PETROGRAPHIC AND MAPPING STUDY OF THE SUBSURFACE "OSWEGO" LIMESTONE IN PART OF THE PUTNAM TREND, T 15-16 N, R 15-17 W, DEWEY AND CUSTER COUNTIES, OKLAHOMA

By

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Bachelor of Science

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Akron, Ohio

1974

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1980

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PREFACE

This study deals primarily with the "Oswego" limestone of the Putnam Field in parts of Dewey and Custer Counties, Oklahoma. Depositional environment and geologic history were inferred on the basis of correlation cross sections, structure contour maps, and isopach maps made by examining well logs, cores, thin sections and well cuttings.

The writer extends his sincere gratitude to Dr. John D. Naff, thesis advisor, for providing guidance and encouragement throughout the study. Advisory committee members, Dr. Gary F. Stewart and Dr. Nowell Donovan gave encouraging "words of wisdom" and Dr. Tom L. Rowland, Geological Consultant, helped examine and interpret the cores. All unselfishly gave their valuable time and made many helpful suggestions. A note of thanks goes to Dr. Zuhair Al-Shaieb for helping with the photomicrographs. Conversations with former and present coworkers proved to be very valuable.

I wish to thank Mr. Eldon Cox of the Oklahoma Geological Survey Core and Sample Library, Messrs. Royce Herndon, Sr. and Royce Herndon, Jr. of Herndon Map Service for supplying the base map at a discount price, and Ms. Faye J. Benton for drafting the maps and cross sections. Appreciation is extended to the Management of Getty Oil Company in the Oklahoma City District Office for reproducing the maps and cross sections. My wife, Muoi, typed the rough drafts and final copy, for which I am eternally indebted.

Finally, the writer gives special thanks to his parents, Michael M. and Cecilia R. Michlik, and especially to his wife, Muoi, whose sacrifice, patient understanding, and encouragement made this thesis possible.

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CHAPTER I

ABSTRACT

The Desmoinesian "Oswego" of the Marmaton Group in the Putnam Field of Oklahoma is equivalent for the surface Fort Scott Formation consisting of five members, in ascending order: Breezy Hill limestone, Excello shale, Blackjack Creek limestone, Little Osage shale, and Higginsville limestone. The "Oswego" is the most widespread Pennsylvanian limestone in the Midcontinent. The "Oswego" in the Putnam Field is an 80 ft thick northwest-southeast trending phylloid-algal mound complex developed on the shelf edge (hinge line) of the Anadarko Basin. Basin equivalent is a black carbonaceous shale deposited in a sediment starved basin.

The "Oswego" represents several marine transgressive-regressive sequences of cyclic deposition. The Breezy Hill was deposited during a marine transgression over the deltaic sediment of the "Cherokee" (Cabaniss) Group. The overlying Excello shale was deposited in a deep euxinic marine sea. The basal and middle part of the Blackjack Creek was deposited by a transgressive sea. The Little Osage shale was deposited in a deep marine sea like the sea that deposited the Excello. The Higginsville was deposited during a regression, but in the study area only the basinal terminus of the Higginsville is represented. The remaining Marmaton carbonates followed this pattern, until clastic detritus from the south filled in the basin.

The "Oswego" in the Putnam Field is a prolific petroleum producer. Estimated gas reserves from all producing formations in the field suggest that the Putnam Field is a potential giant.

CHAPTER II

INTRODUCTION

The stratigraphic section for this study is informally referred to as the "Oswego" in the Marmaton Group of the Desmoinesian Series (Jordan, 1957). The area of investigation is T 15-16 N, R 15-17 W, approximately 216 square miles in southern Dewey and northern Custer Counties, Oklahoma (Fig. 1).

The name Oswego is preoccupied and has been replaced by the name Fort Scott. In the subsurface, the "Oswego" consists of five members, from the bottom, the Breezy Hill Limestone, Excello Shale, Blackjack Creek Limestone, Little Osage Shale, and Higginsville Limestone (Jordan, 1957; Cole, 1967 and 1968). Although preempted, the name "Oswego" will be used in this study to refer to the Fort Scott in the subsurface because the name "Oswego" is entrenched in the literature and used extensively by geologists in the petroleum industry. These units are illustrated on a type log in Fig. 2.

The Putnam "Oswego" Trend is a narrow (1-3 mi wide) 36 mile long northwest-southeast trending limestone bank, of algal origin, which was discovered in 1962 by regional subsurface, and seismic mapping of deeper Morrow sandstones (Biddick, 1963; Breese, 1973).

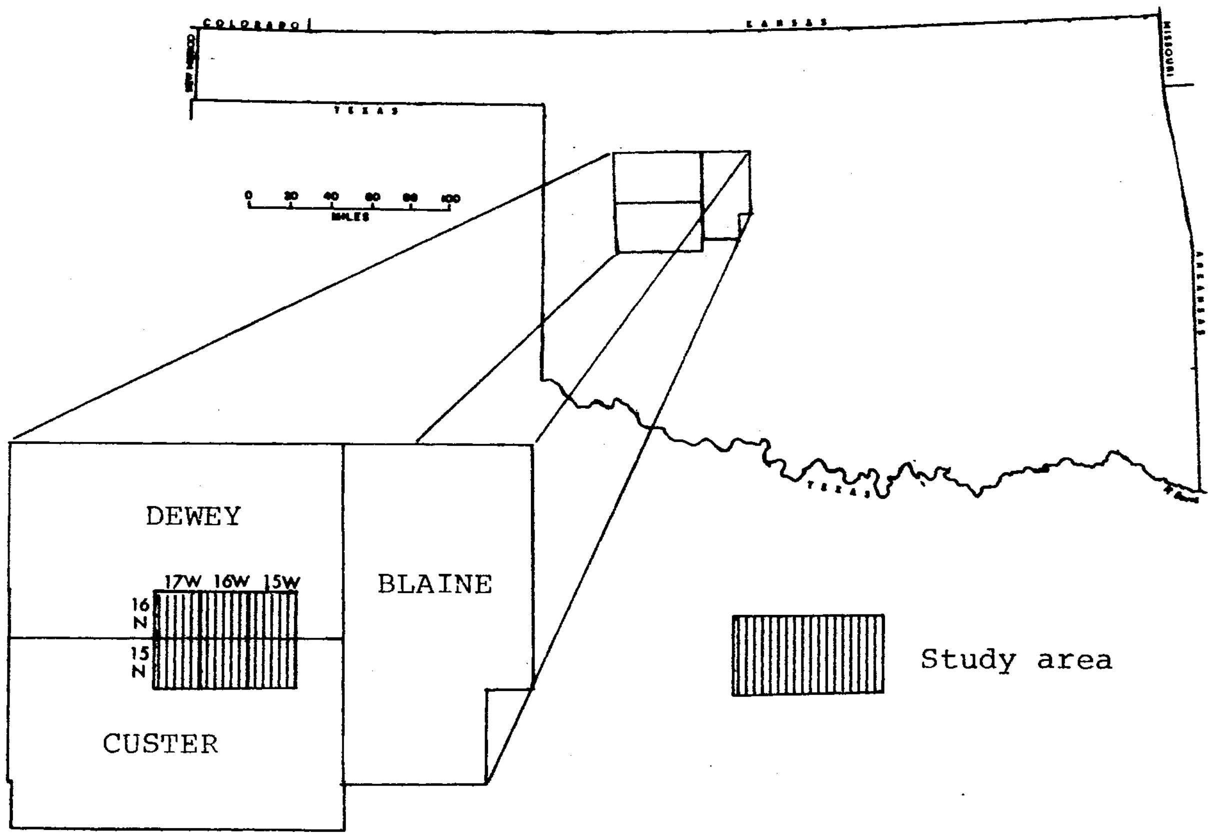


Fig. 1.-Location map.

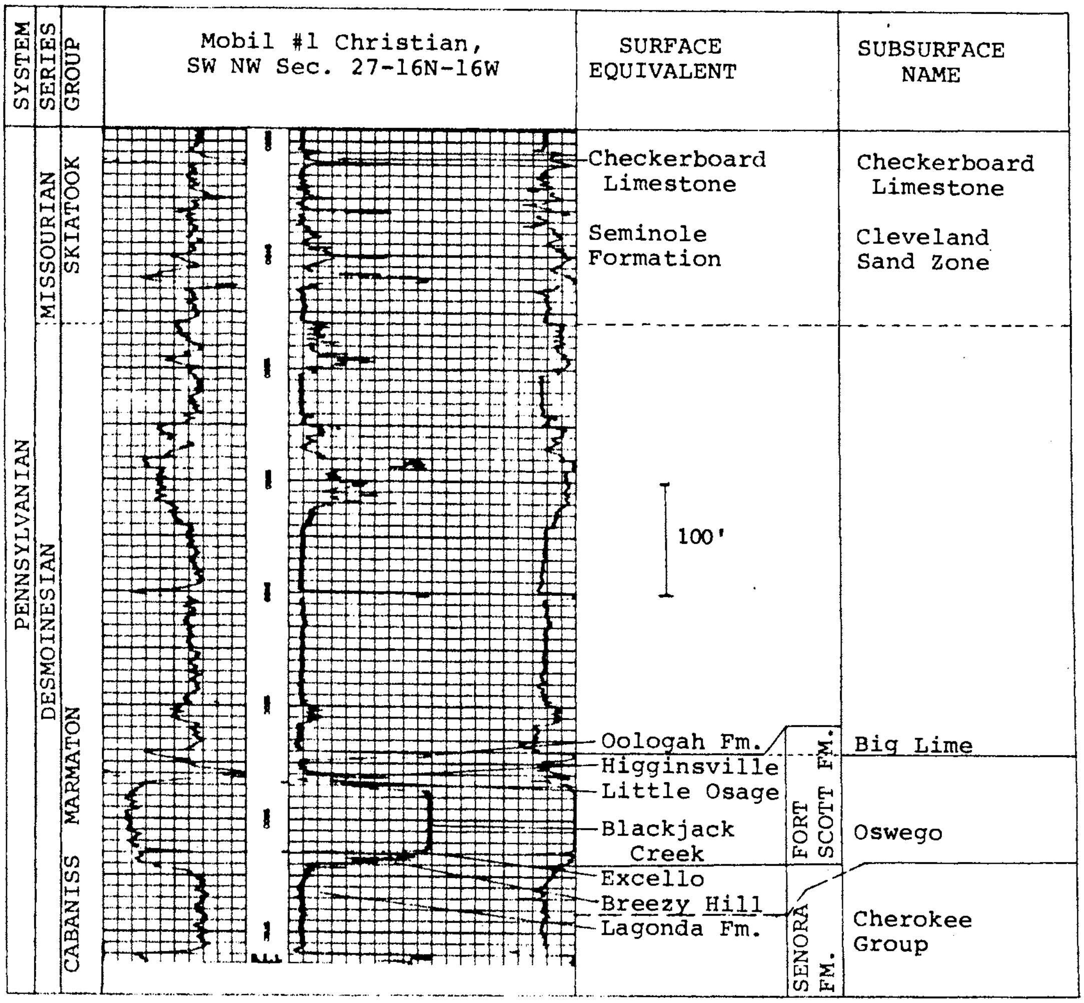


Fig. 2-Type electric log.

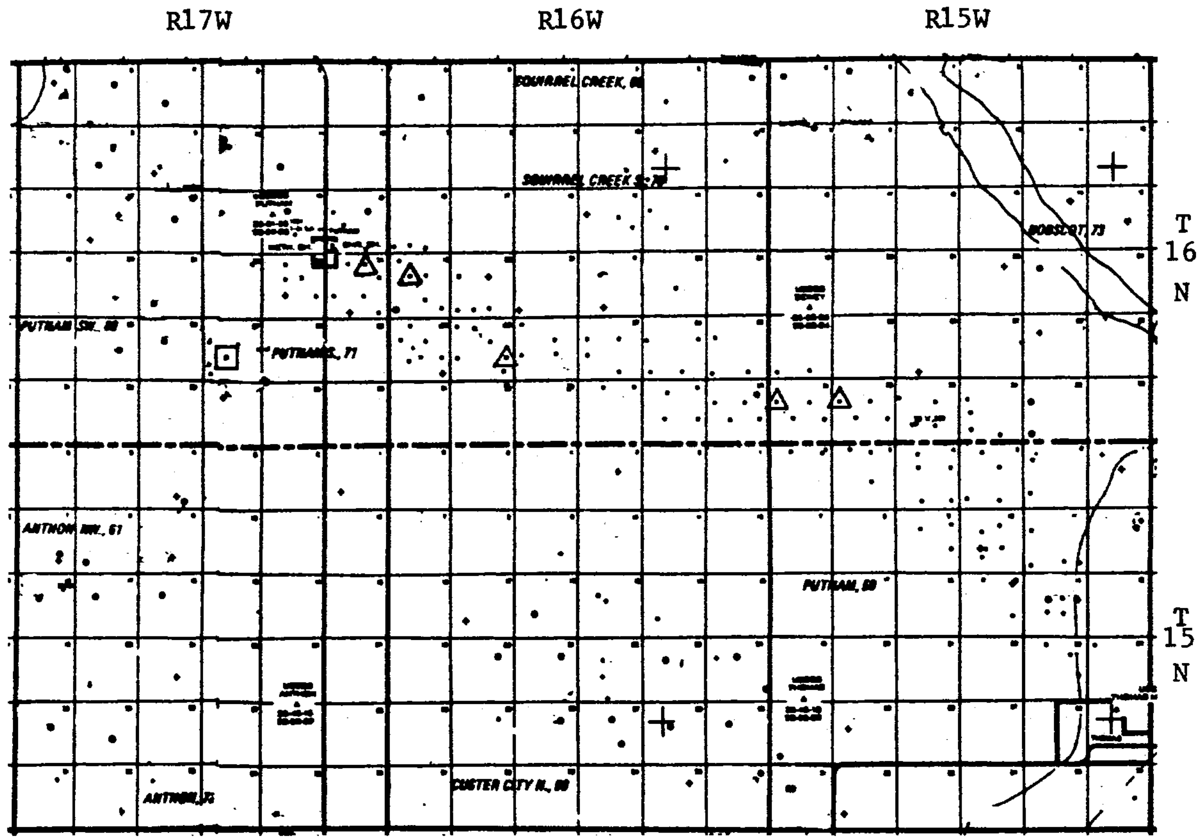
Objectives and Procedures

The objectives of this subsurface study are to determine depositional and geologic history of the Putnam Field "Oswego" within the study area, and to examine and describe cores and thin sections of the "Oswego" within the Putnam Trend.

The principal data for the study are nearly 250 electric logs, 5 "Oswego" cores, and 1 sample log. All cores and the sample log are from wells drilled within the study area (Fig. 3). Oil and gas fields in the area are shown in Fig. 3. Correlation of the stratigraphic units was based on a framework of six correlation cross sections (Pls. 1-6). Variations in thickness and lithostratigraphic changes are best illustrated on the cross sections, locations of which are shown in Fig. 4. Also, one additional cross section (Pl. 7) extending outside the area (Fig. 5) illustrates the lithostratigraphic variations within the "Oswego" shelfward to the northeast.

Present structural configuration of the "Oswego" is portrayed by two structure contour maps, one on the top of the "Oswego", and one on its base. In addition, a structure contour map was prepared on the Checkerboard Marker, which is consistant throughout the area. The Checkerboard structural surface illustrates the configuration of a marker within the Missourian Series stratigraphically higher than the "Oswego".

Two interval isopach maps were constructed, one of the Checkerboard Marker-Top "Oswego" interval, and one of the Top "Oswego"-Base "Oswego" interval. Also, a gross limestone isopach with an accompanying isoporosity map were constructed for the "Oswego" to delineate trends of thickness accompanying carbonate bank development. These maps, in



□ Samples studied
△ Cores studied

Fig. 3.-Location map of wells, oil and gas fields, and cored and sampled wells.

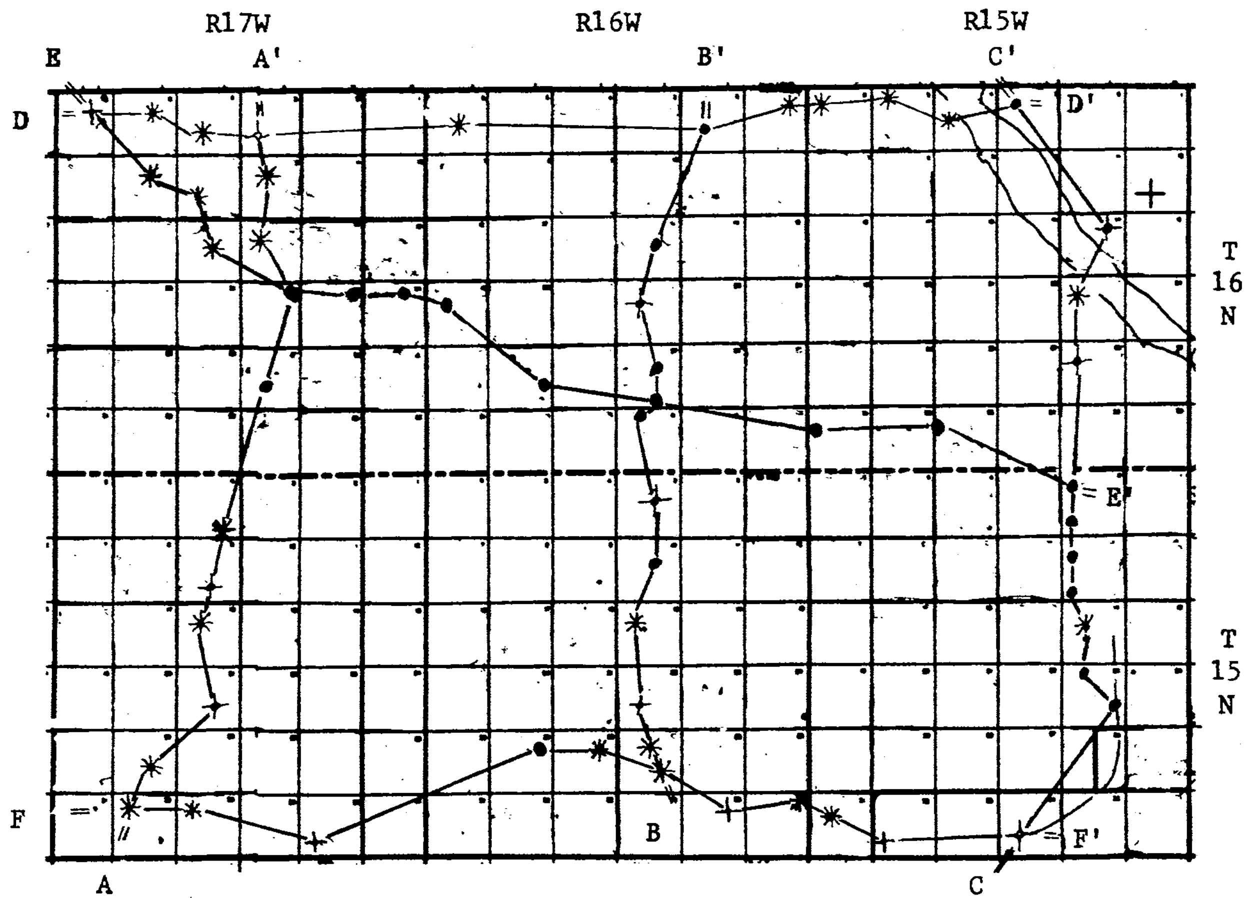


Fig. 4.-Index map of correlation sections.

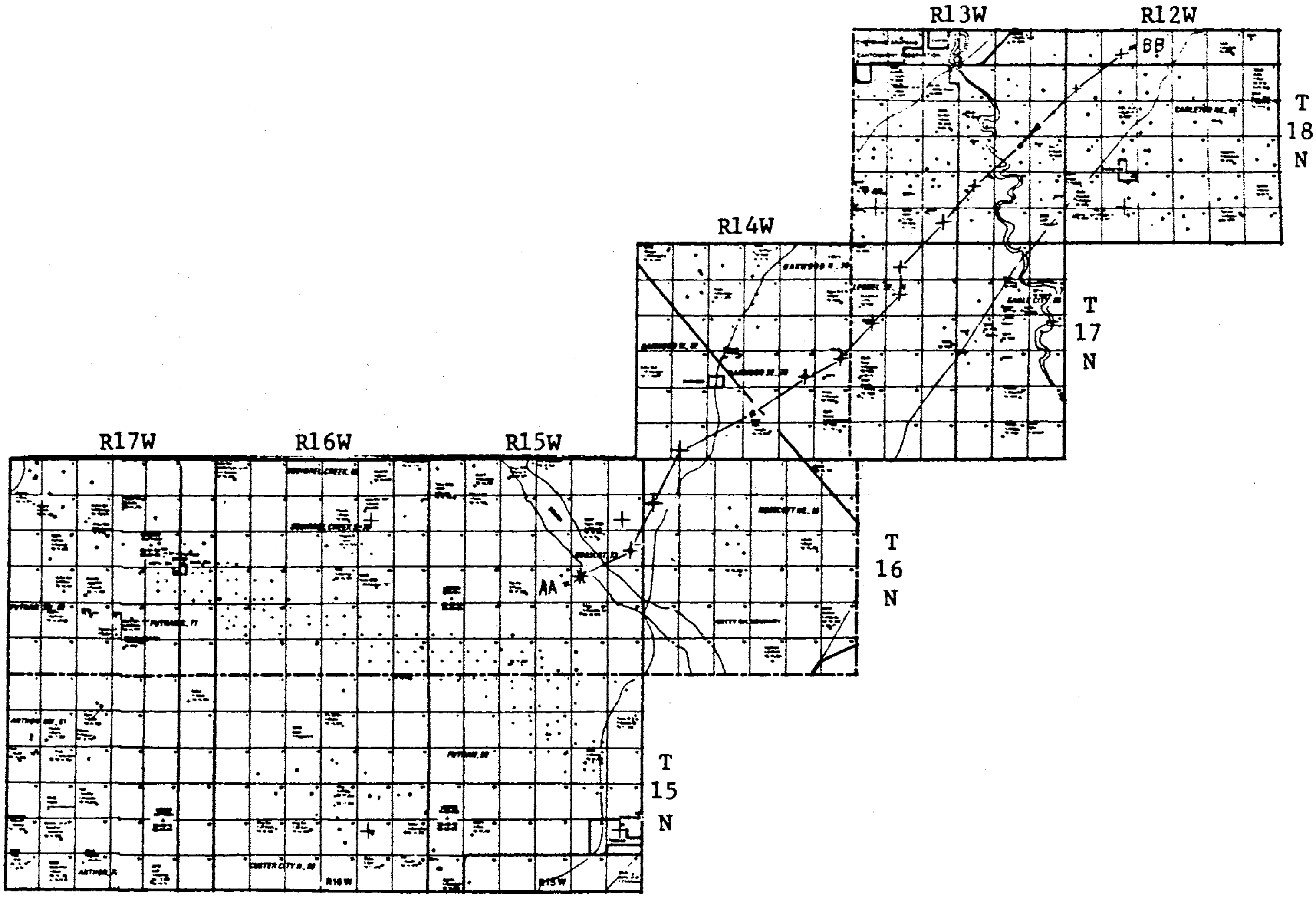


Fig. 5.-Index map of stratigraphic cross section AA-BB.

conjunction with the structure maps, help delineate the hinge line. They also aid in illustrating the major stratigraphic facies changes associated with the "Oswego" in the study area.

Five cores of the "Oswego" within the study area were examined. One core was sampled every two feet for thin section analysis. Samples from one well in the "Oswego" basin shale facies were examined using a binocular microscope. The core descriptions, thin section analysis and sample determination aided interpretation of the depositional environments and geologic history of the "Oswego" within the study area.

Previous Investigations

The Desmoinesian Series was divided into three groups by Searight and others (1953). These groups are: The Krebs, Cabaniss, and Marmaton groups. This study is concerned with only the upper Desmoinesian Marmaton Group and the upper part of the Cabaniss Group. Part of the lower Missourian strata are also incorporated into this study.

The general geology of the subsurface within portions of the study area was studied by Frezon and Dixon (1975), Gibbons (1962), Huffman (1959), Rascoe (1962), Slate (1962), Swanson (1967), and Wheeler (1947-48). More specific work on the "Oswego" within and adjacent to this area are studies by Biddick (1963), Breese (1973), Brooks (1973), Brown (1963), Cambridge (1969), Richardson (1965a, 1965b), Slate (1962), and Wonick (1964).

A prominent facies change from limestone in the north, to shale in the south has been noted and mapped on both the surface Fort Scott, and the subsurface "Oswego". Oakes (1952) mapped a facies change in the outcrop, Cassidy (1962, 1964) and Schell (1955) studied surface exposures and made environmental interpretations of the Fort Scott and underlying members of the Cabaniss Group. Regional mapping of the Fort Scott and "Oswego" by Richardson (1965a), Rascoe (1962), Wanless and others (1963), Berg (1973), Cole (1968, 1967), Fritz (1978) and Krumme (1975) showed the regional facies distribution across the state and adjacent areas.

CHAPTER III

STRUCTURAL FRAMEWORK

Regional Setting

The study area is within the Anadarko Basin structural hinge line between the stable Northern Shelf and the downwarped Basin deep. The area of interest is bordered on the north by the Central Kansas Uplift, on the east by the Nemaha Ridge, on the south by the Wichita-Amarillo Uplift, and on the west by the Hugoton Embayment (Fig. 6) (Arbenz, 1956). Regional dip is to the south-southwest from 50 to 100 feet per mile (Biddick, 1963; Richardson, 1965a; Slate, 1962). Minor structural nosing and closure in the area interupt the regional dip.

Local Structural Features

Pls. 8, 9, and 10 illustrate local structural anomalies within the study area. The major feature is the Custer City North structure located in T 15 N, R 16 W, Custer County. The structure map of the Checkerboard Marker (Pl. 8) shows 50 feet of closure at this level. At depth, the structure is cut by a near vertical fault with 470 feet of throw at the base of the Morrow Group. The displacement across the fault of beds up section is progressively less, indicating that sedimentation filled in the low areas until the structural closure was no longer apparent on the surface (Slate, 1962).

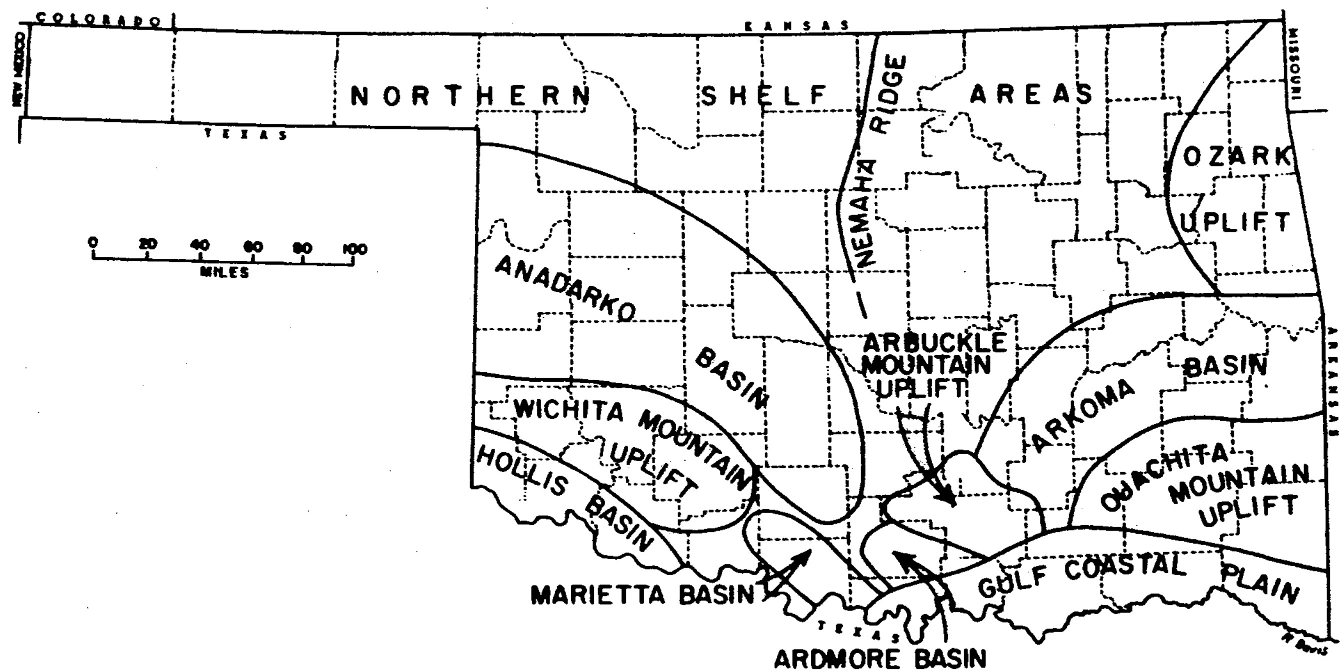


Fig. 6.-Geologic province map. After Okla. Geol. Survey map, undated, Geologic Provinces of Oklahoma.

Two other features are present on the structure maps (Pls. 8, 9, and 10) as prominent ridges or noses. The first one, in the north half of T 16 N and the south half of T 17 N, R 15 W is expressed as a sharp ridge on the Checkerboard structure (Pl. 8). On the Top "Oswego" Marker (Pl. 9) this ridge is sharper and a depression is developed adjacent to it. Pl. 10 shows an even sharper ridge and deeper depression on the Base "Oswego" Marker. This may be due to faulting at this level, or at a deeper horizon. The second ridge is on the western side of the map in T 16 N, R 17 W and is present on all three structure maps. This ridge is a south trending feature just west of the oil-bearing portion of the Putnam Trend and can be traced northwestward along the trend (Slate, 1962 and Brown, 1963). The feature may have influenced the gas-oil contact. One more important feature, and the one responsible for the Putnam Trend's existence, is the "Oswego" hinge line tracable from Thomas, in the southeast corner of T 15 N, R 15 W, through Putnam and into the northwest corner of T 16 N, R 17 W on these maps (Pls. 8-14). These maps show that the Putnam Field is in a structural monocline. The hinge line separates the shelf limestone facies in the north from the basinal shale facies in the south of this area. The structure maps (Pls. 8, 9, and 10) illustrate generally gentle south dip steepening across the "Oswego" buildup into the basin deep.

CHAPTER IV

STRATIGRAPHIC FRAMEWORK

The "Oswego" in this area is a 100 to 200 ft thick sequence of limestones and shales which grades laterally into shales. The "Oswego" conformably overlies the predominantly clastic Cabaniss Group, also of Desmoinesian age. Included in this study is the remainder of the overlying Desmoinesian Marmaton Group and the Checkerboard Limestone of the Missourian Series. This sequence is approximately 500 to 800 ft of predominantly sandstone and shale with some thin limestones. The sequence of strata in this study are equivalent to the surface units listed in Table I.

Regionally, the Marmaton Group is composed predominantly of limestone in northern Oklahoma and Kansas. These limestones grade into dark shales south of the hinge line, and, farther south the limestone and shales grade into arkosic clastics adjacent to the Amarillo-Wichita Uplift (Rascoe, 1962). In Missouri and Illinois the equivalent beds are deltaic sands, shales, and coals (Wanless and others, 1963).

TABLE I

EQUIVALENT SURFACE UNITS OF ROCKS IN THIS STUDY
(MODIFIED FROM COLE, 1967)

SURFACE	SUBSURFACE
Missourian Series	
Skiatook Group	
Checkerboard Limestone *	Checkerboard Limestone
Seminole Formation	Cleveland Sand Zone
Desmoinesian Series	
Marmaton Group	
Oologah Formation	Big Lime
Fort Scott Formation	
Higginsville Limestone Member	
Little Osage Shale Member	
Blackjack Creek Limestone Member	
	Oswego
Cabaniss Group	
Senora Formation	
Excello Shale Member	
Breezy Hill Limestone Member	
	Cherokee Group

* Palynological studies by Wilson (1979) indicate that the Missourian-Desmoinesian contact should be placed at the base of the Checkerboard Limestone.

Correlation

To ensure accurate correlation and to illustrate certain stratigraphic relationships, three north-south and three east-west correlation cross sections were constructed with the Checkerboard Marker as datum. One additional cross section was constructed which illustrates the stratigraphic relationships from the shelf limestone facies, outside the area of investigation, into the bank facies. Locations of these sections are shown on Figs. 4 and 5.

Three time markers were used in mapping the "Oswego" and Checkerboard interval. These markers are thin, persistent, black radioactive shales equivalent to the surface Excello shale, Little Osage shale, and the black shale above the Checkerboard Limestone. These markers were designated, in ascending order: Base "Oswego" Marker, Top "Oswego" Marker, and Checkerboard Marker.

Correlation Sections

North-South Correlation Sections

The three north-south cross sections (Pls. 1-3) illustrate dip into the basin from shelf limestone to a limestone bank or buildup and abrupt thinning into basinal shale. The interval from the Checkerboard Marker to the Top "Oswego" Marker thickens abruptly at the limestone-shale facies.

<u>Correlation Section A-A'</u>. The "Oswego" in wells 1 and 2 on this cross section (Pl. 1) are in the shelf or back-bank facies. Thickness of the "Oswego" is about 50 ft and it is generally too tight to produce

in this facies. The "Oswego" abruptly thickens to 95 ft in well 3 where it is in the thickest part of the bank facies and produces oil and gas. Well 4 has only 45 ft of "Oswego" and is in the fore-bank or slope facies. These wells are generally too tight to produce. The remaining logs on the cross section (wells 5-11) are in the basin shale facies and no limestone is present. This shale gradually thins basinward from the bank.

Correlation Section B-B'. Well 1 (Pl. 2) has about 70 ft of tight, non-productive "Oswego", but there is some suggestion that it may be part of a bank within the shelf facies which is parallel to the Putnam bank. The "Oswego" is 50 ft thick in wells 2 and 3 in the non-productive back-bank area. The "Oswego" thickens abruptly to 70 ft in wells 4 and 5 in which these bank limestones produce oil and gas. Well 6 is in the thin fore-bank with only 40 ft of limestone. Wells 7-12 are in the basin shale facies, but wells 10-12 are on the Custer City North structure, yet no lime bank is developed.

Correlation Section C-C'. The "Oswego" in wells 1-4 (Pl. 3) average 80 ft in thickness and are in the shelf facies. Wells 3 and 4 may be in a part of the bank on the shelf mentioned above. Wells 5-11 also average 80 ft for the "Oswego" but are in the bank facies. Well 12 is in the basin shale facies and exhibits a thin "Oswego" shale interval on the flank of the Custer City North structure.

East-West Correlation Sections

Three east-west cross sections (Pls. 4-6) trend along depositional strike and illustrate each of the three "Oswego" facies.

Correlation Section D-D'. The "Oswego" is 60 to 80 ft thick in these wells (Pl. 4) which are in the shelf limestone facies with the exception of wells 1, 2, and 3 which are in the bank facies. The interval Checkerboard Marker-Top "Oswego" Marker (Pl. 11) gradually thickens westward.

Correlation Section E-E'. All wells (1-13) on this section (Pl. 5) are in the bank facies except well 5 which appears to be in the fore-bank or slope facies. The limestone averages about 80 ft thick in the bank facies.

Correlation Section F-F'. Pl. 6 is a cross section with all wells (1-11) in the basin shale facies. Wells 4-10 are on the south flank of the Custer City North structure.

Regional Stratigraphic Cross Section

The stratigraphic cross section AA-BB (Pl. 7) illustrates the stratigraphic relationships of the strata within the Checkerboard to "Oswego" Markers shelfward.

Stratigraphic Section AA-BB. All the logs on Pl. 7 (wells 1-16) are from wells in the "Oswego" shelf facies. The Checkerboard-"Oswego" interval thins northeastward from 560 ft to 400 ft. The "Oswego" interval (Top to Base) also thins from 80 ft to 50 ft. However, the total Checkerboard-"Oswego" interval increases in carbonate content and decreases in shale, as shown by the increasing resistivities on the logs within the "Big Lime"-"Oswego" interval.

Maps

Three structure and four thickness maps were constructed (Pls. 8-14) to show structural attitude and thickness variations within the interval of interest. The structure maps (Pls. 8-10) were discussed in chapter III on page 12.

North of the bank, the Checkerboard-Top "Oswego" interval (Pl. 11) shows a gradual basinward thickening from 20 to 30 ft/mi. Over the bank and south of it the sediments abruptly thicken from 30 to 50 ft/mi. This interval is thin on the crest of the Custer City North structure and thick on the flanks, apparently indicating that the structure was present during deposition of the sediments in this interval.

The Top "Oswego"-Base "Oswego" interval map (Pl. 12) shows a northwest-southeast depositional strike. This interval is uniformly 70 to 80 ft thick in the NE¼ T 16 N, R 15 W, but it abruptly thickens to 100 ft in the S½ of this township and the NE¼ of T 15 N, R 15 W. The main thick trend of this interval continues from Thomas, northwestward to the NW corner of T 16 N, R 17 W. A thin trend of this interval lay immediately shelfward (NE) and appears to separate two thick trends. Breese (1973) noted two parallel biostromes with an intervening lagoon to the northwest in the Putnam and Lenora Fields (T 17-18 N, R 18-19 W) adjacent to this study. Southwest of the thick trend the interval abruptly thins to 60 ft and gradually decreases to less than 20 ft in the SW corner of T 15 N, R 17 W. Apparently, the Custer City North structure was not present, or had very little influence on deposition of this interval as seen by this thickness map.

The gross limestone thickness map (Pl. 13) was derived by subtracting the amount of shale on the logs from the total "Oswego" interval. The shale is defined as being greater than halfway between the shale base line and the minimum radioactivity of the "Oswego" lime on the gamma ray curve. This map illustrates the geometry of the lime bank, back-bank, and shale facies. The bank facies is a 1 to 2 mi wide, northwest-southeast trending long sinuous feature which is thicker than its lateral equivalents. The shelf, or back-bank facies appears to undulate as hummocky thick and thin areas which are sub-parallel to the shelf edge bank. The shale facies gradually thins basinward. The suggestion of a sub-parallel bank shelfward of the main bank is also evident.

The isoporosity map (Pl. 14) was constructed by counting the feet of porosity greater than 5% using a matrix velocity of 21,000 ft/sec on sonic (accustic) logs, or a bulk density of 2.71 g/cc on density logs. This map shows porosity development as discontinuous pods within the bank trend. Note also, the generally tight, non-productive back-bank shelfward of the main bank.

CHAPTER V

DEPOSITIONAL FRAMEWORK

Petrography

Core chips from 5 wells, 37 thin sections of the "Oswego", and samples of the "Oswego" shale facies from one well within the study area were examined and described. Only one of the available cores was cut into the Breezy Hill, the other 4 cores stopped at the base of the Blackjack Creek or Excello shale. Only one core of the remains of the Higginsville and Little Osage shale was available. All 5 cores are from the bank facies, no cores in the shelf or the shale facies were available in the study area. Samples from one well in the "Oswego" shale facies were described.

Core and Thin Section Descriptions

Generalized core and thin section descriptions are located in Appendix B and C.

Cherokee Shales. The gray to black silty shales at the base of the Breezy Hill Limestone are composed of quartz silt and illite with abundant pyrite and carbonaceous material (Fig. 7). The quartz silt is scattered throughout the shale and in lenses about 5 mm across. The upper contact with the Breezy Hill is more or less gradational.

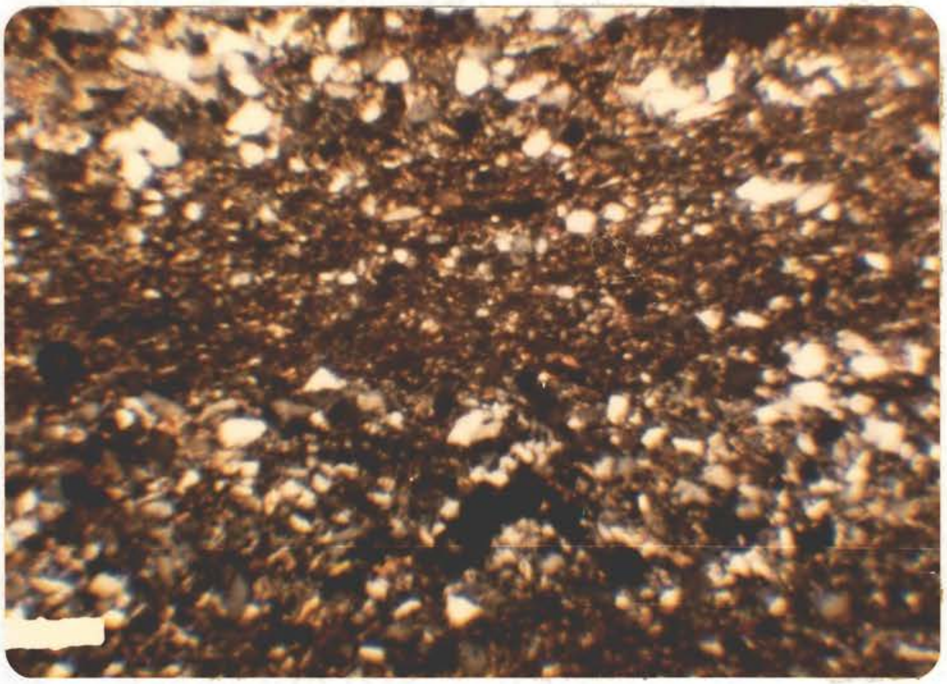


Fig. 7.-Photomicrograph of silty shale. Thin section 7-R-9728, bar approx. 200 μ, crossed nicols, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9728 ft.

Breezy Hill Limestone. This unit is a thin, argillaceous, black phylloid-algal calcilutite with silicified well preserved algal blades and pyrite (Fig. 8). Echinoid fragments and bryozoans are also abundant in the micritic matrix of the Breezy Hill. Porosity is not well developed in this unit. The upper contact with the Excello is somewhat sharp.

Excello Shale. This distinct unit is a black radioactive, carbonaceous, fissile shale a few feet thick. The Excello shale contains discinacean brachiopods, conodonts, fish remains, pyrite, and phosphate nodules (Fig. 9) as well as a few silt lenses and fossil fragments in a shale matrix. The upper contact with the Blackjack Creek is fairly sharp.

Blackjack Creek Limestone. On surface exposures of this member in eastern Oklahoma, Schell (1955) observed 3 distinct lithologies arranged in a definite sequence. The top and base are composed of bioclastic material with algae in a calcilutite matrix. The middle is lithographic, containing pellets, stylolites, fusulinids, and discontinuous shale breaks. The third type is a microfragmental, bioclastic, fusulinid calcilutite which appears to be transitional between the bioclastic algal lithology, and the pelloid lithographic type (Schell, 1955, p. 39-52). Schell (1955) also noted that in central Rodgers County, Oklahoma, near the facies change from limestone to shale, only the algal lithology was present. The Putnam "Oswego" apparently shares lithologic similarity to its surface equivalents, based on the excellent detailed descriptions by Schell (1955), as described above.

The lower part of the Blackjack Creek in the study area consists of a dark gray to black calcilutite with crinoid stems and bryozoans.

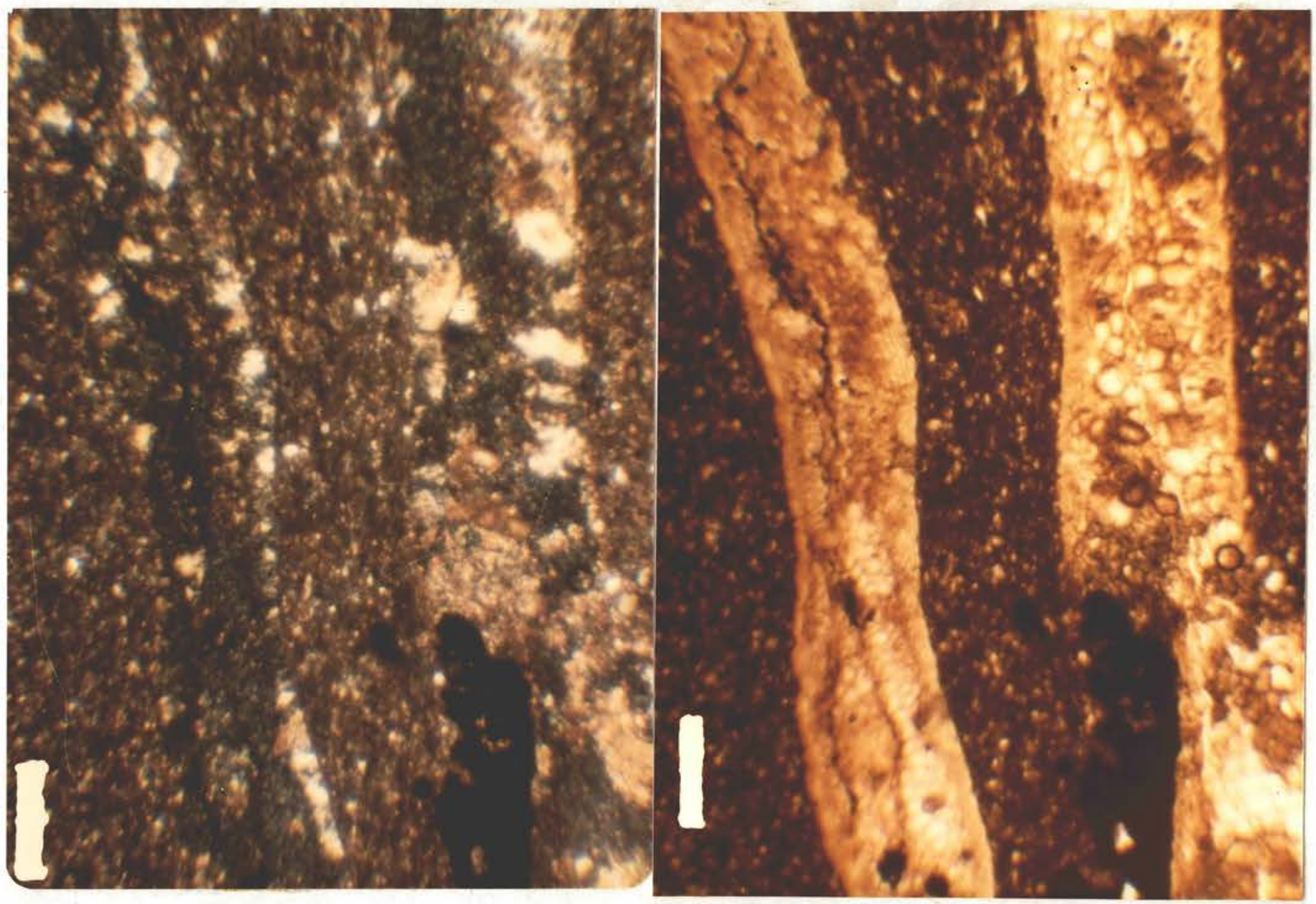


Fig. 8.-Photomicrograph of Archeolithophyllum sp. calcilutite showing cellular preservation and silicification. Right photo: Well preserved algal blades in a calcilutite and shaley matrix. Left photo: Same slide with crossed nicols shows algal blades replaced by chert. Thin section 9-R-9724, right photo plane light, left photo crossed nicols, bar approx. 200 μ, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9724 ft.

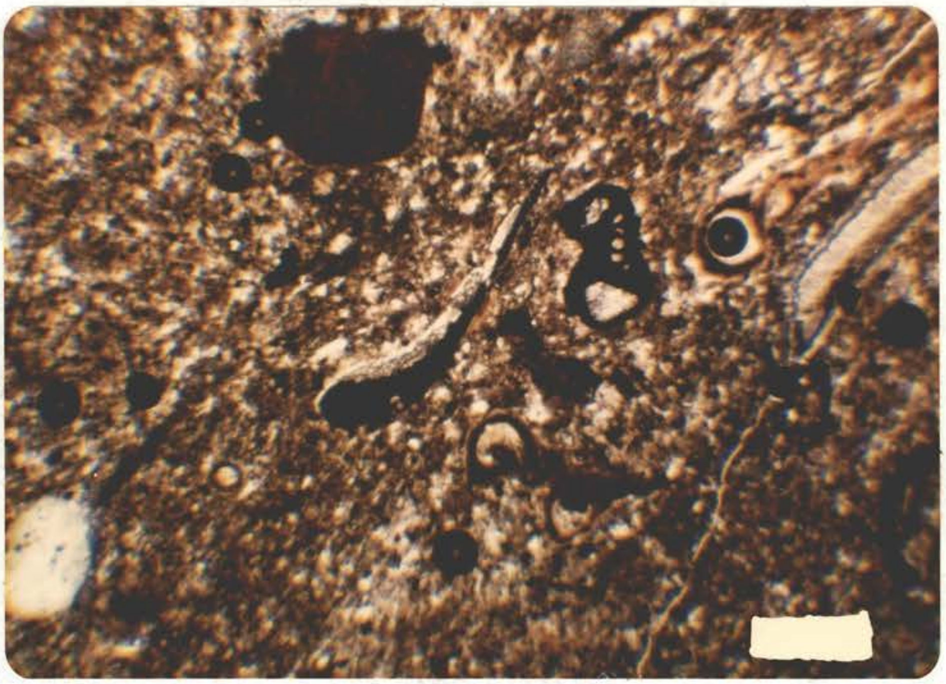


Fig. 9.-Photomicrograph of pyrite and phosphate with fossil fragments in a silty clay matrix. Brown pebble and bands are phosphate, black is pyrite which replaced most of the fossil material. Thin section 1-R-9718, bar approx. 200 μ, plane light, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9718 ft.

Fig. 10 shows this rock type in thin section. This lower part is generally tight and non-productive.

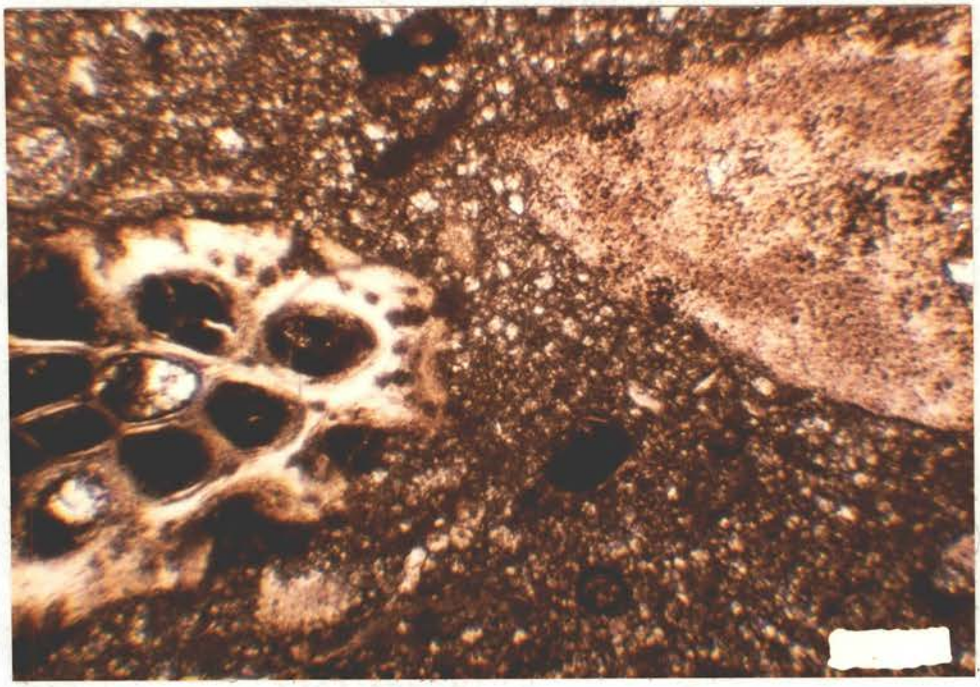


Fig. 10.-Photomicrograph of crinoid stem, bryozoan calcilutite. Crinoid fragment, bryozoan, and pyrite in a microsparite matrix. Thin section 13-R-9716, bar approx. 200 μ, plane light, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9716 ft.

The middle part of the Blackjack Creek in the study area appears to be a gray calcilutite containing algal blades, pellets, and a variety of fossil fragments including crinoid stems, bryozoans, brachiopods, and fusulinids (Fig. 11) which had suffered varying degrees of recrystallization, dolomitization and other diagenetic effects (Fig. 12).

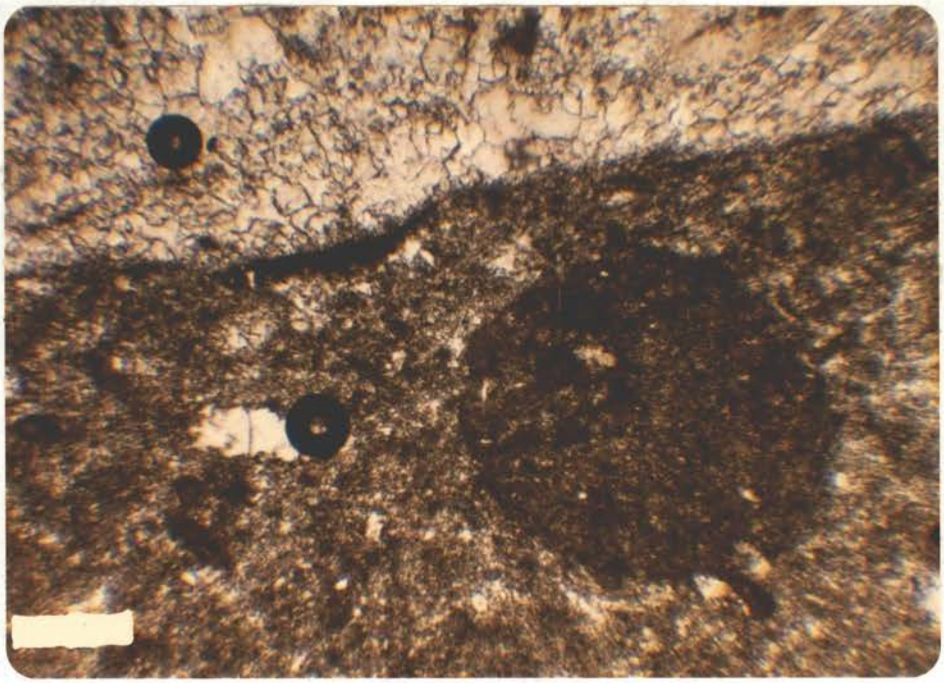


Fig. 11.-Photomicrograph of sparry, algal, pellet calcilutite. Recrystallized algal blade and micritic pellet in calcilutite matrix. Thin section 18-R-9706, bar approx. 200 μ, plane light, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9706 ft.

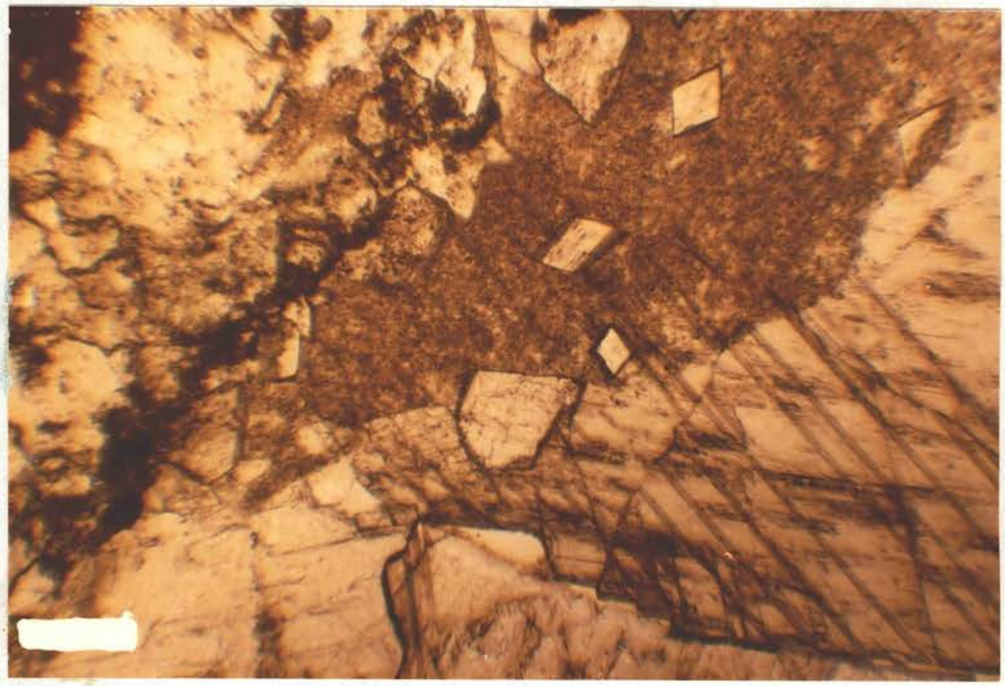


Fig. 12.-Photomicrograph of recrystallized, dolomitized, algal, bryozoan, crinoid calcilutite. Dolomite rhombs in a recrystallized crinoid fragment. Thin section 15-R-9712, bar approx. 200 μ, plane light, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9712 ft.

Porosity is developed in this interval as vugs and fractures. Stylolites, vugs, and both filled and open fractures can be seen in thin section (Fig. 13 and 14).

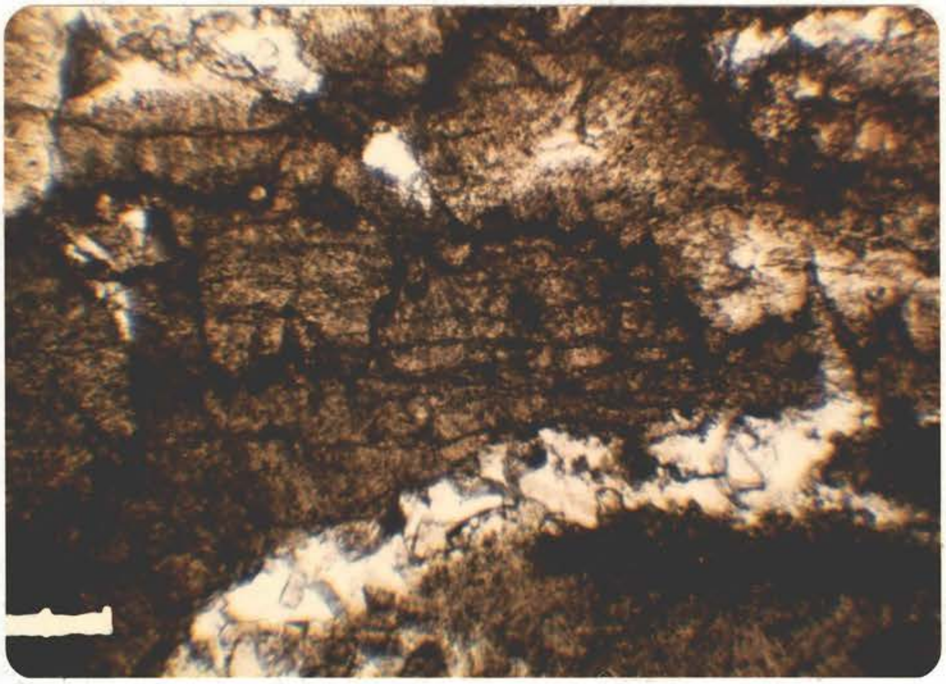


Fig. 13.-Photomicrograph of stylolite. Recrystallized, sparry, pellet, algal calcilutite. Thin section 5-S-8689, bar approx. 200 μ, plane light, Sinclair, #1 Smith, C NE SE Sec. 29-16N-16W, 9689 ft.

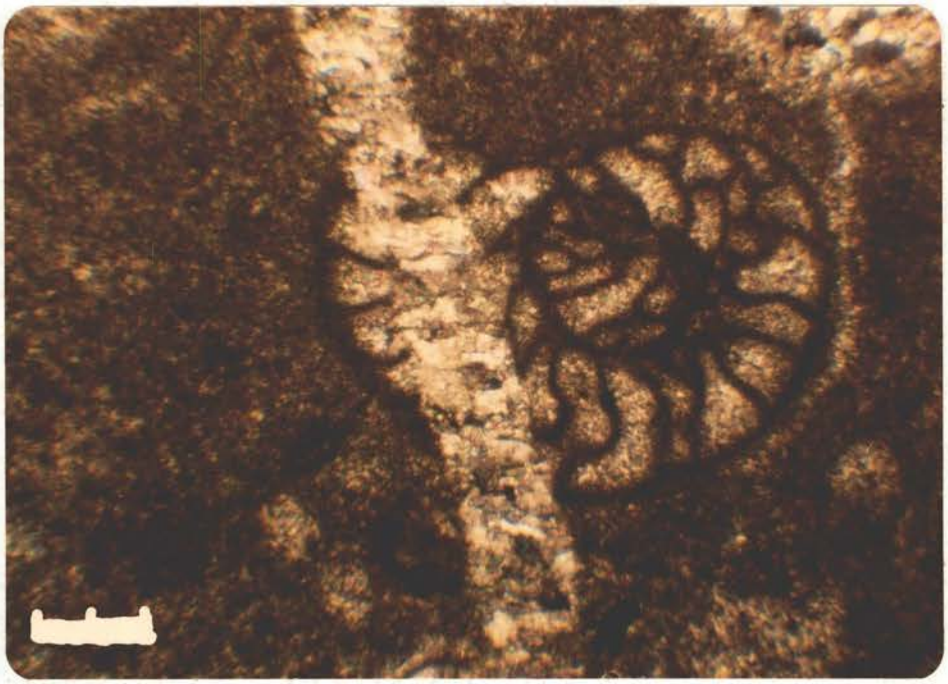


Fig. 14.-Photomicrograph of calcite filled fracture. A sparry, pellet, algal calcilutite with fusulinid foraminifera has been fractured and calcite filled the gap. Thin section 26-R-9690, bar approx. 200 µ, crossed nicols, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9690 ft.

The best porosity is apparently developed in the lower 1/2 to 2/3 of the Blackjack Creek, making this unit the main reservoir rock. Some of the recrystallized algal blades have conceptacles (Fig. 15). Johnson (1961) defines conceptacles as cavities containing reproductive structures.

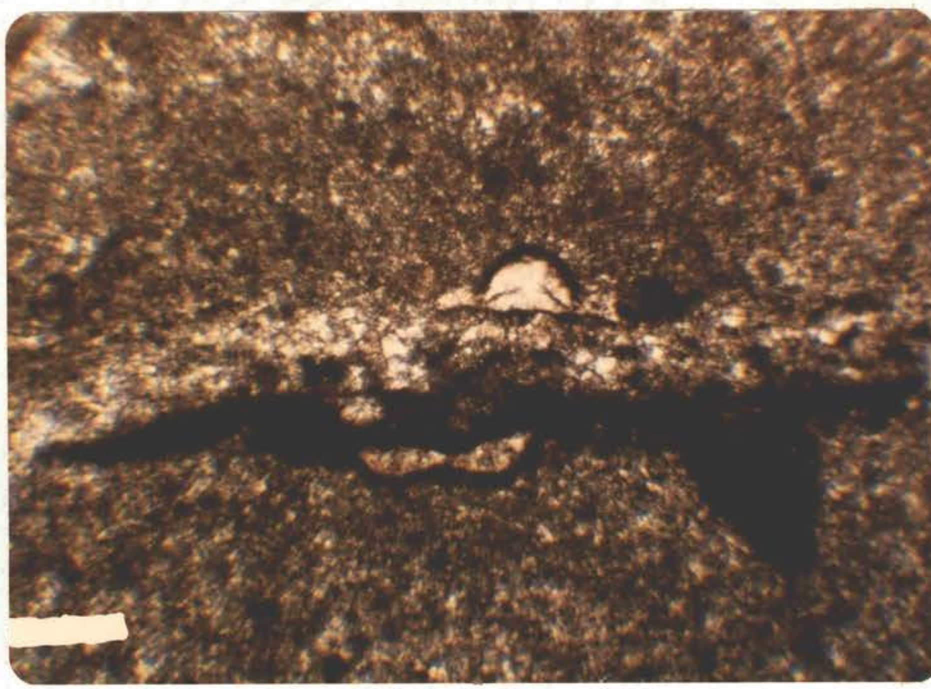


Fig. 15.-Photomicrograph of a conceptacle on a recrystallized algal blade. Sparry pellet, algal calcilutite. Thin section 25-R-9692, bar approx. 200 μ, plane light, Sunray, #1 Richardson, SE NW Sec. 19-16N-16W, 9692 ft.

The upper few feet of the Blackjack Creek resembles the lower part. This section is a thin, dense, dark gray to black calcilutite with fossil fragments, mainly crinoid stems, bryozoans, algae, foraminifera, brachiopods and patches of sparry calcite (Fig. 16).

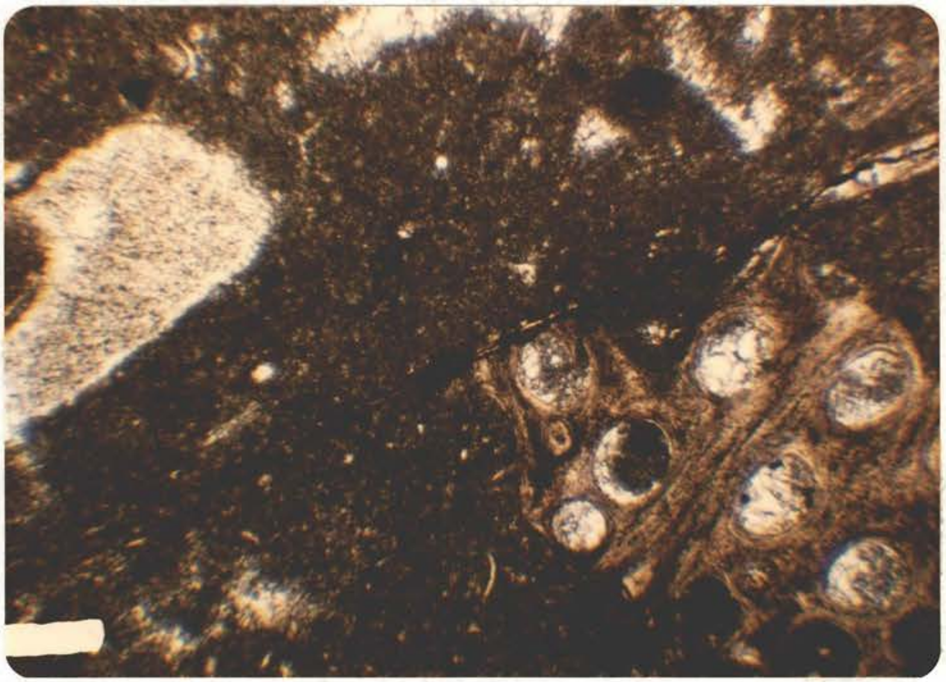


Fig. 16.-Photomicrograph of sparry, crinoid, bryozoan calcilutite. Thin section 2-S-9636, bar approx. 200 μ, plane light, Sinclair, #1 Smith, C NE SE Sec. 29-16N-16W, 9636 ft.

Little Osage Shale. Lying above the Blackjack Creek is a black radioactive, carbonaceous, fissile shale containing discinacean brachiopods and pyrite nodules. The Little Osage shale is nearly identical to the Excello in thickness, lithology and areal extent.

Higginsville Limestone. This unit is present above the Little Osage shale in the study area as a thin (2-4 ft) argillaceous limestone (Brown, 1963) encased in two black shales. An un-named black shale overlies the Higginsville in this area. In Pl. 7 on the regional stratigraphic cross section, the Higginsville can be seen to thicken shelfward, where it is reported to contain oolites (Krumme, 1975), and other shoal water facies (Tim Drexler, 1980, personal communication).

Sample Descriptions

No cores in the shale facies were available, so rotary drill bit cutting from the "Oswego" shale facies in one well were studied. A description of the "Oswego" in this well, the Clark Canadian #1 Williams, SW NE SW Sec. 27-16N-17W, (Fig. 17) from top down is: Dark gray silty micaceous shale; 50 ft of black, carbonaceous shale; 10 ft black and gray carbonaceous shale with dark brown, dense limestone; and gray, micaceous silty shale and dark limestone fragments. Both Top and Base "Oswego" black radioactive shale markers are present, but the Blackjack Creek Member has become a black carbonaceous shale.

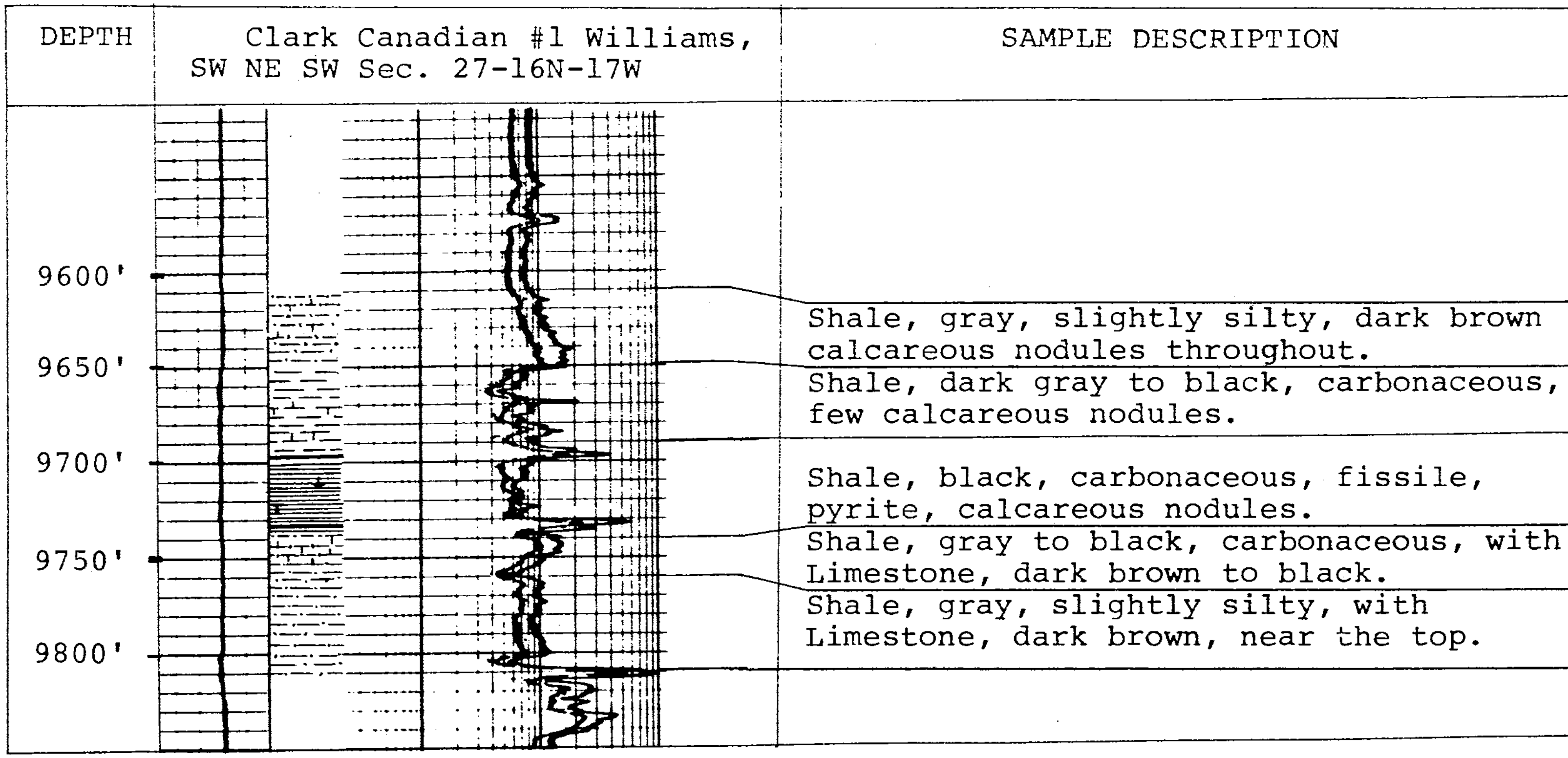


Fig. 17.-Sample description of the "Oswego" in the Clark Canadian, #1 Williams, SW NE SW Sec. 27-16N-17W. The Top "Oswego" Marker is at 9697' and the Base "Oswego" Marker is at 9735', the carbonaceous shale between these is the basin facies of the shelf and bank "Oswego" limestone.

Mound Development

Phylloid algae and the bank or mound-like nature of the "Oswego" in this area has long been known (Schell, 1955; Richardson, 1965a; Cambridge, 1969; and Breese, 1973). The word "phylloid" is a descriptive word coined by Wray (Pray and Wray, 1963) meaning leaf-like. This word denotes the shape of the algae rather than a genetic type. Algae are genetically identified by their internal organic structure which is typically obliterated by diagenesis (Heckel and Cocke, 1969). An algal mound, as defined by the AGI Glossary (Gary and others, 1974, p. 15) is: "A local thickening of limestone attributed chiefly to the presence of a distinctive suite of rock types (such as massive calcilutite) containing algae". The "Oswego" has the characteristics of a phylloid algal mound complex, as defined by Heckel and Cocke (1969). These are: Mound facies, composed of varied amounts of carbonate spar in a predominantly algae-rich calcilutite; and mound-associated facies, consisting mainly of calcarenitic rock types.

There are several different ideas of algal bank formation. Harbaugh (1964) interpreted the algal banks of the Pennsylvanian age Lansing-Kansas City groups in Kansas to have formed by waves and currents in conjunction with biological processes. He felt that wave and current action accumulated mound-like masses of loose carbonate material above the level of the surrounding sea floor. He also contended that phylloid algae and other organisms contributed carbonate material, and helped to trap and bind the fine carbonate mud. Heckel and Cocke (1969) suggested that mounds originated on topographic highs favorably located between a region of great clastic influx and the open sea. Toomey and others

(1977) speculate that mounds grew on accumulations of larger shelly invertebrates which provided a hard foundational surface for the phylloid algae. Ball and others (1977) proposed that algal mounds grew only a few centimeters above the sea floor and that the algae mainly contributed carbonate material rather than building the mounds. In a study of the Missourian Series Avant mound in northeastern Oklahoma, Davidson (1978) postulated that a belt of optimal water depth, related to submarine paleotopography, was a major factor in development of the Avant mound. Mounds shift position with time in response to fluctuations in clastic influx (Harbaugh, 1964; Heckel and Cocke, 1969; Ball and others, 1977). Although algae, bryozoans, crinoids, and corals, mainly Chaetetes (Schell, 1955) are present, the "Oswego" does not appear to be wave resistant. In general, algal mounds should not be classed as organic reefs (Toomey and others, 1977). The "Oswego" in this area apparently originated on a muddy, slightly silty bottom at the shelf edge break in slope. However initiated, once algae and other organisms became established, they grew and kept pace with subsidence.

Depositional Environment

Cyclothems

Heckel (1977, p. 1046) suggested that the depositional environments of the Fort Scott are more complex than other Pennsylvanian cyclothems that he studied. The depositional environments of the "Oswego" can best be interpreted as a complex variation of the Kansas-type cyclothem described by Heckel (1977). Heckel's model is a simplification and combination of Moore's (1936) 10 fold ideal cyclothem. Heckel contended that a single transgressive-regressive sequence, termed a cyclothem, is composed of, in ascending order: 1) "Outside shale" consisting of thick, nearshore sandy shale. 2) Thin, dense, transgressive "middle limestone". 3) A "core" of thin, dark marine offshore shale, commonly with a black, fissile, phosphatic facies. 4) Thick regressive "upper limestone", commonly with shallow water facies near the top. 5) A repeat of the "outside shale". Thus, the "outside shales" are the boundaries, and the "core shale" with surrounding limestones are the center of a cyclothem as illustrated in Fig. 18 (Heckel, 1977, 1978).

Lithofacies

Cherokee Shales. The Cherokee Group is a thick wedge of sediment which grades into arkosic clastics adjacent to the Wichita-Amarillo Uplift (Rascoe, 1962). These shaley sandstones are thought to represent fluvial-deltaic environments from a northern source (Berg, 1969; Cole, 1969; Krumme, 1975) so they may be termed an "outside shale" following Heckel's (1977) 5 fold cyclothem classification.

Breezy Hill Limestone. This unit is interpreted as an open-marine limestone in Kansas and Oklahoma, as a fresh water limestone in Illinois, and occurs at the base of an underclay in Missouri (Hopkins and Simon, 1975). The Breezy Hill is a widespread thin, dense, dark limestone composed of predominantly phylloid algae in a carbonaceous calcilutite matrix. Fine grain size, abundant marine biota, algae and dark color suggest deposition below effective wave base in open-marine environments (Heckel, 1977). The Breezy Hill grades upward into the Excello Shale which is interpreted as a deep water deposit (James, 1970). The dark, thin, widespread nature of the Breezy Hill coupled with its stratigraphic position above an "outside shale" and below a "core shale", suggest that it is a "middle limestone" member of a cyclothem having been deposited during a marine transgression.

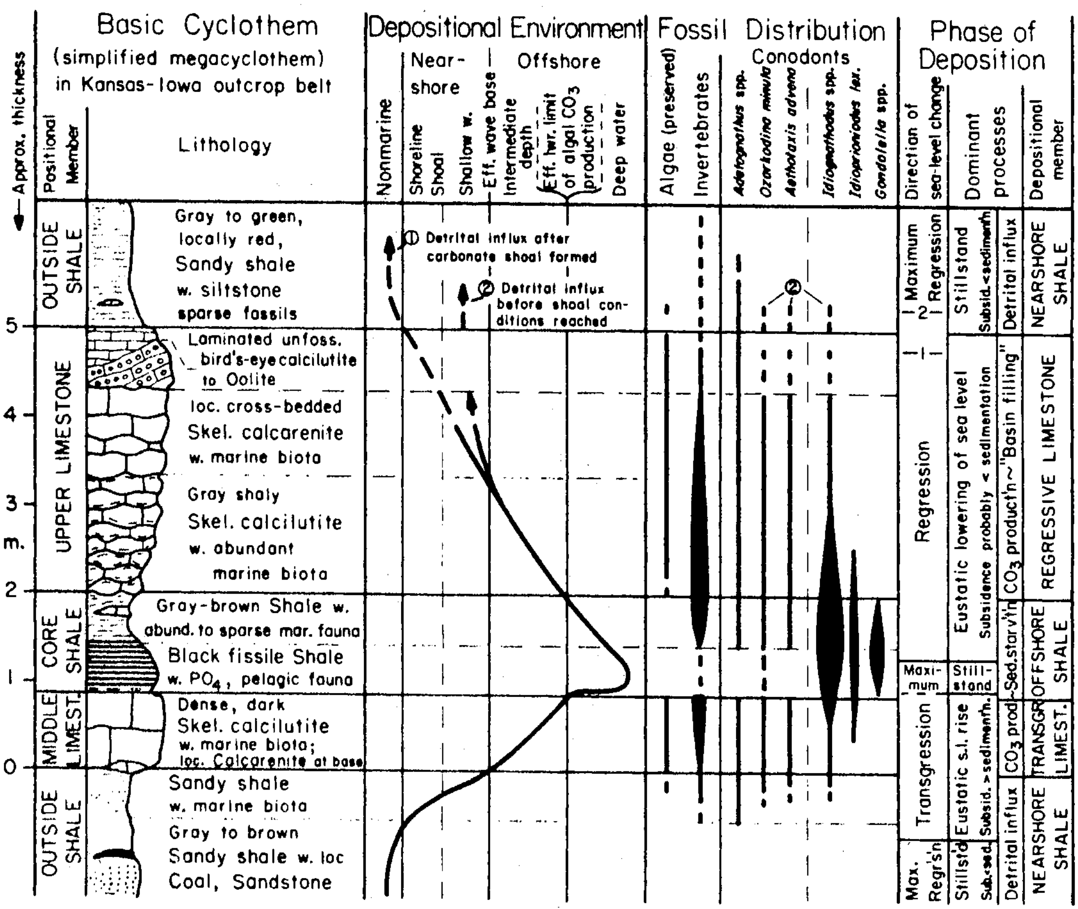


Fig. 18.-Basic Upper Pennsylvanian Kansas cyclothem.
From Heckel, 1977, p. 1047.

<u>Excello Shale</u>. This widespread thin, black, fissile, organic-rich shale contains phosphatic laminae and nodules with a concentration of heavy metals (James, 1970). Abundant marine fossils include discinacean brachiopods and conodonts (Cassidy, 1962; Schell, 1955). Thin black shales of this type are generally regarded as having been deposited in an euxinic marine environment (Wilson, 1975; Heckel, 1977). Evidence to support this is its widespread distribution, thin character, pelagic nectic fauna, significant trace amounts of uranium, and phosphatic concretions (Heckel, 1977). Based on this evidence, the Excello is here interpreted as a "core shale" member of a Kansas type cyclothem. James (1970) interpreted the Excello as having been slowly deposited in deep water, far from detrital influx, under anoxic bottom conditions. Heckel and Baesmann (1975) coined the term "core shale" to describe its position between transgressive and regressive limestones.

<u>Blackjack Creek Limestone</u>. This unit is a thick (70-80 ft) bank of limestone laterally adjacent to a thinner shelf limestone north of the study area, and a black organic-rich basinal shale south of the area. The Blackjack Creek, according to Wanless (1957, p. 101, in Hopkins and Simon, 1975, p. 189), is equivalent to the Hanover Limestone Member of the Carbondale Formation in Illinois, which is ". . . one of the most widespread Pennsylvanian limestones in the central United States . . ." (Hopkins and Simon, 1975, p. 189).

Breese (1973) interpreted the Blackjack Creek as primarily transgressive marine (after Jewett, 1945), but he conceded that the upper part of the Excello and Little Osage shales are regressive deposits. Breese (1973) also interpreted that the Blackjack Creek was deposited in warm, normal salinity water in algal mound and lagoonal environments, based on paleontologic and petrographic evidence. However, outcrop studies by Schell (1955) and this study of the subsurface "Oswego" indicate different lithofacies and environments of deposition, coupled with a complex geologic history.

Schell (1955) interpreted the bioclastic algal facies as shallow marine, nearshore deposits with a firm bottom deposited by strong current action. Schell (1955) further stated that the well sorted microfragmental facies was deposited seaward of the bioclastic algal facies, and the cryptocrystalline lithographic facies was deposited farthest offshore in deeper water. In Missouri, Neal (1968) noted 7 different facies types.

According to Heckel (1977), the basal parts of "upper" regressive limestones are lithologically similar to the "middle" transgressive member. The dense, dark basal part may grade upward into skeletal calcarenite containing algal fragments, abraded grains, crossbedding and shoal-water deposits like oolites. This vertical succession is a result of an offshore, open-marine environment in the lower part, grading upward into shallower water deposits (Heckel, 1977).

The basal part of the Blackjack Creek in the study area is a dense, dark gray calcilutite with algae, crinoid stems and bryozoans, similar in character to the Breezy Hill. The dense, dark basal part grades upward into a light gray to brown calcilutite with algae, pellets, crinoid stems, bryozoans, brachiopods and well sorted bioclastic debris. This zone is probably a combination of the microfragmental and lithographic facies described by Schell (1955). This fragment-pellet calcilutite has been subjected to diagenesis as it is dolomitized, recrystallized, and appears brecciated in parts of the cores. Outside the study area on the shelf, oolites are present in this member (Price, 1963; Edwards, 1963). The basal and middle part of the Blackjack Creek are here interpreted as a regressive deposit because it exhibits the shoaling-upward sequence as described by Heckel (1977). Deposition must have been at a depth sufficient to precipitate calcium carbonate, provide light for the algae, and nutrients for marine organisms. Basinward (south) of the shelf edge algal banks, black organic-rich clays were contemporaneously deposited. These black shales indicate that they were deposited in a basin far from clastic influx and, perhaps below the carbonate compensation depth since so much carbonate was being deposited on the shelf area.

After examining the cores, it became evident that the algal calcilutite mounds could not be correlated from core to core. Therefore, it must be concluded, as surface studies of many algal mounds indicate (Ball and others, 1977), that mounds are small and of a local nature. Apparently the Blackjack Creek in the Putnam Trend is composed of a series of vertically and latterally stacked small algal mounds interstratified with mound-associated beds in a narrow belt at the shelf edge. The porosity map (Pl. 14) seems to substantiate this in the form of small pods of porous limestone developed throughout the trend. However, this may also have been accomplished through diagenesis and be unrelated to the algal mounds.

The middle part of the Blackjack Creek grades upward into another thin, dense, dark gray to black calcilutite with crinoid stems, algae, bryozoans, brachiopods and foraminifera. The upper part is similar to the lower part of the Blackjack Creek, and the Breezy Hill. The upper contact with the Little Osage shale is gradational. The widespread upper part of the Blackjack Creek has the lithologic characteristics, stated earlier, and stratigraphic position below a "core shale" member of a "middle" limestone member having been deposited below wave base during a marine transgression. Apparently, clastic influx was not great enough, in this area, to deposit an "outside shale" before a major marine transgression occured. In Missouri, Neal (1968) interpreted the upper part of the Blackjack Creek to be a transgressive deposit.

Little Osage Shale. This shale is similar to the Excello in thickness, lithology, areal distribution and stratigraphic position within the cyclothem. The Little Osage shale is bound by the transgressive upper Blackjack Creek and the overlying Higginsville limestone. By inference, this shale is interpreted as an euxinic marine "core shale". Breese (1973) felt that the upper part of this shale is regressive, which led to the deposition of the next overlying limestone.

Higginsville Limestone. The Little Osage shale is overlain by the Higginsville. This unit is a thin argillaceous limestone only a few feet thick in the study area (Brown, 1963). Shelfward, to the north, it grades laterally into thicker (about 80 ft) carbonate units as seen on cross section AA-BB (Pl. 7). On the shelf area, this limestone is reported to contain oolites (Krumme, 1975). Schell (1955) noted that the base of the Higginsville is nearly identical with the base of the Blackjack Creek, containing bioclastic material with algae dominant. In the study area, this unit is bound by black shales. The Higginsville in the study area may be interpreted as the basinal near terminus of this unit. The base of the Higginsville was deposited at the end of a regressive cycle, and the upper part deposited during the start of a new transgressive cycle. Thus, the shelfward Higginsville can be interpreted as a regressive deposit because of its shoaling upward sequence. But, in the study area it is regressive at the base and transgressive at the top.

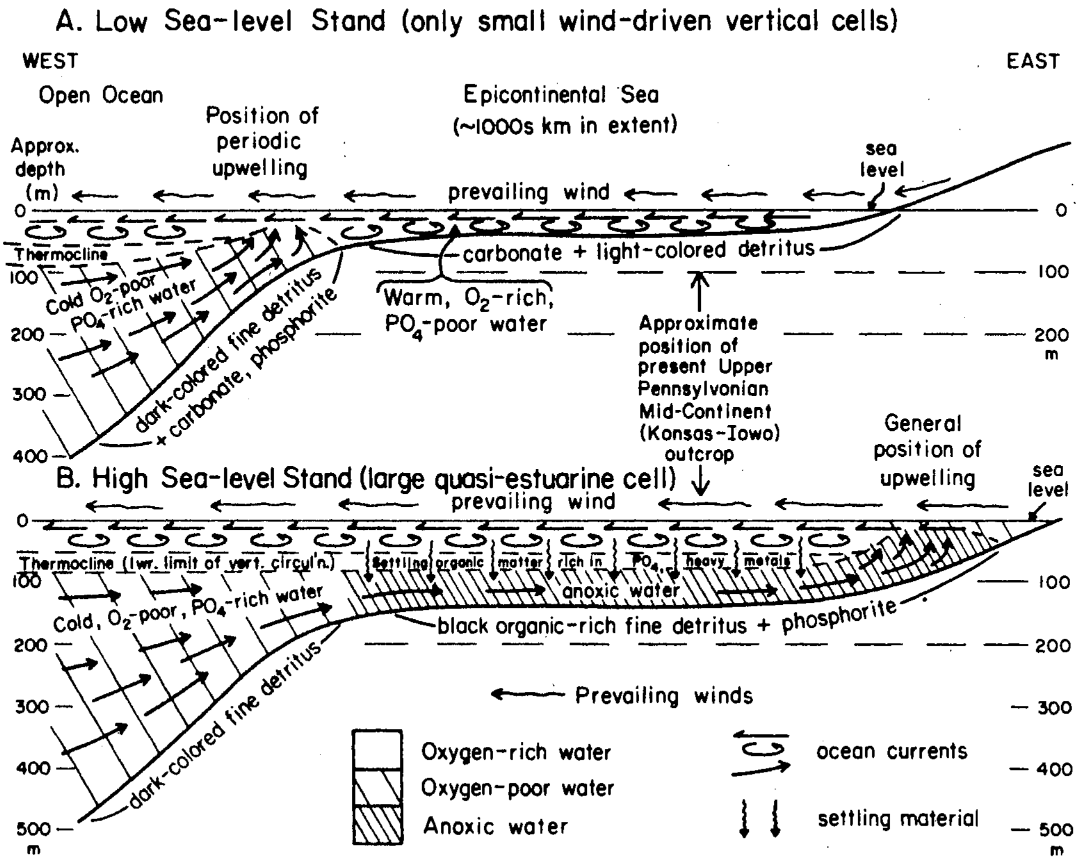
Geologic History

In a regional study of the Marmaton Group in eastern Oklahoma, Krumme (1975) showed that the sands and shales below the Marmaton limestones had a northern source. Whereas, the sands and shales above the Marmaton limestones came from the southeast. Krumme (1975) concluded that the Marmaton was deposited during a period of stable, shallow marine conditions marking the end of one era of deposition and the beginning of another. The southward slope into the basin was slowly reversed. An extensive, flat marine shelf formed where limestone banks grew. Basinward, clay and some sand from the south was deposited. Continued tilting allowed sand and mud from the opposite direction (southeast) to ivade the basin. Continuing clastic sedimentation from the southeast filled the basin, destroying and burying the lime-secreting organisms which had built the banks (Krumme, 1975).

The "Oswego" is the basal part of the Marmaton Group, and its unique geologic history has been interpreted within this framework. A working hypothesis of deposition of the "Oswego" is presented below, synthesizing the above information, and interpreting each unit as a part of the various cyclothem phases.

Pre-transgressive Phase. Sandstones and shales of the "Cherokee" Group were deposited in delta and pro-deltaic environments in a marine basin (Berg, 1969; Cole, 1969; Krumme, 1975). By the end of "Cherokee" time, an overall marine transgression had slowly covered the surrounding highlands. Throughout the rest of Desmoines time, deposition probably occurred in a marine environment (Frezon and Dixon, 1975). These shales in the Putnam area are the basinal marine equivalents of "outside" near-shore shales.

Transgressive Phase. As sea level rose and clastic sedimentation slowed, phylloid algae and marine organisms began to populate the muddy sea floor depositing the Breezy Hill limestone below wave base. As sea level continued to rise, the photic limit for algal carbonate production was reached and clay settling out of suspension in the deep water choked the algae and deposited fine black organic-rich mud. This occurred first in the lower reaches of the basin, and then farther up slope as the sea transgressed the shelf. As sea level reached its maximum, a thermocline (abrupt temperature difference) may have developed between colder bottom water and warm surface water (Heckel, 1977, p. 1053; James, 1970). This would allow cold, oxygen poor water to circulate below warmer surface water. The dead organic matter derived from marine organisms in the warm upper water layer settled into the deeper cold water. This organic material would decay, depleting the remaining oxygen, and deposit black organic-rich shale enriched in phosphorite (Fig. 19, from Heckel, 1977, p. 1054). Such an environment is envisioned for the basal part of the Excello Shale.



Cross section showing expected patterns of vertical circulation in west-facing tropical epicontinental sea. A, Low stand of sea level; small wind-driven vertical circulation cells plus algal photosynthesis maintain bottom oxygenations. B, Sea-level stand high enough to establish permanent thermocline over much of epicontinental sea; large-scale quasi-estuarine cell set up by prevailing trade winds results in upwelling within sea, causing plankton blooms that concentrate phosphate in organic matter, which settles into deeper incoming currents, depleting remaining oxygen, enriching phosphate, and causing deposition of black shale with phosphorite (adapted from Brongersma-Sanders, 1971, p. 129).

Fig. 19.-Cross section illustrating deposition of black shales. From Heckel, 1977, p. 1054.

Regressive Phase. After sea level reached a maximum and the middle part of the Excello was deposited, sea level slowly fell. Carbonate precipitation resumed and marine organisms began to inhabit the muddy bottom as favorable conditions occurred. The basal Blackjack Creek represents marine carbonate deposition below wave base during this period of marine regression. Phylloid algae began to grow as more light filtered though the warm shallowing water. In the Putnam area, carbonate mud banks and associated interbank deposits formed near the break in slope at the shelf edge, depositing the middle Blackjack Creek. According to Ball and others (1977), phylloid algae merely binds loose sediment into cohesive mats a few centimeters high. No reef, or wave resistant structure has been recognized in the Blackjack Creek. Basinward, gray to black organic mud was deposited below wave base. On the shallower shelf, oolites formed and marine shelf organisms and processes dominated. To the south, on the other side of the basin, the Amarillo-Wichita Uplift contributed coarse clastics into the marine basin (Rascoe, 1962). In Missouri, deltaic sediments were deposited (Neal, 1968).

Second Transgressive Phase. Sea level once again rose which slowed algal growth and suspended clay continued to settle to the sea floor, further halting carbonate deposition of the upper Blackjack Creek. A thermocline developed when water depth increased sufficiently and deposited the black, organic-rich, phosphatic Little Osage shale.

Second Regressive Phase. Water depth decreased and carbonate sedimentation again resumed, depositing the Higginsville limestone. On the shelf, to the north of the study area, oolites formed in the shallow water. In the study area a thin, dense limestone was deposited which is the basinal equivalent of this unit. Apparently, the remainder of the Marmaton Group in this area had a similar cyclical geologic history. Each major regional transgression is recorded by a black, offshore "core" shale, and each regression is represented by either shallow marine carbonate deposition, or sandstone and shale intercalations representing "outside shales" such as the Cleveland sand zone below the Checkerboard limestone (Krumme, 1975).

CHAPTER VI

PETROLEUM GEOLOGY

Production History

The petroleum geology of the Putnam area was discussed by Slate (1962). The discovery well for the Putnam Field was the Sinclair Oil and Gas Company #1 Kunc (C SW NE Sec. 11-17N-18W), completed January, 1957 for a calculated flow rate of 201 Bbls. of 48.5° gravity oil and 1,650 thousand cubic feet of gas per day (MCFGPD). The discovery well was drilled on the basis of regional sub-surface and seismic mapping of deeper Morrow sandstone (Brown, 1963). The Morrow sandstone in this well was non-productive, so the well was plugged back to test, and completed in, the "Oswego". Other "Oswego" discoveries linked the local oil and gas fields into their present configuration. The Trend is continually being extended on its outer extremities, mostly by wells drilled to deeper objectives. There is a 500 ft gas column, and the oil column is known to be 250 ft (Brooks, 1973). The Putnam Field has the potential of producing over one trillion cubic feet of gas according to Halbouty (1968), placing it in the category of a giant field.

The oil bearing part of the field in the study area was unitized in November, 1968. The resulting "Putnam Oswego Unit" cumulative production to that date is 16,242,517 Bbls of oil from 122 wells (Vance-Rowe Report, 1970). Cumulative production in the unit from 11-68 to 12-79 is 8,298,199 Bbls of oil from 125 wells (Petroleum Information, 1979). This makes a total cumulative production of 24,540,716 Bbls of oil or roughly 200,000 Bbls of oil per well. Computed current average daily production is about 10 Bbls of oil per well (Petroleum Information, 1979). The cumulative oil production (to December, 1979) for all producing formations in the Trend is 60,568,675 Bbls of oil for 422 wells.

Source Rocks

Brown (1963) attributed the Hydrocarbon source of the "Oswego" oil and gas to the overlying carbonaceous shales. Another possible source is the contemporaneous black organic-rich shale facies of the "Oswego". These shales interfinger with the bank deposits and any hydrocarbons generated may have migrated directly into the "Oswego" bank facies, much like that described by Arthur and Schlanger (1979) for Cretaceous reef reservoirs. Recent studies by Shinn and others (1980) suggest that some ancient limestones were source rocks, and findings by Silver and others (1980) indicate that the Oswego was the source rock for its oil.

Porosity Development

The porosity is mostly secondary in the form of vugs and fractures. The vugs and large calcite crystals may have formed as a result of dissolution by subterranean water as Brown (1963) suggested. Perhaps primary botryoidal cement incompletely filled natural voids and had subsequently been recrystallized, like the Permian algal mounds studied by Mazzullo and Cys (1979). The diagenetic history of this unit is a subject for further study. Brown (1963) proposed that the fractures formed by a sudden down-warping of the basin, whereas Breese (1973) suggested that the fractures formed as a result of faulting in the area. This area is the hinge line for several stratigraphic units throughout geologic time (Slate, 1962; Swanson, 1967) and in the course of basin formation, faulting and fracturing are to be expected (Shelton, 1968).

Exploration Significance

Most of the "Oswego" discoveries in the Putnam Field were made as a result of exploration for deeper objectives. After several new field discoveries were made, an "Oswego" trend became apparent. Stepout and extension wells then rapidly linked these fields into the present Putnam Field. Surface mapping does not reflect deeper geologic structure in this area due to evaporite solution and bed collapse of the shallow salt formations (Six, 1930; Brown, 1967). However, Swanson (1967) suggested that regional subsurface mapping, with the limited well control available in the 1950's, could have provided enough information to establish the existence of a structural hinge line at the level of the "Oswego". It is not known if the "Oswego" facies change in this area is exhibited on seismic records because this data was not available for study. It is probable that the "Oswego" bank could be delineated using modern techniques of seismic stratigraphy.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The objective of this thesis is to interpret the depositional and geologic history of the "Oswego" in the Putnam Field. This was accomplished by studying cores, thin sections, well cuttings and electric logs from wells within the study area, and by mapping the thickness and structure of the "Oswego" and associated beds in the 6 Township area. Principal conclusions of this study are stated below.

1. Pre-"Oswego" topography consisted of a subtle shelf edge break in slope in a marine basin. These deposits are probably delta fringe or slope deposits. As clastic influx diminished, carbonate deposition became established.

2. A major transgression occurred which halted carbonate deposition and deposited a black shale. During the following regressive phase, carbonate deposition again occurred. Marine algae and organisms inhabited the sea floor producing muddy bank-like deposits at the shelf edge. Seaward, black organic mud was deposited in anoxic environments, but oolites formed shelfward of the bank in a higher energy environment above wave base.

3. Another major transgression occurred, cutting off carbonate deposition. A resumption of deep water shale deposition resulted. Transgressive-regressive seas continued for the remainder of Marmaton time and carbonate deposition dominated until Late Desmoinesian-Early

Missourian clastics choked carbonate deposition in the Putnam area.

4. The "Oswego" is a prolific petroleum producer and the Putnam Field is considered a potential giant field with projected recoverable reserves in excess of 1 trillion cubic feet of gas. The oil bearing part of the field in the study area has produced over 24 million Bbls of oil, although production levels have declined greatly.

Suggestions for further study include the complex diagenetic history, specifically the recrystallization and dolomitization as it relates to porosity development.

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APPENDIX A

NAMES AND LOCATIONS OF WELLS

USED IN CORRELATION SECTIONS

No.	Operator and Well Number	Location
	North-South Correlation Section A-A'	
1.	Petroleum Inc., #1 Irvin	SW NE SW Sec. 3-16N-17W
2.	Union Oil Co., #1 Irvin	C SE NW Sec. 10-16N-17W
3.	Union Oil Co., #1 Coit	C SE NW Sec. 15-16N-17W
4.	Union Oil Co., #1-22 Willis	C NE NE Sec. 22-16N-17W
5.	Clark Canadian & McCulloch Oil, #1 Williams	NE SW NE SW Sec. 27-16N-17W
6.	Hunt, #2 Graft	E½ SW SE Sec. 4-15N-17W
7.	Apexco, #1 Manson	W½ W½ W½ SE Sec. 9-15N-17W
8.	Apexco, #1 Coit	C SE NW Sec. 16-15N-17W
9.	White Shield, #1 Kincaid	C NW SE Sec. 21-15N-17W
10.	Clarcan Petroleum Corp., #1 Valentine	C NW SE Sec. 29-15N-17W
11.	Ferguson Oil & Gas, #1 Elaine	C NW Sec. 32-15N-17W
	North-South Correlation Section B-B'	
1.	Hendrick Development, #1 Davis	C NE SW Sec. 2-16N-16W
2.	Wessely Petroleum, #1 Love Unit	C SW NE Sec. 15-16N-16W
3.	Mobil, #1 Herring	C SE NW Sec. 22-16N-16W
4.	Eason Oil, #1 Jones	C SW NE Sec. 27-16N-16W
5.	Mobil, #1 Jones	C SW SE Sec. 27-16N-16W
6.	Eason Oil, #1 Mannering	C NE NW Sec. 34-16N-16W
7.	Sunray DX, #1 Frans	C SW NE Sec. 3-15N-16W
8.	Southern Union Production, #1 Jones Droke	C SW NE Sec. 10-15N-16W
9.	Mobil, #1 Carter	C SE NW Sec. 15-15N-16W
10.	Parker Drilling Co., #1 Miller	C NE SW Sec. 22-15N-16W
11.	Wessely Energy, #1 Miller	W½ W½ W½ NE Sec. 27-15N-16W
12.	Mobil, #1 Davis	NW SE Sec. 27-15N-16W
	North-South Correlation Section C-C'	
1.	Cleary Petroleum, #1-3 Stephenson	W½ W½ E½ NW Sec. 3-16N-15W
2.	Texas Oil & Gas, #1 Cline "A"	C NE Sec. 14-16N-15W
3.	Texas Oil & Gas, #1 Vandiver	NW NW SE NW Sec. 23-16N-15W
4.	Trigg Drilling Co., #1 Venable Estate	N½ N½ S½ NW Sec. 26-16N-15W
5.	Mobil, #1 Deming "B" Unit	W½ NW Sec. 2-15N-15W
6.	Mobil, #1 Deming Unit	W½ SW Sec. 2-15N-15W
7.	Schermerhorn Oil Co., #1 Garner	C SW NW Sec. 11-15N-15W
8.	Mobil, #1 McNeil	C SW SW Sec. 11-15N-15W
9.	Mobil, #1 Horton	C SE NW Sec. 14-15N-15W
10.	W. C. Pickens, #1 Jones	NE NW Sec. 23-15N-15W
11.	Marion Oil Co., #1 McNeill	C NE SE Sec. 23-15N-15W
12.	Sanguine Ltd., #1 Caag	C SW Sec. 34-15N-15W

No.	Operator and Well Number	Location
	East-West Correlation Section D-D'	
1.	Union Oil Co., #1-6 S. J. Sarkeys	C SW NE Sec. 6-16N-17W
2.	Samedan, #1 Lisle Unit	C SW NE Sec. 5-16N-17W
3.	Union Oil Co., #1-4 Lisle	C NE SW Sec. 4-16N-17W
4.	Petroleum Inc., #1 Irvin	SW NE SW Sec. 3-16N-17W
5.	McCulloch, Statex & Amarex, #1-6 Hendrix	NW NW NW SE Sec. 6-16N-16W
6.	Hendrick Development, #1 Davis	C NE SW Sec. 2-16N-16W
7.	Texas Oil & Gas, #1 Schoonmaker	C NE Sec. 1-16N-16W
8.	Texas Oil & Gas, #1 Brundage "A"	C NW Sec. 6-16N-15W
9.	Texas Oil & Gas, #1 Brundage	N½ S½ NW Sec. 5-16N-15W
10.	Texas Oil & Gas, #1 Percy "A"	C W½ Sec. 4-16N-15W
11.	Cleary Petroleum, #1-3 Stephenson	W½ W½ E½ NW Sec. 3-16N-15W
	East-West Correlation Section E-E'	
1.	Union Oil Co., #1-6 S. J. Sarkeys	C SW NE Sec. 6-16N-17W
2.	Union Oil Co., #1-8 Clark	SW NE Sec. 8-16N-17W
3.	Union Oil Co., #1 Robertson	C NE SW Sec. 9-16N-17W
4.	Union Oil Co., #1 Jordan	C SW NE Sec. 16-16N-17W
5.	Union Oil Co., #1-22 Willis	C NE NE Sec. 22-16N-17W
6.	Union Oil Co., #2-23 King	C NE NE Sec. 23-16N-17W
7.	Sinclair, #2 Dobbins	C NW NE Sec. 24-16N-17W
8.	Sunray DX, #1 Richardson	SE NW Sec. 19-16N-16W
9.	Sinclair, #1 C. L. Smith	C NE SE Sec. 29-16N-16W
10.	Mobil, #1 Jones	C SW SE Sec. 27-16N-16W
11.	Sinclair, #1 Jones	C SW NW Sec. 31-16N-15W
12.	Sinclair, #1 Fisher	NW SW NW Sec. 33-16N-15W
13.	Mobil, #1 Deming "B" Unit	W½ NW Sec. 2-15N-15W
	East-West Correlation Section F-F'	
1.	Ferguson Oil & Gas, #1 Elaine	C NW Sec. 32-15N-17W
2.	Ferguson Oil & Gas, #1 Hoelker	C NW Sec. 33-15N-17W
3.	Ladd Petroleum, #1 Matthes	C SW Sec. 35-15N-17W
4.	King Resources, #1-29 Davis	C NE Sec. 29-15N-16W
5.	King Resources, #1-28 Coit Unit	C NE Sec. 28-15N-16W
6.	Mobil, #1 Davis	NW SE Sec. 27-15N-16W
7.	States Oil, #1 Harold Dean Bell	C NE Sec. 35-15N-16W
8.	Texas Oil & Gas, #1 Pyeatt	NE NE Sec. 36-15N-16W
9.	Robert L. Parker, #1 Jones	C SE NW Sec. 31-15N-15W
10.	Sinclair, #1 Howard	E½ W½ SW Sec. 32-15N-15W
11.	Sanguine Ltd., #1 Caag	C SW Sec. 34-15N-15W

No.	Operator and Well Number	Location
	Stratigraphic Cross Section AA-BB	
1.	Texas Oil & Gas, #1 Vandiver	NW NW SE NW Sec. 23-16N-15W
2.	Pan Am, #1 Graham	C NW SE Sec. 13-16N-15W
3.	Woods Petroleum, #1 Surveyor Woman	C NW Sec. 7-16N-14W
4.	Davis Oil, #1 Hutton	W½ W½ E½ SW Sec. 32-17N-14W
5.	Petroleum Inc., #1 Shields	C SW Sec. 27-17N-14W
6.	Woods Petroleum, #1 McNeill	S½ S½ N½ SE Sec. 23-17N-14W
7.	Samedan, #1 Pierce	E½ E½ W½ NE Sec. 24-17N-14W
8.	Shenandoah, #1 Custer	C W½ NE Sec. 18-17N-13W
9.	Seneca Oil, #1 White Hat	C SE NW Sec. 8-17N-13W
10.	L. O. Ward, #1 Smith	W½ W½ W½ SE Sec. 5-17N-13W
11.	Pan Am, #1 Garner Unit "C"	C SW NE Sec. 33-18N-13W
12.	Pan Am, #1 Young Unit "A"	SE NW Sec. 27-18N-13W
13.	Pan Am, #1 Haigler Unit "F"	C NE Sec. 23-18N-13W
14.	Sun Oil, #2 Sankey	SW SW NE SW Sec. 13-18N-13W
15.	Hall-Jones Oil Corp., #1 DeMoss Unit	C SW NE SW Sec. 7-18N-12W
16.	Pan Am, #1 Bartel Unit	C W½ SE Sec. 5-18N-12W

APPENDIX B

GENERALIZED CORE DESCRIPTIONS

SINCLAIR, #2 DOBBINS, C NW NE SEC. 24-16N-17W, DEWEY COUNTY, OKLAHOMA

WELL 7 ON CORRELATION SECTION E-E' (PL. 5)

Condition of Core

Core chips nearly every foot.

Scout Ticket

Cored 9628-78': Recovered 5' shale; 35' dense limestone; 8' tan to gray vuggy limestone with oil stain and odor; lost 2' of core. Cored 9678-9708': Recovered 14½' dense limestone; 8' tan to gray vuggy limestone with oil stain and odor; 2' gray limy shale; lost ½' of core.

Generalized Core Description

Little Osage Shale
9628-31'
Shale: Black, organic rich (oily smell), carbonaceous material, pyrite with discinacean brachiopods.

Blackjack Creek Limestone
9632'
Limestone: Black, organic rich, fossiliferous, argillaceous mudstone with interbedded shale.
9633-65'
Limestone: Mottled dark gray fossiliferous wackestone in a matrix of partially recrystallized dark brown, fine to coarse crystalline calcite. Stylolites, clear calcite filled vugs, and shale partings. Fossils include crinoid stems, bryozoans, fusulinids, and algae. Varying degree of dolomitization throughout the core.
9665-94'
Limestone: As above, but lighter brown with a very vugular texture.
9694-9700'
Limestone: Dark gray fossiliferous wackestone with crinoid stems, and bryozoans.
9701'
Limestone: Dark gray to black, dense, argillaceous mudstone with crinoid stems and bryozoans.

SUNRAY, #1 RICHARDSON, SE NW, SEC. 19-16N-16W, DEWEY COUNTY, OKLAHOMA

WELL 8 ON CORRELATION SECTION E-E' (PL. 5)

Condition of Core

Whole core, sawed in half.

Scout Ticket

Cored 9686-9715': Recovered 29' shale. Cored 9715-39': Recovered 23' shale; lost 1'.

Generalized Core Description

Blackjack Creek Limestone

9686-9710'

Limestone: Mottled light gray to light brown fossiliferous wackestone in a matrix of light to dark brown, fine to coarse crystalline calcite. Varying degree of dolomitization. Fossils include algae, crinoid stems, bryozoans, fusulinids, brachiopod and mollusc fragments and some coral. Stylolites, black shale partings, fractures and vugs occur throughout the core.

9710-14'

Limestone: Mottled dark gray, dense fossiliferous wackestone in a matrix of dark brown, fine to coarse crystalline calcite. Varying degree of dolomitization. Nearly all the fossil fragments are recrystallized and appear as ghosts.

9714-18'

Limestone: Dark gray to black, dense, argillaceous, fossiliferous wackestone. Fossils are predominantly crinoid stems and bryozoans with some algae.

Excello Shale

9718-22'

Shale: Black, dense to fissile, pyrite, fossil fragments, phosphate pellets. Fossils include foraminifera, brachiopods (discinacean) and abundant organic matter.

Breezy Hill Limestone

9722-26'

Limestone: Black, dense, argillaceous, pyrite, fossiliferous wackestone. Fossils are predominantly crinoid stems, bryozoans, well preserved algal blades, brachiopod and mollusc fragments. Some of the fossil debris is sillicified (chert).

Cherokee

9726-38'

Shale: Black, carbonaceous, silty, thin bedded to laminated.

SINCLAIR, #1 SMITH, C NE SE SEC. 29-16N-16W, DEWEY COUNTY, OKLAHOMA

WELL 9 ON CORRELATION SECTION E-E' (PL. 5)

Condition of Core

Core chips every few feet.

Scout Ticket

Cored 9630-89': Recovered 6' gray shale; 14' tan to brown, semi-dense limestone; 9' tan fossiliferous with some vugs; 2' as above with vugs; 3' tan, semi-dense limestone with few vugs; 6' tan to brown fossiliferous limestone with vugs; 10' as above with vugs; 8' fossiliferous limestone with large vugs; lost 1' of core. Cored 9689-9711': Recovered 13' limestone, very fossiliferous with vugs, good oil stain and odor; 3' as above with vugs, fair stain and odor; 2' dark brown limestone; 2' black shale; 2'dark brown to gray shale with crinoid stems and coral.

Generalized Core Description

Blackjack Creek Limestone

9636'

Limestone: Light gray, laminated, fossiliferous mudstone to wackestone with crinoid stems, bryozoans and shell debris dominant.

9639-49'

Limestone: Mottled dark gray fossiliferous wackestone in a matrix of recrystallized dark brown, fine to coarse crystalline calcite. Dominant fossils are crinoid stems, bryozoans, and shell fragments. Stylolites and shale partings are common and the core is dolomitized throughout to varying degrees.

9650-95'

Limestone: Mottled light gray to light brown fossiliferous wackestone in a matrix of light brown, fine to coarse crystalline calcite with abundant vugs. Fossils include phylloid algae, crinoid stems, bryozoans, fusulinids, brachiopods, and gastropods.

9697-9703'

Limestone: As above, but dark gray and dark brown, fewer vugs.

9705'

Limestone: Dark gray to black fossiliferous mudstone to wackestone.

SINCLAIR, #1 JONES, C SW NW, SEC. 31-16N-15W, DEWEY COUNTY, OKLAHOMA

WELL 11 ON CORRELATION SECTION E-E' (PL. 5)

Condition of Core

Core chips every foot.

Scout Ticket

Cored 9555-59': Core barrel jammed; recovered 2½' shale; lost 1½'.
Cored 9559-77': Recovered 1' limestone, shaley; 6' limestone, hard, tite, very fractured, scattered vugs, with slight odor; 9' limestone, tite, fair scattered finger size vugs, oil stain and odor; 1' limestone, fractured and broken with odor; 1' limestone, hard, dense, no oil show.
Cored 9577-9629': Recovered 11' limestone, semi-dense, scattered porosity, vugs; 2' limestone, semi-dense, fair to scattered vugs; 33' limestone, fine to medium crystalline, fair to good finger size vugs, good show of oil; 6' limestone, hard, tite, trace of porosity.

Generalized Core Description

Blackjack Creek Limestone

9559'

Limestone: Dark gray to black argillaceous fossiliferous mudstone containing crinoid stems, bryozoans, and algae.

9560-68'

Limestone: Mottled gray to light brown fossiliferous mudstone in a matrix of dense, dark brown, fine to coarse crystalline calcite.

9569-87'

Limestone: As above, but with vugular pososity.

9588-9626'

Limestone: Mottled light gray to light brown fossiliferous wackestone in a matrix of light brown, fine to coarse crystalline calcite which is very vugular and contains stylolites. Fossils include algae, bryozoans, crinoid stems and brachiopods. The lower part of the core contains more gray wackestone, and a dark brown crystalline matrix.

9627-28'

Limestone: Dark gray, argillaceous, fossiliferous wackestone containing algae and crinoid stems.

SINCLAIR, #1 FISHER, NW SW NW, SEC. 33-16N-15W, DEWEY COUNTRY, OKLAHOMA

WELL 12 ON CORRELATION SECTION E-E' (PL. 5)

Condition of Core

Quartered whole core.

Sout Ticket

Cored 9515-74': Recovered 3' limestone, no show; 26' limestone with fractures and scattered oil stain; 4' limestone, vugular porosity with oil stain; 3' limestone, pin point vugular porosity; 10' limestone, chalky, good porosity; 9' limestone, vugs, good show of oil. Cored 9574-93': Recovered 11' limestone with large vugs; 6' limestone, no show; 3' shale.

Generalized Core Description

Blackjack Creek Limestone

9515-18'

Limestone: Dark gray to black, laminated, shaley, very argillaceous crinoid stem wackestone.

9519-47'

Limestone: Mottled dark gray, dense, argillaceous, fossiliferous wackestone in a matrix of dark brown, fine to coarse crystalline calcite. Abundant black shale partings, stylolites and many fractures. Fossils are mainly crinoid stems, algae, bryozoans and fusulinids.

9548-87'

Limestone: Motted, light gray to light brown fossilliferous mudstone to wackestone in a matrix of light brown, fine to coarse crystalline calcite. Abundant black shale partings, stylolites, fractures and vugular porosity. Fossils are mostly algae with some mollusc, brachiopod, bryozoan, and crinoid stem fragments.

APPENDIX C

GENERALIZED THIN SECTION DESCRIPTIONS

SUNRAY, #1 RICHARDSON, SE NW, SEC. 19-16N-16W, DEWEY COUNTY, OKLAHOMA

FORMATION	THIN SECTION (IN FOOTAGE)	DESCRIPTION
Cherokee	2-R-9738	Shale: Black thinly laminated to bedded, silty, pyrite, burrowed.
	3-R-9736	As above
	4-R-9734	As above
	5-R-9732	As above
	6-R-9730	As above
	7-R-9728	As above
	8-R-9726	As above, but gradational increase in silt.
Breezy Hill	9-R-9724	Limestone: Black, argillaceous, thin bedded to laminated fossiliferous wackestone. Fossils include well preserved phylloid algal blades, bryozoan, brachiopods, crinoid stem. Pyrite and chert are also present, and replace some fossil fragments.
	10-R-9723	Limestone: As above, but algal wackestone to packstone.
	11-R-9722	As above, but bryozoan, crinoid stem mudstone to wackestone.
Excello	1-R-9718	Shale: Black, fossiliferous, phosphatic, pyrite, glaucomite?
Blackjack Creek	13-R-9716a	Limestone: Black, silicified, fossiliferous packstone; pyrite and chert replace some fossils. Fossils include bryozoans, crinoid stems and brachiopods. Stylolite and clayey contact.
	13-R-9716b	As above, but wackestone to packstone.
	14-R-9714	Microfragmental fossiliferous packstone, recrystallized in patches.
	15-R-9712	Recrystallized and dolomitized microfragmental fossiliferous packstone.
	16-R-9710	As above
	17-R-9708	Microfragmental algal packstone, sparry and vuggy with pellets.
	18-R-9706	As above, but sparry wackestone. Fractured, recrystallized, vugs, pellets?
	19-R-9704	As above with large calcite crystals and pellets?
	20-R-9702	Fractured wackestone, recrystallized as above with pellets? Stylolites, crinoid stems, bryozoans,

FORMATION	THIN SECTION (IN FOOTAGE)	DESCRIPTION
		brachiopods, algae?
	21-R-9700	As above, dolomitized.
	22-R-9698	As above with forams.
	23-R-9696	As above
	24-R-9694a	As above
	24-R-9694b	As above
	25-R-9692a	Fractured mudstone. Burrowed, slightly fossiliferous, laminated, with algae?
	25-R-9692b	As above, mudstone to wackestone.
	26-R-9690a	Fractured, recrystallized, dolomitized, fusulinid, algae, bryozoan, crinoid stem packstone.
	26-R-9690b	As above, contact with sparry wackestone and fossiliferous sparite?
	27-R-9688	As 26-R-9690a above.
	28-R-9686	Recrystallized fossiliferous wackestone (brecciated appearance).

SINCLAIR, #1 SMITH, C NE SE SEC. 29-16N-16W, DEWEY COUNTY, OKLAHOMA

FORMATION	THIN SECTION (IN FOOTAGE)	DESCRIPTION
Blackjack Creek	1-S-9640	Recrystallized (brecciated) algal fragment mudstone to wackestone.
	2-S-9636	Bryozoan, crinoid stem, brachiopod wackestone.
	3-S-9662	Algal, crinoid stem, bryozoan wackestone to packstone.
	4-S-9663-76	As above
	5-S-9689	Botryoidal cement? Algae?
	6-S-9693	Coarse, sparry, microfragmental wackestone.

VITA

David Michael Michlik

Candidate for the Degree of

Master of Science

Thesis: PETROGRAPHIC AND MAPPING STUDY OF THE SUBSURFACE "OSWEGO" LIMESTONE IN PART OF THE PUTNAM TREND, T 15-16 N, R 15-17 W, DEWEY AND CUSTER COUNTIES, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Cleveland, Ohio, August 3, 1949, the son of Mr. and Mrs. Michael M. Michlik; married Muoi Thi Pham on March 19, 1977.

Education: Graduated from R. B. Chamberlin High School, Twinsburg, Ohio, in June, 1967; received Associate in Arts degree, with a major in Business Data Processing from Cuyhoga Community College, Cleveland, Ohio, in June, 1969; received Bachelor of Science degree in geology from University of Akron, Akron, Ohio, in June, 1974; completed requirements for a Master of Science degree at Oklahoma State University in July, 1980, with a major in geology.

Professional Experience: Junior member of the American Association of Petroleum Geologists; member of the Oklahoma City Geological Society; member of the Society of Economic Paleontologists and Mineralogists; member of the Geological Society of America; teaching assistant, Oklahoma State University, January, 1975 to May, 1976; research assistant, Erico, Inc., June to September, 1975; geologist, Michigan Wisconsin Pipe Line Company, August, 1976 to June, 1979; development geologist, Getty Oil Company, June, 1979 to present, July, 1980.

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 1

North-South Correlation Cross-Section A-A'

Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 11x

By: D.M. Michlik

Date: 1980

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B
S
12
Tie with F-F'
11
10
9
8
7
6
5
Tie with E-E'
4
3
2
1
Tie with D-D'
Plate 2
Thesis
1980
M624p
cop. 2
B'
N
DATUM: Checkerboard Marker
DATUM: Checkerboard Marker
Top "Oswego" Marker
Base "Oswego" Marker
Top "Oswego" Marker
Base "Oswego" Marker
Basin Shale Facies
Algal Bank Facies
Shelf Limestone Facies
100 FEET
PUTNAM FIELD AREA
Dewey & Custer Counties, Oklahoma
Plate 2
North-South Correlation
Cross-Section B-B'
Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 11x
By: D.M. Michlik
Date: 1980
fjb-dks

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 3

North-South Correlation

Cross-Section C-C'

Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 11x

By: D.M. Michlik

Date: 1980

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Plate 4

100 FEET

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 4

East-West Correlation
Cross-Section D-D'

Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 16x

By: D.M. Michlik

Date: 1980

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E
W
DATUM: Checkerboard Marker
1
2
3
4
Tie with A-A'
5
6
7
8
9
10 Tie with B-B'
11
12
13
Tie with C-C'
Plate 5
E'
E
DATUM: Checkerboard Marker
Top "Oswego" Marker
Base "Oswego" Marker
Algal Bank Facies
Basin Shale Facies
Fore-Bank Facies
Algal Bank Facies
Top "Oswego" Marker
Base "Oswego" Marker
Cores studied
100 FEET
PUTNAM FIELD AREA
Dewey & Custer Counties, Oklahoma
Plate 5
East-West Correlation
Cross-Section E-E'
Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 16x
By: D.M. Michlik
Date: 1980
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F
W
1
Tie with A-A'
2
3
4
5
6
Tie with B-B'
7
8
9
10
11
Tie with C-C'
Plate 6
F'
E
DATUM: Checkerboard Marker
DATUM: Checkerboard Marker
Basin Shale Facies
Top "Oswego" Marker
Base "Oswego" Marker
Top "Oswego" Marker
Base "Oswego" Marker
100 FEET
PUTNAM FIELD AREA
Dewey & Custer Counties, Oklahoma
Plate 6
East-West Correlation
Cross-Section F-F'
Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 16 x
By: D.M. Michlik
Date: 1980
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Plate 7

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 7

Stratigraphic Cross-Section

AA-BB

Vertical Scale: 1" = 100'
Horizontal Scale: None
V.E. Approx. 16 x

By: D.M. Michlik

Date: 1980

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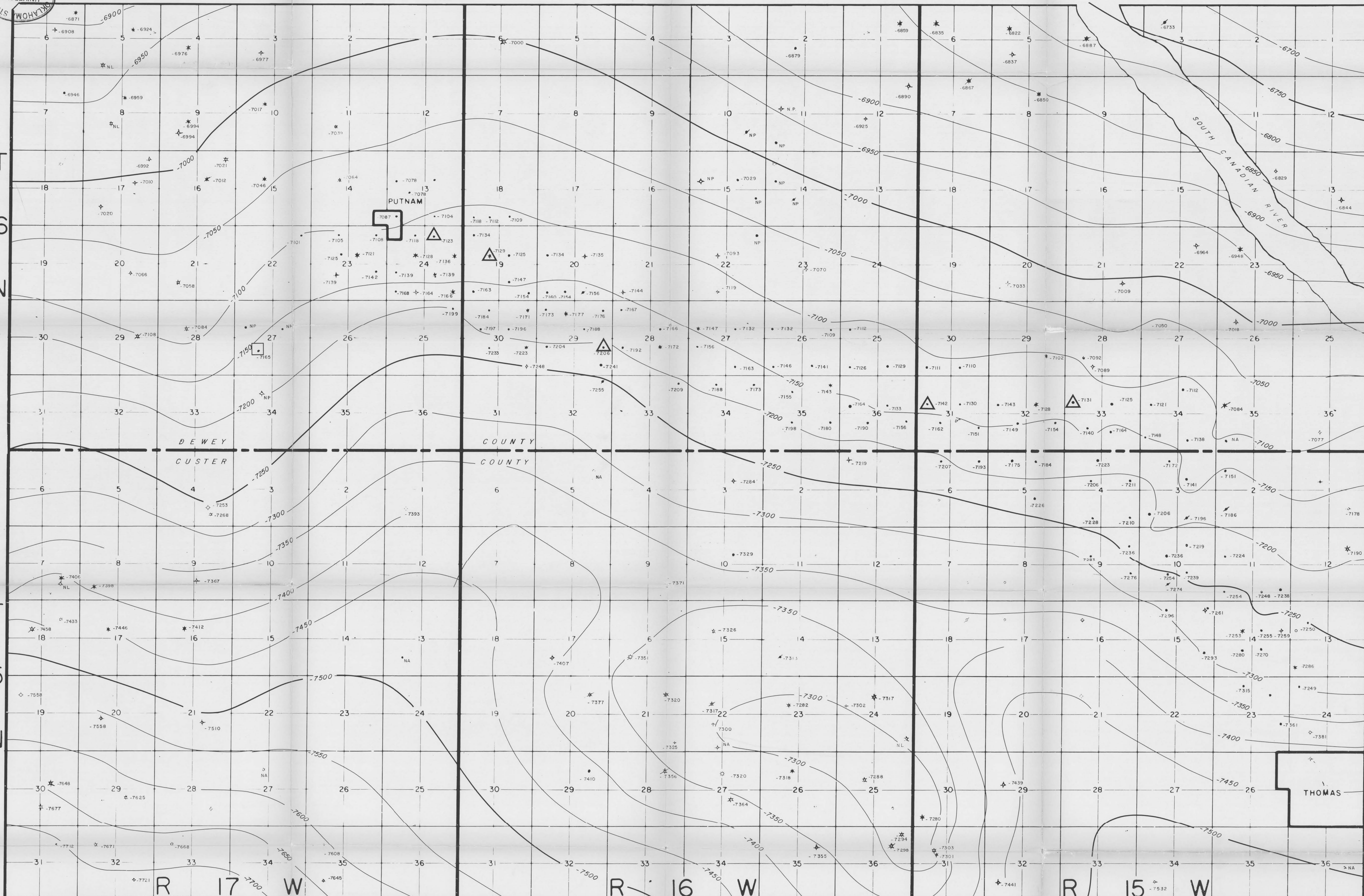


EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

△ Cores Studied

□ Samples Studied

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 8

STRUCTURE: CHECKERBOARD MARKER

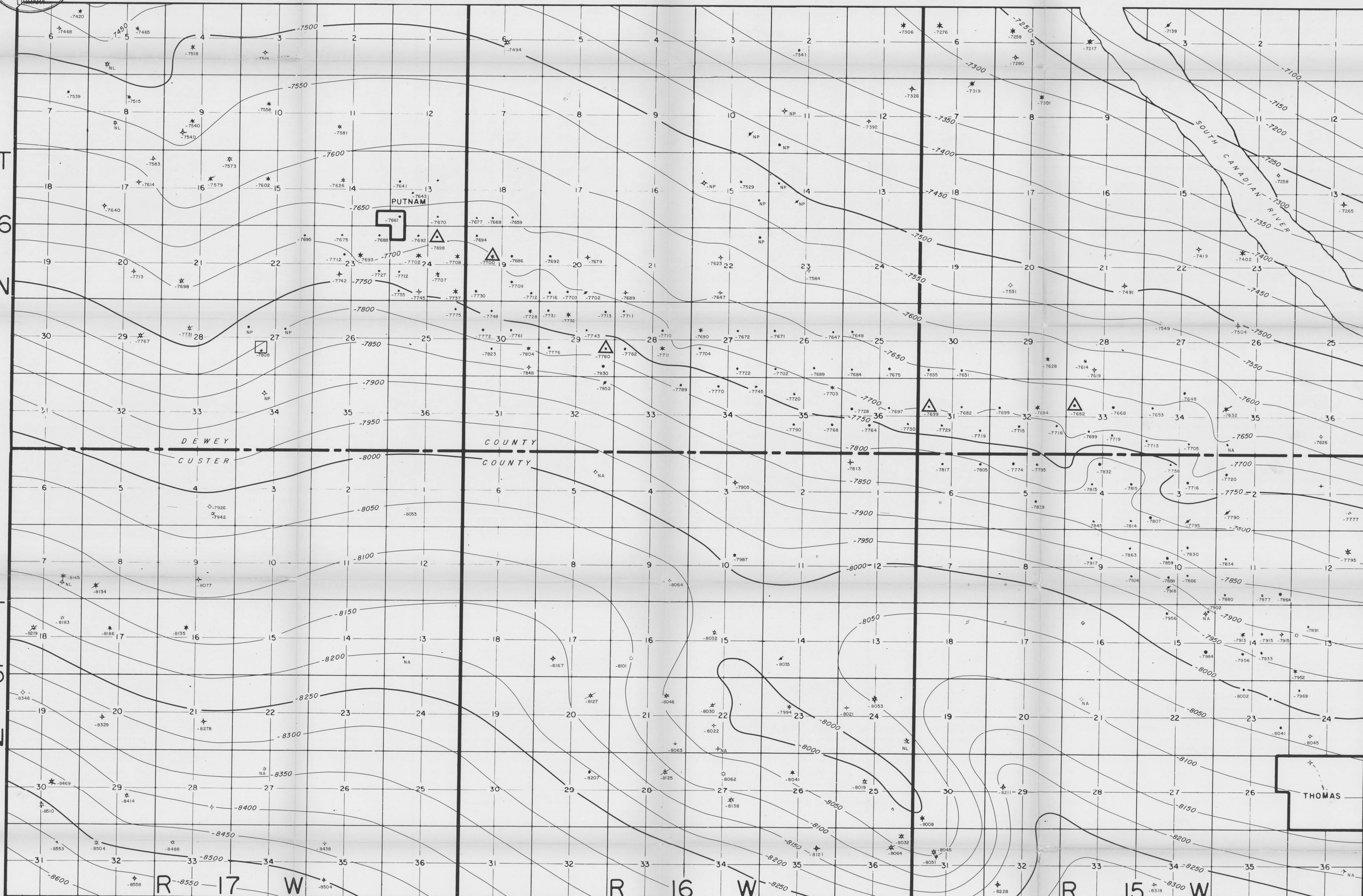
C. I. = 50'

SCALE 2" = 1 Mi., 1:31680

By D. M. Michlik

Date 1980

Plate 9



EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

△ Cores Studied

□ Samples Studied

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 9

STRUCTURE: T/OSWEGO MARKER

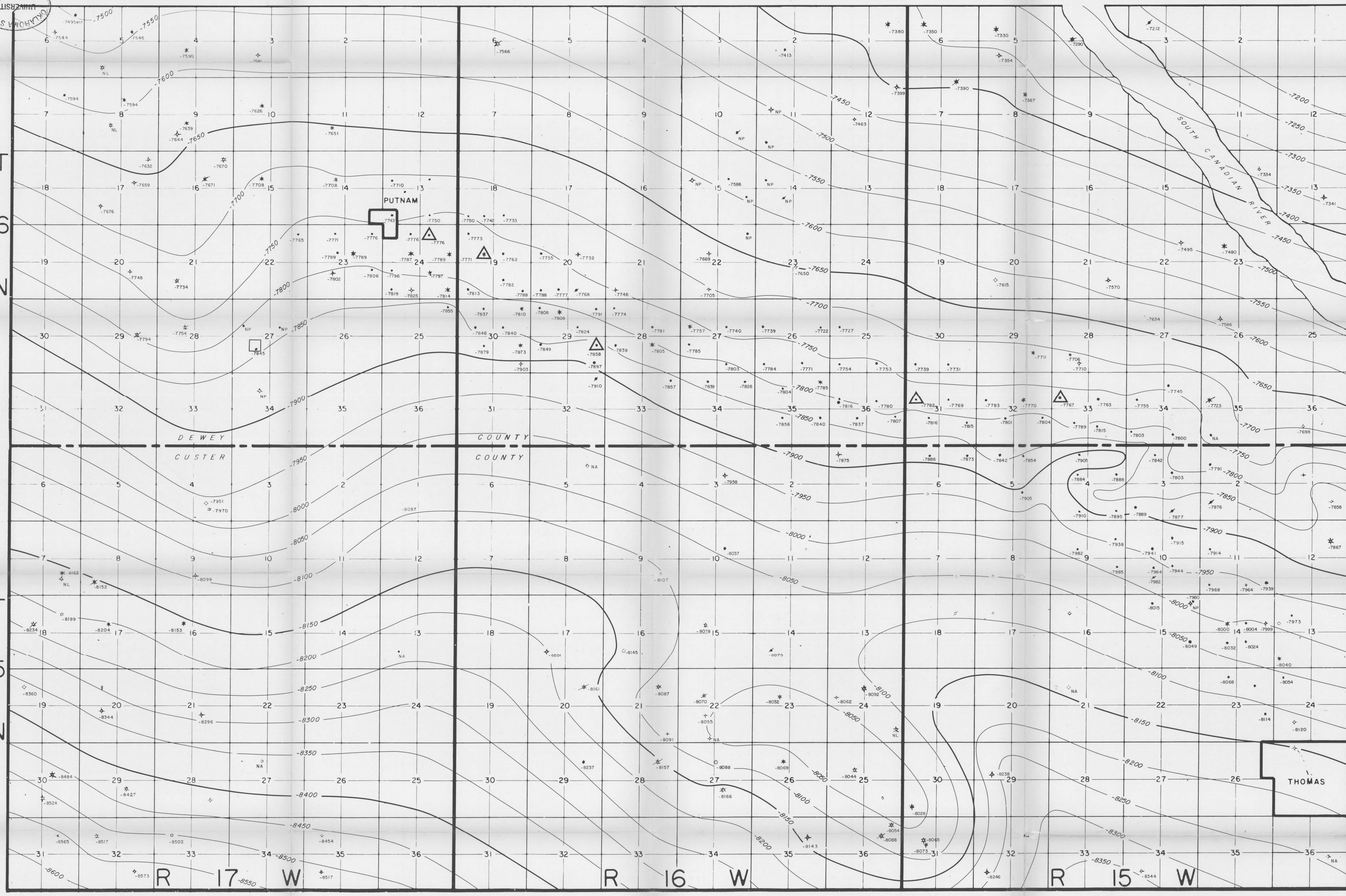
C.I. = 50'

SCALE 2" = 1 Mi., 1:31680

By D. M. Michlik

Date 1980

f.j.b.-dks



EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

Cores Studied

Samples Studied

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 10

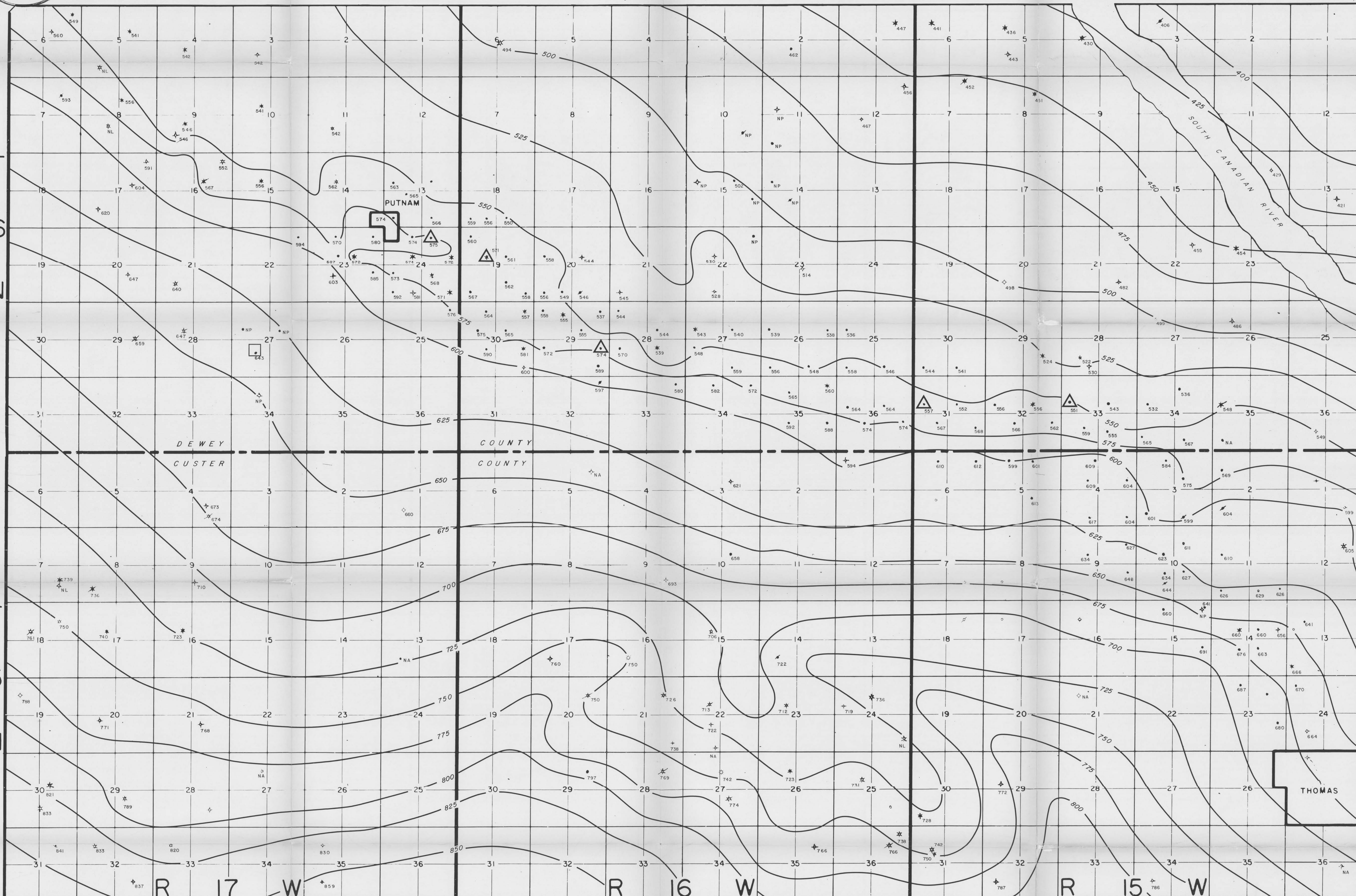
STRUCTURE: B/OSWEGO MARKER

C.I. = 50'

SCALE 2" = 1 Mi. 1:31680

By D.M. Michlik

Date 1980



EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

- Cores Studied
- Samples Studied

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate II
THICKNESS MAP
Interval: Checkerboard Ls.
to T/Oswego Marker
C.I. = 25'
SCALE 2" = 1 Mi.; 1:31680

One Mile
0 1 2 3 4 5 6

By: D. M. Michlik

Date 1980

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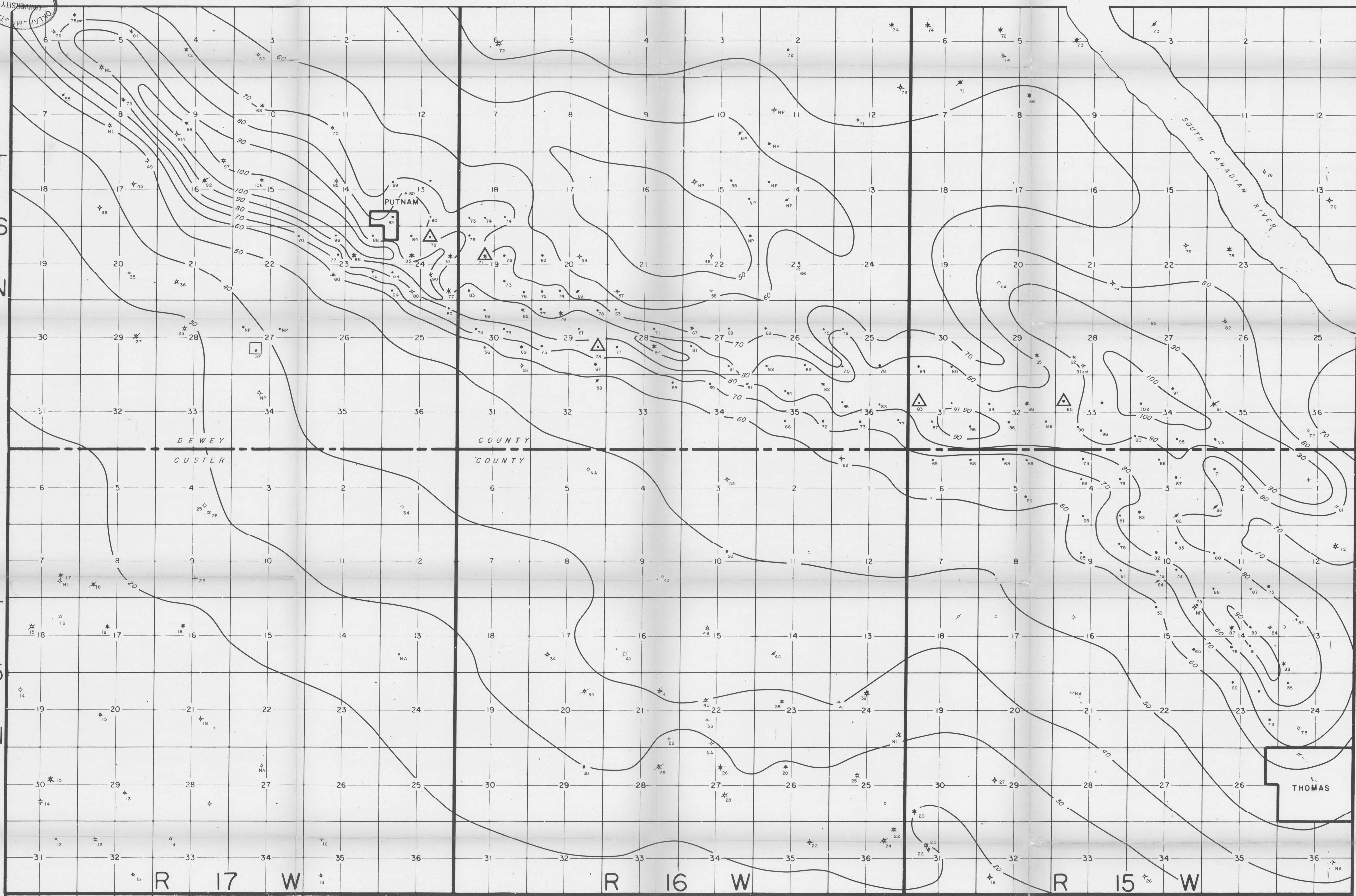


EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

Cores Studied

Samples Studied

PUTNAM FIELD AREA

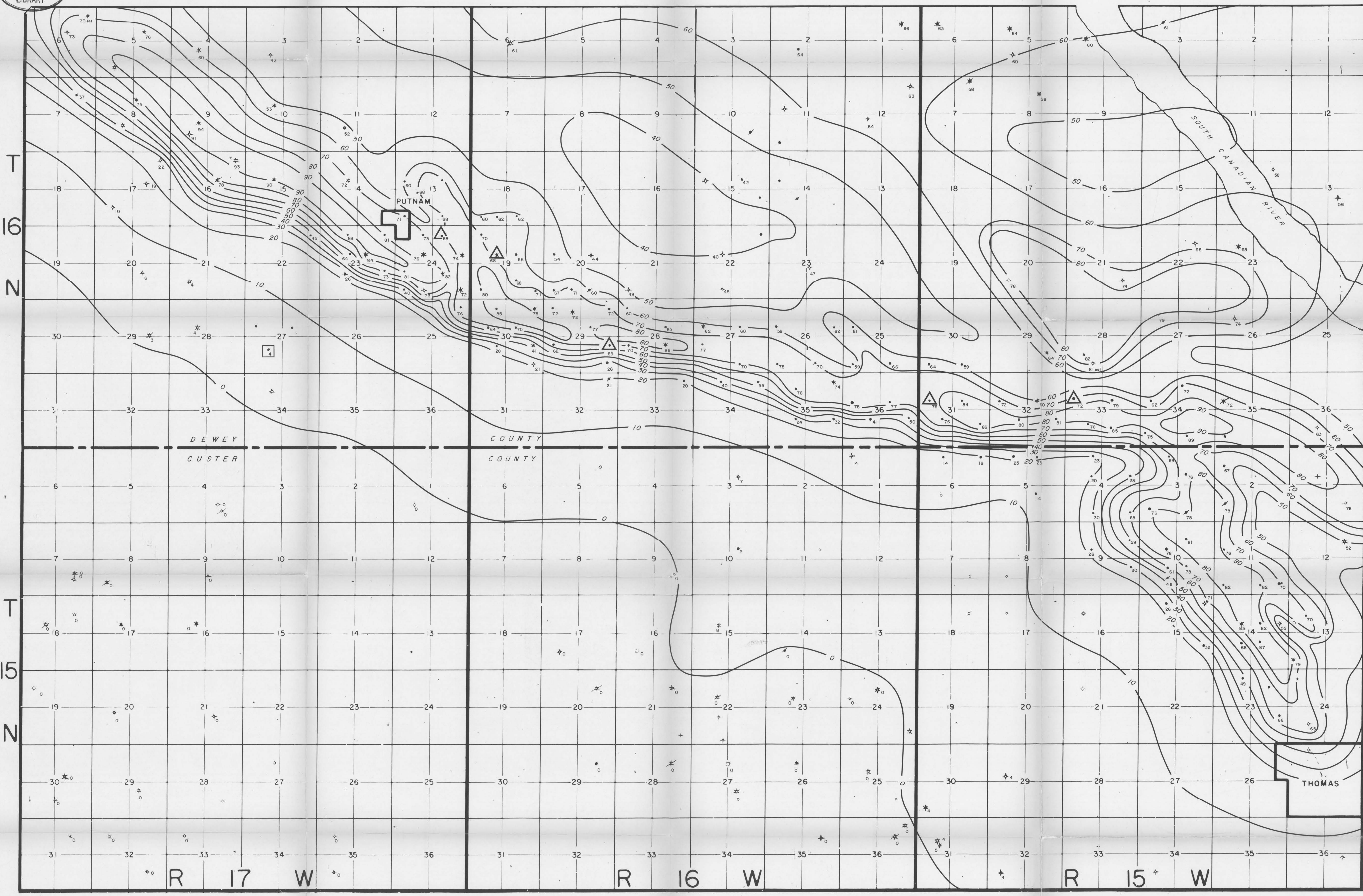
Dewey & Custer Counties, Oklahoma

Plate 12
THICKNESS MAP
Interval: T/Oswego Marker to B/Oswego Marker
C.I. = 10'
SCALE 2" = 1 Mi., 1:31680

By D. M. Michlik

Date 1980

Plate 13



EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

△ Cores Studied

□ Samples Studied

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

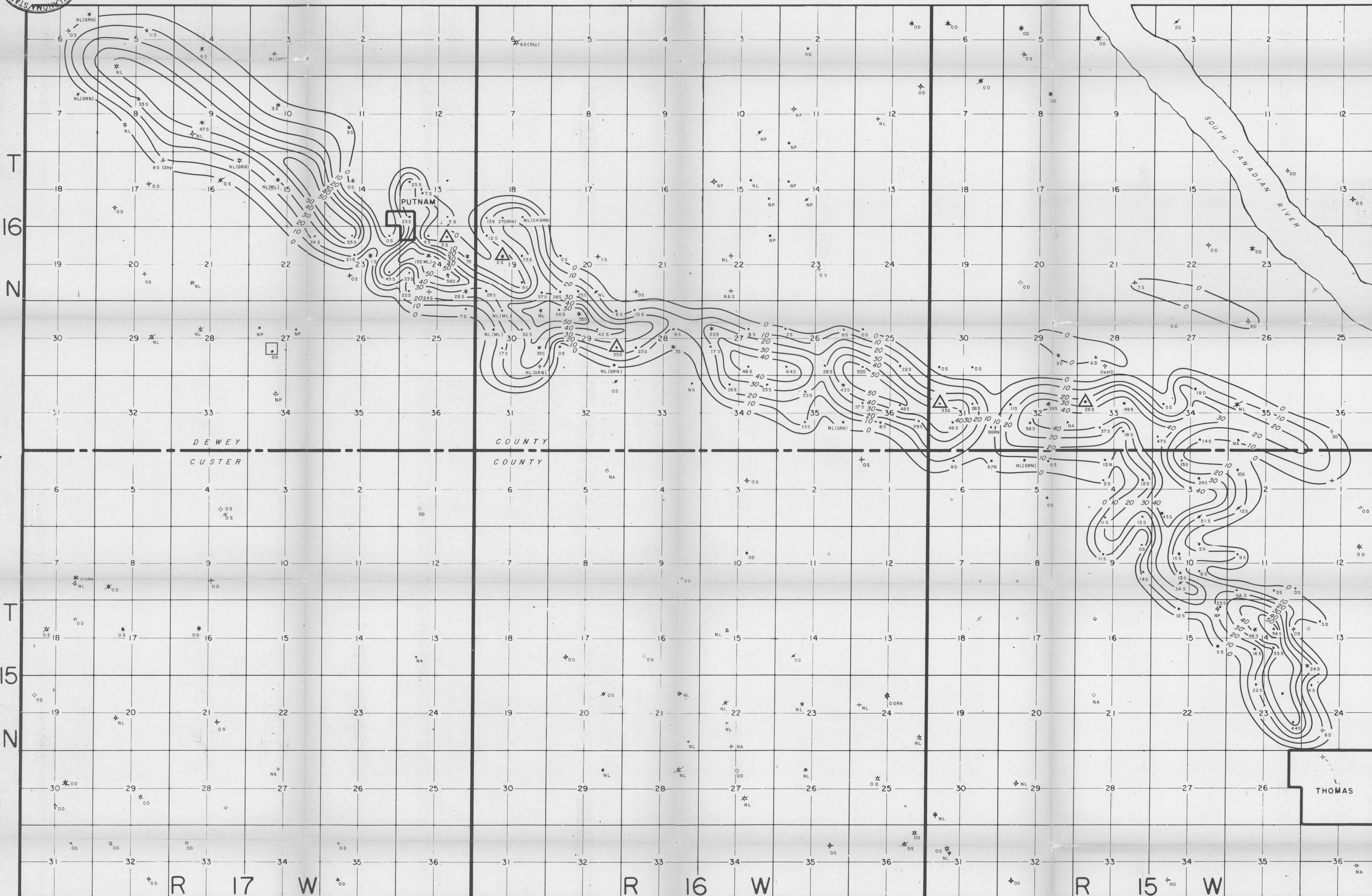
Plate 13
THICKNESS MAP
Gross Ls. in Oswego Marker Interval
C.I. = 10'

SCALE 2" = 1 Mi.; 1:31680

By D.M. Michlik

Date 1980

Plate 14



EXPLANATION

- Plugged and Abandoned
- Gas Well
- Gas and Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Plugged Gas and Oil Well
- Oil Well

Completions Posted to 5-20-79

- Cores Studied
- Samples Studied

NP Not Penetrated
NL Not Logged
NA Not Available
S Sonic (accustic)
D Density
ML Microlog
GRN Gamma Ray Neutron

PUTNAM FIELD AREA

Dewey & Custer Counties, Oklahoma

Plate 14

THICKNESS MAP: OSWEGO POROSITY

>5% @ Pb 2.71 Vm 21,000

C.I. = 10'

SCALE 2" = 1 Mi.; 1:31680

One Mile

0 1 2 3 4 5 6

By: D. M. Michlik

Date 1980

fjb-dks