

LOWER PENNSYLVANIAN RESERVOIRS OF THE PARKWAY-EMPIRE SOUTH FIELD AREA, EDDY COUNTY, NEW MEXICO

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BEFORE THE
OIL CONSERVATION COMMISSION
Case No. DeNovo Exhibit No. **4**
Submitted By:
Fasken Oil & Ranch, Ltd.
Hearing Date: October 30, 1997

ABSTRACT

The Parkway-Empire area is located on the Northwest Shelf in central Eddy County, approximately 15 miles northeast of Carlsbad, New Mexico. This area produces oil and gas from the lower and middle Morrow sandstones, Atoka sandstones, and Strawn limestones. Oil is also produced from the Queen and Seven Rivers sandstones, and the Grayburg, San Andres, and Wolfcamp dolomites. All of these zones are productive from stratigraphic traps.

The lower Morrow sandstones occur at a depth of about 11,400 feet. They are interpreted to be a prograding fluvial-deltaic sequence of channels and point bars sourced from the northwest. They trend toward the southeast, normal to depositional strike. The lower Morrow sandstones are separated from the middle Morrow sandstones by a widespread, dark gray, organic, lagoonal shale. In the Parkway area, the middle Morrow sandstones are thought to be a transgressive series of marine beaches and submarine bars which trend toward the northeast, parallel to depositional strike. Stratigraphic traps are created in the lower and middle Morrow sandstones by variations in cementation and depositional patterns. Productive Atoka sandstones occur at a depth of approximately 10,700 feet. These sands are thought to be a series of prograding beaches with a northeast trend. Strawn limestones produce from a series of small, low-relief algal banks developed along depositional strike to the northeast. The Strawn limestone is about 300 feet thick and occurs between 10,250 and 10,500 feet.

Wells in this area have typical ultimate recoveries of between 1.0 and 3.0 billion cubic feet of gas (BCFG). The combination of stacked reservoirs and good production makes this area of the Morrow trend especially attractive.

INTRODUCTION

The Parkway-Empire area consists of five or more designated fields which coalesced into one field with development during the past five years. It was selected for study for three reasons. First, it is essentially fully developed with excellent subsurface control. Secondly, since the area has been recently developed, most of the wells have modern and definitive wireline logs. Finally, it is an attractive, multi-pay stratigraphic field.

Two discovery wells led to aggressive development during the past five years. The first of these wells is the Southland Royalty Company's Parkway State No. 1. It is located in Section 15, T19S, R29E, and was completed from the middle Morrow sandstones on August 24, 1978, for a flowing potential of 2,714 thousand cubic feet of gas per day (MCFGPD). On December 31, 1982, cumulative production was 1.3 BCFG and 20 thousand barrels of condensate (MBC). The second well is the Southland Royalty Company Empire Federal State Com. No. 1, located in the SW/4 of Section 27, T18S, R29E. It was completed from an Atoka sandstone in June, 1980, for a calculated absolute open flow (CAOF) of 1,800 MCFGPD. It had produced 1.3 BCFG by December 31, 1982, when it was flowing 1,200 MCFGPD. This well was originally completed in the lower Morrow in May, 1980, where it produced

a small amount of gas before being plugged back to the Atoka. Since these two wells were drilled, approximately 30 additional wells have been drilled, extending the Parkway and Parkway West Fields north to the Empire South Field. Besides Southland Royalty Company, other major operators in the area are Petroleum Corporation of Texas, Thresh-old, Amoco, Conoco, and Hondo (Arco).

The Parkway-Empire South Field area is gas productive from four Pennsylvanian zones and oil productive from several Permian zones. The Pennsylvanian production occurs from four distinct sequences: lower Morrow sandstones, middle Morrow sandstones, Atoka sandstones, and Strawn limestones. Permian productive zones include Wolfcamp carbonates, Bone Spring carbonates, San Andres carbonates, Grayburg carbonates, and Queen and Seven Rivers sandstones. The Wolfcamp and Bone Spring carbonates have not yielded commercial quantities of oil to date. The Queen, Seven Rivers, Grayburg, and San Andres sediments produce oil from depths of 1,800 to 2,500 feet in large portions of the study area. These zones are economic objectives and are being developed in portions of the mapped area. Economically, the significant production in this area is gas occurring between 10,200 and 11,500 feet in the Strawn, Atoka, and Morrow sediments. The producing reservoirs from these sediments have been mapped and will be discussed in this paper.

Discrete fields are not apparent in the study area because small stratigraphically trapped productive reservoirs are present from several zones. The productive areas overlap, making field outlines vague and arbitrary. Fields for the study area designated by the New Mexico Oil and Gas Engineering Committee include Parkway, Parkway West, Empire South, Loco Hills, Burton Flat, Turkey Track, Millman, and Winchester. Cumulative production for the Parkway-Empire South Field was approximately 88.3 BCFG and 1.3 MBC from 51 wells on December 31, 1982.

Figure 1 is the stratigraphic column for the area showing the generalized stratigraphic sequence of sediments. Figure 2, a compensated density-neutron log of the Southland Royalty Company Parkway State No. 1, shows the typical log responses through the Pennsylvanian section in this area. A dual lateral log with a microlateral curve is usually run with this log to calculate water saturations and evaluate formation permeability. Wells are drilled with a salt base mud because the Pennsylvanian sandstones are especially susceptible to formation damage when drilled with fresh-water mud systems.

MORROW STRATIGRAPHY

The Morrow sediments consist of limestones, sandstones, shales, and siltstones. These sediments can be divided into three correlatable units. The lower Morrow consists of a fluvial-deltaic sequence of sandstones and shales which rest unconformably on the Mississippian. The middle Morrow consists of primarily marine sandstones and shales with a minor amount of interbedded limestone. The middle Morrow unit is defined in this paper as occurring from the base of a distinct shale, called the Morrow shale, to the top of the Morrow clastics. The upper Morrow

STRATIGRAPHIC COLUMN

WEST TEXAS-SOUTHEAST NEW MEXICO

SYSTEM	SERIES	NORTHWEST SHELF
QUATERNARY	RECENT	ALLUVIUM
	PLEISTOCENE	
TERTIARY	PLIOCENE-EOCENE	OGALALLA
CRETACEOUS	GULF	
	COMANCHEAN	
TRIASSIC	UPPER	DOCKUM
		CHINLE
		SANTA ROSA
PERMIAN	OCHOA	TECOVAS
		DEWEY LAKE
		RUSTLER
	GUADALUPE	SALADO
		TANSILL
		YATES
		SEVEN RIVERS
		QUEEN
		GRAYBURG
	LEONARD	SAN ANDRES
		GLORIETA
	WOLFCAMP	YESO
		ABO
		WOLFCAMP
PENNSYLVANIAN	VIRGIL	CISCO
	MISSOURI	CANYON
	DES MOINES	STRAWN
	ATOKA	ATOKA
	MORROW	MORROW
MISSISSIPPIAN	CHESTER	BARNETT SH.
	MERAMEC-OSAGE	MISSISSIPPIAN LM.
	KINDERHOOK	KINDERHOOK
DEVONIAN	UPPER	WOODFORD
	MIDDLE	
	LOWER	DEVONIAN
SILURIAN	U/NIAGARAN	U/SILURIAN
	L/NIAGARAN	
	ALEXANDRIAN	FUSSELMAN
ORDOVICIAN	CINCINNATIAN	MONTOKA
	MOHAWKIAN	BROMIDE
	CHAZYAN	McKEE
		WADDELL
		CONNELL
	CANADIAN	JOINS
	OZARKIAN	ELLENBURGER
CAMBRIAN	UPPER	
PRECAMBRIAN		

Figure 1. Stratigraphic column for west Texas and southeast New Mexico. From Geomap Executive Reference Map No. 306, 1981 Edition. Reproduced with permission of Geomap, Inc

TYPE LOG

SOUTHLAND ROY.

PARKWAY ST. No. 1

15-18S-29E

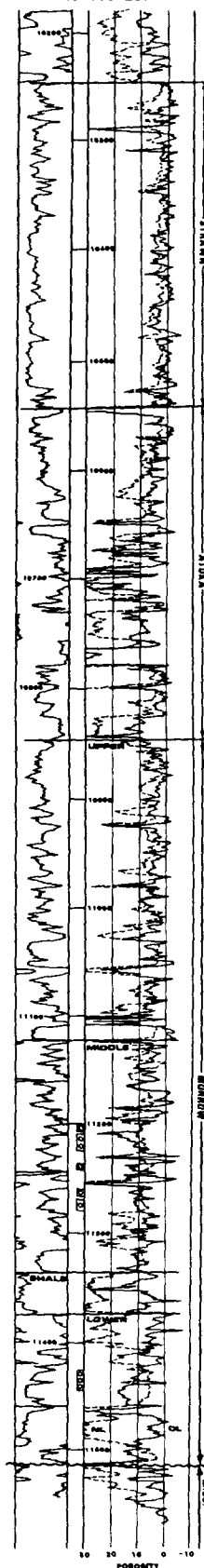


Figure 2. Compensated density-neutron log from the Southland Royalty Company Parkway State No. 1.

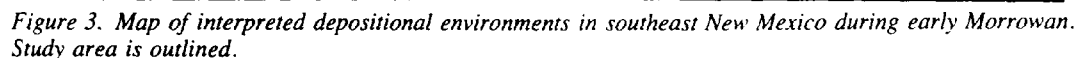


Figure 3 is a depositional environment map for southeast New Mexico during early Morrow time. At this time, sands and shales from the Pedernal Highlands were being deposited in the Parkway-Empire South areas in fluvial-deltaic systems of channels, point bars, and stream-mouth bars. The sea level was static, and these sediments prograded from northwest to southeast into the basin. Resting on top of the lower Morrow sediments is the Morrow shale which occurs over a large part of the Northwest Shelf. It is dark gray and can contain coal. This shale

A structure map was prepared on the base of the Morrow shale.

Figure 4. The Morrow shale occurs between 11,336 and 11,374 feet on the type log (Fig. 2). The Morrow shale structure map shows 150 feet per mile of regional dip with a northeast strike. This present-day dip and strike are probably similar to the dip and strike of the depositional slope during Morrow deposition. This map, in a very generalized fashion, tends to reflect the underlying main depositional channels for the lower Morrow. Arrows have been drawn on the map showing the channel patterns. These reflected patterns may be caused by differential compaction of the shales underneath the sands. They indicate that the main channels may have existed into the early part of the middle Morrow sequence, and influenced early deposition of the middle Morrow marine sandstones.

Stratigraphic traps are formed in the lower Morrow sandstones by variations in the depositional patterns and cementation of the sands. These traps are small, with reservoirs only 200 to 400 acres in areal extent. These small reservoirs can be defined by using the close subsurface control, production data, and test data. The method used to define the traps was to prepare a lower Morrow net sand isopach. Figure 5, which was then used as a contouring guide to prepare a net effective porosity isopach, Figure 6. The porosity isopach was overlaid with the Morrow shale structure map. Mapping was fitted to account for test data, water saturation calculations, and production to define the discrete reservoirs and productive areas. The hachured areas show the proven and probable gas producing areas and the clear areas show the water legs of the reservoirs. Salt water production commonly occurs in the lower Morrow sands throughout the Northwest Shelf.

Log curve shapes, typical for point bars, channels, and distributary mouth bars, can be seen on the wireline logs in the study area. Figure 7 shows several examples of these log responses and gives their interpreted environments.

Figure 7 also shows one example of the middle Morrow marine sands (the Hondo Union "Tx" St. No. 1). Production is found in the middle Morrow sandstones in stratigraphic traps created by the presence of effective porosity and permeability. These traps can be variable in size and shape. Predicting the occurrence of reservoir-quality porosity and permeability is difficult, but in general the thicker sandstones tend to have the better preserved porosity and permeability. To define middle Morrow reservoirs, a net sand isopach, Figure 8, and a net effective porosity isopach, Figure 9, were prepared.

Gas production in the middle Morrow sands is not related to structure, but to porosity development. Areas with approximately 10 or more net feet of effective porosity should be productive. Producing wells in both the lower and middle Morrow sandstones have porosities ranging between 8% and 14%. In contrast to the lower Morrow sandstones, water production rarely occurs in the middle Morrow sands.

Fluvial channels are also present near the base of the middle Morrow section. They represent a fluvial-deltaic system that was largely destroyed during transgression of the seas during middle Morrowan time. Two such channels occur in the mapped area and account for large volumes of gas production. These channels are shown in Figure 9. One channel is located to the northwest in Sections 6, 5, and 4 of T18S, R29E, and the other channel is present in Sections 2 and 12 of T20S, R28E.

Morrow production in the mapped area was 93.2 BCFG and 1,161 MBC on December 31, 1982. The lower Morrow production has a cumulative of 52.1 BCFG and 608 MBC from 46 wells and the middle Morrow has a cumulative of 41.1 BCFG and 553 MBC from 53 wells.

Figures 10 and 11 are southwest-northeast stratigraphic cross sections in the study area of the Morrow and Atoka sediments. These cross sections were constructed with a datum at the base of the Morrow shale to best show the cut and fill depositional relationships of the lower Morrow sandstones. The cross sections are normal to the depositional

trend of the lower Morrow sandstones and parallel to the depositional trend of the middle Morrow and Atoka sandstones.

ATOKA STRATIGRAPHY

Shallow-marine limestone deposition was predominant in late Morrowan and early Atokan time. Renewed uplift during Atokan caused an influx of clastics which were deposited in a shallow-marine environment. These sandstones are interpreted to be a prograded system of beaches and bars. The Atoka sandstones were deposited along northeast trends parallel to the ancient Atokan shorelines. The sand trends migrated with the shorelines into the basin during Atokan time.

Figure 12 shows the regional environmental interpretation for the Atoka. The Atoka marine sands were derived from fluvial systems bringing in sediments from the northwest. The Buffalo Valley Field, located about 20 miles north of the study area, is productive from such a fluvial system. South of the study area, an extensive Atoka bank developed along a slope break on the Atoka shelf. Gas production occurs within this bank, associated with local buildups and later structural uplift.

The most significant Atoka gas production on the Northwest Shelf occurs from the Atoka marine sandstones. Two attractive Atoka sandstone trends are found in the mapped area. One trend occurs in the Parkway area in Sections 10, 11, 14, and 15, T19S, R29E, and the other is present in the Empire South area in Sections 22 and 27, T18S, R29E (Fig. 14). Cumulative Atoka production was 8.4 BCFG and 68 MBC on December 31, 1982, from 12 wells in the Parkway-Empire South area.

Figure 13 is a density-neutron log of the Atoka section in the Southland Royalty Company Empire "A" Federal No. 1. This well has 28 feet of Atoka sand pay with porosities ranging from 9% to 12%. This well, which is located in the NW/4 Section 27, T18S, R29E, was completed on July 7, 1980, from this Atoka sandstone for a CAOF of 2,514 MCFGPD. It had cumulative production of 1.41 BCFG on December 31, 1982, when it was flowing at an average rate of 1.3 MMCFGPD for the month of December. An isopach of this sand, which has been called the "B" sand by Metcalf, is shown on Figure 14. Production for each well is noted on the map. Note the attractive production from the two mentioned areas. Atoka sands only 5 to 8 feet thick can be prolific gas producers. This suggests that good drainage can occur along the long and lenticular reservoirs.

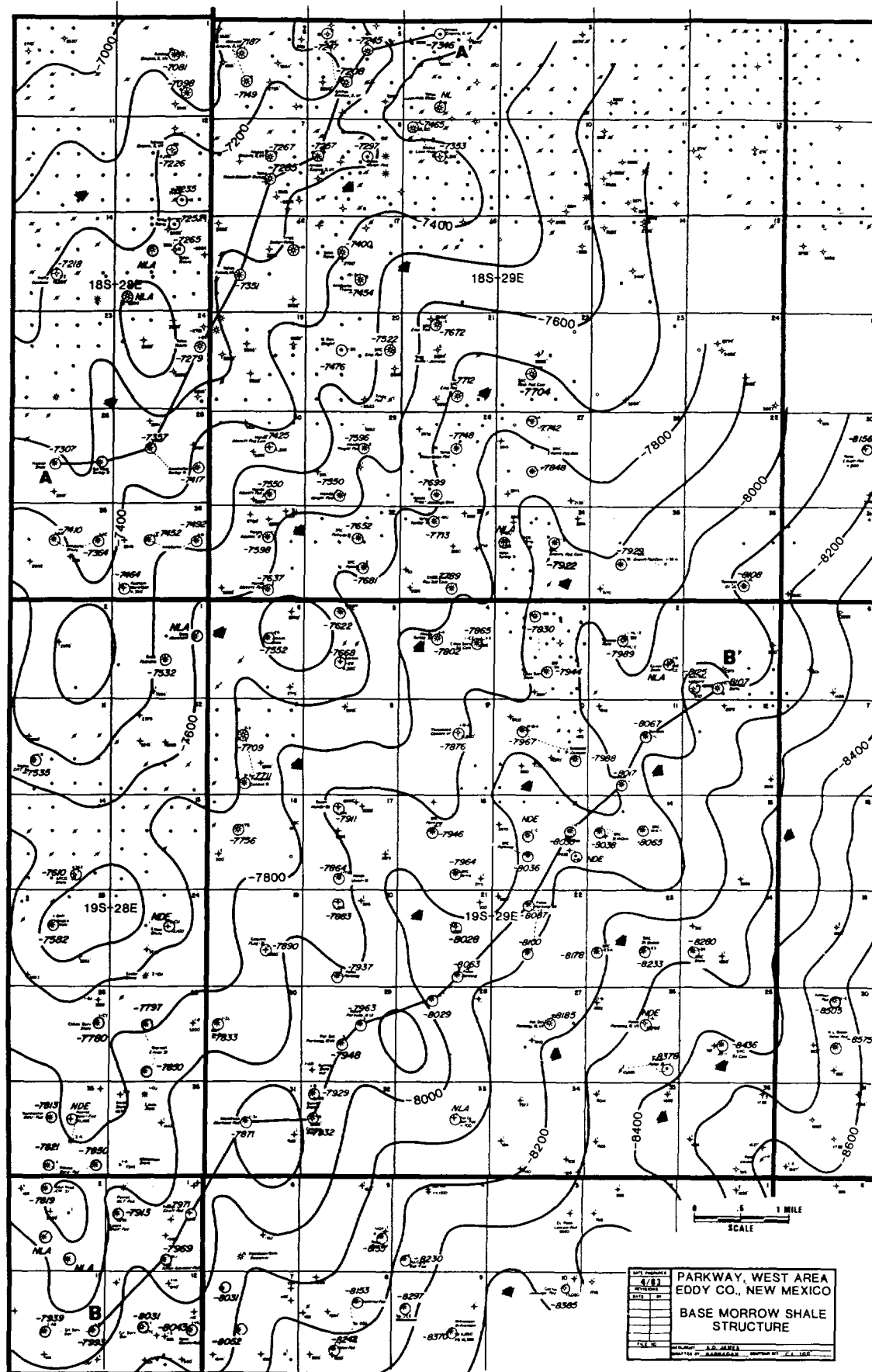
As shown on the cross sections, Figures 10 and 11, three or more Atoka sandstones occur in this area. The lowermost of these sands is the mapped Atoka "B" sand, which accounts for the significant gas production. Significant production has not been documented in the other Atoka sandstones.

STRAWN STRATIGRAPHY

Strawn limestones were deposited on the Northwest Shelf on a broad ramp as shown in Figure 15, the regional Strawn environment map. In the mapped area, northeast-trending localized thicks developed. These thicks are interpreted to be phylloid algal mounds formed primarily from carbonate mud. Porosity ranges from 4% to 10% in the productive Strawn zones. Net clean carbonate and net porosity isopachs, Figures 16 and 17, were prepared to define the reservoirs. Cumulative production from this zone was 7.7 BCFG and 333 MBC from 10 wells on December 31, 1982.

SUMMARY

The Parkway area is an attractive multi-pay area. Typical completions in the Morrow and Atoka zones yield 1 to 2 BCFG and 10 MBC. Initial producing rates are generally about 1,500 MCFGPD with an 8 to 12 year life. The Strawn recoveries vary greatly but contain considerably



◆ LOWER MORROW CHANNEL TRENDS

Figure 4. Structure map of Parkway West area, contoured on the base of the Morrow shale. Contour interval: 100 feet. Lines of cross section for Figures 10 (AA') and 11 (BB') are shown.

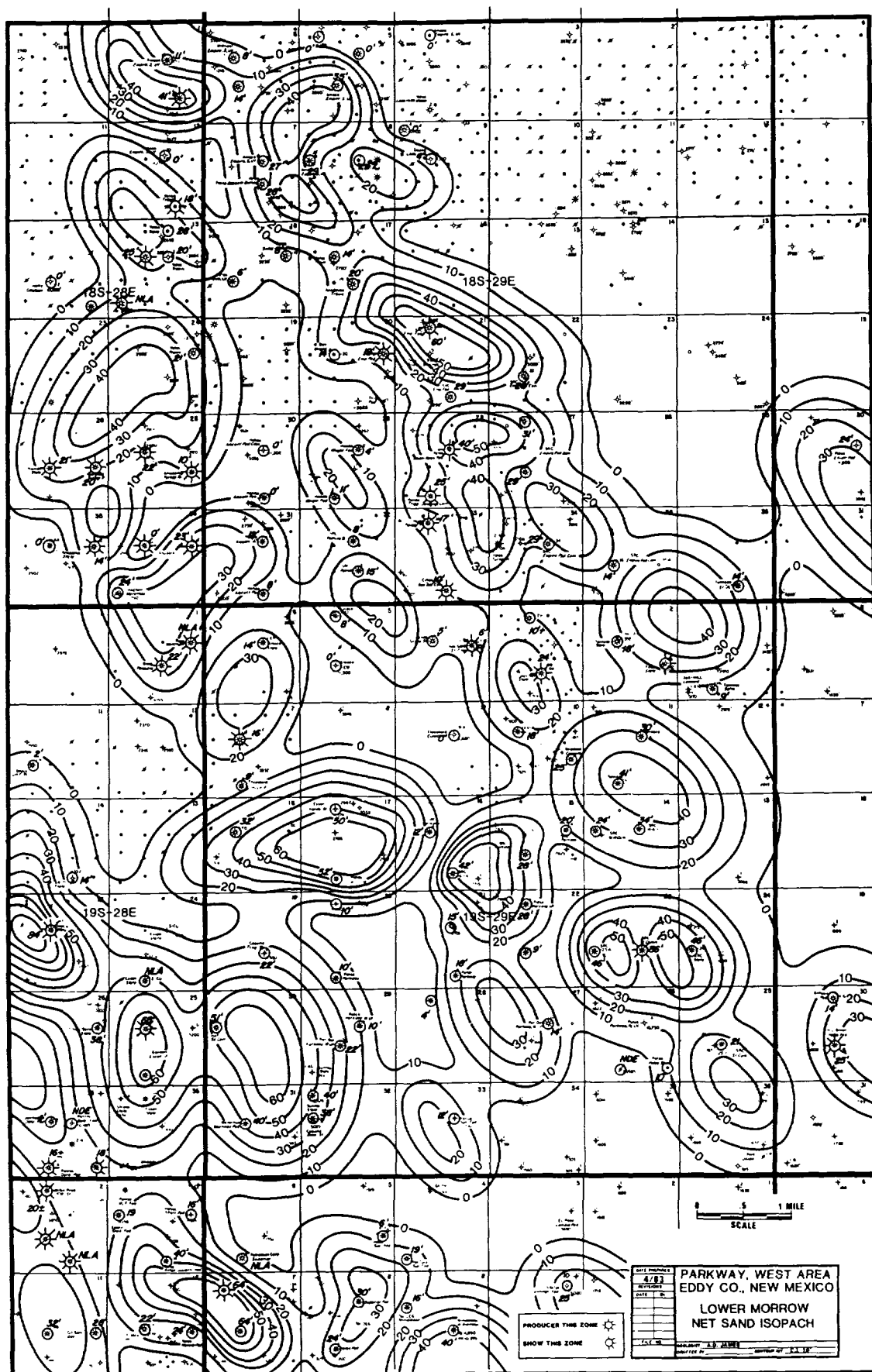
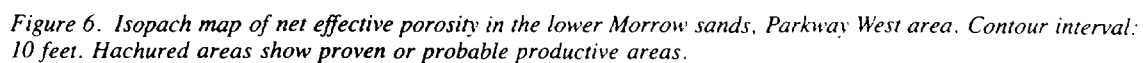
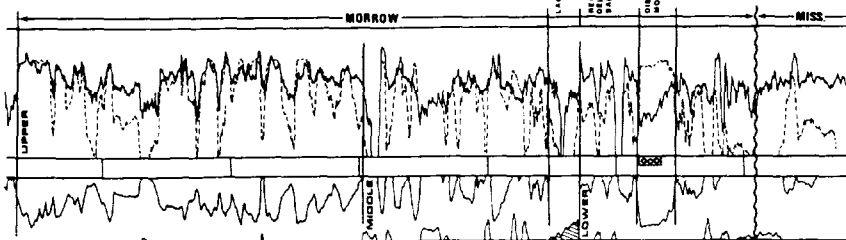


Figure 5. Isopach map of net lower Morrow sand thickness, Parkway West area. Contour interval: 10 feet.

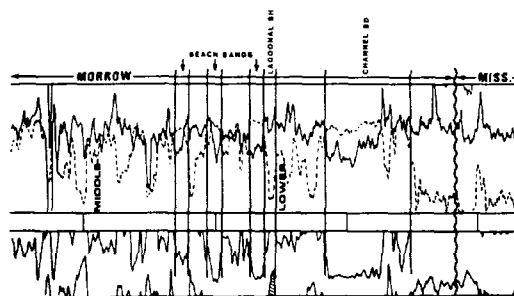


LOGS SHOWING EXAMPLES OF ENVIRONMENTAL FACIES

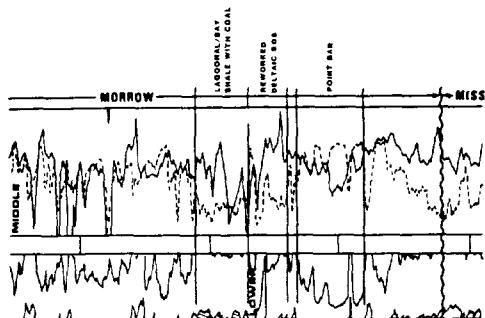
AMOCO
EMPIRE, S. DEEP UT. No. 16
7-18S-29E



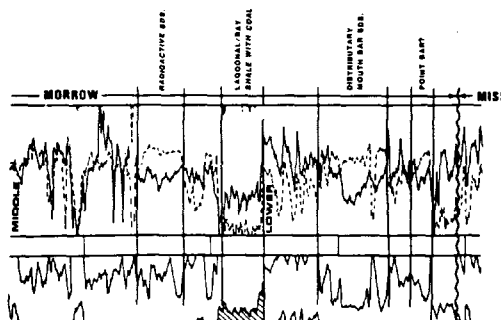
SOUTHLAND ROY.
EMPIRE FED. "35" No. 1
35-18S-29E



COCQUINA OIL CO.
BASS ST. No. 1
32-19S-29E



HONDO DRILG. CO.
UNION "TX" ST. COM. No. 1
17-19S-29E



DEPCO INC.
STATE D.H.Y. No. 1
23-19S-28E

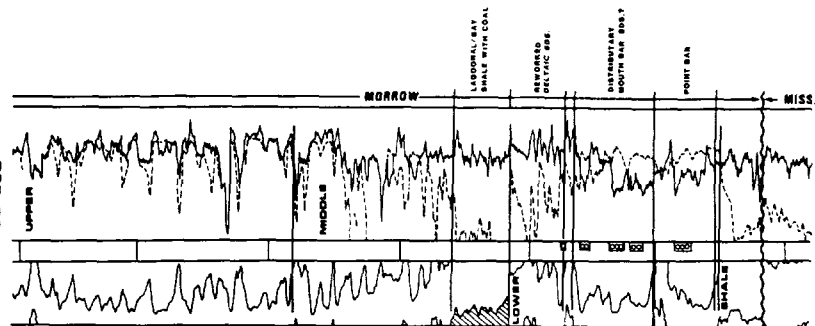


Figure 7. Log comparison showing examples of Morrow sands, their log responses, and their interpreted environments of deposition.

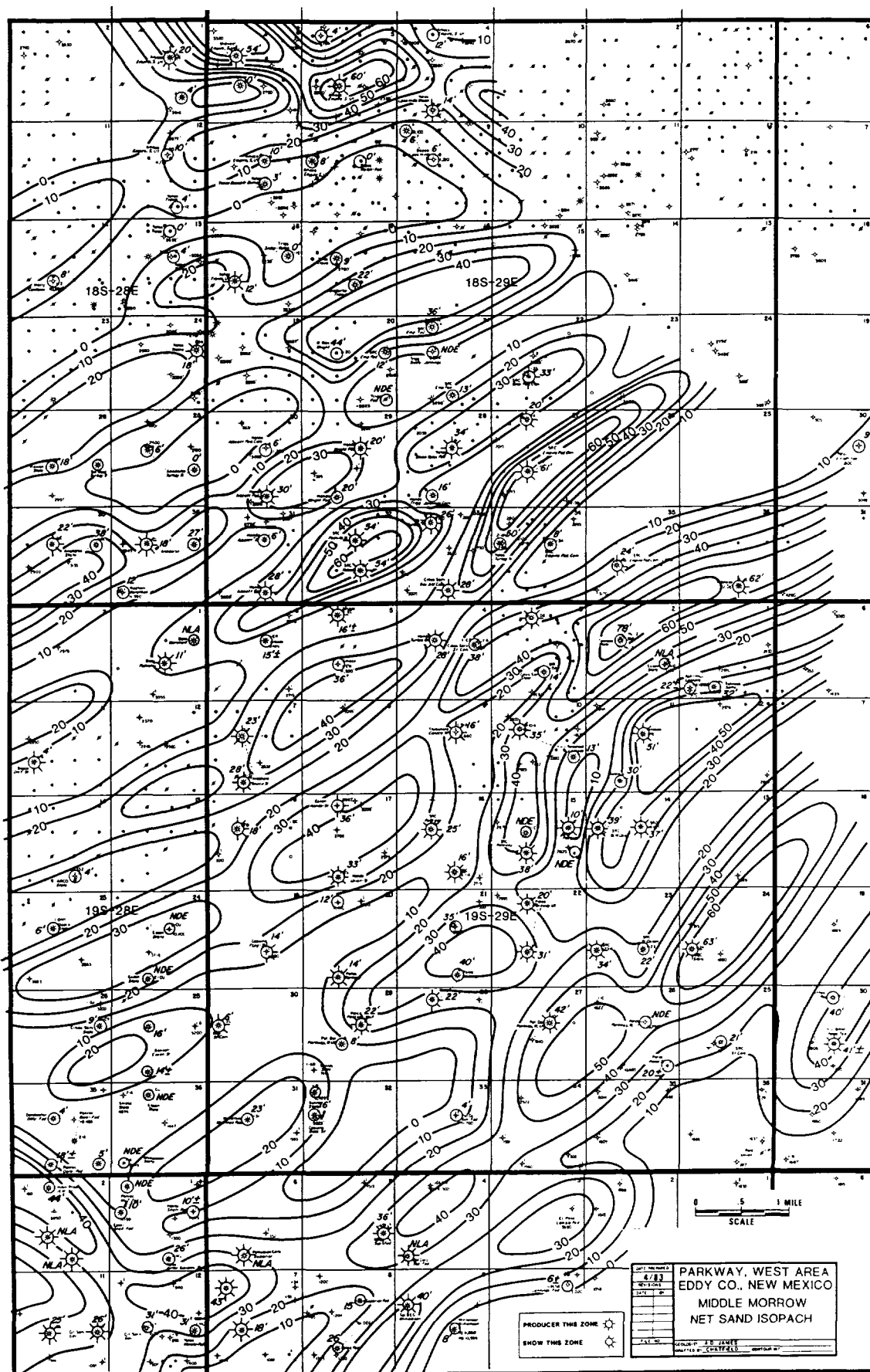


Figure 8. Isopach map of net middle Morrow sand thickness, Parkway West area. Contour interval: 10 feet.

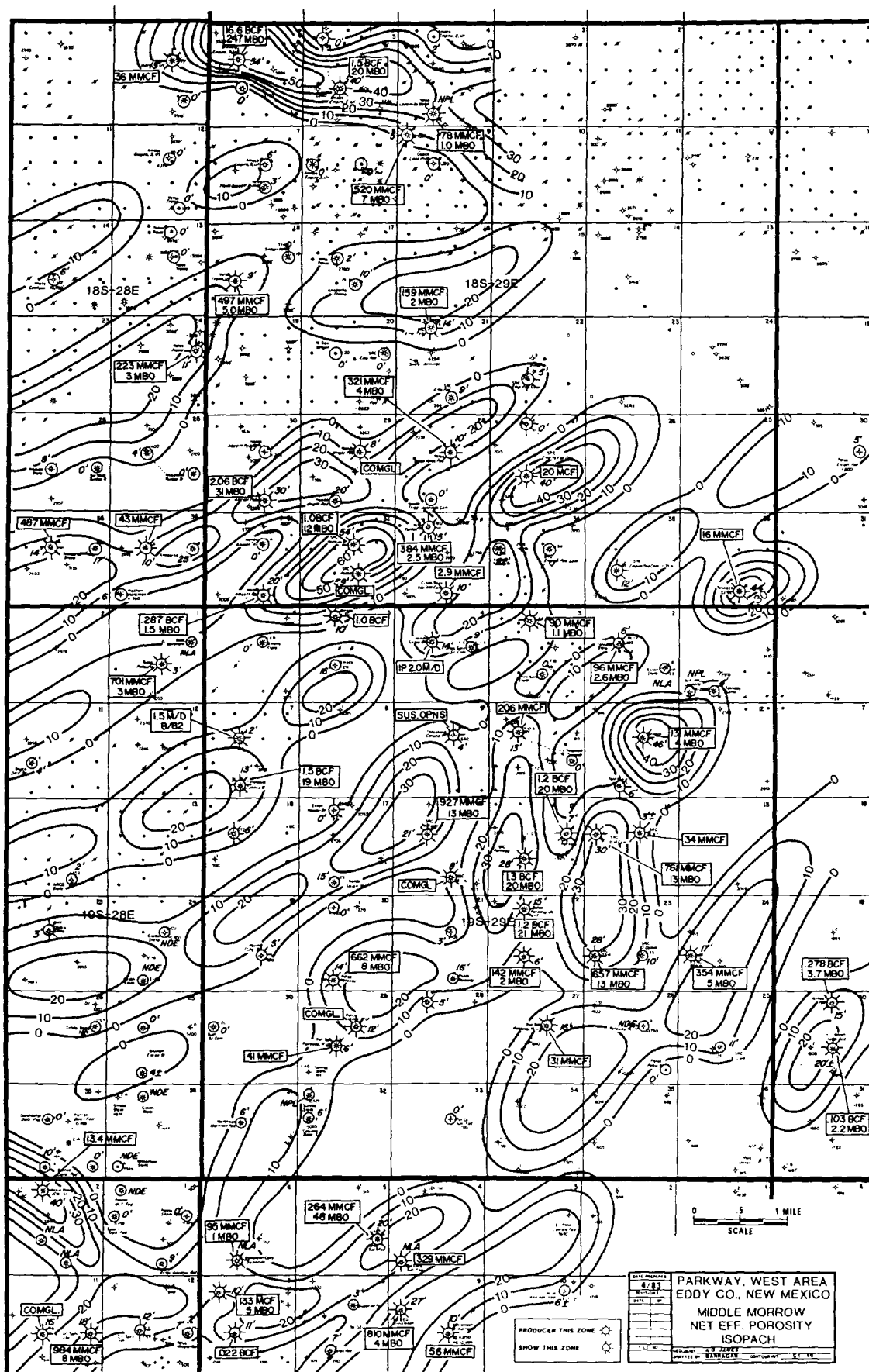


Figure 9. Isopach of net effective porosity in the middle Morrow sands, Parkway West area. Contour interval: 10 feet.

more liquid hydrocarbons than the other Pennsylvanian reservoirs. Typical ultimate recoveries for this zone are 800 MMCFG and 50 MBC with a life of about 10 years. Approximately half the wells in this area have more than one potentially productive zone, which greatly increases the attractiveness of the play.

Predicting the presence of the producing zones is difficult because the reservoirs are relatively small and complex, but having multiple prospective zones increases the success probability, making up for this prediction difficulty. These reservoirs have been developed on 320-acre proration units which will not, in many areas, allow all the gas to be produced. Selected infill drilling will likely be needed to ensure complete drainage.

ACKNOWLEDGMENTS

Jack W. Becher and Michael G. Metcalf helped develop the regional concepts used in this paper. They prepared the diagrammatic environmental maps and Metcalf prepared the detailed Atoka net sand isopach which are presented in this paper. Statistical production data was compiled for the report by E. R. "Gene" Andrews. Gilbert R. Barragan drafted the many exhibits and Neita G. Baccus typed the drafts and final manuscript. All these people are employees of Southland Royalty Company. A special thanks is given to these individuals for their help and efforts and especially to Southland Royalty Company, who permitted publication of this study.