BEFORE THE

Oil Conservation Commission

SANTA FE, NEW MEXICO

IN THE MATTER OF:

CASE NO. 330-330A Special Hearing

VOLUME II

130 through 238

June 22, 1954

TRANSCRIPT OF PROCEEDINGS

OFFICIAL RECORD
OIL CONSERVATION COMMISSION

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I N D E X

VOLUME II

Tuesday Session, June 22, 1954

MORNING SESSION
June 22, 1954
Case 330-330A

MR. SPURRIER: The meeting will come to order please.

Mr. Reeves, I believe you were still on the stand. Does anyone have any further question of Mr. Reeves?

MR. MACEY: I want to ask him a question.

MR. LOCK: I would like to call up Case 729 having to do with the proration of gas in the other fields and made a motion concerning it. I would predicate my motion on these facts. I am advised that the ones are now prepared to go ahead with the hearing. I am further advised that the Commission itself is not at this time ready to go ahead with the hearing. In view of the deliverability, tests will not be completed until 8-31, that is August 31, of this year.

I now move that Case 729 be continued until the September meeting of the Commission.

MR. SPURRIER: Is there objection to Mr. Lock's motion on Case 729? Is there anyone who has testimony to present in Case 729? We will give you an answer on that after the first recess.

D. W. R E E V E S

having been previously duly sworn, testified further as follows:

By MR. MACEY:

Q Unfortunately I wasn't in the room when you were asked about the interference test. I wonder if you would try to bring me up-to-date on that.

A That was not directly taken as an interference test, but the information that was obtained, more or less, incidently, did indicate about the same results as you would have gotten from an interference test. Briefly, I pointed out that Pubco State No. 12 was shut in for 180 days after completion. Of course, we took the initial tubing pressure and casing pressures. Likewise Pubco State 13 was shut in for 120 days. I believe that yesterday I said 180 days for both, and then corrected it later, pointing out it was 180 for one and 120.

During that period there were seven offset wells prior to the time that the Pubco State 12 and 13 were placed on the line. Now, initially Pubco State 12 showed tubing pressure of 1,080 pounds, and at the end of 180, 1,078 pounds. Casing pressure on Pubco State 12 was 1100 pounds at the beginning, and 1100 pounds at the end. Pubco State 13 showed at the beginning a thousand and sixty pounds at the end, a thousand and sixty-four pounds tubing pressure. Casing pressure on 13 showed a thousand and seventy-seven at the beginning, a thousand and seventy-nine at the end. Which indicated to us that the production of the offset wells did not in any way reduce the pressure on 12 and 13, thus indicating there was no drainage occurring during that period.

If it is the pleasure of the Commission, I have a copy of the statement that I would be glad to furnish.

Q How did you determine your pressures, that is take them as a dead weight?

A I am not prepared to say whether it was taken with dead weight pressures or spring gauge. Mr. Maxwell, our production engineer in the field, tells me it was dead weight.

Q Did you, during that period of time, did you continuously take pressures on the well, or was it a matter of just taking the initial tubing pressure of 1,080 and 160 days later take another pressure and determine that it was 1078?

A Might I again ask the gentleman that supervised it?

(Discussion off the record.)

A Mr. Macey, I misread my data here and I would like to correct that and also correct my statements on the previous day, that is that I made yesterday on this check. In other words, at the initial pressure which was a maximum, was 1,071 on 12 and was 986 on 13. That was at the end of fourteen days and eleven days after shut-in. At the end of 120 days the first figure I gave you was 1,080 tubing at 12, 1100 casing pressure on 12, and at the end of 180 days was a thousand and seventy-eight tubing, 1100 casing. In other words, sixty days later.

Now on 13 the initial maximum pressure at the time of I. P. was 986 pounds. At the end of ninety days that well showed tube pressure of 1,060, casing pressure, 1,077, and at the end of 120 days, tubing pressure of 1,064 and casing of 1,079 pounds. Those figures are correct. What I did in the first figures I gave you was omitted the pressure at the time of I.P.

MR. GREINER: Would you give us the pressure again under the initial one, please?

A All right. Pubco State 12 at the time of I.P. after fourteen days, was a maximum 1,071 pounds. At the end of 120 days tubing pressure was a thousand and eighty pounds.

MR. GREINER: We have that. The initial ones.

A I see. Pubco State 13 at the time of I.P. was 986 pounds. As I say, these figures were taken not for the purpose of shut-in in check or anything, but merely occurred because of delay in hooking up those two wells. The other wells, if you are interested, Mr. Macey, that were producing in the general area, I have those. There were seven offset wells at that time being produced.

MR. MACEY: I think that takes care of that little matter, Mr. Reeves. One other point I would like to know, you used a maximum and minimum pressure of 1,114 and 933 I believe, on your range of possible reservoir pressure?

A I did, yes, sir. That was based upon the pressures at the time of initial potential, the initial check. Those were on Pubco wells. Now, I can give you those well numbers if you so desire.

MR. MACEY: No, sir. What I would like to know is, I think you will agree with me that 933 is probably not a static pressure?

A I will agree that that probably would build up somewhat if you continued it. In other words, if there was a long period of shut-in - of course, I might also point this out, if you completely eliminated pressure, your ratio instead of being 46 as I remember it was 39.4 or something of the sort. I think there is definitely a pressure diferential between wells in different areas of the field. There is some multiplier as to whether it is 1.8 or 1.1 or 1.3. I wouldn't dare guess. I think the 1.18 is a reasonable factor.

MR. MACEY: Have you made any attempt to calculate the reserves in place on a per acre basis under a tract that had the most favorable conditions which you have outlined, such as your porosity of 28.4 and connate water and pressure of 1114 and so forth?

A No, sir, I have not. I was depending primarily upon, in other words, in my presentation, maximum variations, the thing I was attempting to show was that the possible variations due to conditions we knew existed. I wasn't trying to relate that to any particular reserves. Simply trying to show that reserves could vary in that ratio. That could, of course, be done very easily. As I mentioned yesterday, independent geologists on our best well there came up with something over a hundred million per acre and later in arguments on getting our reserves accepted perspective, while that figure wasn't filed with the Commission. The basis upon which we arrive at total reserves was discussed. As I remember, that was cut to about 80 million an acre and in some of our poorer acreage, as I remember, figures, they were used on those leases, they were as low as six million an acre. Let's call it eight million, it is ten to one there. That wasn't the poorest well, I might mention, that had the estimate of six million to seven million.

MR. MACEY: Mr. Reeves, are you in a position to hazard an opinion or a guess as to how much gas, or how much money, let's put it that way, an operator should received from his income from a well in order to make it economically feasible to drill a well in the basin?

A We have done quite a lot of studying on that. Our conclusions are necessarily general. In other words, on the basis that a Mesaverde well will cost you $85,000 and that you own the entire working interest, we reached this conclusion that you would have to have an I. P. of approximately two million cubic feet per day in order to get your money back. That is simply changing dollars and getting your money back over a period of time. We think that any well, I don't mean that if you drill a well of less than two million that you shut it in. You have made your investment and the only way to get your money out is to produce what you can. Any well less than two million is not considered desireable, and we don't buy acreage unless it is our estimate that we can get a well with an I. P. in excess of two million.

Yesterday we happened to close some acreage and we closed it on the basis that we could get plus or minus four million I.P., and we considered that economic and desireable.

MR. MACEY: In other words, as I understand, it is your opinion that if you do not have an I.P. of two million feet per day, that you will not get your money back?

A That is correct, yes, sir. Mesaverde well, of course. I assume that this discussion is all Mesaverde. That is right.

MR. MACEY: Do you know how many wells there are in the Blanco Mesaverde that have an I.P. in excess of two million in proportion to the total pool?

A We made some checks on that. I don't recall the figures now. The only figure that runs in my mind was that wells completed in one formation only were about twenty percent of the total of 704. In other words, twenty percent of the wells in the field are less than, completed in one formation, and I would guess that that might be pretty close, but I haven't made any actual study to determine how many wells are uneconomical. Actually the principal concern that we have had is to be sure that the acreage we buy has reserves under them capable of producing in excess of two million I.P. Sometimes we don't guess correctly.

MR. MACEY: That is all I have.

MR. SPURRIER: Anyone else have a question of Mr. Reeves? If not, the witness may be excused.

(Witness Excused.)

MR. SPURRIER: Mr. Keleher, do you have anyone else?

MR. KELEHER: We rest our case.

MR. SPURRIER: I believe that Phillips is next on the list to present testimony. Are you ready, Mr. Foster?

MR. KELEHER: May the record show that the Exhibits which the witnesses have testified to, One-A, One-B, and B-Two and Three, and that the bottles of oil be considered as admitted into evidence?

MR. SPURRIER: Without objection they will be admitted.

W. B. BARRY

having first been duly sworn, testified as follows:

DIRECT EXAMINATION

By JUDGE FOSTER:

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

A My name is W. B. Barry.

Q Where do you reside, Mr. Barry?

A I live in Bartelsville, Oklahoma.

Q You are employed by the Phillips Petroleum Corporation?

A Yes, sir.

Q In what capacity? A As a research engineer.

Q Will you state your educational qualifications and professional experience and background?

A I was graduated from the University of Oklahoma in 1936, Bachelor of Science degree in petroleum engineering. I was employed immediately thereafter by Phillips and have been so employed for eighteen years with the exception of four years in the Army during World War II. First employed by Phillips as a junior engineer in the evaluation section, Comptroller's Department, wherein we calculated reserves and rates of production for tax purposes. After a year in that position I was transfered to the Production Department and spent the next two years in the field drilling, developing, testing oil and gas wells. Transferred then to the Economics Department where I am now in the Research Section with the title of Senior Research Engineer.

That has been since 1939, during that time I have been in charge, directly responsible for the gas, gasoline, oil reserves in the area of the Texas Panhandle of Hugoton, and since January of '53 the San

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Juan Basin.

Q During your period of experience, has it fallen to your lot to be required from time to time to compute and determine reserves of oil and gas in the various areas that you have mentioned?

A Yes, sir, that is my responsibility and my duty, and I have to do it once a year on all properties, and various other times on specific property.

Q You have previously testified with respect to the San Juan Basin reserves before the Federal Power Commission, have you?

A Yes, sir.

Q When was that?

A That was sometime this spring. I have forgotten the date. It was just as a rebuttal witness.

Q As a rebuttal witness. Have you made any special study of the San Juan Basin and the area and the gas pools that are involved in this hearing? A Yes, sir.

Q For the purpose of testifying before this Commission?

A No, sir, I made a report for the company, but not for the purpose of testifying before this Commission.

Q What has been the extent of your experience in the San Juan field?

A Well, I was assigned that area in January of 1953, and I have spent, I would say, a good ninety-nine percent of my time studying there since. I have made trips to the basin and concentrated all my efforts toward learning all I could about this.

Q You have made a study in which you are now in a position to state your opinion with respect to reserves in the San Juan Basin?

A Yes, sir.

Q Of what did your study consist?

A I gathered all the data that I could on the basin. By that I mean scout data, all the electrical logs, gamma ray logs, temperature logs, core analysis, all the data to give me the basic factors needed to estimate reserves. Phillips, in it's development program, has cored eight wells. Four of them were cored, five of them were cored with mud, three of them cored with gas. Of the eight wells, six of them were cored from the top of the Mesaverde to total depth being somewhere in basal Point Lookout or some instances part of the Mancos shale. The other two wells, one was cored only in the Cliff House, the other cored in the Cliff House and Point Lookout.

With these data I was able to obtain basic factors of porosity, permeability, connate water. These eight wells I felt were a good representation of the formations encountered in the basin; by plotting this data on graphs alongside of various electrical and radioactivity logs I was able to get a correlation between the core data and the electrical and radioactivity logs. That allowed me to interpret those logs on wells which were not cored, to give me an idea of what was pay and what was not pay.

By that means I was able to determine a sand count on all wells in which I had radioactivity logs. That gave me the porosity, the permeability, the water and the thickness. The rest of the data necessary to go into a formula to calculate reserves by volumetric method were determined by measured data. That is shut-in pressures calculated bottom hole, bottom hole temperatures were observed on electrical logs, gas analysis gave me deviation factors to be used. We have, by using the regular volumetric formula, I was able to determine the reserves.

Q You had core analyses out of other wells too available for your study, did you not?

A I had some core analyses from other wells in the field besides Phillips' wells. I did not use them only as a check, Maybe I should state that my purpose was to make a reserve estimate of the Phillips' properties only. Therefore I used the Phillips' wells to determine my factors. Since I was doing it I kept on going across the field on my thickness, and in so doing I checked the core analysis of other company's wells in the western portion of the basin, I found their porosity did not vary.much.

MR. SPURRIER: Western portion, or the eastern portion?

A Western portion. My core analyses were in the eastern portion on the Phillips' property. I checked the core analysis on other company's wells in the western portion and found their porosities were not much different than what we had found. Their permeabilities were no different. Their connate water was in agreement than what we had found on our own wells. Therefore, I felt that the composition of the pay in the basin was not much different.

Q How were these other core analyses made available to you?

A There was a tradeout agreement.

Q Just trading information? A Trading information.

Q You don't feel you are violating any confidences in stating that you did examine other cores? A I don't believe I am.

Q Good. Now, will you state what you found from these core analysis with respect to your permeability, porosity of the water, and the pay and so forth?

A I found the factors based upon Phillips' cores only that the intervals that I felt would be pay, the average porosity was ten percent. The average water was thirty percent. The average permeability was .54 millidarces. In determining these factors, I gave a consideration to the lower limit to which I felt I should go in counting pay. That is within the sandstones of the Mesaverde formation. There is a variance in permeability. Not much, but some.

Q In what range?

A Ranges from practically zero to fifteen millidarces. When I stop at fifteen, that is not the highest values that were recorded for us by the core laboratories which we sent the cores to, the core laboratory companies. We had higher values, but there was some thought that they were fractured either naturally or mechanically in cutting the permanent block. Since it takes permeability to move gas in the reservoir, that is the factor I felt should determine my lower limit, which I cared to go to count reserves, to count pay. I selected, after some calculations, comparisons with other fields, and data and literature that I felt it was safe to go down to one tenth of a millidarcy, dry permeability. Gas in that permeability and above will theoretically, and it has been shown to do so, actually move to the well bore under the pressure conditions we expect to find through the years in the San Juan Basin, Blanco-Mesaverde Pool.

That was the lower limit throughout all samples with less than one-tenth of a millidarcy, and calculating my average factors I just gave you. It so happened in studying the core analyses, that I found no zones that average sample had a high porosity and good permeability, it is sort of heterogeneous.

Q What does that word mean?

A It is all mixed up.

A You have zones reflected on gamma ray electrical logs as being sands as we so interpret them, but in those zones we always run across one or two or three samples that has a low permeability. So statistically, I found that in the intervals I picked as pay in this correlation, the core analysis across to the logs that twenty-five percent of those intervals had permeability of less than one-tenth of a millidarcy. So I had to go through a step of, on the wells that were not cored, of counting my pay and then saying from my statistics that only seventy-five percent of that was net.

Q You are talking about how you first determined what you called gross pay and then how you finally determined net pay, is that what you are talking about? A Yes, sir.

Q What pay thickness did you start with?

A In my correlation, core analysis to gamma ray or electrical log, I found that my sand intervals showed a certain characteristic, or character, or you might call swiggle on the electric log.

Q What is a swiggle? A That is where --

Q (Interrupting) You got a log where you can show us a swiggle on?

A It is where the gamma ray log goes to the left with respect to the log as it is printed, otherwise you have characters in the log that has certain --

Q (Interrupting) -- swiggles --

A (Continuing) -- swiggles.

Q Now that I understand it, I don't think it is important for anybody else.

A I found that these sand intervals where we had the core analysis would correlate to those bumps on the electric log, and that if I picked a shale line on those logs where my core analysis and core descriptions showed shale, that there was a correlation between the best pay, the poorest pay, or the shales in the formation.

Q Right now I want to get something in this record. You say best pay and poorest pay, what do you mean by that?

A Well, there is a relative --

Q (Interrupting) It is a relative term, isn't it?

A It is a relative term. You have sands, shaley sands, sandy shales and shale and coals and lignites in this Mesaverde.

Q It means some has more gas in it than others?

A That is right.

Q When you get through talking about it?

A Yes.

Q That is what you get down to? You find there are variations?

A Yes.

Q Go ahead.

A After obtaining this correlation, I found that there was a line that I could draw between approximately fifty percent of the distance between the shale line and the maximum sand line on a gamma ray log that the interval to the left of that fifty percent line would contain sands, which had a permeability and porosity and water that I considered to be pay.

Q That is net pay? A That was gross --

Q (Interrupting) That is gross pay?

A I beg your pardon, I didn't mean to say that was pay. That was sand counted. In that interval so counted my statistics showed me that there was twenty-five percent of it that had too low permeability for me to consider it pay. Therefore, the sand count thickness had to be multiplied by a factor of 75 foot to get net pay.

Q To get net pay. What you did then was to take what you found here as the gross pay and multiply it by 75?

A Yes, sir.

Q To get your net pay, is that right?

A That is right.

Q Tell me whether or not you observed any evidences of fractures in examination of these core analyses?

A We obtained some 4200 feet of core in these eight wells.

Q 4200 feet?

A 4200 feet plus or minus a few feet. That was actually cut in the formation, brought up to the surface and laid down on the derrick floor and under my direction and supervision, geologists in my department examined those cores minutely and recorded what they saw. Lithology, fractures, bleeding of gas, odors, any physical thing similar to the examination of samples, only this was done on cores. These 4200 feet of cores show some five hundred feet of interval that show fractures.

Q How is that made evident in the core?

A The fractures that you see in a core with reference to the surface are only the floor ones that are left, the large fractures are broken up, since they are open, or if they are open, when they come to the surface in your core barrel it means you just have two pieces of core instead of one. You don't know whether it was mechanically fractured in coring and coming up, or whether it was a fracture in the formation.

Those were not the fractures I was talking about. The fractures I was talking about were small hairline, considerable number were

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vertical, considerable number horizontal. Those are visible with a naked eye. Under a microscope we could find more. They were incipient in nature, by that I mean they began and ended within the three to four inch diameter core. Others began in the core and continued out into the formation, after we got them to the surface. But the core was still together.

Therefore, at the very least, we had fifteen percent of the formation had small fractures in them.

Q So you would say that this area that we are talking about does contain fractures. Is that right?

A Yes, sir.

Q With some of these core analyses made where you were using gas as a circulating medium?

A The three wells were cored with gas used as a circulating medium.

Q You recall the statement made here yesterday you couldn't core a well where you were using gas as a circulating medium?

A Yes.

Q I take it you don't agree with that.

A I think "puddin' and pie" we did it.

Q Anyway, it can be done? A Yes, sir.

Q Do you think that is clear, was it clear to you that the fractures which you observed there would extend across the entire field?

A We found them in every well that we cored. That would give me an indication that it was true throughout the field.

Q Give you something to base a statement on that it does exist throughout the field? A Yes.

Q You haven't found it otherwise?

A We found it everywhere we looked for it.

Q Let me ask you this question about this San Juan Basin. Is there anything unusual about the characteristics of this basin that you don't find in a gas field generally?

A Yes, sir.

Q What is it?

A Well, it is upside down.

Q What do you mean by that?

A It is a saucer instead of, I mean the structure of the basin is contrary to what we normally find in gas reservoirs to be. It is low porosity comparable to sandstone gas reservoirs as a rule. It is more similar to the dolmitic reservoir. It has a very low permeability compared to other reservoirs as exhibited by the core analyses we took, and by the deliverability or potential of the wells.

Q When you say it has a low permeability, do you mean that gas is less likely to move rapidly through the formation?

A In the absence of fractures, yes, sir.

Q In the absence of fractures. But you do find in this area, do you not, that there are areas where the gas does move rather rapidly? A Yes, sir.

Q Is that another indication to you that there is a fracture condition in this area?

A Well, knowing from my core analysis there is fractures in the formation and never having seen a core analysis that showed any more than the average porosity or water of all the rest of the core analysis, the only conclusion that I can come to is that it was fractured.

Q Now, you say that the porosity is low compared to other reservoirs?

A Well, sandstone reservoir with an average porosity of ten percent is rather low as compared to other reservoirs that we have delivered gas from.

Q What is the effect in a gas reservoir of low porosity?

A Low porosity would give you a low reserve per unit volume. That is per acre foot as compared to the higher porosity, since it is direct relationship.

Q You mean there is not just the space for gas to be in?

A That is right.

Q That you would expect to find in other reservoirs of this type, is that correct? A That is right.

MR. SPURRIER: Let's take a ten minute recess.

(Recess.)

MR. SPURRIER: Proceed, Mr. Foster.

Q Now, I don't know just where we quit there, Mr. Barry. Have you stated for the record all of the investigations that you made, all of the examinations, logs and core analysis, had you completed that statement when the recess came?

A I feel that I have in a brief way.

Q Is there anything that you would like to add to it before I go to another phase of your examination?

A No, sir.

Q Have you prepared a map on which you have attempted to reflect in graph form, the results of your studies and examination of the San Juan Basin with respect to reserves?

A Yes, sir, I have prepared an Isopachus map showing the gross sand count that I found in examining and correlating the logs that I had as of August 1st, of 1953, in which I had determined the sand count.

Q Just so that everyone will understand it, you use the term isopachus map. What do you mean by that term?

A Lines of the map showing lines of equal thicknesses.

Q In other words, you have placed on a map of the San Juan Basin, lines that you have drawn that show the occurrence of equal thicknesses of pay throughout the basin?

A Yes, sir.

Q Is that correct? A Yes, sir.

Q We have designated that map as Exhibit No. 1, for the purposes of the record. I am going to ask you to go to your map and detail to the Commission the situation as reflected by your map in connection with reserves in the San Juan Basin. Will you just mark that Phillip's Exhibit No. 1?

A (Witness complies.) This is a map of the San Juan Basin area as of August 1st, 1953, showing my estimate of the limits of proved production and placed upon the map, which incidently shows all the wells that were completed at that time, placed upon that map the gross sand count that I found on each well that I had a log to determine it. Some wells, some of the older wells that were not complete logs run on them. That is from the top of the Cliff House to the Point Lookout and I was not able to obtain a sand count from those wells. Other logs have not been released to the log services, so I did not have them available. Those figures were placed on the map and then contour lines of equal thicknesses were put on the map based upon those figures. That is the gross sand count of which statistically I found 75 percent of that thickness to be net pay for reserves.

Q What is the variation in your net pay?

A It varies from --

Q (Interrupting) Indicate what point you are speaking of there now.

A We are speaking of the well in 32, Seven, Section 27, which I found to have 92 feet of sand count as a minimum. Highest figure I find right now is in Section 32, 30 North, 8 West, 328 feet, ratio of slightly over three to one.

Q That condition prevails generally throughout the entire area, does it not?

A Yes, sir, there are sink holes of low pressure.

Q You mean low thickness?

A Low thickness, I beg your pardon, in the field at various points. It does thin toward the edges, but there is still no place that is over three to one difference in thickness.

Q The fact that there is no area that you find that is more than say three to one in thickness, what does that indicate to you with respect to reserves in the field?

A Since that is the only variable that I used in my calculation, why I would say that the reserves of the field are not over, slightly over three to one in the proven area to date.

Q That is as, say between tracts? A Yes.

Q In other words, is this a correct statement of what you are saying, that the so-called better wells don't have more than three times as much gas under them as the so-called poorer wells?

A Yes, sir.

Q That is the best well in the field wouldn't have any more gas in place in reserve than three times the amount under the poorest tract of land? A That is right.

Q That is what you are saying? A Yes, sir.

Q In other words, the order of ratio is in the order of say, three to one? A Yes, sir.

Q That is considerably at variance with the order given here yesterday of some forty-six to one, isn't it?

A Yes, sir quite different.

Q Quite different. As a man experienced in calculating reserves in the San Juan Basin, would you say that based on the studies that you have made and determinations that you have made from those studies, that ratio as between reserves under the different tracts in the field are not very greater than the order of three to one?

A Yes, sir.

Q There has been a good deal of talk here about the big wells. As I understand, the way that term is being used it indicates that they have a very high deliverability. Is that the way you understand it when they speak of the big wells? A Yes, sir.

Q Of course, now, that means as big as compared to something else that is smaller? A Yes, sir.

Q When they speak of the little wells, they are talking about those wells that don't have as great a deliverability as some other wells? A Yes, sir.

Q Is that the way you understand it?

A That is the way I interpret the testimony.

Q What, in your studies, did you make any determination or can you tell us why you would have these so-called big deliverability wells. What causes it?

A I believe that it is fractures, man made or God, made by God.

Q Anyway, God started it? A Yes, sir.

Q Those fractures, I want this record to be pretty clear what we are talking about, are they just open spaces, or broken spaces in the pay formations? A Yes.

Q They are just cracks or open spaces in formation, that is what you are talking about fractures?

A Fractures, I mean a crack that extends some distance, variable distance, variable size, open spaces.

Q As a result of these fractures these wells are able to get what gas they have down there out faster than the so-called smaller wells, wells where the fractures aren't as great, or where the formation is a little tighter, is that correct?

A Yes, sir.

Q Does that indicate to you the fact that you have high deliverability, that there is a great deal more of gas in place, or reserves under a tract of land compared with one that doesn't have such a high deliverability?

A I don't believe that there is any more gas reserves in place appreciably under a well that has a high deliverability as compared to a well that has a low deliverability, with the exception of course in the crack you have a hundred percent porosity for that crack.

Q I see. It is true, isn't it, that the deliverability of the well not only in this area, but in any other area, may be increased by shooting or acidizing? A Yes, sir.

Q What does shooting do to a well?

A Shooting does two things to a well. One, it increases the size of the well bore, and secondly, it fractures the formation.

Q Yes. Do you have another method of doing that called sand-fracing? A Yes.

Q What is that?

A It is merely pumping down a light oil with sand in the oil and forcing it into the formation, forcing it to rupture the formation like the name implies, fracturing the formation and increasing the permeability, the sand stays in there and the oil comes back out. The sand pops open the cracks which you form.

Q Then you have the method of acidizing wells, is that true?

A Yes, sir.

Q What two methods of increasing the production from a well is employed generally in San Juan Basin?

A Shooting, and more recently, the sand-frac.

Q The wells in that area are most of them shot or sand fractured?

A To my knowledge with the possible exception of one well, they have all been shot or fractured.

Q All been shot or fractured, so that at the present time when we speak of deliverability on these wells, we don't have any way of knowing what their deliverability was at the time that they were first brought in or produced? A Before the shot or frac?

Q Before the shot or frac.

A Some operators make a practice of taking a gauge on the well at total depth. It is not entirely general, at least it is not reported in all the services, scouting services.

Q These mechanical means are just employed to increase permeability, are they not? A Yes, sir.

Q That is the purpose of them, is it not?

A Yes, sir.

Q Increasing permeability by any mechanical means does not increase reserves of oil or gas in place, does it?

A No.

Q Whatever God put there is just there?

A Yes, sir.

Q Whatever man does to it doesn't increase it?

A No.

Q Nor does it decrease it? A No.

Q Speaking about this sand-frac and shooting of wells, can you go to your map there and point out some examples of shots that have increased the deliverability of a well?

A By shooting?

Q Yes, or sand-frac, either one. Increasing the productivity of those wells by sand-fracing.

A There has been one well that I could get the records I have available which Phillips holds the twenty-five percent interest, and which has been sand-fraced, the El Paso 3-J Howell, in Section 11, 30 and 8.

Q Put a circle around that.

A (Witness complies.) My Exhibit does not show that well because it has been drilled since recent completion.

Q Yes, sir.

A Wherein there was a natural gauge taken in the Cliff House and the Point Lookout for a total of 163 M.C.F. The well was sand-fraced in both those formations at a three hour official test of three million seven hundred fifty-eight M.C.F. Shut-in pressure of

1085 pounds. Sand-frac increased the potential, or the productive ability of this well from 163 M.C.F. to three million seven hundred fifty-eight M.C.F.

Q That is a ratio of what? A Better than twenty to one.

Q Increased it better than twenty to one. Do you know of any other examples where that would occur or has occurred?

A Well, there are many examples of increases from shots. I have some --

Q (Interrupting) Could you give us just a few more?

A Phillips Petroleum Company 30-6 M Mesa-5-35 tested natural at total depth one million four hundred sixty M.C.F. per day. Official potential of four million one hundred ninety M.C.F. a day at the end of six hours. It was shot through the entire Mesaverde formation with 2,091 quarts.

Q What was the increase in the ratio on that well? What happened? What is the ratio there?

A The ratio there was about four to one.

Q About four to one? A Yes, sir.

Q In shooting throughout the field, do you maintain that ratio of approximately say twenty to one?

A It varies considerably. I just picked two at random here.

Q Give me just one more. Just put the bad ones in with the good ones.

A It is not that I am ignoring the bad ones. I just don't have much data here. As I said before, the operators don't always test the wells at the T.D., naturally --

Q What does your --

A (Interrupting) I am afraid I don't have it.

Q What does your data show the variation to be after shooting in the potential or the deliverability or productivity of the well? What will it range, from what to what?

A Well, the maximum would be 100 percent improvement, because there is some wells out here that produce no gas natural, that after shooting do produce gas.

Q You say there are some wells where when you drill them in they don't produce any gas?

A No measurable of gas.

Q Then you shut them? A Yes..

Q Then they will make producers?

A They will make producers. The minimum I have no figure on. I have not studied it.

MR. FOSTER: I believe that is all.

MR. SPURRIER: Mr. Barry, you don't mean 100 percent do you?

A Yes, infinity.

MR. SPURRIER: Anyone have a question of Mr. Barry?

MR. REEVES: I have a question.

CROSS EXAMINATION

By MR. REEVES:

Q I believe you testified that the maximum difference in reserves was three to one? A That is right.

Q Also believe that you testified that in your interpretation at sands, it varied from 92 to 320 feet of thickness?

A That is the maximum and minimum I could find.

Q That was a ratio of 3.56 to 1, is it not?

A I accept your arithmetic. I said roughly three to one, I intended to.

Q Those sand thicknesses were determined, were they not, primarily on core analysis in the eastern part of the field?

A My correlation to obtain pay count was mainly in the eastern portion of the field.

Q So that different engineers would probably arrive at different interpretations of the logs as to sand thickness, would they not?

A It is normal.

Q It is a matter of judgment?

A It is a matter of judgment.

Q From one. Did you, in taking into account the reserves underlying the well, take any other factors into consideration than sand thickness? Let me phrase the question another way, Mr. Barry. If porosity varied, wouldn't that also affect the reserves underlying the well site?

A If porosities varied, it would vary the reserves.

Q Your judgment is they don't vary, so you ignore that factor?

A I didn't ignore it. I took every data that I had and found it did not vary.

Q It is a difference of opinion as to whether it varies or not?

A I have no data to show it does vary.

Q What about the affect of variation in connate water, wouldn't that also change the recoverable reserves, given sand thickness, given porosity? A Yes, sir.

Q Wouldn't the difference of pressure also vary?

A Yes, sir.

Q In other words, so that if we arrive at a difference in possible porosities, difference in connate water, and difference in pressure, the possible pressure would be multiples of that factor?

A If I did or if we did?

Q If we did, or you did, or any engineer.

A Anybody that comes out with a different factor will come out with a different answer.

Q If there was a difference in porosity, if there is a difference in connate water, if there is a difference in pressure, the ratios and reserves under the well would be considerably more than three and a half to one?

MR. FOSTER: Depends on what order of the ratio.

A That is right, if you come out lower.

Q The point that I am trying to make is that an engineer examing the same data would, interpreting it different, would come up with a higher ratio from three and a half to one?

A No, sir, because I haven't any data that I didn't examine. If you have some data that has the things that you are talking about and, of course I haven't got them available, and you have and you use them, therefore you would come out with a different answer.

Q The point I am making, if I have the data, I could come out with a reasonably higher ratio under --

A Yes, sir, you could come out with higher or lower.

MR. FOSTER: Do you have that data?

MR. REEVES: Yes, sir, I testified about it yesterday.

MR. FOSTER: You didn't give it.

Q There is another question I would like to bring out. On your exhibit and interpretation taking sand thickness only into account, that the well that you pointed out happened to be in the area of highest sand thickness on your map. So deliverability on that is to some extent proportional on your map to variations in sand thickness?

A Could I have that question read back, or would you mind rephrasing it?

Q I will try to, Mr. Barry. The point I am making is, are you aware that the high deliverability well is also in the area of maximum sand thickness on your map?

A I am aware that the larger wells, the larger deliverability wells lie generally in the center here, that is where the majority of my three hundred, two hundred fifty plus feet of sand pay is.

Q In other words, there is some indication that the greater sand thickness increases deliverability of wells?

A Yes, permeability feet is the only thing you are talking about on what the well produces, and if you have got a thicker feet, same permeability, you would have a higher.

Q In other words, there is some relationship between deliverability and reserves there? We differ as to --

A (Interrupting) Yes, we differ as to degree.

Q That is right. One other question I would like to ask you, Mr. Barry. You testified that you threw out certain fractures and cores because they were actually core barrel fractures, mechanical fractures made in taking the core. Could you definitely state that a hairline fracture couldn't be made by core barrel action?

A No, I couldn't definitely state. I would say that it is unlikely.

Q In other words, we get to a matter of opinion of engineers?

A That is right.

Q Then one other question, I believe yesterday that my testimony I stated that we had not cored those wells because we drilled them with gas, isn't coring with gas relatively in the experimental stage and relatively a new development in the field?

A It is not, coring with gas is, well this field is all so new I don't know what it is relative to it. Most of the development has taken place over the last, the majority of development has taken place over the last two years, the most wells have been drilled. We cored wells with gas early in '53 which is a year ago.

Q Experimentally. In other words, that was about the first time it had ever been done? A That I couldn't say.

Q In other words, it was development of experimental and development. And it is not the practice --

MR. FOSTER: (Interrupting) That is another Phillips first.

A Mr. Reeves, --

Q Give Phillips a first on that, Mr. Barry.

A I do not know, I know it is not the practice to core the wells. I don't know whether that is a cost or --

Q Probably it is economic.

A What is the ~~cost~~ of not more of them being cored. Maybe people don't want the data.

MR. REEVES: I think that is all.

MR. SPURRIER: Mr. Smith.

By MR. SMITH:

Q Mr. Barry, in making your calculations of your net sand thickness, was that the phrase you used, net sand thickness of 75 percent? A Yes, sir.

Q I believe you testified that you eliminated from your calculations any sands having less than one-tenth of a millidarcy, is that right? A Yes, sir.

Q That measurement is the measurement applied to permeability, isn't it? A That is right.

Q And permeability is directly tied in with deliverability, isn't that right? A Yes, sir.

Q It is a major factor in considering your deliverability?

A Yes, sir.

Q The ability of the fluid to go through sand. Your elimination then of one factor has become the one controling factor in deciding whether or not it was pay or not pay was permeability?

A That was where I cut off point. It was down to that point that I felt that gas would contribute to the well.

Q In other words, if you have no permeability, you have no gas?

A That is right. Well, you have gas there, but you won't recover it.

Q In going into a matter from the standpoint of proration, aren't we concerned primarily with recoverable gas as distinguished from gas which cannot be recovered?

A I am a reserve man. I am not a proration man. Mr. Culender might be able to answer that.

MR. FOSTER: I have a man that can.

Q You know you can't answer it?

A I have called those proved reserves.

Q I beg your pardon.

A I have called them proved reserves, otherwise my experience and calculations that I made, I said the gas was going to get out of the ground.

Q You said, "I didn't quit".

A I intended for that gas not to stay in the ground, the amount that I have shown to be recovered here.

Q In making your determination, one of your basic assumptions was one factor alone, that is the lack of permeability, you would eliminate a certain percentage of the sand?

A That is true. Because permeability causes the gas to move, allows the gas to move. The lower the permeability, the higher the water, the less gas in there.

Q That is right. So having used that one factor as a basis for elimination of your sand thickness, isn't it logical to assume that permeability can also be a single factor contributing to the productive and the actual gas which you may recover?

A Will you put time in there?

Q I beg your pardon. A Will you put time in there?

Q I don't think time is a factor right now, since we are talking about reserves.

A You are talking about recoverable reserves.

Q That is right. A Time enters into that.

Q That is right, permeability affects your time as well as your ability to produce, but failure to have permeability eliminates it completely.

A Permeability eliminates what?

Q That is what you did when you made your calculation one-tenth millidarcy you eliminated that from the consideration?

A That is right.

Q You could take permeability on the other side and use that as a control factor to determine whether or not you had recoverable gas?

A I didn't do it. I said that is recoverable.

Q I asked you could it be done.

A Could you take your, what you are asking me, could you take the highest measured permeability, say at 200 millidarcy and say that is the only thing you are going to get gas out of?

Q No, I am saying that permeability could be used as a measure of the recoverable reserves as being a more allowable factor than perhaps some of the other factors taken into consideration in the absence of knowledge of the exact extent of the other factors.

A Yes, sir, it could be used. I wouldn't like the answer.

Q Mr. Barry, in making your calculations, I believe you testified that the net pay was, it was, was of a hetergenous nature?

A Hetergenous nature.

Q That means, as you said, I believe, it is all mixed up.

A Not the net pay.

Q The net pay is not mixed up?

A Not the net pay. You mean -- it is all mixed up.

Q Now it all being mixed up and there will be variances so far as porosity is concerned within your net pay and the taking of any arithmetical average, doesn't do justice to the true physical condition, does it?

A Yes, sir. I say it does.

Q That being the case --

A (Interrupting) I say it does do justice.

Q It does do justice? A Yes.

Q Let's say in a particular 320 acre unit you had an average porosity of 20 percent. If you take the entire field you have an average porosity of ten percent. That is what you have done, as I understand it, taken ten percent?

A No, sir, I haven't got the ranges like that.

Q You haven't what?

A I haven't found any area that has twenty percent porosity.

Q What is the figure you took?

A I took a ten percent which is an average.

Q Average of what? A Eight wells.

Q What was the lowest porosity in one of the wells contributing to your average? A 8.84.

Q 8.84. What is the highest? A 13.05.

Q Do you know of any wells in the field other than the eight that you used for your calculations?

A Yes, I have examined core analysis on other wells in the field.

Q What is the highest porosity that you have found on any of the cores that you have examined?

A I don't have that figure. I have got the average is all.

Q I know, but --

A (Interrupting) Average per well.

Q To go back to the question I asked you about the fairness of the arithmetical average, I think we should know whether there is a possibility that the porosity could be as high as twenty percent?

A May I correct you on one thing, on the arithmetic average?

Q I understand you to say arithmetic average.

A It was a weighted average, the number of samples from each well because of the hetergenity of the formation, if we had a lot of samples on one well, very few samples on another well, the few samples might not represent the total of entire well as much. So we weighed them by the number of samples.

Q Did you weight in each well or did you weight the eight wells?

A I weighed the eight wells. I just got through giving you the highest and the lowest for each well.

Q That was the average of high. Assuming that you have a sand thickness of 350 feet and your average is eight, whatever it is that doesn't mean that every foot as you go vertically in that 350 foot zone has eight and a fraction percent of porosity, does it?

A No.

Q In other words, you could have, say, fifty feet that would be as much as twelve percent, have fifty feet, be as low as maybe three or four percent in making your weightage, did you find such a discrepancy as that I described?

A No, we don't find any interval that has uniformly a high porosity. Or new interval that has uniform high, a low porosity. It is mixed up.

Q It is just mixed up all through there?

A One sample would have a twelve percent porosity possibly. The next sample a six percent, the next foot we sampled out of the next one at ten.

Q They vary back and forth?

A Varies back and forth.

Q Going back to our law of averages, isn't it quite possible that in some wells you could have a higher average throughout the entire interval?

A It is quite possible, but I have no data that shows that.

Q Now, Mr. Barry, I have been informed that the ordinary measure of the limits of the field is that the porosity and permeability pinches out, isn't that the usual idea as to the productive characteristics of this reservoir?

A I believe that the exhibit was put on the stand the other day by the Pubco organization, that showed that the sand was present at the outcrop as sand.

Q That is right. So that --

A (Interrupting) So I don't believe there is a pinching out of porosity and permeability.

Q Do you mean that you can draw a gas well over where it out crops? A I don't know.

Q Do you recommend to your company that they try it?

A No, sir, but it doesn't say there is any porosity and permeability there.

Q There is no gas there? A No, sir.

Q How do you account for the fact that the field is limited or stops some distance before the sand outcrops?

A That is a good question.

Q Well, do you have the answer?

A There is lots of reasons I can think of. One, there could be a water seal, that is you get the water, percentage of water high in the sand to your relative permeability to move by the gas or below. Therefore, you would not lose the gas. This is a subnormal pressure reservoir for its depth, some of the gas must have gone somewhere already.

Q Wouldn't also a decline in the porosity account for the fact that the gas isn't present as well as --

A (Interrupting) It could.

Q Since the weaker wells, that is the wells with the poorer deliverability, are at the periphery of the field, isn't it logical to assume that as you go towards the edge of the field you have a decline in your porosity, a higher percentage of connate water and other factors which result in non-production?

A Sir, you asked me which well had the highest porosity.

Q Beg your pardon.

A You asked me a minute ago which well had the highest porosity. I said 13.05. That is it in a, one well which is outside the field. It is the highest porosity.

Q Is there any production on the east of that?

A No, sir.

Q Isn't it possible that the field may go on for some distance the other side?

A It is possible that the field may go on in some distance in lots of ways in this, in any direction.

Q In other words, there has been no definition of the field over in that point. How about down on the south and west sides?

A I have no evidence whether it will or will not. This is so far away from the area I was studying, I don't have too much data on it.

Q Do I understand then, that the area you studied was confined to the eastern side of the field?

A The area I studied, the area for which my report was made, was somewhere in that nature. I had data over here both on cores and logs. I carried them on across.

MR. SPURRIER: For the record, how much of the basin was that? Your pencil doesn't show up in the record.

A I studied 473,545 acres.

MR. FOSTER: Out of how many? A Just a minute.

MR. SPURRIER: Let's take a short recess.

(Recess.)

MR. SPURRIER: Mr. Barry.

A I believe you asked me, the Commission asked me how many acres in my study, what percent of the total field I studied?

Q That is right.

A The gross acreage which Phillips has an interest under the unitization agreements and which my study covered, was 473,546.79 acres. The total area enclosed in my estimated limits of proved productive area is 779,157. Naturally in studying the units in which Phillips had an interest in, I had to study wells just outside those units to get control, so the first figure is on the low side. I studied wells in a larger area than that.

Q Is all of that acreage within the proven limits of the Blanco Field, or is it located elsewhere?

A It is located within the proven limits.

Q I don't believe --

A (Interrupting) Sir, I made a misstatement of fact a minute ago. Some of that acreage is not in the proven limits, by subtracting about four figures I could give it to you.

Q I think the Commission asked the question. Do you want him to subtract those figures?

MR. SPURRIER: If they are wrong we do, yes.

A The corrected figure of the acreage studied within the limits of proved production is 444,301.

Q Your study, however, is primarily devoted to the eight wells from which you took the cores? In other words, I would like to find out the scope of your figure. You studied 440,000 some odd acres. What was the nature of that study?

A The nature of that study was as you say, the eight wells with the starting point. Those were the wells in which I had the basic data necessary to get all the factors necessary to get the reserves, the porosity, the permeability, the water and the correlation between, to obtain a correlation of electric logs. Then that data correlation was applied to the rest of the wells.

Q Where were those eight wells located?

A One well was located in Section 8, 31 North, 7 West, one well was located in Section 29, 32 North, 8 West, one well was located in Section 35, 30 North, 6 West, one well was located in Section 22, 30 North, 5 West, one well was located in Section 25, 29 North, 6 West, one well was located in Section 21, 28 North, 3 West, one well was located in Section 21, 29 North, 4 West. I beg your pardon, 29 North, 3 West, one well was located in Section 20 of 27 North, 3 West. Eight wells.

Q Now referring to the well --

A (Interrupting) In Section 32 of 30 North, 5 West.

Q What was the average porosity in that well?

A That well was cored only in the Cliff House formation within the interval cored and recovered and analyzed. I had 23 samples which were greater than one-tenth of amillidarcy and had an average porosity of 11.02.

Q Let's refer to this well located at this point.

A That is in Section 21, 28 North, 3 West, which is the Phillips Indian B-1 of 78 samples, which I counted pay had an average porosity of 10.38.

Q Let's go back into the more or less center of the field here, let's have the porosity on this well.

A That is Phillips 30-6 Mesa 5-35 located in Section 35 of

30 North and 6 West. That well there was 152 samples that had an average porosity of 9.4.

Q Let's take this well up here.

A Phillips Mesa unit 32-7 No. 1-8 located in Section 8 of 31 North, 7 West, had 132 samples whose average porosity was 9.99.

Q Would you draw an assumption from that brief testimony that as you went to the west the porosity declined?

A My range on the three that I gave you was 9.point --

Q There were two at 9 point something, and --

A (Interrupting) Since this well only --

MR. FOSTER: (Interrupting) What well?

A Since the well in Section 22 of 30, North, 5 West which had 11.02 percent porosity and the highest of the four I just remembered was only for 32 samples, and only out of the Cliff House, and whereas the other wells were for samples from all three formations, I don't think that it is representative in answer to your question based on this alone.

Q How about this well here?

A This well has a higher porosity than the other two.

Q In answer to my --

A (Interrupting) Which is less than one percent of porosity. I do not think that is indicative that it is getting poorer as you go West, no, sir.

Q You don't consider then, that your sampling technique was of sufficient accuracy to establish that it was going poorer as you went west?

A I feel that the wells in which the ranges of porosity that I have, the wells that I used gave me a representative porosity, the range, the maximum and minimum are not too much, it does not tell me anything of a trend of porosities east or west or north or south.

Q Well, if it won't tell you that, would it also not tell you that the average porosity in all these wells are the same?

A Yes, sir. It won't tell me that the average porosity in all the wells are identically ten percent.

Q And you can't --

A (Interrupting) They will have the range of eight percent to ten percent, and in that variance.

Q I got the impression from your testimony that you didn't consider your sampling of sufficient accuracy to establish a trend, am I right?

A I don't believe this is a trend, no, sir.

Q Do you consider that your sampling is of sufficient accuracy to establish a trend?

A If there is no trend I can't establish one.

Q The reason for it is that you don't have sufficient sampling, is that correct?

A There is no trend.

Q No, you misunderstand my question. I am asking about your computation, not about your conclusion.

A I can't establish a trend that I don't know exists.

Q You have taken certain samples there and used them as a basis for making calculations. A surface impression from your sampling there would leave the impression that you had, it had a decline in the porosity as you went west. You say that your sampling was not sufficiently accurate to establish a trend and I am asking the question now, that being the case, is your sampling sufficiently accurate to establish anything?

A It is sufficiently accurage in my judgment. I have 757 samples.

Q From eight wells? A From eight wells.

Q How many wells in the field?

A Approximately 600, 700.

Q 704 I believe was testified to yesterday.

A I will accept your figure.

Q Would you consider that samples from eight wells in the northeast portion of the field and down in the east border, to be representative and to afford sufficient information to establish the porosity for the wells in the rest of the field?

A I believe I testified on direct examination that I had available core analysis in this area.

MR. FOSTER: What area is that?

A That is the central portion of the field.

Q I don't believe you testified as to the highest porosity you found in those core samples? A No, sir, I didn't.

Q Do you know what that is?

A I know some averages is all that I have with me. I have the complete data in my office in Bartlesville. I have core analysis on a well in Section 19 of 30 North and 9 West, whose average porosity of all the coresanalyzed in the Cliff House and Point Lookout formation of 9.4 percent, identical to the 124 miles east that we just talked about.

Q Do you have any others?

A I have an analysis on a well in Section 29, 31 North, 9 West whose average porosity of all the samples analyzed was 6.3. I do not recall whether that well was analyzed by the same laboratory that analyzed the rest of them. I do know that the 9.4 was done, was obtained by the same laboratory that obtained the majority of the core analyses.

Q Do you know how many samples were taken in each of the two wells and from what area?

A In the well in 19, 30 and 9, there were 222 samples. In the well in 29, 31, 9 there were 138 samples, both wells were cored only in the Cliff House and the Point Lookout formation. Not in the Menefee.

Q Not in the Menefee? A No, sir.

Q Coming back to the question I asked you awhile ago, what is the highest average porosity that you found in any of the wells in which samples were taken?

A That was 13.05 on the Phillips Indian 1-A for 76 samples, that well being located in Section 21, 29 North, 3 West.

Q Does that include all of the samples which you analyzed, that was one of the, I believe, is that the highest core analysis percentage that you found in any of the cores you examined in the entire field?

A Yes, I believe it is.

Q What is the lowest that you found on the average?

A That was, I believe I just read, 6.3 on the well in 29, 31, 9, that being the lowest.

Q That would establish an order of magnitude of a two to one diferential then in the average porosity?

A Yes, sir.

Q A little in excess --

A (Interrupting) Those two figures, so multiply up.

Q Wouldn't you consider it to be reasonable in establishing the reserves, since porosity does have a direct connection with the reserves, to consider the possibility of a two to one differential in addition to the three and a half to one which you testified concerning your net pay?

A Knowing what I do about the 6.3 which is the lowest one, I don't know that that would apply, in that I don't know that it was done under the same method that the rest of them were. It wasn't my core analysis, my company's core analysis. If that is true, if that is the porosity average of that well, there appears to be 6.3 average there, a 13.5 there. That figure though, of 6.3 was every sample analyzed in that well. It is not within a pay count, so if you are thinking that the things that you would not count, call pay as being lower porosities, which is taken out of this figure, when you got the average and still remain in this figure, because I just took the total, I can't say that there is a two to one there.

Q Well, assuming that those conditions were more or less similar and since we were working in averages anyhow, wouldn't it be a reasonable assumption for the Commission to make here that you could have as much as a two to one differential in the porosity? In your opinion, don't you think that there exists in this field out here areas where your porosity in a particular well is on the order of two to one higher than in other wells?

A In what we want to call as pay?

Q In what we call as pay, that is right.

A I have no data for that.

Q I am asking your opinion based on your knowledge and the study that you made.

A My opinion is based on the data I have and the study that I made.

Q I was under the impression that you made it in a -- based on core and --

A (Interrupting) I haven't got anything to substantiate the question you asked.

Q Wouldn't it be substantiated by the knowledge of the core data? A There is a two to one?

MR. FOSTER: You want him to base an answer on something he doesn't know about.

MR. SMITH: I think he knows about it, Judge.

A I said the 6.3 was not comparable to the others, I have no data to substantiate that.

Q Taking the other data, you would at least concede that it is on the order of one and a half to one?

A Definitely that, that the porosity well by well shows from the data that I have here, .. I have there that it varies.

Q And due to the variance in samples that were taken, some of them not being taken in certain locations, some of them just in the Cliff House, that it is quite possible that it could be even higher than that, isn't that correct? A No, sir.

Q You don't think it is?

A I have nothing to think that it might be higher than that, no, sir.

MR. FOSTER: Are you asking that could he think it was higher?

MR. SMITH: I am asking him a reasonable assumption. If it is not a reasonable assumption.

A I don't think it is a reasonable assumption.

Q Let's discuss connate water. I believe you testified awhile ago that a possible reason for the limit of the field here is the existence of connate water, water saturation?

A Yes, sir. Somewhere in the reservoir. I don't say this is the ultimate limit of proved production in the San Juan Basin. That is not that line around it. The ultimate as presently proved.

Q You have something on here that says estimated limits of proved production.

A As of August 1st, 1953.

Q That is right. Now as of that date, there being shall we say, let all wells around the side which would lead people to believe they had got to the edge of production.

A That was not my assumption. That is my estimated limits of proved production, proved by well. It has been changed in the last year by wells being drilled outside that line.

Q Well, the existence of connate water has a direct relationship to the quantity of reserve? A Yes, sir.

Q If it is occupied by water, it can't be occupied by gas?

A Yes, sir.

Q Have you run any samples or have any knowledge or information with respect to any of the wells cored, or any of the other wells in the field with respect to the existence of connate water?

A Yes, sir, that is how I got my factor of 30 percent.

Q Thirty percent of what?

A Floor space, thirty percent would be filled with connate water.

Q Does that vary from well to well?

A The connate water, average connate water in Phillips 30-6 Mesaverde 5-35, located in 35, 30 North, 6 West, had a connate water of 30.28 on the samples counted as net pay. The well Phillips Mesa Unit 2-29 located in Section 29, of 32 and 8 had a connate water content average eight samples counted, 24.9.

MR. FOSTER: How far apart are those two wells?

A Twenty to twenty-five miles. The Phillips 29-6 Mesa Unit 30-3-25 located in Section 35, 29-6 had an average connate water sample in net pay of 29.09.

Q What is the --

A (Interrupting) That is all the connate water data that I have on the Phillips wells. That averages 27.89 for the three wells, the value I used for the field was 30 percent. I was just a little bit conservative.

Q Do you have any information on any wells besides the three wells with respect to the content of connate water, in order to shorten the process a little bit, if you have the information, what is the highest percent and what is the lowest percent.

A I have it on the two wells that I gave you on all the samples run again which is every sample regardless of porosity and permeability, which is high because the lower permeability always has more water in it, the samples are 37.9 on the well in 19, 30 and 9.

MR. FOSTER: Whose well is it?

A El Paso Natural Gas. And all the samples in the well in Section 29, 31, 9, averaged 31.7. That is the well that had the lowest porosity.

Q Are those the same three wells or are they additional wells that you first talked about? How many wells altogether do you have information on with respect to connate water?

A Right here and now I have information on Phillips three wells and two foreign operated wells.

Q You don't have any information as to what the connate water may be in other wells in the field aside from those that you just testified about?

A Not with me. I might have one or two more.

Q Do you have any knowledge or recollection of the discrepancy or disparity between the connate well from the highest well to the lowest well that you know of?

A None other than these comparisons.

Q What is the order of magnitude with respect to displacement represented by your highest and lowest figures?

A The lowest figure there was 24.29, the highest --

MR. FOSTER: (Interrupting) The lowest figures where?

A The lowest connate water percentage on any well was 24.29, comparably highest connate water on any well was 30.2-8.

Q Would you answer my question?

A The difference is six percent.

Q Is that six percent factor --

A (Interrupting) Six percent connate water.

Q Six percent difference in displacement by connate water?

A Yes.

Q Going back to the question, changing the subject a little bit, going into the question of sand-fracing.

A Yes.

Q And acidizing, which I believe you testified resulted in increasing materially the deliverability of certain wells, I take it as a basic assumption of your testimony that you are assuming that conditions are equal in respective wells. In other words, that that is the sole cause of the increased deliverability?

A That is all you do to the well. You test it naturally, the T. D. tests so much.

MR. FOSTER: What is the T. D., total?

A Total depth. You test it, then, and you have so much gas. You sand-frac it and test it again and you have additional gas.

Q Have you observed the production history of a well which has been so treated over a period of months or years?

A No, sir. It is rather new.

Q You would anticipate that if the sole cause was due to the sand-fracting or acidizing, that there would be a rather marked drop in the pressures? In other words, you would get back down to the original pressure as soon as you had exhausted the gas, so sand-fracted or acidized.

A That is a rather long question. I will attempt to answer it. Unless you want to rephrase it and shorten it up one phrase at a time.

Q Well, briefly stated, perhaps I might be able to state it more briefly. A well that has been acidized or sand-fracted resulting in higher deliverability should not continue on that higher deliverability for a considerable period of time.

A Is that a question?

MR. FOSTER: Are you testifying or is that a statement?

Q I am asking a question, if that is a reasonable assumption.

A No, sir. The decrease in that deliverability will come about through decrease in pressure. The decrease in pressure will come about through percentagewise depletion of reserves. It depends upon your reserves how fast that deliverability comes down and not on anything else.

Q So that if you found a well to continue to maintain this high deliverability over a period of a year or two years, you would naturally assume that it had greater reserves?

A Or drainage area.

Q Well, we are assuming that this man-made condition is limited to the extent --

A (Interrupting) I am not, maybe you are.

Q I was making that assumption, you weren't apparently.

A I don't know.

MR. FOSTER: That is a little argumentative it seems to me. I don't object to him asking the question, but now he has had an undisclosed assumption here it appears in the question that he asked.

MR. SMITH: Would the witness like to correct his answer?

MR. FOSTER: No, I would like you to state what your assumption is. He will answer the question if you can ever get it up there. You got something in your hip pocket, why get it out. He will answer the question for you if you will get it up there.

MR. SPURRIER: Let's recess until 1:30.

(Noon Recess.)

AFTERNOON SESSION
June 22, 1954

MR. SPURRIER: Come to order.

W. E. B A R R Y

being previously duly sworn, testified further as follows:

By MR. SMITH: CROSS EXAMINATION (continued.)

Q On the spread in the connate water in the three, four or five wells that you looked into, as I recall it, it was between 24 and around 37 percent?

A I gave you such a spread, but they were not comparable, Mr. Smith, in the fact that one of them considered all samples that were taken, the other, that was the higher value, the 37 percent, the other consisted only of those portions that I considered pay.

Q What was the spread in the others?

A The spread in the two comparable figures were from 24.29 to 30.28. That was, I think, we went through that, that was a difference of 6 percent connate water.

Q The differential would not be 6 percent by volume, it would be the differential between 24 and 30 percent?

A The difference between 70 percent and 86 percent.

Q Roughly in the order of magnitude between the two by comparison of about a third increase, or would it be on the order of one and a half to one?

A It would be a difference of 6/70ths. It would be 22.8.

MR. GRENIER: I didn't understand, that was the difference between 24.29 and 30.9?

A 30.8 was the other figure.

MR. FOSTER: What is the difference you gave there?

A That would make a difference in your reserve of whether your gas space was 86 percent or the one minus the connate water, 86 percent on the --

MR. GRENIER: 76, would it not be? I couldn't follow your figuring there.

A 6/70ths. It would be in the neighborhood of 8.6 percent.

Q Is that your final answer now? A Yes, sir.

Q Do you know whether or not certain of the wells over in the northwestern, up in the other side of the Animas River, run as high as 60 percent water saturation? A I don't know.

Q If that fact were true, would it make a difference in the results of your study? A Yes.

Q It would tend to show a large disparity with respect to reserves as constant with the area where you have less connate water?

A If that was the case, yes.

Q Going back to your study, as I understood it, you took the eight wells and from it made certain assumptions, am I correct, and applied that to the 440,000 acres that were under your study?

A From the eight wells I didn't make any assumption. From the eight wells I got the basic data that allowed me to go on.

Q In other words, you arrived at a formula from the eight wells?

A I arrived at a formula. No, the formula is the same in every field. No, I arrived at the basic factors from the core analysis to base a formula.

Q You applied your formulas then, as far as your study, too?

A That is right.

Q Wouldn't you say your study wasn't as much a study of the 440,000 some acres as it was of eight wells?

A No, I would not say.

Q If the assumption of the factors being constant throughout the 440,000 acres, isn't it a necessary incident of your study?

A I used the factors that I obtained from the eight wells as representative of all the wells in the field, yes.

Q What is the permeability in the eight wells that you studied?

A The average was .54, .54 millidarcys.

Q .54 millidarcys. Do you know what the maximum millidarcys may be in any of the wells in the field?

A I believe I testified this morning that I felt that the maximum was varied from practically nothing to fifteen.

Q To fifteen. So that the eight wells you took were not the arithmetical average of the spread and could be considered actually poorer wells?

A I did average that fifteen in, the highest one with the lowest one and got the average of 5544.

Q That is the average of the eight you studied?

A Yes.

Q Noticing that they have up to fifteen millidarcys in the field, it is obvious that there are certain wells in the field which are considerably higher than the average of the eight that you took?

A I don't know that to be the case, no.

Q Isn't permeability the main factor in determining the probability of the gas? A It is a factor, yes.

Q Would you say it is one of the chief factors?

A Well, we got to stick time in there. Are we talking about equal time?

Q No, I am talking about recovering the gas over a period of exhaustion to exhaustion of the reservoir.

A To exhaustion of the reservoir?

Q Yes. A I don't think it is.

Q In other words, it is just a question of time, in your opinion, is all it amounts to?

A It is the product of permeability and time.

MR. SMITH: I believe that is all.

MR. SPURRIER: Anyone else have a question of Mr. Barry?

MR. HOWELL: Ben Howell, representing El Paso Natural Gas Company.

By MR. HOWELL:

Q Mr. Barry, this isopachus map which is Phillip's Exhibit No. 1.

as I understand, was constructed by you from the results of your reserve studies which you have outlined, and does that map show the gross sands or the net pay sands? A It shows the gross sands.

Q It shows the gross sands, so the thicknesses of sands as shown on the Exhibit 1 would be reduced by 25 percent to reach the net pay sand? A Yes, sir.

Q The figure that you took, the arbitrary figure of 75 percent is one which possibly another engineer might have said that maybe 85 percent was the figure. Another might have said 50, is that correct? A No, sir.

MR. FOSTER: I object to the question because it assumes that he said he had taken an arbitrary figure and he didn't say any such thing.

Q How did you take that figure of 75 percent and apply it to every sand in the field?

A I found in the wells that were cored, the intervals that correlated between the core analysis and the gamma ray logs to pay that 75 percent of the samples within that interval contained permeability greater than one-tenth of a millidarcy. Twenty-five percent numerically of those samples means a permeability of less than one-tenth of a millidarcy.

Q So that your 75 percent figure was based purely upon the cores taken from eight wells. That is the basis that you used your 75 percent figure from, is it? A Yes, sir.

Q And someone else in estimating net pay might determine that permeability should be set at a higher figure, in which case the net sands would probably be less, wouldn't they?

A Yes, sir, they could do that.

Q And the estimates which result tend to be liberal, or tend to be conservative according to the method which is used, is that correct?

A You mean you are asking me whether I think mine is liberal or conservative?

Q No, I am just saying that by another set of samples giving a different figure would result in either more liberal or more conservative estimates for the sand thickness in the field, would it not?

A You took another set of samples you would get a different answer, yes.

Q Different studies would have some variations depending upon the basis that was used in selecting the net pay from the gross pay?

A Yes, sir. Do it a different way you get a different answer.

Q However, if the same method is used consistently, why there is a degree of relationship that is consistent within that particular method. Maybe I don't make myself clear here, but suppose someone else used a method whereby they came out with a different net footage, nevertheless that method would indicate somewhat the same relationship between thick sands in one locality and thin sands in another as is indicated by your method, wouldn't it?

A It would depend on how they did it. I don't know how they are going to do it.

Q Suppose somebody used 50 percent instead of 75?

A They would cut the plat 50 percent over the entire area, you would have 50 percent on the east and 50 percent on the west if they did do it that way.

Q You have a bottom cut of point of net thickness of 92 feet, I believe?

A That was, I believe, I read a figure of 98 being the lowest gross sand thickness of any well that I had counted the pay on.

Q There are wells that are completed in the basin that are completed in a net pay thickness of less than that, aren't there?

A To my knowledge, no.

Q You don't know of any?

A I have none so indicated.

Q The quantity of reserves that is in place is the quantity that can be estimated by different methods, I believe you have testified one of them is the volumetric?

A Volumetric method is all I have testified.

Q Way of estimating the reserves. Actually in practice, it is possible to recover only a portion of those reserves, isn't it?

A Of the reserves in places, yes, sir.

Q So that the net recoverable reserves are not necessarily, in fact would be less than the necessary reserves in place?

A The net recoverable reserves would be less than the reserves in place.

Q And one of the factors which makes reserves recoverable is the permeability that exists through fractures, whether existing in the structure or made by man, isn't it? A Yes, sir.

Q There will be more net recoverable reserves in an area which by reason of fractures there is movement of gas into the well bore?

A Are we sticking time on here now?

Q No, I am just saying that --

A (Interrupting) Then, I say no, sir, there will not be.

Q In your opinion the well that has a fracture area around it in which there is a surface that the rock touches in many places there and feeds into the well bore, will not produce a larger percentage of those reserves than one without those fractures?

A An infinite time, no.

Q What would be the period of time?

A I don't know.

Q You don't know? A No.

Q Whether or not it would be economical to produce all of those reserves in the absence of either God-made or man-made fractures, you wouldn't purport to say?

A In the absence of God-made or man-made fractures. I think in the absence of God-made or man-made we wouldn't be developing the San Juan Basin, any of it.

Q The result that has taken place has resulted in all but one well being fractured by shooting or by the sand-frac method?

A That has been the customary, I could think of only one well that I wasn't sure was either shot or sand-frac.

Q So insofar as the man-made provisions, those wells are all substantially on the same basis. They have all used one or the other of the accepted methods of making fractures around the well bore?

A With some degree of efficiency, they have. Yes.

Q The greatest percentage of increase resulting from either shooting a well or sand-fracting a well is with the wells that are small initially, isn't it? A I imagine so.

Q You sited one well that I believe had an I.P. of somewhere around 150,000 that your testimony showed had been increased twenty-fold?

A Yes, sir. The El Paso No. 3 J. Howell.

Q Do you know of any well that had an initial potential of two million that has been increased 40 million?

A I do not know that here, no, sir. I would have to check.

Q That would be such an unusual thing in the field you would, probably would have noticed it, wouldn't you, Mr. Barry?

A No, sir.

Q You mean that 40 million foot wells are commonplace up there?

A What I mean, I know there is few 40 million foot, 40 million foot wells. 30 is more --

Q (Interrupting) You haven't looked up to see what they were, naturally?

A No, sir.

Q As a matter of fact, with your own experience and your own company haven't you discovered that if the well has a good natural flow test that the percentage of increase generally is less by reason of shooting and sand-fracing than the well that has the low natural flow?

A I haven't observed that, no.

Q You haven't made a study on that point?

A I haven't made a study.

Q With reference to the eight wells that you took cores, I notice there is one well, the Indian well, which is outside the line that you give as the boundary of the Mesaverde production. I would assume from that either that the well was a dry hole or non-commercial?

A The well, the Indian 1-A was completed with a small I. P. and made a little bit of water. I did not feel that I wished to extend my limits over beyond that well. It was drilled, well mud could be a mechanical happenstance, but I felt that I was conservative by keeping the limits of production inside of that well until we had further development.

Q So that so far as you are concerned, you wouldn't count that well as being an extension of the field at the present time, or commerical well?

A That well was completed at the time that I put the limit on there, so it was before that.

Q I believe the San Juan 328 Mesa 2-29 was another well that you testified about, wasn't it? A Yes, sir.

Q Has that well been completed?

A I don't believe it has been officially tested, no, sir.

Q The San Juan 3727, the Mesaverde No. 8 was another, I believe? A That is right.

Q That was plugged back to the Fruitland and not productive in the Mesaverde, wasn't it?

A It was a mechanical failure in the Mesaverde, we have drilled another well in another section and successfully completed a commercial well. It was drilled with mud.

Q The 35-5 unit, Mesa unit 1-22, do you recall what the initial potential was on that well when it was completed?

A I do not. It was drilled with mud. I don't expect it to have been as high as if it had been drilled with gas.

Q Would you say that probably 2,800 potential was somewhere around high?

A If that is your figure I will accept it.

Q Assume it that the figure was copied from the Commission records.

A It was a small well. It was drilled with mud rather than gas.

Q Your Indian 1-A Well is, I believe, another one that was cored?

A That had an initial potential, I believe, of 426,000.

Q That is the one we were talking about just a minute ago? Is that the Indian 1-A which is outside?

A Yes.

Q What about Indian C?

A It was drilled with mud, cored, it is outside too.

Q So that --

A (Interrupting) Temporarily plugged and abandoned.

Q So that at least four or five of those wells are wells that are either non-productive for one reason or another, or hardly counted as commercial wells, is that correct?

A Non-productive or hardly counted as commercial wells?

Q Yes.

A Well, we have gone over them and I have told you what the status of each one is. The C-1 is plugged, the A-1 is a producer, small producing well, the 229 has not been tested, the 1-B was a mechanical failure. I think it is obvious that what you say is true.

Q The studies which you made with reference to reserves covering some 440,000 acres, of course, included acreage that other people owned that was checker boarded along with that of Phillips?

A It was the total gross acreage in those units.

Q You studied generally the northeastern and eastern fringe of the field there?

A I studied the northeastern and the eastern half of the field, would be better than the fringe.

Q Generally speaking, as you approached the flanks or the edges of the field, the potentials and deliverability of the wells are lower, isn't it?

A Generally speaking, no. The potentials or deliverabilities of some of the wells in the middle of the field are just as low as the wells on the outside.

MR. FOSTER: Lower.

A Lower too.

Q I believe on your Isopachus map you showed some areas that you call sink holes. What do you mean by that?

A I mean that for a small area the thickness was less than the surrounding well.

Q That is that within the center of the field there would be places in which you would have thin sand sections, relatively thin sand sections?

A No, sir, I wouldn't say that. For example, a general term I use as sink hole, I point to an area of one well.

MR. FOSTER: Where is that?

A In Section 13 of 30 North, 9 West. Which is geographically about in the center of the field. That well has, by my calculations, has 220 feet of gross sand. Immediately surrounding that each well has better than 250 feet. Since this is a 50 foot contour map, I have to show that that area is slightly less than 250. It is not thin only in the fact that it has got 30 feet less than the next well to it.

Q It is thinner than the sand surrounding it?

A Yes. But it is not the thin, well I wouldn't call it thin, 220 feet. It is 30 foot thinner than the ones around it.

Q There are various spots throughout the entire field in which you find areas in which sands are thicker than surrounding sands, and areas in which sands are thinner than surrounding sands, isn't that true?

A It varies from one to three and a half throughout the field.

Q And the depth of the sand generally tends to be thicker toward the center and northeastern portion of the field than it does towards the flanks, is that correct?

A I don't know what you mean by depth of it. The thickness of the sands tends to be thicker toward, I have lost you-toward where?

Q I said, the central and northeastern portions of the field.

A That is pretty broad. I have the intervals of 220 foot and greater thicknesses.

MR. FOSTER: Locate yourself on the map.

A Generally in the south half of Township 31 North, 10 West, North half Township 30 North, 10 West, all of Township 30 North, 9 West, South half of 30 north, 8 West. North half of 29 North, 8 West extending then into the West half of 29 North, 7 West and 28 North, 7 West. Generally in that area all of 250 feet gross sand thickness or better. That is the thickest part. Now, that isn't the Northeastern part as you so described it. It just seems to generally run through there.

Q What interval did you use on your contour lines, 50 foot?

A Yes, sir.

Q And the map is drawn showing the variations of 50 feet?

A Yes, sir.

MR. HOWELL: That is all. Thank you, Mr. Barry.

MR. SPURRIER: Anyone else have a question of Mr. Barry?

MR. GRENIER: I have got one.

By MR. GRENIER:

Q Mr. Barry, in the course of your studies, have you attempted to arrive at an average sand thickness through either the field as delineated by you on the map as of last August, or in this 400 odd thousand acres which you studied?

A Yes, sir, that has to come as an average of, the average, pardon me, did you ask for sand count or pay thickness?

Q Either one.

A The average sand count perimeter of the Phillip's portion was 176 feet. Perimiter.

Q 107.6?

A 176, that is the weight by the amount of acreage in each unit which we buy the percentage that we have in that unit.

Q Did you attempt to arrive at any such average for the field as a whole or for the remainder of this 444,000 acres which you said were under your study, and which were not particularly Phillips acreage?

A The average sand thickness of the entire field including Phillips 195 feet.

Q Are these figures which you have given me on the same basis as the Isopachus lines -- A (Interrupting) Yes.

Q Same as shown on your map? A Gross sand.

Q This is gross sand count. What is the variance from that average either upward or downward, which you encountered as far as individual portions of acreage are concerned?

A Testified this morning, I believe, that the lowest well was 98.

Q That would be about half of the average then, is that correct, for the field as a whole?

A Approximately half, slightly more than half.

Q The maximum was --

A (Interrupting) 328, I believe.

Q I had a figure of 353, I don't know where I got that. That then, is about 75 percent over?

A Your 353, or which figure are we talking about now?

Q Well, we are about down to 328, that relationship is --

MR. FOSTER: (Interrupting) We are not back down there. We have never been above it.

A I accept your records.

Q Do you have any opinion, Mr. Barry, as to whether or not this is a continuous reservoir? A Yes, sir, I believe it is.

Q You believe it is, you have an opinion and your opinion is that it is a continuous reservoir? A Yes.

Q Despite the mixed up character of the formations that you have testified to?

A I testified to their mixed up nature only as that it was not a uniform thickness of good porosity and uniform thickness of, layers of or beds of uniformly good porosity and poor porosity. I didn't intend that there wasn't an inter-connection between all those beds.

Q Yesterday we heard Mr. Gorham testifying that it was very difficult, if not impossible, to trace individual producing sand members from one well to the next. Would that lack of traceability be of importance in your mind as far as the validity of this opinion of yours that they are all inter-connected?

A It is a difficult problem I will agree with the gentleman, but I think it can be done on the Menefee sand members.

Q You indicated that the fracturing which you found, and the cores you examined were both horizontal and vertical?

A Yes, sir.

Q Would the presence of vertical fracturing tend to assist in the flow from one well to the next, or one location to the next, of gas so as to permit greater interflow of gas from one drill site to the next?

A If it extended across there, yes, sir. It would provide a conduit bed whether vertical or horizontal to the other layer.

Q So that the vertical fractures would assist in letting gas move between the more important horizontal ones. We might --

A (Interrupting) The vertical fractures would assist the gas to move to them, then vertically to a horizontal fracture, or conduit bed, which I described as being higher porosity and thence to the well.

MR. GRENIER: That is all.

MR. SPURRIER: Anyone else. Mr. Arnold.

MR. ARNOLD: I have a question.

By MR. ARNOLD:

Q I believe you said that you correlated the gamma ray logs with the core?

A Yes, sir, I prepared core graphs. That is, I plotted the core analysis alongside the gamma ray neutron, gamma ray induction, all the types of logs I had on the cored wells.

Q You arrived at a line on the gamma ray induction log one side which you counted net sand and the other side you threw out?

A That is right.

Q Do you know about what the actual value on the induction log would have been?

A On the induction log. I could find no correlation on my induction log with my correlation.

Q The line was on the gamma ray log?

A It was on the gamma ray log.

Q About where did it fall on the gamma ray?

A It fell close to 50 percent. I used on wells where I did not have cores between 40 and 50 percent, being a little bit conservative, but on the cored wells, it fell about 50 percent of the distance between the average shale line and the maximum, the minimum gamma ray reflection.

MR. ARNOLD: Thank you.

MR. MAXWELL: Mr. Maxwell with Pubco. I have a question.

By MR. MAXWELL:

Q Are you aware of the different sensitivity used on gamma ray neutron logging units throughout the basin?

A I am very aware of it.

Q Did you take that into account in your study?

A Yes, sir.

Q What did it show with respect to your shales interbedded with your sand? In other words, would a low sensitivity deaden your shales and tend to mask the shales as sand?

A Your small stringers of sands in this reservoir are almost impossible to delineate without a core analysis. All we obtained from a correlation was gamma ray logs are the thicker sand bodies.

Q So it is possible to have interbedded shales that were counted as net sand, but actually were shales?

A No, I didn't say that. I said in the sections where you had thin, relatively thin sands it is impossible to count them, and they are not counted in this.

Q How about in your thick sand sections, could you have thin shale beds that were counted as sands --

A (Interrupting) I don't believe I have, no, sir. I am speaking mainly of the interbed shales and sands in the Menefee section.

Q Are you aware that there are quite a number of high productivity wells in the basin that have not been stimulated by shot or acid or --

A (Interrupting) I recalled of one in my mind this morning. I don't know of any other.

Q I believe there are four that Pubco has an interest in in the basin, the Turner State 1 was not stimulated. Pubco State 16 was not stimulated.

A That was the one. I did not know that.

Q Another one of high revenue and fairly good I. P. and deliverability was Pubco Hamilton Federal 2.

MR. GRENIER: What is the question?

MR. MAXWELL: I was questioning the witness if he had --

A (Interrupting) I did not know that. I said I remembered only one well that was not shot.

MR. MAXWELL: Thank you.

MR. SPURRIER: Anyone else?

MR. SELINGER: May I ask a question or two, please?

By MR. SELINGER:

Q Mr. Barry, I believe this morning you gave some illustrations of the artificial stimulation by shooting or fracing of wells and you mentioned, I believe, two or three. I want to ask you as a reservoir engineer, is the ability of those wells to produce after the shot or fracture related in any way with the reserves of those wells?

A I do not believe it is, no.

Q Also this morning you testified at great length about reserves from the outset, I would like to ask you when you talk about reserves, are you talking about reserves in place or recoverable reserves? A Recoverable reserves.

Q You are talking about recoverable reserves?

A Yes.

Q In your study as a reservoir engineer of this field, are there any variations in reserves anywheres in the field that reach a ratio of as much as 33 to 1? A No.

Q In your study as a reservoir engineer, are there any variations in reserves that reach as much as 12 to 1?

A No, sir.

Q As a matter of fact, you testified this morning that in your study from the data that you have available, that in your opinion the reserves did not vary more than three to one anywhere in the field?

A Yes, sir, that was corrected.

Q To three and a half? A To three and a half.

Q So with that correction, nowhere in the entire reservoir there from the information that you have secured, from the data that you have available as a reservoir engineer, there is no variation of reserves anywhere in that field greater than three and a half to one?

A No.

MR. SELINGER: That is all.

MR. SPURRIER: Mr. Utz.

By MR. UTZ:

Q Mr. Barry, I think you answered this question, but I wasn't entirely clear. In your opinion the fracturing in cores that you studied, did you contribute any additional reserves under that acreage due to fracturing? A No, sir.

Q On your Isopachus map up there, or your reserve studies if you have them, what do you believe the maximum variation is between offset wells as to either gross sand, net sand or reserves?

A The greatest difference between offset wells that I know of after a study of the Isopachus map, is between the well located in Section 5, 29 North, 8 West, which has 211 feet of sand count and the well located in Section 7, 29 North, 8 West which has a sand count of 351 feet.

Q 351?

A 351. Those wells are about a half a mile apart.

Q That is the variation considerably less than one to two, isn't it?

A Yes, sir. The relationship is two to three and a half.

Q You may have answered this question, I believe it was asked of you shortly before lunch. I was busy and didn't get back right after lunch. I believe you were asked if a high maintained or a consistently high deliverability necessarily meant a high reserve.

A I think all the evidence indicates that it does not. That high deliverability does not indicate high reserve.

Q Do you have an opinion as to why a well with a consistently high deliverability would maintain that high deliverability?

A Deliverability depends on pressure. If there is enough reserves there through your production, you don't reduce the pressure very much, why your deliverability won't be reduced.

Q But if it didn't have the reserve, still maintained a high deliverability, why would it do it?

A It must be draining from a larger area.

MR. UTZ: That is all I have.

MR. SPURRIER: Mr. Maxwell, may I have a list of those non-stimulated wells?

MR. MAXWELL: Hamilton Federal 2. Pubco State 18, Turner State 1, the other one I never did --

MR. SPURRIER: You got cut off.

A It is not in the basin proper, it is our Russell No. 1 which I don't believe we could call stimulated. It is in the Mesaverde formation. It is not in the Blanco-Mesaverde Pool.

MR. McGRATH: Oil and gas Lamb No. 1, it is in Section 21.

MR. SPURRIER: Is that Glenn River?

MR. McGRATH: Wood River.

MR. WEIDERKEHR: Southern Union.

MR. SPURRIER: Any one else have a question of Mr. Barry?

MR. FOSTER: I have one on re-direct examination, if I might.

MR. MACEY: Would you wait for me?

By <u>MR. MACEY</u>:

Q In connection with the data which you used to determine the average porosity and the average connate water and so forth in the field, as I understand it, you used eight, the cores from eight Phillips wells, is that correct? A Yes.

Q Do you know off-hand how many wells in the field have been cored, the total number?

A I haven't got the figure. I would say probably somewhere in the neighborhood of twelve wells other than our eight. I could be wrong.

Q In addition to your eight, how many other wells did you use core data on?

A The purpose of my report was to prepare the reserves of Phillips. I used only the Phillips wells because they were the only wells on that acreage. I carried the thing across the field with that correlation. Later I checked on the core analysis of other wells in the western portion of the field. Their porosity, connate water and permeability characteristics were similar to those which we had. Therefore, I concluded that the formation did not change. But it was just a general summary.

Q How many were there, that is what I am trying to determine? Can you hazard a guess or do you know the exact figure?

A I believe there were only four that I felt I could rely on. There were others that I had, but for other reasons, why I didn't care to use them.

Q In other words, as I understand it, you hazarded an opinion that there were twenty wells in the field that had been cored and you had access to the information on twelve of those twenty wells?

A Yes, sir.

Q If you thought that the information was applicable and could be used in your study, you used the other information, is that correct?

A I did not use those other wells. I just checked and found that they were just like the ones that I was using.

Q Did you find any trend as to the variation in connate water content? Did it make any rhyme or reason as to its location from a structural standpoint or thickness or anything?

A No, sir.

MR. MACEY: That is all I have.

MR. SPURRIER: Anyone else?

MR. JONES: Rees Jones, representing Delhi.

By MR. JONES:

Q Mr. Barry, as I understand it, in preparing this Isopachus map you were interested in determining reserves of Phillips, is that correct?

A That was the job that I started out on, to find out what Phillips reserves were.

Q And you just went on through the field using Phillip's cores, is that right?

A Using the correlation that I obtained from Phillip's cores, yes, sir.

Q If Delhi Oil Corporation, for example, had requested that you make a study of its reserves, would you have been content to rely on this map?

A Could you provide me with any core analysis of your wells?

Q My question is, would you have relied on this map?

A Sir, you asked me if I was going to make a reserve estimate for you people. I would first ask you to give me everything you got on your wells.

Q That is the answer I wanted. You would have been interested in knowing whether or not Delhi had any cores, is that correct?

A Correct.

Q Then you would have, in effect, have been saying that perhaps taking the average of the Phillip's cores would not have been proper throughout the field, is that not correct?

A I am not saying that, no, sir.

Q You would have been interested in knowing if we had gamma ray logs?

A I have your gamma ray logs. I have everything but your core analysis.

Q You have logs on all of the wells?

A I have gamma ray logs on all the wells that have been released to West Texas Log Service, or the log service in Denver. That includes a majority of the wells, yes, sir.

Q Then your answer to my initial question as to whether or not if Delhi Oil Corporation had asked you to determine its reserves, is that you would not have been content to rely on this map on the wall, Phillip's Exhibit No. 1?

A I wouldn't have had that map. What I mean--

Q Speaking of August 1, 1953, Mr. Barry, at that time would you have relied on this map?

A I would rely upon the data I have, and the only data that I have would have made up the map, yes, I would have relied on the map.

Q Even though the map was principally prepared to determine the reserves of Phillips?

A There was no other data available and I would have to use it.

Q Was the map prepared for introduction before the Oil Conservation Commission of this State? A It was not.

Q Was it prepared for introduction before the F.P.C.?

A It was not.

Q Why was it prepared?

A It was my duty to prepare reserve estimates and my company made them.

MR. JONES: Thank you.

MR. SPURRIER: Anyone else? If no further questions, the witness may be excused. Just a moment, we have a little re-direct from your own counsel.

MR. FOSTER: I promised to put into the record here the reserves per acre. That is a matter just of computation. I was asked by one or two if I would do it. I want to do that.

RE-DIRECT EXAMINATION

By MR. FOSTER:

MR. FOSTER: I would like to offer the Exhibit No. 1 in evidence at that time.

MR. SPURRIER: Is there objection? Without objection it will be admitted.

Q Mr. Barry, have you computed the average reserves per acre in the San Juna Basin? A Yes, sir.

Q What do you find that to be?

A 23,400,000 cubic feet per acre.

Q Per acre? A Yes, sir.

Q Have you computed Phillip's reserves per acre under its holdings? A Yes.

Q What do you find that to be?

A I find that to be 21,120 M.C.F. per acre.

MR. FOSTER: Thank you.

MR. SPURRIER: Anyone else?

MR. UTZ: One more question.

By MR. UTZ:

Q This 23,400,000, was that for the entire Blanco-Mesaverde Pool as designated by the Oil Conservation Commission?

A That is for the entire area within my estimated limits of proved production.

Q The heavy line as shown on your exhibit?

A Yes.

MR. GRENIER: Are those recoverable reserves?

A Yes.

Q To what abandonment pressure? A Five hundred pounds.

MR. GRENIER: That is all.

MR. SPURRIER: We will take a short recess.

(Recess.) (Witness excused.)

MR. SPURRIER: The meeting will come to order. Mr. Foster, before you continue, may I make an announcement on Case 729 on which Mr. Lock moved for continuance? We will continue that case to the regular July hearing which I believe is July 15.

Judge Foster.

M. H. CULLENDER

having first been duly sworn, testified as follows:

DIRECT EXAMINATION

By MR. FOSTER:

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

A M. H. Cullender.

Q Where do you reside, Mr. Cullender?

A Bartlesville, Oklahoma.

Q By whom employed? A Phillips Petroleum Company.

Q In what capacity?

A As an assistant to the Chief Production Engineer, the Natural Gas Department.

Q What are your duties in the capacity that you have stated, Mr. Cullender?

A I direct and supervise the various employees in the production engineering section of the Natural Gas Department, concerned with the operation and production, and performance of the wells assigned to the Natural Gas Department.

Q Will you state your general educational background and your professional experience for the record?

A I graduated in 1939 with a B. S. degree in mathematics from West Texas State College at Canyon, Texas, was employed immediately thereafter by Phillips Petroleum Company where I worked in various gasoline plants, and until 1947, 1947 I went to the Oklahoma-Texas Hugoton area to direct the work of a group of testers engaged in gathering performance data in the Hugoton and Oklahoma and Texas Hugoton fields. In 1948 I went to the Production Engineering Section in Bartlesville where I have since been employed, and in June of 1950 I became the Assistant to the Chief Production Engineer of that department. Since 1950 I have been generally engaged in working on performance of gas wells and working with proration formulas with various State Commission bodies.

Q Over how long a period of time, just for the record, has your experience extended?

A I didn't understand.

Q Over how long a period of time has your experience extended?

A With respect to the performance of gas wells, since February of 1947.

Q In making studies of the performance of gas wells generally, what do you do, what field of information and activity do you cover and study and investigate?

A We are concerned mainly with the rates of flow and the pressures at which those rates occur at various time intervals from shut-in conditions of the wells that we operate, and also with the projected performance of those wells as that projection is integrated into design of field systems and as the information is incorporated into correlations of one kind or another concerned with the performance or proration necessary for various fields.

Q Over how long a period of time has your experience extended in studying the applicable formulas under varying conditions in different gas fields that should be applied in prorating gas?

A Well, the first time that I had anything to do with an allocation formula, I believe was in 1948 with respect to doing some work on the original case for Texas Hugoton Field. Also the West Panhandle Field of Texas when they combined the sweet and sour field. Later and through the years I have worked on Texas Hugoton Field, in Oklahoma Hugoton Field as well as others, and in early last year developed a correlation for the Texas Hugoton Field and presented it to the Commission and modified the Texas Hugoton to respect to the slope to be applied to the deliverability test. I also worked up a similar project and presented it to the Oklahoma Corporation Commission and they rejected it.

Q One of them took it and the other didn't?

A Yes.

Q Fifty-fifty. But since 1948 you have been continuously engaged in the matter of studies of scientific nature for the purpose of determining the proper and applicable formulas for the proration of gas, is that true?

A Off and on in those periods. The rest of the time with the performance of the wells.

Q Have you, in your professional pursuits, prepared and delivered any papers to scientific or professional societies on the matter of proration of gas wells?

A Not on the matter of proration.

Q On well performance, other related matters?

A Yes, sir, I prepared a class, or taught a class, Oklahoma Short Course one year on the application of the back pressure performance curve and the analysis of reservoir performance, and also a year later a similar paper with respect to deliverability. I also delivered to the A.M.I.A. in Dallas last year, a different type of performance test which we call the Isochronal performance method of determining performance characteristics of a gas well.

Q What does that mean?

A It means disturbances of constant duration.

Q Constant time? A Yes, sir.

MR. FOSTER: Anybody got any objection to this witnesses qualifications? Are they acceptable to the Commission?

MR. SPURRIER: Yes, sir.

Q Mr. Cullender, let me ask you when you first became acquainted with the San Juan Basin.

A It was in the latter part of 1952 and early in 1953. We sent three employees that were under my direction to the San Juan Basin to gather information on the wells that Phillips was then drilling in the area.

Q You had never personally been in the field yourself?

A No, sir.

Q But your men that operate under your control and direction and supervision have been?

A Yes, sir, since early 1953.

Q What studies have you made in the San Juan Basin in the area that we have under consideration in these cases?

A I have made studies with respect to the performance of some of the wells in the area, and four or five months ago when a committee of engineers in the San Juan Basin began having meetings concerned with proration of gas in the San Juan Basin, I then started accumulating information on certain other wells in the basin in an attempt to work out some reasonable allocation formula.

Q What has been the nature of the studies of the wells that you have made in the San Juan Basin?

A It has had to do with the performance of those wells under various conditions with respect to pressure and time, and with respect to the various, in an attempt at least to correlate the performance of those wells to some known factor in the reservoir conditions with respect to reservoir conditions.

Q In doing that, have you had in mind the determination of a proper allocation formula to be used in the field in allocating gas as between wells?

A Since about six months ago, yes, when the meetings were begun.

Q Since the engineering committee meetings have started?

A Yes, sir.

Q And what studies have you made in the field for the purpose of making a determination, or making a recommendation to this Committee with respect to the type of formula that should be adopted?

A I studied the effect of the various allocation formulas under consideration with respect to the manner in which they would allocate the market demand among the individual wells, and tried to arrive at some reasonable basis to compare those formulas and arrive at a recommendation.

Q What type of formulas have you considered in these studies? Just name the formulas, the type of formulas.

A I have considered only the type of formula that is known as the additive type of formula which allocates a certain percent of the market demand to one factor and a certain percent of the market demand to another factor. In the studies that I made with respect to different formulas, I considered only two factors, acreage and deliverability, and allocated the market demand certain percentages of the market demand on the basis of acreage, and the balance of it on the basis of acreage times deliverability.

Q You have considered different and separate formulas for the purpose of making comparisons, have you?

A Yes, sir.

Q What are those formulas?

A First one was 100% acreage times deliverability. The second one was 75% pardon me, 75% acreage times deliverability and 25% acreage. The third one was 50% to acres times deliverability and 50% to acreage. The fourth one was 25% to acres times deliverability and 75% to acreage and the fifth one was 100% acreage.

Q I take it that in the course of your studies, for one reason or another best known to yourself, you have eliminated all of these formulas that you have considered except one?

A Yes, sir.

Q And on that one you will make a recommendation to this Commission, is that correct? A Yes, sir.

Q In your professional capacity, what do you consider to be fundamentally, I am talking about fundamentally what do you consider to be the problem that we are dealing here with in attempting to determine the limits of the knowledge that we have regarding this field, a proper allocation formula?

A Well, I think the ideal purpose that you start out to obtain is an allocation formula that will insure --

MR. TURNER: (Interrupting) Can the witness talk a little louder? We can't hear him.

A The ideal formula that would assure each operator an opportunity to produce his share of the gas in the field and his share being that ratio of the recoverable reserves under each individual tract as compared to the total reserve, recoverable reserve in the field.

Q In other words, you are saying the ideal situation is if we had the facts, the necessary facts and the information, we could write a formula so that each man would get just exactly the amount of gas that is beneath his tract of land, is that what you are saying?

A Well, he would be given an opportunity to produce it.

Q He would be given an opportunity, and if you applied it and operated the field, he would be given that opportunity?

A Yes.

Q Of course, for very obvious reasons we can't approach the ideal, is that true?

A It is my belief, yes, sir, that you cannot approach it.

Q That is just --

A (Interrupting) Or that you can't reach it.

Q That is just because of lack of information?

A Largely.

Q And our ability, of course, in some instances, to properly apply the information when we got it? A Yes, sir.

Q What would you consider to be involved fundamentally, just stating the proposition in a formula that can be arrived at, based on the information which we do have?

A Well, that formula should take into account those factors as nearly as possible; in their proper relation they are required to make or to accumulate the reserves in a particular tract. I think you get down to a relative position and you can throw out some of the factors. The ones you need to keep in if possible are area, thickness, that is effective thickness, net porosity and pressure. If those four factors could be properly taken into account in an allocation formula, then I believe that you would approach the ideal condition that we set out to meet.

Q Have you prepared a set of exhibits which you expect to use in presenting to the Commission your suggestion on the adoption of a proper allocation formula for the San Juan Basin?

A Yes, sir.

MR. FOSTER: If the Commission please, I have a set of those that I want to give to the Commission now. We may pass out different ones of them to the Commission and the staff. Give the gentlemen a set of those. Marked Exhibits two through eight.

Q Mr. Cullender, I am going to try and shorten this as much as I can. A Yes, sir.

Q I will ask you to go to the board there and for the record, identify each of the exhibits there beginning with Exhibit No. 2.

A Exhibit No. 2 is a schematic drawing of the Mesaverde sandstones and well bore showing flow of gas in reservoir with well producing. Number 3 is a summary of the data available for those wells by deliverability tests, with deliverability tests. Number 4 is a curve plotting deliverability versus production data for the Blanco-Mesaverde Pool. Number 5 is a map which is an identical map, or a copy of the map introduced as Exhibit No. 1, on which has been superimposed various ranges of deliverability data. The pink or red colored half sections represent wells with deliverability of less than 500 M.C.F.D. The orange color represents those wells with deliverability from 500 to 599 M.C.F.D. The green color represents those wells with deliverability from 1,000 to 1,099 M.C.F.D. The blue represents those wells with deliverabilities from 2,000 to 2,599 M.C.F.D., and purple represents those wells having a deliverability above three million.

I will explain what those deliverabilities are. Number six is a comparison of the effect of the various allocation formulas. Number 7 is a curve entitled Blanco-Mesaverde Pool and is a comparison of deliverability versus allowable for the various allocation formulas. Number 8 consists of a curve and five tabulations which is the distribution of allowable 320 million cubic feet per day market in the Blanco-Mesaverde Pool. The five tabulations present the data that has been drawn on these curves as A, B, C, D and E.

Q Were all of these Exhibits prepared under your direction and supervision, or by you yourself?

A All but one. That was this schematic drawing, and I was outlining a schematic drawing to the draftsman to show them what it was that I wanted and they told me that someone else in another department had already prepared such an exhibit for another purpose. I went and examined that exhibit and adopted it inasmuch as it represented my ideas of what the situation was with respect to flow.

Q Starting there with Exhibit No. 2 I believe it is, that Exhibit is designed to show what?

A That is designed to give a schematic picture of what can happen in a formation of the Mesaverde--Blanco-Mesaverde type under producing conditions. It is not intended to be a typical Mesa Verde well with respect to any one well. It is just a general picture of the flow mechanism by which a well drains an area containing gas.

Q What study and information did you make or conduct in preparing that exhibit?

A Well, that exhibit grew in my mind and on paper and in various places out of discussions that were held in the engineering subcommittee, and was also a take off from a similar schematic drawing that had been prepared a number of years back on Texas Hugoton Field.

Q What was the subject of these discussions?

A As to whether or not the gas, the thickness as represented by the gas entries to the well bore were or were not the only areas contributing to sustained production from that well.

Q With respect to that subject, what does this drawing show or illustrate?

A Well, first, the sand body itself has been drawn as being a square or a rectangle at least. It represents a right angle cross section through your well bore. The thickness of the formation is divided off into various sandstone beds with horizontal and vertical fractures with shale beds with vertical fractures, with shaley sand or sandy shale beds with vertical and horizontal fractures, and into three zones over on the right-hand side. Zone A, B and C. Now, with respect to zone B --

Q (Interrupting) Just a minute, could you relate those zones to the San Juan area?

A Well, zone B, I think undoubtedly represents some type of a conduit zone. Either of high permeability or of high fracturing. That is the zone I think you see when you get a temperature log superimposed on a well bore. At the points that you get the low temperature cooling there is no doubt that that is the point the gas is actually entering the well bore.

Q That is where it is coming into the well bore?

A To the well bore. Zones A and B represent other zones that contain gas, but are not contributing much gas directly into the well bore.

Q I believe you said A and B, you mean A and C?

A Yes, sir, A and C.

Q All right.

A In nearly all fields of low permeability we find conduit zones, we found the same zones in the Hugoton Field.

Q When you say conduit zone, what do you mean by that?

A I mean a zone that is relatively higher in permeability to zones above or below it which actually transport the gas to the well bore. Now, this picture here, of course, shows gas coming all the way from the edge of this block through the conduit zone directly into the well bore with gas coming out of zones A and C through fractures or directly into the conduit zone and being taken from there into the well bore. Actually it is doubtful if you would ever get a situation where you would have one continuous conduit bed throughout a very large area. You would probably have one conduit bed in one part of the zone and maybe above or below it and extending another distance, would be another conduit zone, but the gas can be moved from one of those zones to another and to another until it approaches the well bore.

Q At this point, let me ask you this question, the illustration that you have made there on Exhibit 2, can the conditions that are reflected there be found in the San Juan Basin?

A I believe from what Mr. Barry has told me in various discussions and from the testimony that he put on here today, that those conditions do exist. Now, I didn't make any study to find out if those conditions did exist in the basin myself.

Q But taking the previous testimony that is in this record and predicating it on that?

A Yes, sir, on Mr. Barry's testimony.

Q On Mr. Barry's testimony you find then, that the conditions that are represented here on your Exhibit No. 2 may be applied to the San Juan area?

A Yes, sir.

Q Applying it to the San Juan area, what do you find that is happening in that reservoir?

A Well, the thing that we all have to remember is that a well bore is approximately a half a foot in diameter. We are draining an area which in many cases is 320 acres, which has an effective radius of 2,106 feet. By that I mean that a circle with a radius of 2,106 feet would contain 320 acres.

Q The perimeter of that circle would lie on the outer edges of that much acreage?

A Yes. Under conditions of flow completely stabilized, if the draw down area around the well had reached out and reached that limit of drainage, we would have to pass the gas from the total area in that circle into a hole half a foot in diameter.

Q Into a six inch well bore?

A Now, the area of this 21,000 foot circle is 13,230,000 square feet. The area involved in our well bore is 1-16th of a square foot. We have got to take gas from this large area and bring it into the well bore. Under a radio flow condition such as that you suffer extreme pressure losses immediately surrounding the well bore. Assuming that we have a well in the basin that was completely stabilized with a 1200 pound pressure at 2100 feet from the well bore, and a 600 pound pressure at the well bore, the pressure 500 feet from that well bore would be 1,126 pounds, or pressure loss of only 74 pounds across or from 2100 feet out to 500 feet out. At 100 feet we would have had a total loss of only 183 pounds, or 89 pounds in the last four hundred feet. 100 and 500. We would have had 437 pounds loss in the last 100 feet into the well bore. From this point 100 feet out into the well bore.

Now, it is a well known fact that extreme pressure drops do take place under radio flow conditions, and that relatively smaller pressure drops take place under linear flow conditions. In this area that I was just speaking of, we have lowered the pressure within the outer 1600 feet I believe, within the outer 1,000 feet by 74 pounds. It was the outer 1600 feet, excuse me. From 500 feet out to 2100, the pressure has only been dropped 74 pounds, the drop has occurred essentially on a straight line relationship because the curve has not started to, the gradient, has not started to hook into the well bore.

There is a little bit more pressure drop in the inside portion of that annular area. But if it is assumed that we drop that pressure over the whole area 37 pounds from the 500 feet out to the 1200 feet and set up the linear flow of gas into this conduit zone over that total area, and assume that no gas at all will be produced into the well bore from zones A and zones C, then we have a pressure gradient of 27, 37 pounds over just a portion of this area now to deliver gas into the conduit zone. Assuming very adverse conditions for that linear flow of gas into the conduit zone of a thickness of 300 feet, in other words.

Q Is that a pay thickness that you are talking about?

A In other words, assume that in zone C was 300 feet thick and that there was a conduit bed along the bottom of that 300 foot section, and assuming an effective permeability of that 300 foot section at 300ths millidarsys --

Q .03?

A .03 millidarsys. The 37 pound pressure drop will deliver from zone B a million five hundred thousand cubic feet of gas a day into the conduit zone.

Now, the conduit zone must transport that gas to the well bore. Now, actually the conduit zones are probably the bottlenecks in our production of gas in the Mesaverde area. Now, the purpose of that exhibit, at least the avowed purpose of it, was to show that those areas contributing gas into a well bore are not necessarily the only area or the only thickness that should be counted in arriving at the recoverable reserves that will be produced over a sustained period of production.

Q Now, your Exhibit 3 is related to Exhibit 2, is that correct?

A No, sir, Exhibit 3 is related to Exhibit 4.

Q What is Exhibit 4?

A I would rather do it the other way. Exhibit 4 is a curve relating deliverability to production in the Blanco-Mesaverde Pool.

Q I just want to get it identified with respect to Exhibit 3. Now, will you tell us what Exhibit 3 is?

A In attempting to arrive at the results of various allocation formulas in the Blanco-Mesaverde Pool, considering only those factors of acreage and acreage times deliverability, it was necessary to have deliverability tests data on as large a number of wells as possible. In order to get that data we went to the Commission files and obtained the deliverability test data and the I. P. data on all wells which had had deliverability tests reported for the year 1953.

Q How many wells was that in number?

A That was 346 wells. I was looking for that figure here. As I recall it, there were 346 wells for which we had deliverability data.

Q In other words, the information that reflected on Exhibit 3 came from the Commission files and records, is that correct?

A Yes, sir, with certain modifications. The I. P.'s and deliverability tests that went into this average figure was obtained from the Commission files.

Now, the purpose, one purpose of this tabulation was to arrive at a method by which we could estimate, I could estimate deliverability tests on those wells on which, had no deliverability. Now the usual practice on that, I think in the Basin, is to relate I. P. to deliverability by some factor.

Q Did you do that?

A No, sir. That correlation seemed to have some rather wild figures in it and we looked then for another method. We decided, well, that the production data from the individual wells might reflect to some extent the deliverability of the wells. So for December of 1953 the individual production data for all the wells for which we had production data was tabulated, and the same was done for January and for February. Now, the February production --

Q (Interrupting) What year? A Of 1954.

Q All right.

A The February production figure was converted by a factor of 31 divided by 28 so that the production figure for February would represent a 31 day month so that we could compare it with December and January. It was found that a large number of those wells had quite a fluctuation in production for the three months of December, January, February. So the largest production figure for each of those three months with the February figure being converted as previously stated, was tabulated by the side of the deliverability, and that is the figure that is shown here as production with the note on it "production figure used for each individual well was the maximum production reported for the months of December 1953, January 1954 and February 1954 with the February production being converted by the factor 31 over 28."

Q What is the purpose of this Exhibit, what does it reflect?

A Well, actually the purpose of it was to arrive at, or to show the source of the curve and the data points on Exhibit 4. Actually 3 and 4 are part of the same Exhibit. This information was then separated according, the information with respect to those wells with deliverability tests were separated into deliverability groups as set out in the left-hand column. There were 16 wells from zero to 100 deliverability. That 16 is reflected in column two. Column

3 is the average initial potential. Those initial potentials were averaged as they came off of the records without consideration as to whether there were three or six hour initial potentials. That was --

Q (Interrupting) Do you know whether those potentials were taken with respect to the date of the completion of the well and any shooting or acidizing or sand-fracing of the well?

A No, sir.

Q You do not know that? A No, sir.

Q All right. Is there any way to know it?

A Your files could probably be summarized showing the date that the well was completed and shut and the date the I. P. was taken and the date the deliverability was taken.

Q Now, the next column shows what?

A Column 4 is the average deliverability for the six wells in the group from zero to 163 M.C.F. per day. The average production basis of a 31 day month as shown in Column 5 was 2, 177. For each of those columns each group of wells was separated and summarized as shown in groups of 100 through the largest well in the field.

Q This is average production for 31 day month unregulated, that is what we are talking about, isn't it? It is not a regulated production by the Commission or anything of that sort?

A Well, it is production as it occurred on the wells.

Q Production as it occurred in the field?

A Yes, sir. Now I must point out again that was the maximum production that occurred in any one of the three months. This figure is the average of those maximum figures. If one well produced more gas in December than in January and February, we used that production figure.

Q Yes. Let me call your attention to the last column you have, Mcfd/month.

A Well, will everybody strike the D. That information was plotted on Exhibit No. 4, each one of the data points representing the plot of deliverability versus production, and resulted in the distribution shown.

Q What is that distribution?

A Well, the points there just represent the plotting and the data. There are four points shown there with an X rather than a circle. In drawing the line through the data points as they were set out, I did not lend any weight to those four data points. Those four points are the points represented on the tabulation in Exhibit 3 as a group from seven million one hundred to seven one ninety-nine, representing one well. The second point that was not considered was the value of 98, 9728 versus 87,340. I think the other two are the last two data points. That wasn't a very good thing to do to throw away some of the data that you worked so hard to get. Nevertheless, I couldn't draw a very good straight line through there and take into account those data points. Also in examining the production data on the wells on which we were going to estimate deliverability, it was found that the curve was not going to be used above the deliverability of 5,400,000. It is represented by monthly production at about 106 million.

Q You are not using it beyond the range in which you discarded the points you are speaking about?

A Yes, sir, I am not using the curve beyond the point of 5,400,000 deliverability.

Q The information that you discarded just becomes wholly immaterial, is that correct?

A I don't think it would have materially affected the answer.

Q All right.

A You may want to know why I thought it was necessary to arrive at estimated deliverabilities for those wells when it is quite possible that they are in error. Because of the fact that the wells were probably not producing under the same conditions, in fact, undoubtedly were not producing under the same conditions, but I felt that it was important to get a distribution of deliverability, a probable distribution of deliverability with respect to all the wells in the field.

Now, I think possibly that the distribution is not upset so much by the estimated deliverabilities, although certain individual deliverabilities may be in error, a certain amount, more or less.

Q Why did you want this estimate of deliverabilities on the wells through that field?

A Because I wanted to apply the various formulas that I was going to consider to the market demand of 320 million cubic feet of gas per day for all the wells now producing in the San Juan Basin. Now the number of wells for which production data was available amounted to 572 wells. That is the number of wells that we used in the study and I think the 346 from that will give 226 wells that are included in this 572 which have estimated deliverabilities. The balance of the exhibits will reflect the result of those deliverabilities in those 572 wells including the estimated deliverabilities.

Q I notice on Exhibit 4 you have deliverability versus production data. What is the significance of that?

A It was just a means by which I could estimate deliverability.

values for those wells that were producing for which I did not have deliverability test data.

Q Now, say that again. I want that in the record. Speak a little louder there.

A The curve was drawn for the purpose of being able to estimate deliverability tests for those wells for which production data were available and for which deliverability data were not available.

Q Were not available. In other words, there are a group of wells in the field on which you don't have any deliverability data?

A Yes, sir.

Q And for the purpose of arriving at some deliverability for those wells you used the production data?

A Yes, sir.

Q In plotting your curve, is that correct?

A Yes, sir.

Q That puts all the wells that you considered, therefore, on a comparable basis for the purpose of applying a gas allocation formula to them, is that it?

A It gives me a figure for each one of the wells that I want to include in the study.

Q That is right. All right, go ahead.

A Exhibit No. 5. This Exhibit 5 is titled "Original Map Base San Juan Basin at Colorado, New Mexico," and is a copy of the map that was entered as Phillip's Exhibit 1 and from which Mr. Barry testified. Added to that I think I went through all that.

Q Yes, you gave the legend and so forth on the map, is that correct?

A San Juan Basin of Colorado and New Mexico.

(Recess.)

MR. SPURRIER: Mr. Foster.

Q Mr. Cullender, will you return there to the map and continue with your explanation of it?

A I think that the map has been identified and I was just starting in to identify it again when we recessed. The map has been colored just to show the variations of deliverability from well to well with respect to the thickness from well to well.

Q What does that show? Just put your finger on some examples.

A Well, I would like to say one thing before that.

Q Yes, sir, go right ahead.

A These colors that are on here represent actual deliverabilities as well as the estimated deliverabilities. Now in all likelihood, it should have been a different kind of a marking or something to show which wells were estimated and which were not. But, nevertheless, it represents a deliverability, I think reasonably well, in line with what the deliverability will be.

Q So I don't get crossed up here myself, may I ask the deliverabilities that you are using on the map, are they the ones that you have determined here by the method that you have testified to?

A The deliverabilities on the map include the 346 actual deliverabilities plus the estimated deliverabilities on the 226 wells.

Q Computed from production?

A Yes, sir, as taken from the correlation curve.

Q Okay.

A Of course, the first thing to do is start looking for some obvious discrepancy in the deliverability with respect to thickness.

Q Can you point out a few for us so the Commission can follow it?

A Well, we will take a case right here in Section 29, of 31 and 9 and we have a well located in the east half of that section with a deliverability in excess of three million. In the west half of that section is a well with a deliverability of less than three hundred thousand M.C.F. per day. In section 22, of 30 and 8.

Q What is the pay thickness shown there on the two wells that you have just testified about?

A The well, I can't find it now. I think I am really fouled up because I think I called that Section 29 and it is not Section 29.

Q It is hard to read the Section numbers with those colors on there.

A That is Section 26 of 31 and 9 or in the east half, has a deliverability in excess of three million. The well in the west half has a deliverability of less than three hundred thousand. Those wells are both practically on the 250 foot contour line.

Q Let's get down a little bit. That is a ratio of about what in the deliverabilities?

A Well, it is at least --

Q (Interrupting) --ten to one, in the order of ten to one?

A It is at least six to one because I think I said less than three million. It is less than five million and greater than three million. It is at least six to one.

Q At least six to one with the same pay thickness indicated for both wells? A Yes, sir.

A Now, we continue to pick examples in Section 21 of 30 and 9, there is a well in the east half of the section with an excess of three million in the west half less than five hundred thousand.

Q A ratio of what?

A A ratio of in excess of six to one.

Q Both wells have the same pay thickness indication?

A Yes, sir.

Q How far apart are the two wells that you have just testified about?

A One is located in the northeast quarter of the section and one is located in the southwest quarter.

Q I mean the first two wells that you made a comparison of with respect to the last two wells, by what distance are they separated?

A Oh, about seven or eight miles.

Q Can you give us some more of those illustrations?

A Well, I might take a little larger area.

Q All right.

A Here is an area in Sections 19, 23, 29, and 30 of 30 and 9 wherein we have a group of wells completely within a three hundred foot contour.

Q All right.

A There are one, two, three, four, five, six wells located in that contour. Three of the wells --

Q (Interrupting) That is a pay contour, isn't it?

A Yes, sir.

Q All right.

A Three of the wells have deliverability of less than a half a million, one of the wells has a deliverability between one million and one million nine hundred ninety-nine thousand. One well has a deliverability in the range five hundred to nine nine nine.

Q What is the range in the variation in deliverabilities between the wells in that three hundred contour line?

A ~~Well, from, of at least four to one.~~

Q Four to one? A Yes, sir.

Q Let me ask you this question right there. If deliverability of the well is an indication of reserves, would you expect to find the situation there that you have pointed out in that three hundred foot contour line? A No, sir.

Q If that relationship between the deliverability of the wells and the reserves, if there was a relationship between the range of deliverabilities of the wells and the reserves, what would you expect to find within the inclosure of that three hundred pound, three hundred foot contour line?

A Expect to find wells of practically equal deliverability.

Q Equal deliverability. Let me ask you without pointing any more of these examples, does this variation that you have pointed out between the deliverability ranges of wells and the pay thickness obtained throughout the entire area. In other words, did you find?

A Did you finish that question?

Q Do you find the same situation obtaining that you have just pointed out, not only where you have found it there, but you find it generally obtaining throughout the whole area?

A Yes, I think if you will go on here anywhere you see two different colors, particularly if there is much difference in those colors with respect to the color range in the legend, you have a condition that we have been talking about most likely.

Q What I am trying to find out, this condition doesn't exist just with respect to that particular portion of the field. It exists generally with respect to the field as a whole, does it not?

A Yes, sir.

Q In your profession, would you say that this is proof that there is not a relationship between the deliverability of the wells and the reserves in place?

A That was the purpose for which it was prepared, yes.

Q It does illustrate that --

A (Interrupting) Yes.

Q It does illustrate that that relationship does not exist?

A Yes.

Q That is not something that is just peculiar to the San Juan Basin is it? A No, sir.

Q That would be true, I don't care what basin it is?

A I think undoubtedly it is true anywhere.

Q Any place in trying to effect deliverability to reserve, that is correct, is it not?

A Yes. We have never found an area where there was a direct relationship between deliverability and reserves. In fact, any relationship that you arrive at however slight, is usually very rough.

Q Yes. Have you said about all you want to say about Exhibit 5?

A For the time being, yes, sir.

Q Now, Exhibit 6, will you explain that to us?

A Exhibit 6 is a tabulation representing the results obtained by application of the five formulas to a market demand of 320 million cubic feet of gas per day.

Q Why do you use 320 million?

A That figure was furnished to the engineering committee that was working on an allocation formula, that was considering an allocation formula for the San Juan Basin as estimating the best estimate of El Paso and Southern Union as to what the market demand in the area would be for the ensuing year.

Q Are the El Paso and Southern Union the principal market outlet for the field --

A (Interrupting) Yes, sir.

Q (Continuing) -- at this time? A Yes, sir.

Q Pardon me, I had to get that in.

A Column one is a description representing the factors for, the allocation factors for one hundred percent times acreage.

Q While you are mentioning that one hundred percent acreage times deliverability, on what basis is the field being presently operated?

A It is being produced so far as I can determine, by allowing the wells to flow into the pipeline as they are able to.

Q Does that represent approximately acres times deliverability?

A If all the wells were operating under the same pipeline pressures, you would probably approach a formula of 100 percent deliverability.

Q That is illustrated there on Exhibit No. 3, isn't it?

A To a certain extent it shows that on the average there is a deviation from that situation, actually.

Q You are down on four, I believe, which is --

A (Interrupting) Okay.

Q The same information is reflected on each one.

A May I use four?

Q You may use four if you like.

A If the wells had been operating on exactly a deliverability formula, this line would have had a slope of one. In other words, if it crossed the bottom cycle at three or at a production of 1,000, a deliverability of 30, it would have crossed the cycle at ten million cubic feet, or ten thousand M.C.F.D. at three hundred M.C.F.D. deliverability, and so on for each cycle it would have gone through the three orders which you can see there, a little deviation on the average that at least, as I drew the cruve, the lower capacity wells are operating a little nearer 100% deliverability than the higher capacity wells.

Q You just arrive at it if you aren't there, that is what you are saying, isn't it? A On the average.

Q That is reflected on both Exhibit 3 and 4?

A Yes.

Q All right. That is unregulated in the field. There is no formula in the field that permits those wells to operate that way?

A No, sir.

Q Just as to that, they are just operating now unregulated?

A Yes, sir.

Q Go ahead.

A Column two represents the various factors for the formula, 25% acreage and 75% acreage times deliverability.

Q When you say represents the various factors, can you name those factors?

A Yes, I intend to compare them, each, one by one.

Q Very well. A As we go along.

Q All right.

A The next column which is a third row of figures, actually it is column four, in the tabulation represents the various factors determined by allocating one-half of the market on the basis of acreage and one-half of it on the basis of acreage times deliverability.

The next column being column five represents the same factors for the formula 75% acreage and 25% acreage times deliverability. So, on the last column represents the figures for 100% acreage and 0% acreage times deliverability.

The first heading under description is acreage factor. In this study it was assumed that all wells had 320 acres assigned to them. While this is not actually the case with respect to a few wells, I think on short sections it generally represents the acreage assignment that would be assigned to the wells under an allocation formula, and the factor has been presented on the basis of 320 acres.

Q In other words, there is not enough variation from 320 to make any material difference in your factor?

A Not in the factors. With respect to the allowable of any individual well, of course, it would increase or decrease that allowable in proportion to the acreage assigned to the well, assuming it was not a limited well. Under that, that factor under the formula number one, there would be no acreage factor because none of the allowable would be allocated to acreage. Under the 25% acreage formula the allowable would be 186.1407. Actually that is 186 M.C.F.D. of gas per day assigned to that well on the basis of acreage.

Under the 50-50 formula, the acreage factor is 414.8525. 75, 25 formula. The acreage factor is 644.6538. Under the 100% acreage factor it is 864.4391. Before going into the deliverability factor, I would like to skip that for the moment and go to the third item under description, which is limiting deliverability. That limiting deliverability is the deliverability of a well which would have an allowable under the formula exactly equal to its deliverability after having re-allocated all allowables assigned in excess of a wells deliverability. By that I mean we first applied the factors to all the wells and then assumed that the wells were not capable of delivering gas in excess of their deliverability, and then re-allocated to find the final factors.

Now, actually it might seem by that that I would recommend to the Commission that they not assign allowables in excess of deliverability. Instead, I would recommend to them that they not assign allowables in excess of deliverability unless it could be shown that the well could produce the additional gas that would be assigned to it.

Q Of course that can be found out by its production history?

A Yes, sir, but to avoid assigning excessive allowables and waiting three or four months to find out what gas should be cancelled and allocated back, I would recommend that they first allocate anything back in excess of the deliverability, then if it was shown that a well could deliver gas in excess of its deliverability, that the allowable be raised to that value, limited only by the allowable assigned by the factors in the formula.

Q Yes, limited there, you are saying only by the proportional part of the total field market demand it would get under the applicable formula? A Yes, sir.

Q Okay.

A Now, the deliverability factor represents the factor which would be multiplied times deliverability to determine the allowable for each individual well assigned on the basis of deliverability. Now, under the formula one, 100% acres times deliverability, that factor is point five, six, nine, three, six, two, one, (0.5693621) which means nothing more than that the fact that the 320 M.C.F. per day is 56.93% of the total deliverability of the 572 wells. There would be no re-allocation necessary except as might be shown by the inability of the wells to even produce their deliverability.

Q That is the point where you are telling us for all practical purposes that date in allocation of the gas to the wells up there?

A On an average, I think that is right. I think with respect to individual wells, you will find there is a good possibility that is not the case as one well against another.

Q Yes.

A Each of the other factors are set out there under the appropirate column, deliverability factor gets down to .120 under formula four, which is 75% acreage and 25% acres times deliverability.

I have already stated what the limiting deliverability was and come down to the next item which is the number of wells. Under that is the limited wells and the non limited wells.

Q Right there I want to drive a peg, because we all don't want to get confused over the use of these terms. What do you mean by limited and non limited wells?

A As shown in the footnotes, I defined a limited well as being one for which the allowable is equal to the deliverability.

Q That appears right on the face of it to be a little bit contradictory. Can you explain that to me?

A Well, every time --

Q It appears that it wouldn't be a limited well, but it appears to be a little contradictory on the face of it, would you explain that?

A The normal nomenclature for delineating wells in an allocation schedule is either a limited well or a non prorated well or some other designation, setting out that well as being the well whose allowable is not assigned under the formula, but is limited to some value below what would be assigned under the formula for some reason which is considered necessary to limit that well.

Q In other words, by applying the formula, it is limited in the amount of gas that it can produce?

A No,well,it is limited in the amount of gas that will be assigned to it, the allowable. That is correct. It is limited by some factor other than the allocation factors and to an extent less than the allocation factor.

Q Yes.

A Now, a non limited well is one for which the allowable is less than the deliverability. Actually that well is limited by the allocation factors to its allowable, but it is not limited in its producing capacity.

Q Yes, the allowable is less than its deliverability?

A Yes, sir. Every time that you and I talk about this we get confused, so don't anybody worry about it.

Q I don't get confused, I just stay that way.

A I didn't say you did, I said we did.

Q It is a confusing thing that is the point I want to make, and unless one follows it very carefully, you will get confused and you will draw an erroneous conclusion. That is the point I want to make. Now that we are all fairly confused, will you go ahead?

A Under formula one hundred percent acres times deliverability, there are no limited wells, all wells being assigned an allowable by the allocation formula which is 572 wells. Along with this I will also take up by formulas the next item under the description, which is the percent of the total wells in the field that are limited wells and the percent that are non limited wells. Under formula one, 100% of the wells are non limited. As defined below. Under formula two we have 181 limited wells and 391 non limited wells, or 31.46 percent of the wells limited, and 68.36 percent not limited. Under formula three have 267 wells limited and 305 wells not limited. Under the percentage, under formula three, the limited wells amount to 46.68 percent of the wells and the non limited amount to 53.32. Under formula four being 75% acreage and 25% acreage times deliverability, there are 312 limited wells and 260 non limited wells for percentages of 54.55 and 45.45 respectively for the non limited wells, Under the formula 100% acreage, we have 342 wells limited and 232 wells not limited. The respective percentages being 59.79 and 40.21.

Going on down to the next two items which will be discussed and considered at the same time, we have the allowable M.C.F. per day assigned to the limited wells and the allowable assigned to the non limited wells and the next item below being the percentage of the wells, the percentage of the allowable assigned to the limited wells and the percentage assigned to the non limited wells. Under formula one, 320,000 M.C.F. per day is assigned to non limited wells, or 100%.

Q Right there may I, just may be a little untimely. Let me ask you this, under this column that you are now talking about, you show 100% allocated to limited and 100% allocated to non limited wells, is that what it says?

A No, sir. We show 100% allocated to wells all of which are not limited by the deliverability.

Q Say that again.

A I say that 100% of the market is limited to wells that are not limited by their deliverability.

Q Go ahead.

A Under the allocation formula number two, we show 28,876 M.C.F. per day allocated to the limited wells, 201,124 M.C.F. per day allocated to the non limited wells. This amounts to 9.02 percent of the total allocation being made to limited wells and 199, 90.8 percent being limited to non limited wells. Under allocation formula number three, the limited wells were assigned 66,939 M.C.F. per day. The non limited, 253,061 M.C.F. per day for percentages of 20.92 and 79.08. Under formula four the allowable assigned to limited wells was 96,520 M.C.F. to the non limited 223,480 M.C.F. per day for a percentage of the total allowable assigned to limited wells of 30.16 percent and to the non limited wells of the 69.84 percent. Under the final formula 100% acreage, 121,179 M.C.F. per day was assigned to the limited wells with 198,821 M.C.F. per day being assigned to non limited wells for a percentage of 37.87 for the limited wells and 62.13 percent to the non limited wells.

The purpose of preparing such a tabulation is to compare all the way through the various factors and the effects of each of the five allocation formulas.

Q Now, tell me how you can pick out the formula best suited to the field by making this comparison?

A By making this comparison we can arrive at a formula which can possible distribute the gas in say a manner comparable to the distribution of reserves. Now, initially and at this point, you can't very well make a comparison or determination.

Q I understand that.

A With respect to that formula. The purpose was to apply the formula to the market, make the re-allocation necessary so that we could actually come out and find out what kind of wells we are talking about when we say we are subsidizing these small wells. I want to know which they are. That is the purpose of this and expect to point it out.

I think also a lot of these figures will be kicked around here and just wanted them so that we could kick them around too. At the moment I am through with Exhibit six.

Q All right. Will you explain Exhibit 7 to us?

A Exhibit 7 represents the results of the various factors determined under the various formulas we applied to different size wells with respect to those wells deliverability. We have an allowable in million cubic feet per day on the vertical scale and deliverability in million cubic feet per day on the horizontal scale. By picking out a deliverability for a well and assuming that that well is assigned 320 acres, you can read the allowable from the curve and compare that allowable to the allowable for other wells. The line on the, awhile ago it was pointed out to me that there was an error on this exhibit to the extent that the formulas have been designated as 100% acreage plus deliverability, 25% acreage and 75% acreage plus deliverability, 50% acreage and 50% acreage plus deliverability, and 75% acreage and 25% acreage plus deliverability, each of those plus signs actually should be times, should be acreage times deliverability.

Q Will everyone just correct their exhibit? Put the times factor in place of the plus factor.

A Now, under the assumption that the wells allowable was going to be limited to 100% of deliverability, the line titled one hundred percent deliverability line was drawn as a dashed line which is a 45 degree slope line through the deliverability and the allowable coordinates. Under the allocation formula, 100% acreage times deliverability, we have the 100% acreage line going off showing the relationship between deliverability and allowable under that allocation formula. We come to the 25% acreage formula and we find that all those wells below approximately 320 M.C.F. per day which correspondsto the figure, actually it was 315, are limited. But they come over here and at a deliverability of approximately 1,200,000 a well would have the same allowable under the allocation formula 100% acreage times deliverability and 25% acreage and 75% acreage times deliverability.

Wells in excess of that deliverability would have less allowable, so it is immediately apparent that we have shifted allowable from wells between 315,000 cubic feet a day deliverability and 1,200,000 cubic feet a day deliverability by increasing the deliverabilities of those wells and decreasing -- the allowable as compared to the 100% acreage times deliverability formula.

Under the 50% acreage and 50% acreage times deliverability formula, all those wells under 557 M.C.F. per day will be assigned their allowable as, their allowable equal to their deliverability. We find that at about a deliverability of 1,330,000 we have the same allowable under a 100% acreage times deliverability as under the 50% acreage and 50% acreage times deliverability.

At approximately 1,440,000 we have the same allowable under the 50-50 formula and the 25% acreage and 75% acreage times deliverability formula. Going next to the allocation formula 75% acreage and 25% acreage times deliverability, we find that all those wells below 733 M.C.F. per day will be assigned an allowable equal to their deliverability. We find that at approximately 1,440,000 M.C.F., approximately 1,404,000 M.C.F. per day we have the same allowable assigned under the 75% acreage and 25% acreage times deliverability as the 100%. Well, a thousand and four M.C.F. per day.

Q I believe you said 1 million and 4?

A A thousand and four. At about 1,550,000 cubic feet deliverability per day we find that the allocation formula of 75% acreage and 25% acreage times deliverability gives you the same allowable under the 25% acreage and the 75% acreage times deliverability formula.

Q Is that just a coincidence?

A That is just the way the factors worked out. The purpose of it is to show where in the range of deliverability the shifting of allowable occurs under these various allocation formulas.

Q When you say shifting of allowable, you mean that as between wells?

A As between formulas for the same size wells.

Q Yes. I understand.

MR. SPURRIER: Let's recess until nine o'clock in the morning.

(Recess.)