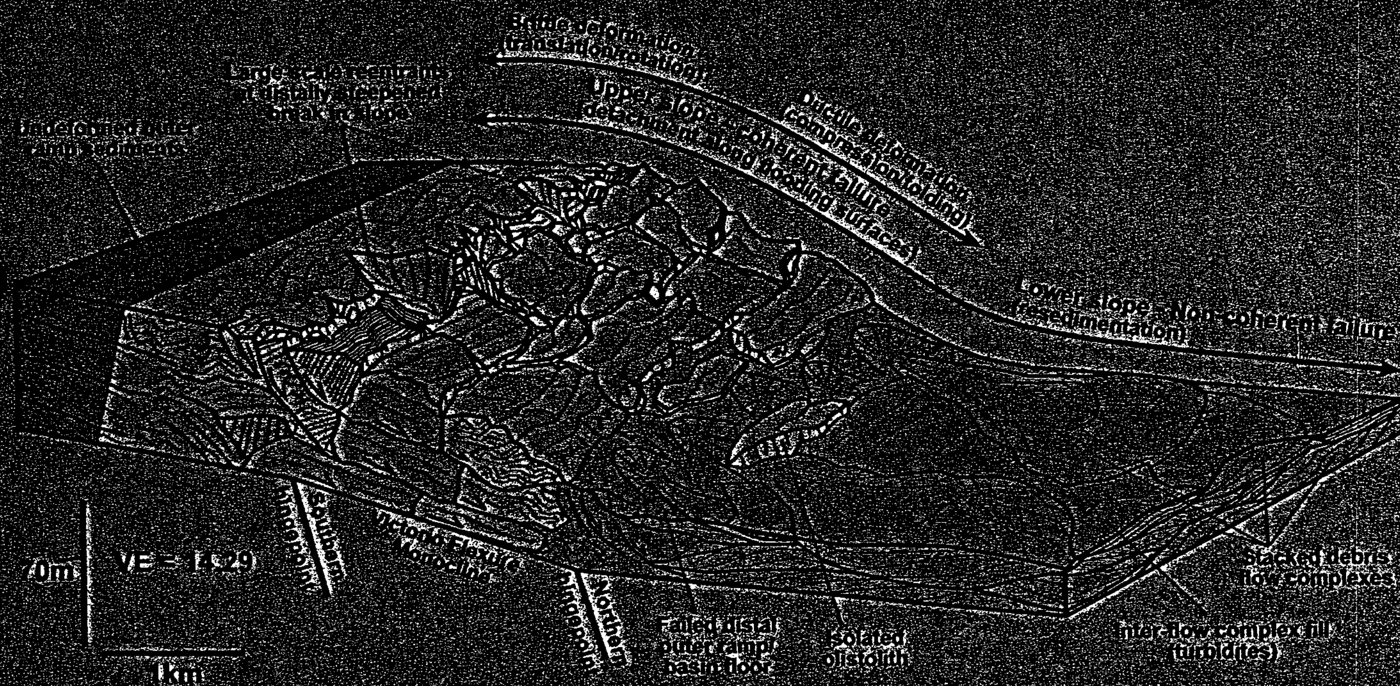
The Permian Basin: Back to Basics

West Texas Geological Society Fall Symposium



Tim J. Hunt and Peter H. Lufholm

Samson Exhibit 5
NMOCD Case Nos. 13492/13493
Submitted 8/10/06

"The Permian Basin: Back to Basics". Tim J. Hunt, Peter H. Lufholm, eds.
West Texas Geological Society Publ. #03-112
Fall Symposium, October 8-10, 2003

DEPOSITIONAL ENVIRONMENTS OF THE MORROW FORMATION IN THE OSUDO FIELD, LEA COUNTY, NEW MEXICO

April Denise Coker

The University of Texas Permian Basin
Odessa, Texas

ABSTRACT

The Morrow Osudo Field, located in Lea County, New Mexico, produces hydrocarbons from distributary channels of a clastic rich marine delta in the Pennsylvanian Morrow Formation. The main producing zone is the middle Morrow. Core description, well log correlation, and reservoir analysis where utilized to make this determination.

Through core description, 11 lithofacies were identified. Coarse-grained sandstones are the predominant producing facies and are found as distributary channel deposits.

INTRODUCTION

The depositional environment of the Pennsylvanian Morrow Formation is complex and has been the subject of different interpretations. In southeast New Mexico the Morrow Formation has been studied on a regional scale, but in detail only in a few specific areas. The problem faced by many geologists is that once they begin looking in detail at a specific field, it may not match the regional facies characterization. Knowing this, one should consider what the detailed depositional environment of the Morrow Formation is in a specific area of study.

Depositional environments of the Morrow Formation range from fluvial to shallow marine and even to outer shelf. Generally the regional studies end, to the south and the east, at the Osudo Field, Lea County, New Mexico. The purpose of this study is to determine the detailed depositional environments of the Morrow Formation in the Osudo Field. A correct interpretation of the depositional environments allows further and more successful exploitation of the area.

DISCUSSION

The Morrow Formation has a diverse depositional history. It is early Pennsylvanian in age and is considered to be one of the most difficult formations in southeast New Mexico to correlate and identify depositional environments on a detailed basis (Mazzullo, 1983). The Morrow Formation was deposited in the present-day Delaware Basin and Northwest Shelf of southeastern New Mexico during the early Pennsylvanian. The Delaware Basin is bordered by the Huapache Fault in the southwest, the Northwestern Shelf to the north, the Tatum Basin to the northeast, and the Central Basin Platform to the west (Figure 1). The Pedernal uplift to the Northwest provided the sediment filling for the Delaware Basin and the Northwest Shelf (Cys and Gibson, 1988).

The sediments that were deposited during Pennsylvanian time range from shallow-marine carbonates to basinal shales to several different siliciclastic materials. The Morrow was deposited during a time of alternating transgression and regression with maximum clastic deposition in the middle and lower Morrow intervals deposited on the Mississippian Formation. The upper Morrow (limestone), followed by the Atoka Formation, was deposited on top of

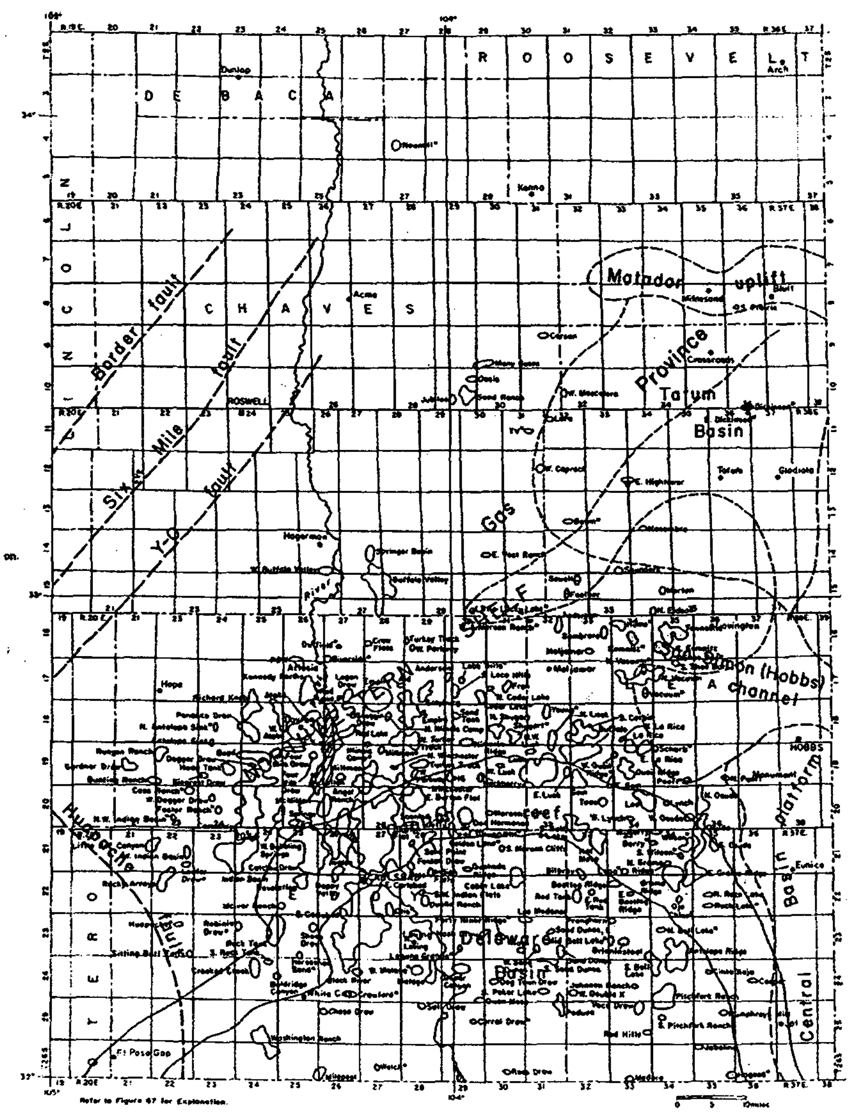


Figure 1. Oil and gas fields producing from the Morrow Formation, also illustrating major structural features (Grant and Foster, 1989)

the thick Morrow clastics (Figure 2). The thickness of the Morrow ranges from 1700 ft in the southeast, to 0 ft in the North and Northwest of the Northwestern Shelf and 0 ft Northeast of the Tatum Basin (Mazzullo, 1983).

Previous work has been mainly on a regional scale. The conclusions drawn from Mazzullo's (1999) regional studies are illustrated in Figures 3 and 4. This work gives a generalized look at the Morrow; however, a more detailed interpretation of the depositional environments is needed for each field. The Morrow is overlain by the Atoka Formation and underlain by the Mississippian Formation. The Morrow is divided into three subdivisions: upper,

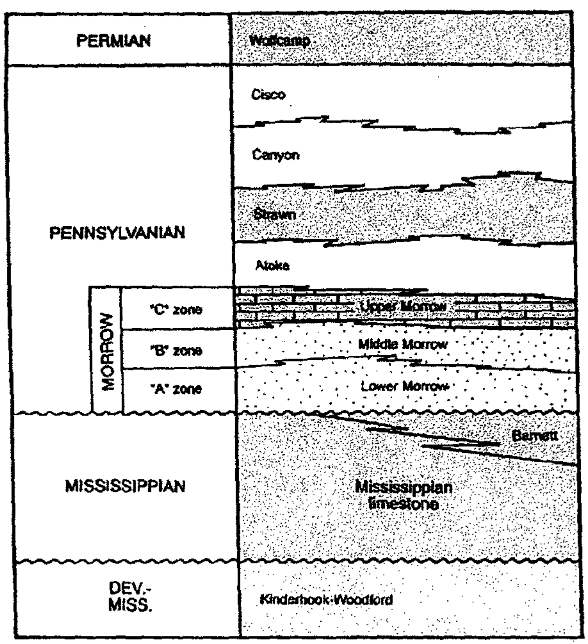


Figure 2- Geologic time scale showing subdivisions of the Pennsylvanian and the Morrow Formation (Speer, 1993)

middle, and lower (Figure 2). Within these three subdivisions depositional environments ranging from proximal fluvial facies to mid-shelf to basinal facies have been recognized. Each stratigraphic interval of the Morrow Formation is bounded by major flooding surfaces and dominated by a specific depositional environment (Speer, 1993).

The upper Morrow is primarily limestone deposited in a carbonate shelf environment (Casavant and Mallon, 1999). This interval is not regionally consistent in thickness and, therefore, problems are often encountered when trying to correlate over more than a few townships (Kholes and Roberts, 1999). This study agrees with that conclusion and focuses on determining the depositional environments in the middle and lower Morrow in the Osudo Field.

From a regional point of view, the middle Morrow is a delta front with terrigenous clastic deposits. It has a shale boundary at the base and top. Sandstone channels are the major depositional facies and are the only reservoir interval that produces gas. The middle Morrow interval has five depositional environments that can be found in southeastern New Mexico: 1) proximal fluvial facies, 2) alluvial plain facies, 3) transitional marine facies, 4) shoreline to inner shelf facies, and 5) mid-shelf to basinal facies (Figure 5). Interpretation of the stratigraphic sequence in the Morrow is further complicated by the interaction of multiple transgressive and regressive sequences (Mazzullo, 1983). One can regionally pick the top and base of the middle Morrow, but trying to make more detailed picks on the sands and shales within this interval is extremely difficult even when the wells are numerous and closely spaced (Mazzullo, 1999).

The lower Morrow has many of the same characteristics of the middle Morrow. The

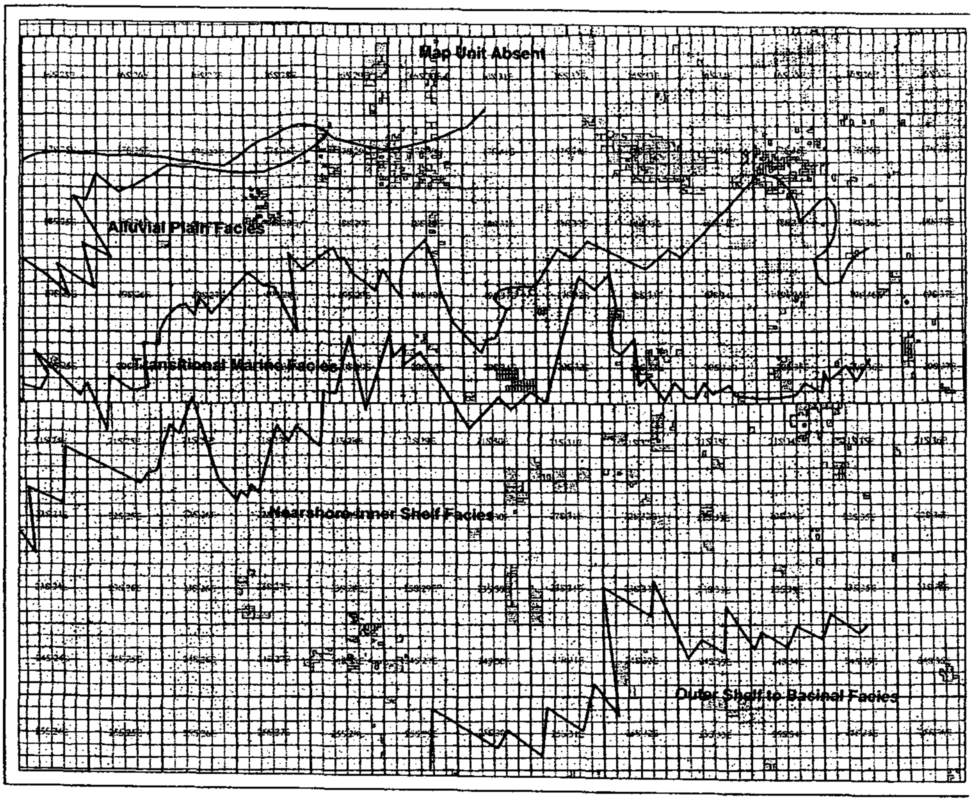


Figure 3. Middle Morrow Facies Map (after Mazzullo, 1999, modified). The sharp point separating the facies are based on control points.

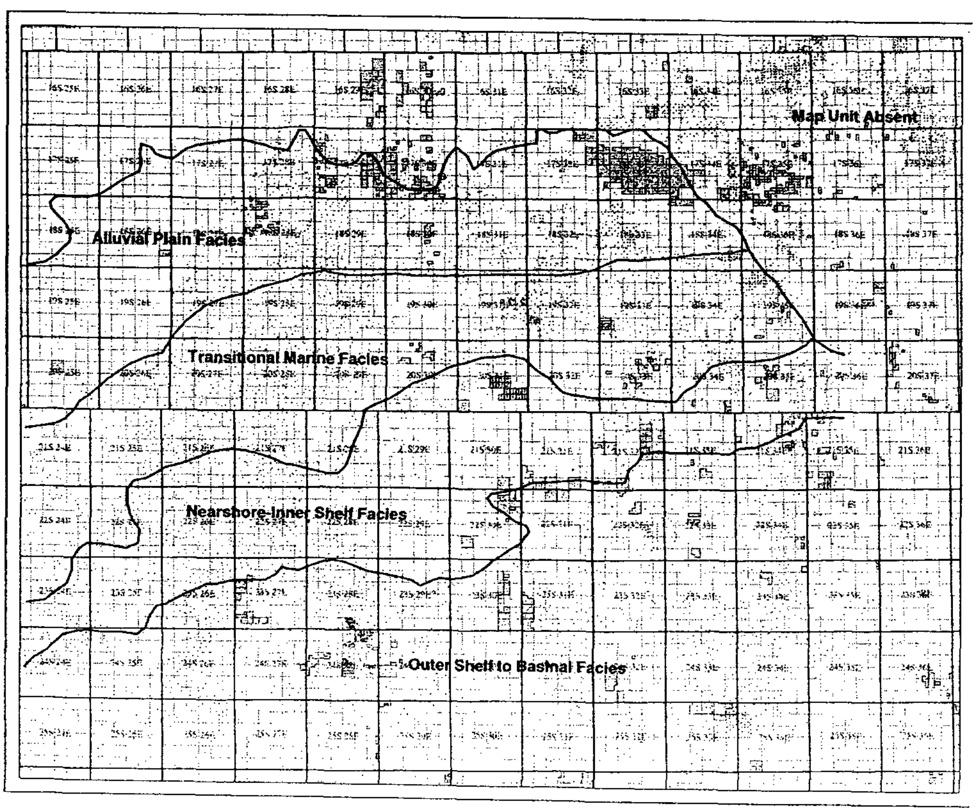


Figure 4 – Lower Morrow Facies Map (after Mazzullo, 1999, modified). The sharp point separating the facies are based on control points.

middle and lower Morrow are often grouped together and called the Morrow clastics. The lower Morrow has the same depositional environments as the middle Morrow with the possible exception of proximal fluvial facies (Figure 5). As in the middle, the lower Morrow is mostly sand and shale deposits, although thin beds of carbonates can be found in this section (Mazzullo, 1983). The lower is separated from the middle by the transgressive marine middle Morrow shale. This marker is regionally recognizable because of the high radioactivity observed in the lowest 10-15 ft of the shale (Casavant and Mallon 1999). The Osudo Field is at the end of the regional studies performed on the Morrow Formation, and no detailed study of the depositional environments has been performed here.

The Osudo Field was discovered in 1963 by Unocal. The Wilson Deep Unit #1 spudded on February 18, 1963 and has produced 1.3 BCF to date. The well is still producing at a rate of 87 MCFD. The Wilson Deep Unit #1 is located in section 13 of township 21S range 34E and was drilled to a total depth of 13,862 ft. The well penetrated the Mississippian Formation and produced from the middle Morrow Formation with perforations from 12,320 ft to12,344 ft. The middle Morrow, as well as the lower Morrow, is a stratigraphic-structural trap. It is a gas-drive reservoir with 142 wells having been drilled to date. A type log is shown in Figure 6.

Ninety-seven of the 142 wells that have been drilled are producing. The cumulative production for the field is 242 BCF and 2.44 MMBC. The most successful producer so far, is the North Wilson Deep Unit #2 drilled in 1965. Its cumulative production is 28 BCF and current rate is 697 MCFD. The least successful producer, drilled in 1980, is the Getty 6 State Com #1 that produced a total of 0.02 BCF. The average production per well is 2.5 BCF.

One hundred and eleven wells that penetrate the Morrow Formation were used in this study. The first of these wells was spudded

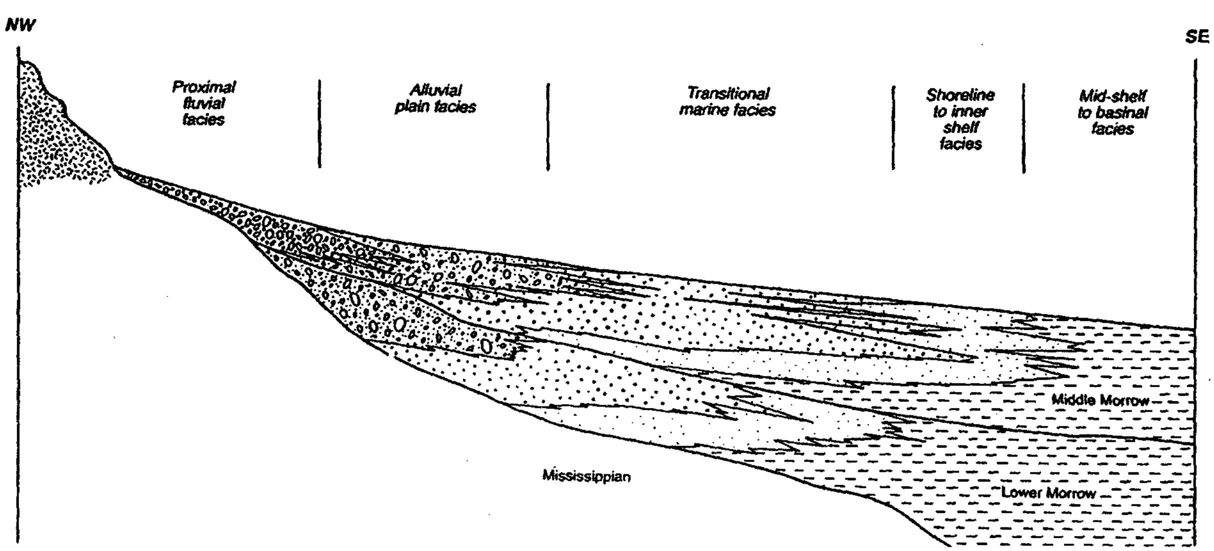


Figure 5- Schematic regional cross-section through the middle and lower Morrow, southeastern New Mexico (Mazzullo, 1983)

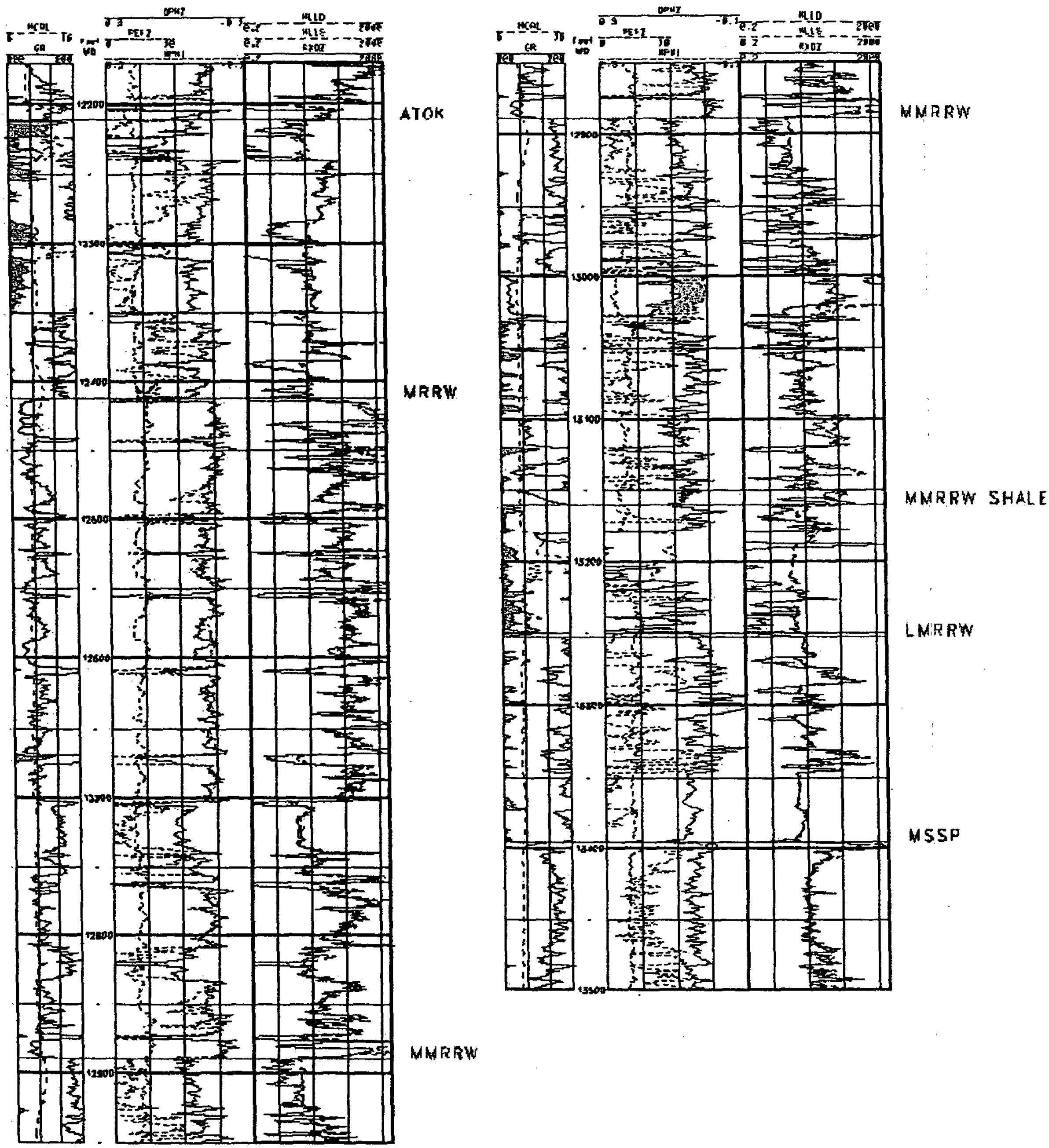


Figure 6-Type log

in August of 1960 and the last in December of 2001. A total of 142 wells were drilled through the Morrow Formation, but 31 were not used either because of lack of sufficient data or because electric logs were not yet released. Whole cores were taken in at least six wells, but cores from only three were located. A total of 229 feet of core were studied from the following wells: State DV #1 with 82 ft, Berry State #1 with 38 ft, and Getty 36 State Com #1 with 109 ft. In addition to the whole cores, 10 sidewall cores from the Prairie Fire State #1 were obtained. Intervals within the middle and lower Morrow were sampled in each core.

Description of the middle and lower Morrow Formation in the Osudo Field is based on macroscopic and microscopic study of the three available whole cores and sidewall cores. Eleven lithofacies were distinguished in the middle and lower Morrow: 1) fossiliferous, fissile black shale, 2) gray siltstone, 3) interbedded shale and silty sandstone, 4) herringbone crossbedded, silty to fine-grained sandstone, 5) incline-bedded, silty to fine-grained sandstone, 6) rippled, silty to fine-grained sandstone, 7) trough crossbedded, silty to fine-grained sandstone, 8) gray to tan fine-grained sandstone, 9) gray to tan coarse-grained sandstone, 10) incline-bedded, coarse-grained sandstone, and 11) ooid grainstone.

Detailed stratigraphic analysis and interpretation of the depositional environments made it possible to construct 2-Dimensional depositional models utilizing cross sections. The depositional environments determined from the core were plotted onto the well logs and then correlated throughout the field. The cross sections demonstrate the complexity of the reservoir. A cross section constructed north to south shows an overall thickening of the Morrow clastics section. Cross sections going from the west side of the field to the east demonstrate the complexity and number of channels. The depositional environment of the entire field is interpreted to be marginal marine to deltaic.

Reservoir analysis shows that the majority of production comes from the middle Morrow. Table 1 summarizes the production information. The 19 wells marked as undetermined lack sufficient data. Either the wells were too new or too old to obtain complete perforation and other needed completion information. A structure map on the top of the middle Morrow indicates there could be two major faults and that the structure is highest to the northeast and lowest to the southwest stepping down across the faults. However, because there is post depositional faulting the present-day structure of the middle Morrow does not necessarily represent the topography at the time of deposition. In addition, a gross thickness map of the Morrow clastics show alternating thicks and thins from north to south across the field. It is possible that these thicks and thins could be attributed to minor faulting between the two major faults.

CONCLUSIONS

The focus of this study is the Morrow clastics interval of the Morrow Formation in the Osudo Field, Lea County, New Mexico. Through examination of core and

Table 1-Production by zone

ZONE	NO. WELLS	CUM PROD.	AVG CUM
Middle Morrow	68	208 BCF	3.1 BCF
Lower Morrow	5	6.5 BCF	1.3 BCF
Middle & Lower	5	6.5 BCF	1.3 BCF
Undetermined	19	20.7 BCF	1.1 BCF

well logs 11 lithofacies were identified. From a detailed stratigraphic analysis it was determined that the overall depositional environment for the Morrow clastics in this field is marginal marine to deltaic.

Of the 11 lithofacies that were identified it was determined that the coarse-grained sandstones were the main producing facies. The depositional environment of the coarse sands is interpreted to be a distributary channel.

Through reservoir analysis it was determined that the middle Morrow is the main producing zone. Structure and isopach mapping illustrate the probability of faults in this interval. In an attempt to correlate production to thickness of the clastics interval a map was made that overlays the cumulative production contours onto the gross thickness isopach color fill of the Morrow clastics. No correlation is observed.

After completion of this study it is evident that further study and a more complete analysis of the field is warranted. A 3-D seismic survey would help determine the exact location, throw, and extent of the faults. As the top of the middle Morrow and the top of the Mississippian are excellent seismic reflectors, these reflectors could be traced through the field and a more complete gross isopach of the Morrow clastics could be made. Once the seismic has been interpreted and mapped it would be possible to make a complete 3-Dimensional depositional model. If the structure is mapped out with the faults, then the drainage pattern could be determined and the distributary channels could be mapped out completely. This complete model would allow for further exploration and exploitation of the Osudo Field.

REFERENCES

Casavant, R.R., and Mallon, K.M., 1999, Facies and Reservoir Characterization of the Morrow Sandstones, White City Penn Gas Pool, Eddy County, New Mexico, p. 55-96, *in* Worthington, R.E. and Browns, M., eds., A Symposium of the Oil and Gas Fields of Southeastern New Mexico; 1999 supplement, Pennsylvanian Gas Fields: Roswell Geological Society.

Cys, J.M., and Gibson, W.R., 1988, Pennsylvanian and Permian Geology of the Permian Basin Region, p. 277-280, *in* Frenzel, H., and 13 others, 1988, The Permian Basin region, *in* Sloss, L.L., ed., Sedimentary Cover-North American Craton, U.S.: Boulder, Colorado, Geological Society of America, The Geology of North America, v. D-2.

Grant, P.R., Jr., and Foster, R.W., 1989, Future petroleum provinces in New Mexico-discovering new reserves, p. 69-74, Authority of State of New Mexico, NMSA 1953 Sec. 63-1-4.

Kholes, K.M., and Roberts, J.E., 1999, The Morrow of Southeastern New Mexico-A Detailed Look at the Big Picture, p. 115-122, *in* Worthington, R.E. and Browns, M., eds., A Symposium of the Oil and Gas Fields of Southeastern New Mexico, 1999 supplement, Pennsylvanian Gas Fields: Roswell Geological Society.

Mazzullo, L.J., 1983, Stratigraphy and Sedimentation of the Lower and Middle Morrow of Southeaster New Mexico, p. 168-189, *in* Exploration in a Mature Area: American Association of Petroleum Geologists, Southwest Section.

Mazzullo, L.J., 1999, Significance of intraformational unconformities in the Morrow Formation of the Permian Basin, p. 55-61, *in* Grace, O.T. and Hinterlong, G.D., eds., The Permian Basin: Providing Energy for America: West Texas Geological Society Publication 99-106.

Speer, S.W., 1993, Permian Basin pre-Permian plays: Morrow, p. 159-161, *in* Hjellming, C.A., ed., Atlas of Major Rocky Mountain Gas Reservoirs: New Mexico Bureau of Mines and Mineral Resources at Socorro, New Mexico.