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DEPOSITIONAL ENVIRONMENTS AND POROSITY DEVELOPMENT IN THE FUNSTON LIMESTONE (LOWER PERMIAN), SOUTHWESTERN KANSAS

by

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ABSTRACT

The Funston Formation (Lower Permian) of southwestern Kansas is comprised of alternating carbonate and terrigenous clastic strata. Rocks of the Funston (26 to 40 feet, 8 to 12 meters thick) represent the marine interval of a larger marine-nonmarine cycle. This cycle is characterized at its base by a rapid transgression and a slow, but continuous regression at its top. Nine major lithofacies were recognized within the Funston Formation. The basis for the interpretations was the examination and analysis of 11 cores and their wireline log signatures.

Deposition occurred on a shallow, broad epicontinental shelf with environments ranging from protected subtidal zones to highly restricted supratidal flats. Sedimentation was greatly influenced by sea-level fluctuations and subtle changes in the configuration and slope of the shelf. Facies prograded southeastward (seaward) during the regressive phase of the cycle in a fashion similar to the modern carbonate-evaporite sabkhas of the Arabian Gulf.

Gas production, in the Funston Formation, is primarily from carbonate unit 9 that was deposited during the regressive phase of the cycle of sedimentation. Depositional facies and diagenesis effectively controlled the development of porosity in the carbonate reservoir.

Porosity is predominantly secondary and includes intercrystalline and moldic types. Carbonate beds characterized by high original porosity (peloid packstones) were preferentially cemented by fresh-water cement and anhydrite, whereas, those with initial low porosity (mudstones

and skeletal wackestones) had their porosity enhanced by dolomitization and fresh-water leaching.

The distribution of porosity in the carbonate reservoir facies is highly irregular and laterally impersistent. Porous and thick carbonate intervals, however, are commonly associated with thin deposits of the overlying red beds of the Speiser Formation.

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INTRODUCTION

Purpose of Study

The Lower Permian Council Grove Group of southwestern Kansas consists of alternating strata of shale and limestone. The Funston Limestone of the Council Grove Group, lying under the Speiser Shale, (Fig. 2) is one of the major gas-producing formations in the Panoma gas area (Fig. 1).

The principle objective of this study is to interpret the depositional environments of the lithofacies that comprise the Funston cycle in the subsurface of southwestern Kansas. Another goal is to determine the nature, distribution, and predictability of porosity trends and the interrelationships between development of porosity and depositional and diagenetic factors.

Area of Investigation

The study area in southwestern Kansas covers Stanton County and parts of Hamilton, Kearny, Grant, Stevens, and Morton counties (Fig. 1). It is located on the western edge of the Panoma gas area in the Hugoton embayment. Natural gas production is limited to the eastern part of the study area. Of particular interest is the presence of nonproducing wells within the field boundary, making this area well suited for a study to determine factors controlling gas production from the Funston Limestone.

An average well density of 1.23 wells per sq. mile (0.5 wells per sq. km.) characterizes the Hugoton embayment (Mason, 1968). Core samples

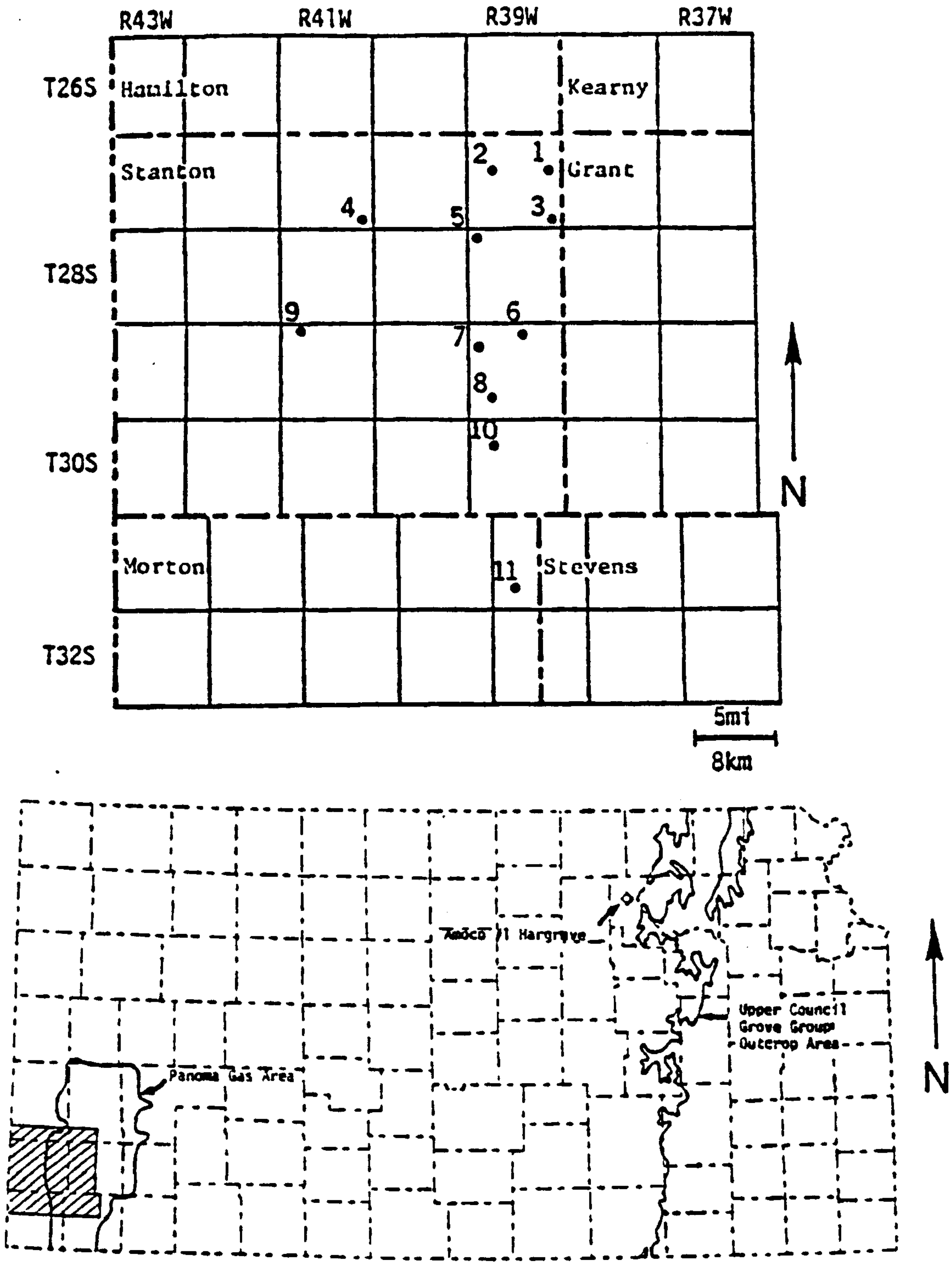


Figure 1. Study area (top), in southwestern Kansas, shows locations of the cored wells (see Table 1 for details). The Kansas map (bottom) shows relation of the study area to the Panoma gas area. Amoco #1 Hargrave and the outcrop area of upper Council Grove Group are identified in eastern Kansas.

Formation	Group	Stage	Series
Nolans Limestone	CHASE	GEARYAN	LOWER PERMIAN (WOLFCAMPIAN)
Odell Shale			
Winfield Limestone			
Doyle Shale			
Barneston Limestone			
Matfield Shale			
Wreford Limestone			
Speiser Shale	COUNCIL GROVE		
FUNSTON LIMESTONE			
Blue Rapids Shale			
Crouse Limestone			
Easly Creek Shale			
Bader Limestone			
Stearns Shale			
Beattie Limestone			
Eskridge Shale			
Grenola Limestone			
Roca Shale			
Red Eagle Limestone			
Johnson Shale			
Foraker Limestone			
Janesville Shale	ADMIRE		
Falls City Limestone			
Onaga Shale			

Figure 2. Stratigraphic position of rocks of the Lower Permian (Wolfcampian) Series in Kansas (Zeller, 1968).

and mechanical well logs, including radioactivity, electric, and acoustic logs, are available and cover the entire clastic-carbonate interval of which the Funston Limestone is a member.

Previous Studies

Studies of paleoecology and paleogeography of formations in the Council Grove Group, based largely on surface outcrops, have been made by Moore (1964), Lane (1958, 1964), Imbrie (1964), and Imbrie and others (1959). Moore (1964) made extensive studies of the Pennsylvanian and Lower Permian rocks of the Midcontinent and recognized their cyclic nature in which each cyclothem consists of nonmarine and marine deposits. The Funston Limestone and the overlying Speiser Formation form a cyclothem called the Funston cyclothem (Moore, 1964).

White (1981) described lithofacies from the Five Finger carbonates, which is the name used in the Kansas petroleum industry for the Funston Limestone in the Hugoton embayment area in southwestern Kansas, and recognized that these lithofacies were deposited on a broad, shallow-water shelf.

GENERAL GEOLOGY OF SOUTHWESTERN KANSAS

Structure and Tectonic History

The study area is located in the Hugoton embayment of southwestern Kansas. The embayment, described by Merriam (1963) as a northern shelflike extension of Oklahoma's Anadarko basin, covers parts of Kansas, Colorado, Oklahoma, and Texas. The eastern side of the embayment is formed by the Pratt anticline, central Kansas uplift, and Cambridge arch (Fig. 3). The western limit is formed by the Las Animas arch of Colorado. The Hugoton embayment plunges southward, and sedimentary strata thicken both toward the axis of the embayment and southward into the Anadarko Basin of southwestern Oklahoma (Merriam and Goebel, 1968).

Downwarping in the general area of the embayment began during the Precambrian and continued through much of the Paleozoic. This was interrupted periodically by broad epeirogenic uplift. Deposits during the Cambrian were formed by transgressing seas initiating a long history of sediment accumulation. In late Paleozoic time regional transgressions and regressions caused accumulation of cyclic marine and nonmarine strata (Merriam, 1956). Most of the structural features that originated during Pennsylvanian time remained active during Permian time. Prominent features such as the Nemaha anticline, the central Kansas uplift, the Las Animas arch, and the Hugoton embayment existed during the deposition of early Permian deposits (Mudge, 1967). Post-Paleozoic deposits mask the structure of the underlying Paleozoic strata. Structural development of the embayment was concluded by the close of the Permian, and the structure of the late Paleozoic strata is, therefore, not reflected in the overlying younger ones (Merriam, 1963).

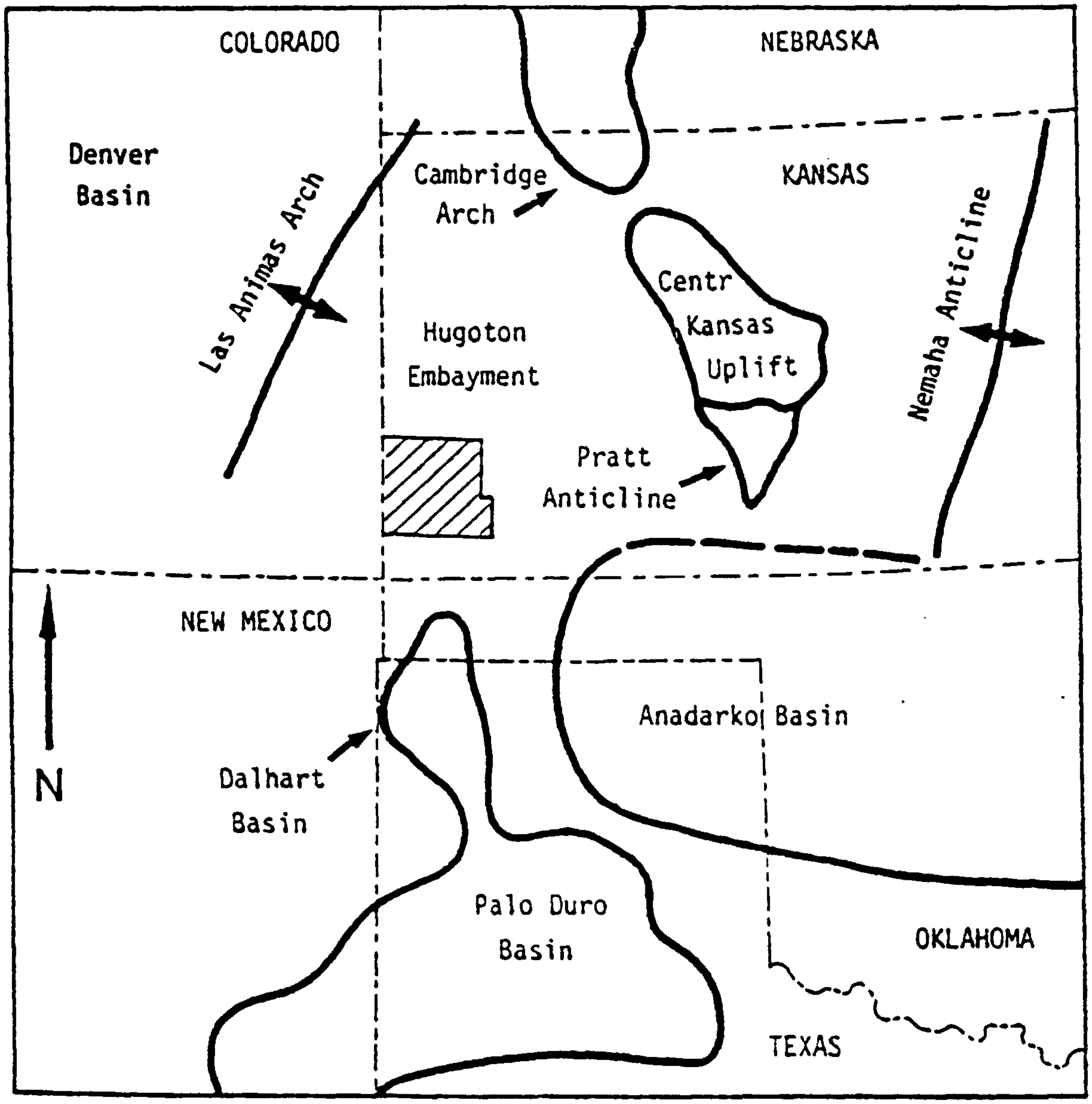


Figure 3. Major tectonic elements of Kansas and adjacent areas in Late Pennsylvanian and Early Permian time. Data for map are from Merriam (1963), Dixon (1967), and Mudge (1967).

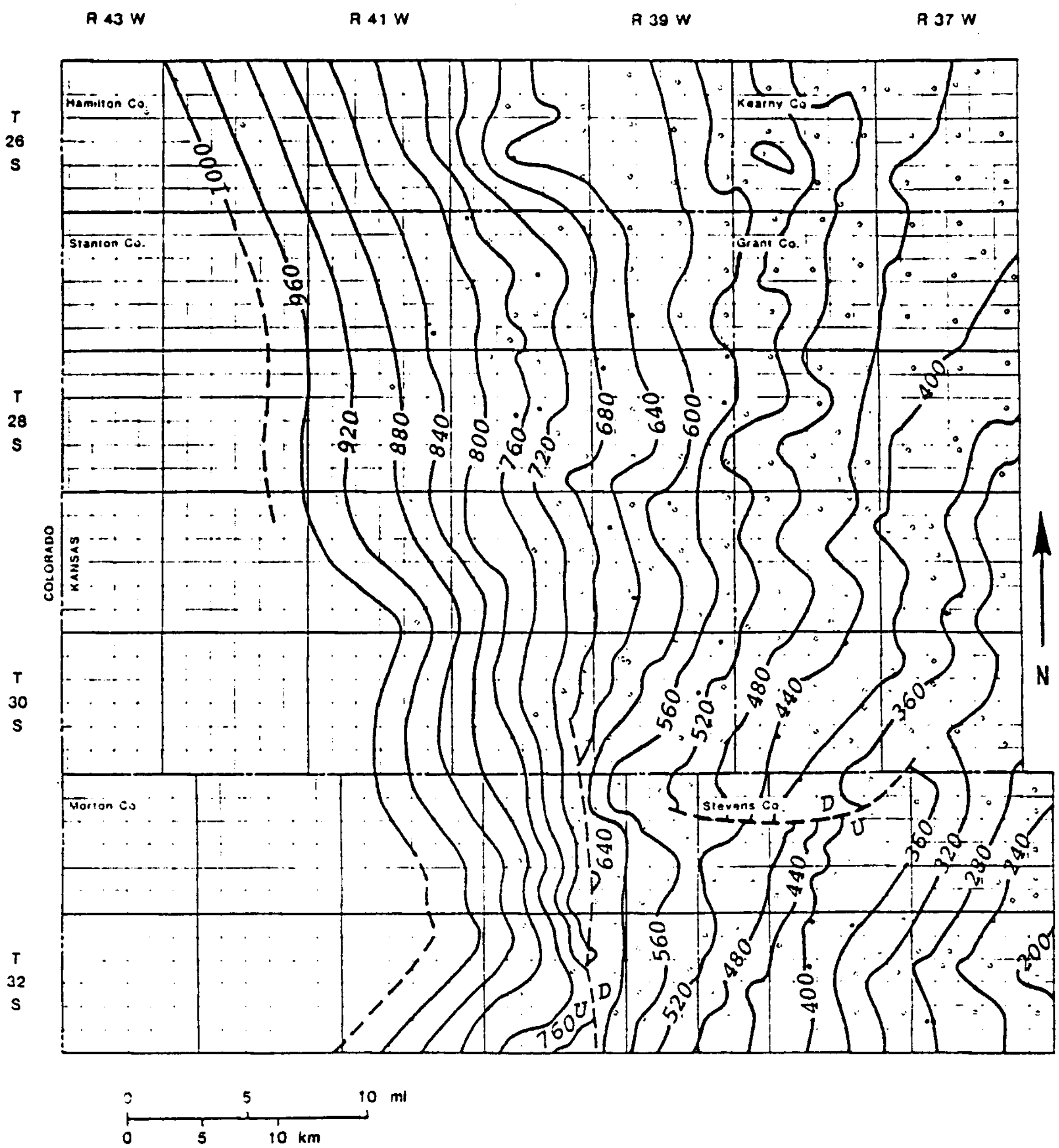
Currently, the structure of the top of the Council Grove Group in the study area is monoclinal (Fig. 4). The dip is east-southeast with a magnitude of 20 feet per mile (3.75 meter per km).

Wolfcampian strata of the Hugoton embayment and their counterparts in the Permian basin of west Texas and New Mexico display similar cyclic patterns. Silver and Todd (1969) suggested that epirogenic movements were largely the cause of the cyclic nature of the Wolfcampian and Guadalupian deposits in the Permian basin. They also remarked that eustatic changes of sea level contemporaneous with subsidence were the major cause of the cyclic pattern of the Wolfcampian-Guadalupian deposits. These eustatic sea-level changes were largely attributed to glacial activity during late Paleozoic time (Silver and Todd, 1969). Recent confirmation of and interpretation of the presence of extensive Permian tillites in ancient Gondwana by Crowell and Frakes (1971) reinforces the opinion of Silver and Todd.

Stratigraphy

The Wolfcampian (Lower Permian) in southwestern Kansas consists of the Chase, Council Grove, and Admire groups (Fig. 2). These groups are mainly composed of alternating shale and limestone units that are traceable for long distances to the outcrop area in eastern Kansas (Mason, 1968). The units exhibit cyclic patterns similar to those in Upper Pennsylvanian deposits (Jewett 1933, in Merriam 1963).

Mason (1968) remarked that westward, toward the Las Animas arch (Fig. 3), the limestone and dolomite beds of the Chase Group grade



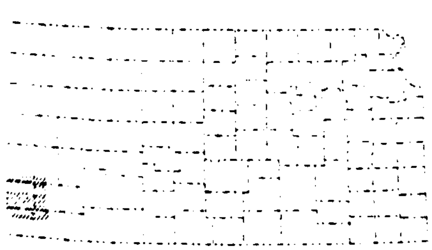


Figure 4. Structural contour map, top of the Council Grove Group; contour interval = 40 Ft.

laterally into red sandstones and siltstones. It was difficult to verify in this study that a lateral facies change occurs in the Funston carbonate beds that is similar to that in the limestones and dolomites of the overlying Chase Group because of the lack of cores from the western one-third of the study area.

The Lower Permian strata are conformably overlain by a sequence of shale, siltstone, and sandstone, most of which is red and interbedded locally with thick deposits of evaporites and dolomite (Merriam, 1963).

HYDROCARBONS

Natural gas discovered in the Hugoton embayment in 1922 was produced entirely from formations of the Chase Group. In 1956, additional gas reserves were discovered in formations of the underlying Council Grove Group (Beene, 1977). Gas reservoirs in the Panoma gas area are restricted to the Council Grove Group.

Mason (1965) described the structure of the Wolfcampian strata as an east-dipping homocline with a more steeply dipping monocline along the western edge of the embayment. He added that gas reservoirs in both the Chase and Council Grove groups belong to a complex hydrodynamic trap. Gas production on the western edge of the area is controlled by the updip position of the gas-water contact in carbonate strata of the Chase Group.

The gas in the Wolfcampian reservoirs may have been derived from the Pennsylvanian shale of the Anadarko basin (Mason, 1968). Irwin (1965), however, suggested that the source of the gas was from adjacent shales rich in plant remains found in the embayment itself. Source rocks rich in terrestrial humic plant material tend to generate gas upon maturation, whereas oil is generated from marine plants and animals. Welte (1965) noted that a good potential for finding gas exists in less easily compacted source rocks, such as limestones, where primary migration has been prevented.

METHODS OF STUDY

Log Correlation and Preparation of Cross Sections

Outcrops of the lower Chase and upper Council Grove groups were examined and sampled at previously measured sections (Jewett, 1941) in Riley County, Kansas. Samples from these formations were correlated to their stratigraphic equivalents in the core of the Amoco #1 Hargrave in Riley County (sec. 32-T7S-R6E) near the outcrop area (Fig. 1). The core of the Amoco #1 Hargrave was then correlated to the radioactivity logs of the same well in order to determine the signatures characteristic of the formations of interest.

In order to develop a regional subsurface cross section to trace the Funston Formation from northeastern Kansas southwestward to the study area, logs of the Amoco #1 Hargrave were correlated with their counterparts from other wells to the west. In correlation using small scale logs, emphasis was given to the contact between the Chase and the Council Grove groups because of its distinctive signature on logs, particularly the gamma ray and neutron logs. This characteristic made it possible to trace these groups in a cross section across 480 km using mainly gamma ray and neutron logs (see cross section A-A's in pocket). Log correlations in the study area correspond to those made on county type logs prepared by the Kansas Geological Society (1966) along the trace of the cross section. Logs of larger scales, providing more detailed information by employing both gamma ray and neutron logs in combination, were used to construct another five stratigraphic cross sections within the study area, again using the top of the Council Grove Group as the datum.

Core and Thin Section Examination

Approximately 700 feet (213 m) of slabbed cores from eleven wells were involved in this study (Table 1). All cores were made available by Amoco Production Company and are located at the company's laboratories in Tulsa, Oklahoma, and Denver, Colorado. Core slabs were examined with a binocular microscope, and carbonates were identified using Dunham's (1962) classification of carbonate rocks. Graphic logs were constructed, and notes were made to describe in more detail the porosity, sedimentary structures, and contacts between the units.

A total of 160 thin sections were prepared from samples representative of the carbonate units in all the cores. All thin sections were stained, using Dickson's (1965) staining technique, in order to differentiate between such carbonate minerals as dolomite, calcite, and ferroan calcite. During petrographic work, an effort was made to verify core descriptions, identify the diagenetic alterations, and examine porosity and pore distribution. The classification of carbonate porosity of Choquette and Pray (1970) was followed.

Well Log Analyses

Mapping

More than 300 logs, most of which are gamma ray and neutron logs, were examined from wells in the study area to obtain information on stratigraphic tops, thicknesses, and porosity of selected intervals in the Funston cycle (Appendix B). These data were used to map structures, thicknesses, and porosity trends. A structural contour map was prepared for the top of the Council Grove Group and the top of the

Well No.	Well Name	Location	Cored interval examined (ft.)	Thicknesses of Rock Units (ft.)										
				Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11
1	Amoco A-2 Mater	NE NW SW 13-27S-39W	2596-2680	4	6.1	0	0	4.6	2.2	1.8	2.5	5.2	0.9	27
2	Amoco E-2 Moore	NW NE SE 17-27S-39W	2541-2608	5.6	2.4	2	0.8	2.1	2.1	2.3	3.4	5.8	0.5	26
3	Amoco #2 Endsley	SW NE SE 36-27S-39W	2590-2655	1.9	10.4	0	0	3.2	2.4	2	4.5	5.2	0.5	25
4	Amoco #1 Cross	C NW 36-27S-41W	2473-2555	6	3	3	1.3	1.9	0	2.3	2.3	5.2	1	27
5	Amoco A-2 Piper	NE SE SW 6-28S-39W	2547-2601	5.3	6.7	0	0	4.5	0.9	2.6	3.8	8.2	0.5	19
6	Amoco #2 Neufeldt	NE SE SW 3-29S-39W	2602-2690	0	10.7	1.6	2.8	2.4	2	1.4	4.2	5.9	0.5	22
7	Amoco A-2 Montgomery	NW NE SE 7-29S-39W	2572-2631	2.6	1.1	1.3	9.4	5.9	2.1	1.3	4.7	7	0.3	18
8	Amoco #2 Myler	NW NE SE 29-29S-39W	2572-2640	1.3	3.3	1.9	8.5	1.6	3.8	1.7	5.5	7.5	0.5	21
9	Amoco #1 Armstrong	SE SW NW 5-29S-41W	2504-2544	5.5	6.3	1	0.5	5.5	2.5	4	0	1.5	1	14
10	Amoco #2 Luke	C N2 8-30S-39W	2599-2669	0	7.2	2	8.9	1.9	3.7	2	4	4.3	0.7	28
11	Amoco Larned	NW NE SE 29-31S-39W	2684-2759	1	9.5	2.9	6.6	5.4	3.6	2.4	6	2.2	0.3	25

Table 1. List of names, locations, cored intervals, and rock-unit thicknesses of cored wells used in the study.

Funston Limestone. Isopacous maps of the Speiser Formation, which overlies the Funston Limestone, and the uppermost, regressive carbonate unit of the Funston Limestone were also prepared. A map illustrating trends of porosity in the generally porous uppermost carbonate unit was prepared by mapping porosity multiplied by thickness derived from neutron logs.

Cross Plots

Logs from six cored wells were digitized for the purpose of plotting one log against another to ascertain any covariation of the logs. Log combinations include gamma ray-neutron, gamma ray-neutron density, gamma ray-density, gamma ray-sonic, and gamma ray-resistivity. The KOALA Log analysis package, developed by Doveton and Cable (1980) at the Kansas Geological Survey, was used in analyzing the logs and generating the cross-plots.

Some logs record variations in lithologic composition and fluid content. The gamma ray log is essentially a measure of the amount of shale in rocks. But the neutron log, for instance, is most strongly affected by the concentration of hydrogen in the rock layer. The log's response can be used as a measure of the porosity in the rock and can be so calibrated. The effects of lithology here are only minor. The density and sonic logs, on the other hand, are strongly affected by both porosity and lithology. Certain lithofacies described in cores are also recognized by distinctive log responses.

The presence of different lithofacies within the Funston cycle reflects changes in the depositional environments. It is possible to identify the different lithofacies on some of the log cross-plots and, in turn, relate these lithofacies to their depositional environments.

LITHOFACIES

Based on examination of cores (see Table 1) and thin sections (Appendix A), eleven depositional facies that comprise the Funston cycle were recognized, and their depositional environments were interpreted.

The typical Funston cycle consists of carbonate and shale beds that are overlain and underlain by reddish-brown, fine-grained sandstones and siltstones (Fig. 5). A thick, upper carbonate unit dominates the cycle. The various lithofacies are summarized in Figure 6 and are described below as units '0' and 1 to 11.

Unit '0'

This unit consists of green, unfossiliferous claystone. Its thickness usually ranges from one to four feet (0.3 to 1.2 meters). The upper contact is commonly erosional and marks a regional transgression. The unit occupies the uppermost part of the Blue Rapids Formation (Fig. 5). Upwards, the unit grades into calcareous siltstones, dark-gray shales, or shaly carbonates.

Root-like structures and caliche carbonate nodules (Fig. 7) are common features. Development of caliche nodules is largely attributed to periodic subaerial exposure of the claystone beds. The green color of the claystone in Unit '0' is probably caused by presence of reduced iron in the clays.

Claystones of this unit are probably fluvial deposits. Hanford and Fredericks (1980) described similar rocks in the Palo Duro basin of the Texas panhandle and suggested that the claystones were formed in a mud-rich coastal sabkha. Terrigenous sediments were transported by rivers into the sabkha flat.

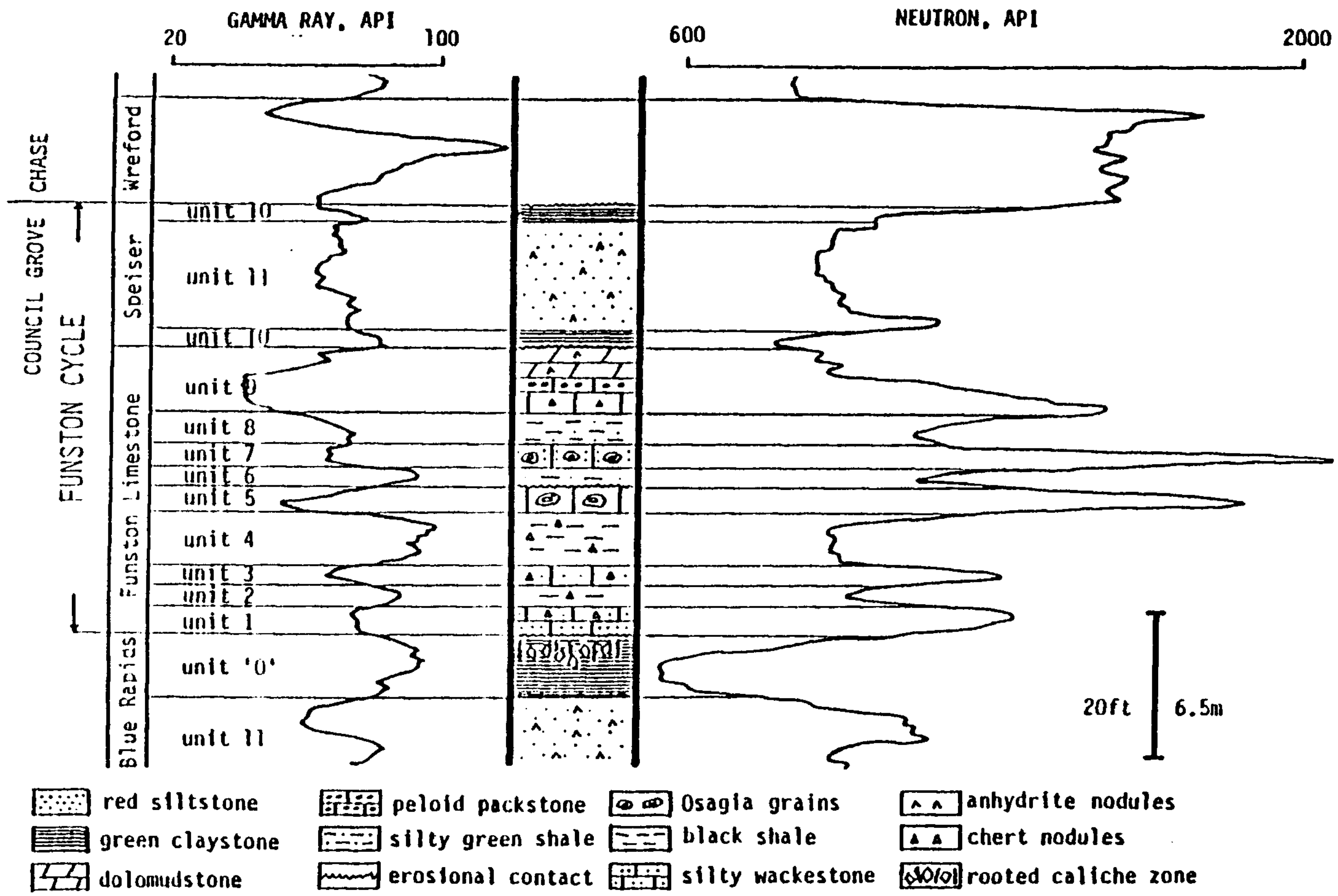


Figure 5. Gamma ray-neutron well-log signature of the Amoco #2 Myler. Depositional facies comprising the Funston cycle are indicated.

Rock Unit	Thickness (ft.)	Lithology	Textures and Structures	Color	Level of Diagenesis	Porosity	Description of Rock Units	Depositional Environments			
								Nonmarine	Supratidal	Intertidal	Subtidal
11	14-28			reddish-brown	minimal to moderate	good	red beds (siltstones), fractured, with anhydrite nodules and veins.				
10	0.3-1		G / S	green	minimal		soft claystone.				
9	1.5-8		G	light gray to tan	moderate to intense	good to locally excellent	dolomudstone, peloidal packstone, dolomitic skeletal wackestone.			B	
8	0-6		G	greenish-gray	minimal		silty, calcareous, massive fossiliferous shale.				
7	1.5-4		G	gray	moderate	poor	silty Osagia wackestone.				
6	0-4		SG	greenish-gray-black	minimal		silty, calcareous, massive, fossiliferous shale.				
5	2-6		SG	gray, mott.	moderate	poor	Osagia packstone.				
4	0-9.5		G	dark gray to black	minimal		massive, calcareous, fossiliferous shale.				
3	0-4.5		G	dark gray	minimal	poor	mixed skeletal wackestone.				
2	1-10		G	black	minimal		massive, calcareous, fossiliferous shale.				
1	0-6		S	dark gray	minimal	poor	mixed skeletal wackestone; base is locally siltstone.			A	
'0'	1-4			green	moderate		claystone with caliche zone				

Key:
- chaotic fractures
- birdseye structures
- mudcracks
- algal laminae
- burrows
- caliche nodules
- rooted caliche zone
- S sharp contact
- G gradational contact
- S G sharp or gradational contact

Figure 6. Description and environmental interpretation of lithofacies comprising the Funston cycle. See Figure 5 for lithologic key.

Figure 7. Core slab from the base of the Funston cycle (2620 ft., Myler #2). Note the erosional contact between the basal siltstone (top) of carbonate unit 1 and the rooted caliche zone of rock unit '0'. Scale is in centimeters.

Figure 8. Core slab of top of a carbonate unit 1 (2531 ft., Armstrong #1). Argillaceous mixed-skeletal wackestone. Dark areas are burrows; light grains are fossil fragments. Scale is in centimeters.

Figure 9. Thin section photomicrograph of the basal siltstone of carbonate unit 1 (2619.5 ft., Montgomery A-2). Calcareous skeletal of quartz siltstones with bivalve and bryozoan fragments. A caliche carbonate nodule occupies the lower left corner. Bar scale is 0.5 mm. Plane-polarized light.

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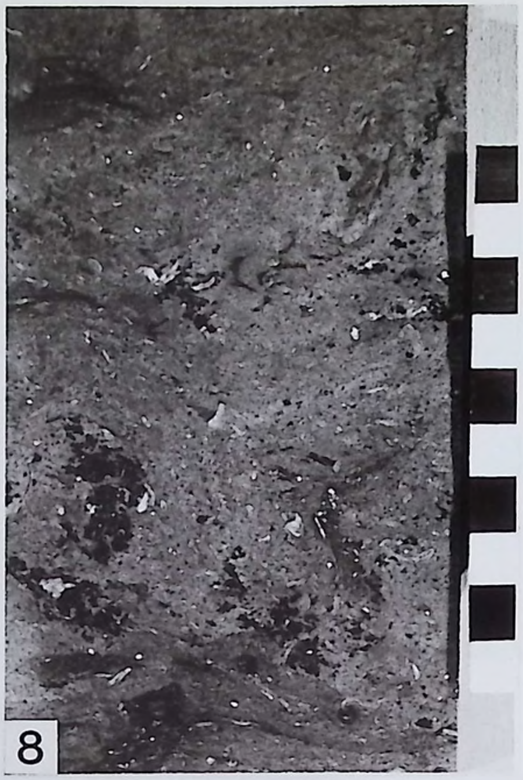

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Unit 1

This is the lowermost carbonate unit in the cycle. It is dark gray and is usually a wackestone (Fig. 8). The thickness varies from one to three feet (0.3 to 1 meter). Locally the unit grades laterally into dark gray, massive shale. The basal part of the carbonate interval is usually composed of sparsely fossiliferous siltstones (Figs. 7 and 9). Swirled fabric, apparently formed by burrowing organisms. locally dominates the basal part of the unit (Fig. 8).

The wackestone is composed of fine-to-coarse-grained, subrounded bioclasts of bryozoans, brachiopods, crinoids, molluscs, and ostracodes. Some of the bioclasts have algal coatings, and a few brachiopod fragments are phosphatized. The upper contact of unit 1 is gradational, whereas the lower contact is usually erosional and marks the regional transgression in the Funston cycle (Fig. 5).

The upper interval of the unit is commonly shaly and grades upward into dark gray to black shale. Little diagenesis has occurred so that the original texture is generally well preserved. Porosity in the unit is usually very low.

Basal siltstone of the carbonate interval was probably deposited in a shallow, restricted intertidal environment during the initial stages of transgression. The remaining part of the unit was formed in a low-energy, subtidal marine environment.

Unit 2

This is a dark gray to black shale that ranges in thickness from one to ten feet (0.3 to 3 meters). The shale is massive, calcareous, and fossiliferous (Fig. 10). Fossils are diverse and include brachiopods, crinoids, bryozoans, and ostracodes. Most of the fossil fragments are either completely or partially silicified. The upper and lower contacts are commonly gradational.

The shale was deposited during an influx of terrigeneous sediments into a subtidal marine environment. The unit grades upward into limestone, suggesting a shallower and less turbid environment.

Unit 3

This unit consists of a gray to dark gray limestone, usually wackestone. Locally, the unit laterally grades into black shale. The thickness varies from nearly zero to four feet (0 to 1.2 meters). Fossil fragments include brachiopods, bryozoans, molluscs, and ostracodes (Figs. 11 and 12). Phosphatized brachiopod fragments also are common.

Silt and clay are disseminated throughout the matrix as well as forming discrete laminae. Sedimentary structures commonly include burrows that indicate reworking of unlithified sediments. The upper and lower contacts are usually gradational.

Diagenetic features are generally very few, except for local development of blocky cement and silicification of some of the skeletal fragments (Fig. 11). Porosity is generally very low.

Unit 3 was formed in a low-energy, subtidal marine environment in which turbidity progressively increased so that the carbonate interval grades upward into black shale.

Figure 10. Core slab of shale unit 2 (2644.8 ft., Luke #2). Black, massive, calcareous, fossiliferous shale. Light grains are skeletal fragments of brachiopods, crinoids, and bryozoans. Scale is in centimeters.

Figure 11. Core slab of carbonate unit 3 (2575.1 ft., Moore E-2). Silicified skeletal wackestone. Light-colored area in the middle of the figure is a silicified interval. Light grains are fossil fragments. Scale is in centimeters.

Figure 12. Thin-section photomicrograph of the same facies in Figure 11 (2575.1 ft., Moore E-2). Silty skeletal wackestone. Bar scale is 0.5 mm. Plane-polarized light.


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11


12

Unit 4

This unit is composed of dark gray to black shale. Thickness varies from nearly zero to nine and one-half feet (0 to 3 meters). The shale is commonly massive, calcareous, and fossiliferous. It is identical to the shale of underlying unit 2. Fossil fragments are diverse and include brachiopods, bryozoans, crinoids, molluscs, and ostracodes, many of which have been silicified. The lower contact is usually gradational, whereas the upper contact is either gradational or erosional.

The depositional setting of this unit was similar to that of unit 2. Terrigenous material was introduced to a subtidal marine zone, shales grade upward into carbonates suggesting decreasing turbidity.

Unit 5

This carbonate unit is dark, mottled-gray Osagia packstone (Fig. 13). Its thickness ranges from two to six feet (0.6 to 1.8 meters). Unlike the underlying carbonate beds (units 1 and 3), unit 5 is present in all the cores examined (see Table 1) and, therefore, serves as a good marker bed. The lowermost part of the unit is more shaly than the upper part and is more burrowed and darker colored (Fig. 14). The limestone changes rapidly from a mud-supported rock at its base to a grain-supported rock upward. A diversity of fossils exists, with brachiopods, dasycladacean algae, and crinoids dominating. Molluscs, bryozoans, and a benthic foraminifera _(Globivalvulina?)_ are common (Fig. 15). Many of the skeletal fragments are coated by algae, here referred to as _Osagia_ (Fig. 15). Peloids, either micritized skeletal particles or pellets, are common in this interval. A few phosphatized brachiopod fragments are also present.

Figure 13. Core slab of carbonate unit 5 (2604.3 ft., Myler #2). Gray, dark-mottled Osagia packstone. Dark areas are Osagia grains; light grains are crinoids. Scale is in centimeters.

Figure 14. Core slab photograph (2624 ft., Endsley #2) showing vertical gradation from black fossiliferous shale (bottom) of rock unit 4 into Osagia packstone of carbonate unit 5 (top). Note wispy shale laminae and burrows in the middle part of the sample. Scale is in centimeters.

Figure 15. Thin section photomicrograph of the same facies as Figure 13 (2604 ft., Myler #2). Skeletal Osagia packstone. Osagia grains were formed by encrusting foraminifera and blue-green algae, coating bivalve and brachiopod fragments. Bar scale is 0.5 mm. Plane-polarized light.


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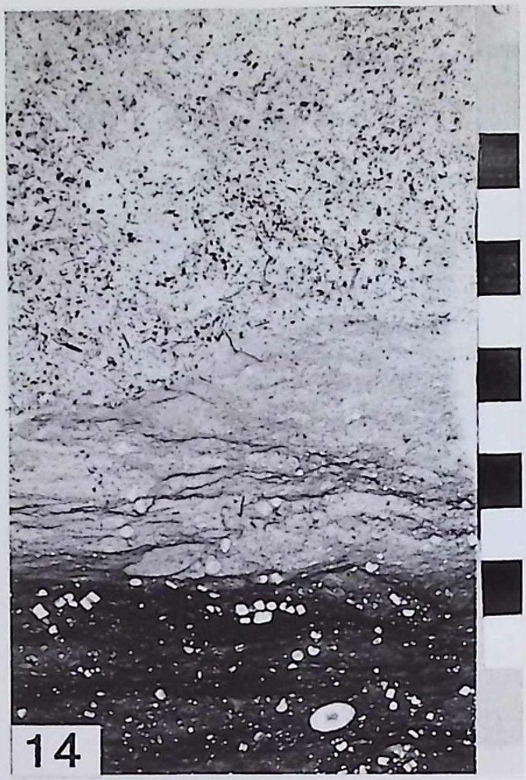
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Diagenetic alterations in unit 5 are more evident than in the underlying carbonate beds (units 1 and 3). These include blocky calcite cement, anhydrite, dolomite, and silica replacements. Porosity is low because cement has occluded the interparticle pores.

The upper and lower contacts are either erosional or gradational. Where the lower contact is gradational, the silty, lowermost interval is commonly burrowed (Fig. 14).

The basal interval of unit 5 was deposited in a low-energy subtidal marine environment. Compositional and textural characteristics suggest that the water was turbid at the time of deposition. The remaining part of the unit was deposited in a moderate-energy, shallow-water, subtidal to lower intertidal, marine environment. The texture is usually grain-supported in the spectrum of packstone to grainstone.

Unit 6

This is a green to greenish-gray, massive shale unit. Locally it is dark gray. The thickness ranges from zero to four feet (0 to 1.2 meters). The shale is usually silty and fossiliferous. Brachiopods, crinoids, and ostracodes dominate fossil assemblages in the unit. The lower contact is either erosional or gradational, whereas the upper contact is commonly gradational.

Unit 6 was formed in a low-energy, turbid, subtidal, marine environment. Color changes probably result from varying amounts of dispersed organic matter and suggest variations in amounts of detritus or degree of oxygenation of the sea floor. The high silt proportion and generally lighter color that characterize this unit indicate a shallower subtidal environment than that of the underlying shale beds (units 2 and 4).

Unit 7

This carbonate unit, like unit 5, was encountered in all the cores examined. It is mottled gray and black. Thickness varies from 1.3 to 4 feet (0.4 to 1.2 meters). The texture is usually mud supported (wackestone), and the grains are fine to medium in size (Figs. 16 and 17). Diversity of fossils is generally uniform both laterally and vertically. Skeletal fragments of brachiopods, molluscs, dasycladacean algae, crinoids, ostracodes, and bryozoans generally have algal coatings that are identical to the coated grains of carbonate unit 5 (Fig. 18). Phosphatized brachiopod fragments are also common. Silt-size quartz and clay are disseminated throughout the facies. Burrows and wispy shale laminae are common sedimentary features of this unit (Figs. 16 and 17).

Diagenesis is more evident in this unit than in the underlying carbonate units. Main diagenetic alterations are limited to early anhydrite replacement, development of blocky calcite cement, and probable replacement of anhydrite by length-slow silica (Folk and Pittman, 1971). Porosity is generally low, although interparticle pores are locally abundant. These pores are of secondary origin and were formed by selective dissolution of unstable carbonate cement, probably high-magnesian calcite, by percolating freshwater that was undersaturated with respect to calcium carbonate.

The unit was deposited primarily in a low-energy, shallow-water, subtidal environment. Abundance of quartz silt and clay suggests turbidity at the site of sedimentation. In the Amoco #2 Endsley, unit 7 grades

Figure 16. Core slab of carbonate unit 7 (2514 ft., Armstrong #1). Silty, burrowed, skeletal, Osagia wackestone. Light grains are mostly crinoids. Scale is in centimeters.

Figure 17. Core slab of carbonate unit 7 (2512.7 ft., Armstrong #1). Burrowed-mottled shaly, crinoidal Wackestone. Burrows are represented by light-colored areas enhanced by the wispy shale laminations. Scale is in centimeters.

Figure 18. Thin section photomicrograph of carbonate unit 7 (2598 ft., Myler #2). Silty, skeletal, Osagia wackestone. Quartz silt is disseminated throughout the matrix. Bar scale is 0.5 mm. Plane-polarized light.


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upward into a peloid mudstone-wackestone with limited fauna indicating a restricted intertidal environment.

Unit 8

This is a shale unit that commonly varies from green to dark green except in the Amoco #1 Cross, where the color is black. Its thickness ranges from nearly zero to six feet (0 to 1.8 meters). The shale is silty, massive, calcareous, and fossiliferous. Fossils in this unit are less diverse than those in the underlying shale units. Brachiopods, crinoids, and ostracodes dominate; most of the fossil fragments have been silicified.

The unit was deposited in a low-energy, turbid, subtidal environment similar to that where shale unit 6 was formed. Both the lower and upper contacts of this shale unit are gradational.

Unit 9

Unit 9 consists of carbonate rocks that occupy the uppermost part of the Funston Formation. The color varies from light gray to tan. Its average thickness is greater than those of the underlying carbonate units, ranging from 1.5 to 8.2 feet (0.5 to 2.5 meters). Generally the unit thins westward (Fig. 19) and probably grades into terrigeneous red beds. The lower contact is commonly gradational, whereas the upper contact is commonly erosional and marks the regional regression (Fig. 6).

The lower interval of unit 9 is a light gray skeletal wackestone (Fig. 20). Color becomes lighter and terrigeneous clay and silt content decreases upward in the interval. Fossils and fossil fragments are

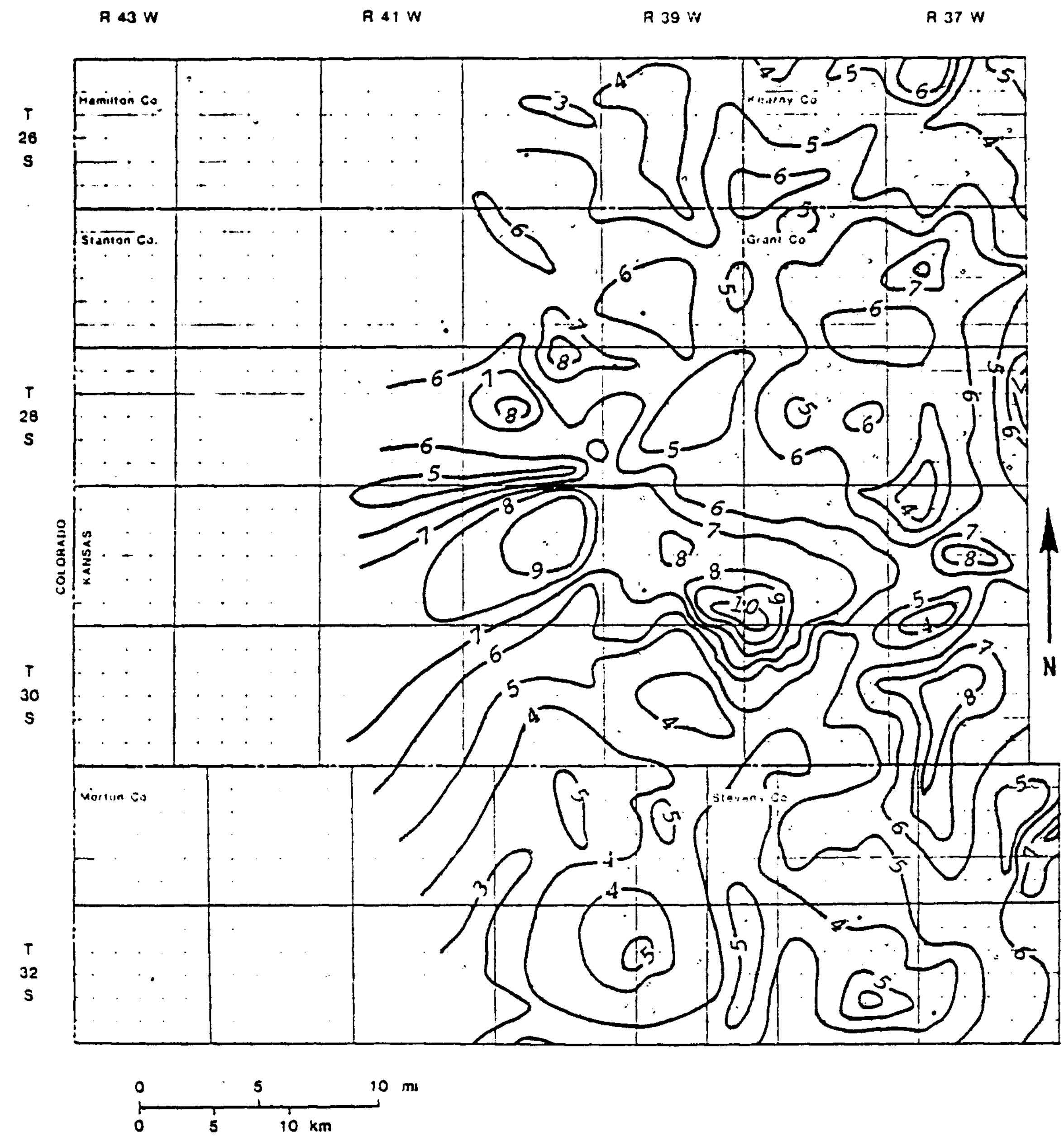

Figure 19. Isopach of carbonate Unit 9 (regressive), Funston Formation; contour interval = 1 Ft.

Figure 20. Core slab of the base of a carbonate unit 9 (2611 ft., Endsley #2). Tan, burrowed, skeletal wackestone. Scale is in centimeters.

Figure 21. Thin section photomicrograph of the base of a carbonate unit 9 (2590 ft., Montgomery A-2). Brachiopod bivalve crinoidal wackestone. Bar scale is 0.5 mm. Plane-polarized light.

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abundant and include brachiopods, crinoids, molluscs, blue-green algae, bryozoans, and ostracodes (Fig. 21). Algally coated grains and phosphatized skeletal fragments also are common. Peloids are uncommon in this interval. Burrows are common, indicating reworking of the sediments. Rocks of the lower interval were deposited in a low energy, shallow, subtidal marine environment.

The upper interval ranges from light gray to tan. The peloid: bioclast ratio increases upwards. Peloids are sand-size particles formed of microcrystalline carbonate that originated as pellets, intraclasts, or micritized fossils. The middle interval of the unit is commonly a peloidal wackestone-packestone (Figs. 22 and 23). Diversity of fossils generally decreases upward in the interval. The texture ranges from packstone and wackestone at the bottom of the interval to mudstone at the top. The uppermost part of unit 9 generally consists of dolomudstone. Stromatolites developed locally in the study area and will be discussed later.

Sedimentary structures include burrows (Fig. 24), algal laminations (Figs. 25 and 26), and fenestral fabric (Figs. 27 and 28). Burrows and algal laminae are common in the subtidal and intertidal facies of these rocks, whereas fenestral fabric is usually associated with the upper intertidal to supratidal stromatolites.

Diagenetic processes were more important in unit 9 than in any of the underlying carbonate units. These processes greatly affected the lithology, the texture, and the pore system. Micritization, anhydrite replacement, dolomitization, and silica replacement have all affected the unit.

Figure 22. Core slab of the middle interval of a carbonate unit 9 (2587.7 ft., Myler #2). Burrowed, peloid wackestone. Scale is in centimeters.

Figure 23. Thin section photomicrograph of the middle interval of a carbonate unit 9 (2584.3 ft., Montgomery A-2). Silty peloid wackestone. Dark grains are peloids, light particles are either skeletal fragments or quartz grains. Bar scale is 0.2 mm. Plane-polarized light.


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Figure 24. Core slab of the top of carbonate unit 9 (2509.2 ft., Armstrong #1). Burrowed peloid wackestone. Scale is in centimeters.

Figure 25. Core slab of the top of carbonate unit 9 (2502 ft., Cross #1) showing algal laminations. Note chert nodules in the upper right corner.

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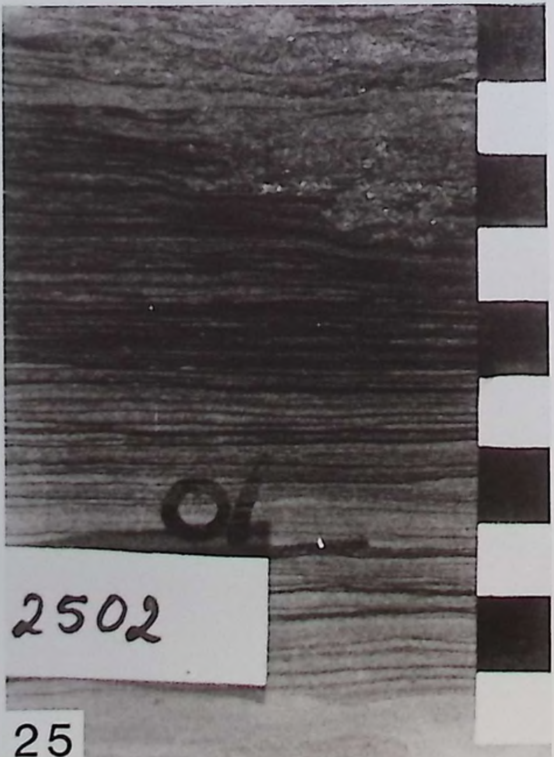

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Figure 26. Thin section photomicrograph of the same facies in Figure 25 (2502.1 ft., Cross #1). Dark areas represent algae, possibly blue-green algae, and peloids. Fine skeletal fragments and quartz grain are represented by light-colored areas. Bar scale is 0.5 mm. Plane-polarized light.


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Figure 27. Core slab of the top of carbonate unit 9 (2586.6 ft., Myler #2). Peloid mudstone showing fenestral fabric. Pores that define this fenestral fabric were first filled with anhydrite that was then replaced by silica. Scale is in centimeters.

Figure 28. Core slab of the top of a carbonate unit 9 (2607.5 ft., Endsley #2). Peloid mudstone showing mudcracks and fenestral fabric. Scale is in centimeters.

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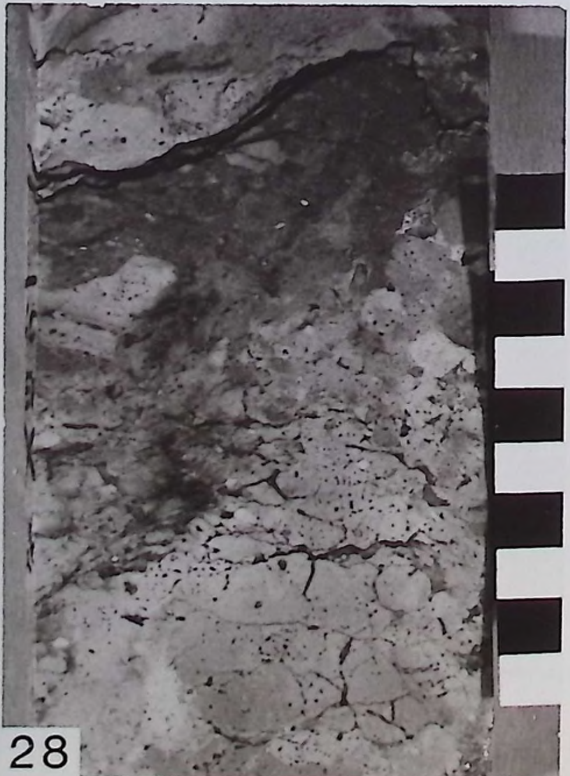

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The rocks in the upper interval of carbonate unit 9 were formed in a low-energy, shallow-water, normal-marine to restricted environment. Depositional environments ranged from lower intertidal at the base of the interval to supratidal at the top.

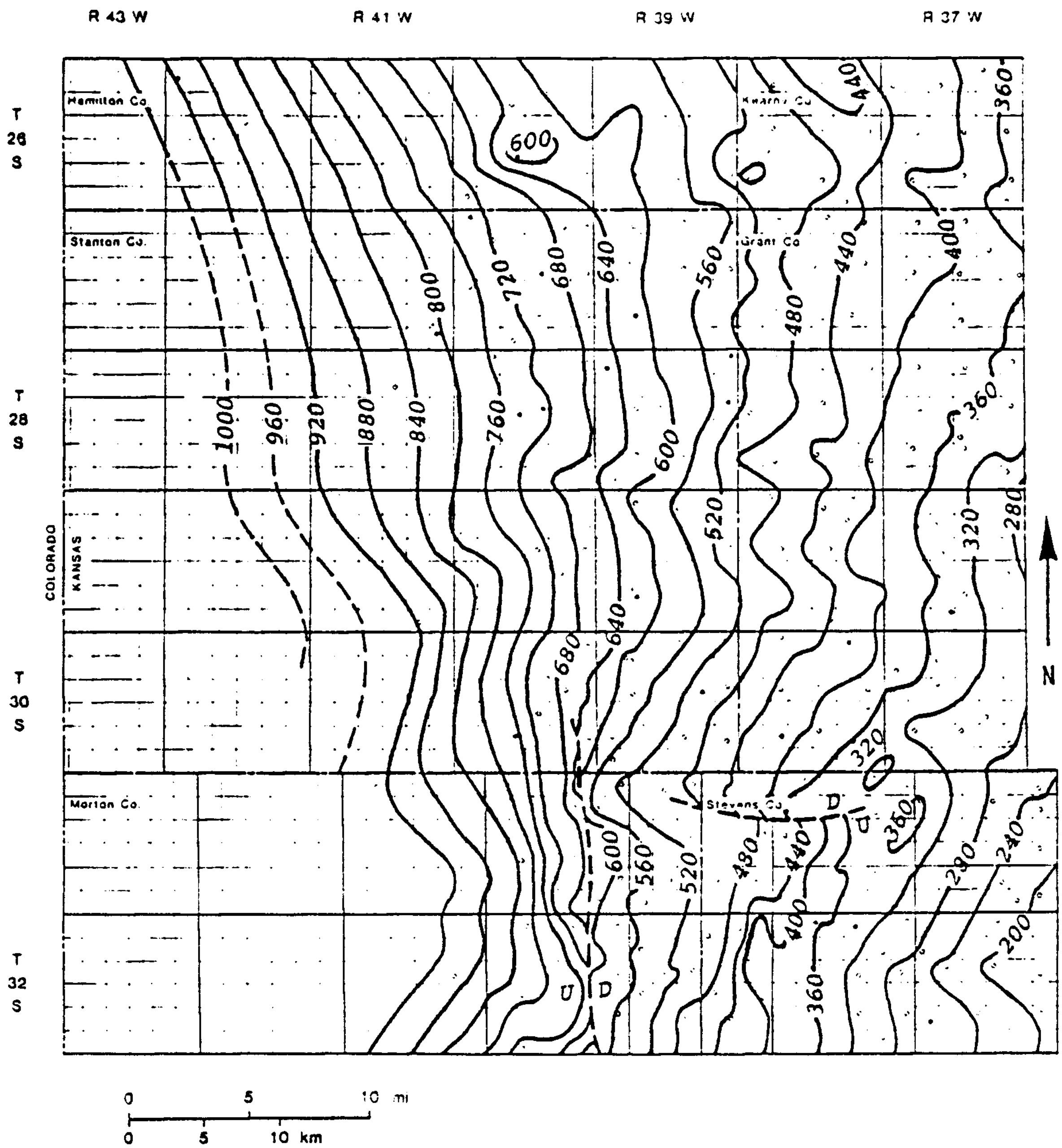
Figure 29 illustrates the structure of the top of carbonate unit 9, i.e., the top of the Funston Limestone. The structure is almost identical to that of top of the Council Grove Group (see Fig. 4).

Unit 10

This is a green, structureless claystone that is similar to the beds of unit '0' immediately below the Funston Formation (Fig. 5). Its thickness usually is one foot or less (0.3 meters). The lower contact of this unit is commonly erosional and marks a regional regression surface overlain by terrigeneous clastics. Claystones of this unit are generally soft, probably due to the dissolution of the supratidal anhydrite that formerly capped the carbonate beds of unit 9 (Fig. 30). The environment of deposition of these rocks was similar to that of the rocks in unit '0'.

Unit 11

Unit 11 consists of reddish-brown, very fine-grained sandstones and siltstones (Fig. 31) commonly interbedded with green siltstones (Fig. 32). The thickness ranges from 18 to 28 feet (6.5 to 8.5 meters). Generally the thickness is greater in the northwestern and southwestern parts of the mapped study area (Fig. 33). Arrows on Figure 33 indicate the probable direction of sediment transportation.



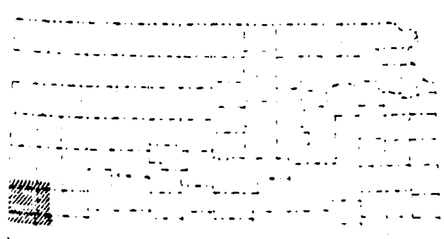
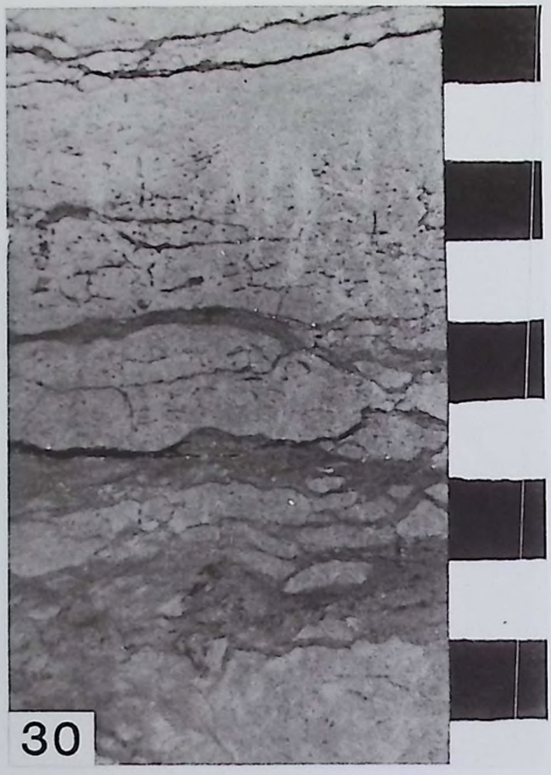


Figure 29. Structural contour map, top of the Funston Formation; contour interval = 40 Ft.

Figure 30. Core slab of the top of carbonate unit 9 (2501 ft., Cross #1). Fenestral mudstone and solution-collapse breccia with green claystone filling areas between breccia fragments. Scale in centimeters.

Figure 31. Core slab of rock unit 11 (2474.5 ft., Cross #1). Red, calcareous siltstone showing chaotic fractures.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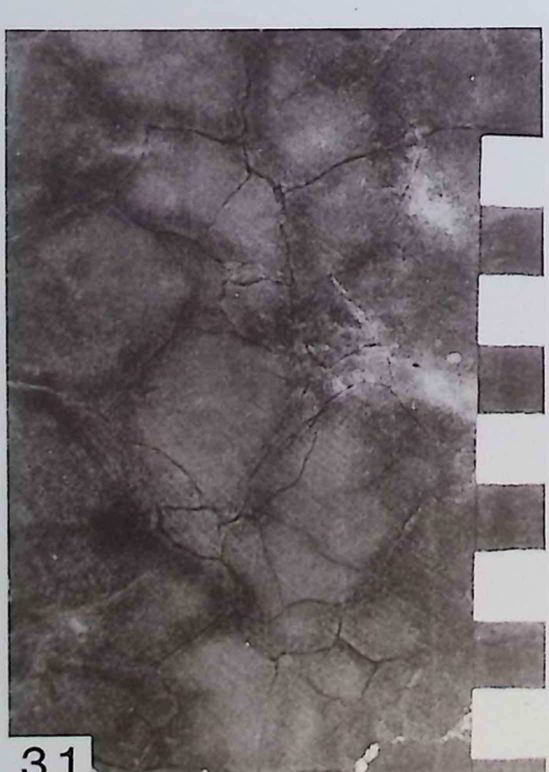
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Figure 32. Core slab of rock unit 11 (2610.3 ft., Luke #2). Green, calcareous siltstone with carbonate caliche nodules. Scale is in centimeters.

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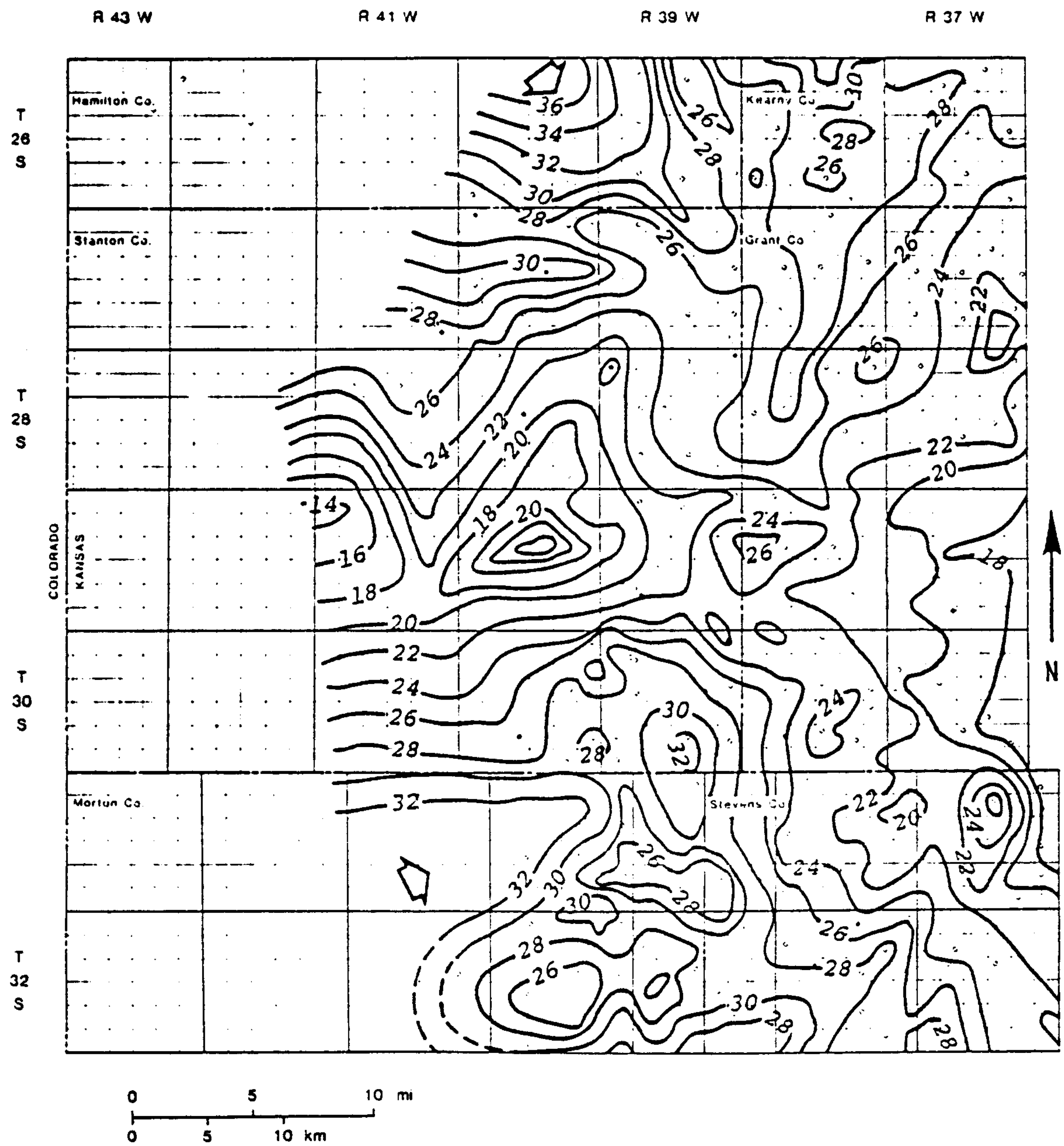

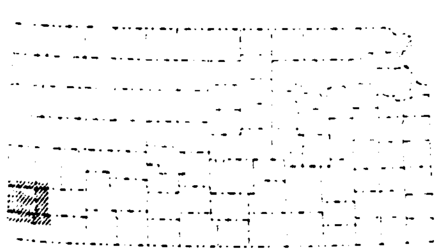

Figure 33. Isopach of the Speiser Formation; contour interval = 2 Ft.

Unit 11 overlies the Funston Formation and is located between two claystone beds of unit 10. Unit 11 and the two intervals of unit 10 comprise the Speiser Formation (Fig. 5). Chaotic fractures (Fig. 31) and lath-shaped crystals of anhydrite (Fig. 34) are common in unit 11, particularly in the lower interval. Gypsum was probably precipitated first and was later replaced by anhydrite. Similar events were reported from the modern sabkhas of the Trucial Coast (Bathurst, 1975).

The siltstones of the Speiser Formation are similar to those of the Red Cave Formation of the Palo Duro basin. Handford and Fredericks (1980) suggested that the sandstones and siltstones of the Red Cave are fluvial or fluvial deposits reworked by the wind.

Terrigenous sediments in the upper half of the Council Grove Group and in the Chase Group along the Las Animas arch were probably derived from south-central Colorado (Mudge, 1967).

Figure 34. Core slab of rock unit 11 (2535 ft., Cross #1). Red, calcareous siltstone showing abundant anhydrite nodules. Scale is in centimeters.

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DEPOSITIONAL ENVIRONMENTS

The various lithofacies comprising the Funston cycle were formed in a wide range of environments that included shelf lagoons with open circulation, restricted lagoons, tidal flats, and sabkhas. The Funston lithofacies and their characteristics are summarized in Figure 6. A summary of the events that occurred in southwestern Kansas during deposition of the Funston sediments are listed below.

1. A rapid regional transgression (designated by A on Figure 6) from the southeast accompanied by an influx of terrigenous sediments resulted in the deposition of rock unit 1. The unit shows rapid lithologic change from terrigenous siltstones at the base to fossiliferous shaly carbonates at the upper part. Environments of deposition ranged from shallow-water, restricted tidal flats to a protected subtidal zone. Because of the rapid rise in sea level little tidal flat sediment accumulated.

2. As the regional transgression proceeded, turbidity increased and black, calcareous, fossiliferous shales (rock unit 2) were deposited. This stage probably represents the culmination of the transgression.

3. A minor regression accompanied by cessation of influx terrigenous sediment caused the deposition of carbonate sediments (rock unit 3). These sediments were formed below wave base level in a shallow-water open shelf lagoon.

4. A minor transgression with high terrigenous clastic influx resulted in the deposition of massive fossiliferous shale (rock unit 4).

5. Another minor regression that curbed water turbidity and allowed the deposition of carbonate sediments (rock unit 5). The shoaling upward sequence exhibited by these rocks was the result of continued regression. Environments ranged from a shallow-water protected subtidal zone to restricted intertidal areas.

6. Increased turbidity that accompanied a minor transgression resulted in the deposition of silty calcareous fossiliferous shale (rock unit 6).

7. As the water began to clear following a minor regression, carbonate sediments accumulated in moderately agitated shallow waters. The carbonates (rock unit 7) are rich in algal-coated grains. Depositional environments of these rocks were similar to those of carbonate unit 5.

8. Carbonate sedimentation was interrupted by high influx of terrigenous clastics and a rise of the sea level. This event represents the last marine transgression within the Funston cycle that resulted in the deposition of silty calcareous shales (rock unit 8).

9. As the turbidity decreased, a major but slow regression (designated by B on Figure 6) started. Carbonate sediments began to accumulate on the sea floor. The regression proceeded without any apparent interruption by influx of clastics. The resulting rocks (carbonate unit 9) were formed in a variety of environments ranging from open shelf lagoons to extremely restricted areas on tidal flats. Beds of the lower part of these rocks show great diversity of fossils indicating deposition in a relatively open shelf lagoon with moderate circulation. Upward in the unit, decreased faunal diversity and vertical lithologic changes suggest a landward shift in the

depositional environments. In response to accumulation of carbonate sediments on the tidal flats with the continuing fall of sea level, facies prograded seaward on the tidal flats. The resulting facies are diachronous and become younger in a seaward direction.

With the continuing fall of sea level, terrigenous sediments were deposited near the shoreline. The top of carbonate unit 9 is capped by green unfossiliferous claystones of rock unit 10. Upward the claystones grade into red beds. The red beds might have formed either by fluvial processes or by eolian reworking of fluvial deposits.

Thick accumulations of the terrigenous rocks commonly overlie thin beds that belong to the regressive carbonate unit (see cross section B-B', in pocket). This suggests that environments of deposition were shifted east-southeastward (seaward) during the regional regression).

The poor development of evaporites at the top of carbonate unit 9 is attributed to the lack of interruption in sedimentation of the prograding red beds. Anhydrite and caliche nodules are common in the red beds, however, suggesting semi-arid climate similar to that of recent sabkhas along the Abu Dhabi coast of the Arabian Gulf.

The Pennsylvanian cyclic strata of the Lansing and Kansas City groups, in western Kansas, were probably deposited during periods of semi-arid climatic conditions (Watney, 1980). Anhydrite development in the regressive carbonate strata of these groups has not been documented. On the other hand, bedded anhydrite in the younger Nolans Limestone (Upper Wolfcampian) was reported by Glossa (1982). Mudge (1967) indicated that climate became more arid at the close of the Wolfcampian. The Funston Limestone, therefore, was probably deposited during a transitional period from semi-arid to arid climatic conditions.

In summary, a rapid regional transgression followed by a slow, continuous regression was responsible for the deposition of the Funston cycle sediments. Interbedded carbonate and shale beds can be explained by the occurrence of both minor transgressions and regressions within the cycle. Faunal and lithologic variations within the shoaling carbonate units 5, 7, and 9, but especially the latter, further support the idea of sea-level fluctuation.

Carbonate Depositional Models:

Irwin (1965) proposed a theoretical model of clear-water carbonate sedimentation in epicontinental seas. Epeiric shelf environments are characterized by low relief and only a slight slope. According to the Irwin model, sediments form in three distinct zones (Zone Z, Zone Y, and Zone X) characterized by different water energies (Fig. 35). This model has proved its applicability in the study of Paleozoic shallow-water carbonates (e.g., Irwin, 1965, Laporte, 1969; Watney, 1980).

The vertical lithologic and faunal changes in the Funston carbonate lithofacies suggests that sedimentation occurred in environments typical of Zone Z of Irwin's model.

Wilson (1975) suggested a pattern of facies belts across a gently sloping shelf atop a carbonate platform (Fig. 35). The pattern consists of nine facies belts and is controlled by factors such as slope, geologic age, water energy, and climate. Changes in one of these factors will affect the pattern they control (Wilson, 1975).

Almost all the lithofacies forming the Funston cycle are incorporated in facies belts 7, 8, and 9 developed by Wilson (1975). Physical and biological conditions of environments in Zone Z are similar to those of

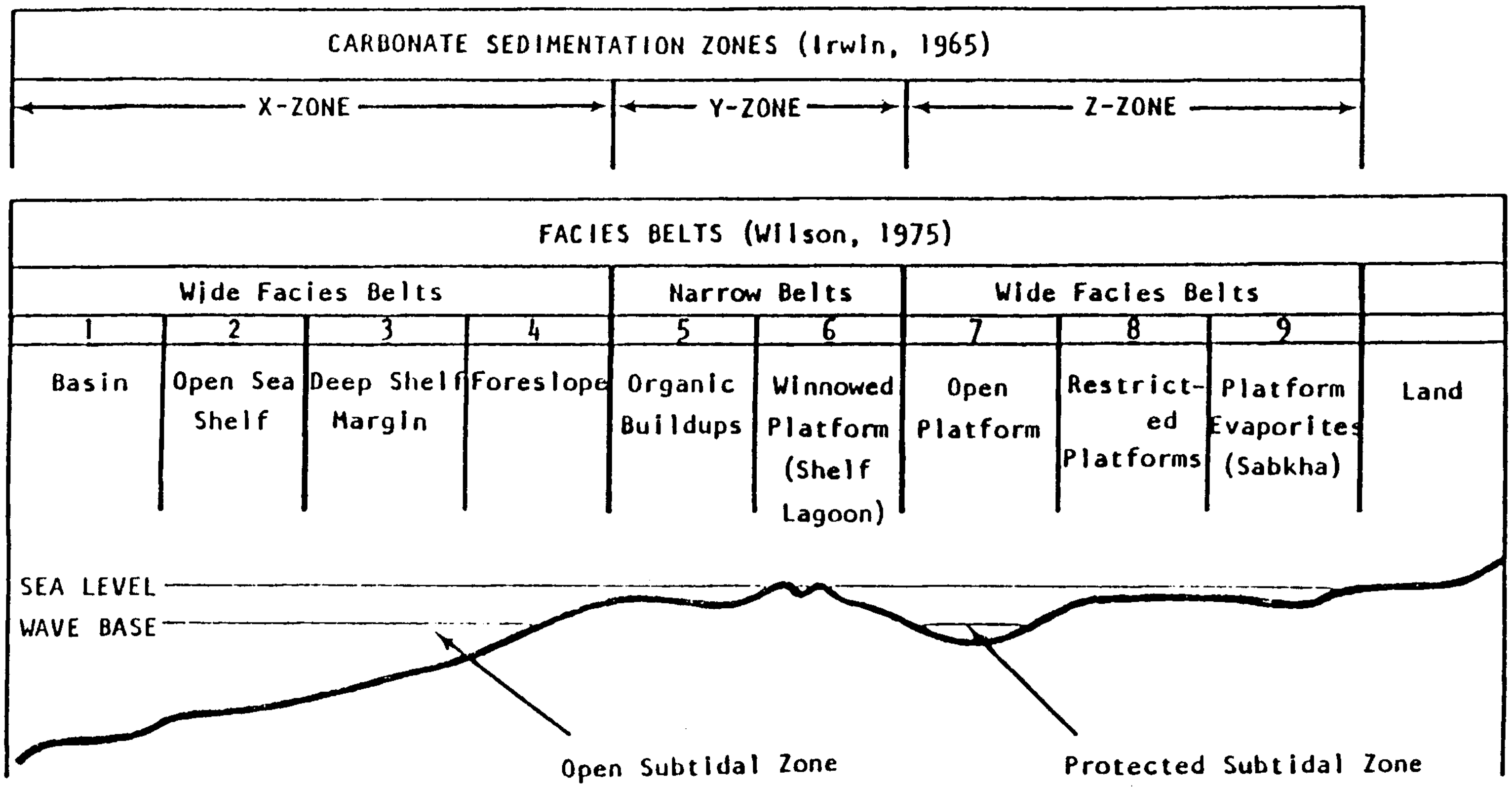

Figure 35. Modified versions of Irwin's (1965) model for carbonate sedimentation and Wilson's (1975) idealized pattern of facies belts on a carbonate platform. After Selley (1975) and Flugel (1982).

Wilson's facies belts (7, 8 and 9). The two models worked satisfactorily in interpreting rocks of the Funston cycle (see Appendix A for lithofacies description).

Lithofacies and Log Response:

Attempts have been made to establish relationships between various log responses and carbonate facies in order to reconstruct ancient depositional environments. Asquith (1979) discussed several methods to determine carbonate lithologies and depositional environments from geophysical logs. Watney (1980) demonstrated that graphic cross-plots of gamma ray versus neutron counts can be used to determine the relative proximity of well locations to ancient shorelines.

One of the shortcommings in using the cross-plot techniques, as noted by Pickett 1977 (in Asquith, 1979) and Watney (1980), is that cores or cuttings from selected wells must be available. Petrographic examination of these cores or cuttings will greatly enhance the reliability of these methods. Once a relationship has been established, logs from wells lacking cores and cuttings can be graphically cross-plotted and their facies and environments determined (Asquith, 1979).

In this study, an attempt was made to determine relationships between the Funston lithofacies and their log responses. The major lithofacies and their depositional environments are shown in Figure 36. Separation of the lithofacies in Figure 37 may suggest a basinward well or a relatively deeper-water setting not affected by influx of terrigenous sediments. Clustered patterns, on the other hand, indicate either a landward location (Fig. 38) or a paleotopographic high (Fig. 39).

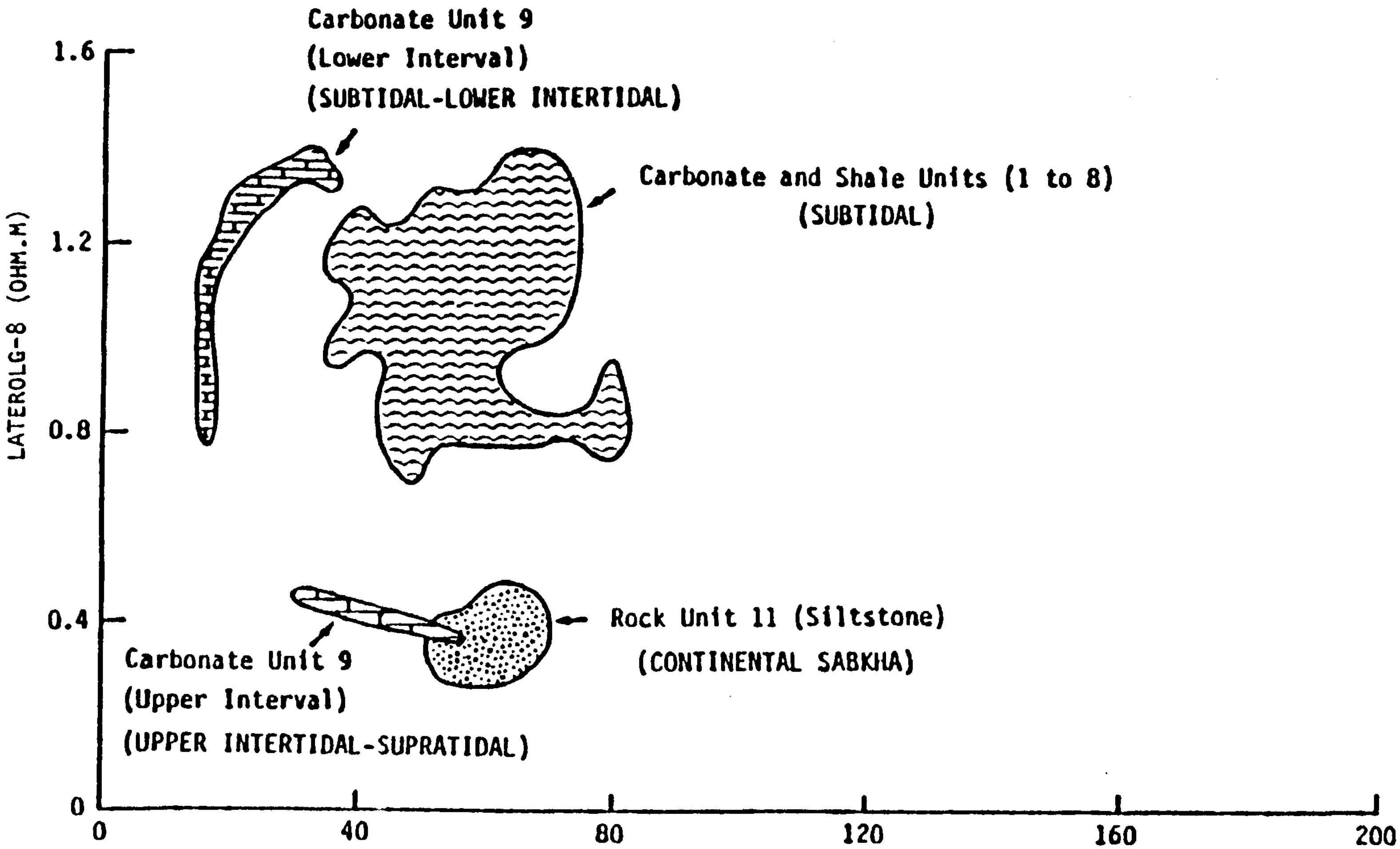

Figure 36. Cross-plot of laterolog-8 (shallow resistivity) versus gamma ray for the Funston cycle interval (2536 ft. - 2587 ft.) from the Amoco A-2 Piper (sec. 6-T28S-R39W). The plot shows depositional environments typical of the major lithofacies comprising the Funston cycle.

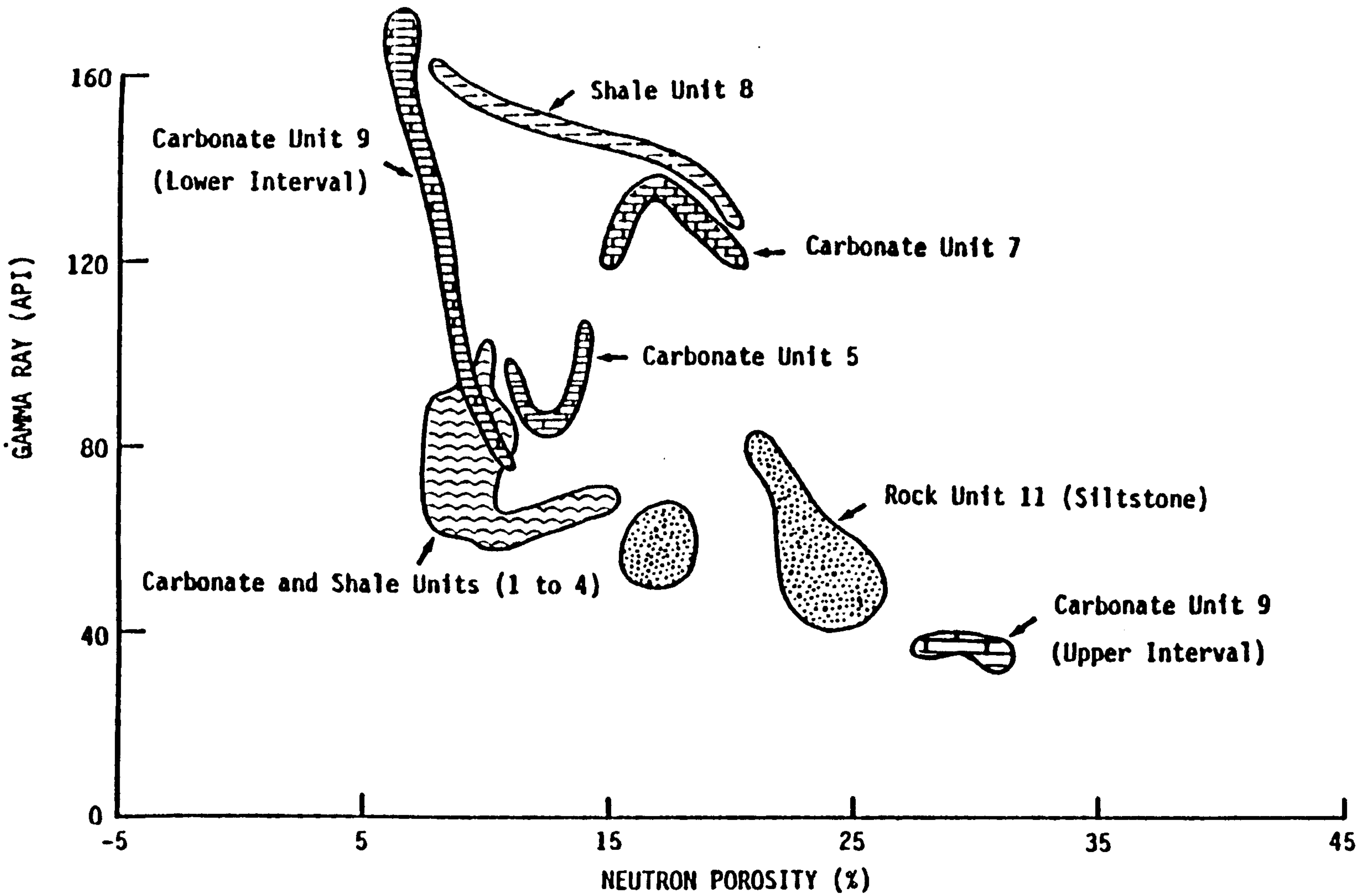

Figure 37. Gamma ray-neutron porosity cross-plot for the Funston cycle interval (2486 ft.-2532 ft.) from the Amoco #1 Cross (sec. 36-T27S-R41W). Separation between lithofacies indicates deposition in a relatively deeper marine water.

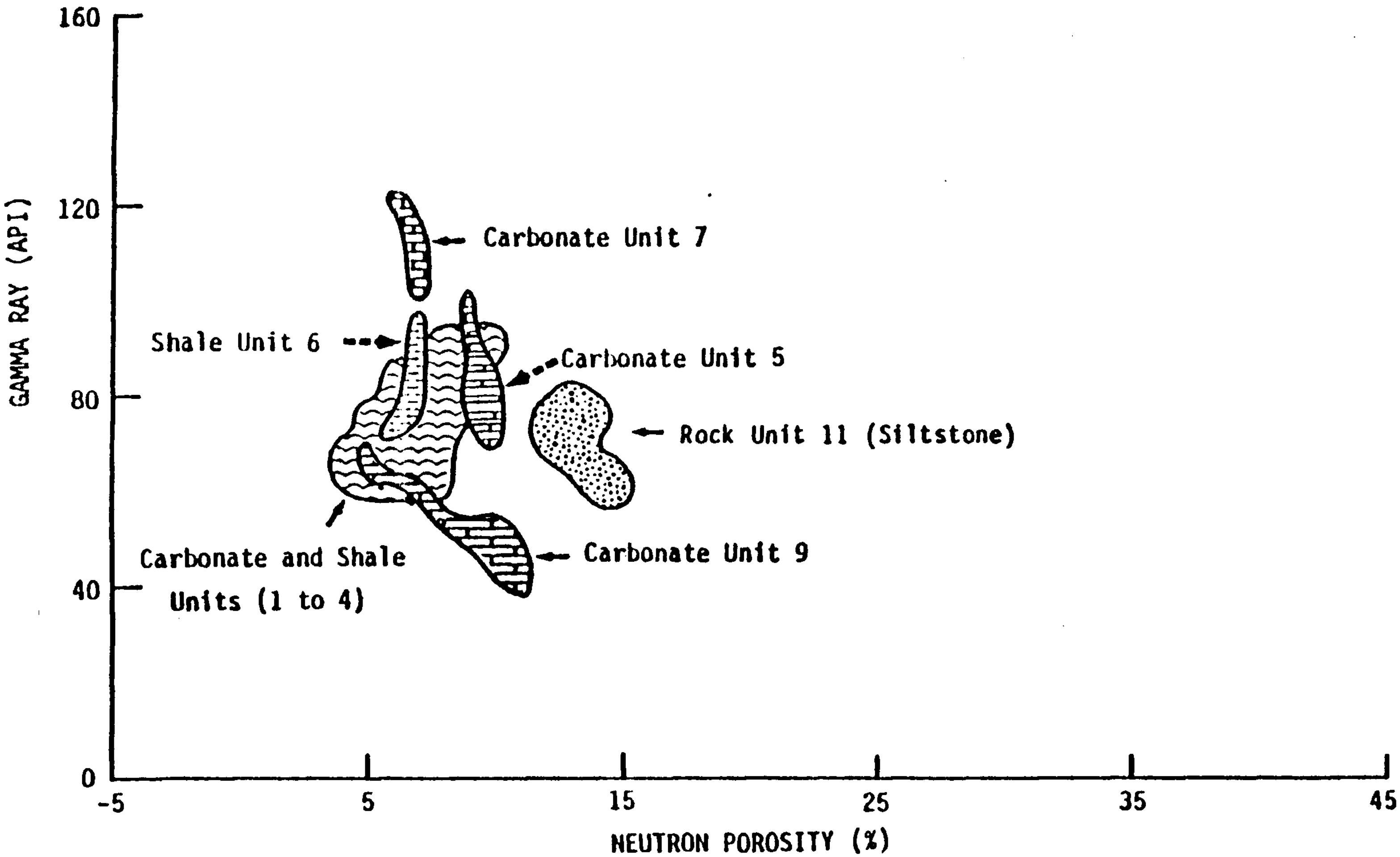

Figure 38. Gamma ray-neutron porosity cross-plot for the Funston cycle iterval (2507 ft. - 2544 ft.) from the Amoco #1 Armstrong (sec. 5-T29S-R41W). The clustered pattern of the lithofacies is typical of a landward location with influx of terrigenous sediments.

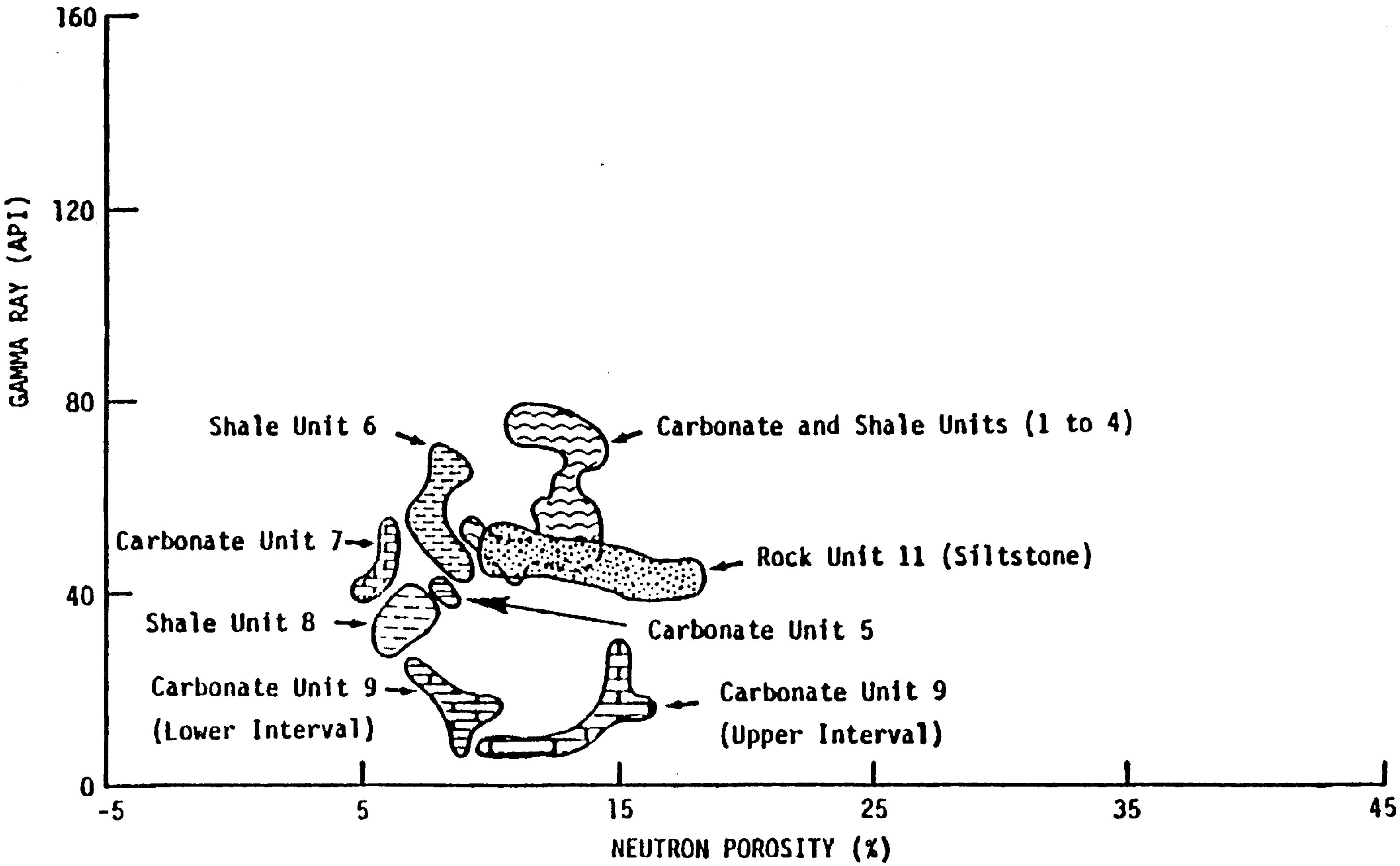

Figure 39. Cross-plot of gamma ray-neutron porosity well log response for the Funston cycle interval (2567 ft. - 2621 ft.) from the Amoco #2 Myler (sec. 29-T29S-R39W). The clustered pattern of the lithofacies suggests deposition on a high area.

In Figure 37, the unusually high gamma ray reading from the lower interval of carbonate unit 9 may be attributed to the local abundance of uranium-rich phosphatized shell fragments. Recent studies (Burnett and Gomberg, 1977, and Burnett and others, 1980) have shown that Holocene marine phosphorites as well as ancient phosphatic deposits contain substantial quantities of uranium.

Shoaling upward carbonate units, particularly unit 9, display a transition in depositional environments from subtidal areas to supratidal flats. Porous lithofacies, especially the upper interval of carbonate unit 9 and the fractured red beds of unit 11, are distinct and show low gamma ray values on the gamma ray-neutron porosity cross-plot in Figure 37.

Variations in log responses of the Funston lithofacies from one well to another suggest subtle changes in the configuration or slope of the epicontinental shelf greatly affected the lithologies of the sediments.

DIAGENESIS

Carbonate lithofacies of the Funston cycle have undergone various degrees of diagenesis. Rocks of carbonate unit 9 may be most intensely altered because of their stratigraphic position in the cycle.

Early Diagenetic Processes:

One of the earliest diagenetic alterations may have been the micritization of calcareous allochems. Bathurst (1966) recognized the process of micritization in which carbonate allochems are converted to microcrystalline calcite. The process is caused by algal boring of the allochems and the subsequent filling of the bores by micrite. Peloids are the product of extensive algal borings (Fig. 40). Micritized skeletal fragments are highly resistant to alteration by other diagenetic processes (Friedman, 1964). Incomplete algal borings of carbonate allochems results in the formation of micrite envelopes. Micritization is common in subtidal and intertidal rocks of the Funston carbonates.

Among other early diagenetic changes are the loss of magnesium from high-magnesian calcite grains and the inversion aragonite into a low-magnesian calcite. The former occurs without noticeable change of fabric and has been documented by Friedman (1964), Land (1967), and Gavish and Friedman (1969). On the other hand, transformation of aragonite to the more stable low-magnesium calcite commonly results in the obliteration of the original fabric.

Figure 40. Thin section photomicrograph from carbonate unit 9 (2584.3 ft., Montgomery A-2) showing abundant peloids in silty peloid wackestone. Bar scale is 0.2 mm. Plane-polarized light.

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Evaporite Precipitation:

The occurrence of anhydrite in the Funston rocks is more evident in the upper rock units, particularly rock units 9 and 11. Nodular grains and crystal laths are the most abundant forms (Fig. 41).

Evaporite deposits of the Funston cycle are somewhat similar to those studied modern evaporite formation in the Abu Dhabi sabkhas along the coast of the Arabian Gulf. According to Kinsman (1969) anhydrite or gypsum form only in supratidal areas. Gypsum precipitates from concentrated, interstitial, lagoon-derived brines and later changes to anhydrite. Gypsum may also form as a byproduct during dolomitization of the subtidal and intertidal sediments. Evaporite formation is largely restricted to the upper level of the sabkha, but dolomitization may extend deeper as brines percolate through the carbonate sediments (Kinsman, 1969).

In the Funston carbonates, especially the upper units, anhydrite occurs in a variety of forms. Void filling anhydrite is common in upper intertidal rocks. Birdseye pores typical of these carbonates were plugged by anhydrite that later was replaced by silica (Fig. 42). Another type of anhydrite forms by growing at a rapid rate in incompletely lithified sediments. This type is displacive and anhydrite crystals incorporate "floating" carbonate particles from the host sediment (Fig. 43).

Freshwater Dissolution and Cementation:

Freshwater diagenesis in Funston carbonate beds was mainly limited to the phreatic zone. Percolating fresh waters affected the composition of the original carbonate sediments. The upper beds of carbonate unit 9

Figure 41. Core slab from the upper interval of carbonate unit 9 (2551 ft., Piper A-2) showing development of anhydrite laths (dark areas) in intertidal peloid packstone. Scale is in centimeters.

Figure 42. Core slab photograph of top of carbonate unit 9 (2586.6 ft., Myler #2). Fenestral porosity plugged by early precipitation of anhydrite that was later replaced by silica. Scale is in centimeters.

Figure 43. Thin section photomicrograph from top of carbonate unit 9 (2627.5 ft., Luke #2). Floating carbonate fragments in the anhydrite crystal (white area) resulted from early growth of anhydrite in partially lithified pellet mudstone. Bar scale is 0.5 mm. Plane-polarized light.

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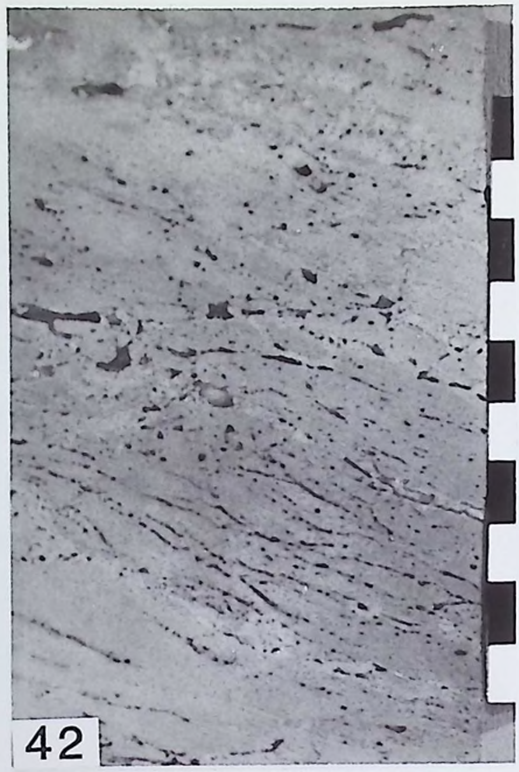

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show well developed moldic pores that resulted from dissolution of undolomitized skeletal particles by percolating fresh waters (Fig. 44). Upon further downward movement, fresh waters became supersaturated with respect to calcite, and cement began to precipitate. The cement is mostly ferroan calcite. Precipitation of cement occluded the original interparticle pores. This is especially important in the Osagia packstones of carbonate unit 5.

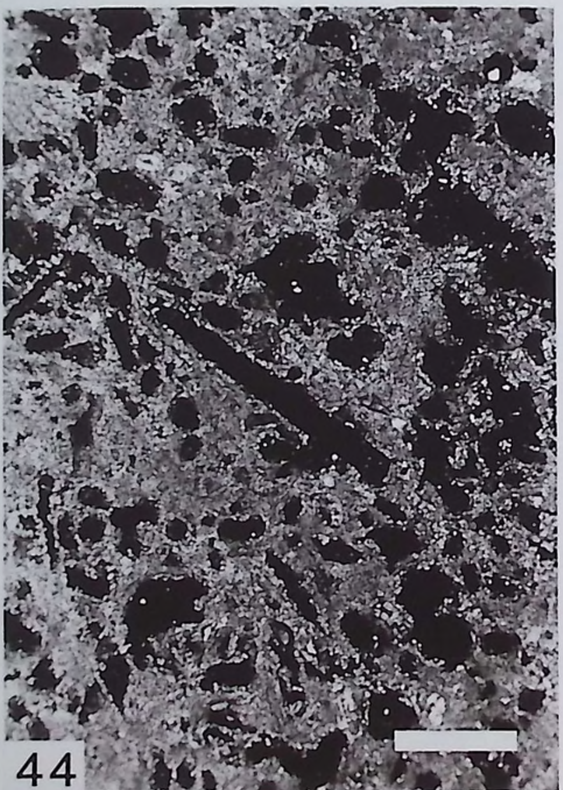
Criteria characteristic of the vadose environment are lacking in the carbonate beds. Caliche carbonate nodules, however, are common in the red beds of rock unit 11. The presence of caliche nodules suggests that an arid or semi-arid climate dominated the area.

Dolomite Formation:

The process of dolomitization involves replacement of calcium carbonate by dolomite. A solution with high Mg/Ca must be available before dolomitization can take place (Friedman, 1964). Dolomitization has greatly affected the upper Funston carbonates.

According to Patterson and Kinsman (1982), intertidal sediments are being dolomitized in the subsurface supratidal environment of a coastal sabkha along the southern shore of the Arabian Gulf. They pointed out that development of abundant diagenetic dolomite results from a combination of high Mg:Ca ratio, sediment permeability, frequency of flooding by lagoon-derived brines, and shoreline configuration. Patterson and Kinsman (1982) demonstrated that highly dolomitized areas are localized along the flanks of remnant channels and the lee of islands engulfed by seawardly prograding sabkhas. The sabkha dolomite is diagenetic and is

Figure 44. Thin section photomicrograph of dolomudstone from top of carbonate unit 9 (2586.6 ft., Myler #2) showing development of moldic porosity as the result of leaching of undolomitized skeletal fragments. Bar scale is 0.2 mm. Cross-polarized light.



44

associated with abundant gypsum and anhydrite. The dolomitization process takes about 1,000 to 15,000 years. Dolomite formation in the Abu Dhabi sabkha postdates carbonate sedimentation, whereas it is penecontemporaneous with sedimentation in the Bahamas, Florida, and Bonair (Patterson and Kinsman, 1982).

The Abu Dhabi model can be used to explain dolomitization in the Funston carbonates. Dolomite in the latter forms mainly in the upper carbonate beds. Two types of dolomite are common in these rocks. The first type is microcrystalline and is limited to rocks deposited in the uppermost intertidal to supratidal areas (Fig. 44). In this type the dolomite apparently replaced aragonitic mud leaving skeletal fragments undolomitized. This later resulted in the formation of biomolds by percolating freshwaters. The second type of dolomite is also replacement in origin. It is sucrosic and largely restricted to lithofacies formed in the subtidal zone (Fig. 45).

Silicification:

Replacement by silica is a common diagenetic feature in all the Funston cycle rocks. Silicification is probably a late diagenetic event. At least two episodes of replacement by silica have affected the Funston rocks. Silicified skeletal fragments (particularly crinoids) are abundant in all the carbonate and shale units. Also, replacement of anhydrite nodules by fibrous silica has been noticed in thin sections from all the carbonate units (Fig. 46). This type of silica has been referred to as length-slow chalcedony by Folk and Pittman (1971), who said that the presence of length-slow chalcedony in anhydrite suggests the existence of former salt-flat or sabkha environments.

Figure 45. Thin section photomicrograph of dolomitic skeletal wackestone from carbonate unit 9 (2589 ft., Montgomery A-2). Sucrosic dolomite replaced matrix and anhydrite (large crystal at middle). Undolomitized (A) grain (stained) is a fossil fragment. Bar scale is 0.2 mm. Cross-polarized light.

Figure 46. Thin section photomicrograph of Osagia wackestone from carbonate unit 7 (2598 ft., Myler #2). Length-slow chalcedony replaced anhydrite that earlier plugged intergranular pores between the coated grains. Bar scale is 0.5 mm. Cross-polarized light.

45

46

Phosphatization:

Phosphatized skeletal particles have been observed in some carbonate intervals of the Funston cycle. These carbonates are commonly skeletal wackestones that formed in subtidal marine environments.

Most of the phosphatized particles show evidence of partial preservation of original fabrics (Fig. 47). Probably all phosphatized particles are brachiopod skeletal fragments.

Birch (1980) suggested that phosphate-rich sediments are commonly located on open shelves and offshore topographic highs that are dominated by carbonate sedimentation. The replacement process is temperature dependent. Warm shoaling waters of transgressive and regressive seas may have facilitated the formation of diagenetic phosphorites on wide, flat-lying shelves (Birch, 1980).

Figure 47. Thin section photomicrograph of skeletal wackestone (subtidal) from lower carbonate unit 9 (2506 ft., Cross #1). Black area is a phosphatized brachiopod shell. Bar scale is 0.5 mm. Cross-polarized light.

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POROSITY

Depositional facies and diagenesis effectively controlled the development of reservoir properties of the Funston cycle carbonates. Porosity is largely restricted to beds of the regressive carbonate unit (rock unit 9). Carbonate beds characterized by high original porosity (commonly peloidal packstones of the restricted intertidal zone) were preferentially cemented by freshwater cement and anhydrite, whereas those of initial low porosity, such as dolomudstones and dolomitic skeletal wackestones of the uppermost intertidal-supratidal zones, had their porosity enhanced by dolomitization and leaching by fresh water.

Types of porosity observed in the Funston carbonates are described below in the order of their importance:

1. Intercrystalline porosity is common in the intertidal and supratidal dolomites. Dolomitization is selective rather than pervasive (Figs. 48, 49). This phenomenon is very important as most of the undolomitized allochems were later leached, thus enhancing their porosity. Intercrystalline porosity is secondary in origin and is fabric selective.

2. Moldic porosity is another common and important type in the Funston carbonates. This type is also secondary and fabric-selective. It is commonly associated with intercrystalline porosity (Fig. 48). It occurs in the same lithofacies as intercrystalline porosity. i.e., upper intertidal and supratidal carbonates. Locally moldic porosity may be as high as 25 percent; however, in most cases the pores are not connected.

Figure 48. Thin section photomicrograph of dolomudstone from top of carbonate unit 9 (2586 ft., Myler #2) shows excellent porosity that includes moldic and intercrystalline. Bar scale is 0.2 mm. Cross-polarized light.

Figure 49. Thin section photomicrograph of dolomitic skeletal wackestone from carbonate unit 9 (2585.3 ft., Myler #2). Good example for development of intercrystalline porosity in selectively dolomitized subtidal-lower intertidal rocks. Undolomitized skeletal fragments (B) are probably crinoid fragments. Bar scale is 0.2 mm. Cross-polarized light.

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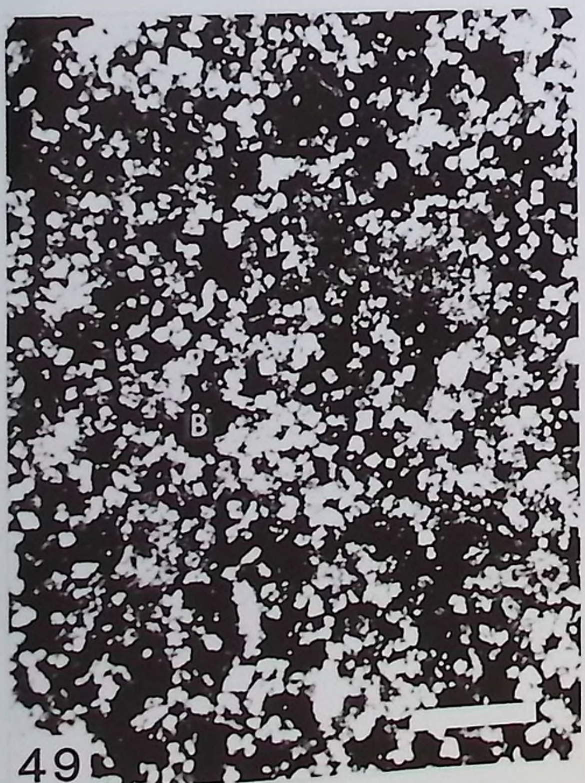

49

3. Vuggy porosity, like moldic porosity, forms in carbonate rocks that have been subjected to freshwater diagenesis. Unlike moldic porosity which is fabric-selective, vuggy porosity is not fabric selective (Fig. 50). According to Longman (1981), vuggy porosity generally forms in homogeneous limestone or dolomite, unlike moldic porosity, which usually forms in heterogeneous carbonates containing both calcite and aragonite. Previously cemented limestones in a freshwater phreatic environment may develop good vuggy porosity if they are again introduced into the phreatic zone (Longman, 1981). Although vuggy porosity exists the Funston carbonate beds, it is not important in contrast to intercrystalline or moldic porosity.

4. Fenestral porosity is primary and fabric-selective. It is commonly abundant in the algal mats of the upper intertidal and supratidal environments. Locally, this type developed at the top of the regressive carbonate unit (unit 9), but pores were plugged later by the precipitation of anhydrite (Fig. 51).

5. Intraparticle porosity is not uncommon but is of minor importance. This type is fabric-selective and becomes locally common in foraminifera peloidal packstones of the restricted intertidal environments. Pores occur in the leached chambers of foraminiferal tests (Fig. 52).

6. Solution channel porosity is rather a rare type in the carbonate beds of the Funston cycle. This usually forms by dissolution of undolomitized carbonate intervals by percolating undersaturated fresh waters (Fig. 53).

Figure 50. Thin section photomicrograph of a peloid packestone facies (intertidal) from carbonate unit 9 (2585 ft., Montgomery A-2). Vuggy, but poorly interconnected, porosity is common in the unit. Bar scale is 0.5 mm. Cross-polarized light.

Figure 51. Thin section photomicrograph of a fenestral dolomudstone from top of carbonate unit 9 (2586.6 ft., Myler #2). Fenestral porosity (C) was destroyed by early anhydrite filling that was later replaced by silica. Bar scale is 0.5 mm. Cross-polarized light.


C

Figure 52. Thin section photomicrograph of dolomitic foraminifers peloid wackestone from carbonate unit 9 (2587 ft., Myler #2). Porosity types include vuggy (D) and intraparticle (in forams). The latter type is less important and rare. Bar scale is 0.5 mm. Cross-polarized light.

Figure 53. Thin section photomicrograph of skeletal wackestone from carbonate unit 9 (2585.5 ft., Myler #2). Solution porosity shown in dark areas is uncommon and is found only in undolomitized intervals due to dissolution by undersaturated fresh waters. Bar scale is 0.5 mm. Cross-polarized light.

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53

Fabric-selective porosity is very important in the carbonate reservoirs of the Funston cycle and includes intercrystalline and moldic porosity. Intercrystalline porosity is most common of these porosity types and is more pronounced in the sucrosic dolomites of the subtidal and intertidal carbonate intervals. Moldic porosity was produced by the dissolution of carbonate allochems in the selectively dolomitized upper intertidal intervals.

Diagenesis played an effective role in the development of reservoir properties of the Funston carbonates. As a result, the best porous intervals are those with the poorest original porosity.

Porosity in noncarbonate beds is limited to the red beds overlying the regressive carbonate unit. Chaotic fractures are common in the red beds and serve as a gathering network for natural gas in these rocks.

Log cross-plots provide a simple, but not fully reliable, method of locating porous lithofacies. For example, the gamma ray-neutron porosity cross-plot of Figure 37 shows that clean and porous lithofacies are those of rock units 9 and 11. The neutron porosity values, however, are apparent and therefore need to be calibrated.

The distribution of the porosity within the reservoir facies of the regressive carbonate unit is highly irregular and laterally impersistent (Fig. 54). Porous carbonate intervals, however, commonly occur in areas characterized by relatively thin accumulations of overlying terrigenous clastics. This probably accounts, at least in part, for the presence of some dry wells in the Panoma gas area.

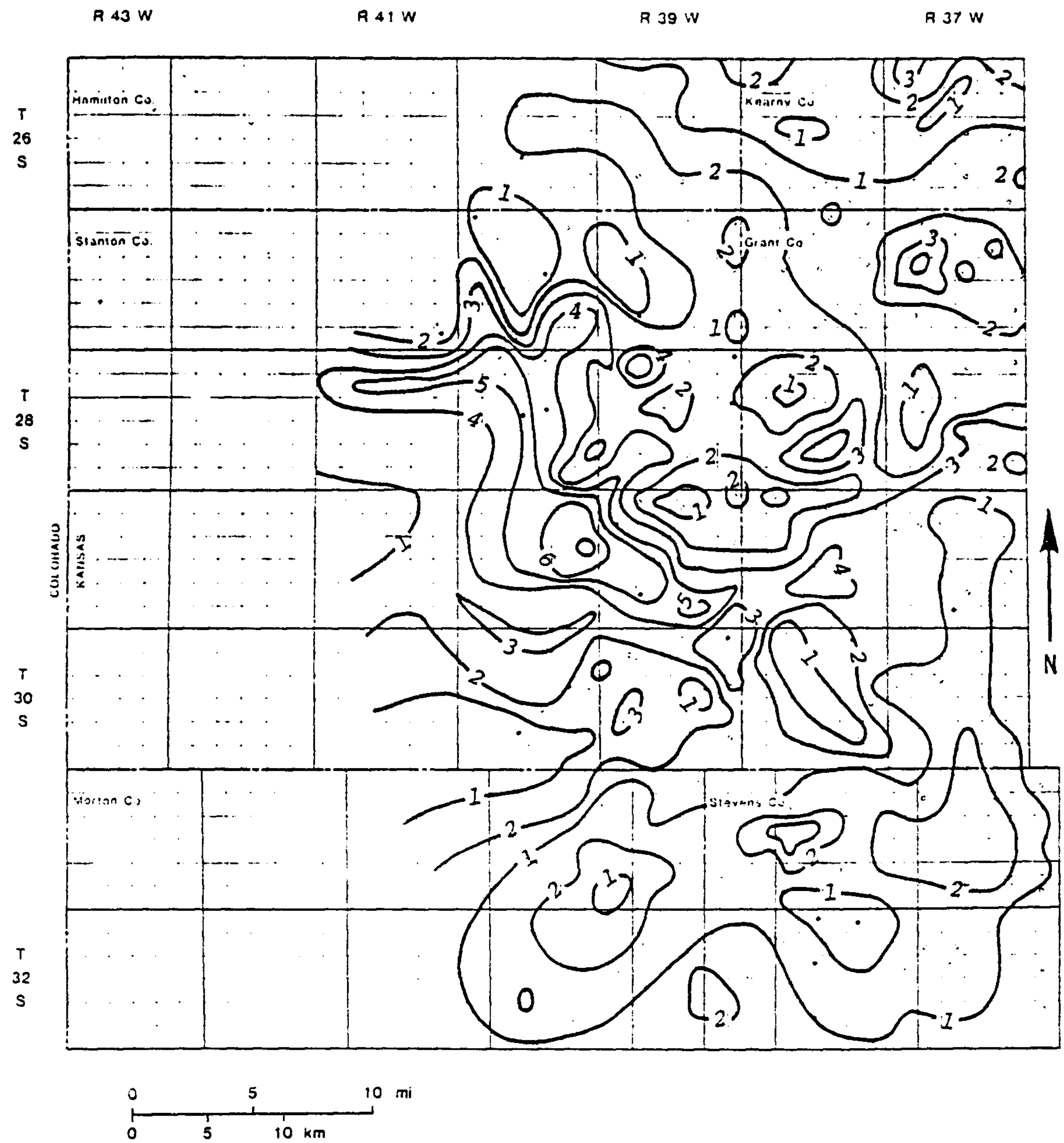


Figure 54. Thickness of porous carbonates (porosity in excess of 8%) in carbonate unit 9 (regressive). Contour interval = 1 porosity-ft.

CONCLUSIONS

1. The Funston carbonates of southwestern Kansas were deposited on a shallow, broad epicontinental shelf. Interbedded carbonate and shale strata resulted from fluctuations of sea level. The Funston cycle is marked at its base by a rapid regional transgression and a slow, continuous regression at its top. Minor transgressions and regressions have been recognized within the cycle.
2. Semi-arid to arid climate prevailed at least during the regressive phase of the cycle. The presence of red beds, with anhydrite and caliche nodules, that cap the cycle supports this idea.
3. Environments of deposition included the protected subtidal marine zone, restricted intertidal areas, supratidal flats, and sabkhas. Lithofacies prograded seaward in response to continued regional regression. A modern analog is the carbonate-evaporite sabkha sedimentation of the Arabian Gulf.
4. Depositional environments and diagenetic events greatly affected the development of porosity in the carbonate facies. Freshwater diagenesis, however, greatly controlled development of reservoir properties in the carbonate beds. Development of porosity is largely confined to the regressive carbonate beds of unit 9. Fracture porosity is important in the red beds of unit 11.
5. Secondary, fabric-selective porosity is of great value in the carbonate reservoirs and includes intercrystalline and moldic porosity. Selective dolomitization of original aragonite mud and leaching of carbonate allochems effectively enhanced reservoir properties.

Generally the best carbonate reservoir facies are those with the poorest original porosity and permeability.

6. Mapped porosity thicknesses within the carbonate reservoir facies using geophysical logs indicate that porosity distribution is highly irregular and impersistent.
7. Porous intervals in the carbonate reservoir facies are commonly associated with thin deposits of the overlying red beds.

REFERENCES

Asquith, G.B., 1979, Subsurface carbonate depositional models: A concise review, Tulsa, The Petroleum Publishing Co., 121 p.

Bathurst, R.G.C., 1966, Boring algae, micrite envelopes and lithification of molluscan biosparites: Geol. Journal, 5, p. 15-32.

__________, 1975, Carbonate sediments and their diagenesis: Developments in Sedimentology, v. 12, (2nd edition), Amsterdam, Elsevier, 658 p.

Beene, D.L., 1977, Oil and gas production in Kansas: Kansas Geol. Survey Energy Resources Series 12, 172-173.

Birch, G.F., 1980, A model of penecontemporaneous phosphatization by diagenetic and authigenic mechanisms from the western margin of southern Africa, in: Y.K. Bentor (ed.), Marine phosphorites-geochemistry, occurrence, genesis: Soc. Econ. Paleo. Mineralogists, Spec. Pub., no. 29, p. 79-97.

Burnett, W.C., and Gomberg, D.M., 1977, Uranium oxidation and probable subaerial weathering of phosphatized limestone from the Pourtales Terrace: Sedimentology, v. 24, p. 291-302.

Burnett, W.C., Veeh, H.H., and Soutar, A., 1980, U-series, oceanographic and sedimentary evidence in support of recent formation of phosphate nodules off Peru, in: Y.K. Bentor (ed.), Marine phosphorites-geochemistry, occurrence, genesis: Soc. Econ. Paleo. Mineralogists, Spec. Pub., no. 29, p. 61-71.

Butler, G.P., 1969, Modern evaporite depositional geochemistry of coexisting brines, the sabkha, Trucial Coast, Arabian Gulf: Jour. Sed. Petrology, v. 39, p. 70-89.

Choquette, P.W., and Pray, L.C., 1970, Geologic nomenclature and classification of porosity in carbonates: Amer. Assoc. Petroleum Geologists Bull., v. 54, no. 2, p. 207-250.

Crowell, J.C., and Frakes, L.A., 1971, Late Paleozoic glaciation of Australia: Geol. Soc. Australia Jour., v. 17, p. 115-155.

Dickson, J.A.D., 1965, A modified staining technique for carbonates in thin section: Nature, v. 205, no. 4971, p. 587.

Dixon, G.H., 1967, Paleotectonic investigations of the Permian system in the United States, northwestern New Mexico and Texas-Oklahoma panhandles: U.S.G.S. Prof. Paper 515, p. 65-80.

Doveton, J.H., and Cable, H.W., 1980, KOALA: Kansas on-line automated log analysis system: Kansas Geological Survey Petrophysical Series 2, 190 p.

Dunham, R.J., 1962, Classification of carbonate rocks according to depositional texture, in: W.E. Ham (ed.), Classification of carbonate rocks: Amer. Assoc. Petroleum Geologists Memoir 1, p. 108-121.

Flugel, E., 1982, Microfacies analysis of limestones: New York, Springer-Verlag, 633 p.

Folk, R.L., and Pittman, J.S., 1971, Length-slow chalcedony: A testimony for vanished evaporites: Jour. Sed. Petrology, v. 41, p. 1045-1058.

Friedman, G.M., 1964, Early diagenesis and lithification in carbonate sediments: Jour. Sed. Petrology, v. 34, p. 777-813.

Gavish, E., and Friedman, G.M., 1969, Progressive diagenesis in Quaternary to Late (sic), Tertiary carbonate sediments: sequence and time scale: Jour. Sed. Petrology, v. 39, p. 980-1006.

Glossa, J.M., 1982, Depositional environments and diagenetic history of the Nolans Limestone (Upper Wolfcampian), Rice County, Kansas: M.S. Thesis, University of Kansas, 30 p.

Handford, C.R., and Fredericks, P.E., 1980, Facies patterns and depositional history of a Permian sabkha complex-Red Cave Formation, Texas panhandle: Univ. Texas, Bur. Econ. Geology, Circular 80-9, Geol. Circ. no. 80-9, 38 p.

Imbrie, J., Laporte, L.F., and Merriam, D.F., 1959, Beattie Limestone facies and their bearing on cyclical sedimentation theory: Kansas Geol. Survey, Annu. Field Conf., no. 24, p. 69-78.

________, 1964, Beattie Limestone facies (Lower Permian) of the northern Midcontinent, in: D.F. Merriam (ed.), Symposium on cyclic sedimentation: Kansas Geol. Survey Bull., no. 169, p. 219-238.

Irwin, M.L., 1965, General theory of epeiric clear water sedimentation: Amer. Assoc. Petroleum Geologists Bull., v. 49, no. 4, p. 445-459.

Jewett, J.M., 1933, Evidence of cyclic sedimentation in Kansas during the Permian period: Kansas Acad. Sci., Trans., v. 36, p. 137-140.

________, 1941, The geology of Riley and Geary counties, Kansas: Kansas Geol. Survey Bull., 39, p. 1-164.

Kansas Geological Society, 1966, Types Logs of Kansas, v. I and II.

Kinsman, D.J.J., 1969, Modes of formation, sedimentary associations, and diagnostic features of shallow-water and supratidal evaporites: Amer. Assoc. Petroleum Geologists Bull., v. 53, no. 4, p. 830-840.

Lane, N.G., 1958, Environment of deposition of the Grenola Limestone (Lower Permian) in southern Kansas: Kans. Geol. Survey Bull., no. 130, part 3, p. 117-164.

________, 1964, Paleoecology of the Council Grove Group (Lower Permian) in Kansas, based upon microfossil assemblages: Kansas Geol. Survey Bull., no. 170, part 5, 23 p.

Land, L.S., 1967, Diagenesis of skeletal carbonates: Jour. Sed. Petrology, v. 37, p. 914-930.

Laporte, L.F., 1969, Recognition of a transgressive carbonate sequence within an epeiric sea: Helderberg Group (Lower Devonian) of New York State, in: G.M. Friedman (ed.), Depositional environments in carbonate rocks: Soc. Econ. Paleo. Mineralogists, Spec. Pub., no. 14, p. 98-119.

Longman, M.W., 1981, Carbonate diagenesis as a control on stratigraphic traps: Amer. Assoc. Petroleum Geologists, Educ. Course Note Series, no. 21, 159 p.

Mason, J.W., 1968, Hugoton Panhandle Field, Kansas, Oklahoma and Texas, in: B.W. Beebe (ed.), Natural Gasses of North America: Amer. Assoc. Petroleum Geologists Memoir 9, v. 2, p. 1539-1547.

Merriam, D.F., 1956, Hugoton Embayment commands fresh look: Oil and Gas Journal, v. 54, no. 44, p. 82-86.

________, 1963, The geologic history of Kansas: Kansas Geol. Survey Bull., no. 162, 317 p.

________, and Goebel, E.D., 1968, Natural gas in Kansas, A) occurrence of natural gas in Kansas, in: B.W. Beebe (ed.), Natural gasses of North America: Amer. Assoc. Petroleum Geologists Memoir 9, v. II, p. 1548-1557.

Moore, R.C., 1964, Paleoecological aspects of Kansas, Pennsylvanian and Permian cyclothems, in: D.F. Merriam (ed.), Symposium on cyclic sedimentation: Kansas Geol. Survey Bull., no. 169, v. 1, p. 287-380.

Mudge, M.R., 1967, Paleotectonic investigations of the Permiam system in the United States, Central Midcontinent Region: U.S.G.S. Prof. Paper 515, p. 97-123.

Patterson, R.J., and Kinsman, D.J.J., 1982, Formation of diagenetic dolomite in coastal sabkha along Arabian Gulf: Amer. Assoc. Petroleum Geologists Bull., v. 66, no. 1, p. 28-43.

Pickett, G.R., 1977, Recognition of environments and carbonate rock type identification, in: Formation Evaluation Manual Unit II, section exploration wells: Oil and Gas Consult. Int. Inc., p. 4-25.

Selley, R.C., 1975, Ancient sedimentary environments (2nd edition): Ithaca, Cornell Univ. Press, 287 p.

Silver, B.A., and Todd, R.G., 1969, Permiam cyclic strata, northern Midland and Delaware basins, west Texas and southeastern New Mexico: Amer. Assoc. Petroleum Geologists Bull., v. 53, no. 11, p. 2223-2251.

Watney, W.L., 1980, Cyclic sedimentation of the Lansing-Kansas City Groups in northwestern Kansas and southwestern Nebraska: Kansas Geol. Survey Bull., no. 220, 72 p.

Welte, D.H., 1965, Relation between petroleum and source rock: Amer. Assoc. Petroleum Geologists Bull., v. 49, no. 12, p. 2246-2268.

White, L.M., 1981, Deposition and diagenesis of the Five Finger Carbonate, Council Grove Group, Hugoton field, Kansas: M.S. Thesis, Texas Tech. Univ. 89 p.

Wilson, J.L., 1975, Carbonate facies in geologic history: New York, Springer-Verlag, 471 p.

Zeller, D.E., 1968, The stratigraphic succession in Kansas: Kansas Geol. Survey Bull., no. 189, 81 p.

APPENDIX A

THIN SECTION DESCRIPTION OF CARBONATE LITHOFACIES FROM THE FUNSTON CYCLE

Sample No.: ML 2586; EN 2608

I. Classification (Dunham, 1962):

Dolomitic Peloidal Mudstone.

II. Depositional Environment:

Extremely restricted tidal flats (upper intertidal to supratidal).

III. Lithofacies (this study): unit 9, top.

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Dolomite; calcite; silt-size quartz; anhydrite; silica.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Blue-green algae; ostracods; foraminifers.

VI. Diagenetic Features:

Anhydrite replacement, Dolomitization, Replacement by silica, Desiccation cracks.

VII. Porosity:

Excellent (20%); Vuggy, intercrystalline moldic.

VIII. Sedimentary Structures:

Fenestral fabrics.

Sample No.: MO 2559; EN 2607; CR 2501.4; PP 2548.8

I. Classification (Dunham, 1962):

Dolomudstone.

II. Depositional Environment:

Extremely restricted tidal flats (supratidal environment).

III. Lithofacies (this study): unit 9, top.

IV. Wilson's 1975 Facies Model: Facies belt 9.

V. Composition:

A) Mineralogy:

Mostly dolomite; calcite; silt-size quartz; anhydrite.

B) Inorganic Constituents:

Peloids (rare).

C) Organic Constituents:

Blue-green algae.

VI. Diagenetic Features:

Anhydrite replacement, Dolomitization, Desiccation cracks.

VII. Porosity

Low (2-6%); Vuggy, channel.

VIII. Sedimentary Structures:

Sample No.: AR 2509.1; MO 2559.8; MO 2620.3: CR 2502.1

I. Classification (Dunham, 1962):

Silty Peloidal Mudstone-Wackestone.

II. Depositional Environment:

Extremely shallow-water, restricted bays or ponds.
Tidal flat (upper intertidal) environment.

III. Lithofacies (this study): unit 9

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Calcite; silt-size quartz; dolomite.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Rare foraminifers and ostracods.

VI. Diagenetic Features:

Dolomitization.

VII. Porosity:

Low (2-5%); Interparticle; Intercrystalline.

VIII. Sedimentary Structures:

Burrows, Laminations.

Sample No.: ML 2688.2; MG 2585; MO 2560.5: MA 2621: LU 2628; NF 2625; EN 2609.2; CR 2502.5: PP 2552.7

I. Classification (Dunham, 1962):

Dolomitic (Peloidal) Skeletal Wackestone.

II. Depositional Environment:

Shallow-water, restricted bays or ponds.
Tidal flat (lower intertidal) environment.

III. Lithofacies (this study): unit 9.

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Mostly dolomite; calcite; silt-size quartz; anhydrite, chert.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Blue-green algae; foraminifers; crinoids; bivalves; ostracods; bryozoans.

VI. Diagenetic Features:

Micritization, Anhydrite replacement, Dolomitization, Replacement by silica.

VII. Porosity:

Varies widely (3-15%); Vuggy, intercrystalline, intraparticle.

VIII. Sedimentary Structures:

Sample No.: ML 2692; AR 2511; MA 2622.4; LD 2704.5: EN 2609.2

I. Classification (Dunham, 1962):

Silty Skeletal Wackestone.

II. Depositional Environment:

Low-energy, open shelf lagoon, lower intertidal to shallow subtidal environment.

III. Lithofacies (this study): unit 9.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; ferroan calcite; silt-size quartz; dolomite; anhydrite; silica.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Blue-green algae; brachiopods; molluscs, ostracods, bryozoans; crinoids; dasyclad algae; fusulinids (rare); few phosphatized skeletal fragments.

VI. Diagenetic Features:

Micritization, Anhydrite replacement, Dolomitization, Replacement by silica.

VII. Porosity:

Low (1-6%); Vuggy, intraparticle, intercrystal.

VIII. Sedimentary Structures:

Burrows.

Sample No.: MG 2589; MO 2563.4; MA 2624.5: CR 2504.9; PP 2554.3

I. Classification (Dunham, 1962):

Dolomitic Algal-coated Skeletal Wackestone.

II. Depositional Environment:

Shallow-water, open shelf lagoon. Subtidal (below wave base) environment.

III. Lithofacies (this study): unit 9, base.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Mostly dolomite; ferroan calcite; anhydrite, silt-size quartz; chert.

B) Inorganic Constituents:

Peloids (rare).

C) Organic Constituents:

Algal-coated grains; crinoids, brachiopods; bryozoans; ostracods; phosphatized skeletal fragments.

VI. Diagenetic Features:

Micritization, Anhydrite replacement, Dolomitization, Replacement by silica.

VII. Porosity:

Varies widely (3-15%) intercrystalline, vuggy.

VIII. Sedimentary Structures:

Sample No.: CR 2509.2

I. Classification (Dunham, 1962):

Ostracod algal Mudstone-Wackestone.

II. Depositional Environment:

Restricted bays or ponds. Tidal flats (upper intertidal) environment.

III. Lithofacies (this study): Unit 7.

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Calcite; dolomite; ferroan calcite; silt-size quartz.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Blue-green algae; ostracods, foraminifers(?).

VI. Diagenetic Features:

Micritization, Dolomitization.

VII. Porosity:

Low; intercrystalline.

VIII. Sedimentary Structures:

Laminations.

Sample No.: ML 2698; AR 2514; MG 2597; MO 2568; MA 2629; LU 2636; LD 2712; NF 2634.5; EN 2618; PP 2560

I. Classification (Dunham, 1962):

Silty algal-coated skeletal Wackestone (Silty Osagia Wackestone).

II. Depositional Environment:

Shallow-water, open shelf lagoon. Shallow subtidal (just below wave base) environment.

III. Lithofacies (this study): unit 7.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; ferroan calcite; silt-size quartz; anhydrite; silica.

B) Inorganic Constituents:

C) Organic Constituents:

Algal-coated skeletal fragments of: crinoids, brachiopods, molluscs, bryozoans, dasyclad algae, ostracods; phosphatized skeletal fragments.

VI. Diagenetic Features:

Micritization, Anhydrite replacement, Replacement by silica.

VII. Porosity:

Low (1-4%); Vuggy, interparticle 1-4%.

VIII. Sedimentary Structures:

Sample No.: ML 2604; MO 2572.5; MA 2632.8; LU 2641.5; LD 2720; NF 2637.5; EN 2622.2; CR 2512.6; PP 2565.5

I. Classification (Dunham, 1962):

Algal-coated Skeletal Packstone (Osagia Foraminiferal Packestone).

II. Depositional Environment:

Shallow-water, open shelf lagoon. Shallow subtidal environment.

III. Lithofacies (this study): unit 5, upper part.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; ferroan calcite; dolomite; anhydrite, silt-size quartz; silica.

B) Inorganic Constituents:

Peloids.

C) Organic Constituents:

Algal-coated skeletal fragments of: molluscs, bryozoans, crinoids, brachiopods, foraminifers (Globivalvulina), dasyclad algae, fusulinids (rare).

VI. Diagenetic Features:

Micritization, Anhydrite replacement, Dolomitization, Replacement by silica.

VII. Porosity:

Very low.

VIII. Sedimentary Structures:

Sample No.: MA 2635.2; LD 2723; NF 2639.6; EN 2624.3; CR 2514.9

I. Classification (Dunham, 1962):

Silty (Dolomitic) Skeletal Wackestone.

II. Depositional Environment:

Low-energy, open shelf lagoon. Subtidal environment.

III. Lithofacies (this study): unit 5, lower part.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; silt-size quartz; ferroan calcite; chert; dolomite.

B) Inorganic Constituents:

C) Organic Constituents:

Brachiopods; crinoids; foraminifers; molluscs, bryozoans; few phosphatized skeletal fragments.

VI. Diagenetic Features:

Micritization, Replacement by silica.

VII. Porosity:

Very low.

VIII. Sedimentary Structures:

Sample No.: ML 2613.6; MG 2615; MO 2575.1; MA 2635.8; LD 2730.5; NF 2643.5; CR 2514.9

I. Classification (Dunham, 1962):

Shaly (Cherty) Skeletal Wackestone.

II. Depositional Environment:

Low-energy, open shelf lagoon. Subtidal environment.

III. Lithofacies (this study): unit 3.

VI. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; ferroan calcite; silt-size quartz; chert.

B) Inorganic Constituents:

C) Organic Constituents:

Fragments of crinoids, bryozoans, brachiopods, ostracods; phosphatized brachiopod fragments.

VI. Diagenetic Features:

Micritization, Replacement by silica.

VII. Porosity:

Very low.

VIII. Sedimentary Structures:

Sample No.: MO 2580; MA 2643; LU 2652.5; CR 2521.7; PP 2578.6

I. Classification (Dunham, 1962):

Shaly Skeletal Wackestone.

II. Depositional Environment:

Low-energy, open shelf lagoon. Subtidal environment.

III. Lithofacies (this study): unit 1.

IV. Wilson's 1975 Facies Model: Facies belt 7.

V. Composition:

A) Mineralogy:

Calcite; ferroan calcite; dolomite; chert.

B) Inorganic Constituents:

C) Organic Constituents:

Brachiopods; molluscs, crinoids; ostracods; bryozoans; fusulinids (rare); phosphatized skeletal fragments.

VI. Diagenetic Features:

Dolomitization, Replacement by silica.

VII. Porosity:

Very low.

VIII. Sedimentary Structures:

Burrows.

Sample No.: MG 2619.5; MO 2585

I. Classification (Dunham, 1962):

Shaly Skeletal Siltstone.

II. Depositional Environment:

Shallow-water, restricted ponds.
Tidal flat environment with high rate of terrigenous influx.

III. Lithofacies (this study): unit 1, base.

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Silt-size quartz; calcite; ferroan calcite; dolomite.

B) Inorganic Constituents:

Intraclasts.

C) Organic Constitutents:

Ostracods; molluscs, crinoids; brachiopods; bryozoans; few algal-coated grains; few phosphatized skeletal fragments.

VI. Diagenetic Features:

Dolomitization.

VII. Porosity:

Very low

VIII: Sedimentary Structures:

Sample No.: ML 2620

I. Classification (Dunham, 1962):

Silty Shale with carbonate caliche nodules.

II. Depositional Environment:

Shallow-water, restricted ponds. Tidal flat environment with high rate of terrigenous influx.

III. Lithofacies (this study): unit 1, base.

Upper Intertidal (unit 1; base).

IV. Wilson's 1975 Facies Model: Facies belt 8.

V. Composition:

A) Mineralogy:

Silt-size quartz; clay; calcite; chert.

B) Inorganic Constituents:

Caliche ($CaCO_3$) nodules.

C) Organic Constituents:

Rare fragments of ostracods and crinoids.

VI. Diagenetic Features:

Replacement by silica, Caliche nodules.

VII. Porosity:

Very low

VIII. Sedimentary Structures:

APPENDIX B

WELL LOGS USED IN CONSTRUCTION OF THE SUBSURFACE MAPS

PART I

FIGURE 1 SHOWING LOCATIONS OF WELLS

USED IN CONSTRUCTION OF THE MAPS

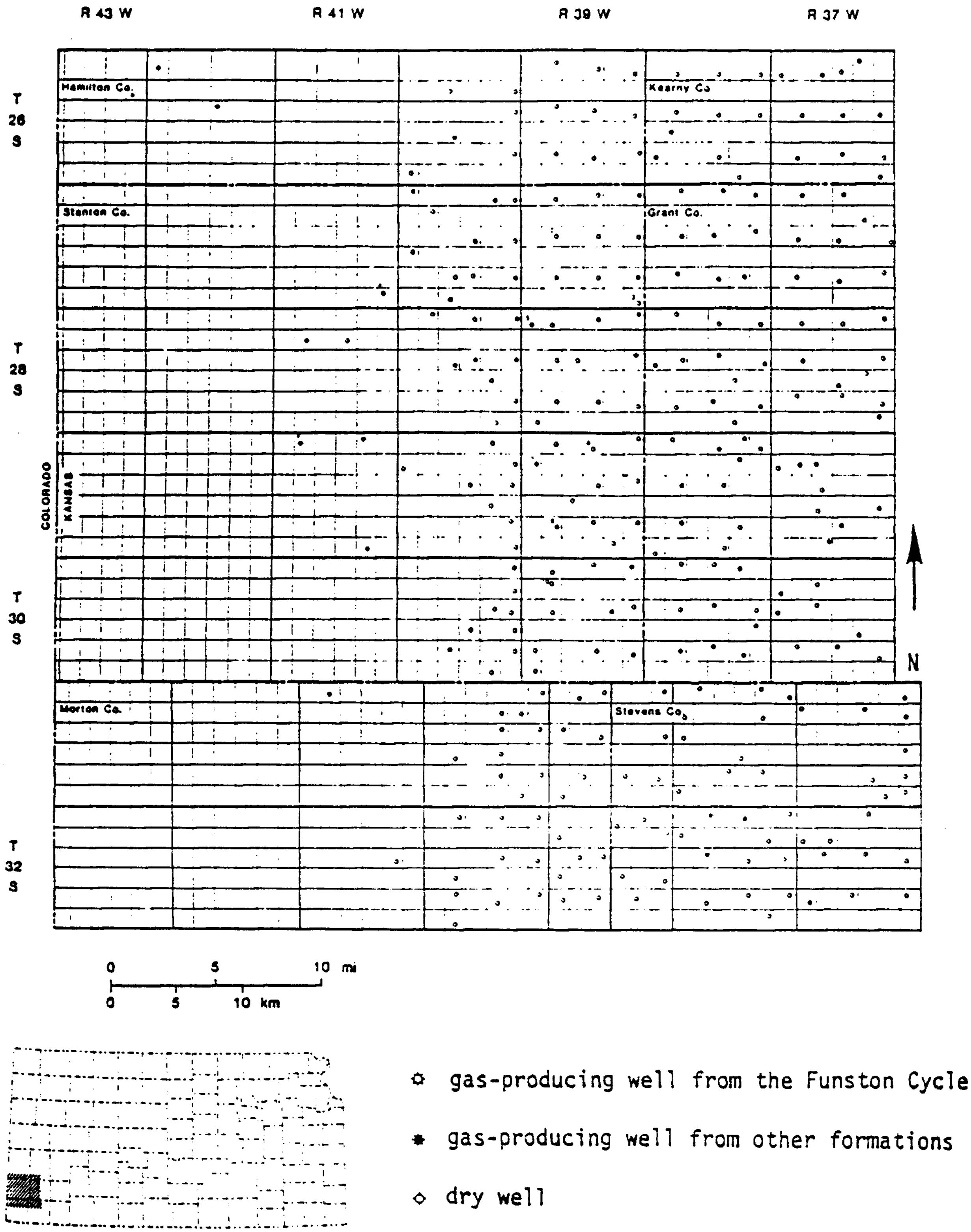


Figure 1. Study area showing locations of wells used in constructing the subsurface maps. Cored wells are indicated by a number on the upper left side.

PART II

TABLE OF DATA FROM WELLS USED IN CONSTRUCTION OF THE SUBSURFACE MAPS

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
1	Kan-Neb. 1-2 Hillyard	C NW 2-26-37W	3056	2660	2686	5	26	2	F
2	Helmerich & Payne 1-A Waechter	C NE NE SW 3-26-37W	3065	2638	2666	4.5	28	1	F
3	Amoco 2-G Waechter	NE SE SE 4-26-37W	3096	2620	2650	6	30	2	F
4	Amoco 2-H Waechter	NE SE SE 6-26-37W	3133	2687	2714	6	27	3	F
5	Mobil & N.N. 5 Lee	C SW 13-26-37W	3112	2731	2758	3.5	27	1	F
6	Amoco 2 Lee	NW SW SE 15-26-37W	3093	2671	2696	4	25	1	F
7	Amoco 2-D O. Waechter	NW SW SE 17-26-37W	3168	2706	2735	4	29	1	F
8	Mobil & N.N. 4 Broadhurst	NW SW SE 25-26-37W	3109	2726	2750	4	24	2	F
9	Shell 1 Broadhurst	C NE SW 27-26-37W	3094	2673	2695	4.5	22	0.5	F
10	Mobil & N.N. 1-D Waechter	C SW 29-26-37W	3141	2716	2744	4.5	28	1	F
11	Mobil #4 Broadhurst	C SW 36-26-37W	3097	2731	2757	4	26	-	F
12	Amoco 2-A McKinney	NW SW SE 1-26-38W	3193	2722	2750	4.5	28	2	F
13	Amoco 2-B McKinney	NW SW SE 3-26-38W	3207	2748	2780	5	32	1.5	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
14	Amoco 2-A L.B. Willts	NW SW SE 5-26-38W	3242	2738	2766	4	28	2	F
15	Amoco 2 Glaser	NE SE SW 13-26-38W	3192	2715	2743	5	28	1.5	F
16	Amoco 2-B L.B. Willits	NW SW SE 15-26-38W	3243	2739	2769	4.5	28	1	F
17	Fogelson et al. #1 Johnson	C NE SW 17-26-38W	3301	2761	2788	5.5	27	1	F
18	Amoco #2 Seitz G.U.	NE NW SW 20-26-38W	3301	2794	2822	5	28	1	F
19	Amoco 2-A McMichael	NE SE SW 27-26-38W	3212	2694	2720	6	26	1	F
20	Amoco #2 Eoual Royalty	NW SW SE 30-26-38W	3262	2712	2738	6	26	2	F
21	Amoco 2-B Burden G.U.	NW SW SE 35-26-38W	3139	2662	2691	5	29	1.5	F
22	Amoco 2-B Zook G.U.	NE SE SW 1-26-39W	3300	2750	2778	4.5	28	2	F
23	Ashland 3-3 Brothers	C N2 SE 3-26-39W	3325	2752	2785	4	23	1	F
24	Ashland 2-5 Barney Akers	C S2 NE 5-26-39W	3400	2778	2811	4	33	1	F
25	Amoco #2 Finnup	NE SE SW 13-26-39W	3329	2778	2804	5.5	26	1	F
26	Amoco 2-B Stuckey	SW SW NE 15-26-39W	3349	2752	2780	4	28	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
27	Ashland 2-17 Stuckey	C NE 17-26-39W	3373	2732	2765	4	33	2	F
28	Amoco 2-B McDonald	SW SE NE 25-26-39W	3299	2763	2792	6	29	2	F
29	Amoco 2-B H. Russell	NE SE SW 27-26-39W	3279	2672	2698	4.5	26	2	F
30	Amoco 2-D Trussel G.U.	NW NE SE 29-26-39W	3303	2671	2702	4	31	1.5	F
31	Amoco #1 Schmidt	NW NW SE 9-26-40W	3449	2778	2814	3	36	2	D
32	Ashland 2-12 Bray	50 N of C E2 12-26-40W	3413	2810	2845	4	35	2	F
33	Ashland 1-13 Denham	50 N of C E2 13-26-40W	3398	2767	2801	3	34	1	F
34	Kansas Pet. #1 Stephens	C SE 21-26-40W	3387	2758	2790	5	32	2	P
35	Ashland 5-25 Heltemes	C E2 25-26-40W	3331	2692	2724	5	32	3	F
36	Amoco #1 Melvin Combs	C SW NE 31-26-40W	3312	2551	2578	6	27	1	F
37	Ashland 1-6 Hughes	SE SE NW 6-26-42W	3463	2462	2502	4	40	-	D
38	Colorado #1 White	C NW 15-26-42W	3427	2480	2519	4	39	-	D
39	Colorado #1 Cornwell	C SW 12-26-43W	3500	2458	2498	4	40	-	D

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
40	Mobil & N.N.G.P. #2 Evans	SW SW NE 3-27-37W	3088	2678	2702	6	24	2	F
41	Mobil & N.N.G.P. #3 Thorpe	NW NW SE 5-27-37W	3088	2650	2676	5	26	2	F
42	Mobil #2 Robert Moore	NE SE SW 11-27-37W	3100	2684	2707	5	23	3	F
43	Mobil #1 Irma Smith	C NW SE SE 13-27-37W	3064	2667	2688	6	31	2	F
44	Mobil & N.N.G.P. #3 Canary	C SW 15-27-37W	3081	2659	2682	6	23	2	F
45	Mobil & N.N.G.P. 1-A Nusser	C SW 17-27-37W	3077	2645	2670	8	25	4	F
46	Mobil #2 Metherd	C N2 25-27-37W	3030	2651	2670	5	19	2.5	F
47	Mobil & N.N.G.P. #2 Fowler	C SW 27-27-37W	3075	2660	2684	6	23	2	F
48	Amoco #2 Williams	NE NE SW 29-27-37W	3080	2655	2680	6	25	1.5	F
49	Amoco 2-C Beymer	NE NW SW 1-27-38W	3111	2642	2670	6	28	1	F
50	Atl. Richfield 2 Frank Schmitz	C NE 3-27-38W	3170	2672	2701	5.5	29	2	F
51	Atl. Richfield 2 Dora Wright	C NE 5-27-38W	3190	2658	2687	5	29	2	F
52	Atl. Richfield 2 Hattie Anderson	C NW 13-27-38W	3099	2648	2675	5.5	27	1.5	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
53	Amoco #2-B Rider G.U.	NE SE SW 15-27-38W	3131	2642	2671	6	29	1.5	F
54	Amoco #2 Waldie	NW NE SE 17-27-38W	3132	2624	2651	6	27	2	F
55	Amoco #2 Shorter	NW NE SE 26-27-38W	3104	2652	2678	6	26	1	F
56	Atl. Richfield #2 Tillie Clow	SE NE SW 27-27-38W	3108	2625	2653	6	28	2	F
57	Atl. Richfield 2-A Sadie Marshal	NW SW NE 29-27-38W	3131	2604	2631	6	27	1.5	F
58	Amoco 2-D Molz G.U.	NW NE SE 1-27-39W	3200	2610	2638	6	28	2	F
59	Amoco 4-A Fegan	NW NE SE 3-27-39W	3241	2637	2667	4	30	1	F
60	Amoco #2 Smith	C SE 5-27-39W	3233	2596	2621	5	25	2	F
61	Amoco 2-A Mater G.U.	NW NE SE 13-27-39W	3172	2597	2624	5	27	2	F
62	Amoco #2 Walters	NW NE SE 15-27-39W	3166	2562	2588	6	26	2	F
63	Amoco 2-E Moore G.U.	NW NE SE 17-27-39W	3182	2544	2570	6	26	1	F
64	Amoco 2-B Molz	SW SE NE 25-27-39W	3157	2609	2634	5	25	1	F
65	Amoco 2-A Molz	NW NE SE 27-27-39W	3158	2567	2592	6	25	2	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
66	Amoco #2 Federal Farm	SW SE NE 29-27-39W	3185	2546	2570	5	24	1	P
67	Amoco #2 Endsley	C SE 36-27-39W	3132	2583	2608	4	25	1	F
68	Atl. Richfield 2 WN Vath Unit	C SE 1-27-40W	3280	2600	2624	5	24	1	F
69	Atl. Richfield 2 WN	C SE 2-27-40W	3255	2554	2581	5	27	1.5	F
70	Kansas Petroleum #1 Holmes	C NE 6-27-40W	3253	2484	2510	6	26	-	P
71	Amerex Inc. #1 Swisher	C NE 8-27-40W	3244	2498	2525	6	27	-	D
72	Atl. Richfield #2 Brown G.U.	C SE 13-27-40W	3198	2505	2535	5	30	1	F
73	Atl. Richfield #2 Shell Winger	C SE 15-27-40W	3227	2487	2518	6	31	-	P
74	Inter-American #1 Lane	C NE 19-27-40W	3280	2476	2508	5	32	3.0	F
75	Amoco 2-D Winger	NW NE SE 25-27-40W	3214	2523	2547	6	24	4	F
76	Ashland Expl. 7-27 Winger	CE2 SW NE 27-27-40W	3242	2505	2531	7	26	3	F
77	Ashland Expl. 9-28 Winger	C E2 28-27-40W	3255	2509	2534	5	25	1	F
78	Ashland Expl. 10-33 Winger	C NW SE 33-27-40W	3273	2497	2521	6	24	2	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
79	Amoco #1 Cross	C NW 36-27-41W	3315	2479	2506	5	27	1	P
80	Mobil #2 Barns	NW NW SE 1-28-38W	3030	2657	2678	6	23	1.5	F
81	Amoco #2 Fogarty	NE SE SW 3-28-38W	3064	2672	2694	6	22	1.5	F
82	Amoco 2-A Hoffman	NE SE SW 5-28-37W	3082	2668	2693	6	25	1	F
83	Anadarko 1-A Cassity	C SE NW 13-28-37W	3000	2630	2650	7	20	2	F
84	Kirby Petroleum #2 Whitson	C NW SE 17-28-37W	3071	2670	2693	5	23	-	F
85	Anadarko 1-B Hall	C SW 22-28-37W	3055	2674	2697	6.5	23	4	F
86	Anadarko 3-A Dyck	C NW NE 23-28-37W	2985	2624	2651	5	27	3	D
87	Anadarko 3-A Patterson	C NE SW 25-28-37W	3018	2671	2691	5.5	20	2	F
88	Peoples Natural Gas 1-2A Ulysses	C NE NW 27-28-37W	3060	2682	2703	6	21	3	F
89	Anadarko 1-A Hart	C NW 29-28-37W	3082	2696	2718	5	22	1	F
90	Anadarko 1-A Smith Estate	C NW 36-28-37W	3020	2711	2732	5.5	21	2	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
91	Amoco 2-A Sturgeon	NE SE SW 1-28-38W	3093	2649	2675	6	26	2	F
92	Amoco #2 Cudney	NE SE SW 3-28-38W	3103	2633	2658	6.5	25	2	F
93	Amoco 2-A Wilson	NE SE SW 5-28-38W	3142	2619	2647	5.5	28	2	F
94	Amoco 2-C Newby	C SE 13-28-38W	3084	2652	2676	6	24	2	F
95	Amoco #2 McLaughlin	NE SE SW 15-28-38W	3103	2616	2642	5.5	26	1.5	F
96	Amoco #2-B Wilson	SW SE NE 17-28-38W	3126	2600	2629	5	29	1	F
97	Amoco #2 Dyck	NE SE SW 18-28-38W	3128	2590	2617	6	27	2	F
98	Amoco 2-D Sturgeon	SE SW NW 23-28-38W	3081	2613	2636	6	23	4	F
99	Amoco #2 Thompson	NE SE SW 25-28-38W	3097	2680	2702	5.5	22	2	F
100	Amoco #2 Leigh	NE NW SW 27-28-38W	3122	2662	2686	6	24	5	F
101	Amoco #2 Johnson	NE SE SW 29-28-38W	3130	2645	2671	6	26	3	F
102	Amoco 2-A Porter	NE NW SW 35-28-38W	3109	2654	2676	6	22	2	F
103	Atl. Richfield 2-A Pinegar	C NE 1-28-39W	3133	2568	2593	5	25	2.5	P

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
104	Amoco #2 Moncur	NW NE SE 3-28-39W	3164	2559	2584	6	25	2.5	F
105	Amoco 2-A Winger	NE SE SW 5-28-39W	3189	2543	2566	7	23	6	F
106	Amoco 2-A Piper	NE SE SW 6-28-39W	3205	2533	2553	7	20	3	P
107	Atl. Richfield #2 Robert Crary	C W2 W2 NE 13-28-39W	3137	2562	2588	5	26	2	P
108	Amoco #2 Surgeon	NW NE SE 16-28-39W	3164	2524	2549	5	25	1.5	F
109	Amoco #2 Horner	NW NE SE 17-28-39W	3185	2535	2558	6	23	2	F
110	Atl. Richfield #3 Phillipi	C SE 25-28-39W	3134	2623	2649	5.5	26	2	F
111	Amoco #2 Scrogum	NW NE SE 27-28-39W	3173	2554	2579	5	25	2.5	F
112	Amoco 1-C Welch	SW SE NE 29-28-39W	3179	2524	2547	5	23	4	F
113	Amoco 2-A Campbell	SW SE NE 31-28-39W	3222	2582	2602	6	20	4	F
114	Amoco #2 Richards	NW NE SE 1-28-40W	3217	2517	2538	7	21	3	F
115	Champlin #2 Winger	NW NE SE 3-28-40W	3245	2508	2530	8	22	4.5	F
116	Graham-Mich. 2-D Plummer	C NE 5-28-40W	3291	2507	2532	6.5	25	6	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
117	Amoco 2-A Richards	SW SE NE 13-28-40W	3240	2540	2560	6	20	3	F
118	Amoco 2-K Baughman	NW NE SE 15-28-40W	3259	2510	2530	6	20	-	P
119	Beren Corp. #1 Bushart	C SE 16-28-40W	3270	2499	2520	8	21	5	P
120	Amoco #2 Puyer	NW SE 23-28-40W	3260	2527	2544	6	17	4	F
121	Atl. Richfield #2 Josserand	C E2 25-28-40W	3230	2530	2549	7	19	2	F
122	Amoco #2 Dimitt	NW NE SE 35-28-40W	3262	2577	2594	4.5	17	2.5	D
123	Amoco #1 Cockrum	NW NW SE 8-28-41W	3381	2456	2481	5.5	25	6	D
124	Amoco L.W. Canny	SW NW SE 10-28-41W	3368	2481	2508	6	27	6	D
125	Mesa 2-7 Sullivan	SW NE SW 7-29-37W	3030	2658	2680	5	22	1	F
126	Mesa 2-8 Sullivan	C E2 W2 8-29-37W	3078	2698	2718	4	20	1.5	F
127	Mesa #2 Luther	NE NW SW 9-29-37W	3090	2726	2746	5	20	-	F
128	Mesa 2-16 Smith	NE SE SW 16-29-37W	3070	2700	2718	8	18	1	F
129	Mesa 2-21 Campbell	C SW 21-29-37W	3097	2717	2738	7	21	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
130	Ashland #3 Kirmayer	C N2 SW 24-29-37W	3071	2764	2782	7	18	-	F
131	Hugoton #2 Eichenberger	C SE NW 27-29-37W	3063	2704	2724	5	20	2	F
132	Hugoton #2 Hindmarsh	C NE NE 33-29-37W	3075	2721	2740	4	19	1.5	P
133	Amoco 2-B Sullivan	C S2 1-29-38W	3096	2668	2688	5	20	3	F
134	Atl. Richfield #2-A Hickok	C NE 2-29-38W	3122	2660	2682	5	22	2	F
135	Amoco #2 Lawrence	NW SW SE 3-29-38W	3116	2656	2680	5	24	2	F
136	Amoco 2-B Goertzen	SE NW 5-29-38W	3135	2621	2644	4.5	23	1	F
137	Atl. Richfield 1-B Hickok	E2 E2 NW 11-29-38W	3099	2654	2676	6	22	3.5	F
138	Amoco #2 Hoffman	N2 N2 SE 15-29-38W	3113	2674	2697	6.5	23	4.0	F
139	Amoco #2 Jennings	C E2 17-29-38W	3130	2650	2675	7	25	2	F
140	Atl. Richfield 2-E Hickok	SW SW NE 26-29-38W	3103	2651	2672	7	21	4	F
141	Atl. Richfield #2 Loewen	C NE 29-29-38W	3135	2622	2644	8	22	4	F
142	Amoco 2-C Johnson	NE SE SW 31-29-38W	3140	2630	2650	11	20	3	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
143	Amoco #2 Brasfield	NW NE SE 34-29-38W	3076	2614	2636	7	22	2	F
144	Atl. Richfield #2 C. Calvert	C NE 1-29-39W	3125	2586	2608	5	22	-	F
145	Amoco #2 Neufeldt	NE SE SW 3-29-39W	3181	2606	2627	6	21	-	F
146	Amoco 2-B Davis	NW NE SE 5-29-39W	3221	2604	2625	7.5	21	1.5	F
147	Amoco 2-A Montgomery	NW NE SE 7-29-39W	3230	2569	2587	7	18	4	P
148	Atl. Richfield 1-A Fred Shore	C NE 13-29-39W	3144	2618	2644	7	26	1.5	F
149	Amoco 2-A Jones	SE SW NE 15-29-39W	3188	2600	2622	8	22	2	F
150	Amoco 2-C Fed. Land Bank	SW SE NE 21-29-39W	3199	2577	2598	8	21	-	F
151	Atl. Richfield #2 Williams	C NE 25-29-39W	3126	2572	2596	8.5	24	4	F
152	Amoco #2 Fell	C N2 27-29-39W	3201	2594	2616	8	22	4	F
153	Amoco #2 Myler	NW NE SE 29-29-39W	3210	2565	2586	7.5	21	5.5	P
154	Amoco #2 Fizzell	C N2 35-29-39W	3173	2590	2612	10	22	5	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
155	Amoco #2 Collingwood	NW NE SE 2-29-40W	3265	2558	2576	9	18	6	F
156	Amoco 1-B Trostle	C SW 7-29-40W	3324	2517	2534	8	17	4	D
157	Amoco 2-C Julian	NW NW SE 12-29-40W	3244	2560	2578	8	18	6	F
158	Amoco #2 Grisell	NW SE 13-29-40W	3240	2544	2564	8	20	5	F
159	Amoco #2 Kelman	C SE 15-29-40W	3269	2512	2537	9.5	25	6	F
160	Amoco #1 Bennett	NW NW SE 23-29-40W	3260	2528	2545	9	17	7	F
161	Amoco 2-G Collingwood	NE SE NW 25-29-40W	3242	2550	2570	6	20	4	D
162	Amoco #2 Holt	SW SE NE 36-29-40W	3243	2547	2570	6	23	3	F
163	Amoco 1-A Arnold	C NW 2-29-41W	3368	2498	2521	4	23	1	D
164	Amoco #1 Armstrong	C W2 5-29-41W	3429	2504	2518	5	14	-	D
165	Amoco #1 Cullers	C NW SE 35-29-41W	3374	2432	2452	8	20	2	D
166	Mesa 2-7 Cornwell	NW SW SE 7-30-37W	3133	2723	2744	6	21	1	F
167	Mesa 2-9 Tuttle	C NW 9-30-37W	3103	2733	2754	6	21	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
168	Mesa 2-16 Bosser	NW SE NW 16-30-37W	3105	2747	2766	8	19	-	F
169	Mesa 2-18 Gorman	SW NE SW 18-30-37W	3124	2749	2769	7	20	-	F
170	Saturn O&G 1-B Towler	C SW 23-30-37W	2980	2664	2681	7	17	1	F
171	Saturn O&G 1-G Parsons	NE NW SW 25-30-37W	3047	2741	2759	6	18	1	F
172	Saturn 1-A Towler	C NW 27-30-37W	2998	2683	2702	6.5	19	2	F
173	Saturn 1-B Brollier	C NW 29-30-37W	3107	2768	2790	7	22	1	F
174	Atl. Richfield #2 Ralf Kepley	SW SW NE 2-30-38W	3128	2690	2712	5	22	2	P
175	Atl. Richfield #2 Ball	C NW 3-30-38W	3122	2656	2677	5	21	-	F
176	Atl. Richfield 2-C Kepley	C NE 5-30-38W	3123	2639	2658	8	20	-	F
177	Mesa 2-13 Hennigh	N2 N2 SW 13-30-38W	3140	2734	2760	7	26	1	F
178	Mesa 2-15 Scully	C NW 15-30-38W	3153	2722	2745	4	23	1	F
179	Amoco #2 Hein	C E2 17-30-38W	3127	2666	2691	5	25	1	F
180	Atl. Richfield 2-D Kepley	C NW 24-30-38W	3143	2747	2767	6.5	20	3	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
181	Mesa 2-26 Witt	NE SW SE 26-30-38W	3160	2778	2801	4.5	23	-	F
182	Mesa 2-27 Parr	C NW 27-30-38W	3144	2726	2751	5	25	1	F
183	Amoco #2 Weeks	SW SE NE 29-30-38W	3142	2704	2728	4	24	2	P
184	Pan America Julian	C SE NW 1-30-39W	3168	2622	2644	8	22	1	P
185	Amoco 2-A Julian	SW NW NE 3-30-39W	3176	2578	2604	5	26	3.5	F
186	Amoco #2 Shipman	NW SW SE 5-30-39W	3221	2588	2615	6	27	2.5	F
187	Amoco #2 Luke G.U.	C N2 8-30-39W	3224	2604	2634	4.5	30	0.5	F
188	Amoco 2-A Copper	SE NE NW 13-30-39W	3169	2653	2680	6	27	3.5	F
189	Pan American 1-D Nicholas	C NE SW 14-30-39W	3169	2638	2666	4	28	1	P
190	Amoco #2 Switzer	NW SW SE 17-30-39W	3213	2604	2633	4	29	3	F
191	Amoco 2-A Cobb	NE SE SW 25-30-39W	3168	2686	2715	4	29	1	F
192	Amoco 2-A Sentney	NW NE SE 27-30-39W	3178	2636	2668	4	32	2	F
193	Amoco #2 Collingwood	NW NE SE 30-30-39W	3222	2624	2653	5.5	29	3	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
194	Amoco #3 Dietz	NW NE SE 31-30-39W	3238	2671	2700	4	29	2	F
195	Amoco #2 Verning	NE NW SE 1-30-40W	3259	2571	2598	6	27	2	F
196	Amoco #2 Sprunger	C N2 SE 12-30-40W	3249	2579	2605	5	26	1	F
197	Amoco 2-B Koenig	NW SW SE 13-30-40W	3237	2561	2589	5	28	1.5	F
198	Amoco #2 Isreal	N2 N2 SE 14-30-40W	3255	2549	2578	5	29	2	F
199	Amoco #2 Lindsley	S2 S2 NE 22-30-40W	3274	2533	2561	4	28	2	F
200	Amoco 2-B Hinshaw	NW NE SE 24-30-40W	3230	2578	2607	4.5	29	1.5	F
201	Amoco 2-A Parks	SE SE 25-30-40W	3238	2591	2618	4	27	1	F
202	Pan American # Herrick	C SW NE 28-30-40W	3304	2503	2530	4	27	-	P
203	Amoco 1-D Park	NW NW SE 35-30-40W	3268	2546	2575	4.5	29	1	F
204	Mobil #2 Bollier	C SW 1-31-37W	3084	2824	2841	5	17	0.5	F
205	Panhandle-East #1 Perrill	C NW NW 7-31-37W	3104	2720	2740	8	20	1.5	F
206	Saturn 1-A Parsons	C NW 10-31-37W	3058	2764	2791	5	27	2	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
207	Mobil 2-B Kenoyer	NE SW SW 12-31-37W	3082	2837	2854	5	17	1	F
208	Mobil #2 Kenoyer	C NW 24-31-37W	3087	2865	2882	8	17	1	F
209	Mobil #2 Miller	SE SW NW 25-31-37W	3093	2870	2889	7	19	1.5	F
210	Anadarko 1-A Lightcap	C SE 27-31-37W	3094	2848	2868	5	20	2	F
211	Mobil #2 Lemert	SE SW NW 35-31-37W	3102	2872	2893	7	21	1	F
212	Mobil #2 Blackmer 1	C NW 36-31-37W	3093	2875	2986	7	21	0.5	F
213	Hugoton #2 Mason	NW SE SE 1-31-38w	3123	2753	2773	7	20	1	F
214	Mesa 2-2 Tuttle	C NW 2-31-38W	3110	2774	2798	5	24	1	F
215	Amoco 2-A Witt	SE NE NW 5-31-38W	3170	2774	2797	4	23	1	F
216	Amoco 2-A Security	NW SW SE 7-31-38W	3182	2797	2821	5	24	1.5	F
217	Mesa 3-11 Gray	NW SE SW 11-31-38W	3019	2652	2672	6	20	2	F
218	Amoco 2-E Security	NE SE SW 18-31-38W	3183	2699	2720	7	21	4	F
219	Kansas #2 Leonard	C SW 22-31-38W	3139	2762	2785	5	23	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
220	Anadarko #2 Schowalter	C NW 26-31-38W	3140	2761	2782	4	21	2	F
221	N.H. Wheless 2-C Leonard	C NE 28-31-38W	3135	2750	2774	4	24	-	F
222	Mesa 2-31 Cavner	SW NE SW 31-31-38W	3124	2656	2683	4	27	1	F
223	Pan American 1-B Joslin	C SW NE 1-31-39W	3186	2744	2770	4	26	-	F
224	Amoco 2-B Baker	S2 S2 NE 4-31-39W	3198	2693	2724	5	31	2	F
225	Amoco 2-B Montgomery	NE SE SW 5-31-39W	3209	2684	2715	4	31	1.5	F
226	Amoco 28-C Security El.	NW SE SE 13-31-39W	3203	2699	2725	4	26	3	F
227	Amoco 2-A Daniels	NW SW SE 16-31-39W	3210	2666	2696	4	30	0.5	F
228	Amoco 2-B Daniels B	C NE 18-31-39W	3227	2676	2704	5	28	1	F
229	Anadarko 2-B Simmons	SE NW SW 25-31-39W	3185	2688	2716	4	28	-	D
230	Amoco 2-D Security El.	NW NE SE 27-31-39W	3208	2696	2716	4.5	20	1	F
231	Amoco 1st State Bank	NW NE SE 29-31-39W	3256	2681	2706	3.5	25	2	F
232	Amoco 2-B Milburn	SW SE NE 31-31-39W	3256	2686	2715	4	39	2	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
233	Amoco Brehm	NW NE SE 1-31-40W	3246	2700	2728	3.5	28	1	F
234	Amoco 2-A Smith	C SW NE 10-31-40W	3306	2596	2629	5	33	2	F
235	Amoco #2 Keller	SW SE NE 11-31-40W	3276	2693	2724	3	31	-	F
236	Amoco 2-A Allen	C E2 12-31-40W	3239	2686	2713	5	27	1	F
237	Amoco #2 Bond	NW SW NE 13-31-40W	3246	2625	2652	3	27	-	F
238	Amoco 2-B Northcutt	C E2 14-31-40W	3276	2629	2659	4	30	1	F
239	Amoco 2-B Atkinson	C NE 15-31-40W	3300	2581	2612	5	31	1	F
240	Amoco #2 Brees	W2 W2 SE 20-31-40W	3333	2461	2494	3	33	1	F
241	Amoco 2-A Wratil	C E2 22-31-40W	3302	2569	2598	5	29	2	F
242	Amoco 2-A Lutz	C E2 23-31-40W	3286	2636	2664	4	28	1	F
243	Amoco 2-A Breeding	C E2 24-31-40W	3258	2636	2661	4	25	0.5	F
244	Amoco 2-B "KU"	NW NE SE 25-31-40W	3245	2642	2667	3.5	25	1	F
245	Amoco #2 Swanson	C E2 26-31-40W	3293	2650	2675	3.5	25	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
246	Amoco #2 Winter	S2 S2 NE 27-31-40W	3310	2580	2608	3.5	28	2	F
247	Amoco 2-A Cowan	C E2 34-31-40W	3301	2604	2634	4	30	1	F
248	Amoco #2 Hayword	C E2 35-31-40W	3281	2646	2678	4	32	0.5	F
249	Pan American #1 Richardson	C NE SW 5-31-41W	3419	2453	2484	6	31	-	D
250	Mobil #2 Riney	SE NE NW 3-32-37W	3118	2880	2902	6	22	1	F
251	Mobil #2 Webber	C SW 7-32-37W	3161	2862	2886	5	24	1.5	F
252	Mobil #2 Moorhead	C SE 8-32-37W	3175	2913	2936	5	23	1	F
253	Mobil #1 Wilson	C SW 13-32-37W	3126	2936	2958	6	22	1.5	D
254	Mobil #3 Ellis	C NW 15-32-37W	3131	2918	2941	5.5	23	1	F
255	Anadarko I-A Grubbs	SE NW NW 17-32-37W	3160	2906	2931	4	25	1.5	F
256	Mobil #2 Baker	C NW 25-32-37W	3121	2902	2926	6	24	1	F
257	Mobil #1 Madden	C NE 28-32-37W	3153	2891	2915	6	24	1	F
258	Mobil #1 Great American	C SE 30-32-37W	3163	2881	2910	4.5	29	1	P

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
259	Mobil #1 F. Dold	C NE 1-32-38W	3156	2828	2854	5	26	1.5	F
260	Anadarko 2-B Leonard	C NE SW 3-32-38W	3172	2810	2835	4.5	25	-	P
261	Anadarko 2-A Curtis	C SE NE 5-32-38W	3161	2770	2796	4	26	1	P
262	Mesa 2-7 Youngren	NW SE SW 7-32-38W	3151	2726	2752	4	26	2	F
263	Mobil #2 Republic Fee	C SE 11-32-38W	3170	2836	2865	3	29	-	F
264	Anadarko 1-A Keefer	NE SW SW 13-32-38W	3155	2860	2886	4	26	2	D
265	Anadarko 1-A James	C SE 15-32-38W	3173	2846	2875	5	29	1	F
266	Anadarko 1-F McClure	C NE 17-32-38W	3199	2804	2832	4	28	0.5	P
267	Mobil #2 Crawford	C NE 25-32-38W	3171	2876	2902	5	26	1	F
268	Mobil #2 Roach	C NE 27-32-38W	3206	2868	2895	6	27	1.5	F
269	Mobil #2 Gustason	C SE 29-32-38W	3211	2810	2840	4	30	1	F
270	Mobil #3 WRD	C NE 35-32-38W	3179	2857	2884	4	27	1	F
271	Anadarko 2-A Vanselons	NW SE SE 2-32-39W	3199	2703	2734	6	31	1	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
272	Mesa 2-34 Close	SE SW SW 3-32-39W	3231	2700	2727	4	27	1	F
273	Cities Service 3-A Renshaw	NW NW SE 7-32-39W	3291	2715	2742	5	27	1	F
274	Anadarko 1-A Ford	SW NE NE 12-32-39W	3108	2648	2775	4.5	27	1	D
275	Anadarko 1-D Simmonds	SE NE 16-32-39W	3250	2719	2742	4	23	2	F
276	Cities Service 2-A Lantaret	C Section 17-32-39W	3272	2708	2738	4	30	1	F
277	Amoco 2-B Tillett	C NE 19-32-39W	3257	2673	2703	3.5	30	1	F
278	Anadarko 1-B Rinehart	SW NE 22-32-39W	3210	2706	2737	4	31	1.5	F
279	Anadarko 1-C Hayward	NW SE SE 24-32-39W	3211	2783	2813	4	30	1.5	F
280	Anadarko 1-B Stecher	C W2 26-32-39W	3148	2684	2712	5.5	28	2	F
281	Amoco 2-C Drew	C SE NW 28-32-39W	3164	2667	2698	4	31	2	F
282	Amoco 2-A Santa Fe	NW NE SE 30-32-39W	3187	2630	2658	3.5	28	0.5	F
283	Cities Service 3-A Drew	SE SE NW 1-32-40W	3285	2673	2702	3.5	29	0.5	F
284	Amoco 2-13 Hayward	C S2 2-32-40W	3301	2670	2700	5	30	1.5	F

No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
285	Amoco 3-C "KU"	C S2 S2 NE 3-32-40W	3279	2532	2561	4	29	2	F
286	Amoco #2 Drew	N2 N2 SE 5-32-40W	3334	2481	2510	4	29	2	F
287	Amoco 2-B Johnson	C E2 10-32-40W	3320	2570	2594	4.5	24	0.5	F
288	Amoco 2-A Miles	C S2 11-32-40W	3313	2668	2694	4.5	26	1	F
289	Cities Service 3-A French	C Section 12-32-40W	3297	2690	2713	5	27	1	F
290	Amoco 2-B Fid. Savings	NE SE SW 13-32-40W	3303	2700	2727	5	27	3	F
291	Amoco 2-A Kelly	C N2 14-32-40W	3319	2694	2721	4.5	27	1	F
292	Amoco 2-B Light	S2 S2 NE 15-32-40W	3338	2551	2576	4	25	2	F
293	Amoco #2 Cargill	NE SE SW 20-32-40W	3356	2524	2549	4	25	1	F
294	Amoco 2-A Light	C S2 21-32-40W	3354	2530	2556	3.5	26	1	F
295	Amoco 2-D Baker	C N2 22-32-40W	3339	2530	2555	4	25	1	F
296	Amoco #2 Tennis	C E2 23-32-40W	3309	2701	2727	5	26	1	F
297	Amoco 2-B Bonham	C N2 24-32-40W	3294	2692	2716	4	24	1	F

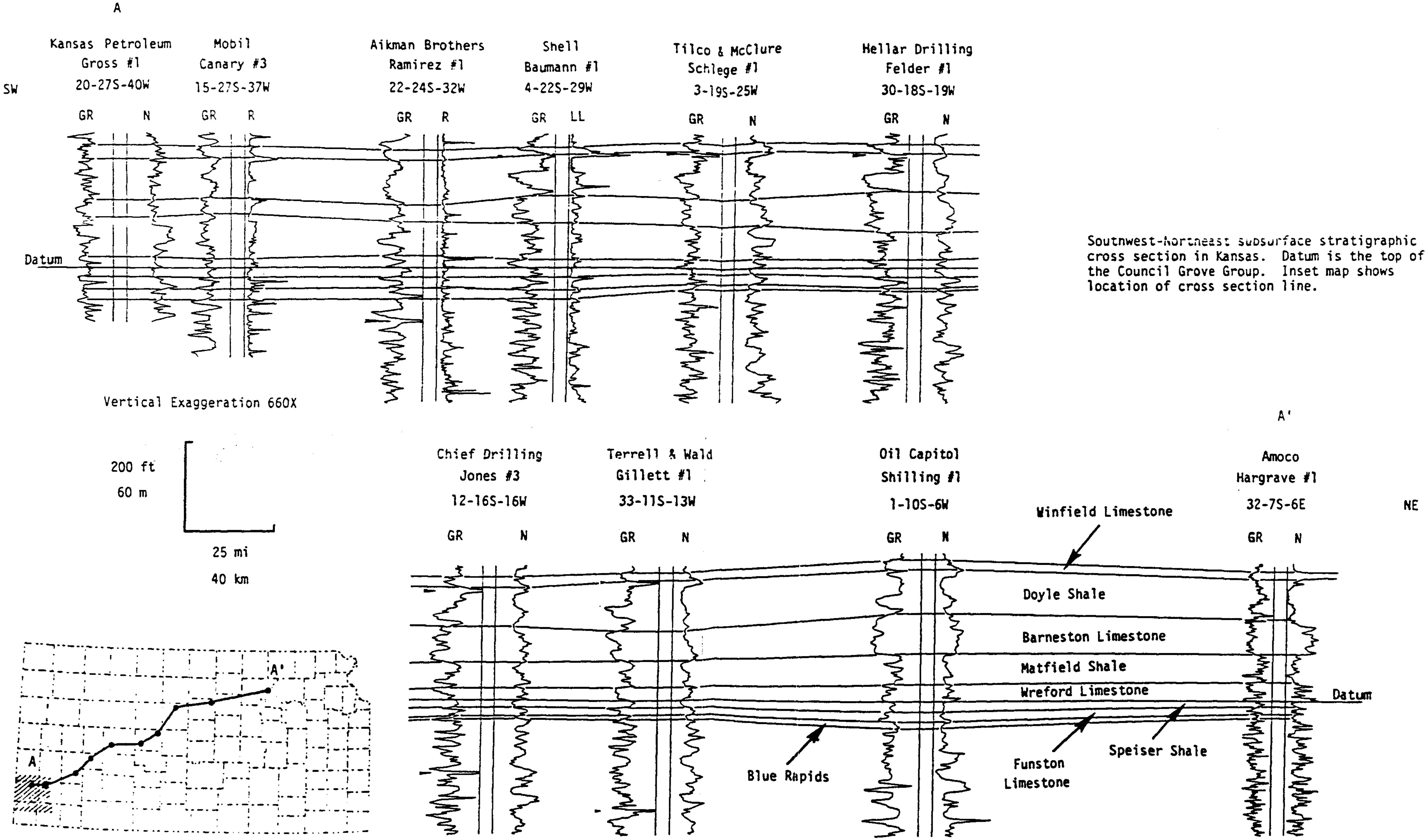
No.	Well Name	Spot Location	Kelly Bushing (ft.)	Top Council Grove (ft.)	Top Funston (ft.)	Thickness of U. Carb. Unit (ft.)	Thickness of Speiser (ft.)	Porosity-Thickness in U. Carb. Unit (ft.)	Well Status
298	Amoco 2-C White	NW SW NE 25-32-40W	3217	2628	2659	3.5	31	1	F
299	Amoco #2 Speakman	C NE 26-32-40W	3254	2648	2674	5	26	1	F
300	Amoco 2-B Myers	NW SW SE 27-32-40W	3346	2556	2582	4	26	2	F
301	Amoco #2 Hayward	NE NE SW 28-32-40W	3360	2556	2580	4.5	26	1	F
302	Amoco 2-A Myers	SW NW NE 29-32-40W	3365	2548	2574	3	26	1	F
303	Anadarko 1-B Krey	NW SW SE 32-32-40W	3367	2584	2614	4	30	1	F
304	Anadarko 1-B Myers	SW NE NE 33-32-40W	3321	2548	2573	5	25	1	F
305	Amoco 2-A Drew	C E2 36-32-40W	3247	2681	2710	5	29	3	F
306	Amoco 2-E "KU"	C SE 14-32-41W	3387	2468	2497	2.5	29	1	F

Abbreviations:

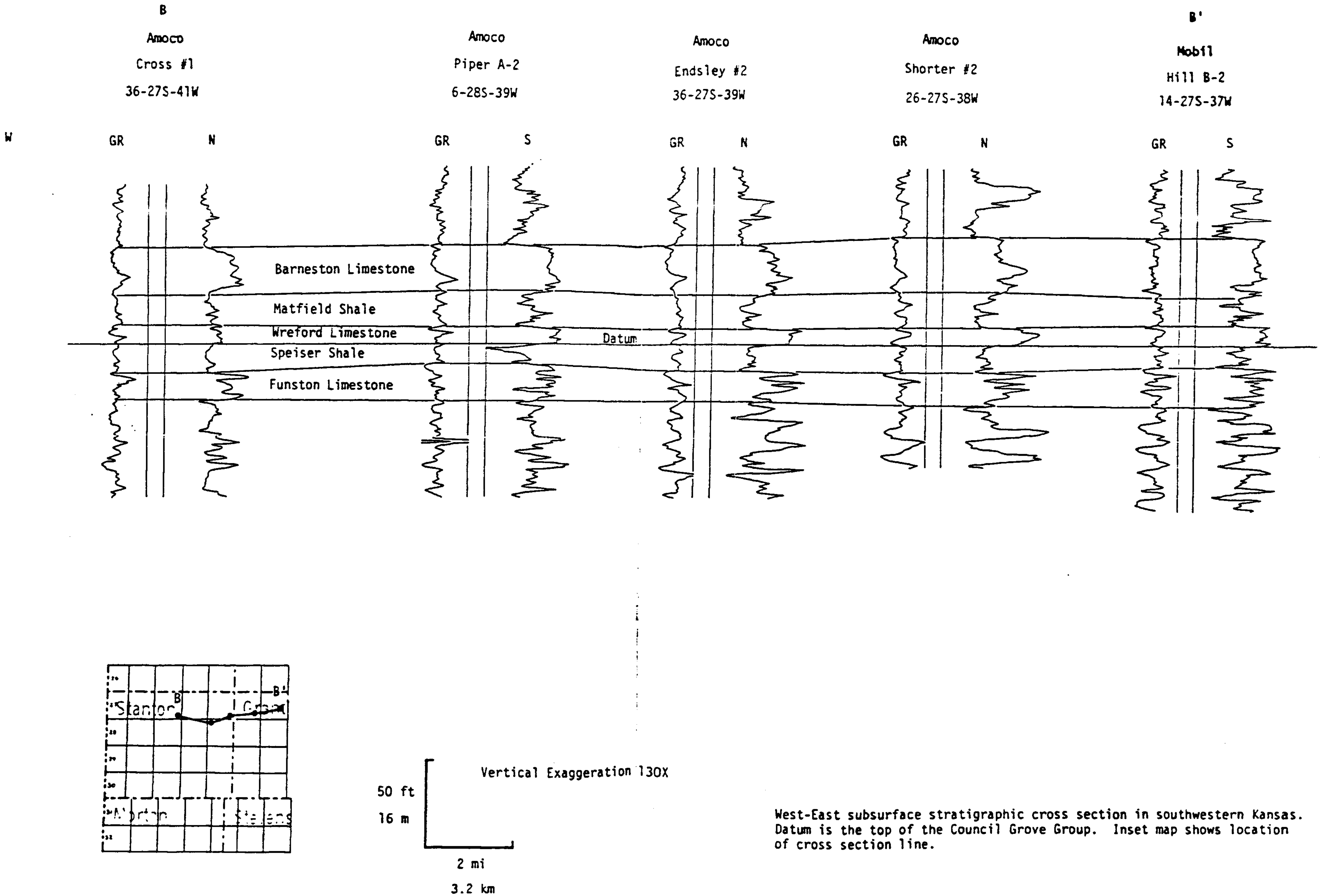
F: Producing from the Funston Cycle.

P: Producing from other formations above and below the Funston Cycle.

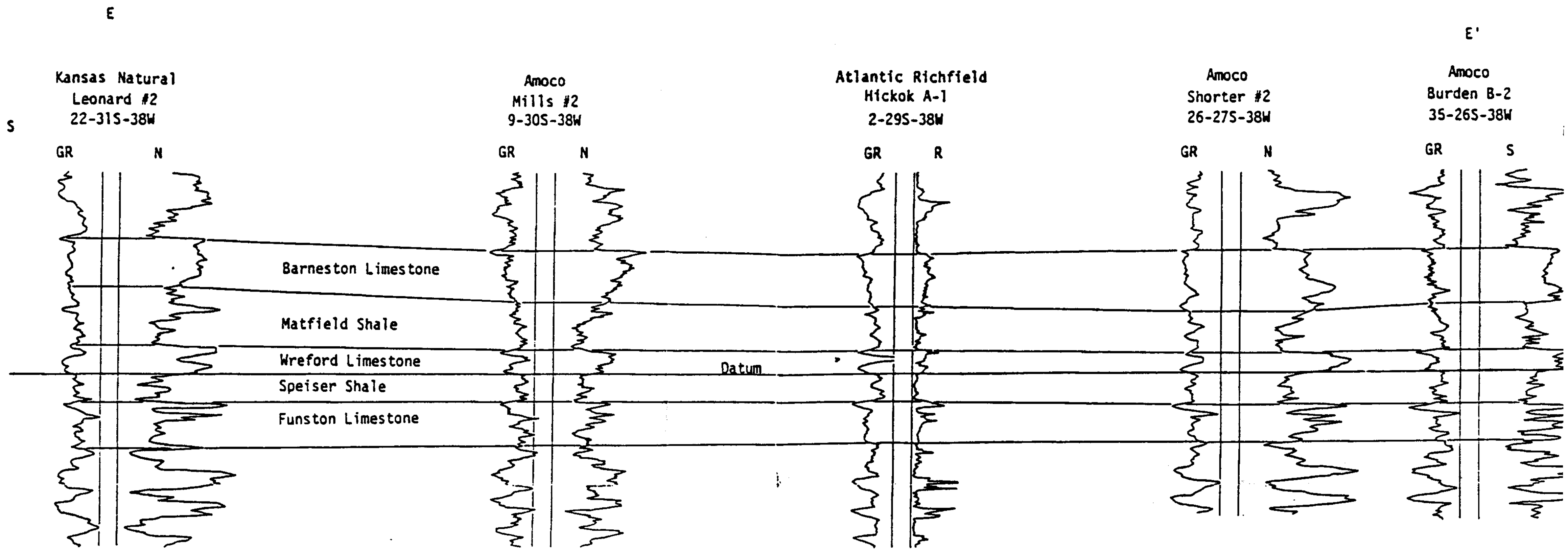
D: Dry hole.

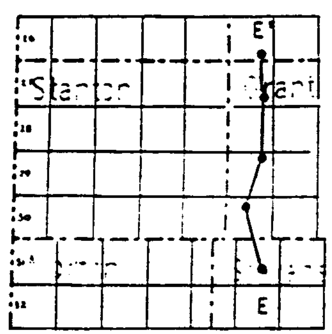


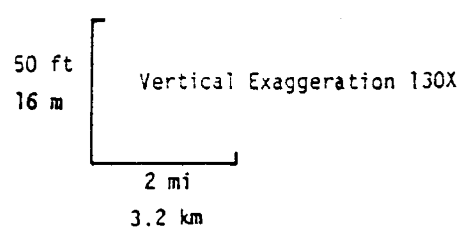
Southwest-Northeast subsurface stratigraphic cross section in Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.



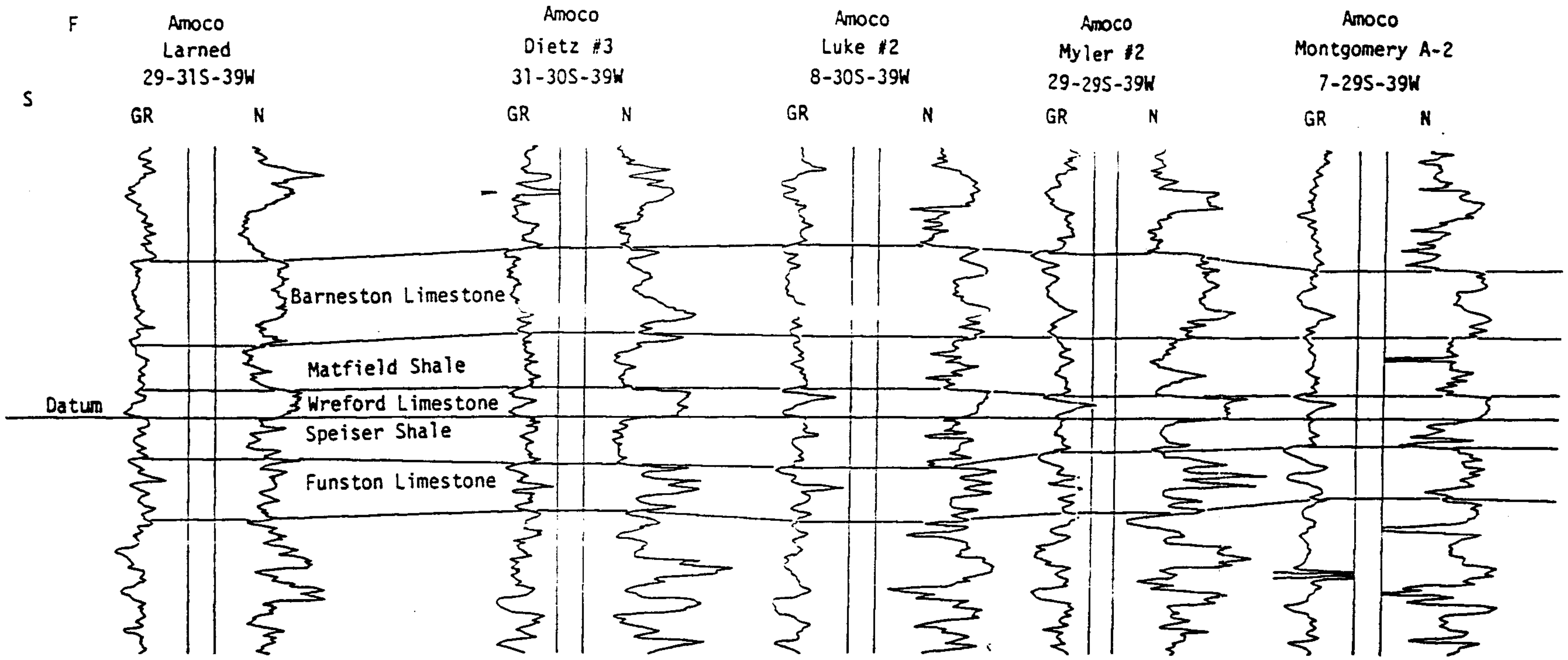
West-East subsurface stratigraphic cross section in southwestern Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.



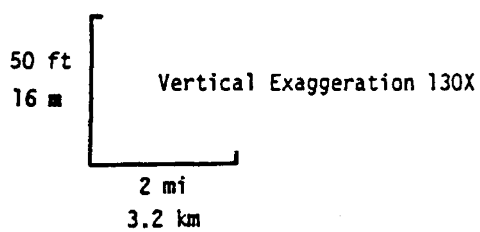


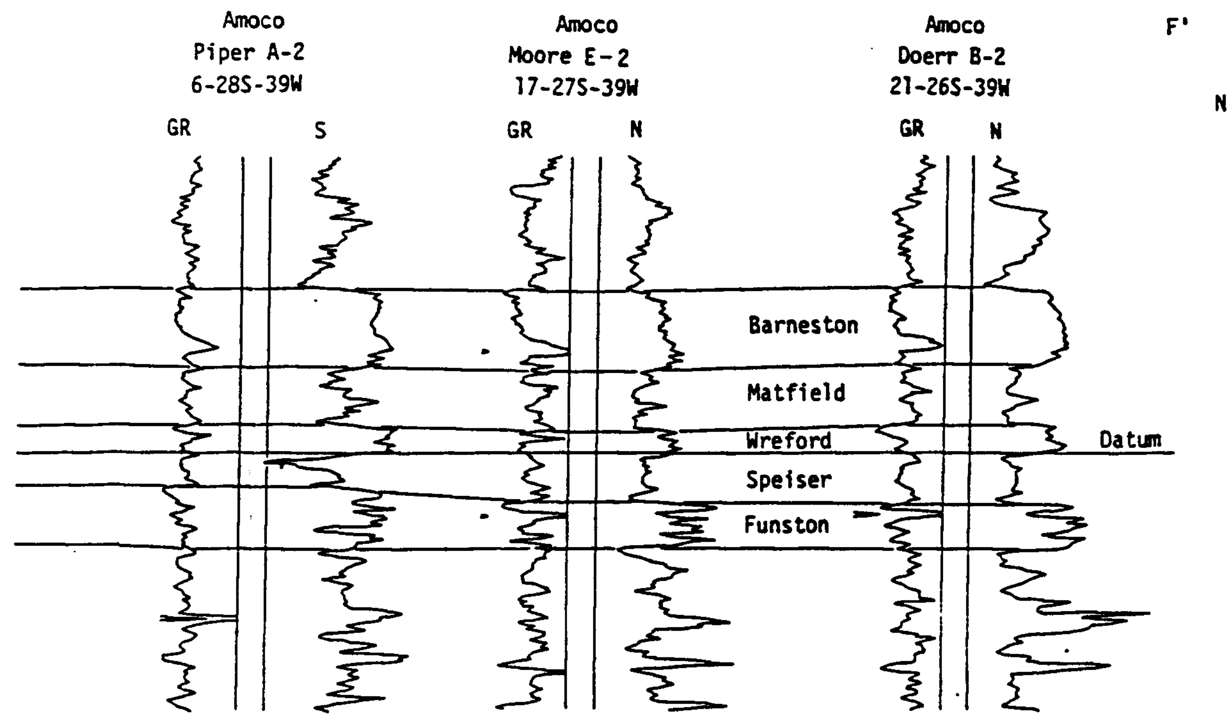


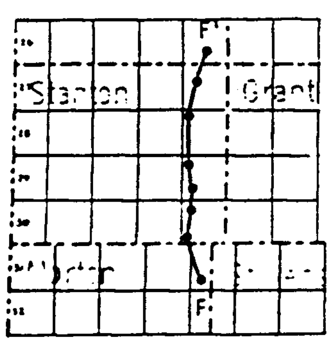
South-North subsurface stratigraphic cross section in southwestern Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.

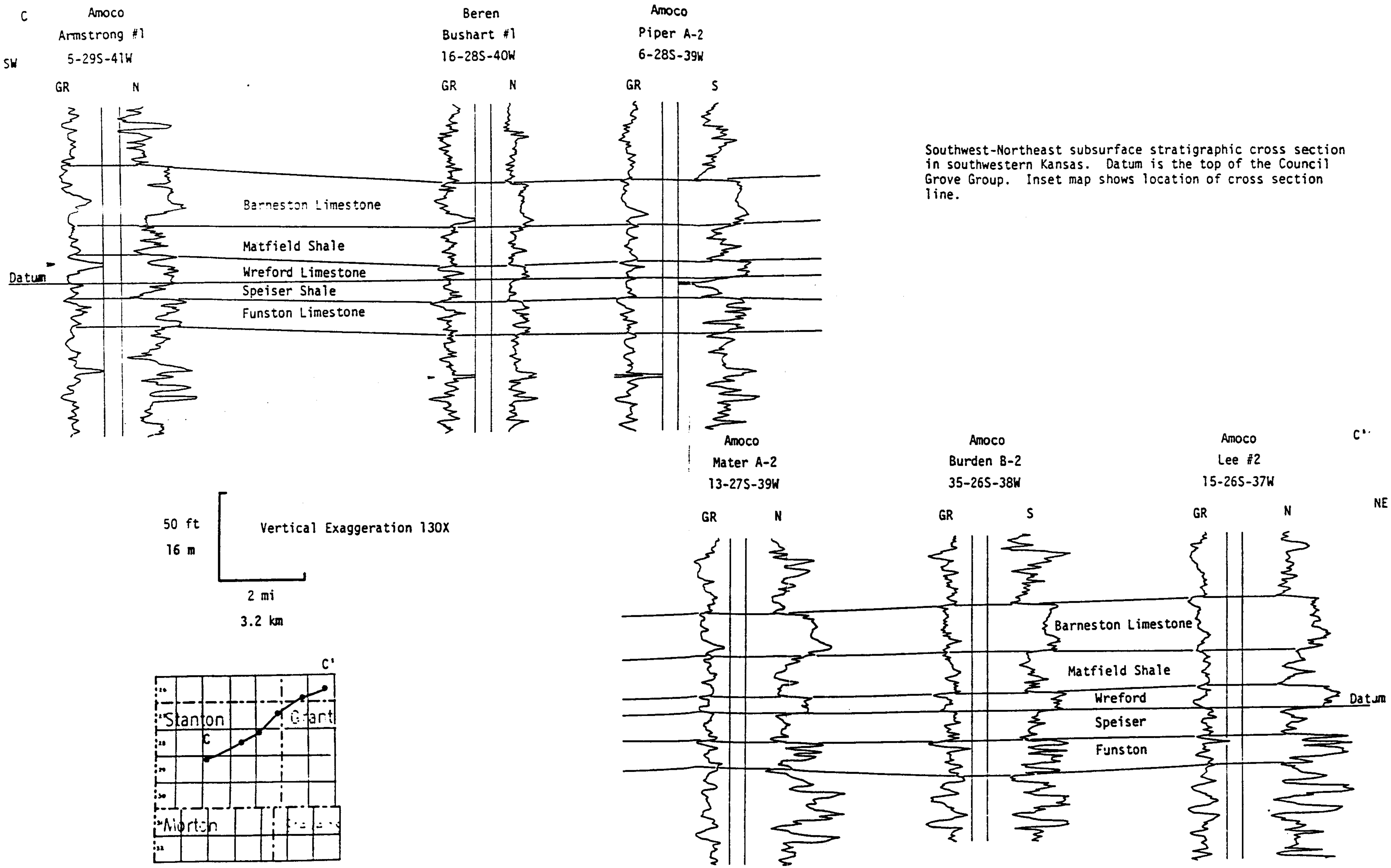


South-North subsurface stratigraphic cross section in southwestern Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.

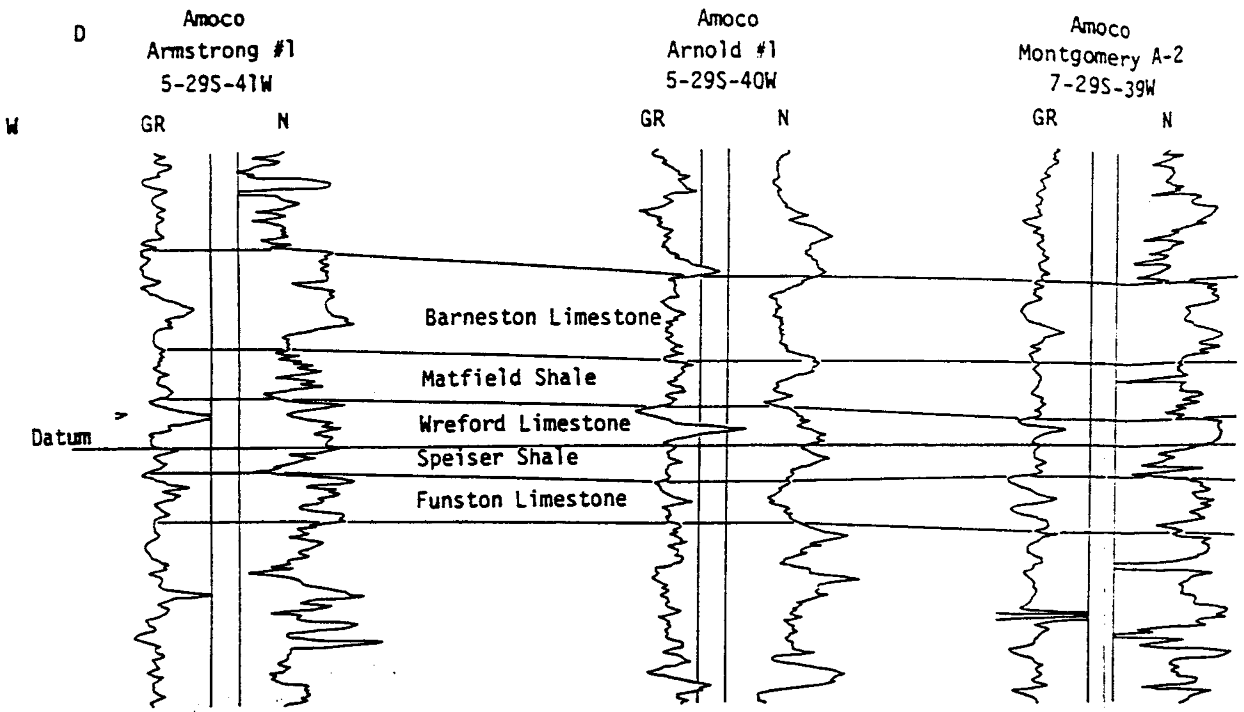








Southwest-Northeast subsurface stratigraphic cross section in southwestern Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.



West-East subsurface stratigraphic cross section in southwestern Kansas. Datum is the top of the Council Grove Group. Inset map shows location of cross section line.