters is 5.74 percent, whereas in fourth-sand waters it is 4.96 percent. The average reacting value of sodium are 35.59 percent in upper-sand waters and 34.81 percent in fourth sand waters. This would indicate that in area B, as in area A, upper-sand waters have lower specific gravities and lower reacting value of calcium and higher reacting values of magnesium and sodium than do fourth-sand waters.

In areas C and D samples of fourth-sand waters only were collected; therefore a quantitative comparison, such as that for areas A and B, cannot be made. However, the average reacting values of the several ions in these waters in areas C and D can be compared with the average reacting values of ions in the fourth-sand waters in areas A and B. It will be noted that the average reacting values of the three metallic ions (calcium, magnesium, and sodium) in waters from areas C and D are very similar and that for both areas they agree closely with the respective reacting values in fourth-sand waters from areas A and B. In the absence of upper-sand-water analyses, it may be assumed that the relationship that existed between upper-sand waters and fourth-sand waters in areas A and B also would exist between upper-sand waters and fourth-sand waters in areas C and D.

Averages of analyses of upper-sand waters from five wells in area E and from two wells in area F are shown in table 9. The average reacting values of the metallic ions were comparable to those in upper-sand waters from areas A and B. No sample of fourth-sand water from E and F was analyzed, but it may be assumed that in fourth-sand waters from areas E and F, as in fourth-sand waters from other areas, the reacting value of calcium would be higher and the reacting values of sodium and magnesium lower than in upper-sand waters.

For area G analyses of waters from four upper-sand wells and six fourth-sand wells are shown. From comparison of these analyses it can be seen that the average reacting value of calcium in upper-sand waters is slightly higher than that of calcium in fourth-sand waters. The average reacting values of magnesium and sodium in upper-sand waters are slightly less than those of magnesium and sodium in fourth-sand waters. The average reacting values of these waters are completely reversed from what has been shown to be the normal relation of the reacting values. Such a discrepancy may be explained as follows. A well drilled in 1918 in area G in the vicinity of wells 5, 7, and 8 (fig. 27) was plugged and abandoned to prevent flooding of lower sands after it had encountered large quantities of water in an upper Healdton sand. Two other upper Healdton sand wells in the vicinity were abandoned about 1930 because

of high water production. A well drilled in 1939 reported water in the upper Healdton sands also. Most of the wells that penetrated the fourth sand were open to production in the upper Healdton sands also, and these wells may have permitted a mingling of waters. From all available data as to the volume of water and the high percentage of water from these wells, it would appear that water is being produced from both the upper Healdton sands and the fourth sand and that the waters have been mixed. If this is the case, the analyses should be similar, and by comparing the average reacting values of calcium, magnesium, and sodium in the two groups such a similarity is evident. Therefore, it is believed that, in this limited area, these two waters have mingled.

Table 9 shows five analyses of water produced from wells in upper Healdton sands in area H. In this area few wells produce from the fourth sand alone, and the one analysis shown in table 9 as fourth-sand water is of water produced from a well open in the upper Healdton sands as well as the fourth sand.

The specific gravity of the fourth-sand water is higher than that of the upper-sand waters, but the relative reacting values of calcium and magnesium for the two groups of waters differ from those that would be expected by comparison with waters from areas A and B. The one analysis of water that probably is from the fourth sand is not conclusive evidence as to the character of fourth-sand water in this area.

Produced Gas

The mass-spectrometer analyses of a raw gas and a gas from which gasoline has been removed are shown in table 10, part A. Field analyses listing the air, carbon dioxide, and gasoline content of natural gas from a number of leases in the Healdton field, as of October 1950, are shown in table 10, part B. The air content ranges from 7 to 52 percent, carbon dioxide from 0 to 4.8 percent, and gasoline content from 0.56 to 3 gallons per thousand cubic feet. The large air content undoubtedly resulted from leaks in the vacuum gathering-lines because comparatively little air has been injected into the sands. No earlier gas analyses are available.

"Infill" Drilling

Most of the wells in the Healdton oil field drilled before 1920 were completed with a series of perforated liners set through 200 to 400 feet of the Healdton-sand section. Sometimes caving sands and shales plugged the liners, and often the operators found that the necessary "work-over" job was almost as expensive as drilling a new well. Undoubtedly this factor is the main reason approximately 440 additional producing wells have been drilled to the Healdton sands since 1919. Figure 28 shows the productive limits of the field in 1919 and 1950 and the location of wells drilled during the intervening period.

Several companies initiated planned infill drilling of wells between the original wells in 1926, 1935, and 1946. Thirty-eight wells were drilled between 1926 and 1935, 288 wells drilled between 1935 and 1946 (the principal infill-drilling period), and 114 wells between 1946 and 1950. The initial production of a new well usually was much greater than the daily oil production of an offset old well. Many old wells in the field were deepened after 1920 to lower oil sands.

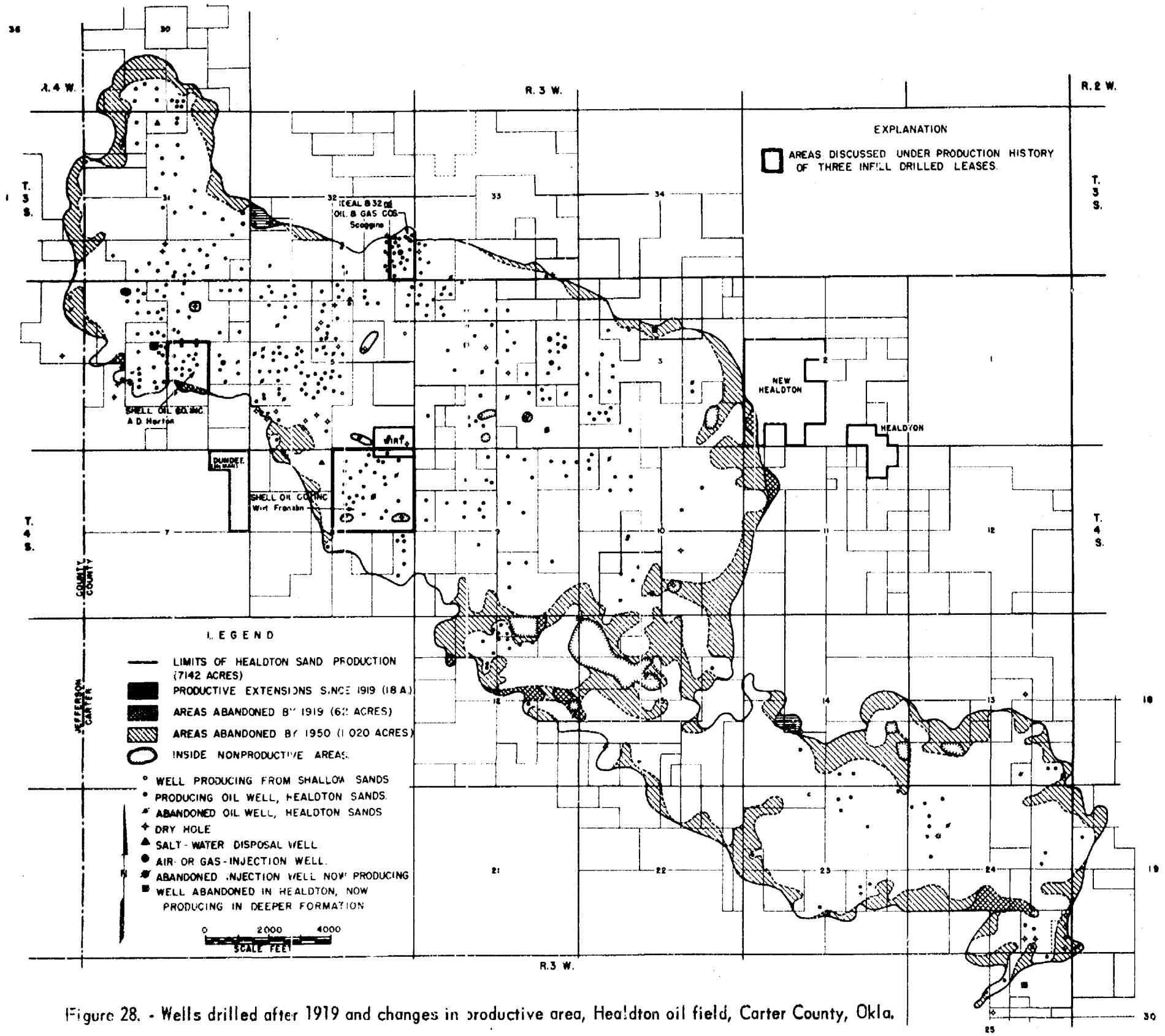


Figure 28. - Wells drilled after 1919 and changes in productive area, Healdton oil field, Carter County, Okla.

TABLE 10.--Analyses of gas samples, Healdton oil field, Carter County, Okla.

Part A - Mass Spectrometer Analyses
November 22, 1950

Sample source	Harry Ells, Inc., gasoline plant (denuded gas from compressor)	Sinclair Oil and Gas Co., J. S. Mullens lease (raw gas)
	Percent	Percent
Methane	35.21	29.38
Ethane	8.37	8.30
Propane	6.25	7.68
Normal Butane	.25	1.56
Isobutane	.18	.86
Normal Pentane	.13	.41
Isopentane	0	.07
Cyclopentane	.04	.05
Hexanes plus	.10	.27
Nitrogen	39.90	42.41
Oxygen	7.80	6.15
Argon	0	.51
Helium	.02	.01
Carbon Dioxide	1.75	2.34
Total	100.00	100.00
Calculated gross B.t.u./cu. ft.*	695	763

* Dry at 60°F. and 30 inches mercury.

Part B - Field Analyses

Company	Lease	Specific gravity	Volume percent CO_2	Volume percent air	Gasoline content, gal./M c.f.
The Pure Oil Co.	Titsworth	0.936	0.0	14.0	1.76
Do.	W & D 80 acre	.992	0	31.0	1.20
Do.	Ruby Ingram	.880	7.4	10.0	.94
Do.	W. R. Ingram	.929	5.0	33.0	1.08
Do.	J. McCoy	.935	0	19.0	1.44
Do.	Watson	.904	0	52.0	60
Do.	Ardhoma #1	.981	1.4	35.0	1.04
Do.	F. Lowery	1.058	2	30.0	1.42
Do.	W & D 60 acre	1.085	2.0	27.0	1.82
Do.	Ardhoma #2	1.141	1.4	36.0	1.76
Do.	J. Moyer	.951	4.8	30.0	1.30
Do.	J. Davis 1/	.991	0	36.0	.78
Ring and Trachenburg	J. McCoy	.748	0	10.0	.28
Kewanee Oil Co.	J. Ott	.990	2.8	7.0	1.30
Carlock and Dexter	Tillis	1.018	.6	47.0	1.32
Do.	Brokenshoulder	1.264	4.4	8.0	3.06
Texas-Gulf Producing Co.	Apple and Franklin	1.202	1.2	15.0	2.50
Sun Oil Co.	Mullen "A"	1.000	1.0	23.0	1.40
Do.	Mullen "B"	1.136	1.0	16.0	2.28
Do.	Mullen "C"	1.136	1.0	16.0	2.28
Tomlinson	O. Johnson	1.041	0	7.0	2.76

1/ Analysis of October 12, 1949.

By January 1, 1935, when the principal infill-drilling program was begun, 166,008,000 barrels of oil had been produced from Healdton oil sands. Figure 29 shows the recovery, in barrels per acre, for each lease to that date. On eight leases, including 170 productive acres, recovery exceeded 80,000 barrels of oil per acre, while on eight other leases, including 408 productive acres, recovery exceeded 60,000 barrels of oil per acre. However, in most of the field (4,324 acres) oil recovery was less than 20,000 barrels per acre.

Figure 3, production history of the Healdton oil field, shows that between 1926 and 1950 20,198,000 barrels of oil over and above that expected by normal production methods was produced as a result of additional drilling, deepening, clean-out, vacuum application, and gas injection. The estimated normal decline rate between 1926 and 1950 was 7.7 to 5.0 percent per year. It is estimated that during this period approximately 285,400 barrels of additional oil was gained by injecting air and gas into the Healdton sands. The remaining 19,912,600 barrels of additional oil recovery is attributable to the drilling of new wells, deepenings, clean-outs of oil wells, and vacuum application.

Between 1925, when annual oil production was 5-1/4 million barrels, and 1950, when it was 2-1/4 million barrels, 88-1/2 million barrels of oil was recovered from Healdton sands. During this interval the over-all decline rate was less than 3-1/2 percent per year, much lower than that of most fields of comparable age. Additional drilling, deepening of wells to new sands, and clean-outs of old wells have sustained this oil-production rate. Very little is attributable to secondary-recovery operations.

Although 440 new wells have been drilled in the Healdton oil field during the last 25 years, it is interesting to note that at no time since 1920 has the number of producing wells equaled the number of wells (1,971) producing at that time. The number of wells abandoned exceeded the number of new wells completed, and in 1950 the number of producing wells was 95 less than in 1920.

The recovery per acre to January 1, 1951, from individual leases in the field is shown by degrees of shading in figure 30. The oil recovery from 5 leases, including 135 productive acres, exceeded 120,000 barrels per acre, whereas the recovery from 10 leases, including 338 productive acres, exceeded 80,000 barrels of oil per acre. An idea of the oil recovered from the leases between 1935 and 1950 may be obtained by comparing figures 29 and 30. Oil recovered since January 1, 1935, from a few leases has been nearly 40,000 barrels per acre and from most of the leases in the main part of the field has been nearly 20,000 barrels of oil per acre. Oil recoveries in the southeast extension are much lower.

Oil recovery, between 1935 and 1950, from Healdton sands underlying infill- and noninfill-drilled leases has been compared. The cumulative oil recovery from 31 infill-drilled leases, including 2,100 productive acres, was increased from 80 million to 105 million barrels between 1935 and 1950, 31.2 percent increase over their cumulative recovery to 1935. By contrast, the oil recovery from 44 noninfill-drilled leases, including 1,726 productive acres, was increased only 22.2 percent over their cumulative recovery to 1935. Assuming that without infill drilling the increased recovery after 1935 normally would be about 22 percent of the cumulative recovery through that date, the infill-drilled leases recovered an additional 3,430 barrels of oil per acre or 29,500 barrels per infill well between 1935 and 1950 by drilling the 244 additional oil wells. In general, the infill wells were drilled in the more prolific parts of the field, which had lower decline rates. No attempt was made to estimate future oil production from the leases in these two groups.

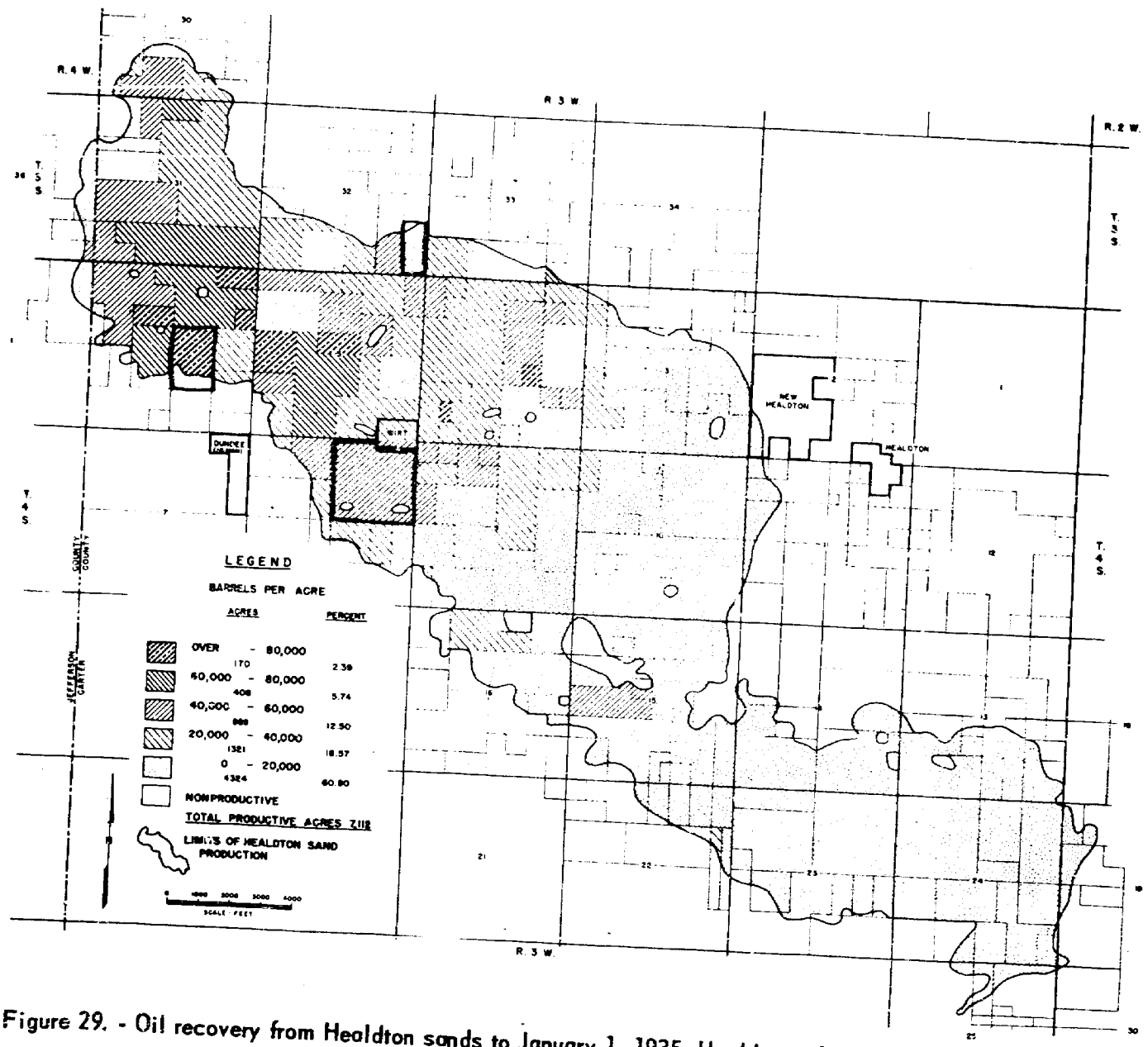


Figure 29. - Oil recovery from Healdton sands to January 1, 1935, Healdton oil field, Carter County, Okla.

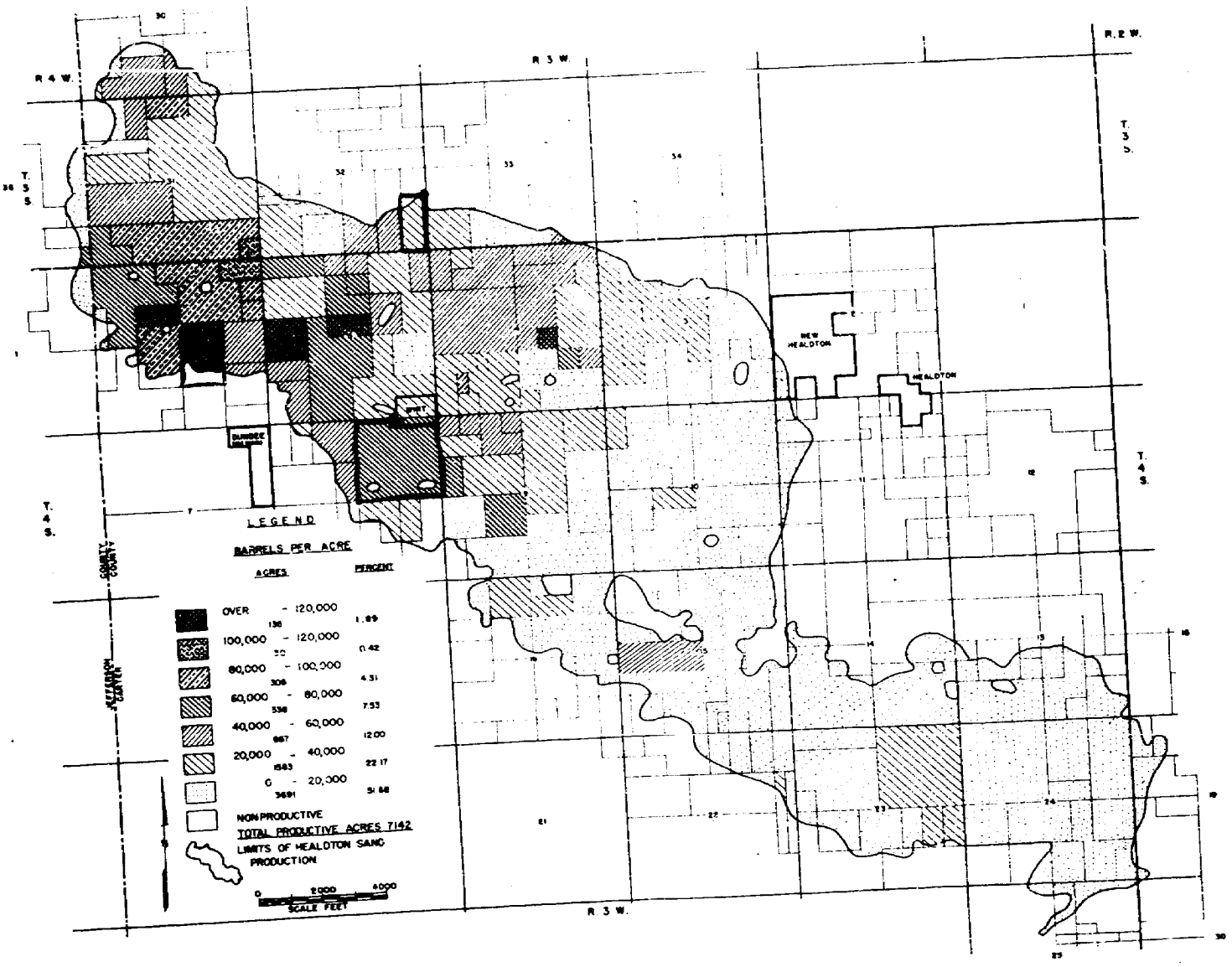
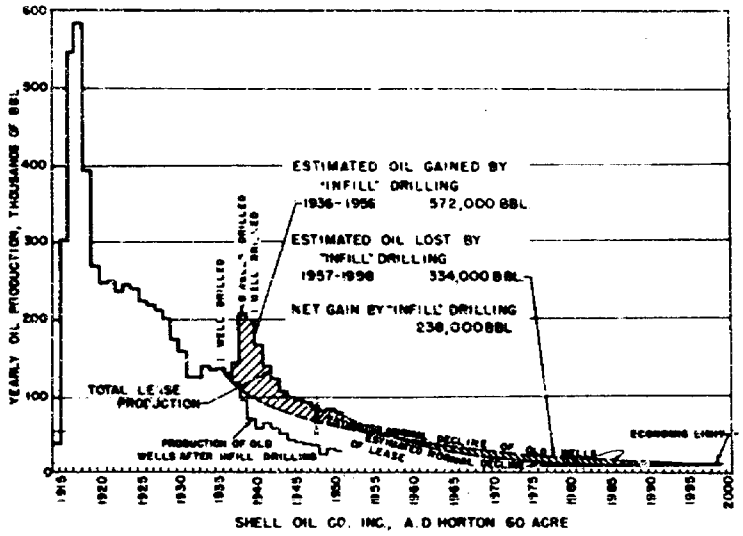
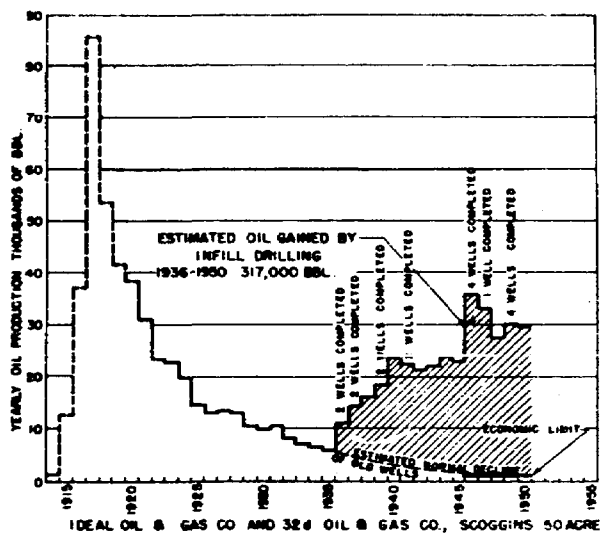


Figure 30. - Oil recovery from Healdton sands to January 1, 1951, Healdton oil field, Carter County, Okla.





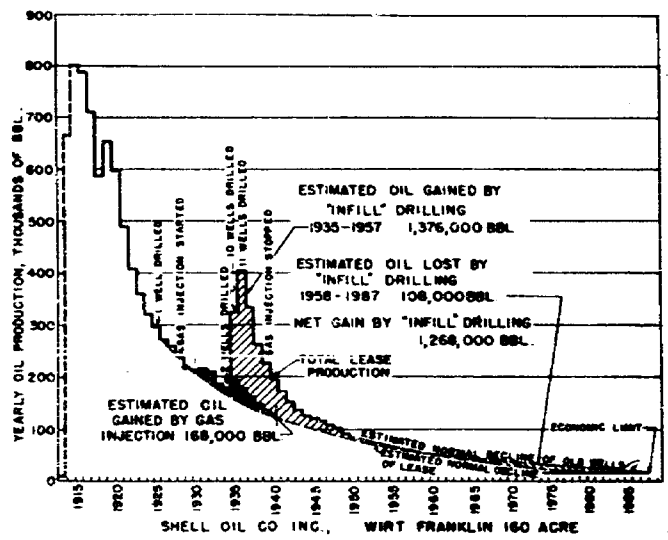


Figure 31. - Oil-production histories of three infill-drilled leases, Healdton oil field, Carter County, Okla.

Production History of Three Leases

A detailed study was made of the results of drilling infill wells on three leases in an effort to determine the effect of closer spacing of wells in the Healdton sands. These three leases were selected because data were available regarding oil and water production and sand conditions. From these studies it is concluded that closer spacing will recover more oil from these leases before the production from the wells declines to the economic limit. These conclusions are based upon expected oil production, as indicated by extrapolations of decline curves of old wells, and of decline curves after infill drilling. The increases, after infill drilling, in the rates of oil production from these leases resulted not only from closer spacing but from penetration of deeper, undrained oil sands and reconditioning of old wells.

Shell Oil Co., Inc., A. D. Horton. - The Shell Oil Co., Inc., A. D. Horton 60-acre lease in sec. 6, T. 4 S., R. 3 W., includes about 45 oil-productive acres; the productive limits are defined by two dry holes. The yearly oil production had declined from a peak of 587,780 barrels in 1917 to 131,507 barrels in 1935 before the infill-drilling program began. Eleven oil-producing wells were drilled between 1936 and 1939.

The results of this infill-drilling development are illustrated graphically in figure 31.

Yearly oil production from the lease reached a second peak of 203,411 barrels in 1938 after 10 wells had been drilled on locations between the original wells. The graph shows that the decline rate of old wells was abnormally high after infill wells were drilled. The curve showing the estimated normal decline of production from the old wells was extrapolated from 1936 to an economic limit in 1998, as shown by the dashed heavy line, to calculate how much oil the lease would have produced had the infill wells not been drilled. The estimated normal decline in the rate of oil production of the lease from 1950 to an economic limit in 1982, as shown by the dashed light line, illustrates the more rapid decline of the closer-spaced lease. By January 1, 1951, an additional 538,000 barrels of oil over and above the expected decline had been recovered on this lease, and by 1957 the increased oil production should total about 572,000 barrels. After that year, the more-rapid decline in the rate of oil production from the closer-spaced wells should result in lease production below the estimated normal decline, effecting a calculated production loss of 334,000 barrels of oil between 1957 and abandonment date.

The total cumulative oil production between 1914 and 1998, assuming that infill wells had not been drilled, is estimated to be about 7,514,000 barrels, whereas the cumulative oil production to 1982 is estimated to be approximately 7,752,000 barrels. This is an increased recovery of 238,000 barrels, or 5,300 barrels per acre, attributable to drilling new wells. By January 1, 1951, the lease already had produced over 150,000 barrels of oil per acre.

Ideal and 32d Oil & Gas Cos. Scoggins. - The Ideal Oil & Gas Co. and 32d Oil & Gas Co. Scoggins lease is the east 50 acres of the SE1/4 sec. 32, T. 3 S., R. 3 W. The estimated productive area of this lease, as defined by two dry holes drilled on the north edge of the field, is 29 acres.

Nine productive wells were drilled on this lease during the primary development period between 1914 and 1921. Yearly oil-production data before 1920 are not available, but the peak yearly oil production is estimated to have occurred in 1917 and

TABLE 11.--Gas injection projects, Healdton oil field, Carter County, Okla.

	Company	Lease	Total prod. area, acres	Estimated affected area, acres	Location Sec.	Twp.	Rge	Average sand thickness, feet	Date injection started	Date injection discon.	Total No. of injection wells	Original wells Total No.	Original wells No. affected	New wells drilled	Gas injected Avg. inc. pressure, p.s.i.	Gas injected Ave. da. vol. inj., M c. f.	Avg. da. Oil prod. bbl. Before inj.	Avg. da. Oil prod. bbl. Maximum during inj.	Avg. da. Oil prod. bbl. 1-1-51 or when discon.	Oil gained, bbl.
	Operating Projects																			
1	Ideal & 32nd Oil & Gas Cos.	S. Scoggins	28	12	32	3 S.	3 W.	64	8-47	Oper.	1	21	6	2	7-10	-	83	68	60.3	3,500(1)
2	McGraw Oil Co.	Stewart & Hawk	50	44	(33 (4	3 S. 4 S.	3 W. 3 W.	50	11-44	do.	1	14	11	5	18-20	8-17	1/82.7	99.7	96	39,000
3	Do.	W. Woodworth	24	24	32	3 S.	3 W.	57	11-43	do.	2/2	6	6	3	15-20	10-15	46	56	3/70	19,800
4	The Pure Oil Co.	Boetheimer & Daube 80 Acre	80	33	(9 (10	4 S. 4 S.	3 W. 3 W	115	3-37	do.	1	23	14	1	3- 8	4/30-85	160	169	40	-
5	Sinclair Oil & GasCo.	J. S. Mullen	80	52	4	4 S.	3 W.	82	11-43	do.	3	19	17	3	50-200	33-144	49.7	63.3	42.6	35,800
6	Kewanee Oil Co.	H. Willis	40	14	8	4 S.	3 W.	25	6-46	do.	1	17	5	1	17-25	6-12	42	3/55.2	3/50	3,500
	Discontinued Projects																			
7	Shell Oil Co., Inc.	W. Franklin	156	156	8	4 S.	3 W.	110	6-29	12-39	5/6	35	35	23	60-65	65-175	587	644	370	188,000
8	Do.	L. Tubbee	160	149	24	4 S.	3 W.	39	5-26	1931(?)	1	35	32	0	-	31	105	152	107	12,500
9	Kewanee Oil Co.	S. Jones	120	75	4	4 S.	3 W.	89	6-36	9-46	3	34	15	1	15-18	30-40	232	265	3/133	1,740
10	The Pure Oil Co.	F. Lowery	88	37	4	4 S.	3 W.	40	5-46	11-47	2	28	10	0	16-32	16-20	59.8	61.5	53.8	-
11	Do.	Boetheimer & Daube 80 Acre	80	10	9	4 S.	3 W.	87	7-46	10-46	1	21	2	0	14-18	3	30.6	31.5	25.9	-
12	Schermerhorn Oil Co.	Fee 40 Acre	40	34	5	4 S.	3 W.	90	3-35	11-35	2	15	15	3	30	450	382	404	382	1,740

1/ Average daily production on affected wells only.
2/ Well No. 11 took only a small amount of gas.
3/ Production from all wells including new wells.
4/ Injection of gas discontinued during winter months.
5/ Some wells were used only a short time for gas injection.

The first gas-injection operation was begun in 1928 on what is now the Shell Oil Co., Inc., Lucy Tubbee lease, and other projects have been initiated at various times since; the last one was begun in August 1948. On some leases gas injection was discontinued after several months, but on one lease gas has been injected intermittently over a period of 14 years. Currently gas is being injected into wells on six leases.

Figure 32 shows the location and area affected by the gas injection projects in the field. Denuded gas from the Harry Ells, Inc., gasoline plant comprises most of that injected, although some additional gas has been purchased from the Oklahoma Natural Gas Co. On a few leases air was injected at the beginning of the operation and then later augmented with gas.

An attempt was made to direct the injected gas into a definite sand zone using packers in one instance. Usually no change was made in the casing depth when producing wells were converted to gas-injection wells. Gas was injected through the casing, often with the tubing left in the well. Although some of the projects were highly successful, others yielded little increase in oil production that could be attributed to gas injection. In many instances drilling additional wells during the gas-injection program has masked the effects of gas injection.

It is estimated that, between May 1928 when injection was begun and December 1950, approximately 285,400 barrels of oil was recovered from nine leases as a result of gas injection. Results on three other leases, where gas was injected primarily for storage, were inconclusive. On the 12 leases only 168 wells on 678 acres showed increases in the rate of oil production attributable to gas injection compared with 1,971 wells and 7,142 acres in the field.

It is believed that the poor results obtained on many of these projects do not necessarily condemn those areas for gas injection, because with better control of the injected gas much additional oil could be recovered from the sands.

Table 11 shows that by 1950 only six projects, with eight injection wells, were operating. Daily volumes of 6,000 to 144,000 cubic feet of gas were being injected at pressures ranging from 7 to 200 p.s.i. on individual projects. Following are descriptions of several of the more important projects.

Description of Individual Leases

Ideal and 32d Oil & Gas Cos. Scoggins. - In August 1947, the Ideal Oil & Gas Co. and the 32d Oil & Gas Co. began to inject excess gas into well 16 on the Scoggins lease in the SE1/4 sec. 32, T. 3 S., R. 3 W. In this area the first Healdton sand is split into two members by a thick shale and limestone section. The top member of the first sand was cored in three wells, and analyses show that the porosity ranges from 16 to 28 percent. A total of 64 feet of oil-productive sand, including parts of the first and third Healdton sands, was penetrated in this well. The second Healdton sand was shaly and nonproductive.

Oil production from this lease was increased in 1946 by drilling additional wells, as described under infill drilling, so that results from gas injection are not clearly defined.

Well 16, converted in August 1947 to an injection well, was completed in April 1941 with an initial production of 3 barrels of oil daily from first and third sands, at depths from 955 to 1,018 feet and 1,107 to 1,188 feet, respectively. An 8-1/4-inch casing was set above the first sand at 948 feet, and a 6-inch liner, perforated

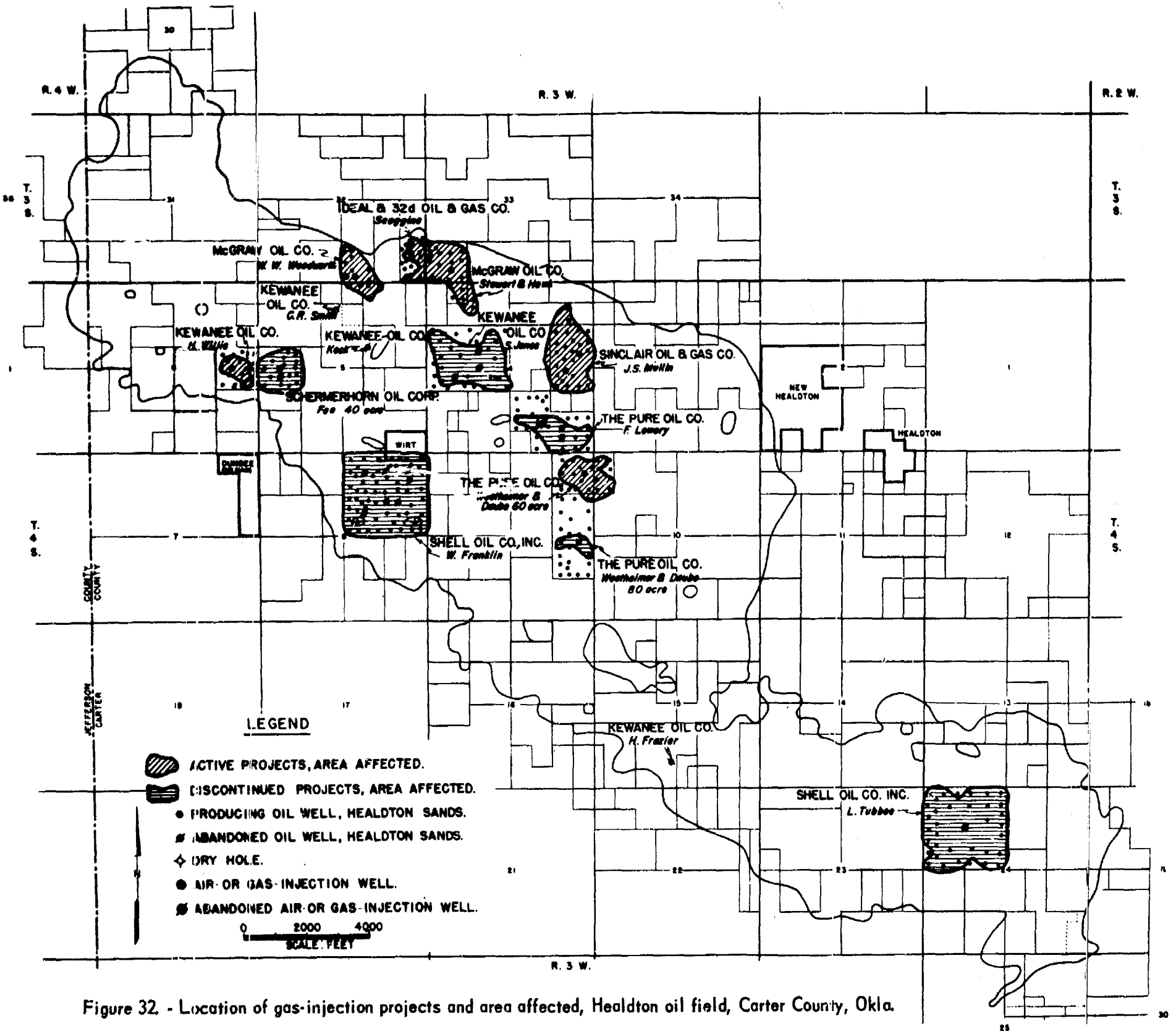


Figure 32. - Location of gas-injection projects and area affected, Healdton oil field, Carter County, Okla.

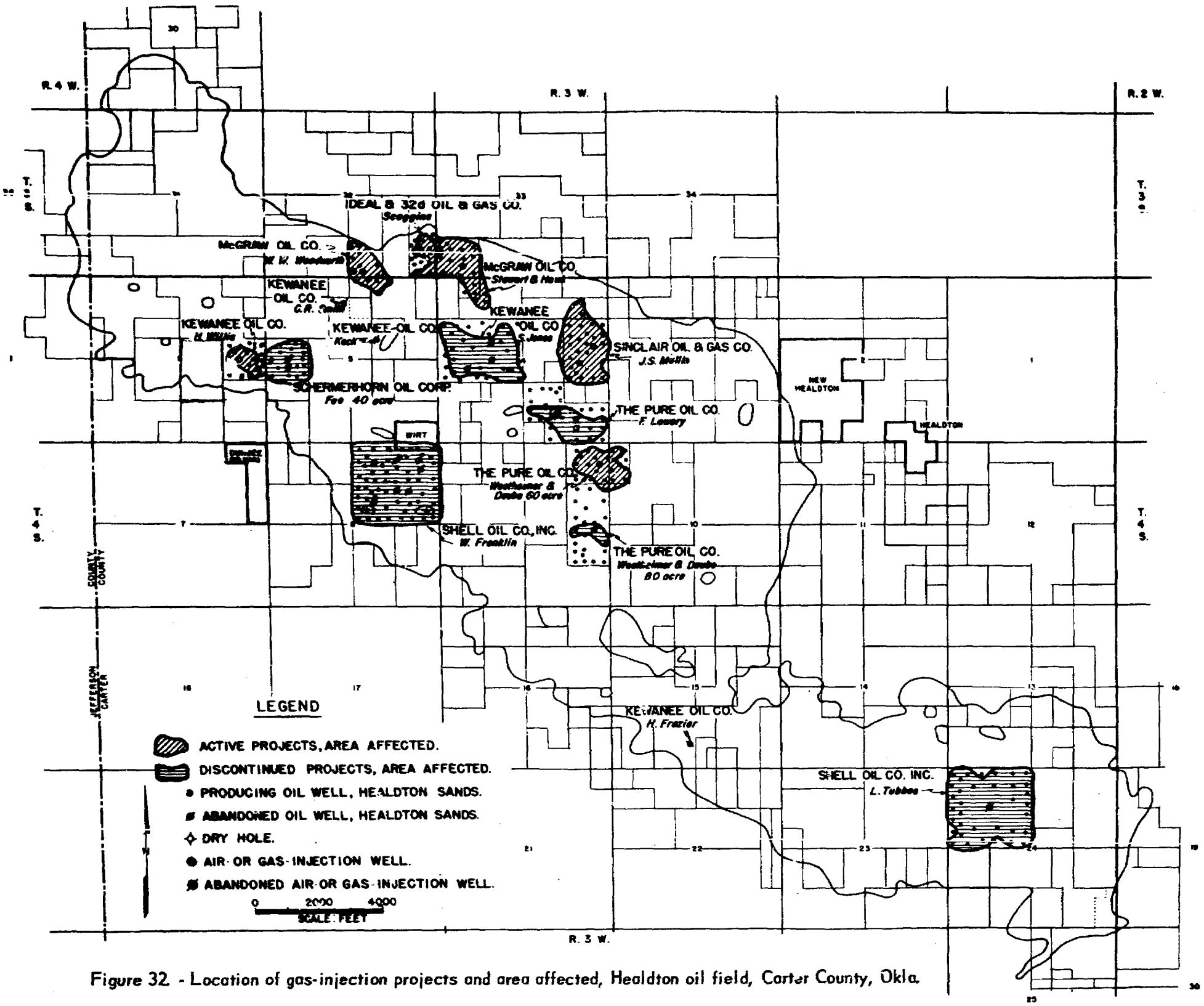


Figure 32. - Location of gas-injection projects and area affected, Healdton oil field, Carter County, Okla.

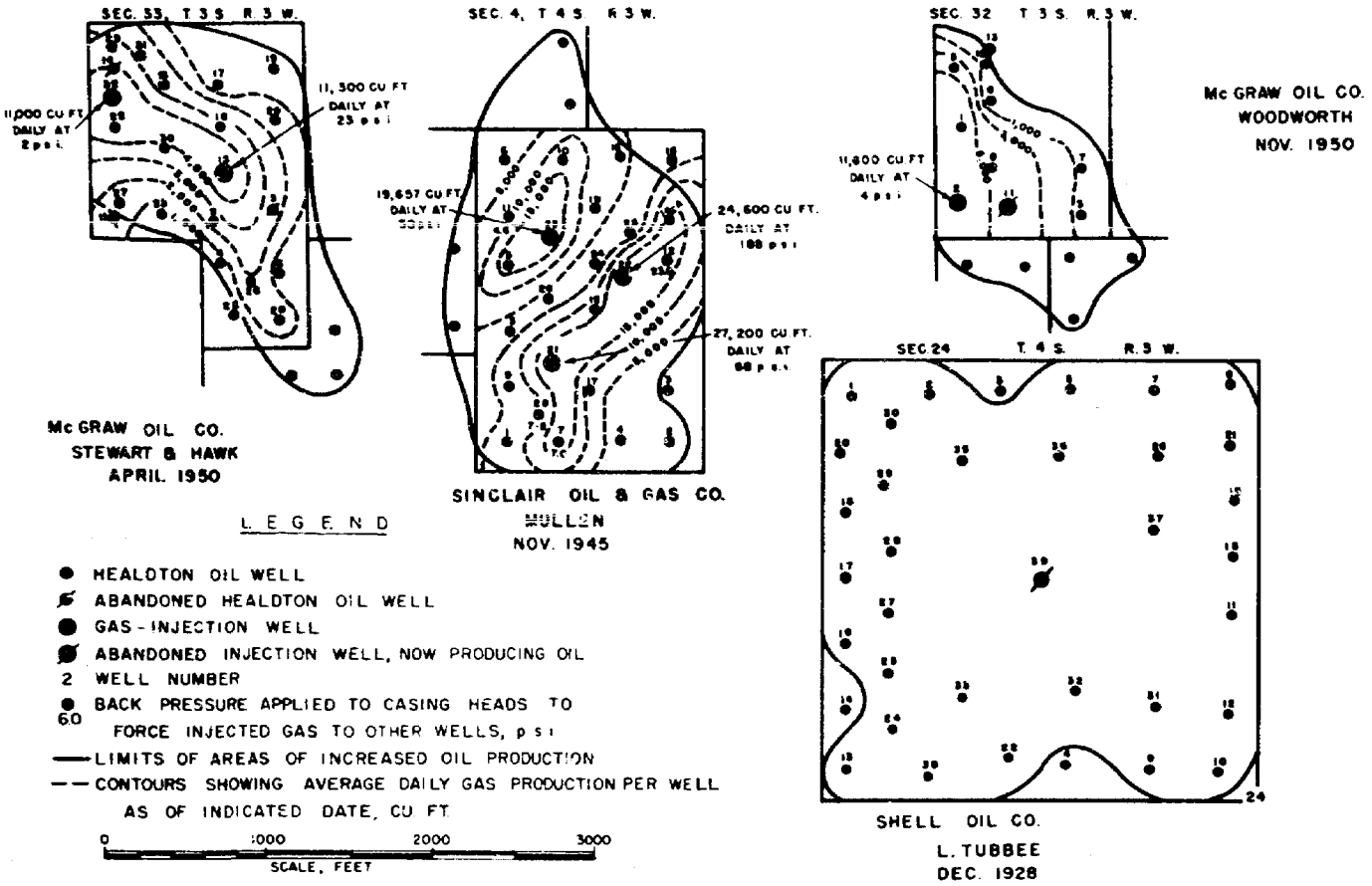


Figure 33. - Map of four leases showing areas and wells affected by gas injection, Healdton oil field, Carter County, Okla.

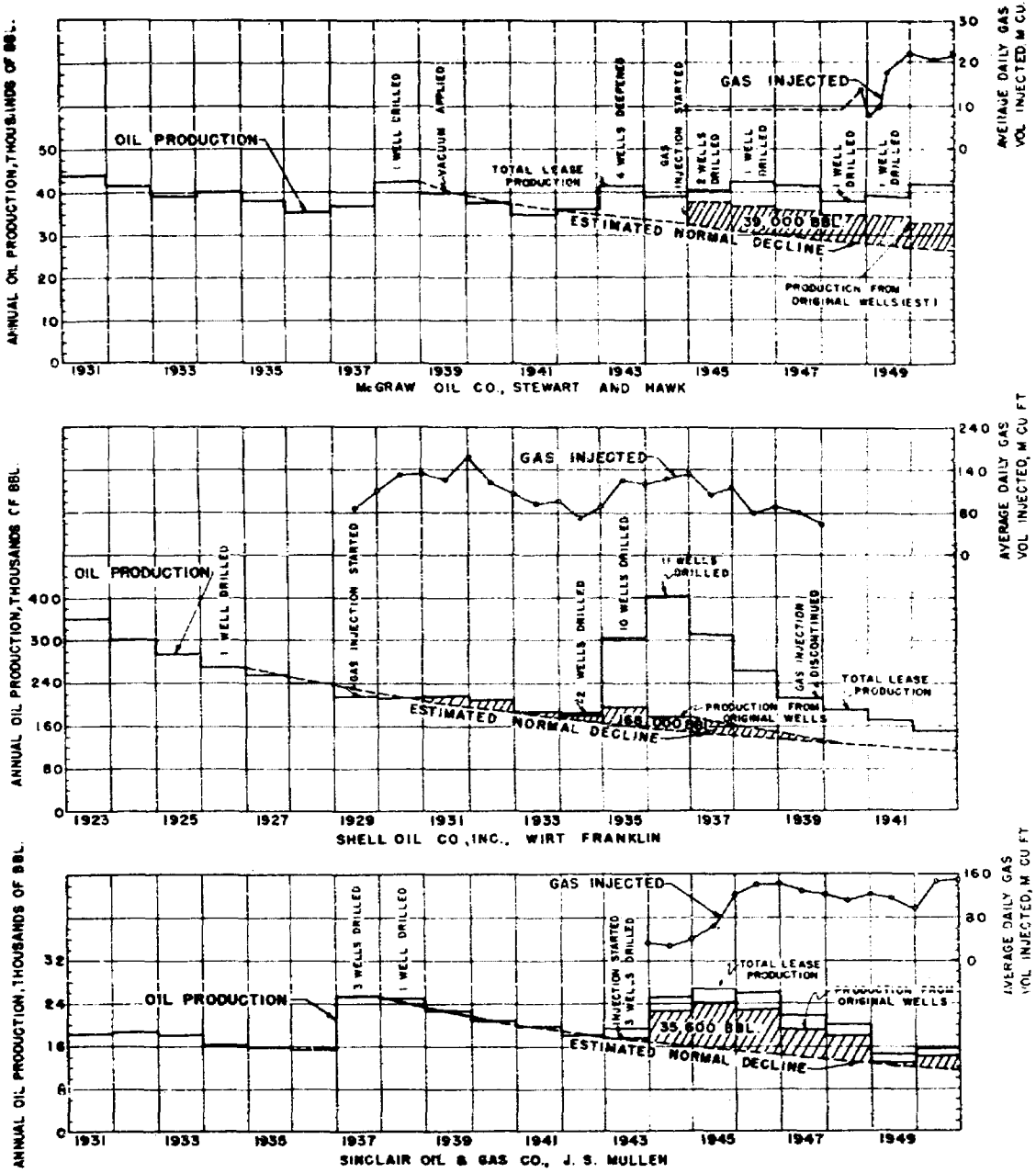


Figure 34. - Histories of gas injection on three successful projects, Healdton oil field, Carter County, Okla.

opposite the first and third sands, was set on bottom. This completion was not changed when this well was converted for gas injection.

During the period of gas injection no attempt was made to measure or control the volume of gas injected into the sands. During 1950 an average of 12,500 cubic feet daily of denuded gas was returned from the gasoline plant to the Scoggins lease. All of the gas not used by the 25-hp. central-power engine and in a five-room dwelling was injected into well 16 at pressures from 7 to 10 p.s.i. Casing-heads of the producing wells on this lease are connected to the Harry Ellis, Inc., gas-gathering line under a vacuum equivalent to 6 inches of mercury.

The average gas-oil ratio for the entire lease increased from about 160 cubic feet per barrel in 1947 to 182 cubic feet per barrel in 1950. Gas produced from individual wells was not measured.

Oil-production tests taken in 1948 and 1949 show that eight wells surrounding the injection well had slight increases in the rate of oil production, ranging from 0.2 to 2 barrels of oil daily. Total lease production, continued to decline during these years, but this decline may have been influenced by the more rapid decline of five new wells completed shortly before gas injection was begun. Undoubtedly, the total lease production would have declined more rapidly without gas injection, but it is undeterminable just how much of the total oil production can be attributed to gas injection. Table 11 shows 3,500 barrels of oil gained as a result of gas injection, but this figure is based upon the individual well tests and is questionable.

McGraw Oil Co. Stewart & Hawk. - Late in 1944 the McGraw Oil Co. began to inject gas into well 15 on the 50-acre Stewart & Hawk lease in sec. 33, T. 3 S., R. 3 W., and sec. 4, T. 4 S., R. 3 W. Figure 33, upper left, shows the location of injection and producing wells on the lease, the total area affected by gas injection, and an isogram map of gas-oil ratios as of April 1950.

In this area the first Healdton sand is approximately 50 feet thick, and the combined thickness of the second and third sands ranges from 10 to 50 feet. Few wells have penetrated below the first sand. The fourth Healdton sand is not productive in the area of this lease (see figs. 10 and 19). Two wells on this lease have been cored, and analyses of first-sand cores show that the porosity ranges from 25 to 28 percent and the permeability from 230 to 900 millidarcys.

When gas injection was begun in 1944, 14 oil wells were producing about 105 barrels of oil and 72 barrels of water daily. The upper graph of figure 34 shows the oil-production history of the lease between 1931 and 1950.

The first 22 wells on this lease were completed between 1914 and 1917, three additional wells were drilled between 1926 and 1928, and one well was drilled in 1938. Beginning in 1940 and continuing to the present, vacuum equivalent to 6 inches of mercury has been applied to casingheads of the wells. In 1943 four wells were deepened to untapped sands, resulting in substantial increases in the rate of oil production. Five wells were drilled on the lease between 1945 and 1949.

Injection of gas into well 15 was begun in November 1944. This well was completed in June 1917 at a total depth of 1,128 feet, producing oil from sands between 972 and 1,087 feet in depth. The well was cased with 8-1/4-inch casing set above the first sand at 967 feet and 200 feet of 6-5/8-inch perforated liner set on bottom.

A total of 77 feet of oil-productive sand was penetrated in the first and second sands, but the third sand, composed of broken sand and shale, was nonproductive. Late in 1949 well 32, drilled in June of that year, was converted to an injection well. Only 1 barrel of oil daily was produced from a sand between 1,183 and 1,195 feet. As the lower part of the sand was watered-out the well was plugged back to 1,190 feet. Seven-inch casing was set through the shaly first sand and cemented at 1,183 feet, and only the second sand is open for gas injection. The upper curve in figure 34 shows the average volume of gas injected per day during each year from 1944 to 1950. Between 8,000 and 15,000 cubic feet of gas daily was injected into the sand through well 15 during the first 4 years at pressures between 18 and 20 p.s.i. During 1949, additional gas was purchased from the Oklahoma Natural Gas Co. to increase the average volume injected through wells 15 and 32 to 17,000 cubic feet daily. During 1950 about 11,000 cubic feet of gas per day was injected into well 32 at a pressure of 2 p.s.i., but the volume injected into well 15 was decreased, so that the total volume into the two wells was 22,000 cubic feet per day.

Since 1946 periodic measurements of gas production have been made on the oil wells to observe the spread of injected gas. Below are produced gas volumes from several oil wells in 1946 and 1950.

Well No.	Daily gas production, cubic feet	
	November 1946	April 1950
6	1,061	337
9	1,061	2,133
16	671	2,868
17	820	598
20	1,061	1,547
23	475	331
25	3,350	4,567
27	672	1,512

The comparatively high gas production in April 1950 of the wells surrounding the injection wells is shown by the gas-o l-ratio contour lines in figure 34.

Available records of gas sales beginning in 1940 show that during that year an average of 24,400 cubic feet of gas per day was sold. In 1942 gas sales were 45,600 cubic feet per day. They declined to 21,000 cubic feet per day in 1944 before injection was begun and then increased to 33,100 cubic feet in 1950.

The first increases in the rate of oil production were noted in 1945, and by January 1946 six wells had shown increases in the rate of oil production, totaling 20 barrels daily.

The production curve in figure 34 shows an increase in yearly lease production in 1943 as a result of deepening four wells. Since gas injection was begun five new wells have been drilled to the Healdton sands, and the oil produced from these deepened and new wells has masked the effects of gas injection. The dashed extrapolated curve in figure 34 illustrates the expected normal decline in yearly oil production before wells were deepened and gas injection was begun. Actual tests on individual wells indicate that 11 old wells and 4 new wells showed increases of 1/2 to 6 barrels daily in their rates of oil production. The probable increased production attributable to gas injection, as calculated from these well tests, is shown as the shaded area in figure 34. This total increased production between 1945 and 1950 amounts to approximately 39,000 barrels or 780 barrels per acre.

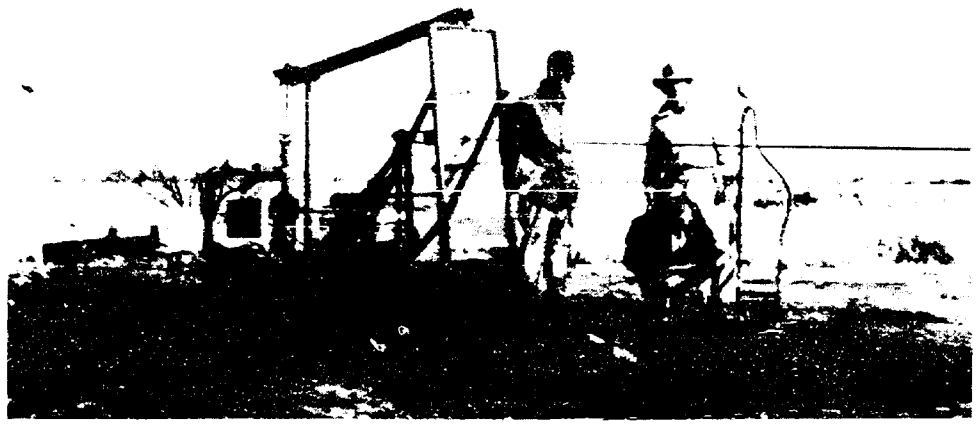


Figure 35. - Measuring produced gas from a well on a gas-injection lease, Healdton oil field, Carter County, Okla.

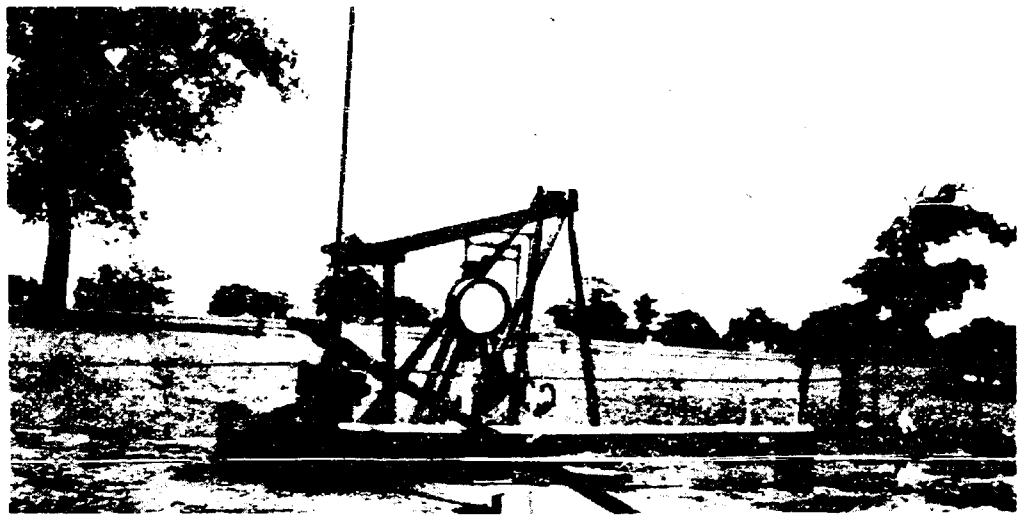


Figure 36. - Gas-injection well, Healdton oil field, Carter County, Okla.

This project has been in operation for 7 years, and although increases in the rate of oil production attributable to gas injection have been overshadowed by the increased production from deepened and new wells, substantial amounts have been recovered by gas injection with little cost of operation.

McGraw Oil Co. Woodworth - The McGraw Oil Co. has been injecting gas into well 2 on the Woodworth lease, sec. 32, T. 3 S., R. 3 W., since November 1943 to increase oil production and store gas for future use.

The Woodworth lease includes 24 productive acres along the north edge of the field where the first Healdton sand is oil-productive and the sands below are water-saturated and nonproductive. The total thickness of oil-productive sand ranges from 4 to 62 feet (fig. 12), with the individual sand members being separated by shale beds.

First wells were drilled in 1914, but records of initial daily production are not available. Nine wells (seven oil-productive) had been drilled before the present owner took over the operation in 1941. By January 1943 approximately 894,000 barrels of oil or 37,000 barrels per acre had been recovered on the lease. At that time the seven wells were producing about 48 barrels of oil and 11 barrels of water daily. Since 1939 vacuum equal to 6 inches of mercury had been applied to the casinghead of the wells. Before injection was begun in November 1943, approximately 19 000 cubic feet of gas daily was produced from the lease. In 1949 gas production averaged 15,300 cubic feet daily.

In November 1943 well 2, which had been producing one barrel of oil daily from the first sand at depths from 1,050 to 1,117 feet, was converted to a gas-injection well, and 10,000 to 15,000 cubic feet of gas daily was injected at pressures of 15 to 20 p.s.i. Dry gas returned from Harry Ells, Inc., gasoline plant was augmented with gas purchased from the Oklahoma Natural Gas Co. for injection. In 1946 an attempt was made to inject gas through well 11, but very little gas could be forced into the sand at 150 p.s.i., the pressure limit of the injection pump. In November 1950 an average of 11,600 cubic feet of gas daily was being injected into well 2 at a pressure of 4 p.s.i.

Few data are available regarding the movement of injected gas during the first few years of gas injection, but since 1946 periodic tests of gas production have been made at the wellheads of the oil-producing wells (see fig. 35). In 1946 tests showed higher gas production from wells surrounding the injection well than from the more remote wells. Daily gas production from all wells on the lease in November 1950 is shown by the gas-oil-ratio contour lines on the lease map in the upper right corner of figure 33.

Daily oil-production tests on individual wells indicate that seven wells on the Woodworth lease and five wells on adjacent leases to the south increased oil production 1 to 16 barrels daily as a result of gas injection. Yearly oil production from the Woodworth lease increased from 17,300 barrels in 1942 to 20,000 in 1943 and 1944. In 1946 wells 11 and 12 were completed as oil producers, and yearly production increased to 26,200 barrels, principally as a result of the completion of the two wells. Well 13 was completed in 1949. The increased lease production resulting from these completions made it difficult to estimate the volume of oil recovered by gas injection.

It has been estimated that, without gas injection, yearly oil production would have declined about 3-1/2 percent per year. Using this decline rate and deducting the oil produced from new wells as indicated by well tests it is estimated that to

January 1951 gas injection resulted in recovery of an additional 19,800 barrels of oil from the lease, equivalent to 825 barrels per acre.

The Pure Oil Co. Westheimer and Daube 60-Acre. - Gas injection into well 17 on The Pure Oil Co. Westheimer and Daube 60-acre lease, secs. 9 and 10, T. 4 S., R. 3 W., was begun in March 1937.

The total oil-productive thickness of upper Healdton sands in this area ranges from 60 to 100 feet (see fig. 12), but the individual sand numbers are lenticular and contain shale and limestone streaks. The fourth sand is not productive in this area (see fig. 10).

The lease was developed in 1914 and 1915 by drilling 17 oil wells. Initial daily oil production ranged from 60 to 900 barrels of oil. Nine wells were deepened 10 to 40 feet in 1926, resulting in an increase in annual lease production from 27,000 in 1925 to 49,000 barrels of oil in 1926. Seven wells were drilled during 1936 and 1937, and the annual lease production increased from 44,000 to 57,000 barrels. Since 1937 oil has been produced from 23 wells on the lease.

Well 17, in the center of the lease, was drilled in 1916 and had an initial production of 150 barrels of oil daily. This well, later converted to a gas-injection well, penetrated three sands with a total thickness of 115 feet. In March 1937 a gas line from The Pure Oil Co. Lowery-lease gasoline plant was connected to the casinghead of the well (see fig. 36). From 20,000 to 100,000 cubic feet of gas daily, depending upon the volume available, was injected into this well at pressures of 2 to 8 p.s.i. In April 1943 gas injection was discontinued until May 1944 and has since been interrupted for a few months each winter, when excess gas is not available for injection. In May 1950 when gas injection was recommenced after the regular winter shut down about 28,000 cubic feet of gas daily at a pressure of 9 p.s.i. was injected into the well. Injection continued until November 1950 at about 30,000 cubic feet of gas per day.

In April 1937, 1 month after injection was begun, eight wells surrounding the injection well had shown increases of 1/2 to 2 barrels in daily oil production. Since March 1937, 15 wells on 33 acres have shown increases in the rate of oil production that could be attributed to gas injection. One well on The Pure Oil Co. Westheimer and Daube 80-acre lease to the south also was affected.

Production increases resulting from new well completions and deepening of other wells make it difficult to calculate increases in the rate of oil production resulting from gas injection, and no attempt has been made to estimate this gained oil. However, each time injection was discontinued temporarily, the rate of lease production decreased sharply. The volume of gas injected has steadily decreased in recent years, and the annual oil production from this lease had declined to approximately 15,000 barrels by 1950.

Sinclair Oil & Gas Co. Mullen. - Gas injection on the Sinclair Oil & Gas Co. J. S. Mullen 60-acre lease, sec. 3, T. 4 S., R. 3 W., was begun in November 1943 and is still in progress.

Figures 6 and 7 show the stratigraphy of the sands in this area. A more or less continuous stray sand, open to oil production in most of the early wells, overlies the first Healdton-sand member. Analyses of cores of the stray sands cut in November 1943 using water-base mud show the porosity, permeability, and oil saturation to be 19 percent, 20 millidarcys, and 26 percent, respectively. Averages of analyses of

cores from the upper member of the first sand were as follows: Porosity, 30.1 percent; permeability, 1,632 millidarcys; and oil saturation, 35 percent.

All injection wells were cased through the stray sands and through the upper member of the first sand.

The first 16 wells on the Mullen lease were drilled between 1914 and 1916, and by 1936, when infill drilling was begun the rate of oil production was declining at about 3.2 percent per year. Four wells were drilled in 1937 and 1938, and one old well was abandoned. By 1943 the rate of decline in oil production from the 19 producing wells on the lease was about 5.8 percent per year.

In November 1943 about 36,000 cubic feet of gas daily was injected into newly drilled wells 21 and 23 (see fig. 34) at pressures of 27 to 48 p.s.i. In July 1944 well 22, drilled in August 1943, was converted to an injection well. Casing in this well was perforated opposite the upper member of the first sand, and a tubing packer was set below the perforations. For a few years 24,000 to 31,000 cubic feet daily of air and gas was injected through the perforations at about 7 p.s.i. pressure, while a similar volume was injected through the tubing into lower sands at pressures ranging from 167 to 205 p.s.i. Before gas injection was begun, the casingheads on the producing wells on this lease were open to the atmosphere until vacuum applied to offset wells on adjacent leases caused a flow of air into six of the Mullen wells. When gas injection was begun in November 1943 vacuum equivalent to about 1 inch of mercury was applied to the casingheads of all Sinclair Oil & Gas Co. Mullen wells.

The volume of gas injected was increased to 140,000 cubic feet daily in 1945, was decreased slightly in 1947 and 1948, and was increased again to about 150,000 cubic feet per day in 1950 (see fig. 33). As the injected gas spread to nearby wells 7, 11, and 20, back pressure was applied to the casingheads of these wells, and vacuum on the more remote wells was increased to an amount equivalent to 3 inches of mercury. Areas of high gas production and the amount of back pressure applied to wells 7, 11, 12, and 20 in November 1945 are shown in figure 33. As the gas spread over the lease, vacuum and back pressure of the casingheads of the producing wells were manipulated so as to force the gas to, and increase the oil production from, the more-remote wells. Since injection was begun, virtually all of the injected gas has been produced from the wells on the lease, so that gas has not been stored underground and reservoir pressure has not increased.

First increases in the rate of oil production were noticed early in 1944 on wells 7, 9, 10, 11, 17, and 20; by November 1945 20 wells on the Mullen lease and 4 wells on adjacent leases had shown increases in the rate of oil production (see fig. 33).

At the same time the three injection wells were drilled three new oil wells also were drilled. Figure 34 shows the total lease production and the assumed production of the original wells (those drilled before 1943) as obtained by subtracting the production of the new wells from the total lease production. Although it is possible that the new wells received some benefit from the gas injection, the gained oil has been calculated from the increase in yearly oil production of the original wells only. Figure 34 shows that the maximum yearly oil production from the original wells was 24,000 barrels in 1945, and the rate of oil production in 1950 (15,500 barrels) is shown to be only slightly above that estimated by extrapolating the normal production curve at 5.7-percent decline per year. From these data the oil gained from the original wells by gas injection is estimated to be 35,600 barrels, or 685 barrels per acre, from 52 affected acres on the lease.

Kewanee Oil Co. Willis. - The Kewanee Oil Co. Willis 40-acre lease, sec. 6, T. 4 S., R. 3 W., lies along the southwest flank of the field structure.

Drillers' logs show that two to five sands were penetrated in the producing wells on the lease. The upper sands produce little oil and usually are cased off, but one to three of the lower sands are left open for production. The injection well, well 17, penetrated about 25 feet of oil sand.

Operations on this project were begun on June 1, 1948, when the Kewanee Oil Co. began injecting about 8,000 cubic feet of gas daily into well 17 at a pressure of 25 p.s.i. Injection was suspended in the winter when excess gas was not available. During 1950, 11,000 cubic feet of gas daily was injected into well 17 at pressures between 14 and 17 p.s.i.

At the beginning of gas injection, there were 17 wells on the lease producing 43 barrels of oil daily. Three wells were abandoned in November 1948, and one new well (well 9-A) was completed in January 1950.

Produced gas from the lease is gathered at a vacuum by the Harry Ells, Inc., gasoline plant. In 1948 gas sales were 5,071,000 cubic feet, an increase of 781,000 cubic feet over those of the previous year. Based on these figures the average lease gas-oil ratio increased from 278 cubic feet per barrel in 1947 to 328 cubic feet per barrel late in 1948. In 1949 gas sales were 3,922,000 cubic feet but, in 1950 had declined to 3,527,000 cubic feet.

The effects of gas injection on oil production from this lease have not been too well defined. When gas injection was begun oil production was declining at the rate of approximately 4 percent per year. Monthly oil production for June 1948, when injection was begun, was 1,276 barrels and in August was 1,337 barrels. Oil production from well 9-A, drilled in January 1950, increased the rate from the Willis lease much more than did gas injection, so that it is impossible to calculate the increase resulting from the injection accurately. In 1949 individual well tests showed increases totaling 2-1/2 barrels of oil daily from six wells on 12 acres surrounding the injection well. In 1950, five wells were showing increases in the rate of oil production totaling 5-1/4 barrels daily. Based upon these well tests it is estimated that approximately 3,500 barrels of oil was gained by January 1951, as a result of the injection of excess gas into well 17.

Shell Oil Co., Inc., Wirt Franklin. - In June 1929, the injection of gas was begun into the Shell Oil Co., Inc., Wirt Franklin lease, sec. 8, T. 4 S., R. 3 W., wells 1, 20, and 22. Well 1 was the discovery well for the Healdton field. Structure sections (not presented) through this lease show four Healdton sands with stray sands above. The strays were open in the early wells but cased off in those drilled later. Most wells penetrate only the upper Healdton sands, but some were drilled through the fourth sand and into the Ordovician limestone. The three injection wells penetrated about 110 feet of the upper Healdton sands. Well 28, converted to gas injection in August 1929, originally was drilled into the Ordovician limestone, but oil was not found below the third sand, and the well was plugged back before being used for gas injection. Figure 34 shows the gas-injection and oil-production history of the lease between 1928 and 1942. When gas injection was begun, about 88,000 cubic feet of gas daily was injected into the three wells.

By November 1929, after well 28 was converted to a gas-injection well, the total volume of gas injected was increased to about 150,000 cubic feet daily (see fig. 34).

In April 1930 wells 20, 22, and 28 were abandoned as gas-injection wells and converted to oil producers. Average daily volumes varying from 160,000 cubic feet in 1931 to 72,000 cubic feet in 1934 were injected into well 1 at pressures of 60 to 65 p.s.i. In December 1934 gas was injected through well 45. The initial daily production of this well, drilled in November 1934, was 36 barrels of oil per day. Gas was injected for 2 months without results, so the well was returned to oil production in February 1935. Well 47, drilled as a dry hole in April 1935, was used for gas injection. The average volume of gas injected into wells 1 and 47 in 1939 was about 70,000 cubic feet daily. The project was discontinued in December 1939; well 1 was returned to oil production and well 47 shut down.

Produced gas from the lease was gathered by the Shell Oil Co., Inc., Barco gasoline plant. Average daily gas sales were 141,000 cubic feet in 1928 before gas injection was begun but increased to 170,000 cubic feet in 1931 and 1932. Gas production increased considerably in 1935, and sales of about 475,000 cubic feet daily were made in 1936. These increases are attributed to the 23 oil wells completed during the infill-drilling program in 1935 and 1936, some of which produced large volumes of gas. Gas production dropped sharply after 1936; gas sales averaged 130,000 cubic feet daily in 1940. Two of the 35 oil wells, which were producing at the beginning of gas injection, were abandoned during the injection period.

The rate of oil production first increased in August 1929 and amounted to 25 barrels daily for wells 24 and 25. Ten wells on 50 acres surrounding the injection wells had shown increases in oil production by January 1930, and by 1934 the entire lease had been affected by the injection. Daily lease production in May 1929 averaged 595 barrels of oil and increased steadily to a maximum of 644 barrels in July 1931. Total lease production increased rapidly after the infill-drilling program, which was begun late in 1934 and reached a peak in 1936. Injected-gas volumes were increased in 1935, causing an increase in the rate of oil production from the original wells. The increased oil production from the original wells, which can be attributed to deepenings and clean-outs in 1935, has been deducted from the total increase from the original wells, and only the increase due to gas injection is shown in figure 34.

After 1936 interference from the infill wells caused an abnormal decline of oil production from the original wells. The normal decline of the original wells without gas injection was calculated to be 6 to 4.5 percent per year. Based upon the history of other projects, it may be assumed that, with gas injection, the actual output of the original wells would have declined at a rate greater than the normal decline rate without gas injection, as is shown in figure 34. A rate of 8 percent per year has been used to illustrate this more rapid decline in the production of the original wells with gas injection.

The cross-hatched area above the estimated normal-decline curve (fig. 34) is an estimate of the oil gained as a result of gas injection, amounting to about 168,000 barrels. Oil production from infill wells may have been increased by the gas injection, but the production from these infill wells was not considered, so that the above figure is a reasonable estimate of the amount of oil attributable to gas injection.

Humble Oil Co. (now Shell Oil Co., Inc.) L. Tubbee. - Gas injection on the L. Tubbee lease, sec. 24, T. 4 S , R. 3 W., was begun by the Humble Oil Co. in May 1928. The injection well, in the center of the 160-acre lease (see fig. 33), was completed in January of that year and had an initial daily production of 5 barrels of oil.

The well penetrated a number of sandy shales that showed oil, but most of these were cased off. A perforated liner was set on the bottom opposite about 43 feet of shale and oil sand.

During the injection period oil was being produced from 35 wells. It is not known if vacuum was applied to these wells during the life of the project.

Repressuring operations were undertaken with the idea of checking the decline in rate of oil production. Crude-oil prices were decreasing, so it was not deemed advisable to make any great effort to increase the rate of production. In the beginning air was injected into the formation at the rate of 50,000 cubic feet daily at unknown pressures.

The first noticeable effect of injection was an increase in the rate of oil production from wells 27 and 28 along the west side of the lease. Well 17, also on the west side, was affected early in the life of the project, and within 11 weeks the combined oil production from wells 17 and 28 had increased from 17-1/2 to 44-1/2 barrels daily. Other wells on the west side showed slight increases, but those east of the injection well were not appreciably affected. Since much of the gas appeared to be moving toward the west side of the lease, the fluid level was raised on those wells along the west side of the lease to try to force the gas toward other wells. On July 14 the tubing in well 17 was raised 42 feet, and oil production from the well decreased abruptly. Oil production increased by November 1928 until it was at the former rate of production. On July 18 the tubing in well 27 was raised 54 feet, which resulted in a drop in daily oil production from that well that continued until the middle of December 1928. Raising the tubing in the two wells on the west side of the lease caused the gas to spread to other parts of the lease. By the end of July 15 wells - 3 on the east side - had shown increases in the rate of oil production.

Total lease production increased to a peak of 4,432 barrels during July 1928. Gas was substituted for air in July 1928, and the daily injected volume was decreased from 50,000 cubic feet to about 17,000. The rate of oil production declined in August but increased to a new peak of 4,563 barrels in October following an increase in the rate of gas injection to 36,000 cubic feet per day. By the end of 1928 an area of about 149 acres, which included 32 producing wells, had been affected by the injection (see fig. 33). Wells 3, 4, and 14 on the lease had shown no change in rate of oil production.

During 8 months of operation between May and December 1928 an average of 30,700 cubic feet daily of air and gas, or a cumulative volume of about 7,500,000 cubic feet, was injected. Injection may have continued until early in 1929, but the exact date of discontinuance is not known.

Semiannual production for the L. Tubbee lease averaged about 22,000 barrels during the period immediately before gas injection. Based upon the average decline of other leases in this area, it is estimated that the normal 6-month rate of decline for the Tubbee lease would have ranged from 4 percent in 1925 to 1.1 in 1931. Semiannual oil production remained above this estimated decline rate between 1928 and 1931 but dropped below it between 1931 and 1936. During the earlier period (1928-31) the increased oil production attributable to gas injection amounted to about 18,200 barrels, whereas the lost production in the later period (1931-36) amounted to 5,700 barrels. Undoubtedly a large part of the lost production was the result of operation curtailment during the depression years because of low crude-oil prices. If all of the lost production is subtracted from the oil gained during the earlier period, the net gain as a result of gas injection would amount to 12,500 barrels, or 84 barrels per acre.

Infill drilling, beginning in 1936 and continuing through 1940, resulted in increases in annual oil production from 33,500 to 80,000 barrels - overshadowing the former increases by gas injection.

Kewanee Oil Co. S. Jones. - The Kewanee Oil Co. S. Jones 120-acre lease, sec. 4, T. 4 S., R. 3 W., is in the north central part of the field. On June 1, 1936, the Kewanee Oil Co. began to inject excess gas into well 32 primarily as a gas-conservation project and not as a planned repressuring operation. Later other injection wells were added.

About 89 feet of the second and third Healdton sands was open in the injection wells. Structure and correlation sections Y-Y' and Z-Z' (figs. 6 and 7) show the thickness and attitude of the upper sands underlying the northeast part of the lease. The fourth Healdton sand is absent in certain areas of the lease (see figs. 10 and 19).

Oil was being produced from the Healdton sands through 34 wells when gas injection was begun in June 1936; one well was abandoned in July 1937, and one new well was drilled in October 1937.

Vacuum in varying amounts was applied to the casingheads of most of the producing wells, less vacuum being applied to those wells surrounding the injection wells than to those more distant. During the period of gas injection through well 32, a back pressure of approximately 18 p.s.i. was maintained on the casinghead of the adjacent well (well 30) to prevent channeling to that well and to force the gas to more remote areas.

At the beginning of gas injection in June 1936 approximately 30,000 cubic feet per day of gas was injected into well 32 through the casing, while oil was being produced through the tubing. In 1940, when wells 29 and 39 were converted to gas-injection wells, the total volume of gas injected was increased to 90,000 cubic feet per day. After injection through well 39 was discontinued in June 1940 volumes injected were decreased irregularly until 1944, when only 4,000 to 5,000 cubic feet per day was being injected. Gas injection was discontinued in August 1946.

By January 1937, 11 wells on 45 acres surrounding injection well 32 had shown increases in the rate of oil production. By January 1941, 5 other wells also had shown increases, thus raising the total area affected to approximately 75 acres. From the data available it appears that during the later life of the injection project additional acreage was not affected. Monthly oil production from the lease increased from 7,288 barrels in January 1936 to a peak of 8,222 barrels in December of that year, a daily increase of about 30 barrels of oil. Records of volumes of gas produced before 1940 are not available, but in 1940 the average daily gas sales were about 170,000 cubic feet. After 1940 the amount of gas produced and sold declined irregularly to about 65,000 cubic feet daily in 1945 but thereafter increased to an average of 98,000 cubic feet daily in August 1946. Gas produced from the lease was sold to the Harry Ells, Inc., gasoline plant, and the dry gas returned from the plant was used for injection.

Based upon earlier production records and the decline in yearly production of unaffected wells, an extrapolated curve representative of a normal decline rate of from 4 to 2 percent per year was constructed for the lease. As a result of gas injected, the actual rate of oil production between July 1936 and January 1941 exceeded that estimated from the extrapolated curve, but after January 1941 it dropped below that estimated rate. By implication, oil recovery was hastened by gas injection, and the net gain to January 1951 was only in the neighborhood of 1,700 barrels.

The Pure Oil Co. F. Lowery. - Well 28 on this lease in sec. 4, T. 4 S., R. 3 W., was connected to the return gas line from the Harry Ells, Inc., gasoline plant in May 1946; during that month about 25,000 cubic feet of gas daily was injected through the well at a pressure of approximately 20 p.s.i.

Structure sections (not presented) across the lease show two main oil-producing sands, with the thickness ranging from 26 to 120 feet. Thirty feet of the oil-productive sand was open in injection well 28.

Between May and October 1946, when gas injection was suspended, an average of 20,000 cubic feet of gas was injected daily into well 28 at pressures ranging from 16 to 20 p.s.i. Between May and November 1947 well 32 instead of well 28 was connected to the return gas line and about 40,000 cubic feet of gas daily was injected, at pressures between 5 and 32 p.s.i. For short periods during the summers of 1948, 1949, and 1950, limited amounts of excess gas were injected into the casinghead of well 32. The well was producing oil through the tubing at the same time.

Twenty-eight wells on this 90-acre lease were producing about 31 barrels of oil daily from Healdton sands when injection was begun. Ten of the wells surrounding the injection well have shown slight increases or sustained rates of oil production as a result of the gas injection; however, the volume of gas never was enough to stem the steady decline in yearly oil production from the whole lease. In 1950 the Healdton-sand wells were producing approximately 24 barrels of oil daily.

Schermerhorn Oil Corp. Fee 40-Acre. - The Schermerhorn Oil Corp. Fee 40-acre lease, sec. 5, T. 4 S., R. 3 W., contains 40 oil-productive acres on which 24 wells have been drilled.

The thickness of the oil-productive upper Healdton sands, into which gas was injected, ranges from 13 to 181 feet, being thickest in the middle of the lease and thinnest along the north line and in the southeast corner (fig. 12). Injection well 16, drilled in November 1916, penetrated an upper oil sand, about 90 feet thick, and a thinner, limy sand below, about 20 feet thick. Well 26 (drilled in September 1926) penetrated a thick, nonproductive upper sand and a lower, oil-productive sand 26 feet thick.

The injection project was begun late in March 1935, when there were 15 old and 2 recently drilled oil wells on the lease. Oil produced from the 40- and 20-acre Fee leases is produced together into the same tanks, so that the production from the 40-acre lease could not be computed separately. In March 1935 daily production of oil from both leases averaged 400 barrels.

Because of new wells completed just before and during gas injection, a graph of total lease production does not indicate clearly the results of the injection. The graph does show that the oil production was considerably higher than the estimated yearly production obtained by extrapolating a decline curve before infill drilling and gas injection. The production decline curve was extrapolated at yearly percentage declines ranging from 11.7 to 7 percent.

Well 16 was converted to an injection well late in March 1935, and an average daily volume of about 450,000 cubic feet of air was injected at 30 p.s.i. On April 13, 1935, gas was added to the air for injection. Injection through well 16 was discontinued in July 1935 and begun through well 26. The compressors were shut down on August 15, 1935, and injection was not recommenced until late in October of the same year. In November 1935 the plant was shut down for repairs, and there is no record of any gas injection after that date.

During the period of air and gas injection it appeared that channeling occurred to the line wells on leases west and south of the Schermerhorn Oil Corp. Fee 40-acre lease. The wells on these leases were reported as producing air during the early period of the air injection. When shut in, the pressures in the line wells on Schermerhorn Oil Corp. Fee 40-acre lease decreased rapidly. Casing leaks in the line wells, which allowed air to migrate to upper sands with accompanying decreases in pressure, was considered another possible cause of the loss of pressure.

The daily gas production from the Schermerhorn Oil Corp. Fee 40-acre lease increased from about 4,600 cubic feet per day in March 1935 to a peak of 493,300 cubic feet per day on August 19, 1935. After the plant was shut down in August 1935, gas production declined, so that, by December 15, 1935, the daily gas production was about 163,000 cubic feet, and in January 1935 daily gas production was 22,500 cubic feet.

The scarcity of tests of the rate of oil production of individual wells does not permit an estimation of the affected area on the basis of oil increases. However, monthly gas-production tests show that gas production from virtually all wells increased as a result of the injection.

From an extrapolation of the decline curve of the rate of oil production from the 40- and the 20-acre leases it is estimated that approximately 1,740 barrels of oil was gained during the 8 months of operation. This estimate is conservative because new wells drilled during the period of gas injection were not considered as being affected by gas injection.

The Pure Oil Co. Westheimer and Daube 80-Acre. - Since July 1946 small amounts of excess gas have been injected through the casing of The Pure Oil Co. Westheimer and Daube 80-acre lease, well 18, sec. 9, T. 4 S., R. 3 W. In October 1946 about 3,000 cubic feet daily was being injected at 14 to 18 p.s.i. During the gas-injection period some oil was produced through the tubing of the same well. The injection well near the center of the lease penetrated three oil sands totaling 87 feet in thickness.

Individual tests show that adjacent wells 8 and 16 had temporary increases of about 1/2 barrel in daily oil production. Well 4 in the northeast corner of the lease showed some increases in daily oil production as a result of the gas injection on the adjacent Westheimer and Daube 60-acre lease.

Miscellaneous Injection Projects. - On several small leases one or more wells called volume wells have been connected temporarily to the gas-return line from the Harry Ells, Inc., gasoline plant. The primary purpose was to cycle any excess dry gas returned from the gasoline plant during the summer months so that it would pick up gasoline vapors from the formation oil and the enriched gas could be sold to the gasoline plant. Included in this group of volume wells are Kewanee Oil Co. Frazier lease, well 13 in sec. 15; Keck 30-acre lease, well 1 in sec. 5; and C. R Smith lease, well 5 in sec. 5, all in T. 4 S., R. 3 W.

In 1934 an attempt was made to inject gas into Magnolia Petroleum Co. Smalley well 35 in sec. 10, T. 4 S., R. 3 W. Very little gas could be injected at 1,500 p.s.i.

Brine Disposal

In recent years large quantities of produced brine have been disposed in subsurface formations in the Healdton field. As of November 1, 1951, 14 disposal wells, most of them on leases in the western and northwestern part of the field, were receiving

approximately 7,100 barrels daily of produced brine. This was nearly half of the 14,600 barrels of brine produced daily in the field. In most of the disposal wells, brine was being injected into Ordovician formations through 7-inch casing set and cemented through the Healdton sands. However, in three structurally low wells, produced brine was being returned to the fourth Healdton sand.

Usually treatment is not required to condition the brine for subsurface injection, although at one disposal well the produced brine is aerated in an open tank before being injected (see fig. 37, lower photograph). To inject the brine a 3-cycle, 2-1/2- by 4-inch Gaso pump was being used to pump nearly 2,000 barrels per day of produced brine into the well at a pressure of about 400 p.s.i. At four other disposal wells surface-injection pressures ranging from 150 to 550 p.s.i. are required to inject volumes ranging from 320 to 2,500 barrels of brine per day. In nine other disposal wells, all available brine was injected by gravity. Figure 37, upper photograph, shows one of these wells in sec. 16, T. 4 S., R. 3 W. In March 1942 this well was converted from an oil well to a disposal well in the fourth Healdton sand. To September 1, 1951, 677,000 barrels of produced brine from the Healdton sands had been injected into this well. Several structurally higher wells on this lease, which produce oil from the fourth sand, are receiving some benefit from the flooding by the injected water.

MOBILE-OIL RESERVES

In the section Reservoir Conditions, it was stated that the volume of mobile oil originally present in the Healdton sands (measured at stock-tank conditions), was approximately 422 million barrels. To January 1, 1951 about half of this mobile oil had been recovered.

Figure 38 shows the areal distribution, in barrels per acre, of the remaining oil. The illustrated data were obtained by subtracting the total produced oil for each lease from the mobile oil originally present and dividing this remainder by the number of productive acres of the lease. To compensate for possible drainage, production data and estimated reserve data for several adjoining leases occasionally were combined, as shown by the outlined areas in figure 38.

Because in most of the wells, oil was produced simultaneously from several sands it is impossible to calculate what fraction of the 211 million barrels of produced oil was recovered from the separate sands and, by deduction, how the remaining mobile oil is distributed among the several sand zones. Much of the oil undoubtedly was produced from the first developed and more extensive upper sands, but probably 180 to 200 million barrels of mobile oil remain in these sands. Reserves in the naturally waterflooded fourth-sand zone are comparatively less important.

The economic recovery of oil reserves remaining in the Healdton sands depends upon the type of mechanism that displaces oil from the pore spaces and upon the pressure differentials available to move it through the reservoir sand into the well bores. It is well-recognized that the mobility or freedom with which oil will move through the sand depends upon the oil saturation of the sand and upon the viscosity of the oil and that as oil saturation decreases and viscosity increases more pressure is required to move oil through the sand to the producing wells.

In the upper-sand reservoirs relatively inefficient solution-gas expansion was the displacement mechanism; and, since little, if any, of the original reservoir pressure now remains, only that relatively small pressure differential created by vacuum





Figure 37. - Brine-disposal wells, Healdton oil field, Carter County, Okla.

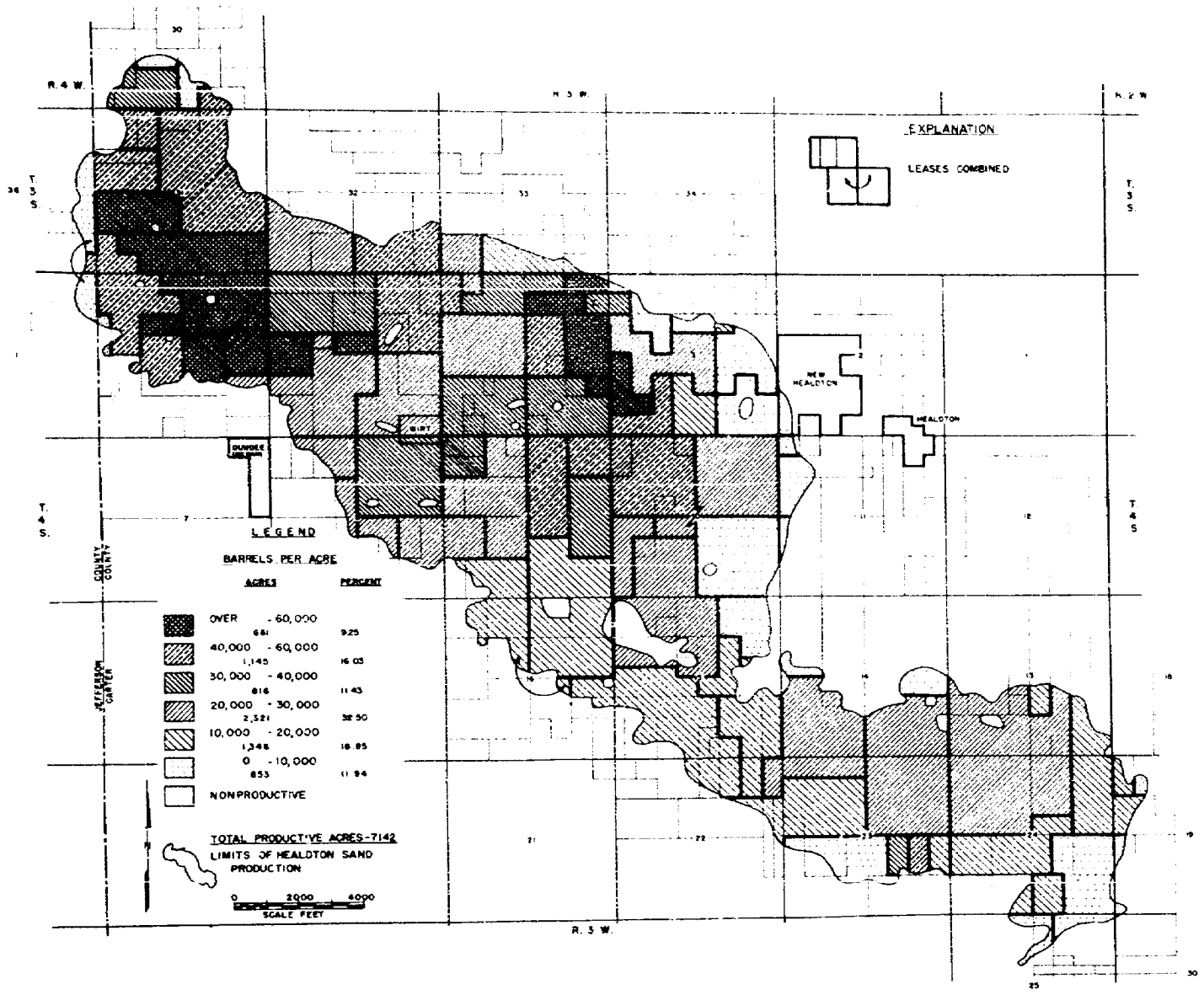


Figure 38. - Mobile oil reserves, Healdton sand, Healdton oil field, Carter County, Okla., 1951.

application and gravity is now acting to move oil to the wells. The rate of production is decreasing yearly, and the history of wells and leases producing from the upper sands clearly indicates that much mobile oil will not be recovered unless some extraneous pressure is applied to the reservoir to move oil to the producing wells.

In most areas of the fourth sand a natural water drive is supplying the mechanism and pressure necessary to effect an efficient recovery of mobile-oil reserves. Calculations made for one lease showed that the efficiency of this natural water drive in recovering mobile oil from the fourth sand was about 83 percent, as compared to a calculated efficiency of less than 50 percent for depleted upper sands without benefit of water displacement.

WATER FLOODING

The oil-production history and reserves remaining in the Healdton sands have been discussed in the preceding pages. The principal purpose of this report is to encourage recovery of these oil reserves by outlining methods and problems involved in their production.

The injection of water into partly depleted oil-bearing sands simulates a natural water drive and is the most efficient secondary-recovery method in common use. Water flooding has been used successfully in many oil fields in Kansas (18), Oklahoma (19, 20), Texas (21), Illinois (22), Pennsylvania (23), and California (24). Recoveries exceeding 100 percent of the primary recovery have been obtained in some of these areas. By carefully considering the many factors involved and controlling the injected fluid, water flooding can be used to recover much additional oil from the Healdton sands.

Theoretical Considerations

Efficiency

Earlier in this report efficiency was defined as the ratio of recovered oil to mobile oil originally in place, mobile oil in the Healdton sands being that oil in the interconnected pore space that exceeds 29 percent saturation. Theoretical calculations show that at the time the injected water first reaches the producing well in the conventional five-spot pattern (four input wells surrounding one oil well), about 72 percent of the area between the wells has been swept by the injected water. For other patterns, the area swept ranges from 32 to 80 percent. This theoretical area swept applies only to a homogeneous sand or uniform thickness. Discontinuous sands, open channels, fractures, tight streaks, highly water-saturated zones, and differences in fluid viscosity are other important factors affecting the area swept and the efficiency of any water flood.

Mechanism

Buckley and Leverett (25), in describing the mechanism of water flooding, have stated that during an initial phase the water saturation in the sand increases rapidly and oil is ejected ahead of an advancing water front. During a subordinate phase both oil and water flow through the sand with a gradual increase in water saturation, so that water flows more readily and effects the removal of comparatively small and continuously decreasing volumes of oil.

According to Dickey and Bossler (26):

> The percentage saturations of oil, water and gas in a depleted field determine whether it will be economically possible to recover oil by secondary methods, and whether water-flooding or gas-driving, or either, will be successful.
>
> It is suggested that economic recovery of oil by secondary water-flooding can occur only when a rich bank of oil is formed by the encroaching water. If the sand has a greater effective permeability to water than it has to oil before flooding, a bank will not be formed, and water flooding will not be successful, . . .

Horner (27) has cited leases where water flooding has failed because of high initial water saturation.

Relative Permeability

Leverett and Lewis (28) have shown that, in unconsolidated sands, the relative permeability to either oil or water depends primarily upon the saturation of that phase. Their experiments were made on unconsolidated sands and their quantitative results are exact only for loose sands. Inspection and analyses of core samples indicate that many of the Healdton sands are loose or poorly cemented. Without definite relative permeability data on the Healdton sands, it is assumed that, with care and within certain limitations, the data of Leverett and Lewis can be applied to many of the sands in the Healdton field to indicate relative permeability.

Mobility

The mobility of a liquid depends upon the relative permeability of the sand to that liquid and upon its viscosity. Dykstra and Parsons (29) have defined mobility as the ratio of a liquid's relative permeability to its viscosity. The mobility ratio, the comparative ease with which two liquids will move through a sand, depends directly upon the relative permeability of the sand to those liquids and inversely upon the viscosities of the liquids. If the ratio of the mobility of the water to the mobility of the oil is less than 1, a bank of oil is formed ahead of the water when it is injected into an oil sand.

In an attempt to apply mobility ratios to water flooding of the Healdton oil sands, figure 39 was constructed to show the limiting initial oil and water saturations that, at representative viscosities, would result in a mobility ratio of 0.9. A mobility ratio of 0.9 instead of 1.0 was arbitrarily selected to provide a safety margin of oil saturation, which would assure the formation of an oil bank ahead of injected water.

Viscosity

Table 8 lists viscosities of Healdton oils at 80° F., ranging between 8.7 and 58.9 centipoises. Because sample C-4 may have been weathered and therefore is not representative of Healdton oil in the reservoir, sample C-1 with a viscosity of 31.7 centipoises, was considered in the calculations as the upper viscosity limit of Healdton crudes. Temperatures of Healdton sands range between 86° F. at 1,250 feet and 73° F. at 650 feet. At these limiting temperatures, the extremes of viscosity of Healdton oils are 8.1 and 34.0 centipoises. The viscosity of injected water is considered to range from 1.1 centipoises at 60° F. to 0.8 centipoises at 86° F.

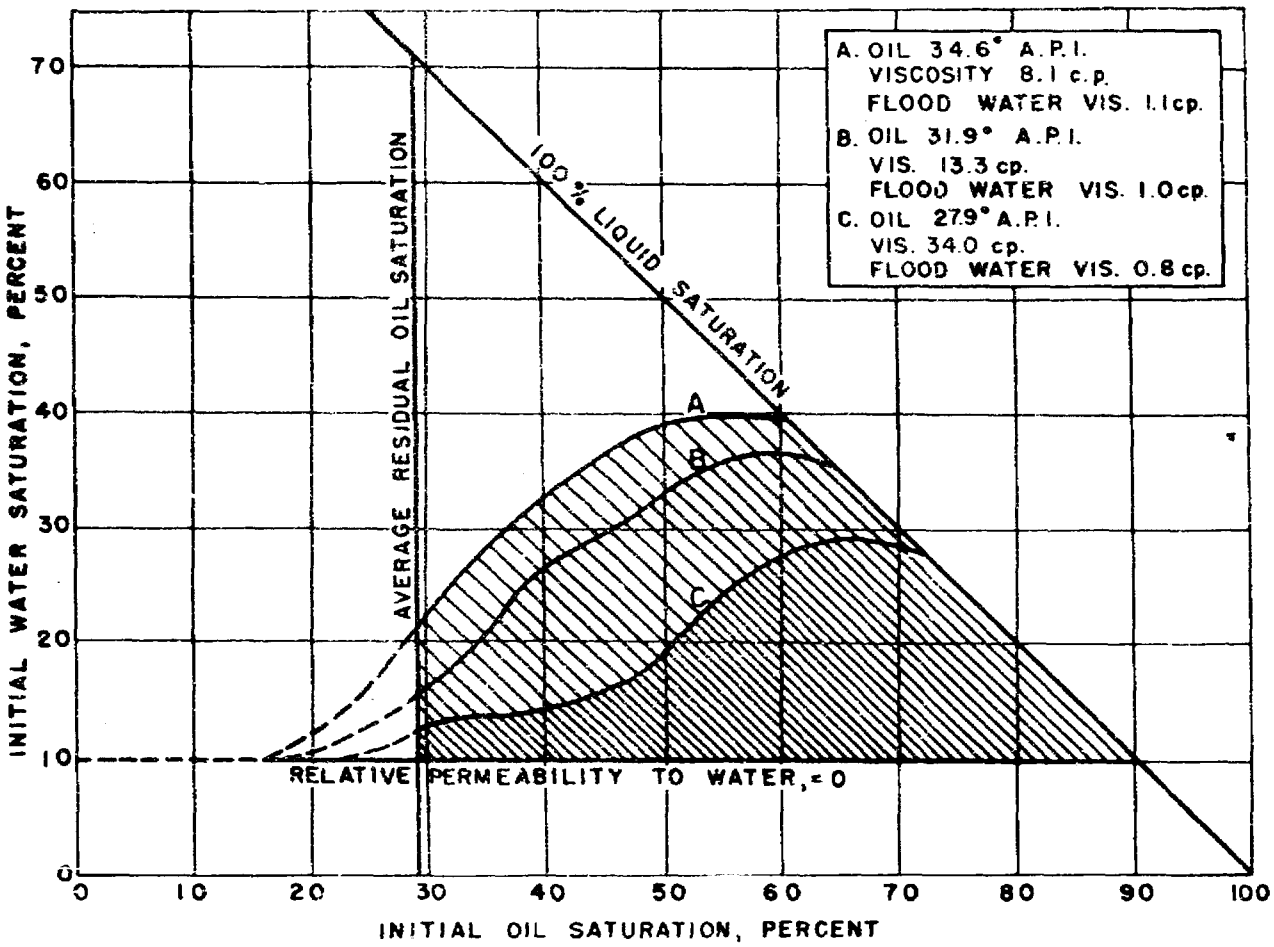


Figure 39. - Limiting initial liquid saturation for successful water flooding of loosely consolidated sands in the Healdton oil field.

(After Data by Leverett & Lewis)

Theoretical Application to Healdton Field

Curves A, B, and C (fig. 39) show the minimum oil and maximum water saturations permissible to water-flood Healdton sands successfully under assumed flooding conditions.

Curve A is the limit of liquid saturations, in percent, to permit a mobility ratio of 0.9 for an oil viscosity of 8.1 centipoises and a flooding-water viscosity of 1.1 centipoises. This combination of oil and water viscosities is considered to include the widest range of floodable liquid saturations possible in the Healdton field. Curve C marks the limit of liquid saturations for an oil of 34.0 centipoises viscosity and a flooding-water viscosity of 0.8 centipoise, which would include the narrowest range of permissable liquid saturations in the Healdton field. Curve B represents the limiting liquid-saturation conditions for the average oil in the Healdton field - oil 13.3 and water 1.0 centipoises.

In figure 39, the shaded areas bounded by the three curves, A, B, or C are those areas that contain the combinations of water and oil saturations that in the Healdton sands could be flooded successfully. The area above any of these curves includes saturations unfavorable for water flooding - oil saturations too low or water saturations too high to permit the formation of an oil bank.

From a study of figure 39, it is apparent that, under similar conditions, more water saturation and less oil saturation are permissible for less viscous oils to permit formation of an oil bank. In deep sands a wider range of oil and water saturations is floodable, since viscosity of the oil is lower at the higher temperatures prevailing there. For example, the C-type oil illustrated in figure 39 should not be floodable at 50-percent oil and 20-percent water saturation at a viscosity of 34 centipoises, which would obtain at a depth of 600 feet, whereas a sand with these oil and water saturations should be floodable at a depth of 1,300 feet, where the temperature would be about 90° F. and where the viscosity of the same oil would be 27.5 centipoise.

Injection Rates and Pressures

Water-injection rates and pressures are the subject of much controversy. Some operators believe that low injection rates (2 to 5 barrels per acre-foot per day) increase efficiency, whereas others claim that higher rates recover more oil. Usually there is a critical pressure (about 1 p.s.i. per foot of depth) above which the formation may be ruptured, resulting in extreme bypassing and channeling to producing wells with subsequent loss in efficiency.

Sources and Treatment of Water

In considering water flooding of oil sands in the Healdton field an adequate volume of water for injection probably would be the most important problem confronting the operators. In other fields developed for water flooding, both surface and subsurface water commonly are used for flooding. Where a river or large stream is available, such as the Verdigris River in Nowata and Rogers Counties, Okla., or the Arkansas River in the Burbank pool, surface water is being used successfully. Sometimes rain water collected in ponds is used, but this seldom is satisfactory for a regular flood. The streams draining the Healdton field area are not large enough to provide the volume of water necessary for successful flooding. Possibly a combination of several sources of water could be used to obtain the volume of water required.

Many of the wells drilled in the field penetrated a number of upper Permian sands that were reported by the driller as water-bearing. Water for the city of Healdton in sec. 2, T. 4 S., R. 3 W., and for many lease operations is obtained from these shallow Permian sands at depths between 175 and 400 feet. The city-water-supply wells showed initial daily production rates ranging from 500 to 1,000 barrels. It is problematical whether such volumes of water could be produced continuously by these wells.

Table 12 gives analyses of six samples of water produced from wells in the Healdton field. Three of the mineral analyses were made on samples of water produced from Permian sands, two on samples produced from the Healdton oil sands, and one on a sample of water produced from an Ordovician formation.

Study of the analyses shows that the Permain-sand water could be injected into the Healdton sands with comparatively little chemical or physical conditioning in a water-injection system completely closed from the atmosphere. Because of the fairly high oxygen content and the low supersaturation of carbonates, it might be necessary to use an inhibitor to minimize corrosion (30). Even in a closed water-injection system it is likely that the Permian-sand waters, as produced, would contain organic matter, and an algaecide or bactericide should be used, particularly in warm weather, to prevent plugging in the injection wells.

Examination of the clay minerals associated with the Healdton oil sands indicates that these clays are of the nonswelling type, and probably Permian-sand waters could be injected without hydrating the clays and plugging the sand.

Although considerable water is produced with the oil in the Healdton field (see figs. 17, 18, 21, and 22), the volume of the water produced on any lease would not be adequate for a regular water-flooding project. Produced water from several leases might be gathered at a central point to constitute a major portion of the water requirements for a small flood. For instance, in the northwestern part of the field about 4,400 barrels of water is produced daily from 21 leases. This might be enough water to flood a sand 30 feet thick on one 80-acre lease.

Analyses of two samples of brine produced from Healdton sands in separate areas of the field are shown as samples 4 and 5, table 12. The brines contain comparatively large quantities of dissolved iron, free carbon dioxide, and carbonate supersaturation. Because of changing conditions of temperature and pressure accompanying production and injection, it would be almost impossible to maintain these components in solution. In a closed water-injection system they might be precipitated and plug the formation. An open water-injection system permitting complete aeration and settling would be more satisfactory.

Brine sample 6, in table 12, was produced from an Ordovician formation approximately 3,900 feet in depth. When this well was drilled in 1924 a large volume of water was reported in the formations below the present depth of the well, and the well was plugged back. Water from this lower formation would be suitable to use in water flooding the Healdton oil sands, provided it is properly treated before injection. The possibility of using waters from Ordovician formations as a supply source should be investigated further.

TABLE 12. - Analyses of water available for water flooding, Healdton oil field, Carter County, Okla.

Field Analyses

Sample No.	Sampling-point location				Source formation	Volume produced, bbl./day	Oxygen, p.p.m.	Carbon dioxide, p.p.m.	Hydrogen sulfide, p.p.m.	pH value	Iron, p. p. m.		Alkalinity as $CaCO_3$, p.p.m.		Supersat. of carb. as $CaCO_3$, p.p.m.
	Q.	S.	T.	R.							Total	Dissolved	P.1/	M.1/	
1.....	NW	4	4S	3W	Permian	500-1,000	1.8	14	0	7.3	0.8	0.2	0	509	-28
2.....	SW	1	4S	3W	do.	500-1,000	4.9	0	0	8.8	0	0	30	486	+14
3.....	SW	2	4S	3W	do.	500-1,000	1.1	0	0	8.4	.2	0	21	568	-10
4.....	SE	31	3S	3W	Healdton	1,400	0	153	0	6.5	35.5	29.4	0	216	+72
5.....	NE	15	4S	3W	do.	2,500	0	127	0	6.4	46.0	44.8	0	190	+71
6.....	SE	4	4S	3W	Ordovician ls.										

Mineral Analyses

Sample No.	Spec. grav., 60° F.	Calcium (Ca)		Magnesium (Mg)		Sodium (Na)		Carbonate (CO_3)		Bicarbonate (HCO_3)		Sulfate (SO_4)		Chloride (Cl)		Total solids3/	
		P.p.m.	R.v.2/	P.p.m.	R.v.	P.p.m.	R.v.	P.p.m.	R.v.	P.p.m.	R.v.	P.p.m.	R.v.	P.p.m.	R.v.	P.p.m.	R.v.
1.....	1.000	38	7.79	18	6.07	203	36.14	30	4.10	329	35.61	30	2.54	67	7.75	710	4/100
2.....	1.000	8	2.01	4	1.66	212	46.33	33	5.54	464	38.32	17	1.76	31	4.38	591	4/100
3.....	1.000	4	.80	2	.64	278	48.56	36	4.82	597	39.35	7	.60	46	5.23	719	4/100
4.....	1.084	7,260	8.82	2,700	5.41	33,800	35.77	0	0	144	.06	0	0	72,700	49.94	116,604	100
5.....	1.101	12,200	11.96	3,130	5.05	38,600	32.99	0	0	137	.04	0	0	90,200	49.96	114,267	100
6.....	1.127	15,627	12.09	3,700	4.72	49,222	33.19			872	.22	526	.17	113,469	49.61	183,416	100

1/ End-points as determined by P. - phenolphthalein, M. - methyl orange.
2/ R.v. - reacting values in percentage (Palmer).
3/ Stoichiometrical.
4/ Total solids by evaporation.

Barium content: Samples 1, 2, and 3 - 0 p.p.m.; 4 - 67 p.p.m.; 5 - 60 p.p.m.; 6 - no test.

Where an extraneous water is used for flooding provisions usually are made to recycle the brine produced with the crude oil. In many water-flooding projects two or more water-supply sources are used. If water from the Permian sands was mixed with produced brine a closed water-injection system would not be practical because the Healdton sand waters contain barium in quantities ranging from 20 to 70 p.p.m. If these waters were mixed with the Permain-sand waters containing 5 to 30 p.p.m. of soluble sulfates, insoluble barium sulfate would be precipitated and would plug the formation. The dissolved oxygen in the Permian-sand waters would oxidize the dissolved iron in the Healdton-sand waters, causing it to form a precipitate, which might plug the formation also. Without chemical treatment the dissolved oxygen would cause excessive corrosion of metallic equipment.

The most practical method of conditioning the waters for injection would be to use an open system and condition the produced brines before mixing them with Permian-sand waters. Figure 40 is a diagram of a proposed open-type treating system. The produced brine should be aerated to oxidate the ferrous iron compounds to insoluble ferric compounds, to release part of the dissolved free carbon dioxide, and to reduce the supersaturation of carbonates. Chemical treatment with lime probably would be needed to stabilize the free carbon dioxide, to maintain the carbonate balance, and to reduce the supersaturation of carbonates to a concentration where only a thin, protective coating of carbonates would be deposited on the interior walls of pipes and other metallic surfaces. A coagulant, such as aluminum sulfate, should be added to aid in congealing of the precipitates.

Chemicals might be added to the waters by dry-chemical feeders as the mixed water gravitated from the aeration pond through a chamber set in the pond dike and into the sedimentation pond. Water and chemicals could be agitated with a mechanical mixer in the chamber. For reserve supply and detention time, the sedimentation pond, as shown in figure 40, should be large enough to hold a volume of water equivalent to that injected in 3 days and should contain baffles designed to afford maximum mixing and detention of the water to permit sedimentation.

In an open water-injection system some sterilizing agent probably would have to be used to control the growth of organic matter, particularly during the summer months. The most advantageous point to introduce the sterilizing agent would be between the sedimentation pond and the filters, or in the last compartment of the sedimentation pond.

Probable characteristics of a water resulting from the mixing of waters from different sources cannot be predicted. Details as to definite treatment procedures and quantities of chemicals needed for adequate conditioning would have to be worked out from theoretical consideration of characteristics of waters available and the ratio in which they were to be mixed. Tests and analyses should be made after the plant is operating.

The filter medium could be sand, crushed anthracite, or diatomaceous earth, which could be supported on successive layers of graded, crushed rock or a screen. The filters should be connected so that the beds could be back-washed with water from the clear-water tank pumped into the bottom of the filters, upward through the bed, and then to the reaction end of the sedimentation pond.

The effluent from the filters would flow into a clear-water tank or a partly submerged concrete clear-water well from where it would be pumped to the input wells.

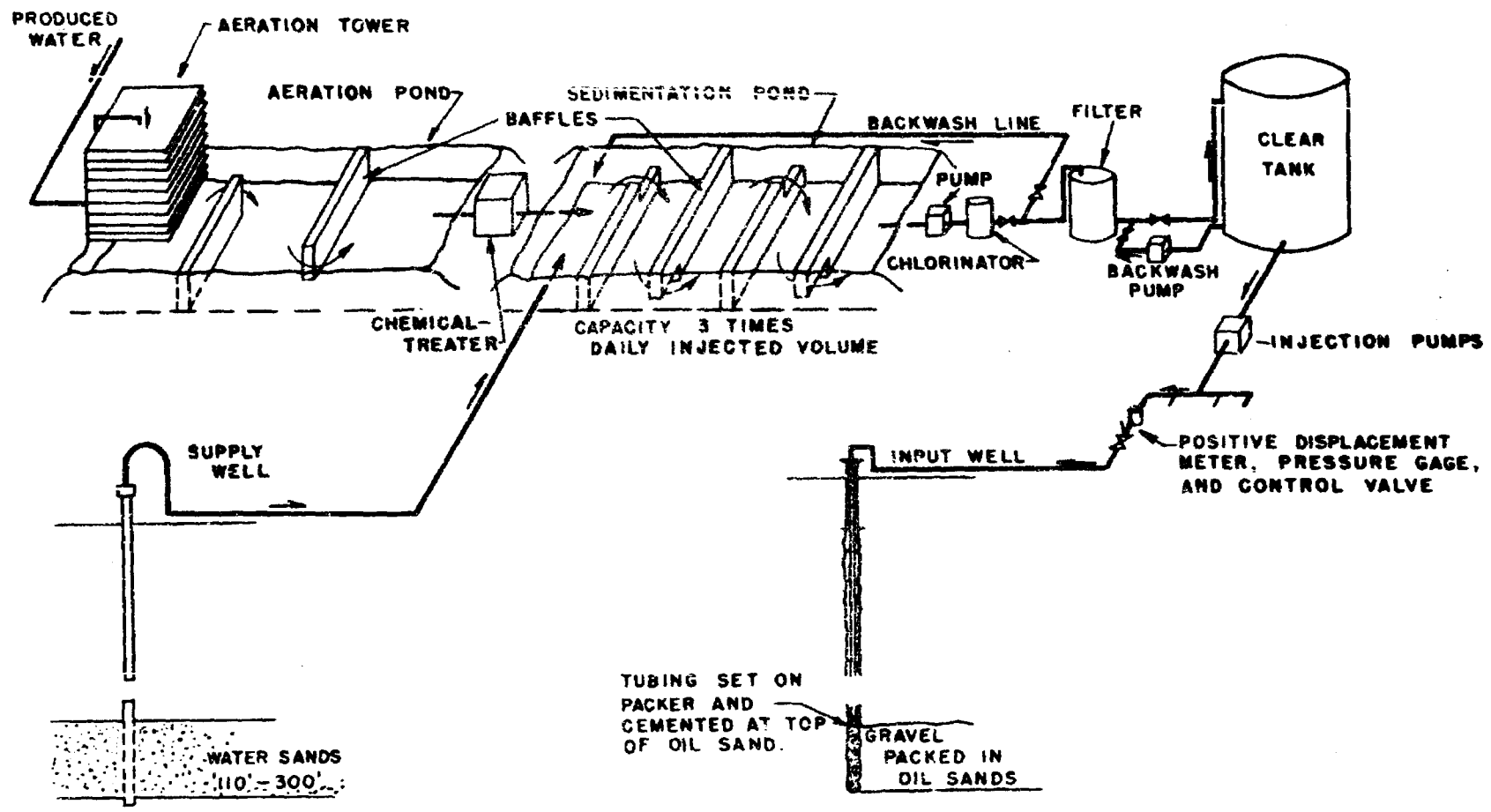


Figure 40. - Flow diagram of suggested water-conditioning and injection system, Healdton oil field, Carter County, Okla.

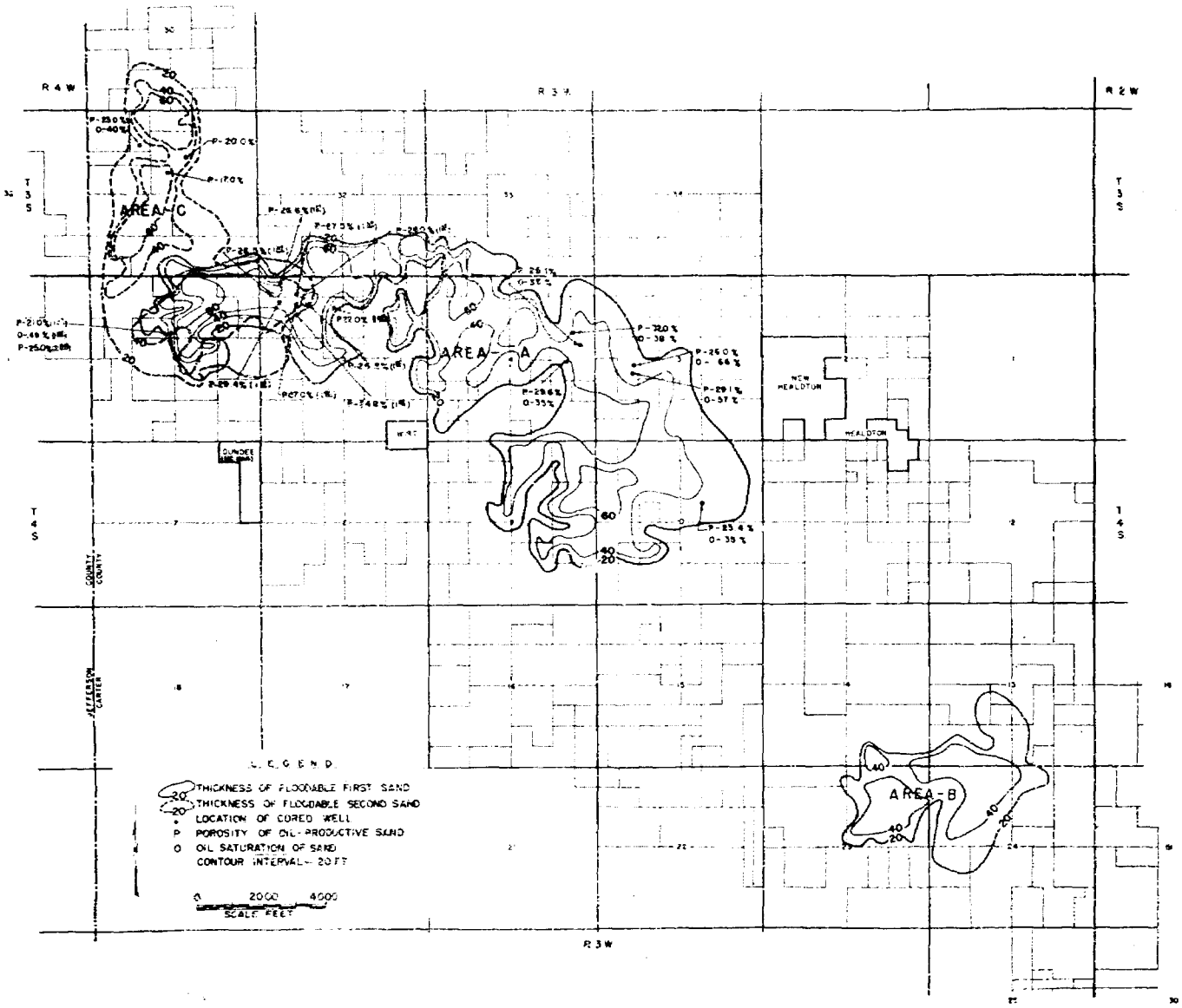


Figure 41. - Areas and sands most suitable for initial water-flooding development, Healdton oil field, Carter County, Okla., 1951.

If the input wells are drilled with rotary tools, they could be completed inexpensively without casing. To prevent caving, washed gravel should be packed in the hole opposite the producing sands. Two-inch tubing could be set on a packer above the sand and securely cemented to prevent upward movement of the injected water. Normally, input wells require little servicing except to back-flow or treat with mud acid, and such an input well should last the life of the flooding project. To aid in salvaging the tubing after the project was flooded out, right- and left-hand-thread nipples could be installed just above the top of the cement.

Three Areas Suitable for Water-Flooding Tests

Although many of the sands in the Healdton field might be flooded successfully, certain sands in local areas are considered especially suitable for initial water-flooding tests. Figure 41 shows three areas, A, B, and C, where the first or second Healdton sand probably could be flooded successfully.

In area A, containing 2,400 acres along the northeast flank of the structure, the upper member of the first Healdton sand varies in thickness between 20 and 100 feet. Detailed correlation studies indicate that this sand is fairly continuous throughout the ares. The structure of the top of this sand member is shown in figure 11. The depth varies from about 150 feet above sea level in the southwest corner of sec. 4, T. 4 S., R. 3 W., to about 150 feet below sea level along the east edge of sec. 10, T. 4 S , R. 3 W.

The upper member of the first Healdton sand was cored, using water-base mud in 16 wells in area A, and analysis of the cores show the average porosity of the sand in individual wells to range from 20.9 to 31.7 percent. The oil saturation of these cores ranged from 34.6 to 60.0 percent. As some of these cores presumably were partly flushed by the drilling fluid, the actual oil saturation of the reservoir rock might be higher than the reported values. The permeability of cores from these wells ranged from 210 to 2,316 millidarcys. Based upon the permeability - connate-water relationship as shown in figure 15, the connate-water content of the oil sands represented by the cores should range between 12.3 and 22.0 percent and average 15.4 percent.

Throughout most of this area the first sand has been under vacuum for a number of years and is partly depleted, so that recently drilled wells do not record "free" oil from these sands. In sec. 6, T. 4 S., R. 3 W., many logs of early wells show 100 or more feet of solid sand section, but logs of later wells drilled in this area, show sand and shale or broken sand. Electric logs show 40 to 50 feet of oil-productive sand in a total of 60 to 70 feet of section.

In the NW1/4 sec. 5, T. 4 S., R. 3 W., the sand was cored in many wells, and analyses of these cores show the sand to be fairly uniform and continuous with only minor shale partings. However, several faults (see fig. 11) are present in the north half of section 5 and could act as barriers to the movement of fluids. Because of these faults, much of the NE1/4 sec. 5 is not considered as the most satisfactory area for water flooding.

In sec. 4, T. 4 S., R. 3 W., the upper member of the first Healdton sand is shown as having thicknesses of approximately 40 to 60 feet (see fig. 41). In many areas this sand member is split by a shale or limestone bed 5 to 15 feet thick. In some areas the upper portion of the sand originally was gas-saturated in the gas-cap area and consequently has been excluded from consideration as floodable oil sand. Three wells on the Sinclair Oil & Gas Co. J. S. Mullen property, NE1/4 sec. 4, T. 4 S., R. 3 W., were cored. Analyses of cores show the porosities to range from 28 to 31 percent.

In secs. 9 and 10, T. 4 S., R. 3 W., this upper member of the first Healdton sand reaches a maximum thickness of 60 feet, although the sand bed may contain some shale layers. Only one well was cored through this sand, and analyses show the average porosity to be 23.4 percent and the average oil saturation 35 percent. Drill cuttings of several more recently drilled wells were available for microscopic study, which shows that here the sand contains more shale and limestone than do the soft, clean sands in secs. 5 and 6, T. 4 S., R. 3 W. Radioactivity logs were made in five wells in sec. 10, T. 4 S., R. 3 W., and comparison of these logs with the original drillers' logs, made in 1915 and 1916, show considerable difference in the depth and thickness of sands. Where the drillers' logs show a total of 25 to 40 feet of oil sand, radioactivity logs show shale partings 2 to 8 feet thick 6 to 11 feet below the top of the sand.

In the southeast extension, an area of approximately 500 acres (area B) is outlined as being suitable for water flooding in the first Healdton sand. In this area the thickness of the sand ranges between 20 and 80 feet, although most of the sand is less than 40 feet thick. In this area the depth to the top of the sand ranges from 100 feet above sea level to 200 feet below.

Wells in this area were not cored, and only one electric log of a recent well is available. However, drill cuttings from several wells have been examined, and these show the sand to be fine-grained and somewhat shaly, with the shale content increasing with depth. The porosity of the first sand has been estimated to range between 18 and 23 percent.

Figure 41 shows an area of approximately 900 acres (area C) in which the second Healdton sand is continuous and suitable for water flooding. In this area the sand ranges between 20 and 100 feet in thickness, although the average thickness may be close to 40 feet.

In sec. 31, T. 3 S., R. 3 W., the sand is described as fine-grained, shaly, and somewhat calcareous, with pitted grains. In sec. 6, T. 4 S., R. 3 W., the formation contains more limestone. In a few wells beds of oolites, composed of limestone surrounding sand grains, were encountered near the top of the second Healdton sand.

Five wells in this area were cored, and the analyses show the porosity ranges from 17 to 25 percent and the oil saturation from 20 to 40 percent.

Some water is produced from wells along the west edge of this area in sec. 31, T. 3 S., R. 3 W., and sec. 6, T. 4 S., R. 3 W., and it is possible that there is a limited, natural water drive in the second sand. However, it is believed that this water drive is not adequate to insure maximum oil recovery.

The above areas and sands are by no means the only ones that might be water-flooded successfully. Rather, they are those about which enough data now are available for water-flooding consideration.

In selecting any area for water flooding, detailed studies of the sand conditions and the production history should be made. The continuity of the sands, as well as their oil and water content, are most important. Where the accuracy of drillers' logs may be doubtful, radioactivity logs can be made in the old holes. New wells should be cored and electrically logged.

Water-Flooding Calculations

Suder and Cahoun have presented a method for predicting the water-flood behavior of a property from core analyses data and water-injection pressures (30). Their method assumes that water flooding progresses in a horizontal plane with no vertical movement and that the total water flowing in a formation, including beds of different permeability, can be represented by the sum of the volumes of water flowing in the individual beds. An adaptation of this method, assuming a constant injection rate, was used in calculating the probable water-flood behavior of two leases in the Healdton field.

These calculations were based upon a uniformly spaced five-spot pattern with four input wells surrounding each producing well. Upon repetitive development, the five-spot pattern becomes one in which four producing wells surround each input well, and in the entire flood there are an equal number of producing and input wells. The fraction of the total five-spot area theoretically swept by the injected water, when it first reaches the producing well, is 0.72 as described by Muskat (32), and this value was used in the calculations as the theoretical sweep efficiency. After injected water from each bed first reached the producing wells, it was assumed that water and no oil would be produced from that bed. In actual practice some oil is continuously produced with increasing volumes of water before the residual-oil-saturation value of 29 percent is reached. When the oil saturation in the more permeable beds is reduced to 29 percent or less, these beds might permit disproportionately large volumes of water to move to the producing wells, so that when the total volume of water pumped becomes too great to be handled economically, only in the more permeable beds would the oil saturation be reduced to the theoretical minimum. Selective plugging or packing off of these watered-out beds then would be necessary to effect oil recovery from the other less permeable sands.

Based upon the amount of flooding water that might be available, an injection rate of 500 barrels of water daily into each input well was assumed.

Lease 1

The first lease considered was in area A (fig. 39), where the thickness of the upper member of the first Healdton sand averaged 34.7 feet at a depth of approximately 900 feet. Analyses showed that the permeability of the individual core samples ranged from 400 to 3,100 millidarcys and the porosity from 18 to 38 percent. For the calculations a spacing between like wells of 660 feet was assumed.

The entire sand body was considered as 17 individual homogeneous beds 0.9 to 3.6 feet thick, and each bed was assumed to have uniform horizontal permeability with values for the different beds ranging from 450 to 3,000 millidarcys.

It was calculated that during the life of the flood, 500 barrels of water daily could be injected into the sand body at pressures exerted by a hydrostatic head of water in the input wells.

An average oil and water saturation of 35.0 and 14.2 percent, respectively, before flooding was used for each individual bed. The relative rate at which the injected water entered each individual bed was assumed to be proportional to the ratio that the millidarcy-foot capacity of that bed bore to the total capacity of the sand.

The volume of water necessary to effect flood-oil production is that volume required to saturate the gas space and commonly is referred to as the fill-up volume. This fill-up volume can be calculated by the following equation:

$$V = 0.72\ D^2\ T\ P(1 - C_w - 0)\ 0.178;$$

where:

V = fill-up volume, barrels;

0.72 = theoretical sweep efficiency at water breakthrough for five-spot pattern;

D = spacing between like wells, feet;

T = thickness of bed, feet;

P = porosity, decimal fraction;

C_w = water saturation, decimal fraction;

O = oil saturation, decimal fraction;

0.178 = factor converting cubic feet to barrels.

The time required to fill up or begin flood-oil production from each bed was calculated by dividing the fill-up volumes of the bed by the injection rate into that bed.

As discussed earlier under the topic or original mobile oil, the oil saturation after water flooding is assumed to be reduced to 29 percent. If after fill-up 1 barrel of injected water displaced an equal volume of oil to the producing wells, the total volume of water required to reduce the saturation of the bed to 29 percent in the area theoretically swept would be the fill-up volume plus 4.32 percent (0.72 (35-29)) of the total pore volume of that bed.

Based upon these data and assumptions it was calculated that the first flood oil would reach the producing well about 11 months after the water injection was begun. The peak rate of oil production probably would occur about 6 months later. It was calculated that the life of the flood to an economic limit of 1 percent oil in total fluid would be about 7 years and that during this time approximately 3,470 barrels of oil per acre would be recovered from this sand.

Because early in the life of the flood several of the more permeable beds would be depleted of oil and would be producing mostly water, provisions should be made to handle comparatively large volumes of water.

Lease 2

Water-flooding calculations were made for a second lease included in area A, where the average thickness of the upper member of the First Healdton sand was 21.4 feet at approximately 1,000 feet.

Analyses of the one cored well were considered to be representative of the sand underlying the flood area, where the assumed spacing was 900 feet between like wells. These analyses showed that the porosity of individual core samples ranges between 19.0

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Because early in the life of the flood several of the more permeable beds would be depleted of oil and would be producing mostly water, provisions should be made to handle comparatively large volumes of water.

Lease 2

Water-flooding calculations were made for a second lease included in area A, where the average thickness of the upper member of the First Healdton sand was 21.4 feet at approximately 1,000 feet.

Analyses of the one cored well were considered to be representative of the sand underlying the flood area, where the assumed spacing was 900 feet between like wells. These analyses showed that the porosity of individual core samples ranges between 19.0

and 28.3 percent and that the oil saturation ranges between 24.5 and 49.3 percent. It is entirely possible that these cores were somewhat flushed and that the oil saturation of the sand would be greater than that of the core samples. The permeability of the core samples ranged between 15 and 548 millidarcys.

Calculations based upon the data presented in the core analyses indicate that at an injection rate of 500 barrels per day per well the first flood-oil production would be obtained 1 year after injection was begun, and that the peak rate of oil production would be reached very soon thereafter. During the estimated 6 years of flood life, a total of 1,756 barrels of oil per acre would be recovered at a limiting ratio of 1 percent oil in total fluid.

If the oil saturation of certain beds were as low as indicated in the core analysis, large volumes of water would be produced early in the life of the flood.

The above calculations are exemplary only, and the conclusions should not be construed as predicting the actual water-flood behavior of any particular lease. These data and discussions are presented to encourage oil operators to examine the water-flooding possibilities of leases in the Healdton oil field.

APPENDIX

Calculations of Porosity and Water Saturation from Electric Logs

Archie (14) and other investigators have studied the relationships between electrical resistivity, porosity, and water content of a formation. Since, in most cases, brine is the only conductor of an electric current in a sand, the measured electrical resistivity of the sand is inversely proportional to the porosity and water saturation of the sand. The relationship for brine-saturated sands is expressed by the equation:

(A) $$\frac{Ro}{Rw} = P^{-m} = F;$$

where:

Ro = resistivity of brine-saturated sand, ohm-meters;

Rw = resistivity of brine, ohm-meters;

P = porosity, fraction;

m = cementation factor;

and F = formation resistivity factor.

For oil sands partly saturated with brine the equation becomes:

(B) $$F = \frac{W^{n}Rt}{Rw};$$

where:

W = brine saturation, fraction;

n = a positive exponent, approximately 2;

Rt = true resistivity from electric logs,

and F and Rw are the same as defined above.

Fifty-eight clean core samples of the first, second, third, and fourth Healdton sands were saturated under vacuum with formation brine. The saturation of these cores ranged from 57 to 100 percent of the pore volume as measured using helium. Any relationship between this percentage of brine saturation and other measurable properties of the core was not apparent.

The formation resistivity factor (Ro/Rw) and other measured properties of each core are shown in table 5 (p. 16). A plot of these formation resistivity factors versus percent porosity is shown in figure 42. Considering the entire range of porosity between 2 and 33 percent, the scattering of data may be assumed to lie within a band, the slope of which is minus 1.67. However, for porosity values between 18 and 32 percent, which includes most of the oil-productive sands in the Healdton field, there is no such alinement of the data and consequently no assurance that porosity calculations based upon an exponent of minus 1.67 would be valid. The spread of the data is not explainable.

The conception that clays or other solids were made conductive by water absorption was suggested by Patnode and Wyllie (33). DeWitte (34) pointed out that the conductivity of these solids in association with conductive liquids is not constant, and, although related to the brine resistivity and the percent of brine saturation, it is not entirely dependent upon these factors.

In an attempt to make quantitative use of electric logs to calculate porosity and brine saturation of a sand, it is important to determine the presence or absence of conductive solids. The presence and significance of conductive solids, when associated with brines of different salinity and resistivity, should be indicated by lower Ro/Rw values for saturation with less saline brines. When it is associated with the more resistive brines, the conductivity of any conductive solids would have a greater relative value. Given below are resistivity measurements of four brine solutions at 76° F. and of five cores saturated with each of these brines at the same temperature.

Chloride content, p.p.m.	1,000		2,000		10,000		100,000	
Brine resistivity, Rw	0.0349		0.0189		0.00514		0.00065	
Core No.	Ro	Ro/Rw	Ro	Ro/Rw	Ro	Ro/Rw	Ro	Ro/Rw
2808	0.7386	21.157	0.4031	21.268	0.0958	18.642	0.0123	18.987
2809	.1924	5.510	.1160	6.120	.0376	7.316	.0047	7.282
2812	.8925	25.564	.5396	28.470	.1134	22.080	.0148	22.858
2814	.4512	12.925	.2686	14.172	.0709	13.803	.0088	13.670
2827	.2907	8.327	.1740	9.181	.0373	7.253	.0044	6.855

A trend of lower formation resistivity factors (Ro/Rw) accompanying the higher brine-resistivity values may be indicated by cores 2809 and 2814. A decrease in the Ro/Rw values for the more-concentrated brine saturations, as shown for cores 2808, 2812, and 2827, is more difficult to explain. Possibly all of these differences are within the limits of accuracy of the measurements and are not conclusive evidence as to the presence or absence of conductive solids in the formation.

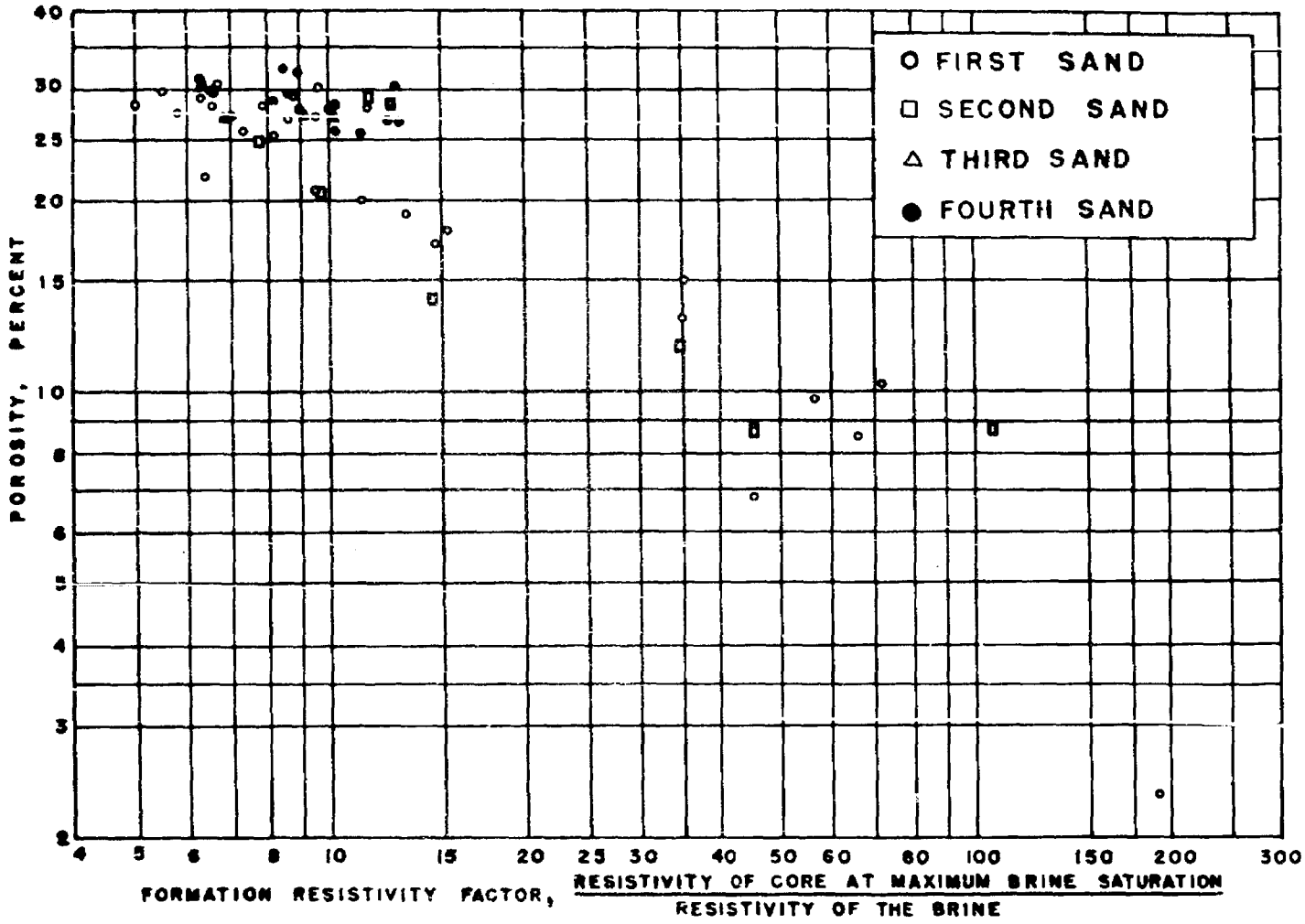


Figure 42. - Relationship between porosity and formation resistivity factor, Healdton oil field, Carter County, Okla.

Resistivity measurements at a series of different brine saturation were made on three core samples. The ratio of the resistivity of the core partly saturated to that of the core completely saturated (known as the resistivity index) was plotted on logrithmic paper versus the percentage of brine saturation. The water-saturation exponent, n in equation (B), is the slope of the average line of such a plot and should approximate 2.0. The summarized results of the resistivity measurements on the three cores are as follows:

Core No.	Porosity, percent	Permeability, millidarcys	Formation factor F	Water-saturation exponent n
2808.....	28.7	1,200	8.1	1.874
2812.....	15.1	12	24.2	1.115
2814.....	25.6	500	11.2	2.97

Only for core 2808 did the slope of the average of the water saturation versus resistivity-index curve approximate the experimental value of 2.0 as set forth by other investigators. Because neither a porosity exponent m or a water-saturation exponent n could be calculated from the data with reasonable accuracy, it was assumed that computations by Archie's basic equation would not be valid. Graphical solutions were then considered.

Separate plots were prepared on logrithmic and semi-logrithmic paper for 58 Healdton core samples, the formation resistivity factor was plotted versus air porosity, water porosity, permeability, and a product of porosity times permeability. The wide scattering of points on logrithmic paper again indicated that one exponent would not fit all the data and satisfy Archie's basic equation. On semilogrithmic paper the points fell more nearly along two straight lines, the slopes of which differed in the high and low porosity ranges. However, in the range of porosities between 20 and 32 percent, the slope of the average was very flat, indicating a wide divergence in porosity for a slight change in the formation resistivity factor. In general, it appears that the formation resistivity factor of these cores is more closely related to permeability than to porosity.

Forty oil-productive sand zones in 13 wells were electrically logged and cored. Sixteen of these beds on which core analyses were available were selected to compare porosity values graphically calculated from electric logs with those determined in the laboratory.

A water-saturation value, estimated from the relationship between water saturation and permeability (fig. 15), was used for each bed. Formation resistivity factors were calculated by equation (B), using water-saturation exponents 2 and 1.87 and the true resistivity values from electric logs. Using these formation resistivity factors, porosity values were read from figure 42. The calculated porosity values differed widely from porosity values measured in the laboratory. Calculated porosity values approached those measured in the laboratory in only 5 of the 16 beds studied.

Considerable data are available from oil-base-mud cores and restored-state measurements (see fig. 15) to show that the average connate-water saturation of most of the Healdton sands ranges from 10 to 20 percent. Since calculated porosity values are roughly inversely proportional to the square of this low connate-water-saturation value, a slight error in assumed connate-water saturation in this range, results in a large error in computed porosity values. Usually electric logs are used with an estimated porosity to calculate the water saturation of a sand bed, but in the Healdton-field study it was considered that the exact connate-water saturation was less valuable in reservoir calculations than a reasonable porosity value.

After considering the matter from all viewpoints, it was decided that electric-log resistivity measurements could not be used with any degree of accuracy to calculate porosity.

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5125

Int. - Bu. of Mines, Pgh., Pa.

R. 4 W.

R. 3 W.

T. 3 S.

T. 4 S.

36

1

12

JEDSCO & GOLDFFDER

30

TEXAS

KENDRICK

Gunsberg

E B COX

MAGNOLIA

M Doney

BURTON

PRODUCERS

Woodruff

Zweigle

TOMLINSON

KEWANEE

SINCLAIR

Hurie

31

Esperson

TWIN STATE

Tucker

COLSON

Colbert

E T Richards

C Richards

Bailey

Kostka

Downe

32

SHELL

McGRAW

MAGNOLIA

IDEAL & 32 d

COBBIN

Kostka

CREEL

Woodworth

Stoppani

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ROCKLAND

Pitts

Stewart

Clara

TOBLINSON

R M JOHNSON

Johnson

Harrington

Wm Smith

Kock-40A

R Chilton

K W Dawson

Mullen-A

S Jones

J S Mullen

Kornahrens

C B Mc

Doney

Tillis

F Lowery

Davis

Moore

C R Smith

Fee 40A

Schef

C L Mc Clure

Million & Thomas

WIRT

Meyer

W Davis

A D Harlan

Willis

COLINE

J Davis

Smith

Smitz

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DUNDEE (McMAN)

JONES & SHELBORNE INC.

Abbott

RELIANCE

LESS

Appl-Franklin

Roberts

Arrington

SUN

TEXAS

ARDMORA

TOMLINSON

Walker

Cochrane

Ansley

Apple-Franklin

West Franklin

SCHERMERHORN

Williams

MAG

Thompson

PURE

Ardmore

L Thompson

TEXAS GULF

W B D-80 A

Apple-Franklin-Harfield

Apple-Fromm

STEWART

R Nicholas

F Lamon

SWAN

Smalley

V Collins 40A

J A Baker

Holman

Jones

Carter

9

JEFFERSON CO

CARTER CO.

EXPLANATION

MAP NAME

FULL NAME

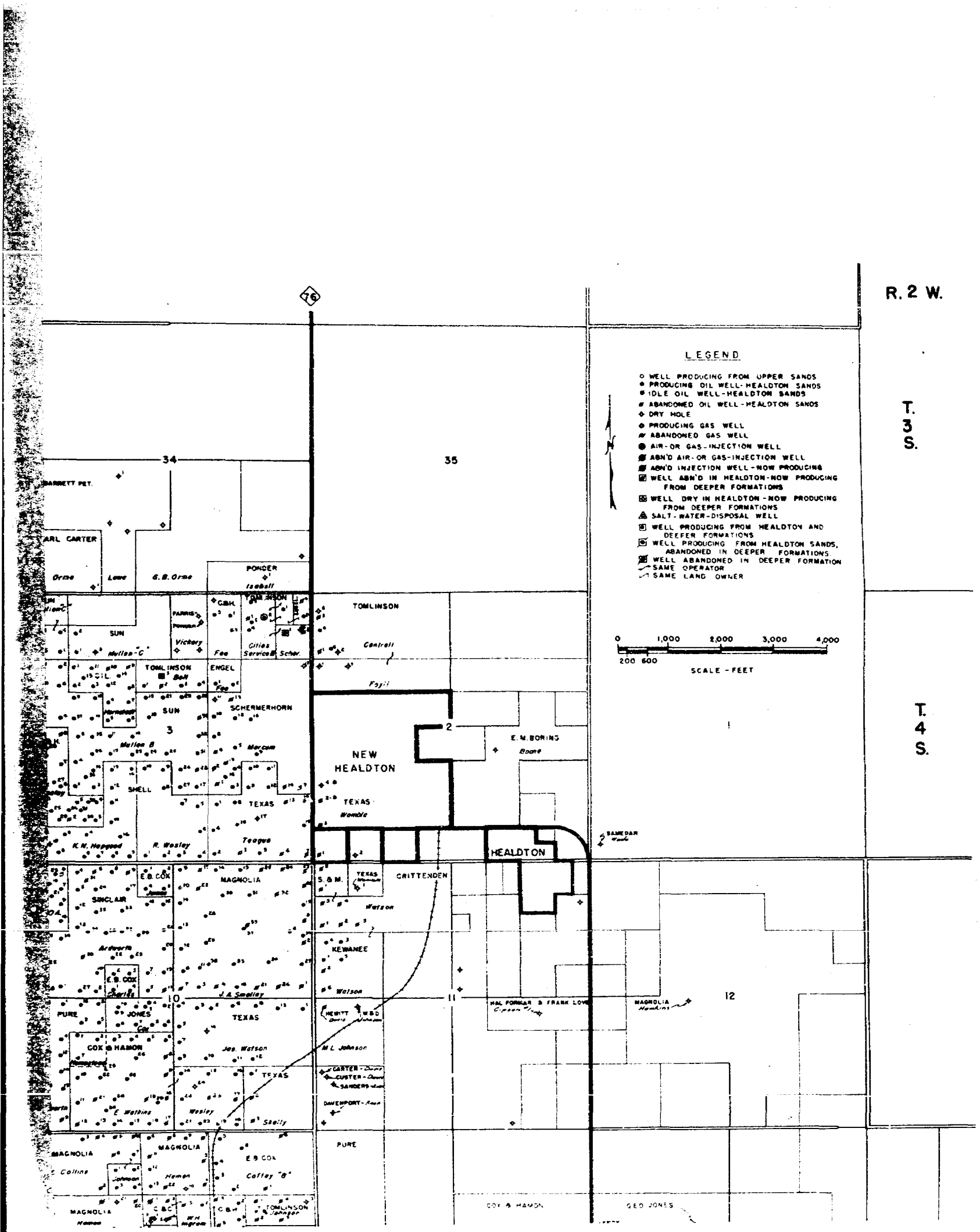
ARDMORA

APPLE

BARNETT PET

SAM APPLE

BARNETT PETROLEUM CORP


76
34
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BARRETT PET.
EARL CARTER
Orsie
Lowe
G. B. Orsie
PONDER
Isabell
TOMLINSON
Centrell
Fejil
SUN
Mullen "C"
Vickery
PARRIS
POWELL
GBH.
Fee
Cities Service
Scher.
TOMLINSON
Bell
ENGEL
Fee
SUN
SCHERMERHORN
Mullen B
Marcum
SHELL
TEXAS
K. N. Haywood
R. Wesley
Teague
3
2
NEW HEALDTON
TEXAS
Womble
E. M. BORING
Boone
HEALDTON
SAMEDAN
Wade
S. & M.
TEXAS
GRITTENDEN
Watson
E. B. COX
MAGNOLIA
SINCLAIR
Ardworth
KEWANEE
Watson
J. A. Smalley
10
11
12
PURE
JONES
Cox
COX & HAMON
Jos. Watson
TEXAS
E. Watkins
Wesley
Skelly
HEWITT
W & D
Davis
M. L. Johnson
CARTER
CUSTER
SANDERS
DAVENPORT
HAL FORMAN & FRANK LOVE
Gipson
MAGNOLIA
Hawkins
MAGNOLIA
Collins
Johnson
MAGNOLIA
Hamon
E. B. COX
Coffey "B"
MAGNOLIA
Hamon
C. B. C.
Wilmgren
C. B. M.
TOMLINSON
Johnson
COX & HAMON
GEO. JONES
LEGEND
WELL PRODUCING FROM UPPER SANDS
PRODUCING OIL WELL-HEALDTON SANDS
IDLE OIL WELL-HEALDTON SANDS
ABANDONED OIL WELL-HEALDTON SANDS
DRY HOLE
PRODUCING GAS WELL
ABANDONED GAS WELL
AIR-OR GAS-INJECTION WELL
ABN'D AIR-OR GAS-INJECTION WELL
ABN'D INJECTION WELL-NOW PRODUCING
WELL ABN'D IN HEALDTON-NOW PRODUCING FROM DEEPER FORMATIONS
WELL DRY IN HEALDTON-NOW PRODUCING FROM DEEPER FORMATIONS
SALT-WATER-DISPOSAL WELL
WELL PRODUCING FROM HEALDTON AND DEEPER FORMATIONS
WELL PRODUCING FROM HEALDTON SANDS, ABANDONED IN DEEPER FORMATIONS
WELL ABANDONED IN DEEPER FORMATION
SAME OPERATOR
SAME LAND OWNER
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200 600
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T. 3 S.
T. 4 S.
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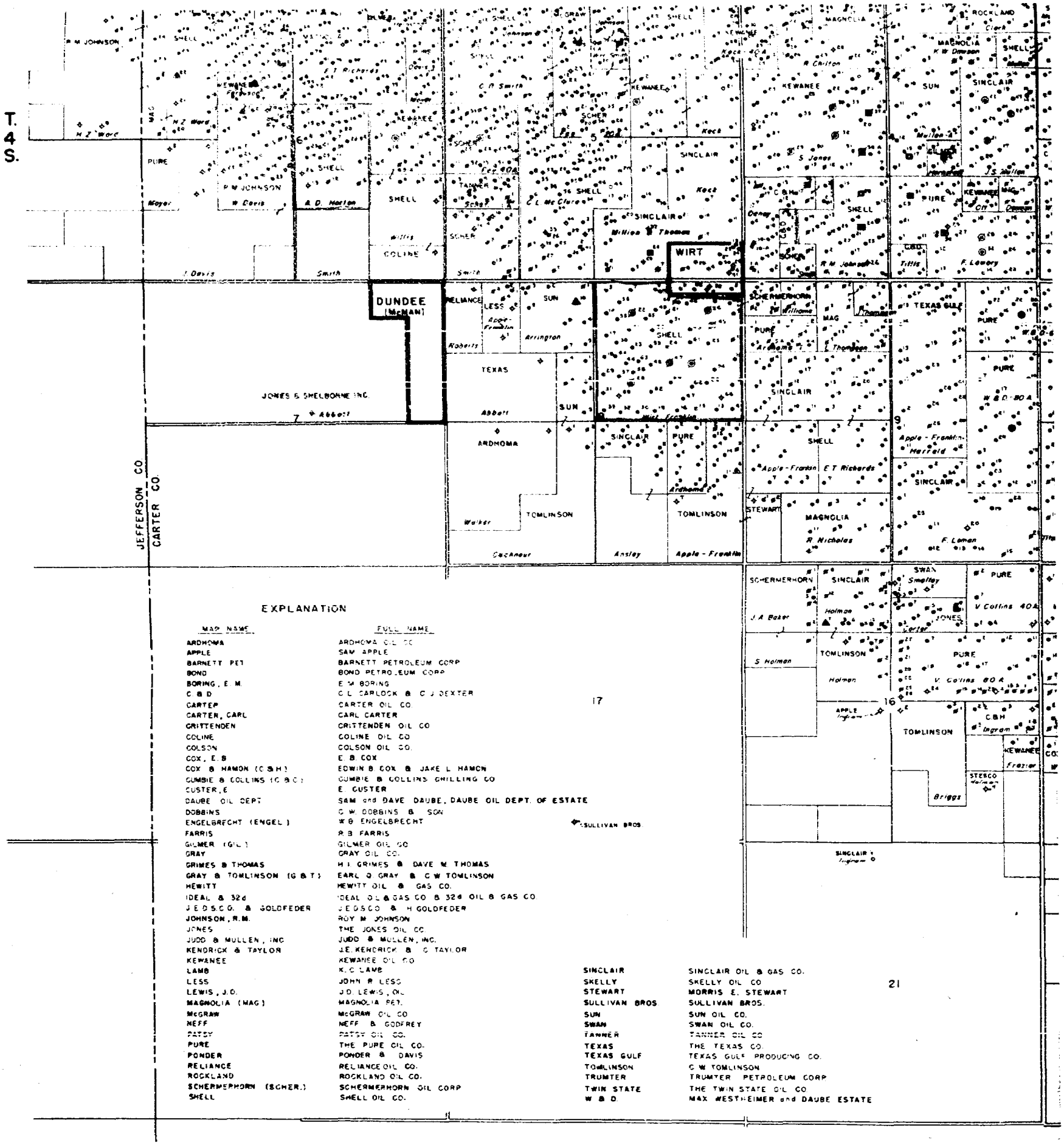
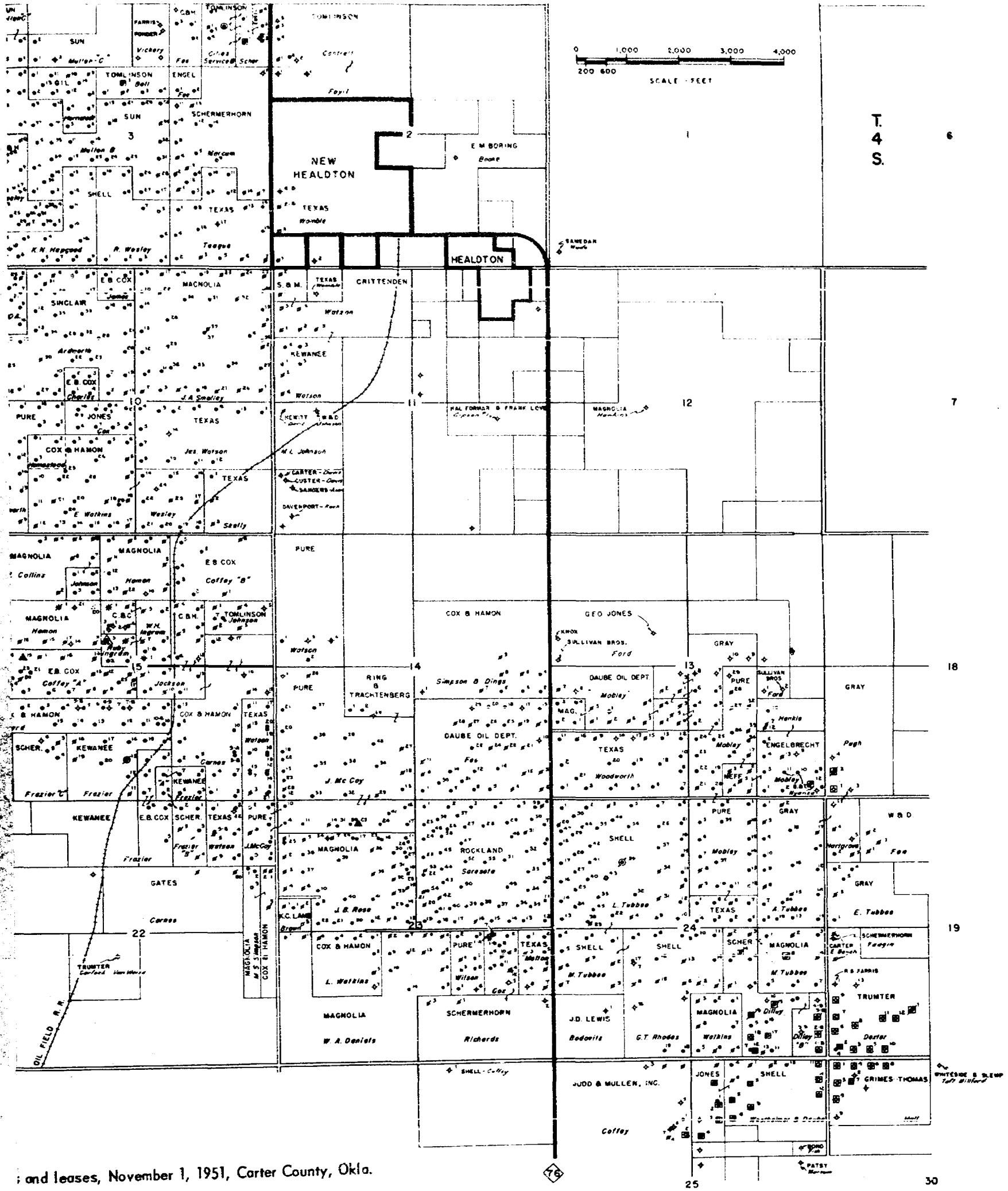


Figure 1. - Healdton oil field showing location and status of wells



; and leases, November 1, 1951, Carter County, Okla.

R. 4 W.

R. 3 W.

T. 3 S.

T. 4 S.

JEFFERSON CO.

CARTER CO.

DUNDEE (McMAN)

JONES & SHELBORNE INC.

TEXAS

30

31

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17

16

21

EXPLANATION

MAP NAME	FULL NAME
ARDMORA	ARDMORA O. & G. CO.
APPLE	SAM APPLE
BARNETT PET	BARNETT PETROLEUM CORP
BOND	BOND PETROLEUM CORP.
BORING, E. M.	E. M. BORING
C & O	C. L. CARLOCK & C. J. DEXTER
CARTER	CARTER OIL CO
CARTER, CARL	CARL CARTER
CHITTENDEN	CHITTENDEN OIL CO
COLINE	COLINE OIL CO
COLSON	COLSON OIL CO.
COX, E. B.	E. B. COX
COX & HAMON (C & H)	EDWIN B. COX & JAKE L. HAMON
CUMBIE & COLLINS (C & C)	CUMBIE & COLLINS DRILLING CO
CUSTER, E.	E. CUSTER
DAUBE OIL DEPT	SAM and DAVE DAUBE, DAUBE OIL DEPT. OF ESTATE
DOBBINS	C. W. DOBBINS & SON
ENGELBRECHT (ENGEL)	W. B. ENGELBRECHT
FARRIS	R. B. FARRIS
GILMER (G.L.)	GILMER OIL CO
GRAY	GRAY OIL CO.
GRIMES & THOMAS	H. F. GRIMES & DAVE M. THOMAS
GRAY & TOMLINSON (G & T)	EARL O. GRAY & C. W. TOMLINSON
HEWITT	HEWITT OIL & GAS CO.
IDEAL & 32d	IDEAL OIL & GAS CO. & 32d OIL & GAS CO
J.E.D.S.C.O. & GOLDFEDER	J.E.D.S.C.O. & H. GOLDFEDER
JOHNSON, R. M.	ROY M. JOHNSON
JONES	THE JONES OIL CO.
JUDD & MULLEN, INC	JUDD & MULLEN, INC.
KENDRICK & TAYLOR	J. E. KENDRICK & C. TAYLOR
KEWANEE	KEWANEE OIL CO.
LAMB	F. C. LAMB
LESS	JOHN A. LESS
LEWIS, J. D.	J. D. LEWIS, JR.
MAGNOLIA (MAG.)	MAGNOLIA PET.
MARTIN	MARTIN OIL CO.
MAYER	MAYER OIL CO.
MCGRAW	MCGRAW OIL CO.
MORRIS E. STEWART	MORRIS E. STEWART
MULLEN, A.	A. MULLEN
OHIO	OHIO OIL CO.
PURE	PURE OIL CO.
ROCKLAND	ROCKLAND OIL CO.
SCHERMERHORN	SCHERMERHORN OIL CO.
SCHER	SCHER OIL CO.
SHELL	SHELL OIL CO.
SINCLAIR	SINCLAIR OIL & GAS CO
SKELLY	SKELLY OIL CO
STEWART	MORRIS E. STEWART
SULLIVAN BROS	SULLIVAN BROS
SUN	SUN OIL CO.
TANNER	TANNER OIL CO.
TEXAS	TEXAS CO.
TEXAS GULF	TEXAS GULF PRODUCING CO.
TOMLINSON	TOMLINSON OIL CO.
WIRT	WIRT OIL CO.
WOODWORTH	WOODWORTH OIL CO.

R. 3 W.

R. 2 W.

T. 3 S.

T. 4 S.

76

LEGEND

- WELL PRODUCING FROM UPPER SANDS
- PRODUCING OIL WELL-HEALDTON SANDS
- IDLE OIL WELL-HEALDTON SANDS
- ABANDONED OIL WELL-HEALDTON SANDS
- DRY HOLE
- PRODUCING GAS WELL
- ABANDONED GAS WELL
- AIR-OR GAS-INJECTION WELL
- ABN'D AIR-OR GAS-INJECTION WELL
- ABN'D INJECTION WELL-NOW PRODUCING
- WELL ABN'D IN HEALDTON-NOW PRODUCING FROM DEEPER FORMATIONS
- WELL DRY IN HEALDTON-NOW PRODUCING FROM DEEPER FORMATIONS
- SALT-WATER-DISPOSAL WELL
- WELL PRODUCING FROM HEALDTON AND DEEPER FORMATIONS
- WELL PRODUCING FROM HEALDTON SANDS, ABANDONED IN DEEPER FORMATIONS
- WELL ABANDONED IN DEEPER FORMATION
- SAME OPERATOR
- SAME LAND OWNER

0 1,000 2,000 3,000 4,000

200 600

SCALE - FEET

34 35 1 2 3 6 7 10 11 12 15 14 13 18 19 22 23 24

BARNETT PET.

EARL CARTER Orme Lowe G.B. Orme

PONDER Isabell

SUN Mullen-C

FARRIS PONDER Vickery

G.B.H. Fee

TOMLINSON Orlas Service Suher

TOMLINSON Cottrell

TOMLINSON OIL Bell

ENGEL Fee

Foyil

SUN Mullen-C

SCHERMERHORN Morcom

SHELL Wesley

TEXAS Teague

NEW HEALDTON

E.M. BORING Boone

TEXAS Womble

HEALDTON

SAMEDAN Woods

S.B.M. TEXAS Womble

CRITTENDEN Watson

KEWANEE Watson

HAL FORMAR & FRANK LOVE Gipson Flag

MAGNOLIA Hawkins

E.B. COX James

MAGNOLIA Ardworth

SINCLAIR E.B. COX Davis J.A. Smalley

PURE JONES Cox

COX & HAMON Homestead E. Watkins

TEXAS Jos. Watson Wesley Stelly

HEWITT W.B.D. Davis Johnson M.L. Johnson

CARTER-Dunn CUSTER-Dunn SANDERS-Kane DAVENPORT-Kane

MAGNOLIA V. Collins

MAGNOLIA Hamon Johnson

E.B. COX Coffey "B"

MAGNOLIA Hamon

C.B.C. W.K. Ingram

C.B.H. TOMLINSON Johnson

E.B. COX Coffey Jackson

COX & HAMON Ward Frazier

TEXAS Watson

SCHER KEWANEE Frazier

KEWANEE Carnes Frazier

E.B. COX SCHER Frazier

TEXAS Watson

PURE J. McCoy

KEWANEE Frazier

GATES Carnes

PURE Watson

RING & TRACHTENBERG

COX & HAMON Simpson & Dings

DAUBE OIL DEPT. Fee

J. McCoy

MAGNOLIA J.B. Rose

ROCKLAND Sarasota

K.C. LAND Bryan

GEO JONES ERROR SULLIVAN BROS. Ford

DAUBE OIL DEPT. Mobley

MAG. TEXAS Woodworth

PURE Mobley

SULLIVAN BROS. Ford

GRAY

Henkle

ENGELBRECHT Mobley

Pugh

NEFF

PURE Mobley

SHELL L. Tubbee

GRAY

TEXAS L. Tubbee

W.B.D. Fee

GRAY E. Tubbee

SCHERMERHORN

[redacted]

[redacted]

[redacted]

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

April 16, 1953

- -

Case 407: This is a continued case. The Matter of the Application of the Oil Conservation Commission upon its own motion for an order extending Section G (Oil Proration and Allocation) to provide for the addition of Rule 508, Establishment of a Temporary 80-Acre Proration Units - said proposed rule to provide as follows:

1) Temporary 80-Acre proration units are hereby established for a wildcat well as defined in Rule 104a completed as oil wells with a pool depth range of 10,000 feet or more determined in accordance with Rule 505a.

2) After the effective date of this order, no owner of a producing well completed as a wildcat with a pool depth range of 10,000 feet or more shall be required to drill more than one (1) well to each 80 acres in order to secure his proportionate part of the production.

3) Upon the completion of five (5) wells to the same producing formation, within a radius of two miles of a wildcat well, the burden shall be on the operator to show by competent evidence that one (1) well will efficiently and economically drain the 80 acres assigned to the well,

and such other provisions as may properly be included therein as supported by proper testimony and evidence produced at said hearing.

MR. KELLAHIN: If the Commission please - Jason Kellahin of Phillips Petroleum Company.

MR. SPURRIER: Mr. Kellahin.

MR. KELLAHIN: I'm sorry. I'll withdraw.

MR. SPURRIER: Does the committee appointed by the Commission have its report ready at this time? Mr. Hanners?

MR. HANNERS: G. T. Hanners. We do have a - - - If the Commission please, we have at this time ready to file with the Commission a report of the Committee heretofore appointed by the Commission but we do not have enough copies of the report to circulate. I would therefore like to read it for the committee. The letter appointing this committee directed it to report on the three features of a proposed spacing rule and also to report on any questions that the committee may desire, the wisdom of the proposed rule not being fair and Bliss, Amerada and Magnolia members of the committee having advocated such a rule, the Chairman Harry Leonard, acting chairman G. T. Hanners and committee-member F. J. Danlade felt that the independent disinterested petroleum engineers should be consulted as to the questions and problems necessarily connected with the proposed rule before any attempt be made to report on the three specific features of the rule. After consultation with R. W. Tesch, an independent and disinterested petroleum

engineer and geologist and after a thorough study of the proposed rule, it is the considered opinion of the undersigned chairman and committee members that the features of the rule are so foreign to the orderly development of the oil pools of this state that no further consideration should be given to any of the features of the proposed rule and that the rule, in its entirety should be rejected. Not only would the adoption of the rule hamper the development of the fields but it would tend to the reduction of the recovery of oil and thereby to the creation of waste. We therefore recommend that the proposed rule be rejected for the following general reasons:

First: The adoption of such a spacing rule for new fields in advance of their discovery necessarily assumes that all fields are identical and that one well will always adequately and efficiently drain and develop 80 acres which experience in New Mexico fields has shown not to be true.

Second: Each field after discovery should be judged on its own particular condition and if peculiar condition warrant exception to the normal rules, the same should be considered after the establishment of facts warrant it; but adoption in advance of exceptions is necessarily based on false premise.

Three: The public policy of New Mexico as expressed in the recent session of the Legislature is for the Commission in establishing proration units to consider the - - - among other things, the rights of royalty owners and reduced recovery and physical waste which result from too few wells and the adoption of the proposed rule in advance of discovery of the field or any technical data or knowledge would thwart the expressed intent of the Legislature.

Four: Although the proposed rule is disguised as a temporary one, practical experience in such matters convince impartial observers that the actual effect of it would be to shift the burden of proof to the royalty owners and that the rights of royalty owners, including the beneficiaries of our state lands, could be jeopardized.

Five: The orderly development of oil fields would be hampered by the adoption of any rule that sanctioned the drilling of fewer wells than reasonably necessary to efficiently and adequately drain and develop the field and that waste of natural resources would thereby be created. A copy of the report of R. W. Tosch, petroleum engineer and geologist, setting

forth his conclusion in more detail and in a more technical manner, after study of the proposed rule and questions and problems necessarily connected with it, is attached to this committee report as Exhibit A.

Mr. Tesch is presently present and prepared to testify with respect to his conclusions and in support of this report.

We respectfully recommend that the proposed rule in its entirety be rejected.

Signed Harry Leonard, Chairman - myself - and Ed Danlade as committee members.

The report has attached to it the conclusion of Mr. Tesch.

MR. SMITH: I'm J. K. Smith of Stanolind. May I inquire, Mr. Hanners, if the other three committee members have submitted a report?

MR. HANNERS: The other three committee members, as indicated in the report, advocated the rule and at earlier hearings had submitted a suggested rule.

MR. SMITH: Am I to understand then that the report that is submitted is a report merely of the -- with the recommendations -- a report merely of the three committee members named therein.

MR. HANNERS: That is correct. As a matter of fact, the committee found itself hopelessly deadlocked.

MR. SMITH: I should like to suggest to the Commission that this is not a committee report but a report of three members of the committee.

MR. SPURRIER: Mr. Hanners, do you want to put Mr. Tesch on the stand to be sworn?

MR. HANNERS: I have assumed that if there is to be a request made for the adoption of the method, that the proponents/order of the would have technical proof for the Commission as well as transcripts of it to show such proof. We feel that the rule should not be adopted and we find ourselves rather in a defensive position and it occurred to me that if the proponents of the rule have technical evidence that they desire to submit to the Commission, we feel our position is somewhat that of the defendant rather than the plaintiff.

MR. SMITH: May it please the Commission, I was under the impression that the Commission had made the suggestion on its own motion and that therefore there are no proponents of the rule other than the fact that the Commission

wishes information respecting the advisability of it.

MR. SPURRIER: Is there anyone else who would like to be heard in this case? Proponents or opponents?

JUDGE FOSTER: Mr. Chairman.

MR. SPURRIER: Judge Foster.

JUDGE FOSTER: E. H. Foster representing the Phillips Petroleum Company. The committee report here - - or the minority report - - or the report, however you want to identify it, comes as somewhat of a surprise to say the least. It was my understanding that after the first committee meeting that the chairman would call another meeting for further discussion of this matter and as one member of that committee, I have waited to hear that call but it never came. Now, it occurs to me that this report which has been submitted here, without any sworn testimony, couldn't possibly be received as a committee report. It doesn't represent any more than just the views or ideas of three members of that committee. It seems to me that the proper procedure should be for these who want that report adopted to support it with some sworn testimony. I believe that the committee report states that the engineer is here and available to testify and that that report will be supported with his sworn testimony. Now, I believe it would be orderly to proceed in that manner, if I might make that suggestion to the Commission. Certainly, I would like to ask the witness some questions and I think he really should be put on the stand in support of the statements that have been made in the motion. Now, no other member of this committee as far as I know has been furnished even with a copy of this report. That's a little unusual to say the least. It seems to me that just as a matter of courtesy, the other three members of the committee should be given a copy of that report. That would appear to me just to meet the eye. And if what's in the record here is not supported by any testimony on this report or anything of that kind - it seems to me this witness should be called to testify.

MR. HANNERS: Mr. Chairman.

MR. SPURRIER: Yes, sir.

MR. HANNERS: May I make a suggestion to the Commission?

MR. SPURRIER: Certainly.

MR. HANNERS: The committee being hopelessly deadlocked and three members

having appeared before the Commission at an earlier hearing and submitted the proposed rule which has been submitted here this morning. We would recommend to the Commission that the proponents of the rule submit their technical data and we have Mr. Tesch available to support our report - it being a negative report, we feel that the proponents should proceed first but whatever the Commission desires, we will abide by. However, we recommend that the plaintiff take the burden of proof and the defendant the exception.

MR. SMITH: I object!

(Laughter)

MR. SMITH: May it please the Commission.

MR. SPURRIER: Mr. Smith.

MR. SMITH: I should like to move at this time that the report attached to the purported report of the committee be stricken as being an ex parte statement unsworn by the witness from consideration by the commission.

MR. SPURRIER: In view of what you have said and in view of the fact that Mr. Tesch is here, the Commission would like to have Mr. Tesch take the witness stand to testify both to direct and cross.

MR. HANNERS: Mr. Tesch will you come forward, please?

JUDGE FOSTER: I wonder if there is available copies of this report?

MR. HANNERS: There are not too many, Judge. But there are enough to get to all of our members.

JUDGE HANNERS: We only need three.

(Laughter)

R. W. TESCH

having first been duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. HANNERS:

Q. Your name is R. W. Tesch?

A. Yes, sir.

Q. Do you live in Ft. Worth?

A. Yes, sir.

Q. What is your occupation?

A. I'm a petroleum consultant.

Q. How long have you been engaged in this type of work?

A. I have been consulting as an independent since 1949.

Q. What was your experience prior to that time?

A. My experience prior to that time consisted of a degree in petroleum engineering from the Colorado School of Mines in 1933; graduate of the North Texas School of Law; experience in the oil fields since 1933, starting with Stanolind Oil and Gas Company in 1933 till 1942. In 1942 and until 1945, I was with the Army Engineers.

Q. Mr. Tesch, I believe you have previously testified before the Commission?

A. Yes, sir.

Q. And your qualifications have been admitted?

A. I assume so.

Q. When did you first become acquainted with oil conservation matters in New Mexico?

A. My first experience in New Mexico was in 1934 when I was employed by the Stanolind Oil and Gas Company. Actually, as far as proration is concerned, it started in 1935 at the time the first conservation rules were put in by the Commission. I have been acquainted with them since that time.

Q. Are you engaged in the production of oil and gas in your own right?

A. Yes, sir. In Texas. Unfortunately, not in New Mexico.

Q. Do you have any producing or royalty interests or financial interest in oil and gas production in New Mexico?

A. Not directly or indirectly.

Q. Mr. Tesch, were you requested by Harry Leonard, Jack Danlade and myself to attend the meeting of a committee last fall with regard to the matter that had been delegated to us by the Commission?

A. Yes, sir.

Q. After that time, did you make a study of the problems connected with - - necessarily connected with the adoption of the petroleum rule?

A. Yes, sir.

Q. You have filed as an exhibit to the committee's report a sheet showing some eight or nine conclusions. Do you have that sheet readily available?

A. I think you have it.

Q. I have one. Mr. Tesch, the letter appointing the six-member committee has asked for a report on three features of the proposed rule. After you

had begun the study, did you find it possible to accept any of those three features except by considering the rule as a whole?

A. That is right.

Q. Now, you have attached to the report an exhibit - about eight or nine conclusions - which you feel are valid objections to the bill. How would you proceed with respect to your discussion?

A. Well, I would suggest that perhaps I should read these conclusions of mine that I submitted to your committee.

Q. Will you read your first one, please, sir?

MR. SMITH: I'd like to object at this time on the grounds that there have been no proper predicate laid factually to support the conclusions. It's sort of like the cart before the horse.

MR. HANNERS: We plan to read the conclusion and then discuss them.

MR. SMITH: I renew my objection.

MR. WHITE: Will you explain your objection?

MR. SMITH: He is going to state his conclusions and there has been no testimony that the witness has done anything other than study the problem. I don't know what facts he's examined into - whether they are proper conclusions. I'd like to have cited better data to support the conclusions and then the conclusions.

MR. SPURRIER: The witness may proceed.

A. Conclusion No. 1. Many of the deeper structures in New Mexico have revealed steeply dipping flanks and complex faulting. Thus staggered 40-acre spacing with 80-acre proration units could result in one operator forcing another operator to drill at a location which might be dry or located at an inferior structural position.

Q. How would that happen under the adoption of the proposed rule?

A. It already has happened.

Q. I don't understand.

A. That same thing has already happened in the Crossroads field. There one operator was forced to drill a dry hole on an 80-acre tract of land, then he moved over and got an oil well on the tract that he would have normally drilled at if it hadn't been for the staggered plan.

Q. Do you have an exhibit showing the matter you have just described?

A. This is hypothetical exhibit - but it actually did happen in a field.

Q. Will you have the lady mark that exhibit?

(the document was marked Exhibit 1.)

Q. What do you mean when you say it could force an operator to drill on an inferior structure?

A. Well, simply this. There are - - these deeper structures in New Mexico are so - - have such high dips and rates of dip structurally speaking, that you don't have to move very far in order to be way down dip - possibly at a poor well or in a dry hole. And the operator who drills the first well in any patterned drilling, sets the pattern and naturally he's going to drill at that - - his location at the most advantageous point he figures he can. This exhibit here is merely to demonstrate what can happen in a short distance by the operation of such a rule. I have shown on this exhibit three different operators - one operator is colored in brown with his acreage, another operator is colored green, and another operator's acreage is colored in pink. The operator in the brown section establishes the pattern. Now it so happens that he is all right because he - - his next well on a staggered plan is within the confines of the field. That throws it over to the green operator. He has to step out and drill but fortunately he's in the field. Now that operator in the pink would like to off-set him directly but under the staggered plan, he can't do that. So he's forced out beyond the limits of production of the field leaving him with 40 acres that are within the limits of the field that he has no well on. Now that actually happened in the Crossroads field.

Q. Could it happen in other fields if this proposed rule is adopted as in the Crossroads field?

A. It certainly could and it is very well evidenced by the fact that nearly every operator in the field below 10,000 feet, at one time or another, including the Phillips and Amerada and all proponents of this matter, have drilled on 10-acre spacing simply to get better structural position.

Q. By ten-acre spacing, I assume you mean 330 foot instead of 660 foot location?

A. That is right.

Q. And what would be the purpose of this 330 foot location?

A. The purpose of it is, obviously, to get better structural position. I don't blame them a bit. I'd do the same thing myself, if I were in their position. But I wouldn't be advocating that somebody else step over 1,800 or 1,900 feet to drill another well.

Q. Do I understand them from your statement on the first problem that the adoption of an 80-acre spacing unit might compel an operator to drill at the - - beyond the limits of a field?

A. That is entirely correct.

JUDGE FOSTER: I object to that question. The question before this Commission is not of 80 acres or 40 acres. As far as this proposed rule is concerned, it doesn't establish 80-acre spacing in New Mexico. As I understand the proposed rule and the call is simply a question of whether or not you should have a temporary 80-acre rule for the purpose of collecting reservoir data so that the Commission will know after five wells have been drilled or at the expiration of 18 months, whichever event occurs first, what the nature of the reservoir is and whether it then should or shouldn't continue with the 80-acre pattern in the field or revert to the 40-acre pattern. And the rule as proposed, as shown in this record, is that at the end of this time, why then the burden is upon the operator to come in and show that the matter should continue on an 80-acre pattern. I don't see any room here, under the issue before this Commission, to debate or consider for one moment the merits of 40-acre spacing as against 80-acre spacing. That's simply not before the Commission. And this question is based upon the assumption that this Commission has before it the question whether it ought to adopt 80-acre spacing in New Mexico. And I submit that that's not the issue before this Commission at all.

MR. HANNERS: If the Commission please, it is my understanding that the Committee was to consider the extension of Section G to provide for a temporary spacing rule - that the rule had not yet been adopted - that the matter is now before the Commission for advisement and we think it is entirely proper for this witness to state his reasons why an 80-acre rule should not be adopted and why the 40-acre spacing pattern should be followed

until technical information proves that a departure from it is warranted. We assume that the rule itself has not already been adopted.

JUDGE FOSTER: But the question calls for him to state whether or not there ever should be 80-acre spacing in New Mexico and that's not the issue before this Commission. The rule proposes to furnish a means of providing reservoir data on a particular field so that any operator there in that field can come in before this Commission and lay the facts before them as shown by actual drilling and core analysis before this Commission in order that the Commission may more intelligently apply the spacing pattern for that particular field. It isn't a question of whether we should have 80-acre spacing in New Mexico or whether we should have 40 or whether we should have 20 or some other spacing pattern. That's simply just not before this Commission under the call and this question calls for his opinion on whether New Mexico ought to have 80-acre spacing. Nobody, as far as I know, presently supporting the proposed order of the Commission, is advocating at this time that New Mexico ought to go to 80-acre spacing. All we're saying is that the Commission has in times past, granted 80-acres in this state. But in some instances, perhaps the Commission has acted a little too hastily and granted it without having the proper information before it. Now the only way that this Commission can function at all, with respect to any particular field and what the pattern in the field should be, is to give it the chance to make it and that's the purpose of this proposed rule, as I understand it. Not whether you ought to have 40 or whether you ought to have 80.

MR. HANNERS: Judge, may I have a copy of your proposed rule which you circulated this morning?

JUDGE FOSTER: I believe that's it. It doesn't propose that this Commission adopt 80-acre spacing in this state at all. It simply says that you hold the matter in abeyance in the field until you get the field data so that this Commission will know what the facts are and will not have to go at it by guess work.

MR. HANNERS: If the Commission please, the first paragraph of the rule, proposed rule, reads that no operator shall drill more than one well to 80 acres. It seems to me that that would establish an 80-acre pattern and

would mean an 80-acre spacing rule.

JUDGE FOSTER: That is not correct. And I'll read you the rest of the rule: The second section of the proposed rule provides that the location of the discovery well shall set the pattern for the location of additional wells drilled while the temporary 80-acre proration units are in effect. Subsequent wells drilled to the same reservoir should be located at 150 feet of the center of the quarter quarter section of the identical description of that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of the quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units running either north and south or east and west. Third: Unless within not more than 18 months after the completion date of the discovery well or within sixty days after the completion of the fifth well of the same producing formation, within a radius of two miles of such wildcat well, whichever date occurs first, one or more of the operators of said wells files an application for a hearing to determine the permanent spacing pattern for said reservoir, such spacing pattern shall revert to 40 acres and upon such hearing, the burden shall be upon the operator or operators to show that one well will efficiently and economically drain the 80 acres, failing which such spacing pattern shall revert to 40-acres. Now, it is evident from the rule itself that nobody is advocating that this Commission should at this time, adopt 80-acre spacing. All this is, is a temporary thing, to last for the period specified, and if at that time, the operators in the field can't come in and justify a continuance of 80 acres, why then it reverts to 40.

MR. SPURRIER: We'll have a five minute recess.

(Laughter)

(The meeting recessed for five minutes)

MR. SPURRIER: The meeting will come to order again, please. Mr. Hanners.

JUDGE FOSTER: I believe I have an objection which has to be ruled on.

MR. SPURRIER: Objection overruled. The witness may proceed.

Q. In your second paragraph you have stated that 80 acres will result

in less oil being recovered than closer development. What factors have you taken into account to arrive at any such statement as that?

JUDGE FOSTER: If the Commission please, I'd like to renew the objection. I don't suppose the Commission wants to try here the merits of 80-acre spacing and that's what this second objection represents. I didn't understand that that was the purpose of the rule, or proposed rule. It seems to me that we ought to try to follow the call of the hearing at least. And if you study that second proposal that they're on right now, it seems to me that that's just a question as to the merits of 80-acre spacing - whether you ought to have or whether you oughtn't to have 80-acre spacing. And that's not the question before the Commission.

MR. SPURRIER: Judge Foster, with all due respect for your sense of propriety, the Commission has never been too exacting in its rules of evidence. We have one Commissioner here who has never heard any of this testimony, on either side, and we feel that we are trying to get information - we feel that we should let this witness proceed and then we feel that you may proceed however you wish.

MR. WALKER: I would like to add, just from a personal standpoint, I'm inclined to agree with you from a technical standpoint. However, as far as this man's testifying, for additional information for my own part, I would like to hear it. Although I can agree with you from a technical standpoint. I can't see that it has too much bearing on the question that is before us now. And that's my feeling.

JUDGE FOSTER: Just so I won't be interrupting the orderly proceedings I'll just have this objection throughout the record.

(Laughter)

I don't want to make myself obnoxious, in presenting my views.

Q. Mr. Tesch, in making the statement that an 80-acre development would reduce the ultimate recovery of oil in the field, what factors did you consider in arriving at this statement.

A. I considered that from an engineering standpoint. It is generally accepted regardless of whether you are talking about 80 acre, 40 acre or 20 acre, everything else being equal - the more wells you drill, the more

oil that will be recovered from the reservoir. Now in the case of these deep reservoirs in New Mexico, they are essentially carbonate reservoirs. And when you have that condition, you have many conditions arise, for example, that you do not have in sandstone reservoirs. Permeability is erratic, your porosity is erratic, these structures present faulting - vertical fracturing. There are many things that enter in. Not just one thing - but everything. All those that I have mentioned enter into my conclusion in that respect.

MR. HANNERS: Does the adoption of an 80-acre rule - I use that phrase loosely, Judge - -

JUDGE FOSTER: I observe that!

MR. HANNERS: Does that presume that there will be uniform permeability throughout the area?

A. Well, of course, you have got to have a lot of things that are uniform in order for everything to be equal which you do not have in these carbonate reservoirs.

Q. If a rule for 80-acre spacing be adopted in advance of the discovery of a field, does that necessarily assume that one well would efficiently drain 80 acres?

A. It would.

Q. What other geological factors would the adoption of the rule in advance of a discovery necessarily assume?

A. Well, there are many - - it assumes that the one well primarily will get all the oil out of an 80-acre pattern that it could get out of a one-acre pattern. And that assumption is just not correct.

Q. Would there be any harmful effect from this rule, Mr. Tesch, by drilling wells on an 80-acre basis with increased rate of withdrawal from the 80-acre well as compared to wells spaced on a 40-acre pattern?

A. Well, that comes back to my conclusion four. That high concentrated draws for dispersals of wells could conceivably result in large quantities of oil being trapped off by uneven encrouchment or coning of water.

Q. Would you explain a little more fully what you mean by quantities of oil being "trapped off"? Or uneven encrouchment or coning of water?

A. Well, it's been my observation that the majority of these deep

reservoirs apparently have an active water drive. Now that being the case, it's well recognized that highly concentrated withdrawals tend to the fact that you'll either have premature encrouchment of water or you'll have coning of water and in such cases as that, you loose some oil that you'll never get again. Even in the east Texas fields itself, with its active water drive, and it's water drive has nearly encrouched across the field in one or two spots, there are many areas left behind - islands of oil completely surrounded by water. Now this East Texas field was drilled on a very close pattern of one well to five acres but even in that case, you have right today islands of production surrounded by water that if you'd had water spacing you'd probably never would have got that oil.

Q. Would the spacing of oil wells on a 40-acre pattern tend to minimize the danger of water encrouchment or water coning?

A. Well, it would. Of course, you come back again to your allowable for those wells as set out by Rule 505. And that comes back again to conclusion three in regard to the economics of the matter, that Rule 505 Of the Commission provides for a higher allowables with depth and is based upon economic considerations so an operator recovers his investment at practically the same time for different depths. So you have got to go ahead and consider each reservoir by itself, each one as its own particular problem. What is good for one may not necessarily be good for the other. Each reservoir should stand on its own legs. I can conceive that there will be occasions where the economic considerations won't justify one well to 40 acres but I say again that that shouldn't be judged prior to the time that the field is discovered. You can cause a lot of hardship even with 18 months or five wells with these steep dips that we have in these fields. Some of these dips run up to better than a 1,000 feet to the mile. Well, if you force an operator to move over with a staggered plan from his normal direct off-set, you could conceivably force him off the structure entirely. And incidentally, I've had some personal experience with administration of staggered spacing. When I returned from overseas with the Army, I was assigned by the Army to the Petroleum Administration for War and the Petroleum Administration for War adopted many rules as a steel conservation matter, among which they promulgated this patterned drilling as set by discovery well.

and I can personally vouch for the fact that this patterned drilling, from the administrative standpoint, caused a whole lot of headaches and it certainly was not successful and the minute the PAW abandoned its rules, the operators forgot all about their staggered plan and went back to their regular development.

Q. Do you have a chart showing the ability of wells to make their allowables, Mr. Tesch?

A. Yes, sir. I took the April 1st schedule and it's merely a compilation of the schedule itself - - -

MR. HANNERS: Will you hand it to the young lady for marking, please?

(The chart was duly marked Exhibit 2)

Q. Now will you explain what you have on the chart that is marked Exhibit 2, Mr. Tesch?

A. All this exhibit 2 amounts to is a compilation of the allowable, the number of wells, the number of wells incapable of producing their top allowable for all fields 10,000 feet or below as designated by the Commission. This schedule shows that their are a total of 155 wells in the various fields. Of this 155 wells, only 34 are incapable of producing the top allowable for the field. The total allowable of these 155 wells is 36,106 barrels. Of that amount, the allowable for wells incapable of producing the top allowable amounts to 4,282 barrels or 11.86 per cent of the total. I merely bring that out to show that these deep wells are getting along pretty well here. They seem to be producing in pretty good shape.

Q. Does that mean that about 12 per cent of the allowable is being made by wells - - isn't being made by all the wells in the deep field combined?

A. Yes. Approximately 12 per cent of the allowable of these fields in that category is delegated to wells incapable of producing the top allowable of the particular field they are located in. It's a statistical summary of these fields that are under consideration at this time.

Q. In your experience, do you know of any other state that has 80 - acre spacing?

A. As far as I know, there is not.

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A. Yes. Approximately 12 per cent of the allowable of these fields in that category is delegated to wells incapable of producing the top allowable of the particular field they are located in. It's a statistical summary of these fields that are under consideration at this time.

Q. In your experience, do you know of any other state that has 80 - acre spacing?

A. As far as I know, there is not.

Q. Do you know of any state that has adopted a rule in advance of discovery of a new field as to what the proration pattern will be?

A. There - not below 10,000. The State of New Mexico has a 40-acre that's set out in advance but that's a state-wide proposition also - - it's not 80-acre.

Q. Based on your experience as an Engineer, Mr. Tesch, what are the principal objections to the adoption of an 80-acre rule in advance of the discovery of the field?

A. Well, the principal objections are those I already gave. Briefly, my principal objection is that each field should stand on its own particular legs. It should be judged on its own particular conditions. It should not be prejudged. There are many danger signals when you get to wider spacing, as advocated; especially in these highly dipping structures that have been evidenced to date in this state. You have the problem of delegating large allowables to these wells in advance of knowing whether or not they are capable of producing at that rate without injury to the reservoir. Those are briefly the main objections I have in addition to this proposition of unfairness to some operators that might be caught by not having a location that would be best for their particular structural position.

Q. Are there any other matters or questions that you would like to discuss that I have perhaps overlooked?

A. Well, frankly, I see no particular reason for a rule. I think that the operators can get together and work out their own problems and not force the Commission to stand between them and any royalty owner that may have objection to their particular plan of development. I think that the operators themselves - - and I speak from experience - - along those lines, can get together and work out their own particular plan without the Commission's being forced to adopt it in advance.

Q. Is there anything else we should discuss, Mr. Tesch, before we submit to cross examination?

A. I don't think of anything at this moment.

MR. HANNERS: I yield the chair.

JUDGE FOSTER: May we have just a few minutes recess?

MR. SPURRIER: Yes, sir.

(The meeting recessed for five minutes)

MR. SPURRIER: Judge Foster?

CROSS EXAMINATION

By JUDGE FOSTER:

Q. Mr. Tesch, in submitting this report to the committee, do you recommend that the proposed rule here be rejected for the nine reasons that are set out here. Now, I'm going to go over each one of these rules with you separately in the light of what the proposed rule is. First, you say that the proposed rule should be rejected because the adoption - - -

MR. TESCH: Mr. Foster, I didn't say that. That is the committee's report. My report - - - -

JUDGE FOSTER: It's based on what you said, isn't it?

A. That's true, but - - you have my conclusions, sir.

Q. Do you agree with the committee's report?

A. Yes, sir.

Q. All right.

A. It is confined to the committee's report.

Q. You say there that the adoption of such a spacing rule in a new field in advance of their discovery necessarily assumes that all fields will be identical and that one well will always adequately and efficiently drain and develop 80 acres which experience in New Mexico fields has shown not to be true. Now, I wish you'd tell the Commission here how you get to that assumption?

A. Just a whole lot of experience, that I've seen in various oil fields in Texas and New Mexico.

Q. Well, just for the record, just tell us how you arrive at that assumption.

A. The more wells that are drilled, the more oil that will be recovered.

Q. That's your opinion?

A. Yes, sir. And it's backed up by a lot of other people, Mr. Foster.

Q. Well, that's a controversial issue, isn't it?

A. It certainly is.

Q. There are other men who are just as reputable as you who hold

a contrary view, aren't there?

A. That's true.

Q. Well, I want you to tell this Commission on what facts you base the statement that the adoption of this rule assumes that all fields will be identical and that one well will always adequately and efficiently drain 80-acres?

A. Well, if you have 80-acre development you naturally assume that that well is going to drain 80 acres efficiently.

Q. But you say that these proposed rules do that. Now, where in these rules do you find any such proposal?

A. Well, they propose staggered spacing and 80-acre development, don't they?

Q. Well you take the rule here and you point out to me -- here I'll give you the rules and you point out to me in these rules where these rules contain any such proposal, as you say here.

A. It says that in the Commission order itself.

Q. Well, read it. Where?

A. After the effective date of this order, no operator in a new reservoir established as a result of the completion of a wildcat well at a depth range of 10,000 feet or more shall drill more than one well to each 80 acres.

Q. Well, read the next one.

A. That, in itself, answers the question.

Q. Read on.

A. Sure, sure. O.K. The location of the discovery well shall set the pattern for the location of additional wells while the temporary 80-acre proration units are in effect. Subsequent wells drilled to the same reservoir shall be located within 150 feet of the quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of the quarter quarter section diagonal to such quarter quarter section. Each quarter section shall be divided into two proration units running either north and south or east and west.

Q. Now read the third one, please.

A. Unless within not more than 18 months after completion date of the discovery well or within 60 days after completion of the fifth well to the same producing formation within a radius of two miles of such wildcat well, whichever date occurs first, one or more of the operators of said well files an application for a hearing to determine the permanent spading pattern for such reservoir. Such spacing pattern shall revert to 40 acres and upon such hearing, the burden shall be upon such operator or operators to show that one well will efficiently and economically drain 80 acres, failing which, such spacing pattern shall revert to 40 acres.

Q. Now that rule don't assume, as you state here, that one well will always efficiently and economically drain 80 acres, does it?

A. You say you can't drill more than one well to 80 acres.

Q. Well, that rule you just read there, number three, doesn't make any such assumption at all, does it?

MR. HANNERS: If the Commission please, we don't argue that the rule makes the assumption.

JUDGE FOSTER: Very well.

MR. HANNERS: We merely state that the proposed rule is based on a false premise.

Q. That ain't what this report says. You say here, in point number one that the adoption of such a spacing rule for new fields in advance of their discovery necessarily assumes that all fields will be identical and one well will always adequately and efficiently drain 80 acres. That's what you say when you signed it and he says he agrees with it. And I want to know - - -

A. I still think it does. That's what you're after - 80-acre development the same as you were in the Denton field. You wanted 80-acre development there but the Commission found you weren't entitled to it.

Q. Mr. Tesch, let me make this statement for your benefit. I don't know who you mean by "you", but - - -

A. Phillips.

Q. Phillips Petroleum Company and I want to say that that's not what we're after. What we are proposing here in these rules is simply this -

that you wait and let, as you said in your direct testimony, the field stand on its own merits.

A. Yes.

Q. Now, we can't tell in advance whether the spacing should be 80 acres or 40 and that can only be told by actual development. What objection can you find in that?

A. You will force an operator to drill where he might not drill by setting this pattern drilling.

Q. Well you do that on 40-acre drilling.

A. You're always allowed to make a direct off-set.

Q. Isn't it true that you do that on 40-acres?

A. You don't have patterned drilling on 40-acres.

Q. You have uniform pattern on 40 acres in this state, don't you?

A. Yes, sir, but a man's always entitled to make a direct off-set. To this, you say no. You can't make a direct off-set.

Q. Now, that's just for the first five wells, is all. Then it may revert back to 40-acre spacing.

A. From this example that I showed you right there, you can force a man to drill a dry hole.

Q. Well you can do that on 40 acres too.

A. Sure, but he'd at least have a chance for a direct off-set.

Q. Well, it would just get him to a dry hole quicker on 80 than it would on 40, isn't that right? That's all that happends, isn't it?

A. Not necessarily. Because if you drill on 40, you develop a whole lot more information and a whole lot faster to know - to keep away from trouble.

Q. Well, I'm still at a loss to find anywhere in these rules where they assume that each well will efficiently and economically drain 80 acres. Can you show me or point that out to me?

MR. H/ .NERS: If the Commission, please. We don't own that the proposed rule makes any such assumption. We merely state that if adopted - - -

JUDGE FOSTER: Well, if you adopted it, it would be in there, wouldn't it? If you adopt the rule - - -

MR. HANNERS: It would be making an assumption on the part of the Commission - - -

JUDGE [illegible]: Well, I don't think so and that ain't what you said. Now, here, you say you feel each new field after discovery should be judged on its own particular condition. Isn't that what this rule proposes?

A. Not until 18 months have passed.

Q. Well, now assume you have discovered a new field, how soon would you judge it?

A. Well, it would depend upon its characteristics as you find them.

Q. How are you going to find out the characteristics without drilling?

A. That's exactly what you'll have to do.

Q. Well, now, do you say that there never should be any case where fields shouldn't be developed on 80-acres?

A. No, sir.

Q. Do you admit that there are instances where fields should be developed on 80 acres?

A. Yes, sir.

Q. Doesn't this rule merely implement that?

A. No, sir.

Q. How can you best determine when a field should be or should not be developed on 80 acres?

A. Well, there are - lots of things you need to know.

Q. I know. But what are they?

A. You need to know what kind of a pay section you have, how much you have, what the general structural conditions are. If you need to know how your reservoir fluid acts - many things from an engineering standpoint you need to know to weigh the economics of the proposition.

Q. How best can you determine those factors?

A. By drilling.

Q. Would you suggest to the Commission that you should start out on a 40-acre pattern when the conditions that are developed in the field might indicate that it ought to be on 80?

A. If that is the case. You should ask for a hearing and ask - - and

submit those findings to the Commission and let them pass upon it.

Q. Before you develop the field?

A. No, after you find that out, as you have assumed.

Q. Now, don't you recognize that in New Mexico that you either - - - that you start on 40 to begin with - that you have a state-wide 40 acre rule?

A. That's right.

Q. Now, if you start out on 40 acres and then after you get your reservoir information and find out that it ought to be 80 acres, just how would you then get to 80?

A. You stop drilling. Because no operator is going to drill any wells that he thinks won't bring his money back. Now, I say that as a practical operater, which I am.

Q. That doesn't answer my question. If you start out on 40 acres, and the field information when developed shows that it should have been on 80, how do you then propose to get the 80 acres?

A. You won't.

Q. That's correct. But this rule - - -

A. But you won't get that far if you're a prudent operator.

Q. Just a minute. This rule permits you to start on 80 and then if the operator can't sustain the burden that the rule places on him to show that it ought to go on on 80, it reverts to 40. What objection can you possibly find with that?

A. As I have said before, you can force an operator to drill a dry hole. You don't permit him to drill an off-set well. You force him to stagger. You're assuming from the start that the well will efficiently drain 80 acres.

Q. Well, I don't think the rule assumes that, Bob.

A. Well, I sure interpret it that way.

Q. Well, I don't think the rule assumes that and I don't think the rule is intended to assume that.

A. Well, in that case, you don't need any such rules then. As I see it, I don't see why you need any such rules at all. If you and your

brother operators can't get together between you and work out your own problem. I don't see why you should dump it on the Commission.

Q. Well, isn't that the Commission's function to regulate the operators when they can't agree among themselves?

A. Now, now you're getting somewhere. When they can't agree among themselves. Then you should have a hearing.

Q. Well, if you force an operator to start on 40 acres which you are doing unless you adopt this rule, then it's obvious to everybody that you'll never get to 80 acres in the field and you say that you won't.

A. You can still hold it down to one well to 80 acres, if you want to without forcing a man to drill on a diagonal pattern.

Q. Well, you can't do that, Bob, unless you start out on an 80 acre pattern. You can't get to 80 and stay on 80 unless you start on 80.

A. Sure, but you run into the same thing that you ran into in the Denton field where you drilled on 10 acre location. You were fighting for structure and I don't blame you any. I'd do the same thing myself. But that doesn't mean that you ought to force a man ought on an 80-acre plan.

Q. Well, neither should you force him on a pattern where he can't ever go to 80 if he should?

A. Well, why don't you get together with the operators then. Surely, - - - if you can't get to gether with your brother operators - - off-set operators, you're never going to get together with them at a hearing here.

Q. How do you know that?

(Laughter)

A. I've been in this business a long time, Judge, and I've had a lot of experience with such things.

Q. Now you say here in your third point against the adoption of this rule that it would go against the expressed wishes of the Legislature. If the Commission were to establish proration units and consider among other things the rights of royalty owners and to reduce recovery and physical waste which might result from the drilling of too few wells and the adoption of the proposed rule in advance of the discovery of the field or

any technical data or knowledge about it would cross the expressed intent of the Legislature. How do you figure that?

A. Well, in my opinion, it could because it's my belief that the more wells you drill, the more oil you will get.

Q. Well, you just don't believe in 80 acre spacing, isn't - - -

A. Oh, yes, sir. I do. Yes, I do, judge. In its proper place. Where you don't have enough recoverable oil to get - - to pay out your well, sure! It all depends upon the particular facts of that particular field which you do not know in advance.

Q. And that's what this rule proposes to do - find out the facts in each particular field - whether you go to 40 or 80. Isn't that fair?

A. I don't think it works that way, Judge.

Q. You don't think it works what way?

A. The way you said.

Q. Well, I can't argue with anybody's inability to read!

A. Well, I can read.

(Laughter)

Q. Now it sets forth here - - - -

A. Well, I don't think that was necessary, Judge. I'm perfectly capable of reading.

Q. Well, I beg your pardon. I get kind of aggravated with you - - - exasperated with you sometimes when you don't answer my questions.

A. I'm answering the questions as I see them, Judge, and I don't think it called for that remark of yours.

Q. Well, suppose I apologize and we'll start all over again.

A. All right. Let's start all over again.

Q. Now this proposed rule is a temporary one. Practical experience in such matters has convinced impartial observers that the actual effect of it would be to shift the burden of proof to the royalty owners and that the rights of royalty owners, including the beneficiaries of our state lands, would be jeopardized. Well, now, you've read those rules and they expressly provide that the burden shall be upon the operator - so your conclusion that it shifts the burden to the royalty owners just can't

stand, can it?

A. I think as a practical matter that in actual effect what will happen - - -

Q. You think the Commission wouldn't follow the rules?

A. No. I didn't say that.

Q. Well, in what way would that happen then - as a practical matter. I just don't understand that!

A. Because, I've seen time and again, when fields after they have been discovered have been developed in a certain length of time and somebody wanted to come in and change the rules, that everybody says you're depriving us of our property. We've gone along on this basis and we don't want to change now. We can't change. And you've seen the same thing happen too. That's a stock answer. When anybody comes up and attempts to change the rules - the plan of development.

Q. I'm not talking about changing the rules. You should direct your remarks with respect to the proposed rule which expressly states that the burden shall be on the operator. Now, your statement just isn't sustained by the language of the rule, is it?

A. Judge, the royalty owner never knows when a field rule is going to be called. He has no notice of such things. It's up to the Commission to look after the royalty owner.

Q. How does this proposed temporary rule jeopardize the interest of the royalty owner?

A. Well, I suppose your Bagley - - not the Bagley but the Crossroads field is a good example. The operators started out on 80-acre spacing and it was fought bitterly by the operators, they didn't want to change to 40 acres. Finally, the Commission saw that 80 acres wasn't wished and changed it back to 40 acres. But that was only after the royalty owners had come in and insisted on it being changed to 40 acres.

Q. Just how could a temporary rule jeopardize the interests of the royalty owners?

A. How would it jeopardize them?

Q. Yes. This is a temporary - - this is not a permanent rule. It

is a proposed temporary rule.

A. Well, I don't look at it as a temporary rule, Judge.

Q. How does that jeopardize the interests of the royalty owners?

A. Because you lay a precedent for keeping on with 80-acre development when it might not be to the interest of the royalty owner.

Q. How do you lay the precedent?

A. You started out on a staggered plan, as recommended.

Q. The burden is still on the operator at the end of five wells, or 18 months, to come in and show whether it ought to continue. How does that jeopardize the interest of the royalty owner?

A. Well, perhaps in the meantime sombody's drilled a dry hole on his particular royalty like happened up there at the Crossroads field.

Q. Well, it don't hurt a royalty owner not to get any oil if there isn't any there, does it?

A. Well, suppose he's got 40 acres that's got some like -- you got 80 acres and 40 of it's dry and 40 of it's good and they drill on the 40 acres that's dry. He sure is hurt all right.

Q. Don't you think in that case that the operator could get an exception?

A. You don't provide for any exception.

Q. I understand that you don't provide for any exception but you know that an exception can be had to any rule.

A. I assume you can.

Q. Yes, sir. Would that take care of that situation?

A. It would. If the operator would do it. There are a lot of individual 40 acre tracts. How are you going to take care of them? I don't see -- this makes no provision for any individual 40-acre tract.

Q. Well, this don't propose to write all the rules on the matter, you understand. The other rules that are in the rule book don't say you couldn't.

A. All right.

Q. Now, you say it would shift the burden of proof to the royalty owner. What do you base that on?

A. Well, of course, that's a legal conclusion. You'll have to ask Mr. Hanners about that.

Q. This is a legal conclusion here. You - - -

A. I didn't write these.

Q. You gave them the dope on it?

A. They wrote it from my report - - from the report I wrote, Judge, in which I stated my conclusions with regard to 80-acre development.

Q. Do you agree with this conclusion as stated here?

A. Well, you'll have to ask Mr. Hanners.

Q. Do you agree with it? That's what I want to know.

A. That's a legal question. I didn't qualify as a lawyer.

Q. Well, you don't know then whether it would shift the burden to the royalty owners or not, do you?

A. I think Mr. Hanners - - - -

Q. I'm asking you. You don't know that, do you?

A. I don't know. I didn't qualify as a - - - -

Q. So you're not in any position to agree with this statement, are you? Since you don't know.

A. Well, I'll tell you. I'll tell you. If you want to, I am a member of the bar in the State of Texas, Judge, and I don't make any pretense of being an able lawyer but I think that that would be what would happen and I think Mr. Hanners would be able to demonstrate that a lot more clearly that I could.

Q. Well, then , you do agree that the proposed rule would shift the burden to the royalty owner?

A. After discussing it with Mr. Hanners, I see no reason why it wouldn't. But he can give you his answers on that, Judge.

Q. Now, tell me, in the rule itself, where do you find anything that would support such a conclusion? Or statement?

A. What statement?

Q. That this rule here would shift the burden to the royalty owner?

A. You ask Mr. Hanners, there.

Q. Well, I'll put him on the stand.

A. All right, sir.

Q. Would you mind telling us, Mr. Hanners?

MR. HANNERS: Be most glad to.

JUDGE FOSTER: All right. Read it into the record here as to how the proposed rule would shift the burden from the operators to the royalty owners.

MR. HANNERS: As a matter of fact, there have appeared before the Commission where the rights of royalty owners are involved depend on two things. Where the royalty owners have come prepared at the expense of technical information to oppose the operators in their plan of operation. Particularly in the Crossroads field where a tremendous amount was spent. The average royalty owner is not in a position to appear at a one-sided hearing. And under the proposed rule, as proposed, when the time comes for the hearing and it says that the burden of proof shall be on you, and you have no opponent, it would be very easy to discharge that burden of proof.

Q. You just don't think the Commission would function properly then?

A. That's right. They would only hear one side of the case. Yours. From the practical standpoint, that's what will happen.

Q. Well, what you're saying then isn't -- there isn't a rule that could be written for the interests of the royalty owners?

A. That's right. Although you have the burden of proof, you can discharge that when you have no opponent.

Q. Well, with the very high regard that I have for you, I just don't agree with what you say.

(Laughter)

Q. You have that same condition whether you have 80-acre spacing or not.

A. I'm not sure that I understand.

Q. He asked me to ask you the question, that is, if the royalty owners interest wouldn't be protected if the hearing were held on the

merits of the field - whether you have 80 acres or 40 acres. It just don't apply to this temporary order - that applies to any hearing.

A. But the temporary order, Judge, prescribes that after 18 months or five wells, you will then have the hearing to consider whether you should go back to 40 acre or remain on the 80. At that time, it is almost certain that when you have the experience behind 5 wells or 18 months - you have the burden of proof that that is the proper spacing plan. You will then have a much easier job of discharging that burden. The royalty owner is ordinarily not able to pay the freight of a contested hearing before the Commission.

Q. Well, that would be true whether you had the temporary rule or not on making application and for that reason, you disagree with 80 acre spacing even though it's a matter of fact that it ought to be 80.

A. I disagree Judge, until the facts show that it should be that. I don't mean to argue with you, Judge.

Q. I understand that. I'm just trying to get your views. As I understand your position and Mr. Tesch too, it seems that you want the royalty owners interest protected - but I think the Commission can protect the interests of everybody. Now, then your fifth point here is that the orderly development of oil fields would be hampered by the adopted of any rule that sanctioned the drilling of fewer wells than reasonably necessary to efficiently and adequately drain and develop the field and the waste of natural resources would thereby occur. Now, how do you apply that statement to the proposed rule?

MR. TESCH: Again I'll have to ask you - - answer youthis way. The general conclusion of mine is that the more wells you drill, the more oil will be recovered.

Q. Well, then, are you advocating that we ought to go off the 40 and go to the 20 or something less than 40?

A. You mean, for these deep fields?

Q. I mean for any field. It doesn't make any difference if it's deep or shallow, does it?

A. Depends on the field itself.

Q. Well, your theory - more wells, more oil - doesn't have any - -

doesn't have any relationship to depth, does it?

A. No, sir.

Q. All right. Now, in New Mexico we have a 40-acre pattern. Are you advocating that we ought to drop the 40 and go to something smaller?

A. No, sir.

Q. Well, on the basis of your statement we're loosing a lot of oil, aren't we? Because we aren't drilling on 20 instead of 40?

A. That again assumes that your economic conditions are such, that the best interests are served by 40-acre development.

Q. Do you thin- - - -

A. At the time, if you will recall judge, - at the time that the rules were put in - 1935 - there was considerable opposition to it and that one of the reasons for permitting an operator to drill on a 330 pattern instead of forcing him to drill in the center of these 40-acre units was to allow him that latitude. And an operator can drill below one well in 40 acres if he so desires. Some of them have.

Q. But they don't get any more allowable.

A. No, but that's what you want with this 80-acre. You want to take - you want practically double your allowable - - -

Q. Where do you get that?

A. That's in the rule.

Q. That's not in the rules I have!

A. Oh, yes, sir. Rule 505 provides for it.

Q. That just comes along as a matter of a general state-wide rule on allowables - that they will consider the depth factor.

A. But that's an actuality of what will happen.

Q. Well, don't you think you ought to get an additional allowable on these deep wells?

A. Certainly.

Q. Do you think that this rule - this proposed rule here would hamper the orderly development of the oil fields in the state of New Mexico?

A. I certainly do.

Q. In what way?

A. By the bare fact that you can only drill one well to 80 acres.

You have no option where you're going to drill.

Q. Don't you think that that might promote the development of the oil fields?

A. I certainly don't.

Q. Hm-m-m?

A. I do not.

Q. Well, don't you think that you can determine the limits of an oil field quicker by development on a wider pattern?

A. You may and you may not. With these steep dips up here, you may or you may not. You might do like the Amerada and the Hightower did, drill three dry holes while they were getting three wells.

Q. Now, you make a statement here that 80-acre development would result in less oil being recovered than a closer pattern. Now that can only be true if you assume that one well won't efficiently and adequately drain 80 acres.

A. That's right.

Q. And why do you assume in making that statement to this Commission in opposition to this proposed rule, that one well won't efficiently and adequately drain 80-acres when you don't know anything about - - -

A. That is true. But I am judging that on past experience.

Q. Well, you know, as a matter of fact, that there are fields in this state now where one well will efficiently and economically drain 80 acres, don't you?

A. I do not.

Q. Do you know, as a matter of fact, that the Commission has already granted 80-acre spacing to 4 fields in this state?

A. That is correct. That is one of my conclusions.

Q. And you know that - - -

A. That is the reason that I say it is not necessary to have a rule in advance. The Commission has already recognized where the case - - the facts so warrant that 80 acre is proper.

Q. Well, don't you recognize the fact that the Commission granted those 80 acres spacing rule to the 4 fields in this state on the theory that one well will adequately and efficiently drain 80 acres?

A. I don't think that that is entirely correct, Judge. I think it's a matter of weighing economics against what oil you will get by developing it on that basis. I don't think there was any conclusion that you will get as much oil by drilling on an 80-acre pattern that you get - - as if the fields were developed on a 40-acre pattern.

Q. You don't think that the Commission then on this 80-acre spacing based on the theory that one well in those particular fields perhaps would drain 80 acres?

A. No, sir.

Q. You don't think they did that?

A. No, sir. Not on that fact alone.

Q. Well, I understand. But on that and other facts, they did.

A. Well, chiefly, I presume it was economic factors which influenced the matter.

Q. You make the broad assumption here, in the statement to this Commission, that this proposed rule ought to be denied for the very simple reason that one well won't efficiently and economically drain 80 acres.

A. That's right. - - - I didn't say economically. I didn't say economically. I said it wouldn't - - that drilling on 80 acres wouldn't get as much oil out as drilling on 40 acres. Now, I didn't say anything about economics in that case.

Q. Don't you recognize that there is a matter of economics in this oil business?

A. I certainly do. I'd have to - or I'd soon be out of business.

Q. Yes, sir. You wouldn't drill two wells on 80 acres unless you thought the second well would be a paying proposition, would you?

A. No, sir. - - - I hope I wouldn't.

Q. Don't you think this Commission ought to consider the economics of this matter in determining what the spacing should be?

A. Yes, sir.

Q. Well, then your statement that 80-acre development will result in less oil being recovered than closer development, doesn't mean very much unless you imply that that's - that there's an economic factor, does it?

A. But it does - it certainly does, Judge. Because you start out with the premise that you are going to get less oil with 80-acre development. Then you have to apply the economic factors to that to see where you stand in regard to that.

Q. Now you know - now you make the statement here that no oil producing state has ever ordered state-wide 80 acre spacing for oil wells.

A. As far as I know, there hasn't been.

Q. Well, that's just as far as you know.

A. If you know of some other, I'd sure like to know about it.

Q. Well, I think before this is over with, we'll give you some.

A. All right, sir. State-wide field - - state-wide 80 acre for oil wells.

Q. This is a temporary matter, at most. - - - -

A. I'm not so sure.

Q. Now, do you think that the Commission here is ordering a state-wide 80-acre spacing rule for oil wells by adopting this temporary order?

A. Yes, sir. For fields below 10,000 feet.

Q. It's only a temporary rule, isn't it?

A. Well, it could or could not be.

Q. Well, I understand. But the order states that it is temporary, isn't it?

A. It's so called but as a practical matter, it isn't.

Q. As a practical matter, you think it's a permanent thing?

A. Yes, sir.

Q. Now, you state down here that the proposed 80-acre rule is only a device to force the Commission to assume responsibility for acts by operators that are contrary to their lease contracts and obligations. Will you explain that to me?

A. Certainly. Every operator has certain obligations to his royalty owners.

Q. Well, now, will you - - -

A. If you just force - - if you come in and drill on 80 acres, then get the Commission to sanction it, they've got to sue the Commission.

Q. How's that?

A. If you drill on 80 acres and then come in and present just your side of the case to them and they sanction it and order 80 acres, then if they do anything about it, they've not only got to sue you but they have to sue the Commission.

Q. Do you think that this Commission would sanction the drilling wells on 80 acres where the facts wouldn't justify it?

A. No, sir. But it could be that they'll only have your facts, Judge.

Q. Well, they're here to judge the facts, ain't they?

A. I think so.

Q. And you make the statement here though that this is just a scheme or device to force the Commission to have the responsibility for the acts of operators.

A. That's what I think.

Q. And you say in another place that royalty owners which includes the public schools, state and federal governments would be in a position of being forced to assume responsibility for the illegal acts of an operator.

A. Yes, sir.

Q. How would an operator be acting illegally if he acted in compliance with the rules.

A. Well, probably the word illegally isn't correct. I'm talking about his obligations to the royalty owners under the - - -

Q. Is this your - - -

A. Yes, but that probably is an unfortunate way to state it. But that is, in general, the conclusion that I - - - - -

Q. What would be illegal about it?

A. As I said, that probably is an unfortunate word. But the obligation of a lessor - or lessee to the lessor to the royalty owners could certainly be circumvented.

Q. Well, now, what word would you substitute for this word "illegal"?

A. Well, let's see. We'd put it "imprudent" acts.

Q. You say then that this is just a device to force the Commission to act "imprudently"?

A. No, sir. I do not. I said it was getting in to take the axe for anything that you might do or not do that you are obligated to do to take care of your royalty owners.

Q. Then you say down here, that there are four fields in New Mexico to which the Commission has granted 80-acre development so that that proves that there is no necessarily for a state-wide rule providing for 80-acre development below 10,000 feet.

A. That's right.

Q. How do you get to that conclusion?

A. It shows right there that the Commission, where the facts warrant, will issue 80-acre development.

Q. Well, - - - -

A. And the operators don't have to come in ahead of time before a field is discovered to get any such rule.

Q. Well, they don't here. You understand that this here just applies to wildcat wells, don't you?

A. It applies to wildcat wells and wells that are drilled after that up to five wells or 18 months.

Q. That's right. One wildcat and four other wells.

A. Or 18 months.

Q. Or 18 months. What is the objection to having a temporary order that will permit an operator and the Commission to know what the reservoir conditions are before you adopt a rule about the pattern?

A. Judge, if I owned an off-set forty acres to the discovery well, I'd sure be pretty unhappy if I couldn't drill a direct off-set to it, or if I owned an 80-acre tract. I would certainly want to be in a position to make a direct off-set to that discovery well.

Q. If there was a provision in this temporary rule for a direct off-set would that cure your objections to this rule?

A. Not necessarily. That's one - - - I still say you have to judge each field on its own particular facts and until you establish those facts, you can't tell whether its - - what you should do.

Q. Well, that's what we attempting to do, to have each field stand on its own legs and then when we have sufficient information, we can

set it at either 40 or 80, isn't that what we're proposing?

A. No, sir. You assume right from the start that a well will drain 80 acres.

Q. Well, we don't assume that it will drain 80 or it will drain 40. We don't make any such - - -

A. Why can't you get together with your other operators then?

Q. And determine in advance whether a well will drain 80 or 40?

A. I'm sure you do it right along - most companies do.

Q. In a new field?

A. Certainly.

Q. I don't know how many do that. But I want to put you straight about what I consider this rule to be. We don't assume that it will drain 80 or that it will drain 40. In fact, the assumption is to the contrary as I understand the rule. All we're asking is an opportunity to find out the actual field condition and then come in and lay these facts before the Commission and let them decide from the reservoir conditions whether one well will drain 80 or it will only drain 40. And if you can find anything else in that rule, I wish you'd point it out to me because if that's in there, I want it corrected.

A. I didn't say that.

Q. What's that?

A. You said that, I didn't say that.

Q. Well, I say, if you can point out anything like that in this rule, by taking the rule and the language of the rule itself, rather than just the expression you're objecting to - - -

A. I don't see any necessity for a rule.

Q. Well, - - -

A. I don't see any necessity for a rule for a field in advance of its discovery.

Q. Don't you see the necessity of having a rule that would hold everything in abeyance until whether you find out whether a well will drain 40 or 80?

A. Not necessarily.

Q. Well, - - -

A. How are you going to hold everything in abeyance. You can't do it, Judge!

Q. Under this rule you do.

A. Well, you'll force everybody else whether they agree with you or not to hold back on 80-acre development.

Q. Well, it would force all the operators on the entire field to do that, wouldn't it? Suppose the operator owns the entire area that is going to be developed. This rule applies to him too.

A. He doesn't need a rule.

Q. No, he doesn't need a - - -

A. Only thing he has to do is fight with himself and decide how he's going to do it.

Q. The only time you need a rule is when you have another operator in the field, isn't it?

A. That's true. Well, if you need a rule.

Q. Well, that's the only time you need a rule when you have more than one operator in the field. You do need a rule then, don't you?

A. You'd need a rule based on the facts of that particular field. Yes, sir.

Q. Yes. You'd need a rule to establish the facts as to what that field is - - -

A. No, sir. I didn't say that. You've already got a rule for the field.

Q. 40 acre.

A. Yes, sir.

Q. You're objection is just going to 80, isn't it? You don't want to go to 80 on any basis.

A. No, sir. It is not. As I have repeatedly said, the facts are the controlling elements on what is proper for it.

Q. Now, will you explain just one thing to this Commission? How can you get to 80-acre spacing in the field if you start with the development of that field on 40?

A. The operators can do it themselves.

Q. But suppose you have one operator who wants to drill on 40 regardless of how much a well will drain and another one that wants to

drill on 80. What are you going to do?

A. I don't think that operator is going to drill on 40 acres unless he thinks he's going to make money out of it, Judge.

Q. Now, but I'm just saying - - - -

A. That's just - - anybody that does, isn't a prudent operator. They might even do as you've done, drill on 10-acre spacing.

Q. But how are you going to get to 80-acre spacing if you start out on 40? If you convince the operators that they ought to start on 40 or force them to start on 40 and not give them a chance to start on 80, how are you ever going to get - - - -

A. You're not. Nobody's being forced to drill on 40 acres. There's nothing in the rules right now that an operator can't drill one well to 80 acres.

Q. There's nothing in the rules either that permits him to make a direct off-set on a 40-acre pattern, is there?

A. That's right. And I don't think any operator should be precluded from making a direct off-set.

Q. I understand that - - -

A. And you wouldn't either if you were in the practical end of the business, either. When it was your own money you were putting out.

Q. Don't you think I've been in this oil business as long as you?

A. I don't think you've been an independent operator like I have, Judge, where you've put out your own money for it.

Q. Whose money do you think these other operators are putting out?

A. I don't know. But you're talking about the operator that wants to drill on 40 acres.

Q. No, I'm not talking about the operator that wants to drill on 40 acres. I'm talking about - - I want you to explain to this Commission how you plan to start on 40 acres in the field - 40 acre pattern in the field and then get to 80.

A. If you can't get together with your brother operators, you never will get to it. That's true.

Q. Well, don't you think - - -

A. I don't see any reason why an operator that thinks he should drill one well to 40 acres should be stopped from doing it. You always have the privilege after the first well is drilled to call a hearing to present the facts to the Commission.

Q. But you might not have enough field information to determine the limits of the field. That's what happened in the Crossroads field, isn't it?

A. To do what?

Q. To have a hearing that is based on one well. You didn't have enough field information to determine whether they ought to have 40. Do you think the Commission would have enough information generally from one well to determine whether it ought to be 40 or 80 acre spacing?

A. Sometimes yes. Most times no.

Q. All right. Then how would you correct that situation?

A. I believe I'd drill some more wells.

Q. All right. And how would you propose to drill these wells to keep them off the 40-acre pattern if you wanted to get to 80?

A. I don't think you should ever prevent an operator from drilling on a 40-acre pattern if he wants to drill on it.

Q. You don't?

A. No, sir.

Q. You just think you should - - -

A. Because he's not going to drill unless he thinks he's going to make some money out of the job and what's good for one is good for the other.

Q. You're just saying that if they can't voluntarily agree, how to develop the field, then they'll just have to settle on 40. Is that right?

A. If somebody is of that opinion. Yes, sir.

Q. That's the way it ought to be?

A. Yes, sir.

Q. You think that 80-acre spacing should be voluntarily agreed upon rather than through orderly process of hearing before the Commission?

A. I certainly do.

JUDGE FOSTER: That's all.

MR. MASON: I'd like to ask a few questions, please. Bob Mason, Cities Service Oil Company.

CROSS EXAMINATION

By MR. MASON:

Q. Mr. Tesch, this proposed rule about which the Judge has just finished examining you deals with two matters instead of one, doesn't it? It deals with the matter of spacing and the matter of well pattern.

A. Yes, sir.

Q. Isn't that correct?

A. Yes, sir.

Q. Are they inextricably bound up with each other, in your opinion?

A. Well, er, to a degree they are. Yes, sir.

Q. Well, they can be separated very well, can't they?

A. Restate that again, Judge. I don't believe I follow you exactly. You're question - - I'm sorry - - I just didn't follow you there.

Q. This committee in its instructions from the Commission had no instructions - - or had no directions to go into the matter of pattern, did they?

A. Well, ah - - - - -

Q. At least, that's what the letter - - - -

MR. HANNERS: We submit that the letter from the Commission is the best evidence.

MR. MASON: I withdraw the question.

Q. Do you think that 80-acre spacing is inextricably bound up with wildcatting?

A. I can see where it couldn't be in some cases, yes, sir.

Q. If you had 80-acre spacing and the matter of wildcatinng was left just as it is now in the State of New Mexico on your 40-acre spacing, I'll ask you, if in your opinion, the matter about which the Judge is concerned with - - that is, the nature of the reservoir - drilling of five wells couldn't be accomplished much more quickly?

A. It would depend upon the particular structural conditions that the operators might anticipate.

Q. How do you reconcile that, Mr. Tesch, with your answer that

the driller of the wildcat well ordinarily just likes to step out a little ways?

A. That's right.

Q. He could do that if well pattern wasn't mentioned in the 80-acres?

A. Yes, sir. Yes, sir.

Q. And what I'm pointing out here or seeking to point out is that if you have 80-acre spacing and you leave the matter of well pattern out, you would have the nature of the reservoir, particularly in the vicinity of the discovery well cleared up much more quickly than you would if the wells had to be stepped out 80 acres.

A. That is probably correct.

Q. Or a half a mile?

A. Yes, sir. That's probably correct.

Q. Yes, sir. Now, you have pointed out that the driller of the discovery well may be required to drill an off-set under this proposed rule to a distance of perhaps a half-mile.

A. Well, I think it figured out nineteen hundred and some feet as I recall that.

Q. Now, with respect to your testimony, you sought to be realistic in saying that most operators would be coming right back to the Commission for exceptions for they would all be unhappy if they drilled a discovery well and then have to step out eighteen hundred and sixty-seven feet or perhaps a half mile.

A. Some of them would. Yes, sir.

Q. That in your opinion would be most of them?

A. Well, it all depends on who they are. Now, I know this to be a fact. That when I was with the Petroleum Administration for War, and we were trying to administer our staggered plan that we were certainly swamped with exceptions by all -- nearly everybody.

Q. And I believe you testified immediately after the POW -- what was that?

A. The Petroleum Administration for War.

Q. Those orders - - yes. After they went out, the operators immediately went back to - - -

A. To their regular, customary drilling.

Q. Yes - as they had done in the past?

A. Yes, sir.

Q. I believe you pointed out, and pointed out rather definitely that the dry hole possibility is increased considerably to the driller of the discovery well in that type of - - -

A. Not the driller of the discovery well.

Q. If he'd have to step out a half mile or - - -

A. Well, any operator. Regardless whether it's the driller or w ho it is. The hazard is increased. Off-set operators.

Q. May I just ask you, I believe you stated to the Judge on cross examination, that you would be very unhappy if you held land adjoining a discovery well and you would be disappointed if you couldn't drill that 40.

A. Yes, sir.

Q. If you were stepping out next to the discovery well on a 40, you'd be very unhappy?

A. Yes ,sir.

Q. If you couldn't drill it?

A. Yes, sir.

JUDGE FOSTER: I didn't ask any such question as that!

MR. MASON: I believe you're right, Judge. I believe he volunteered it.

(Laughter)

Q. This diagonal spacing is entirely theoretical. I believe that's your objection to it, isn't it?

A. Well, that's just one of the objections.

Q. It doesn't take into consideration the structure, at all, does it?

A. No, sir.

Q. And one operator can see down just as far into the ground

as far as the structure is concerned as another.

A. I assume that's right.

Q. You pointed out that you had to find out that you had to find out about structures by drilling.

A. That's right. Of course, you always have a certain amount of geo-physical information available to you - as a general rule, you do. It gives you some idea but not always.

Q. Mr. Tesch, in all fairness, I realize that Cities Service Oil Company occupies a different position from everybody here present. But in all fairness, would you state to the Commission your objections to 80-acre spacing and you've pointed out that there are many fields that should not have been drilled on an 80-acre basis - - -

A. I didn't say many - I said some.

Q. Well, there are some.

A. Yes, sir.

Q. Particularly where you have to drill to 11,000 feet.

A. Yes, sir.

Q. There are considerable economic factors in development.

A. Yes, sir.

Q. I'd like for you to point out your objections to what Cities Service Oil Company advocates here and that is an 80-acre spacing with the option just as you have now in your 40-acre spacing of drilling on the other 80. Now what objection do you have to that?

A. I'm not sure - - that question wound around a little bit, Judge.

Q. I think it did too.

(laughter)

A. I'm not trying to evade your question, Judge.

Q. I don't think you were.

A. I just couldn't follow you.

Q. I'm not trying to answer any trick - - - to ask any trick question either. But I'll try to get it out a little more clearly. I'd

like for you to state just what objection you have to 80-acre spacing if what Cities Service advocates - that is, permitting the operators to drill at any location - just as you have it now on your 40-acre spacing on the 80.

A. Well, there are two reasons for that. I don't think that any field rule should be adopted prior to its discovery. Second, I still hold to my contention that you have the basic premise that drilling on 40 acres will result in more oil to be recovered than drilling on 80 acres, therefore, until the economic factors can overcome that, I think that as demonstrated by actual drilling, I don't think that any field rule should be promulgated.

Q. Do you admit that 80-acre spacing of that character would tend to encourage going into these deep fields and developing? More than the 40-acre spacing?

A. I don't know. You've got a lot of fields here being developed on 40 acres. I don't think there's been much discouragement there, Judge.

Q. Well, now, this economic factor is a difficult one and it's and important factor, is it not?

A. Yes, sir. Yes, sir. But there's been one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen fields below 10,000 feet and out of those, there's only been four, so far, that have been found by the Commission - - -

Q. But you're not an expert - - -

A. All I'm saying is that four out of nineteen, thus far, have in the opinion of the Commission been worth drilling on 80 acres, that 80 acres is the proper plan.

Q. Well, now, in your opinion, wouldn't the drilling on 80 acre spacing, with the option to an operator to off-set at any place they choose on the 80 be much preferable to the rule that has been suggested here by - - -

A. If it's a choice of two evils, yes, sir.

Q. I'd like for you to point out the evils.

A. I've already done so. That I don't think a field should have rules promulgated for it until after the facts are there to substantiate it - - - -

Q. Well, that argument of yours that no fields should have rules promulgated for it could be obviously carried until you don't have any spacing can't it? And you are making spacing an instrument of the operator.

A. You always have your basic 40 acres.

Q. Well, you didn't have that until you got it, did you?

A. 1936.

Q. Yes, sir.

A. I was - - -

Q. You can carry your argument until you got down to one acre, then a half acre and then a quarter acre, wouldn't it?

A. Well, no prudent operator is going to do that.

Q. That's right. You've got the economic factor.

A. Yes, sir. Yes, sir.

Q. And if you carry this stepping out 80 acres at a time, that the other side promulgates, if you carry that to its ultimate, why you'd step out and define and delimit your pool much more quickly with 160-acre spacing.

A. That's right.

Q. And you'd delimit it much more quickly - than that - with 320 acre spacing.

A. You'd probably wind up with a lot of dry holes, Judge.

Q. Yes, sir. That's right. So you can sort of run off to a ragged end either way you go, can't you?

A. Yes, sir.

Q. And wouldn't you say that what the Cities Service Oil Company is advocating here is sort of a middle ground between the two extremes?

A. Well, it takes away one of the objections. Yes, sir.

Q. Yes, sir. And isn't it a matter of fact that that's one of the objections as far as the other side is concerned? Now, isn't what Cities Service Oil Company's advocating here exactly what this Commission advocated when they formed this committee?

A. I don't know about that.

Q. There's no mention - - - -

JUDGE FOSTER: I don't believe the record shows what Cities Service has advocated.

MR. MASON: What?

JUDGE FOSTER: I don't think the record yet shows - - -

MR. MASON: I think it does. I t may not show in this particular - - - - - It may not show for the benefit of the new member, but - - - - -

MR. ADAMS: That statement was made in the November hearing, I think.

MR. SPURRIER: Would you be willing to read it into the record?

MR. MASON: Yes, sir.

MR. SPURRIER: We'll recess until 1:30 p.m.

(The meeting recessed until 1:30 p.m.)

[illegible]: The meeting willcome to order, please.

MR. MASON: Mr. Chairman and members of the Commission, both sides seem to have requested that Cities Service state its position. The Cities Service position has already been stated in the record in November - at the hearing in November, but I will be glad to state it again. I couldn't find anyone on either side who was interested in our position until just a little before noon. Our position is this. We favor the suggested state-wide rule as drawn and submitted by Judge Foster with the following sentence deleted: "Subsequent- - - -

VOICE: What paragraph is that?

MR. MASON: In paragraph 2. "Subsequent wells drilling to the same reservoir shall be located within 150 feet of the center of the quarter quarter section of identical description to that quarter quarter section in which the discovery well was drilled or within 150 feet of the center of a quarter quarter section diagonal to such quarter quarter section." We favor the rule with that sentence deleted. We do, however, favor 150 feet tolerance on account of surface obstructions as regards succeeding wells. Now, does that make our position clear to you?

MR. TESCH: As I understand what you want - you want 80 acre units but you want to be able to drill any place on these 80-acre units. - - -

As I understand your position, you want 80-acre proration units but with its consequent higher allowable but you want to be able to drill anyplace on this 80-acre unit.

Q. That's right. 80-acre units. Well, of course, they want it a temporary rule.

A. Yes, sir.

Q. So that you can go back to 40-acre spacing if the reservoir proves after drilling the 5 wells to be rich enough to justify 40 acres. Is that right?

A. Did you state a question to me?

Q. Yes, sir. I did. I said do you understand our position?

A. Yes, sir. Yes, sir.

Q. You're an operator - - -

A. Yes, sir.

Q. That's exactly the way you'd operate in those areas where you have 80-acre spacing in Texas, isn't it?

A. No, sir. We do not. There are only a very few fields with 80-acre spacing in them.

Q. Well, I'm talking about the fields where there is 80-acre spacing.

A. Now, that, I can't tell you.

Q. I see. I want to clear up one thing for the record here because I may have misunderstood when you testified and the Commission may have. Did you intend to say that you didn't know of any other state that had spacing rules adopted prior to the drilling in the field?

A. I said that I knew of no state that has an 80-acre state-wide rule.

Q. Well, I thought you said you didn't know of any other state besides New Mexico.

A. No, sir. I don't know of any state that has an 80-acre state-wide rule for oil.

Q. But you do know of other states that have 40-acre, don't you?

A. Yes, sir.

Q. Isn't that the rule in Mississippi?

A. Yes, sir.

Q. Is it in Louisiana?

A. I'm not positive about Louisiana. I don't believe that's correct.

Q. They say - - -

A. It's true in Arkansas.

Q. What was that?

A. It's true in Arkansas. As a matter of fact, for a long time in Arkansas the Commission was prohibited from granting anything larger than 40-acre spacing. By statute.

Q. Then you don't know, as a matter of fact, if that is the way that 80-acre spacing, if they have it in Texas, is operated?

A. Well, Judge, there are a few but they are so few and far between that I'm just not familiar with them.

Q. Do you know of any over in Texas where the spacing is diagonal was drilled from the start on diagonal 80-acre diagonal basis?

A. With 80-acre spacing?

Q. Yes.

A. No, sir. It may be, but I don't know of it.

Q. It is true, is it not, that the position of Cities Service Oil Company as stated here allows more elasticity so far as the operators in a given pool for going to either 40 or 80 than either of the plans that have been proposed - - - -

A. Well, sir, we don't want any rule. Now, I think - - I'll say this. I think what you have suggested is an improvement over what Judge Foster has offered.

Q. Are you familiar Weaver-Eldonberger pool in Texas?

A. Very remotely.

Q. You have no production there?

A. No, sir.

MR. MASON: I believe that's all. Oh, I do have one more question.

No, sir. I believe not.

MR. SMITH: May it please the Commission, may I examine the witness?

MR. SPURRIER: Yes, sir. This is not directed at Mr. Smith by any means, but the Commission has directed me to request all counsel to refrain from gett ing into an argument with the witnesses and please confine your arguments to the proper phases of the hearing and if the witness answers a question to the best of his knowledge, let it go at that - rather than try to argue with him, I think it will go more smoothly.

MR. SMITH: My name is J. K. Smith, attorney for Stanolind Oil and Gas Company.

CROSS EXAMINATION

By MR. SMITH:

Q. Mr. Tesch, I'm a little confused. Being a lawyer and not being familiar with some of these things, I hope that you will bear with me on some of the stupid questions I will ask.

(Laughter)

In the first place, do I understand your testimony to be that there is no state rule for 80-acre spacing that you know of?

A. Not for oil.

Q. Are you familiar with the field rules for the Wheeler field in Texas?

A. I said state wide.

Q. Oh, I thought you said state.

A. No, state-wide rules.

Q. No state-wide rules for 80-acres?

A. That's right.

Q. I wanted to make sure that I understood you.

A. Yes, sir. As I said, there are a few.

Q. Now, did I understand you correctly a moment ago to say that you have had no experience with the operation of fields on 80-acre spacing?

A. You mean as an operator?

Q. Well, as an operator - yes.

A. No, sir.

Q. Have you had any experience as a consulting engineer with the operation of 80-acre spacing?

A. Except up here in New Mexico. Yes, sir.

Q. And what fields up here are you familiar with? On 80-acre?

A. Well, the -- principally the Crossroads field is one.

Q. Did you testify as an expert witness in that case?

A. No, sir. But I - - -

Q. Have you made any personal examinations or investigations in that field?

A. I have -- not in the field. I have seen numerous records of the field. I have read all the testimony in the case that - - -

Q. Any testimony then that you have given in the Crossroads field is based upon investigations made by other people or testimony given by other people. Is that right?

A. That is always correct.

Q. So your conclusions should be qualified from the standpoint that you have no personal knowledge of operations under 80-acre spacing.

A. In the Crossroads field? That is correct.

Q. All right. Now, do you have any personal knowledge of the operation of 80-acre spacing elsewhere in the state of New Mexico?

A. No, sir.

Q. Then your primary premise - may I see those conclusions of his. I haven't seen them yet! Trying to understand your statements in my poor way, your position in this matter - - as I understand it, your primary premise upon which you state that this rule is undesirable is bottomed on the theory that if you have more wells, you get more oil. Is that correct?

A. This is part of it, yes, sir. Also, part of what your own superintendent wrote the Commission about the faulting conditions and the steep dips in these fields which I agree with. That is part of it also.

Q. I beg your pardon. You say my own superintendent?

A. Well, Mr. Pettry wrote the Commission to that effect.

Q. That there are those steeply faulting conditions?

A. The faulted and steep dips of these deep fields in New Mexico.

Q. Have you personally seen the letter?

A. I have a copy of it right here.

Q. May I see it?

A. If I can find it.

Q. Is this the letter?

A. Yes, sir. I want to - -

Q. May I see it?

A. I want to - - read part of it. And I want to get it back!

MR. HANNERS: If the Commission please, we ask that the witness be t reated with fairness. He was asked if he had the letter and the witness has answered that he has.

MR. SMITH: I asked him if I could see it and he said yes.

MR. TESCH: As soon as you get through examining it, let me have it back - there's some parts that I want to read that Mr. Pettry wrote.

Q. Mr. Tesch, I should like to ask that you read the entire letter into the record.

A. I'll let you do that. The part that I'm talking about - - -

Q. I think that the witness should voluntarily read this into the record inasmuch as it's a matter of interpretation and I think orderly proceedings require that he answer my question.

A. All right. I'll read it all to you then. There's part of it, of course - - but you asked for it, I'll read it to you.

Q. You can make your point after you've read it.

A. This was addressed by Mr. Bedford - the letter is dated October 20, 1952 and addressed to Mr. Harry Leonard, Mr. Christie, Mr. McKeller, Mr. Foster, Mr. Hanners and Mr. Danlade, as members of the committee.

"Since you have been appointed as committee by the New Mexico Oil Conservation Commission to advise them on Case 407 pertaining to the adoption of 80-acre spacing, we believe it is appropriate that our thoughts on this matter be conveyed to you, for consideration in preparing recommendations to the Commission.

In general, the Stanolind Oil and Gas Company is very much in favor of the adoption of a rule of this type. We agree that it is a desirable,

progressive step which will result in the prevention of waste by eliminating the drilling of unnecessary wells. It will encourage deeper exploration and by more quickly defining sub-surface structure, such a rule will enable the operators to obtain more conclusive data on which to establish a more suitable spacing pattern. In order to make this rule more effective, however, we recommend that consideration be given to the following additional points:

1. The rule should remain in effect until five wells have been completed. A hearing should then be held to determine the final spacing pattern, and this rule should continue in effect until a formal order has been issued. This procedure should enable an operator to acquire the minimum necessary data to support an application for an appropriate field rule. Since the development of deeper origins which proceeds at a relatively slow rate, we do not believe the time limit should be placed upon this rule limiting the period of time during which the origin effected might preclude the acquisition of sufficient reservoir data to determine the optimum spacing pattern.

Now, this is the part that I referred to, Mr. Smith. I would like to - - - - -

2. This rule should apply to any newly discovered origin in which all or any part of the producing interval is encountered below 10,000 feet. It is virtually impossible, on initial drilling, to determine the relative position of a well on a sub-surface structure. And we believe that such a provision is necessary to give the rule desired flexibility since our experience has indicated that many deep structures have steeply dipping flanks with relatively high closure and they reveal complex faulting.

That is the part that I had reference to - - -

MR. MASON: I don't know whether it's proper at this time but Cities Service would like to have that exhibit marked as Cities Service Oil Company exhibit.

(Laughter)

MR. TESCH: Well, you claim it - I don't claim it, Judge. It's all right with me.

Paragraph 3. Provision should be made in the rule for controlling the location of the first five wells drilled in order to assure uniform and

and orderly development to an 80-acre proration unit if they should eventually be adopted in the field on a permanent basis. For the five initial wells, this should require development of an alternate 40-acre spacing plan - - pattern. Depending upon the outcome of the hearing, then it would be a simple matter to continue on uniform 80-acre spacing or drill the necessary wells to increase the density to 40-acre spacing proration units.

Yours very truly, C. K. Bedford.

Q. Am I correct in that you disagree with this letter.

A. Well, from an engineering and geological standpoint, I concurred with Mr. Bedford that that is the case up here in regard to steeply dipping flanks of these structures and complex faulting.

Q. Well, I - - -

A. That is one of the rules - - one of the reasons that I stated before in which your company apparently concurs.

Q. Now, let me ask you this question to get your position firmly delineated. I understand then that you have two points in support of your proposition - one, steeply dipping structures and the other, the more wells, the more oil. Now do you have any other reason? To support your refusal to - - - -

A. Certainly. I don't think any field should be judged before it's discovered.

Q. Then, I understand your position to be that the Commission should eliminate the present 40-acre rule?

A. No, I didn't say that.

Q. Well, isn't that a state-wide rule?

A. Yes, sir.

Q. Doesn't it have application for discovery wells and other wells before they are developed? Before any field is developed?

A. Certainly. But that was put in in 1935.

Q. Well, apparently, I guess I'm confused, Mr. Tesch because I understood youto say - - - that you objected to any rules with respect to the judging of any field before it is discovered.

A. That is correct. And that's what you're asking here.

Q. Now, to go into that proposition just a little. That statement of yours, of course, is not bottomed on any specific practical data, I presume - - -

A. What statement?

Q. Well, the statement that you don't think they ought to have any rules for the - - -

A. Let me tell you something. I have been in this business 19 years - since I got out of college. I've been in the proration angle for your company and I know how your company works in those respects as well as a lot of the others. You have no more intention of going back to 40-acres than flying over the moon.

Q. I'd like to ask the Commission disregard the last statement on the part of the witness as being based on pure surmise, without any knowledge of what he's talking about.

(Laughter)

A. Don't forget that I was with the company before you were. I worked for them for a long time. - - Your own company.

MR. SPURRIER: Without objection, the letter which was just read will be received as an exhibit. Mr. Smith, you may proceed.

Q. Now, with respect to your statement on sharply dipping structures which I assume can be recognized as being a geological fact, I want to ask you if you do not think that aside from the question of expediency, that the Commission by proper exception which it has under its rules, could in any case where a particular operator was fearful that he was on a narrow steeply dipping structure, make an exception, whereby he could drill his well closer.

A. I assume they could. However, your committee in this proposed - - - have provided for no exception.

Q. Well, doesn't that provided for in the state-wide rules?

A. You are probably more familiar with that than I am. I don't know.

Q. Well, I didn't know. I thought I'd inquire. Passing from that proposition of the steeply dipping structure, on this statement - more

wells, more oil. You have testified that you are not familiar with the operation on 80-acre spacing, so I assume that you are not really in a position to want to qualify your statements.

A. Well, there have been so very few fields developed on 80-acre spacing. There is very little history available, Mr. Smith.

Q. You are not in a position to testify on the amount of recovery that could be expected on 80-acre spacing as against 40?

A. No, sir. No, sir. It will be more.

Q. Would you like the Commission to disregard your testimony then when it comes to the question of comparing the two?

A. How can you compare something in advance?

Q. Well, after it has been developed - are you familiar with its operation?

A. I have a rough idea - - but to tell you exactly how many more barrels you would recover, I can't do neither can any other engineer. But we do know from practical experience that you will recover more oil.

Q. Well, that's a relative term, isn't it?

A. Well, a very interesting report came out from the Bureau of Mines, just in February up at the old Healton field where they had a lot of history. There's been a lot of in-fill drilling. They showed very conclusively that - - and they so reported - - that a lot more oil has been recovered by in-fill drilling, closer spacing.

Q. Do you have that report with you?

A. Yes, sir.

Q. I note that the petroleum engineering study of the Healton Oil Field, Quarter County, Oklahoma.

A. Yes, sir.

Q. Are its findings restricted to that particular field?

A. Yes, sir.

Q. Isn't it true that that particular field has a very lenticular structure?

A. Lenticular?

Q. That's right.

A. Not lenticular structure - no, sir.

Q. Well, I mean, isn't the structure then lenticular?

A. The what?

Q. The structure itself lenticular?

A. No, sir.

Q. The interference in the structure itself?

A. There are a number of pays in the field, yes, sir.

Q. I'm not familiar with this report so I'll have to ask you a few more stupid questions. In the first place in this particular field, are you familiar from reading this report or from personal observation the type of structure from which it was produced.

A. Only from the report says.

Q. Does the report make any reference to the fact that there is some lenticular development within the structure?

A. I don't recall.

Q. You don't recall it's being there?

A. No, I was particularly interested in their conclusions with regard to in-fill drilling there.

Q. Of course, if you have interference within the structure so that the wells are completed at different locations, they might not have positive communication - back and forth - then of course, the same conclusion wouldn't be true with respect to other fields where you do have communication. Isn't that correct?

A. That would be correct.

Q. So that if this report does reflect that that condition does exist - that there is interference or lack of communication from one well to another or imperfect communication, then it would be an isolated instance compared to the great number of fields with which you are personally acquainted.

A. Well, I don't recall anything in there that - - this study was confined to individual leases where there apparently was continuous sand throughout the area that they were investigating.

Q. You just don't recall that?

A. Not exactly.

Q. Well - - - -

A. You can read that part in there about in-fill drilling.

Q. What is the spacing pattern in that field?

A. Oh, I think they started out - - it was very close spacing and they drilled in some instances at 4 to 5 acres and then they drilled it down to maybe 1 to 2 acres and then 1 acre.

Q. You aren't recommending that type of spacing for New Mexico, are you?

A. No. I can well remember though a couple of examples on your own properties - Stanolind properties - I remember in 1935 when I was a field engineer for Stanolind in the King field. I remember Stanolind started to drill their inside locations. All the rest of the oils were pumping - pumping at capacity and we drilled inside that lease - the old Bowleson lease and got flowing wells that flowed for awhile. If you'll check your records on your T88-M and N lease in the north end of the Ender field, you'll find a very concise record of a well, which you call, T88-M3.

Q. Well, Mr. Tesch, I didn't understand that we were on trial.

A. I'm just reminding you.

Q. I understand, of course, that each field represents an individual problem and you can have a situation where that might occur but it may be isolated. Now, getting down to your general statement about more wells, more oil, I assume that you mean for instance that if you have 40-acre spacing and go to 20-acre spacing, you'll get twice as much oil.

A. I didn't say that.

Q. Well, I'd like to know just exactly - - -

A. I don't know how much you will get. You'll just get more oil.

Q. Are you familiar with the Inter-State Oil Compact Report on well spacing?

A. Briefly. Briefly.

Q. Have you read it?

A. Parts of it.

Q. Which parts did you read?

A. I don't recall. I know that there was a very interesting discussion by Mr. Tomlinson of Oklahoma in regard to oil spacing.

Q. That's right. Did you read Mr. Cantalier's statement with regard to oil spacing?

A. Well, you know, I never did read anything by Cantalier because I don't believe much in what he has to say.

(Laughter)

Q. Did you read the article by Grayson?

A. No, sir.

Q. Did you read Mr. Crays statement?

A. No, sir.

Q. Or Mr. Buckley's statement?

A. Who?

Q. Mr. Buckley. As I recall it, I think - - -

A. Yes, I think I read Buckley's statement. As I recall it.

Q. As I recall it, according to the report here, there were some nine people's studies investigated and the Oil Compact got out a report more or less summarizing and stating what they had to say about it. I assume that you will admit that possibly Barton and Crays and Buckley are of equal authority with Tomlinson.

A. I don't think they are.

Q. That's just your own personal - - -

A. I'll tell you, Mr. Tomlinson has made a fortune by in-fill drilling 'cause he believes in close - - the more wells, the more oil and he's made a fortune by doing that. Now, none of these other gentlemen have done that. It's only theory with them. He's made money on it.

Q. All right. Now, let me ask you also if you are familiar with the report of Keller and Calaway on the Critical Analysis of the Effect of Oil Density on Recovery Efficiency?

A. Yes, sir.

Q. You've read that report, I presume?

A. I have read that.

Q. And you are familiar with the table that they have worked out upon the relative percent of oil recovered under their theoretical conditions.

A. It's been some time since I read it. I remember something about that table but I don't recall - - -

Q. Does this refresh your recollection somewhat? Is that it?

A. It seems to me that they had a curve. I don't remember this. I think they had a curve showing how much more oil could be recovered by closer spacing.

Q. Well, let me ask you to read a little bit further here and see if it does refresh your recollection.

A. I don't believe it would. Why don't you read it into the record. That's part of your exhibit.

Q. Well, I'd like to know just how much - - -

A. I told you it's been several years since I read that. I just don't remember all those details of the report.

Q. Several years? This report is dated September 10, 1951. You must have read it right after it came out. You say that you are not familiar with it. Now, I'll ask you if the statements in this report on oil spacing by the Inter-State Oil Compact Commission which has this statement - - quoting from this report of Keller and Calaway: The average permeability of 15 millidarcys , spacing acres per well, 160, percent of original oil recovered 16.45. For 80 acres, the percent of original oil recovered 16.52, for 40 acres, the percent of original oil recovered is 16.60.

MR. MASON: May I interrupt right here. What are you reading?

MR. SMITH: I'm reading from Keller and Calaway's report as reported in this document here.

MR. MASON: Does it show on what field this was made?

MR. SMITH: If you'd like this to go into evidence, I would be glad to have it go in.

MR. TESCH: Why don't you bring Mr. Keller and Mr. Calaway here so that we can talk to them?

MR. SMITH: Would you like to have it go in? I'd like to ask Mr. Teach if he's in agreement with respect to the theoretical conclusions which were just now stated?

A. I don't know what they are.

Q. Have you made any personal investigation of the percentage of recovery of oil - the differential between 80 and 40 acres? To go on a permanent spacing pattern to that effect?

A. Nobody can.

Q. Well, you just stated that you are familiar with the fact that Keller and Calaway have made such an analysis.

A. They made a report, yes. But that doesn't mean that it's correct. I don't know whether it's correct or not.

Q. Your position, as I understand it is, that you just don't know. You're not in a position to challenge it and you're not in a position to testify to the contrary.

A. I've seen a whole lot of oil fields, Mr. Smith. I've seen a lot of operations and I have observed things personally and that's principally what I base my conclusions on. Just like on your own properties.

Q. Mr. Teach, I would prefer for you to use some other illustration.

(Laughter)

You do know of some others, don't you? Other than those that you have worked in?

A. Of course, those are very pertinent to me.

Q. In the first place, you haven't identified the specific reasons.

A. Sure, I have. The first instance that I was talking about was your Bolesen lease in the King field. The second instance was in the north end of the Hendricks field.

MR. SMITH: May it please the Commission, I'd like to ask at this time that the matter be continued so that we can get these people here that it has been suggested that we bring here for the edification of the Commission. I think we can get Mr. Buckley and get certain people up here who are recognized authorities on the subject.

MR. HINKLE: Members of the Commission. My name is Clarence Hinkle representing the Humble Oil and Refining Company. I would like to join in the request made by Mr. Smith that this hearing be continued in behalf of the Humble. I think there are a lot of other members of the industry here that feel the same way we do that this report came as a complete surprise. We didn't think it was due before the committee because we couldn't get together. There has been this report submitted here and in fairness to the other members of the committee, they should be given an opportunity to file their report and I think we should be given time to go into the matters a little further.

JUDGE FOSTER: Mr. Chairman.

MR. SPURRIER: Judge Foster.

JUDGE FOSTER: M. H. Foster, representing Phillips Petroleum Company. I would like to join with Humble in their request and I would further like to point out that we had no way of knowing in advance that this hearing would be extended to matters not included in the original call. And we came here prepared of course, to present our testimony upon the proposed temporary 80-acre spacing rule not whether we ought to have 80 instead of 40 and to let the matter go as far as it has. We stated our objection this morning on it and we feel we are entitled to bring in experts to go over the whole matter. We feel we should be permitted to bring them. We can bring them and we will bring them if we had known that this hearing was going to take the turn that it did here this morning. We ask this Commission and we urge it again to confine it to the issues that were made by the call but for the benefit of State Land Commissioner, and very properly so, you have extended the scope of it and leave us here without any witnesses, to meet some of these mere conclusions that have been put into this record. We feel that we ought to have the opportunity to meet those.

MR. SPURRIER: Do I understand that you don't have any witnesses, Judge?

JUDGE FOSTER: I have one witness in this but I don't have anybody here to testify on the relative merits of 40 versus 80-acre spacing and that's what this hearing seems to have gotten down to. And had I known that you were going to go into this question, as I told you this morning, we could have had some witnesses here. But I assumed that we would stay within the call. But I don't believe we have. I think if you gentlemen want to be enlightened about

it, we would be very glad to do it. If you want to kick the thing wide open, we're willing to bring the witnesses here. Just give us thirty days and we'll be here.

MR. MASON: Bob Mason, Cities Service Oil Company.

MR. SPURRIER: I don't believe you're getting into the record.

MR. MASON: I'd like to join with Judge Foster in asking that the matter be continued. We are very anxious to have them put on their evidence with reference to the 80-acre spacing, and we feel they should be given that opportunity.

MR. HANNERS: G. T. Hanners, one of the members of the Committee. We have understood that the matter today - - - our objection is that we should not adopt any rule in advance of information on the whole. That has been the basis of our presentation. We have put on all the testimony we have showing the fallacy of adopting a rule in advance. We have assumed that Judge Foster would have testimony ready here to support it. Whatever is the pleasure of the Commission, we will abide by it. I would merely like to state that if the hearing is continued, Mr. Tesch's prior committments are such that we would like for it to be continued for sixty days rather than at the next regular session.

MR. SPURRIER: Now, Mr. Smith. Do we understand your original motion for continuance?

MR. SMITH: That is correct.

MR. SPURRIER: To June 16th?

MR. SMITH: Whatever the Commission desires, will be satisfactory to us.

MR. SPURRIER: I stand corrected. I don't believe you asked for sixty days, it was Mr. Hanners.

MR. HANNERS: We will meet the Commission's pleasure in the matter. We would like to inquire, however, if Phillips will give their testimony today?

MR. SPURRIER: We will ask Judge Foster about that.

JUDGE FOSTER: We'd be happy to. We'd be happy to. Our testimony however, will be confined within the limits of the call.

MR. SPURRIER: Isn't it true, Judge, that if he testifies today, you will probably call him back later?

JUDGE FOSTER: I don't see anything to be gained by it but if it is the wish of the Commission, all right.

MR. HANNERS: I'd just like to ask your indulgence and ask the Commission to let him testify so that I might ask him a few questions just in case Mr. Tesch is not able to get back.

MR. TESCH: I've got some committments and they are uncertain and if anybody has any questions, I would prefer that they do it now because I may not be able to get back here.

MR. MASON: This has been made more important by the statement of counsel here at this time. I have a question I'd like to ask.

MR. SPURRIER: Very well, you may proceed. And if anyone else has a question of this witness - - Mr. Smith I don't know if you were through or whether you - - -

MR. MASON: There's one question. That's all I have. I'm Bob Mason for Cities Service Oil Company, Bartlesville, Oklahoma. Oh, I'm sorry - - -

MR. SMITH: That's all right. Go right ahead.

CROSS EXAMINATION

By: MR. MASON:

Q. Mr. Tesch, I understood you to say that you didn't favor any future statement before information was available in connection with a given field or pool. Is that correct?

A. Yes, sir. That is essentially my thought.

Q. Does this mean that you are opposed to the present 40-acre spacing rule?

A. No, sir. It's been in so long that you can't change that.

Q. Well, then logically, you'd then have to be opposed to that, wouldn't you?

A. I'm not here to upset or try to change something that has been in effect for a good many years. But basically I think and it's my position that there's no collateral attack on my part on any of these - - what's going on.

Q. Yes, sir.

A. It's my own personal convictions that any field should not have its rules promulgated until after sufficient evidence is available to determine what is -- what are the proper rules.

Q. Well, then you're against any future stating of rules whether it's 40 acres which is in force in New Mexico now or whatever pattern or [illegible]

A. No, I'm not. If the facts warrant it I'm for it. But I think every field should stand on its own merits. That's my - - -

Q. The facts don't warrant it if you don't have any facts on the pool, does it?

A. That's right.

Q. So that -- now your counsel has said the same thing that he is opposed to any future spacing of a pool - - -

MR. HANNERS: That is not correct. I wish to reiterate so that the record may be straight. The witness now on the stand makes no attack on our present 40-acre state-wide spacing rule. The committee members make no attack on it. Our only objection is the adoption in advance of any departure from our 40-acre normal state-wide rule.

Q. Well, then, if that's your position then it's just a difference between 40 and 80, isn't it?

MR. HANNERS: No, it is not. 80-acre would be an exception to the normal state-wide 40-acre pattern and we oppose any exception in advance that is not based on any knowledge to support it.

Q. Well, then, you're not opposed to the future spacing of a pool that's never been drilled, as you stated you were awhile ago.

MR. HANNERS: I - - -

Q. You stated to the Commission here a little while ago that you were opposed to the futube spacing of a pool, one that hasn't been drilled, that you were opposed to that - - -

MR. HANNERS: No, we are opposed to any exception to the normal state-wide 40-acre pattern on any pool prior to its discovery.

Q. Then you are in favor of the 40-acre spacing rule?

MR. HANNERS: Wholeheartedly.

Q. That clears it up. I believe that that does it.

MR. SPURRIER: Mr. Smith?

MR. SMITH: I believe that the question I wanted to arrive at was fully covered by Mr. Mason.

MR. SPURRIER: Does anyone else have a question of this witness? Before I ask that question, maybe I should say that the Commission will continue the case until June 16th to give you the opportunity to bring the witnesses you would care to bring.

MR. HANNERS: May I ask, will the witness for the proponents of the rule be allowed to testify today?

MR. SPURRIER: Judge Foster, will you have your witness take the stand, please? We'll take a five minute recess.

(Five minute recess)

EDWARD N. WASHBURN

having first been duly sworn, testified as follows:

DIRECT EXAMINATION

By JUDGE FOSTER:

Q. What is your name?

A. Edward N. Washburn.

Q. Where do you reside, Mr. Washburn?

A. Bartlesville, Oklahoma.

Q. You're a graduate engineer from the University of Oklahoma?

A. That's right.

Q. Do you hold a degree?

A. Yes, sir.

Q. And when did you graduate?

A. 1934.

Q. And since then, by whom have you been employed?

A. Phillips Petroleum Company.

Q. And in the capacity of an engineer?

A. That's right.

Q. And during the course of your 19 years of employment, have you had occasion to study the matter of well spacing and related problems?

A. Yes, sir.

Q. Have you ever testified before the Commission before?

A. Not before the New Mexico - no, sir.

Q. I believe you're qualified. Mr. Washburn, are you familiar with the rules which have been proposed here for a temporary 80-acre - - for the establishment of a temporary 80-acre proration unit?

A. Yes, sir.

Q. I'd like to get the record straight. Do you make any distinction between the term well spacing and the establishment of proration units?

A. No, sir.

Q. Have you examined these rules that have been proposed?

A. That's right.

Q. Now can you tell us any good reason why these rules shouldn't be adopted?

A. The rules will permit a temporary 80-acre spacing until information can be obtained or assembled at an early date to permit the study of the field and a decision made as to what type of spacing is best for that particular field.

Q. Do you think that's a desirable way to proceed in the orderly development of oil fields?

A. Yes, sir.

Q. Do you find anything in the rules, Mr. Washburn, that you consider to be unfair to any operator or any producer or to the State of New Mexico or to a royalty owner?

A. None.

Q. Sir?

A. None.

Q. Would you state to the Commission what the advantages would be in starting on an 80-acre temporary basis over the present 40-acre basis which is now in existence in the State of New Mexico?

A. It has been - - four examples where 80-acre spacing was proven to the Commission was the most desirable spacing. If a field initially starts on 40-acres, it's very nearly impossible to get a pattern 80-acre spacing at a later date.

Q. And it's true, is it not, that if you continue to drill on

in this State on 40-acre that if an when you do discover an oil pool, that would be adaptable to 80-acre spacing, that it would be almost impossible to take advantage of 80-acre spacing?

A. That is right.

Q. That's true?

A. Yes, sir.

Q. Now, can you find any objection - any valid objection why the Commission should not issue a temporary 80-acre rule?

A. No, sir.

Q. On the other hand, there are those valid reasons which you stated why the Commission should do such a thing?

A. That's right.

Q. Now, do you find anything in the proposed rules that would permanently fix the development of an oil field on an 80-acre pattern?

A. No. That will be decided after the fifth well - what pattern is to be used. This merely leaves it open as to what pattern will be most efficient.

Q. And do you think that at the end of drilling of the five wells or at the end of 18 months, whichever occurs first, that ordinarily an operator or operators in the pool would have sufficient information to come in before the Commission and show whether the field will adequately drain 80 or should go back to 40?

A. Yes, sir. By that time, they should know what type of reservoir they've got, have it fairly well outlined and be able to present their information to the Commission, -- either supporting or returning to 80-acre spacing - - - ah, 40-acre spacing.

Q. Now, starting a new pool on temporary 80-acre spacing, will that more readily give you the information with respect to reservoir conditions than starting on a permanent 40-acre basis?

A. By diagonal off-setting on 80-acre spacing, they would cover the area - - the field could be defined at a quicker date, than they could at 40.

Q. Than they could at 40?

A. With a - - -

Q. Do you regard that as an advantage or a disadvantage?

A. It would be a definite advantage. It would be early information needed by the Commission to make these decisions.

Q. Would you regard that in any way injurious or detrimental to the interest of the State of New Mexico which might happen to be the royalty owner under some of these fields?

A. No.

Q. Would you regard it as any way detrimental or not beneficial to any other royalty owner in the pool?

A. No, sir.

Q. Now you don't take any position on these proposed rules as to whether a field should or should not be developed on 40-acres or 80-acres, do you?

A. No, sir.

Q. Is it your position that in order to determine whether a field should be developed on 40-acre or 80-acres, that it would be a wise policy to first find out what the nature of the reservoir is?

A. That's right. I believe that's the purpose of the rule.

Q. You believe that's the purpose of the rule?

A. Yes, sir.

Q. Now, I call your attention to the fact, whether you know it or not, that in this State the Commission has already established 80-acre proration units in four fields. Now would you regard the proposal here of adopting this 80-acre - - temporary 80-acre order as a means of implementing the Commission's policies, which is already evidenced, by the establishment of the 80-acre field?

A. Yes, sir.

Q. And that's about all that it really amounts to at this time, is it not?

A. That's the way I see it, yes, sir.

Q. Is it your position that in a given oil pool that you should establish the widest spacing pattern or establish the largest proration unit

that can be efficiently and economically drained by one well?

A. Yes, sir.

Q. And if it can be efficiently and economically -- one well won't efficiently and economically drain the 80-acres, then obviously the field should be developed on a smaller pattern, should it not?

A. That's correct. Yes, sir.

Q. By what other means, other than drilling that field and taking core analysis and analyzing them and the other data that you get from drilling is there to guide an operator or a Commission such as this in determining what the proration unit should be. What other information is there?

A. The only way to get that information is to drill wells.

Q. Drill wells?

A. Yes, sir.

Q. Now, I'll ask you if the establishment of a temporary 80-acre order here establishing a temporary 80-acre proration unit, I'll ask you if that wouldn't more readily flesh out the wells in the area where you apply?

A. That's true. Yes, sir.

Q. Now, there's been some contention here today that it might cause somebody to drill a dry hole. Now, that's true, isn't it?

A. Yes, sir.

Q. But the effect of that is that he'll just hit the dry hole quicker than he would on a smaller pattern. Isn't that true?

A. Yes, sir.

Q. Is it your idea, Mr. Washburn, that in the case of an isolated 40 that the Commission would very well grant an exception in that instance, if they had a case like that presented to them?

A. Yes, sir.

Q. It would be an anomalous situation wouldn't it where a man had 40 acres and couldn't drill a well? You don't think the rule would propose that, do you?

A. No.

Q. As a matter of fact, they don't propose any such thing, do

they?

A. No.

Q. Now, you realize, of course, that the State of New Mexico is a large royalty owner under a lot of state-owned land in this state, do you not?

A. Yes, sir.

Q. Do you feel that with the provision in this rule - the expressed provision in here to the effect that the burden of proof is upon the operator in the field to establish whether they should have permanent 80-acre proration units in that field, or not, adequately protects the interests of the royalty owner?

A. Yes, sir.

Q. Do you think it does?

A. Yes, sir.

Q. And, of course, you realize that the State of New Mexico as a royalty owner, is represented by the State Land Commissioner on this Commission, do you not?

A. Yes, sir.

Q. And it's obvious, isn't it, as far as the state is concerned, that there is one member of this Commission to look after it's interests as a royalty owner?

A. Yes, sir.

MR. MASON: I would like to suggest that there are three members on the Commission who are looking after the State's interest.

(Laughter)

Q. Do you have any information on the drilling of dry holes in this State during the last year?

A. Yes, sir. Some statistics from the trade journals. Merely to indicate how the drilling is in New Mexico. Of wildcats drilled in 1952 in New Mexico, 48 oil wells were successful wildcats and they had an average depth of 7,230 feet. There was 152 dry holes drilled in 1952 at an average depth of 5,120 feet. In other words, the successful wildcats were about almost 2,000 feet deeper than the average dry hole that was - - - -

Q. What does that indicate to you?

A. That deeper drilling is going to be required to bring up the reserves of the State.

Q. To bring up the oil reserves of this State. How many wildcat wells did they drill in this state, last year?

A. The Oil and Gas Journal - my information is from the 3 and 30 Oil and Gas Journal of this year, page 141. They list 170.

Q. How many of those were dry holes?

A. 152.

Q. Percentage wise, how many is that?

A. It's about 3/4 - - three dry holes to each successful well. Correct - three dry holes to each successful producer.

Q. Three out of four of those wells drilled were wildcat wells?

A. That's right.

Q. Is that right?

A. Yes, sir.

A. Yes, sir.

Q. Now do you think that the adoption of this proposed temporary 80-acre order might encourage wildcating?

A. Yes, sir.

Q. Is there any other way to build up the oil reserves in this State except through wildcating?

A. That's the only way I know.

Q. That's the only way you can do it, isn't it?

A. Yes, sir.

Q. Do you recommend it as a matter of policy to this Commission that they adopt the rule that would encourage wildcating?

A. Yes, sir.

JUDGE FOSTER: I believe that's all.

CROSS EXAMINATION

By MR. HANNAHS:

Q. Mr. Washburn, from the drilling of a wildcat well, you are generally unable to determine its relative position on the structure, isn't

that correct?

A. Usually, yes, sir.

Q. Ordinarily where would a prudent operator want to drill the second well to test where it and the first one were on the structure? Would he want to drill a direct off-set?

A. Not necessarily.

Q. Why would he not?

A. If he had the possibility of returning to 40-acres at a later date, he could drill on 80-acres and prove his structure much faster.

Q. Isn't it true, ordinarily, Mr. Washburn, that from the first well a reasonably prudent operator would prefer to drill a direct off-set so that he would know whether he was still on the structure? Isn't that generally true?

A. That is true because of the 40-acre spacing more or less in effect right now.

Q. Speaking of the dry holes that have been drilled in New Mexico from the Oil and Gas Journal, did it also show the national average?

A. Yes, sir. It did.

Q. What was that national average?

A. The national average oil -- successful oil wells -- do you want the depths - is that what you're interested in?

Q. I want the percentages - you said three out of four.

A. I don't have it divided into percentages. I believe that the percentage is about 80 percent.

Q. Was the percentage for New Mexico better than the national average?

A. Slightly higher.

Q. By slightly higher, do you mean the percentage in New Mexico or the national average -- higher than the national average?

A. Yes, sir. At a much shallower depth.

Q. Now, of the 19 fields that we have in New Mexico, below 10,000 feet, four of them, I believe, are on 8[illegible]cre spacing pattern and 15 on the

40-acre pattern?

A. I believe that's right. Yes, sir.

Q. So that about 75 percent of our fields are on the 40-acre spacing pattern. Isn't that true?

A. About. Yes, sir.

Q. I believe you said that the purpose of the proposed rule is looking toward the establishment of 80-acre proration units.

A. It's looking forward to see what is the most efficient unit.

Q. When Judge Foster asked you if it would implement some statement he made, he asked you if it was looking toward the establishment of 80-acre proration units. Is that the purpose of the rule?

A. State that again please?

Q. Is the purpose of the rule to eventually establish 80-acre proration units?

A. No, sir.

Q. Is it looking toward the establishment of proration units of 80 acres?

A. It's not -- it's looking toward the possibility.

Q. Now, a proration unit as defined by law is the area that can be efficiently and economically drained and developed by one well. So if you adopt a rule looking toward the establishment of 80-acre proration units, you necessarily assume that an 80-acre pattern will economically and efficiently drain and develop one well.

A. You don't decide that until you have the information to determine it.

Q. But the adoption of the rule looking toward the establishment of 80-acre proration units necessarily assumes that an 80-acre unit can be efficiently and economically drained and developed by one well.

A. I can't answer that because it's implying things.

Q. The rule implies and the facts will support an 80-acre permanent proration unit.

JUDGE FOSTER: The rules speak for themselves. Here's the rules. I submit that the rules answer that.

Q. A proration unit on a - - - I'll rephrase the question. I want to get this one question and then I'll be through with you. If the purpose of the rules is looking toward the establishment of 80-acre proration units, isn't it necessarily based on the premise that geological facts when developed will show that one well will efficiently and economically drain and develop it?

A. That will have to be - - I can't - - that's implying that we want 80-acre spacing and we do not. We want to define the information as quick as possible to decide what kind of spacing is needed.

Q. What is there to prevent you and your associate company from following the 80-acre proration on your own when you discover the first well? Why do you need this rule?

A. We could, ourselves, I assume, have a special hearing.

Q. And if - - -

A. Providing, we didn't have objections from off-set operators.

Q. Now, suppose you had an objection from an off-set operator who wanted to drill on 40-acres. How do you provide for that in your proposed rule?

A. This rule applies to wildcats. I assume it would be the first well.

Q. Now if a man owning a 40-acre tract adjoining the discovery well wanted to drill on that 40-acre tract, direct off-set, to the discovery well, do your rules permit that?

A. No, sir. Not for the first five wells or until the field has been - - -

Q. So until five wells have been drilled, the holder of the off-set 40, would not be permitted to drill a direct off-set but would be compelled to move in a diagonal direction.

A. Would you please define how much of a lease he has?

Q. I don't think it makes any difference.

A. If he has 40 acres only, he could get an exception.

Q. But if he had more than 40-acres directly off-setting the well, and wanted to drill it, would your rule permit him to do it?

A. He could call for a special hearing, I believe.

Q. Now, a man having a larger lease, wanted to drill on the 40-acre directly off-setting the discovery well, would he also have to apply for an exception to the rule?

A. Yes, sir. If he didn't want to - - -

Q. So your rule in its - - -

JUDGE FOSTER: Let the witness answer.

Q. If you have not finished your answer, please do sir.

A. He would - - - State your question to me, please.

Q. I believe - - -

A. I'm getting a little crossed up here.

Q. I will clarify it if I can. The rule as proposed does not provide originally for drilling of an off-set location by a man who owns the off-set 80 except by the granting of a special exception?

A. That's right.

Q. The rules would not permit a direct off-set to the discovery well and could only be done by the granting of an exception.

A. That's right. We're talking about after the discovery well. This is the second well we are drilling?

Q. In your discussion with Judge Foster, did I understand you to say that after the drilling of five or more wells you couldn't come back to an 80-acre pattern if you wanted to?

A. I believe that is - - you can read the rules. The proposed rule states that after five wells are drilled that a hearing will be called before the Commission and the proration unit will be decided at that time.

Q. But did I understand you to say that one of the reasons for proposal of this rule is that if you start on a 40-acre basis you can't change it to an 80? Is that what you said?

A. Yes, sir. I believe I said that.

Q. Do you know of any fields that have operated for some period of time on a 40-acre basis and have then been changed to 80-acre basis?

A. I know of one in New Mexico that tried to and it wasn't successful.

Q. Wasn't there a rather large field in Texas recently placed on 80-acre proration pattern?

A. I don't recall it.

Q. Wasn't it the Spaberry area?

A. Yes, that's right.

JUDGE FOSTER: Fact is, it's on 160 now.

MR. WASHBURN: Incidentally, that Spaberry deal was not the type of development we're talking about here. They merely assigned additional acreage.

JUDGE FOSTER: Just what was the Spraberry picture?

MR. WASHBURN: It was a situation of economy where the operators found out that they were about to go broke.

JUDGE FOSTER: Why?

MR. WASHBURN: Because there wasn't the recovery - there wasn't the oil that was there initially. They'd drilled it fast on 40-acre spacing - - - - - -

Q. How many wells - - -

JUDGE FOSTER: Let him continue about this Spraberry matter. Go ahead and explain.

MR. WASHBURN: They asked - - they had to have relief from the Texas Railroad Commission for wider spacing to more or less - - - from an economy standpoint. And they also proved that the fractured pay that they have there would efficiently drain 80-acre or 160 as it is now. That's all.

MR. SPURRIER: Mr. Witness, the Commission would like to know if you know how these four pools that we have based on 80-acre spacing, how they arrived at that point?

A. No, sir. I don't.

VOICE: Mr. Washburn, Judge Foster has asked you to state the advantages of the proposed rule over the uniform 40-acre spacing which you answered. Now, will you explain the benefits under the proposed order as against the existing rights of an operator upon application to obtain 80-acre exceptions.

A. This rule would automatically start a wildcat out on an 80-

acre spacing with the understanding that after the fifth well or 18 months a hearing would be had and it would be -- evidence would be given to either support the continuation of 80 acres or it automatically would return to 40 acres. Now, -- the other -- give me the last part of that sentence.

VOICE: What advantage would the proposed order in comparison with existing rules whereby an operator can apply to the Commission for an exception whereby he can go in and drill on an 80-acre spacing pattern on showing that this particular field would be more adaptable to 80-acre spacing rather than 40?

A. You're talking about a wildcat against a field. This ruling is merely for wildcat wells so that the Commission can have information at an early date. -- an earlier date. That's all it's supposed to be. I don't see that it has any relation to the last part of your sentence - of your question.

VOICE: Well, now, it was my understanding that an operator should come in and request an exception. May you not do that after drilling the first well? If they come in and present their case?

A. That's right.

MR. WHITE: Well, then if that be true what advantage does the proposed order have over our existing rule?

A. It will start out on 80-acre spacing with the idea that if it can be shown that 80-acres is the right proration unit that you can continue. If you start out on a 40-acre spacing, you run into this -- problems that you've had in the past.

MR. WHITE: But you still have the right to come in and make application before the Commission for an exception?

A. Right. You do.

MR. WHITE: Now under proposed rule, after you have drilled the five wells or 18 months have elapsed, then the burden is upon the operator to come in and testify for continuance of the 80-acre spacing or else to revert to the 40. Is that correct?

A. That's right.

MR. WHITE: And during the interim of 18 months, if an operator

wants to come in and drill an off-set on 40, would he have to come in and bear the burden of proof to establish the right to drill on 40 as an exception to the 80 whereas under the present rule, he has that right to come before the Commission.

A. That's right.

Q. And he doesn't have to bear the burden of proof to drill on 40. Is that the main feature, as I see it.

A. I think the main one is the fact that the Commission will be furnished information -- when a field first starts, it's going to start on 80-acre spacing, then you can decide what is the proper spacing at the very start.

Q. If that be true, the field can be more readily established on an 80-acre spacing pattern, how do you account for the fact that there have been only four applications for it?

A. I don't know unless it's the difficulty you have in starting 80-acre spacing at the present time in a proven field or in a - - - where's it's not a wildcat.

JUDGE FOSTER: Mr. White, there have been many more applications than there have been those granted.

MR. WHITE: I stand corrected.

MR. GRAHAM: What would be the situation with respect to very small pools? Where all succeeding wells would be dry?

A. If you faced that fact a little further, you could bring that point in a little farther and do it with 40 acres. If it's a small, small pool.

MR. SPURRIER: Does anyone else have a question of the witness?

MR. WALKER: Mr. Washburn, did you have any definite depth - would you recommend any definite depth that these wells should be drilled?

A. You mean the - - are you referring to the 10,000 foot depth?

MR. WALKER: Any well. The reason that I ask that question was because a few minutes ago when Judge Foster was questioning you you made reference to a comparison of the dry holes drilled and the ones that were

producers. And he asked why you made that point and you were apparently suggesting - at least that was the interpretation that I had - that if they had gone deeper, possibly they would have hit oil.

A. That is just guessing. It appeared that the successful wildcat that hit oil was about 2,000 feet deeper than your average dry hole drilled last year.

MR. WALKER: Well then, is there the possibility then that if operators that drilled the dry holes and had they gone another two or three thousand feet, is it possible then that they would have hit oil?

A. From the statistics it would. Now, I don't know the circumstances where they were drilling.

MR. WALKER: I was just curious, I wasn't trying to grill you.

MR. SPURRIER: Anyone else? If not, - - -

MR. ADAMS: R. E. Adams, Cities Service Oil Company. With reference to your statement on the 80-acre spacing that was established in the Spraberry field in Texas, do they permit direct off-set?

A. I believe they do. Yes, sir.

MR. ADAMS: Do you know of any Texas fields where they don't, regardless of the spacing pattern?

A. No, sir.

MR. ADAMS: That's all.

MR. SPURRIER: Anyone else?

JUDGE FOSTER: Mr. Commissioner. I'd like to offer something on this rule that I don't think has been offered here today. But I want to get them in. These rules haven't been entered yet and I'd like to have that marked Exhibit 1.

MR. SPURRIER: Without objection, they will be received - - it will be received.

JUDGE FOSTER: There was one question there that was asked of this witness by Mr. White, that I didn't ask him. The rule here states 10,000 feet. I don't know if you want an explanation on that or not. If you do, the witness can give it to you - why we set it at 10,000 rather

than 9,500 or 7,000 or 12,000. I believe I'll just ask him to state why, in his opinion, the depth should be at 10,000 rather than another figure.

MR. WASHBURN: I believe that that 10,000 to start with was arbitrary. But there is still -- on the basis of drilling costs, there is some evidence for it. I have a drilling cost analysis on 225 wells drilled by Phillips Petroleum Company in 1951 and 1952 in the West Texas-New Mexico area.

MR. SPURRIER: Would that be the Permian basin?

MR. WASHBURN: Yes, sir.

JUDGE FOSTER: And what's the -- what does that chart show?

MR. WASHBURN: It shows a marked break around 9,500 or 10,000 feet in a cost per foot of depth drill. Wells from 5 to 8 thousand feet have a fairly straight line but when you get to 10,000 feet you get a gentle slope with respect to cost, it's cheaper as you go down deeper, because of heavier rigs and equipment.

JUDGE FOSTER: What are the costs reflected there by the depths with respect to those 225 wells?

MR. WASHBURN: Do you want the average cost per well?

JUDGE FOSTER: Yes.

MR. WASHBURN: Wells - 3 to 4 thousand feet cost about -- I'm going to round these out - about $45,000.00. From 4 to 5 thousand feet was $57,000.00. From 5 to 6 thousand feet was $69,000.00. From 6 to 7 thousand feet was $85,000.00. From 7 to 8 thousand feet was $95,000.00, 8 to 9 - $138,000.00; 10 to 11 - $253,000.00; 11 to 12 was $255,000.00; 12 to 13 was $317,000.00; and 13 to 14 thousand feet was $392,000.00 per well. That is for well and equipment only - it doesn't include overhead or district expenses or lease-hold expenses. Merely the cost of the well and the equipment that went into it.

MR. SPURRIER: The witness may be excused. Anyone else to be heard in this case?

JUDGE FOSTER: I'd like to reserve the right to put on additional testimony at the next hearing. I've used up all the ammunition I've got here today.

MR. SPURRIER: I thought that that was the intent of the conversation, Judge.

JUDGE FOSTER: Well, I just wanted to be sure.

(Laughter)

MR. SPURRIER: You mean you want to testify or you'll have other witnesses to testify?

JUDGE FOSTER: Well, I would like to testify and probably will.

(Laughter)

MR. SPURRIER: If there is no-one else to be heard, we'll go on to the next case.

STATE OF NEW MEXICO)
) ss.
COUNTY OF SANTA FE)

I hereby certify that the foregoing and attached transcript of hearing in Case 407 before the Oil Conservation Commission on April 16, 1953, at Santa Fe is a true record of the same to the best of my knowledge, skill and ability.

DATED at Santa Fe, this 25th day of April, 1953.

Audrey M. Henrickson

My commission expires September 20, 1955.

