HIGH-RESOLUTION CORRELATION AND TYPE LOG DEVELOPMENT OF THE COUNCIL GROVE GROUP IN SOUTHERN KANSAS

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure		Page

LIST OF PLATES

I

INTRODUCTION

Problem

Correlation of the formations and members of the Council Grove Group in the subsurface of southern Kansas is generally difficult due to its highly complex lithofacies. Type logs for the Council Grove Group in which formation boundaries have been correctly identified do not exist or are not publicly available.

Purpose

The Council Grove Group is a large natural gas producer in the Hugoton Embayment of southwestern Kansas (Fig. 1). In order to aid in the search for and recovery of gas in this part of Kansas, wireline logs must be correctly correlated. Because rocks of specific ages tend to contain more gas than others, it is critical to correctly identify and correlate those rocks in the subsurface.

The purpose of the thesis is two fold, (1) accurately correlate the 14 formations of the Council Grove Group from the subsurface of southwestern Kansas to the subsurface of southeastern Kansas, and (2) develop type logs of the Council Grove Group for the southern counties of Kansas using wireline logs in which the entire Council Grove Group interval can be recognized.

Scope and Location

The stratigraphic interval investigated in this study consisted of the 14 formations of the Council Grove Group, Upper Pennsylvanian-Lower Permian, from southwestern Kansas to southeastern Kansas (Fig. 2).

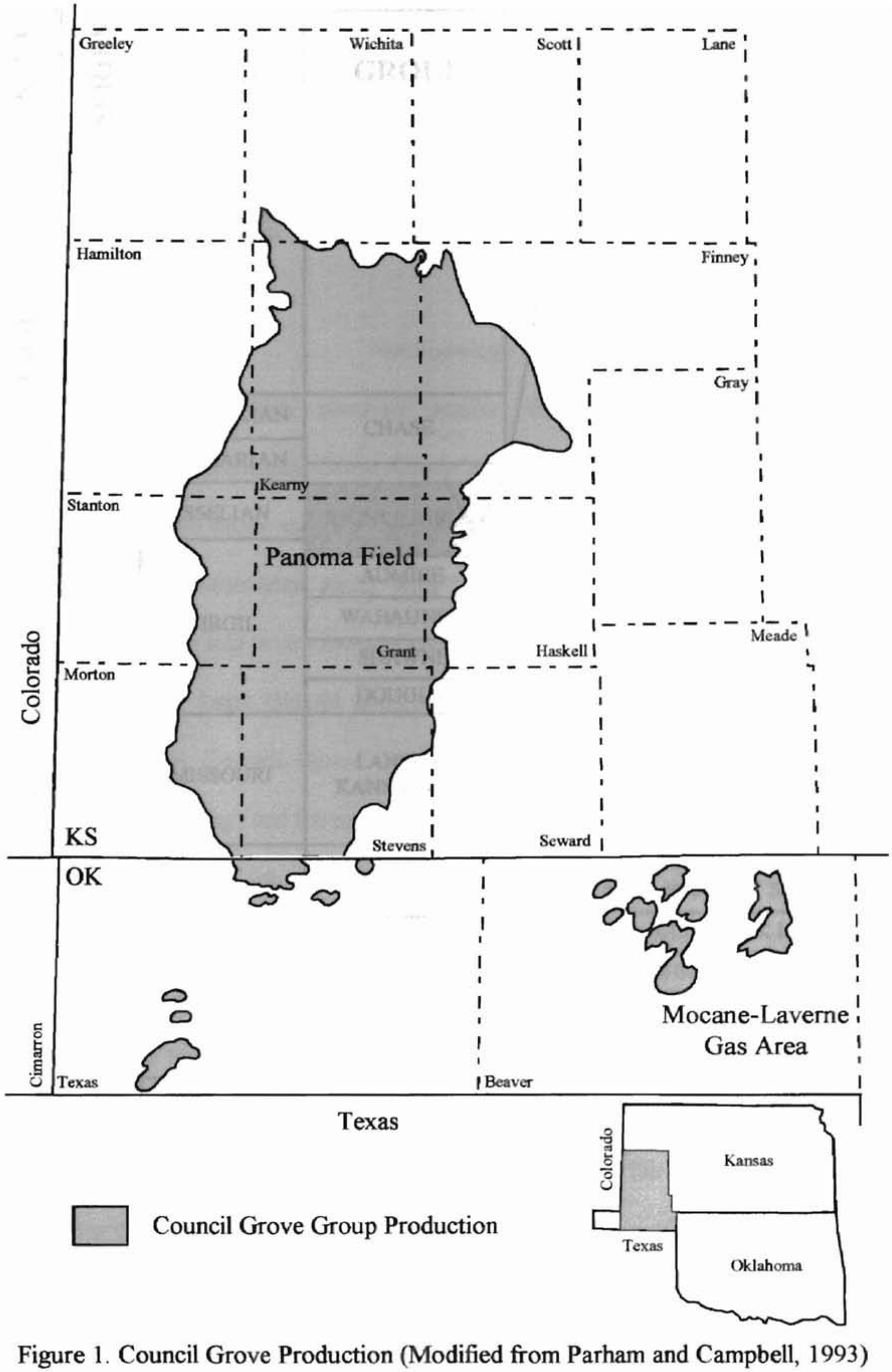

Figure 1. Council Grove Production (Modified from Parham and Campbell, 1993)

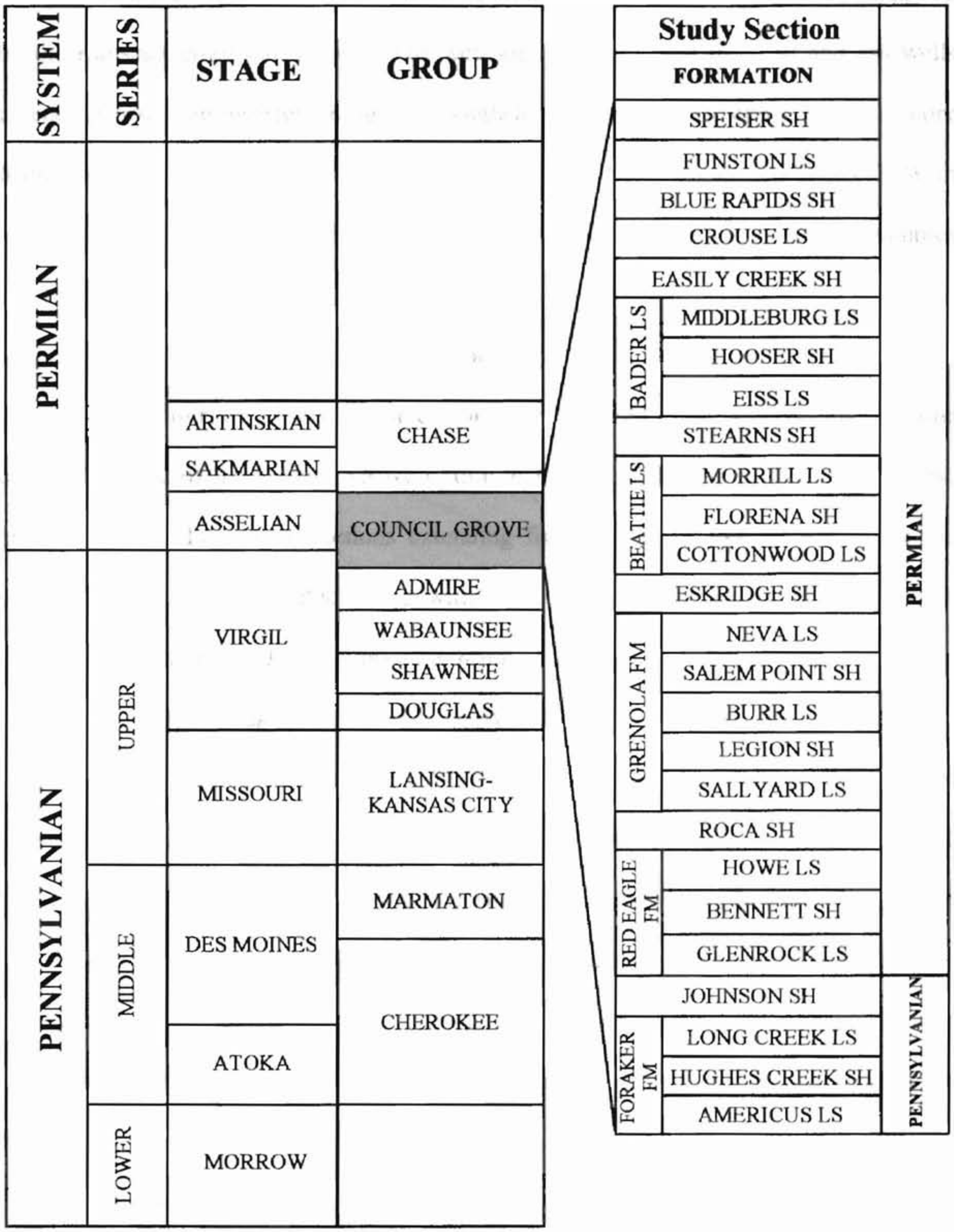

Figure 2. Classification of Pennsylvanian and Lower Permian rocks in Kansas.

Subsurface data was obtained from 56 well logs and one continuous core supplied by the Kansas Geological Survey. The well logs were selected from oil and gas wells extending from southwestern Kansas to southeastern Kansas (Appendix A). The core from Amoco Luke GU #4 well was located in Section 8 Township 30S Range 39W in Stanton County, Kansas (Fig. 3). The Luke GU #4 core was used to collect 77 samples for thin-section preparation.

Methodology

The subsurface study involved detailed description and sampling of one continuous core of the Council Grove Group and the construction of four stratigraphic cross sections. Two cross sections extending from the cored well to wells near the outcrop belt were constructed along with two cross sections extending north-south through the Panoma Field in southwestern Kansas.

The Amoco Luke GU #4 core, provided by the Kansas Geological Survey, contained the entire Council Grove Group as well as the lower part of the Wreford Limestone (Chase Group) and the upper part of the Admire Group.

The entire cored interval was measured and described (Appendix B). Core descriptions included color, bedding, contact characteristics, macrofossil paleontology, grain components, and Dunham rock classification for carbonate rocks. Photographs of each box of core were taken and supplied by Martin Dubois of the Kansas Geological Survey.

Following the core description, 77 samples from the limestone units were collected for thin-section preparation. Petrographic descriptions of the thin-sections

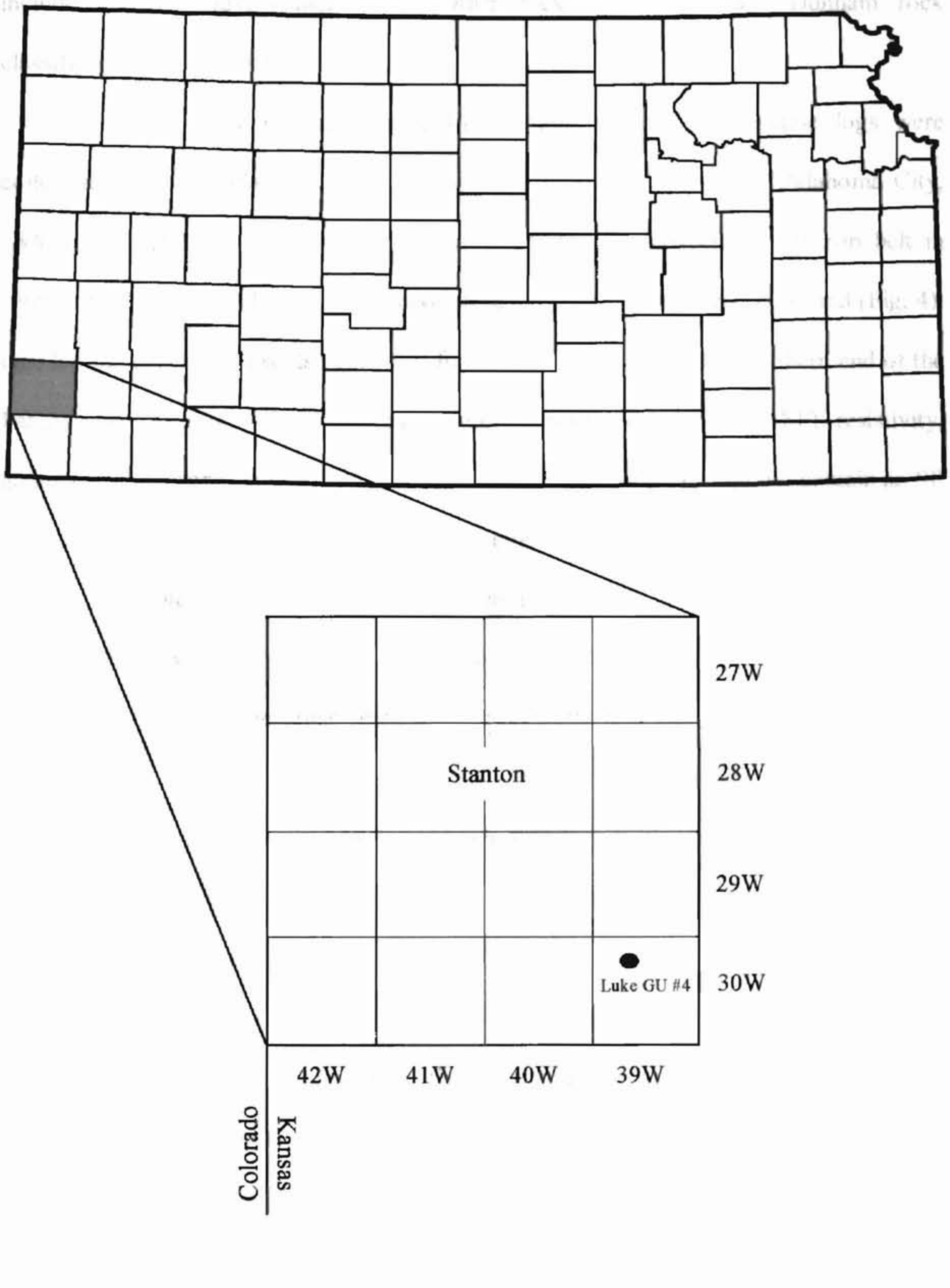

Figure 3. Location of the Luke GU #4 core.

included paleontology, cement types, other rock constituents, and Dunham rock classification (Appendix C).

Following core description and thin-section analysis, 56 wireline logs were collected from the Oklahoma City Geological Society Log Library in Oklahoma City, Oklahoma (Appendix D). One log from each township between the outcrop belt in southeastern Kansas and the cored interval in southwestern Kansas was collected (Fig. 4). One log per township was also collected from the southern end to the northern end of the Panoma Field (Fig. 4). Wireline logs containing spontaneous potential (SP), resistivity, gamma-ray, and sometimes caliper were collected. Some well logs did not contain an SP or caliper log. A minor amount of logs contained neutron and density readings. Well logs near the outcrop belt could not be found until Range 2E due to the close proximity of the Council Grove Group to the surface. A total of 11 well logs were used to construct a wireline log stratigraphic cross section that tied wells near the outcropping section in southeastern Kansas with the Amoco Luke GU #4 core in southwestern Kansas. A total of 7 well logs were used to construct a wireline log stratigraphic cross section that correlated the Council Grove Group through the Panoma Field.

Type logs for the southern counties of Kansas were then chosen from logs located within respective counties (Fig. 5). Type logs were chosen based on their representation of the county and the completeness of the log parameters run on the well bore. Logs containing the largest suite of log parameters were chosen as representative type logs.

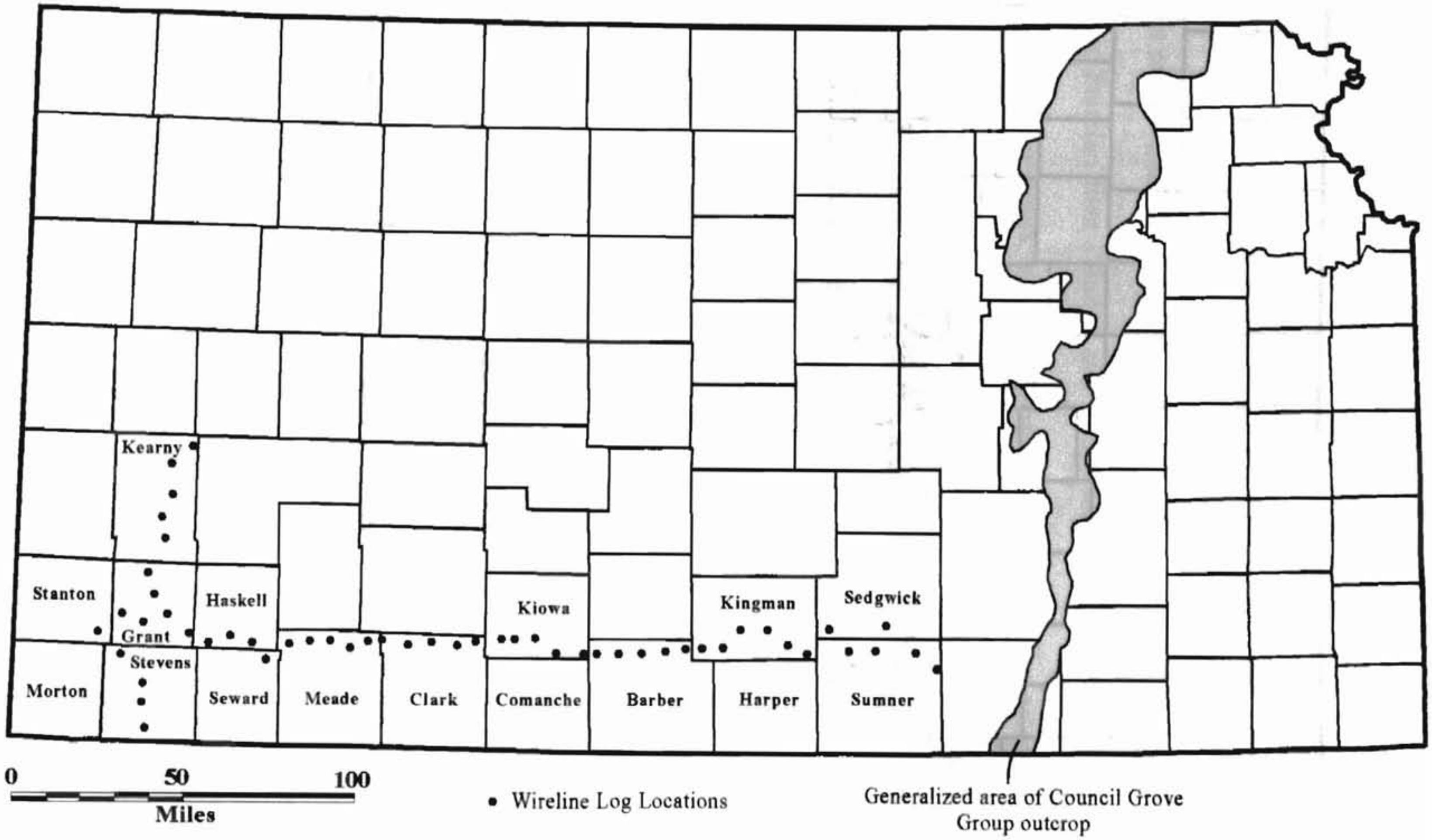

Figure 4. Location of wireline logs used to correlate the Council Grove Group.

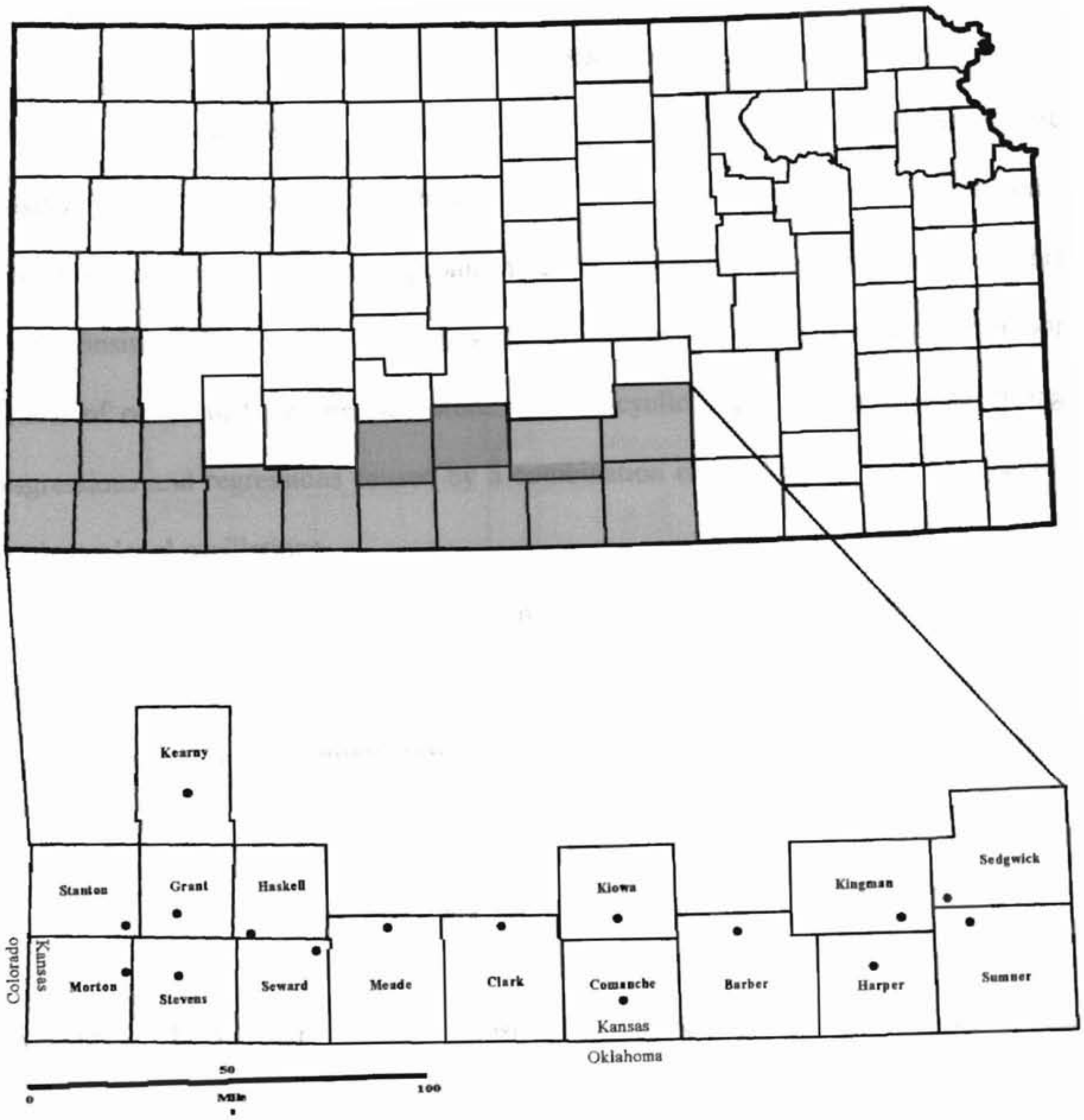

Figure 5. Type Log locations for the southern counties of Kansas.

II

LITERATURE REVIEW

Geologic Setting

The formations of the Council Grove Group Group, in the Kansas basin, were deposited in normal marine, brackish-water, and continental depositional environments during Lower Permian time (Mudge and Yochelson, 1962). The stratigraphy of this interval consists of limestones, mudstones, shales, variegated shales, paleosols, and minor amounts of coal, siltstone, and sandstone. Thick cyclic deposits accumulated during transgressions and regressions caused by a combination of local subsidence and glacio-eustatic sea level oscillations.

The shelf area that is now Kansas underwent nearly continuous deposition during Permian time and approximately 3,400 feet of sediment was deposited in places (Mudge, 1962). Most of the structural features that originated during Pennsylvanian time remained prominent during Council Grove Group deposition (Fig. 6). Although these structures were prominent, there is no evidence of truncation of upper most Pennsylvanian and Lower Permian strata in the rock record of Kansas (Mudge, 1967). Movement of the structures during deposition of Council Grove Group rocks is best observed by general thickening and thinning of the interval.

In northeastern Kansas the Nemaha anticline can be defined by the thinning of Council Grove Group rocks along its crest (Mudge, 1967). Some of the thickness trends of the interval have been obscured by Cenozoic erosion. Local thickening of the Council Grove Group in southeastern Kansas reflects an early origin of the Sedgwick basin (Mudge, 1967). In north-central and central Kansas minor thinning of the Council Grove

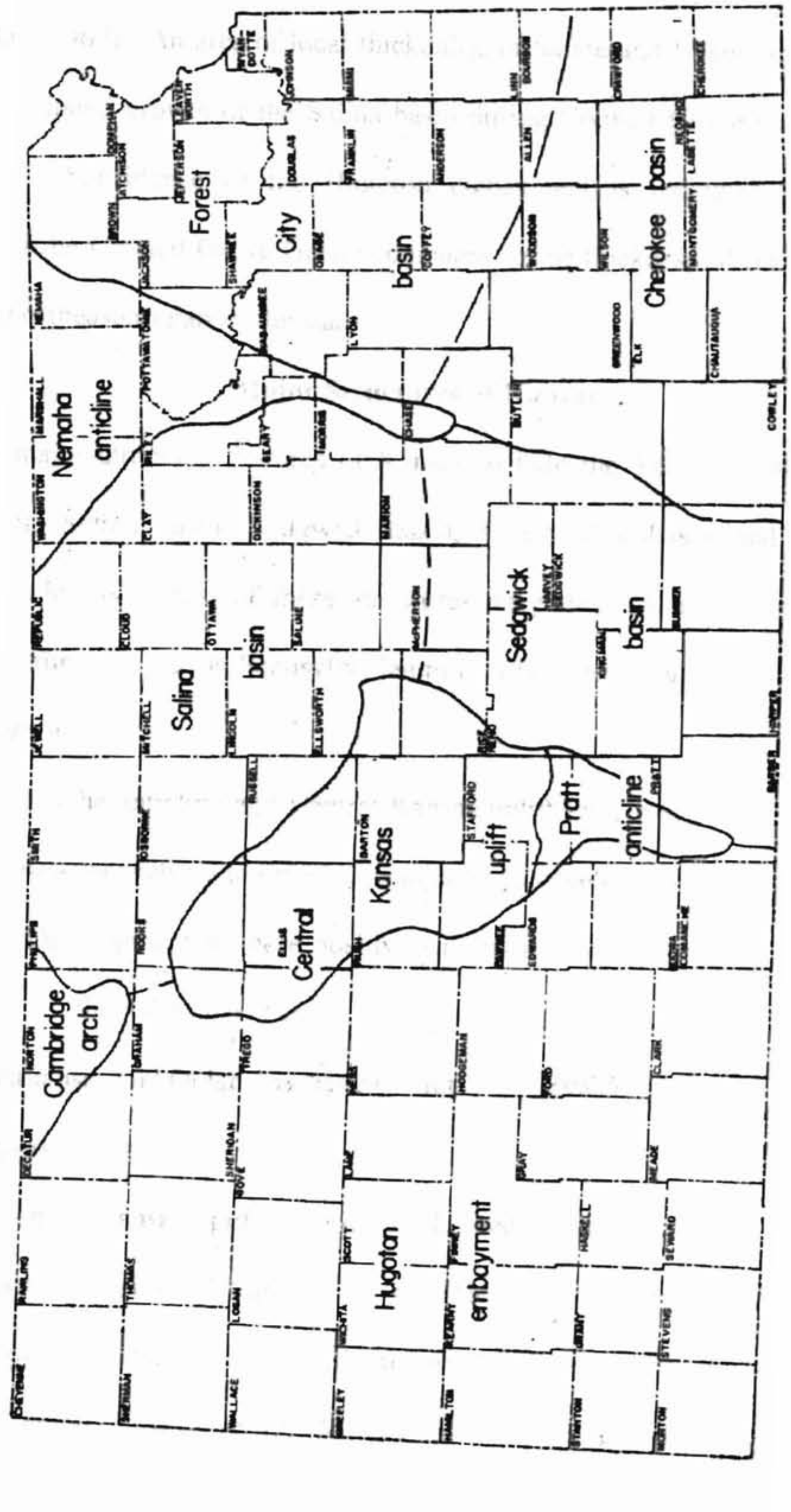

Figure 6. Structures of Kansas (Modified from Hilpman, 1958).

Group indicates slight movement along the Central Kansas uplift during Lower Permian time (Mudge, 1967). An area of local thickening in Saline and Ellsworth Counties may represent continued growth of the Salina basin during Council Grove Group deposition (Lee, 1956). Subsidence of the Hugoton embayment is indicated by the overall thickening of the Council Grove Group compared to the thickness of the interval in the central and northeastern part of the state.

Major Structures of Kansas

The major structural features of Kansas include the Nemaha anticline, Central Kansas uplift, Salina basin, Sedgwick basin, Forest City basin and the Hugoton embayment (Fig. 6). Most of these structures developed mainly during the end of Mississippian time and during Pennsylvanian time with decreasing movement in Permian time (Lee, 1956).

The Nemaha anticline and Central Kansas uplift were positive features that first developed in pre-Pennsylvanian time but continued to develop during the Pennsylvanian (Lee, 1956). Development of these positive structural features and their corresponding negative features, the Salina basin and Forest City basin, has been related to the Ouachita Orogeny in Arkansas and Oklahoma (Rascoe and Adler, 1983).

Central Kansas Uplift

The Central Kansas uplift is generally defined by the pre-Pennsylvanian limit of Mississippian strata in central Kansas (Fig. 6). The uplift was mildly developed during pre-Mississippian time but became reactivated toward the end of the Mississippian (Lee, 1956). Along much of the uplift, Des Moines and Missouri-age strata lie unconformably on the Arbuckle Group, and in some areas Pennsylvanian strata lie unconformably on rocks as old as the Precambrian. During Lower Pennsylvanian time the Central Kansas uplift continued to develop and large parts of it remained above sea level. During Missourian and Virgilian time, development of the structure slowed and most of the uplift was inundated as evidenced by isopach maps of strata deposited during this time. During the uppermost Pennsylvanian and earliest Permian, movement along the uplift had nearly ceased (Lee, 1956). Isopach maps of strata from the Chase Group and Sumner Group indicated no movement along the uplift during the time of deposition.

Nemaha Anticline

The Nemaha anticline is located in eastern Kansas and extends from southeastern Nebraska into south-central Oklahoma (Fig. 7). It is the most pronounced structural feature in eastern Kansas. The eastern limb is much steeper than the west limb, and post-Mississippian faulting has been interpreted along the eastern limb (Lee, 1943). Minor development of the structure began in earliest Mississippian time and was excellerated at the end of the Mississippian (Lee, 1943). Along the crest of the anticline, middle and Upper Pennsylvanian strata unconformably overlie pre-Pennsylvanian rocks and sometimes rocks as old as Precambrian (Rascoe, 1983). Minor development of the anticline continued through the Pennsylvanian and early Permian and had ceased in the Permian (Lee and other, 1948).

Forest City Basin/Cherokee Basin

The Forest City basin is located in northeastern Kansas, east of the Nemaha anticline, and extends into Iowa, Nebraska, and Missouri (Fig. 6). The Cherokee basin is located in southeastern Kansas and is a counterpart of the Forest City basin.

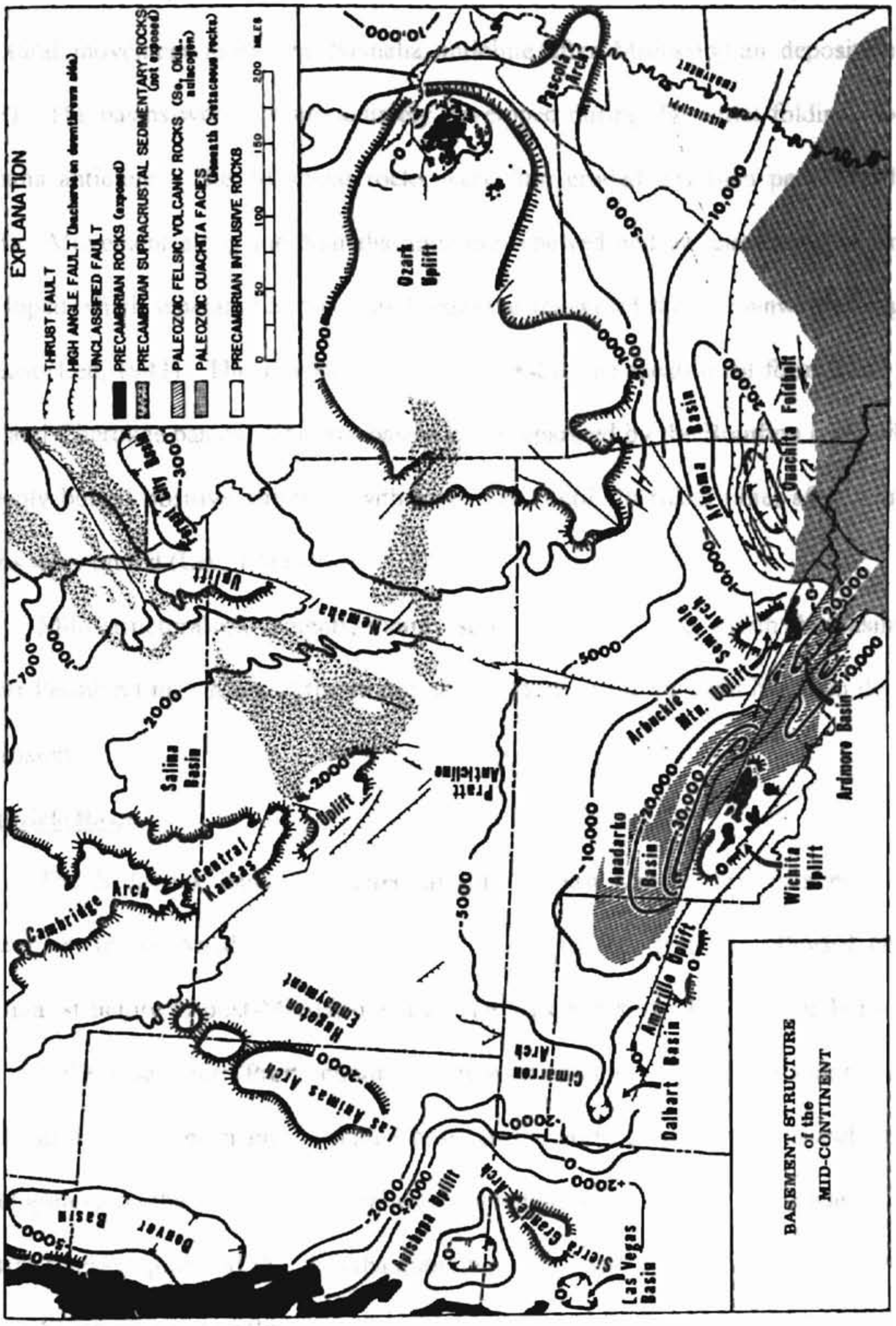

Figure 7. Basement structure of the Mid-Continent (Rascoe and Adler, 1983).

The development of the Forest City/Cherokee basins is intimately related to the structural movement along the Nemaha anticline after Mississippian deposition (Lee, 1943). The basins were not immediately developed during the initial folding along the Nemaha anticline. The deformed rocks were first eroded and then peneplaned (Lee, 1943). Movement along the Nemaha anticline renewed and an east-facing escarpment developed which separated a re-elevated region to the west from a downwarped region to the east (Lee, 1943). This downwarped region east of the escarpment formed the Forest City and Cherokee basins. The two basins were separated by the Bourbon arch, which is a deeply buried positive structure with low relief, until Cherokee time, after which the basins were united (Lee, 1943).

Mild structural movements, mainly subsidence, occurred within the basins until Lower Permian time. Most of the stratigraphic record of the Permian has been destroyed by erosion.

Sedgwick Basin

The Sedgwick basin is located in southeastern Kansas, and is a northeastern embayment of the Anadarko basin of Oklahoma (Fig. 7). It is a southward plunging synclinal structure of post-Mississippian age (Adkison, 1966). The basin is bordered by the Central Kansas uplift/Pratt anticline to the west and the Nemaha anticline to the east. The basin is separated from the Salina basin to the north by a low broad arch (Fig. 6). Development of the Sedgwick basin was contemporaneous with the formation of the Central Kansas uplift and the Nemaha anticline. The basin contains numerous anticlines of post-Mississippian age that are subparallel to the Nemaha anticline (Adkison, 1966).

Salina Basin

The Salina basin is bordered to the west by the Central Kansas uplift and to the east by the Nemaha anticline. The basin was developed when the Nemaha anticline bisected the older North Kansas basin into the Salina basin on the west and the Forest City basin on the east during post-Mississippian time (Lee, 1956). Within the basin, the Cherokee Group unconformably overlies rocks of Osage and Meramec time. Younger Mississippian strata are present in the deepest parts of the basin. The basin contains anticlines trending northeast which were contemporaneously formed with the Nemaha anticline (Lee, 1956).

Hugoton Embayment

The Hugoton embayment is a northwestward extension of the Anadarko basin of Oklahoma (Fig. 7). The embayment is a broad southeastward plunging synclinal structure bordered to the northeast and east by the Central Kansas uplift/Pratt anticline. The Las Animas arch and Sierra Grande uplift of Colorado limit the embayment to the west and northwest (Fig. 7). Downwarping in the area began as early as Precambrian time and continued through much of the Paleozoic (Adkison, 1966). During this time, subsidence was interrupted periodically by epeirogenic uplift (Adkison, 1966). Most of the sediments within the basin thicken toward the axis and south into the Anadarko basin (Merriam, 1963).

Stratigraphy

General Statement

The Council Grove Group in Kansas is composed of interbedded limestones and shales. The group is subdivided into 14 formations that consist of seven limestone formations alternating with seven shale formations (Fig. 2). In ascending order they are the Foraker Limestone, Johnson Shale, Red Eagle Limestone, Roca Shale, Grenola Limestone, Eskridge Shale, Beattie Limestone, Stearns Shale, Bader Limestone, Easly Creek Shale, Crouse Limestone, Blue Rapids Shale, Funston Limestone, and the Speiser Shale.

In Kansas, The Council Grove Group averages between 310 and 330 feet along its outcrop belt (Fig. 8) (Moore and others, 1951). In the subsurface of central Kansas the average thickness is generally the same as the outcrop average. In the subsurface of southern Kansas the thickness can be as much as 498 feet (Adkison, 1966).

The rocks of the Council Grove Group are composed of approximately equal amounts of shale and limestone (Lee, 1956). The shales are mostly variegated with colors of red, green, gray, brown, and black (Lane, 1964). Minor amounts of coal may be found in some shale formations (Lane, 1964). Shale formations commonly contain thin limestone beds, which are not laterally continuous. The limestone beds of the Council Grove Group are light-colored, commonly fossiliferous, and in some areas they are partly dolomitic (Adkison, 1966). Limestones are sometimes locally silty or oolitic and some contain thin chert layers (Mudge and Yochelson, 1962).

The rocks of the Council Grove Group are differentiated from the underlying Admire Group in that the limestone beds are thicker, generally lighter in color, and some contain chert (Mudge and Yochelson, 1962). The Council Grove Group is also different than the Admire Group in that the Admire contains a higher percentage of shale than limestone (Lee, 1956).

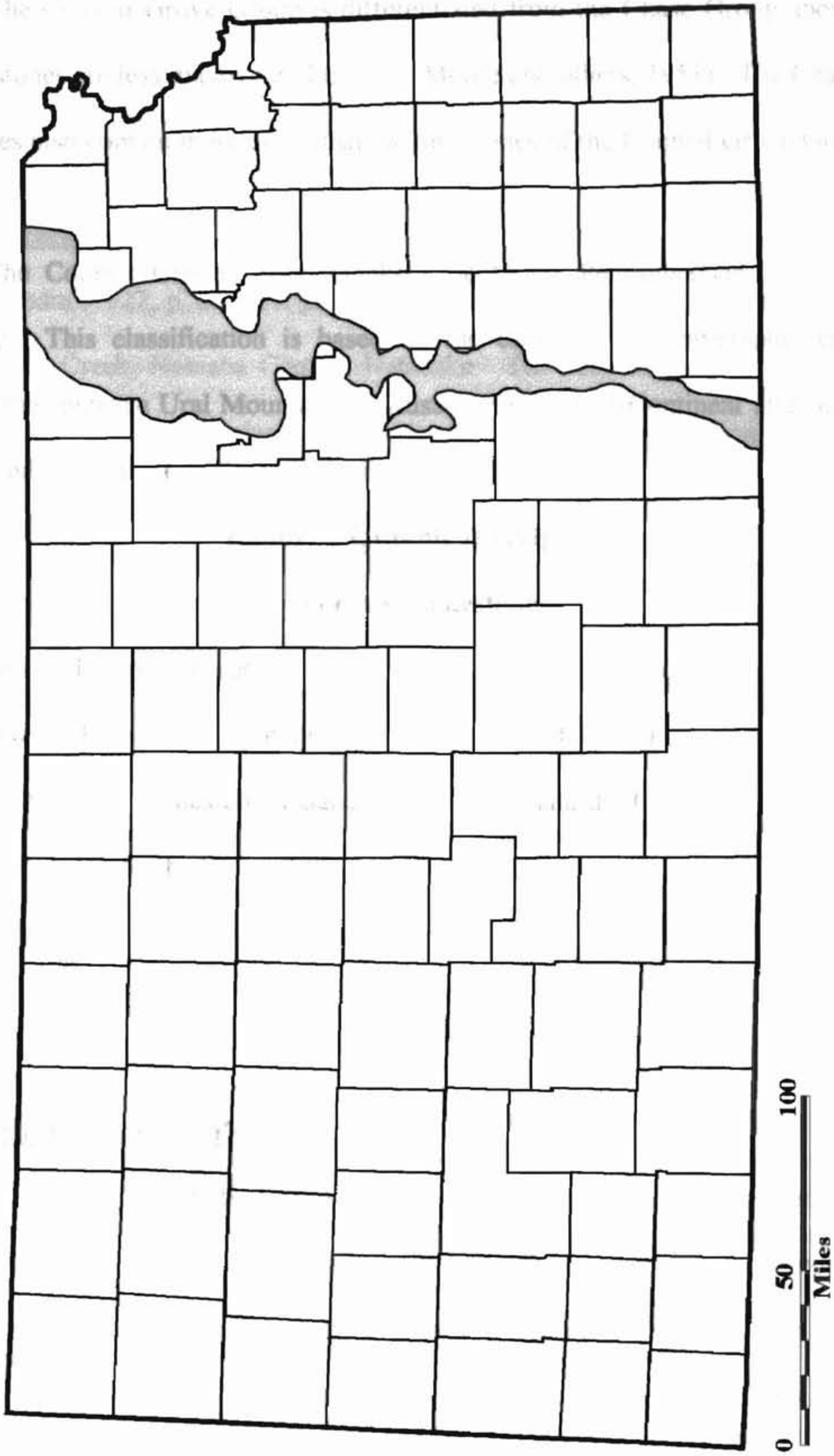

Figure 8. Generalized outcrop area of the Council Grove Group.

The Council Grove Group is differentiated from the Chase Group above in that the limestones are less massive and thinner (Moore and others, 1951). The Chase Group limestones also contain more chert than the limestones of the Council Grove Group (Lee, 1956).

The Council Grove Group brackets the Upper Pennsylvanian-Lower Permian boundary. This classification is based on the conodont biostratigraphic correlation between the southern Ural Mountains in Russia and the Mid-Continent after Boardman, Nestell, and Wardlaw, (1994), and Ritter, (1994).

Lithostratigraphic Descriptions

Foraker Limestone

Heald (1916) proposed the name Foraker Limestone for the Foraker quadrangle, Osage County, Oklahoma. Condra (1935) subdivided the Foraker Limestone into three members, Americus Limestone, Hughes Creek Shale, and the Long Creek Limestone, in ascending order. The thickness of the Foraker Limestone ranges from 30 feet in northern Kansas to as much as 70 feet in southern Kansas (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness of the Foraker Limestone ranges from 40 to 87 feet.

Americus Limestone Member

Kirk (1896, p. 80) first proposed the name Americus Limestone for exposures near Americus, Lyons County, Kansas. Kirk described the Americus Limestone as two thin limestone beds separated by approximately four feet of shale. Moore and others (1951, p. 49) described the Americus in a general section in Kansas as follows:

> "Commonly two limestone beds separated by shale, the upper bed containing flint nodules in southern Kansas. The limestone commonly is bluish-gray and the shale is gray to nearly black. Fusulines and brachiopods are plentiful. The upper limestone

ranges from about 1 to 5 feet in thickness. It is shaly in part. Northward from Wabaunsee County it is represented by shaly limestone or calcareous shale, and strata between the Long Creek limestone and the basal limestone bed of the Americus are included in the Hughes Creek shale. The shale between the two main limestone units, where identifiable, ranges from about 3 to 13 feet in thickness. The lower limestone, commonly with a shale break, ranges from about 2 to 4 feet in thickness. Rhombic blocks of limestone mark the outcrop of the lower bed across the State."

Hughes Creek Shale Member

Condra (1927, p. 85) first proposed the name Hughes Creek Shale for exposures near Hughes Creek, Nemaha County, Nebraska. The beds that constitute the Hughes Creek Shale were originally classified as units of the "Elmdale Formation." The "Elmdale Formation" included what are now all the beds of shale and limestone from the base of the Long Creek Limestone Member down to the top of the Houchen Creek Limestone of the Admire Group. Moore and Condra (1932) later revised the boundaries of the Hughes Creek Shale to the beds between the Americus Limestone and the Long Creek Limestone. Condra (1935) included the Hughes Creek Shale as a member of the Foraker Limestone. At the type section designated by Condra (1927, p. 186) the Hughes Creek Shale was described as follows:

(7). Hughes Creek Shale. The top of this division is exposed below the Long Creek Limestone near the middle of section 11 southeast of Bennett and what may prove to be its base is shown in a ravine north of the railroad two miles east of town. Section:
a. Shale and thin limy layers, 18' 6" with the following subzones:
(a). Shale, bluish to dark argillaceous, massive to bedded, with some thin seams of limestone and a few fossils, about 10'.
(b). Seams of limestone and shale, 1' 6" to 2'. This rises from below the river in the southwest quarter of the northeast quarter of section 11, becomes well exposed in the cut-bank near the road east of this section and at places along the creek in the north half of section 12. The limestone seams are dark gray, arenaceous, fossiliferous, weathering buff. The shale partings are dark blue, argillaceous, plastic, and fossiliferous. Fauna: Productus cora, Chonetes granulifer, bryozoa, and other fossils are plentiful in the stone, Productus cora being the leading species.
(c). Shale, best exposed southeast of Bennett in a cut-bank near the east side of section 11, about 6' 6", top 1' 6" bluish, argillaceous, bedded, with Chonetes granulifer, Composita subtilita, Spirifer cameratus, and other fossils; middle portion with calcareous seams carrying many Chonetes granulifer, Productus semireticulatus, Spirifer cameratus, Septopora biserialis, Thamniscus, Rhombopora lepidodendroides, Meekopora prosseri, and other species, about 1' 6"; basal portion, bluish, argillaceous, bedded, jointed, massive, with

Ambocoelia planoconvexa, Chonetes geinitzianus, Spirifer cameratus, Rhombopora lepidodendroides, and other species scattered throughout but fewer than in the calcareous seam zone next above, 3' 6".

b. Limestone and shale, 19' 6" +:
   (a). Limestone, the topmost layer on creek bed one mile southeast of Bennett, blue to dark gray, hard, massive, with some earthy material, fossiliferous, jointed, forms small rectangular blocks which shell off on weathering, 8" to 9". Pugnax osagensis is the leading fossil.
   (b). Shale, dark bluish or black, argillaceous, with Derbya crassa, Composita subtilita, Ambocoelia planoconvexa, bryozoa, and many Orbiculoidea, 1' 8" to 2'.
   (c). Limestone, dark gray, somewhat earthy, quite fossiliferous, forms large blocks, 1' to 1' 2", with shale near middle. Fauna: Echinoid spines, Chonetes granulifer, Spirifer cameratus, crinoid joints, Meekopora prosseri, Rhombopora lepidodendroides, Composita subtilita, etc. This and the succeeding layers are exposed north of the creek in the ravine two miles east of Bennett.
   (d). Shale, bluish, dark at base, weathers buff, argillaceous to earthy, with some sand and lime concretions, 3' 6". Fauna: Brachiopods and Orbiculoidea.
   (e). Limestone, dark gray, earthy, fossiliferous, with crinoid joints, Ambocoelia, Pustula, Chonetes, etc., 10" to 1'.
   (f). Shale, bluish to dark, mottled, argillaceous to calcareous, 2'. Fauna: Crinoid joints, Chonetes granulifer, Derbya crassa, Ambocoelia planoconvexa, Spirifer cameratus and bryozoa.
   (g). Limestone, dark gray, quite earthy, with Derbya and Pustula, 8".
   (h). Shale, black , very arenaceous, 3"
   (i). Limestone, dark gray, sandy, with Pustula, Productus semireticulatus, Ambocoelia planoconvexa, etc., 4" to 5".

c. Shale, thickness (?), probably 8'.

Long Creek Limestone Member

Condra (1927, p. 85) first proposed the name Long Creek for exposures on Longs Creek, at the foot of the bluff west of the cemetery at Auburn, Nemaha County, Nebraska. The beds that make up the Long Creek Limestone were originally included as units of the "Elmdale Formation." Condra (1935) included the Long Creek as a member of the Foraker Limestone. At the type locality, Condra (1927, p. 85, 86) described the Long Creek as:

> "...stone usually weathered buff to yellowish, somewhat cavernous and irregular; thickness 2 to 7 feet, averaging about 4 feet. This unit usually carries small geodes and a few fossils representing bryozoa, brachiopods, and two or more genera of pelecypods."

Johnson Shale

The name Johnson Shale was first proposed by Condra (1927, p. 86) for exposures 1.5 miles north of Johnson, Johnson County, Nebraska. The beds that make up the Johnson Shale were originally included as units of the "Elmdale Formation." Moore (1936) classified the Johnson Shale as a formation of the Council Grove Group. The thickness of the Johnson Shale ranges from 14 to 25 feet along its outcrop belt (Mudge and Yochelson, 1962). In the subsurface of southern Kansas, the thickness ranges from 2 to 47 feet. At the type locality, Condra (1927, p. 86) described the Johnson Shale as:

> "...formed of bluish argillaceous shale modified by thin, grayish, sandy layers, calcareous plates, and some gypsiferous material, and geodes: thickness 16 to 18 feet. There are very few fossils."

Red Eagle Limestone

Heald (1916, p. 24) first proposed the name Red Eagle Limestone for exposures near the Red Eagle School, southwest of Foraker, Osage County, Oklahoma. Condra (1927, p. 86) named the three units that he later (1935, p. 8) classified as members of the Red Eagle. These members are the Glenrock Limestone, the Bennett Shale, and the Howe Limestone, in ascending order. The beds that make up the Red Eagle were originally included as units of the "Elmdale Formation." Moore (1936) classified the Red Eagle as a formation of the Council Grove Group. The Red Eagle ranges from 6 to 28 feet in thickness along its outcrop belt in Kansas (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness ranges from 13 to 42 feet.

Glenrock Limestone Member

Condra (1927, p. 86) first proposed the name Glenrock Limestone for exposures in a valleyside northwest of Glenrock, Nemaha County, Nebraska. At the type locality, Condra (1927, p. 86) described the Glenrock Limestone as:

> "...dark gray, dense, weathering light gray or slightly buff; thickness 1 to 2 feet. This forms rectangular blocks. The leading fossils are Fusulina, bryozoa, brachiopods, and Pinna sp."

Bennett Shale Member

The name Bennett Shale was first proposed by Condra (1927, p. 86) for exposures along the Little Nemaha and its branches south of Bennett, Lancaster County, Nebraska. At the type section designated by Condra (1927, p. 185) the Bennett Shale was described as follows:

(3). Bennett Shale, exposed from west of Bennett and the south side of section 10 eastward; thickness about 8' including:

- a. Shale, bluish, argillaceous, part calcareous, fossiliferous, 2' 6" to 4'. Fauna: Meekopora prosseri, sea urchin spines, and a few brachiopods.
- b. Limestone, just above creek bed southwest of town and gradually higher in the cut-banks down-valley, 1' to 1' 2". This stone is bluish gray, and not very fossiliferous. It weathers buff or yellowish.
- c. Shale, well shown in creek bank southwest of town, 3' 7":
  - (a). Shale, light blue, arenaceous to argillaceous, weathers dark gray, 10".
  - (b). Shale, nearly black, carbonaceous, resembles coal, 5". This is in the right bank of the creek near water level west of Bennett. It is higher in the slope farther southeast, and near the top of the cut-banks southeast of town.
  - (c). Shale, dark gray, argillaceous to sandy, somewhat calcareous, 8" to 10". Specimens of Orbiculoidea missouriensis are common.
  - (d). Shale, 6" to 8".
  - (e) Shale, dark, argillaceous, in four bands at places, somewhat slabby, bedded to massive, 1' 6". The basal 3" is hard and earthy. It carries Orbiculoidea, Composita subtilita, Ambocoelia planoconvexa, and other fossils.

Howe Limestone Member

Condra (1927, p. 86) first proposed the name Howe Limestone for exposures south of Howe, Nebraska. At the type locality, Condra (1927, p. 86) described the Howe Limestone as:

"...stone in its unweathered condition, dark gray, massive, and dense, with considerable free calcite; weathers buff to yellowish, granular, vesicular or cavernous, and very irregular; thickness about 4 feet. This carries geodes at places. It has few fossils."

Roca Shale

Condra (1927. p. 86) first proposed the name Roca Shale for exposures at Roca, Lancaster County, Nebraska. The beds that make up the Roca Shale were originally included as units of the "Elmdale Formation." Moore (1936) classified the Roca Shale as a formation of the Council Grove Group. The thickness of the Roca Shale ranges from 9 to 31 feet along its outcrop belt in Kansas (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness ranges from 3 to 28 feet. At the type section designated by Condra (1927, p. 180) the Roca Shale was described as follows:

Near the center of section 8, south of Warner Creek, is the following complete exposure of the Roca Shale:

a. Shale, bluish, argillaceous, with calcareous material, 1' 6".
b. Siltstone, buff colored, massive, with calcite in joints and cavities, 1' 2".
c. Shale, bedded, 5' to 6'; lower portion olive green, with a few calcareous concretions and very thin seams of fossiliferous limestone in one zone at places.
d. Shale, grayish blue, with three thin yellowish bands probably formed from weathered limestone, and a faint band of purple shale, 4'.
e. Shale, massive, maroon, mottled with gypsum, 1' 6".
f. Shale, grayish blue, argillaceous, calcareous, massive, 1' 6".
g. Shale, maroon, massive , argillaceous, 1' 2".
h. Shale, grayish blue, massive, weathers yellowish, 1' 4".

Grenola Limestone

The Grenola Limestone was first proposed by Condra and Busby (1933, p. 7) for exposures four to five miles west of Grenola, Elk County, Kansas. Condra and Busby (1933) subdivided the Grenola into five members, the Sallyards Limestone, Legion Shale, Burr Limestone, Salem Point Shale, and the Neva Limestone, in ascending order. The beds that make up the Neva Limestone, Salem Point Shale, and the Burr Limestone were originally included as units of the "Neva Formation." The lower units, the Legion Shale, and Sallyards

Limestone members, were included as part of the "Elmdale Formation." Condra and Busby (1933) classified the Grenola as a formation within the Wabaunsee Group. However, the term Grenola Limestone was not formally applied in the Kansas Stratigraphic Section as a formation of the Council Grove Group until Moore (1936). Moore (1936) abandoned the term "Neva Limestone" and replaced it with the Grenola Limestone. In Moore's (1936) classification, the Grenola Limestone did not include the Sallyards Limestone and Legion Shale members. He included these members as part of the Roca Shale. Moore and others (1951) reassigned the Sallyards Limestone and Legion Shale as members of the Grenola Limestone. The thickness of the Grenola Limestone ranges from 32 to 54 feet along its outcrop belt (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness ranges from 29 to 84 feet.

Sallyards Limestone Member

Condra and Busby (1933, p. 9) first proposed the name Sallyards Limestone for exposures along the south bank of a ravine one mile northeast of Sallyards, Greenwood County, Kansas. In the type section designated by Condra and Busby (1933, p. 19) the Sallyards Limestone was described as follows:

> (5). Sallyards limestone, best exposed ¾ to 1 mile northeast of Sallyards, bluish-gray, top rough, weathers light gray to yellow with shale re-entrant, contains *Myalina, Aviculopecten*, gastropods, *Chonetes*, bryozoa and crinoid joints, 2' 6".

Legion Shale Member

The name Legion Shale was first proposed by Condra and Busby (1933, p. 9) for cuts on U.S. Highway No. 40, just southwest of the American Legion grounds, located about 1 ¾ miles southwest of Manhattan, Kansas. At the type section designated by Condra and Busby (1933, p. 18) the Legion Shale was described as follows:

(4) Legion shale, 4' 6":
  a. Shale, black carbonaceous, fissile, 8"-10".
  b. Mudstone, dark gray, argillaceous, 4".
  c. Shale, dark gray, calcareous, blocky, 1' ±
  d. Shale, gray, calcareous, blocky, weathers yellow, 2'.

Burr Limestone Member

Condra and Busby (1933, p. 9) first proposed the name Burr Limestone for Burr, Otoe County, Nebraska. The type locality is located in the bluffs and ravines west of the south fork of the Little Nemaha River, 2.5 miles northwest of Burr. At the type section designated by Condra and Busby (1933, p. 15) the Burr Limestone was described as follows:

(3) Burr limestone, 10'-11'.
  a. Limestone, gray, massive, weathers buff-brown, upper 6" pitted, with a crustal ostracodal layer, middle portion weathers yellow and slabby, contains a gastropodal layer, thickness 3'6"-4'.
  b. Shale, gray and black, carbonaceous, fissile, with calcareous slabs, contains plant remains, weathers brownish, 3'6".
  c. Limestone, light gray, massive, in one, two or three layers with shale partings, 1'6"-3'6".

Salem Point Shale Member

The name Salem Point Shale was first proposed by Condra and Busby (1933, p. 9) for road cuts at Salem Point, located 1 ½ miles northwest of Salem, Richardson County Nebraska. In the description of the type section, Condra and Busby (1933, p. 15) listed the Salem Point Shale as "7 to 8 feet of calcareous shale." Moore and others (1951, p. 48) described the Salem Point in a general section in Kansas as follows:

"Shale, gray, lower part dark to black, calcareous, without fossils or very sparingly fossiliferous. Thickness ranges from 6 to 10 feet."

Neva Limestone Member

Prosser (1902, p. 709) first proposed the name Neva Limestone for exposures near Neva, Chase County, Kansas. At the type locality Prosser (1902, p. 709) described the Neva as:

"...a massive bluish-gray limestone or of a lower and upper massive limestone, each one a little over four feet in thickness, separated by two feet of shales, with a total thickness of about ten feet. The limestone, forming frequent ledges seven feet or more in thickness, breaks off in large blocks with sharp angles and a rough, jagged surface, weathering to a color not dissimilar to that of bleached bones."

Eskridge Shale

The name Eskridge Shale was first proposed by Prosser (1902, p. 709) for exposures in the vicinity of Eskridge, Wabaunsee County, Kansas. Prosser (1902) originally classified the Eskridge Shale as the uppermost division of the "Wabaunsee Stage." Moore (1936) reclassified the Eskridge as a formation of the Council Grove Group. The thickness of the Eskridge Shale along its outcrop belt ranges from 22.5 feet in southern Kansas to 41 feet in northern Kansas (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness ranges from 4 to 40 feet. Prosser (1902) described the Eskridge Shale at the type section as:

"...a mass of shales, with perhaps some thin limestone layers, varying from thirty to forty feet in thickness. The shales are of greenish, chocolate, and yellowish color, and usually form covered slopes between the two conspicuous limiting limestones."

Beattie Limestone

The name Beattie Limestone was first proposed by Condra and Busby (1933, p. 13). The type section was designated at Beattie, Marshall County, Kansas. Condra and Busby (1933) followed the proposed classification by the Kansas Geological Survey and subdivided the Beattie Limestone into three members. In ascending order the members are the Cottonwood Limestone, Florena Shale, and the Morrill Limestone. The thickness of the Beattie Limestone averages about 20 feet along its outcrop belt in eastern Kansas (Mudge and Yochelson, 1962). In the subsurface of southern Kansas the thickness ranges from 8 to 78 feet.

Cottonwood Limestone Member

Prosser (1895) named the Cottonwood Limestone for exposures along the Cottonwood River above and below Cottonwood Falls and Strong City, Kansas. Previously the Cottonwood Limestone member was called many different names such as Alma Limestone, Manhattan Limestone, Cottonwood Falls Limestone, Fusulina Limestone, and Alma Massive Limestone. The Cottonwood Limestone was originally classified as a division of the "Council Grove Group Stage" by Prosser (1895, p. 698). Moore (1936) reclassified the Cottonwood Limestone as a member of the Beattie Formation. Prosser (1895, p. 698) originally described the Cottonwood Limestone at the type locality as follows:

> "...limestone on a fresh fracture is yellowish-gray in color weathering to a light gray and generally appears along the side of moderately steep bluffs as a series of rectangular blocks that have been separated from the main ledge. The stone is very strongly calcareous containing about 85 percent of calcium carbonate and less than two percent of magnesium carbonate. The amount of flint contained in the rock varies:***there are very few fossils, with the exception of *Fusulina cylindrica*, Fisher, which is extremely abundant in the upper part of the stratum."

Florena Shale Member

Prosser (1902, p. 712) first proposed the name Florena Shale for exposures in quarry walls in the vicinity of Florena, in the Big Blue Valley of Kansas. The Florena Shale was originally classified as a unit of the "Garrison Formation." The Florena Shale was reclassified by the Kansas Geological Survey as a member of the Beattie Limestone Formation (Moore, 1936). Prosser (1902) described the Florena Shale at the type locality as follows:

> "The lower shales have a thickness of thirteen feet near Strong, but decrease to two or three feet in the northern part of the state. The lower part of these shales contains immense numbers of a few species of fossils and on this account may be readily identified wherever outcrops occur."

Morrill Limestone Member

Condra (1927, p. 234) first proposed the name Morrill Limestone for exposures two miles northwest of Morrill, Brown County, Kansas. The beds that constitute the Morrill Limestone were originally classified as part of the abandoned "Garrison Formation." Moore (1936) reclassified the Morrill as a member of the Beattie Limestone. At the type locality, Condra (1927, p. 237) described the Morrill Limestone as "...yellowish, poorly exposed, 1' to 2'." At a section ½ mile north of the type locality, Condra and Upp (1931, p. 18) described the Morrill Limestone as follows:

> "...consists of two dark gray, granular limestones separated by a thin, gray, calcareous shale. Its thickness is usually about 4 feet in the northern occurrence, but becomes 7'-13' at places in central and southern Kansas, as near Strong, Hooser and Dexter. In some outcrops where the member has been leached by ground water, it is yellowish-brown and reduced to a thickness of two feet or less."

Stearns Shale

The name Stearns Shale was first proposed by Condra (1927, p. 234) for exposures south of the Stearns School, northeast of Humboldt, Richardson County, Nebraska. The beds that make up the Stearns Shale were originally included as units of the "Garrison Formation." Moore (1936) classified the Stearns Shale as a formation of the Council Grove Group. The thickness of the Stearns Shale along its outcrop belt ranges from 7 feet in southern Kansas to about 20 feet in northern Kansas (Moore and others, 1951). In the subsurface of southern Kansas the thickness ranges from 15 to 45 feet. At the type section designated by Condra (1927, p. 234) the Stearns Shale was described as follows:

(3). Stearns Shale, 14':

a. Greenish gray, bedded, calcareous, 4' 6".
b. Maroon with purplish tint, massive, jointed, 1'.
c. Variegated greenish brown, massive, nodular, leaches gray, 2'.
d. Gray, earthy, silty, massive, resists weathering, resembles limestone, 1'.
g. Maroon, with greenish gray lenses, massive, 4'.

h. Gray, bedded, quite calcareous, leaches white, 1' 6".

Bader Limestone

The name Bader Limestone was first proposed by Moore and others (1934). Condra (1935) subdivided the Bader into three members, the Eiss Limestone, the Hooser Shale, and the Middleburg Limestone, in ascending order. The beds that make up the Bader Limestone were originally included as units of the "Garrison Formation" until Moore's (1934) classification. Along its outcrop belt the thickness of the Bader Limestone ranges between 15 and 30 feet (Moore and others, 1951). The thickness of the Bader in the subsurface of southern Kansas is between 22 and 46 feet.

<u>Eiss Limestone Member</u>

Condra (1927, p. 234) proposed the name Eiss Limestone for exposures at the Eiss farm located 8 miles south of Humboldt, Richardson County, Nebraska. At the type section designated by Condra (1927, p. 229) the Eiss Limestone was described as follows:

(2). Eiss Limestone, 9' 10":
   a. Limestone, one layer, dark gray, siliceous, hard, massive, forms large rectangular blocks, 1' 3" to 2'. This holds the rim of the escarpment.
   b. Shale, bluish, argillaceous, with fine calcareous material, quite fossiliferous, about 7'. Fauna: Chonetes granulifer, Rhombopora lepidodendroides, etc.
   c. Limestone, dark gray, earthy, becomes hard on exposure and shatters, 1' 4". Fauna: Chonetes granulifer, pelecypods and many specimens of Thamniscus, Fenestella, and Rhombopora at the top.

<u>Hooser Shale Member</u>

The name Hooser Shale was first proposed by Condra and Upp (1931, p. 20) for exposures east of Hooser, Kansas. At the type locality designated by Condra and Upp (1931, p. 27) the Hooser Shale was described as follows:

7. Hooser shale, 11'; zones:
   (1) Shale, gray above and pink to red below, 2'.
   (2) Shale, gray, with lime seams, very fossiliferous, 3' 6".
   (3) Shale, olive, 3'.

(4) Shale, in bands of red and gray, nodular at base, 2' 6".

Middleburg Limestone Member

Condra and Upp (1931, p. 20) first proposed the name Middleburg Limestone for exposures near the Middleburg School in northwestern Richardson County, Nebraska. At type section designated by Condra and Upp (1931, p. 25) the Middleburg Limestone was described as follows:

6. Middleburg limestone, about 4'; zones:
   (1) Limestone, gray, massive granular, dense, weathers buff-gray, about 1' 4".
   (2) Limestone, variegated light to dark gray, massive, tough, with many small dark-colored, high-spired gastropods, 1' 6".
   (3) Shale, olive, 6"-1'.
   (4) Limestone, dark gray, blocky, dense, 2"-3".

Easly Creek Shale

The Easly Creek Shale was first proposed by Condra (1927, p. 234) for outcrops on Easly Creek, Richardson County, Nebraska. Condra (1927) originally classified the Easly Creek as a unit of the "Garrison Formation." Moore (1936) classified the Easly Creek Shale as a formation of the Council Grove Group. At the type section designated by Condra (1927, p. 233) the Easly Creek was described as follows:

(3). Easly Creek Shale, about 26':
   a. Shale, in blue, gray, greenish-gray, and reddish bands, part quite calcareous, 12'.
   b. Limestone, gray, 2' to 4'; massive and hard above; somewhat earthy and shattered below, with myriads of small gastropods in the basal portion at places.
   c. Shale, 10' to 12':
      (a). Shale, buff gray, massive, 1'+.
      (b). Limestone, blocky, 2" to 3".
      (c). Shale, weathered buff, massive, 1' 10"+.
      (d). Shale, limy, irregular, like box-work in places, 10".
      (e). Shale, grayish, with small calcite concretions, about 7' to 8'. This has a reddish band at places.

Crouse Limestone

Heald (1916, p. 21, 22) first proposed the name Crouse Limestone for Crouse Hill, 2 ¼ miles east of Frankfort, Osage County, Oklahoma. Condra (1927, p. 234) named this limestone unit the "Sabetha Limestone" for exposures on the Omaha-Tulsa Highway just north of Sabetha, Kansas. Bass (1929) traced the Crouse Limestone from Oklahoma into Kansas, and it was then realized that the Crouse and "Sabetha" were the same unit. Condra and Upp (1931, p. 21) abandoned the term "Sabetha Limestone" for Crouse Limestone. The beds that make up the Crouse were originally recognized as units of the "Garrison Formation." Moore (1936) reclassified this unit as a formation of the Council Grove Group. The Crouse Limestone ranges in thickness from 10 to 18 feet along its outcrop belt in Kansas (Moore and others, 1951). The thickness in the subsurface of southern Kansas ranges from 6 to 26 feet. At the type section designated by Heald (1916, p. 22) the Crouse was described as follows:

> "Its outcrop is almost invariably conspicuous, and the rock is distinctive enough to make it easily recognizable. The characteristic features of this limestone are the form of the outcrop, which shows many large, massive blocks, the absence of recognizable fossils in any abundance, with the exception of small Fusulinas, which are plentiful, and the presence of many smooth, round holes that are vertical or steeply inclined to the bedding."

Blue Rapids Shale

The name Blue Rapids Shale was first proposed by Condra and Upp (1931, p. 22) for cuts of Highway 77 about 1 ¼ miles north of Blue Rapids, Marshall County, Kansas. The Blue Rapids Shale was originally classified as a unit of the "Garrison Formation." Moore (1936) classified the Blue Rapids as a formation of the Council Grove Group. The thickness of the Blue Rapids Shale ranges from 15 to 30 feet along its outcrop belt in Kansas (Moore and others, 1951). In the subsurface of southern Kansas the thickness ranges between 9 and 44 feet. The type section designated and described by Condra and Upp (1931, p. 22) was as follows:

1. Shale, gray, argillaceous; dark and bedded at middle; calcareous and very fossiliferous in basal 1' which carries many specimens of *Thamniscus octonarius*, and some specimens of Septopora, Derbya, etc.; thickness, 6'.

2. Limestone, gray, fossiliferous, with high-spired gastropods, Thamniscus, Polypora, Fenestella, Septopora, etc., about 1'.
3. Shale, gray, probably 1'.
4. Limestone, gray, blocky, granular, with gastropods and some ostracods, 5".
5. Shale, olive colored, with nodular lime at top, 1' 6".
6. Shale, not so plastic as division 5, weathers buff, 1' 10".
7. Shale, red, with some gray, 3'.
8. Shale, gray, with platy seams, 1' 6".
9. Limestone, gray, with crinoid joints in upper portion, 1'.
10. Shales, gray with some calcareous material, 1' 6".
11. Mudstone, dark gray, bedded, loosely indurated, 2' 6".

Funston Limestone

Condra and Upp (1931, p. 23) first proposed the name Funston Limestone for exposures in the bluffs along the Kansas River Valley south of Funston, Riley County, Kansas. The beds constituting the Funston limestone were originally included as part of the "Garrison Formation." Moore (1936) classified the Funston Limestone as a formation of the Council Grove Group. The thickness of the Funston Limestone ranges from 5 to 26 feet along its outcrop belt in Kansas (Moore and others, 1951). The thickness in the subsurface of southern Kansas ranges from 19 to 52 feet. At the type section designated by Condra and Upp (1931, p. 23) the Funston Limestone was described as follows:

1. Limestone, gray, massive, fossiliferous, 1' 6".
2. Shale, badly covered, greenish-gray, argillaceous, about 1'.
3. Limestone, gray, massive, fossiliferous, 1' 6".
4. Shale, greenish, 6" -1'.
5. Limestone, medium dark gray, massive, blocky, sandy at places, 3'.

Speiser Shale

The name Speiser Shale was first proposed by Condra (1927, p. 234) for the Speiser Township, Richardson County, Nebraska. Condra (1927) originally included all the beds between the "Sabetha Limestone" and the Wreford Limestone, of the Chase Group, as part of the Speiser Shale and included these beds as units of the "Garrison Formation." Condra and Upp (1931, p. 23, 24) redefined the Speiser Shale as all the beds between the Funston and the Wreford. Moore (1936) classified the Speiser Shale as a formation of the Council Grove Group. The thickness of the Speiser Shale along its outcrop belt in Kansas ranges between 18 feet in the northern and central part of the state and 35 feet in the southern part of the state (Moore and others, 1951). In the subsurface of southern Kansas the thickness ranges from 6 to 31 feet. At the type section designated by Condra and Upp (1931, p. 24) the Speiser Shale was described as follows:

Section Number 4

1. Shale, dark gray, fossiliferous, 1'.
2. Limestone, dark gray, earthy, fossiliferous, 5".
3. Shale, dark gray, fossiliferous, 1' 6".
4. Limestone, dark gray, earthy, fossiliferous, 6"-8".
5. Shale, olive, argillaceous, 2' 6".
6. Shale, chocolate and some gray, 6".
7. Shale, gray, 1'+.
8. Shale, in gray and red bands, 10'.

III

SUBSURFACE RESULTS

Core Description

A total of 424.3 feet of core was described. The Council Grove Group was a total of 362.5 feet thick (Appendix B). The core contained 11.3 feet of the base of the Chase Group and 50.5 feet of the top of the Admire Group. The entire core was measured and described. Divisions between formation units were made based on changes in color, bedding, lithology, and fossil content. Plate 1 shows the lithology of the core, formation units, unit thickness, formation and group boundaries, and locations of thin-section. Also included on Plate 1 is a preliminary relative sea-level curve. This is a preliminary curve because the micro-paleontology of the core was not studied during this project. Once the micro-paleontology has been studied, a more accurate sea-level curve can be constructed. This sea-level curved is based on changes in lithology, macrofossil content and assemblages, and siliciclastic content.

Chase Group/Wreford Limestone

The core contained 11.3 feet of the Wreford Limestone (Fig. 9). The Wreford Limestone was subdivided into five units and was composed of gray-dark gray wackestones and packstones (Plate 1). Macro and micro-fossil assemblages and type both suggest that the Wreford Limestone was deposited in a shallow subtidal environment.

Council Grove Group/Speiser Shale

The Speiser Shale was 27.1 feet thick and was composed of red and olive green mudstones/siltstones (Fig. 9-10). The Speiser Shale was subdivided into nine units and the entire interval was interpreted to represent paleosol development in a coastal plain depositional environment. All of the shale-formations of the Council Grove Group are interpreted to be paleosols deposited in coastal plain environments. Evidence for this interpretation is the red color caused by subaerial exposure, the lack of any type of sedimentary structure or bedding, caliche nodules, and root-traces infilled with calcite.

Funston Limestone

The Funston Limestone was 32.2 feet thick along the cored interval (Fig. 10-11). The Funston Limestone was subdivided into 20 units with lithologies ranging from carbonate mudstone-grainstone with minor silty shale (Plate 1). Silt is a common component in most of the formation units. Depositional environments of this interval range from subtidal to lagoonal.

Blue Rapids Shale

The Blue Rapids Shale was 19.9 feet thick and composed of red and olive mudstones and siltstones (Fig. 11-12). This interval was subdivided into five units and is interpreted to represent paleosol development in a coastal plain depositional environment.

Crouse Limestone

The Crouse Limestone was 10.7 feet thick (Fig 12). This interval was composed of light gray-gray carbonate mudstones to grainstones. Karstic features such as terra rosa and vugs infilled with red clay are common (Fig. 12). The Crouse Limestone was deposited in subtidal, lagoonal and shoal depositional environments.

Easly Creek Shale

The Easly Creek Shale was 11 feet thick along the cored interval and was composed of red and gray mudstone and siltstone (Fig. 12). This interval was subdivided into three units and is interpreted to represent paleosol development in a coastal plain depositional environment.

Bader Limestone

The Bader Limestone was the only formation in which its members were easily recognized. The Bader Limestone was 29.4 feet thick along the cored interval and is composed of two carbonate intervals separated by a paleosol (Fig. 12-13).

The Middleburg Limestone Member makes up the upper carbonate interval of the Bader Limestone and was divided into five units (Units 7-11). This interval is composed of tan and light gray wackestones to grainstones. The Middleburg Limestone is interpreted to represent lagoonal and shoal depositional environments.

The Hooser Shale was 14.8 feet thick (Units 3-6) in the cored interval and was composed of red and light gray siltstones and mudstones (Fig. 13). The Hooser Shale is interpreted to represent paleosol development in a coastal plain depositional environment.

The Eiss Limestone is the lower carbonate member of the Bader Limestone (Fig. 13). This interval is composed of light gray packstones that were deposited in shallow lagoonal environments.

Stearns Shale

The Stearns Shale was 22.3 feet thick in the cored interval and was composed of two paleosols separated by a thin carbonate interval (Fig. 13-14). This formation was separated into seven units (Plate 1). The red and olive shale and mudstones represent paleosols developed in a coastal plain depositional environment. The carbonate interval was deposited in a shallow lagoonal and possibly sabkha depositional environment.

Beattie Limestone

The Beattie Limestone was 17.8 feet thick along the cored interval (Fig. 14-15). The Beattie Limestone was composed of tan and light gray dolomitized carbonate mudstones to grainstones (Plate 1). The Beattie Limestone was subdivided into eight units and was deposited in subtidal to supratidal depositional environments.

Eskridge Shale

The Eskridge Shale was 27.3 feet thick along the cored interval and was composed of red and light green mudstones and siltstones (Fig. 15-16). This formation was separated into five units (Plate 1). The red and green siltstones and mudstones represent paleosols developed in a coastal plain depositional environment.

Grenola Limestone

The Grenola Limestone was 33.4 feet thick along the cored interval (Fig. 16-17). The Grenola Limestone was subdivided into 22 units with a wide range of lithologies (Plate 1). The Grenola Limestone was deposited in subtidal to terrestrial depositional environments.

Roca Shale

The Roca Shale was 23.3 feet thick along the cored interval and was composed of red and olive mudstones and siltstones (Fig. 17-18). This formation was subdivided into three units (Plate 1). The red and green siltstones and mudstones represent paleosols developed in a coastal plain depositional environment.

Red Eagle Limestone

The Red Eagle Limestone was 29.2 feet along the cored interval (Fig. 18-19). The Red Eagle Limestone was subdivided into 14 units (Plate 1). The lithologies of this unit range from carbonate mudstone-packstones to silty carbonates. Depositional environments of this interval range from subtidal to lagoonal with an influx of siliciclastics during early deposition of the formation.

Johnson Shale

The Johnson Shale was 16.1 feet thick and composed of red and olive mudstones and siltstones (Fig. 19). This interval was subdivided into two units and is interpreted to represent paleosol development in a coastal plain depositional environment (Plate 1).

Foraker Limestone

The Foraker Limestone was 62.8 feet thick along the cored interval (Fig. 19-21). The Foraker Limestone contains highly complex lithologies (Plate 1). This formation was separated into 24 units. Siltstones, black shales, and limestones are all present in this interval. Depositional environments of the Foraker Limestone range from shallow lagoonal to deep subtidal. There was a large amount of siliciclastic influx in Units 14-17 (Plate 1).

Admire Group/Hamlin Shale

A total of 50.5 feet of the upper part of the Admire Group was present in the cored interval (Fig. 21-23). The Admire Group was subdivided into two units (Plate 1). The group is composed of non-fossiliferous, olive and dark gray siltstones interpreted to represent marginal marine environments with a high amount of siliciclastic influx.

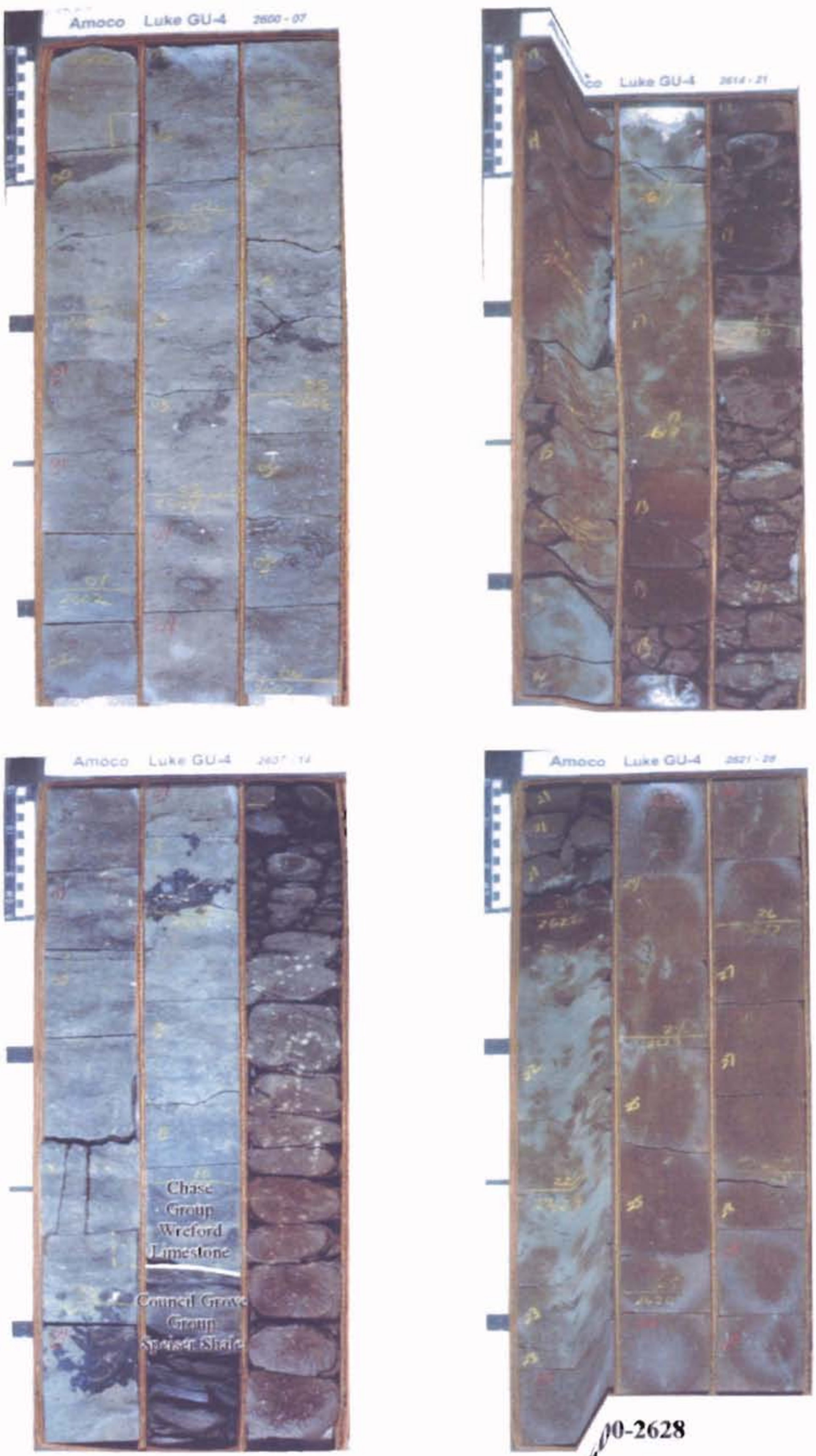

Figure 9. Amoco Luke GU #4 Core 2600-2628

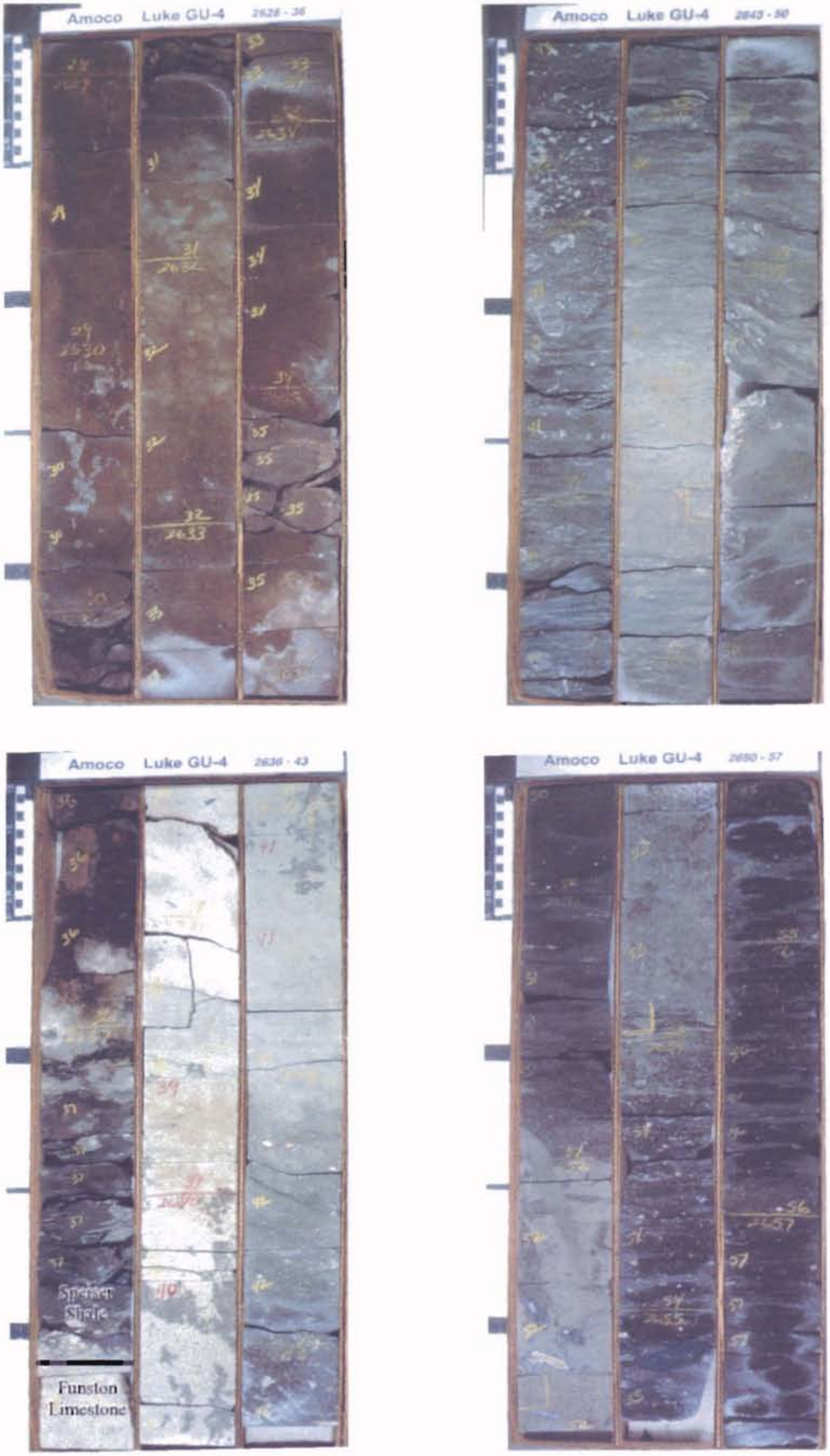

Figure 10. Amoco Luke GU #4 Core 2628-2657

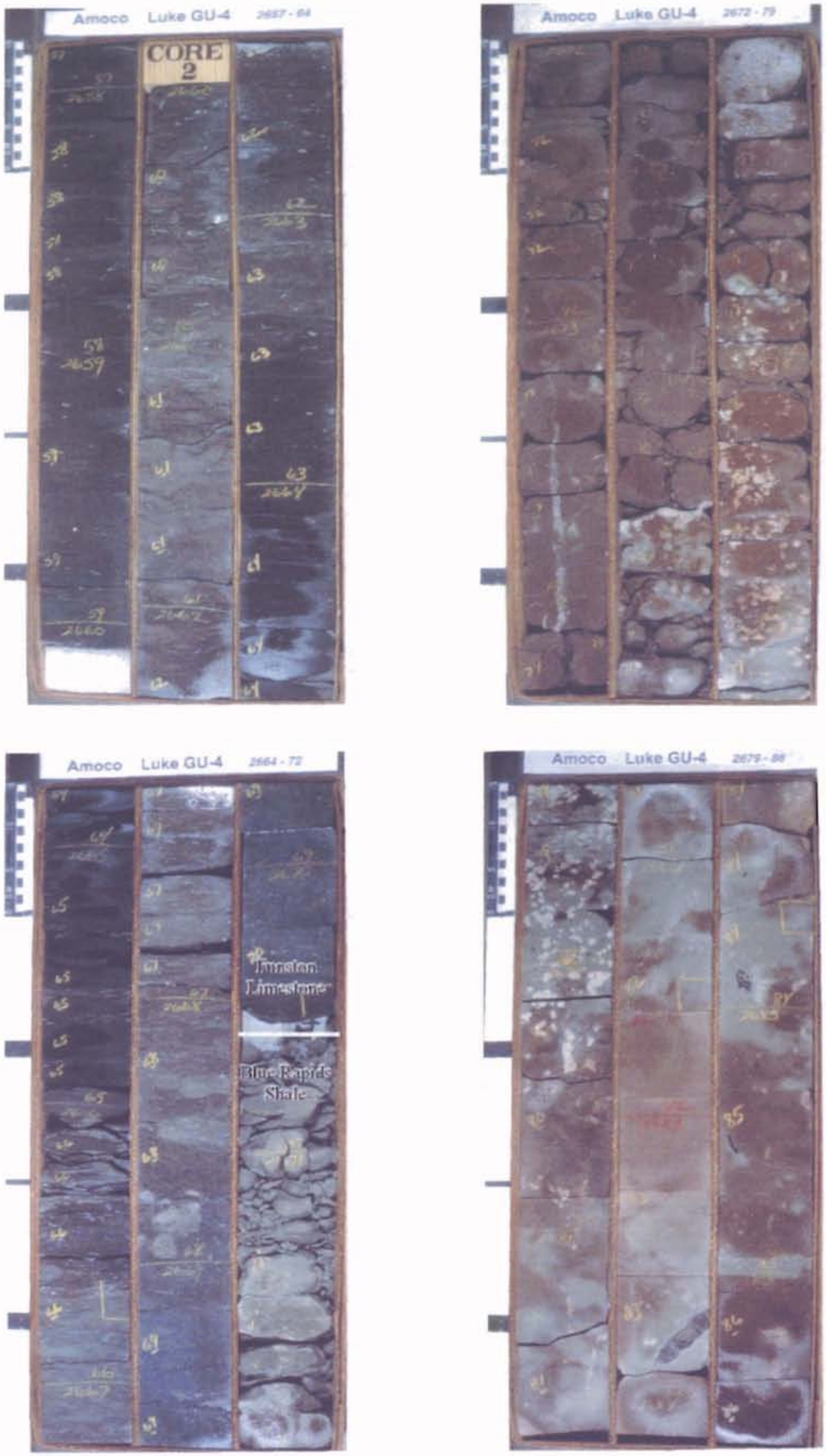

Figure 11. Amoco Luke GU #4 Core 2657-2686

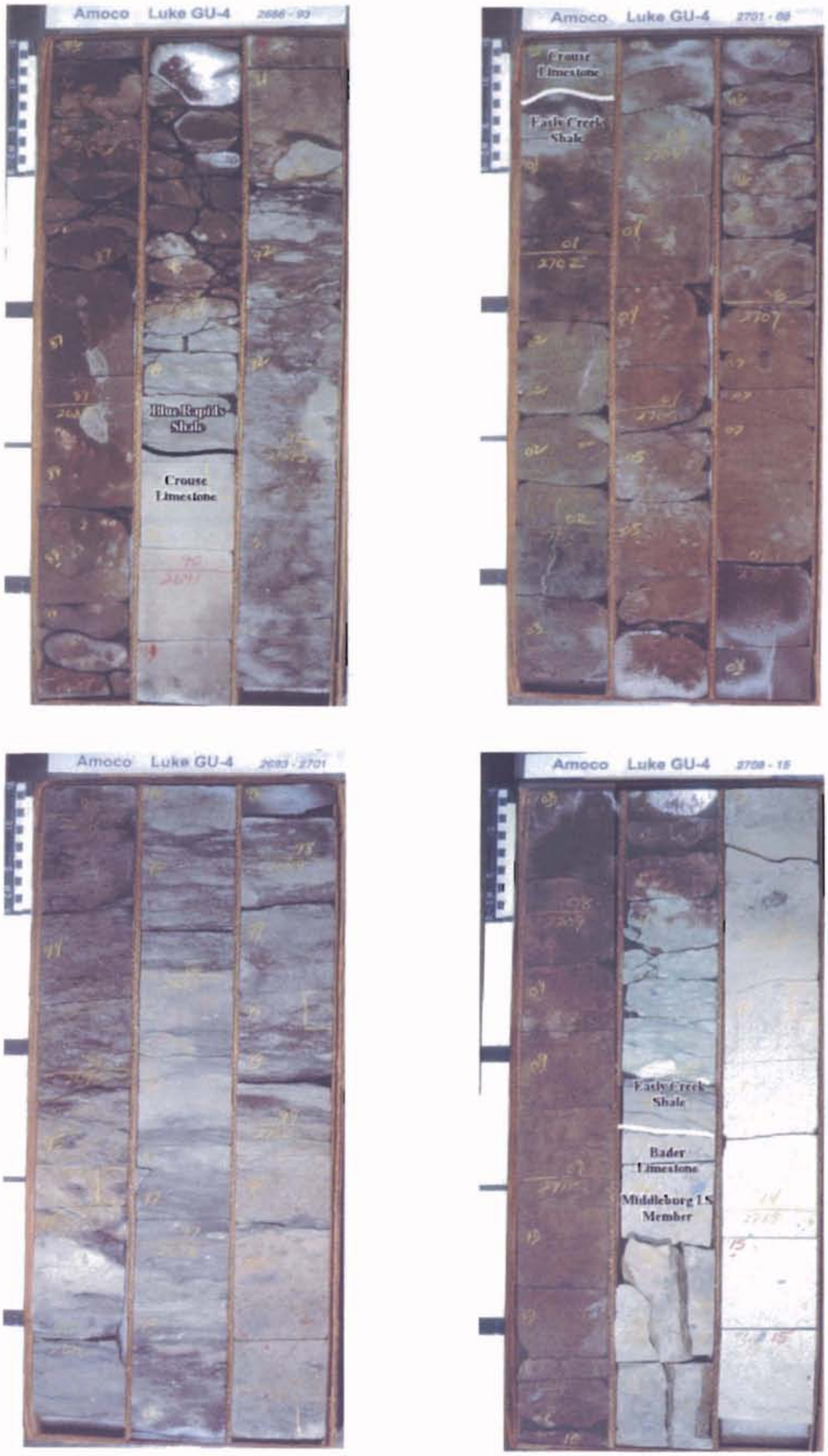

Figure 12. Amoco Luke GU #4 Core 2686-2715

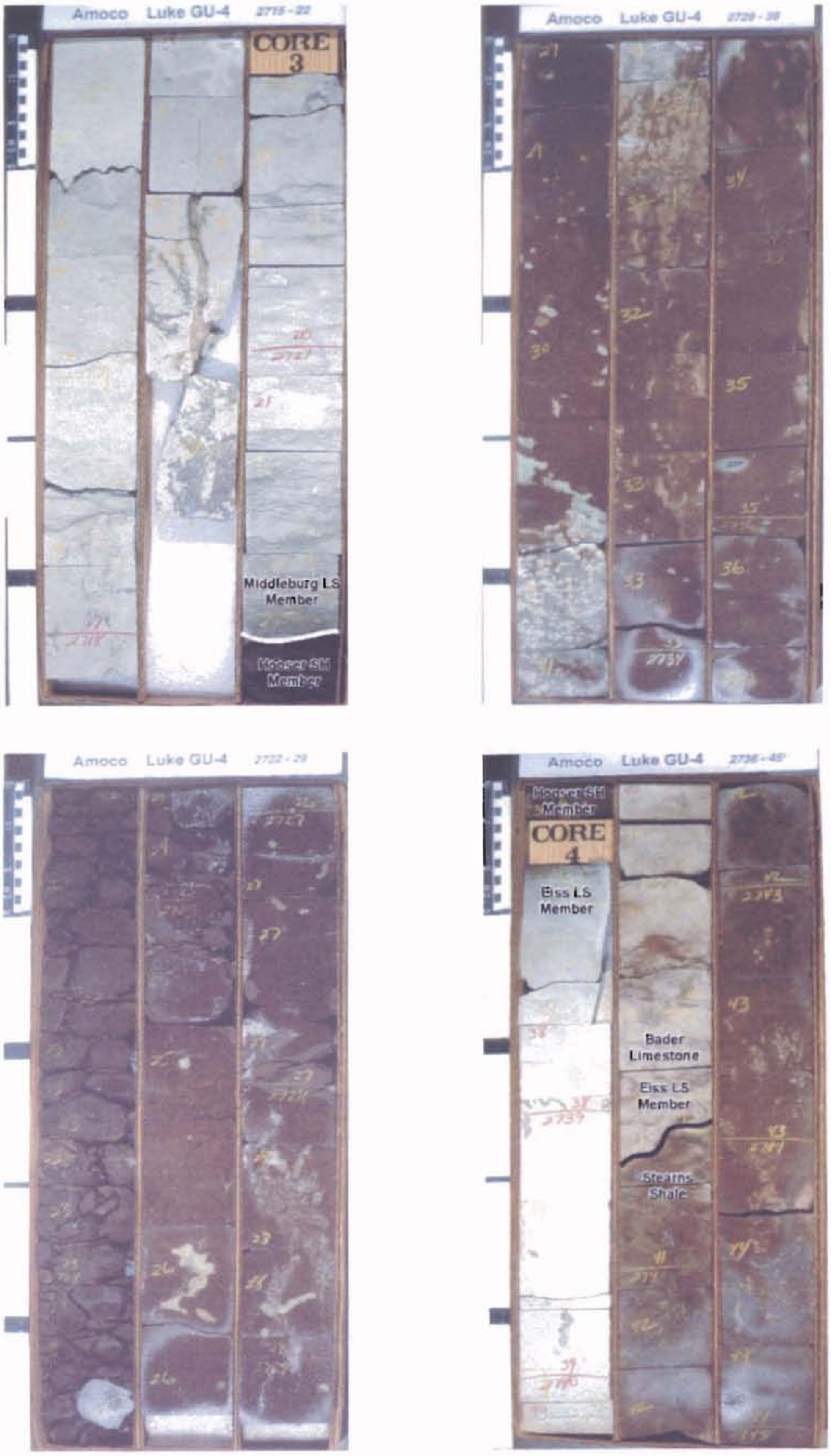

Figure 13. Amoco Luke GU #4 Core 2715-2745

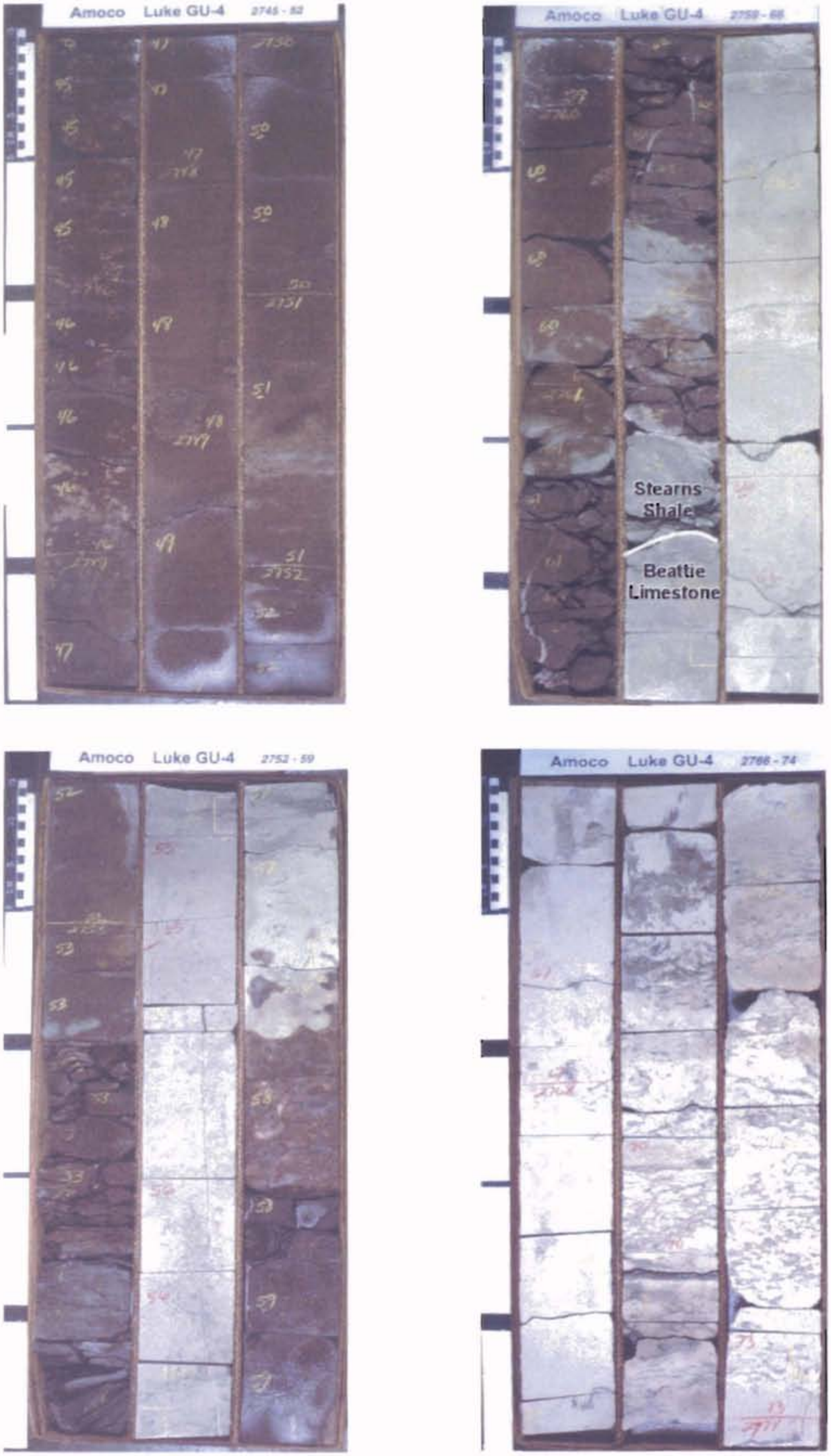

Figure 14. Amoco Luke GU #4 Core 2745-2774

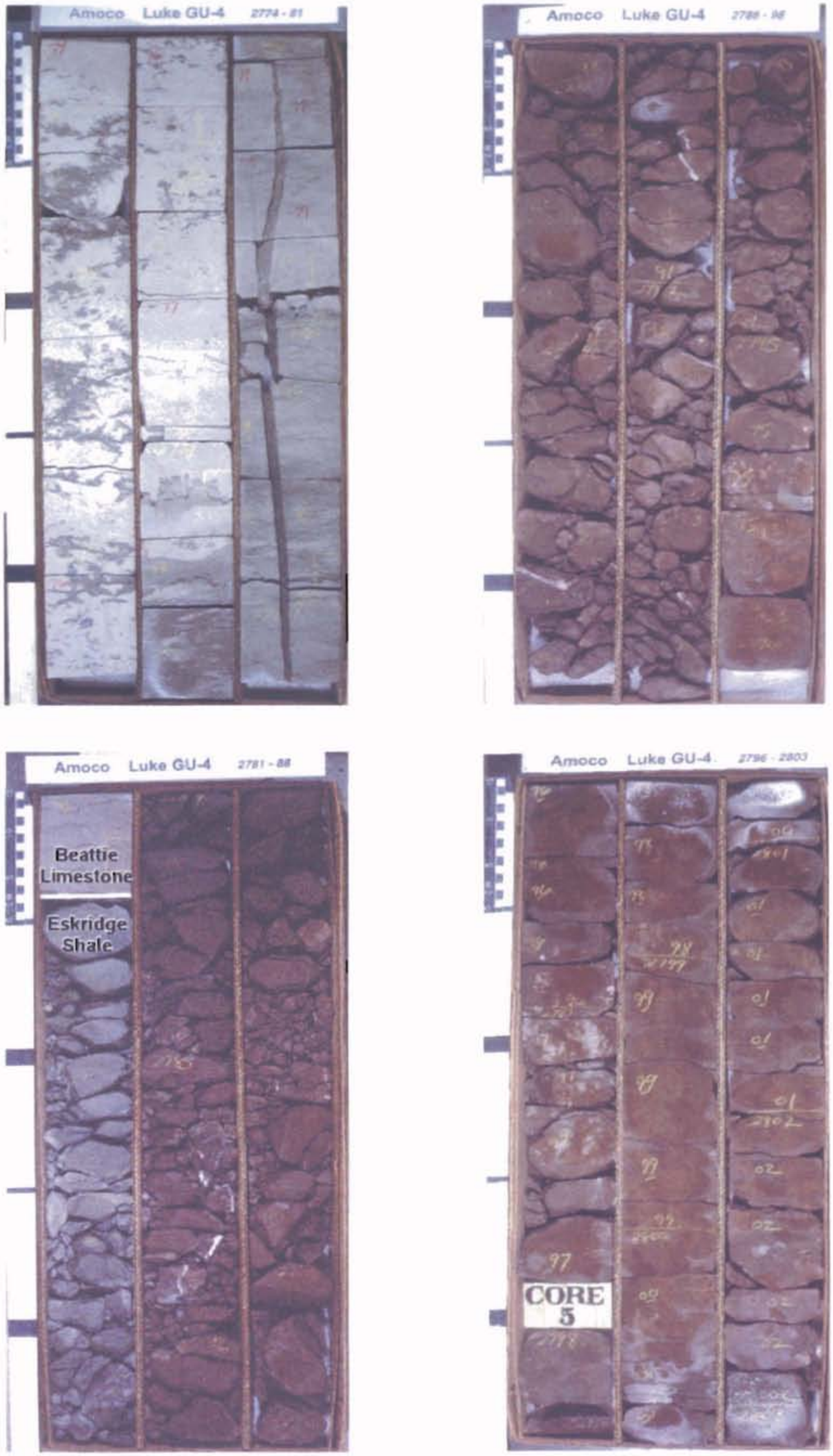

Figure 15. Amoco Luke GU #4 Core 2774-2803

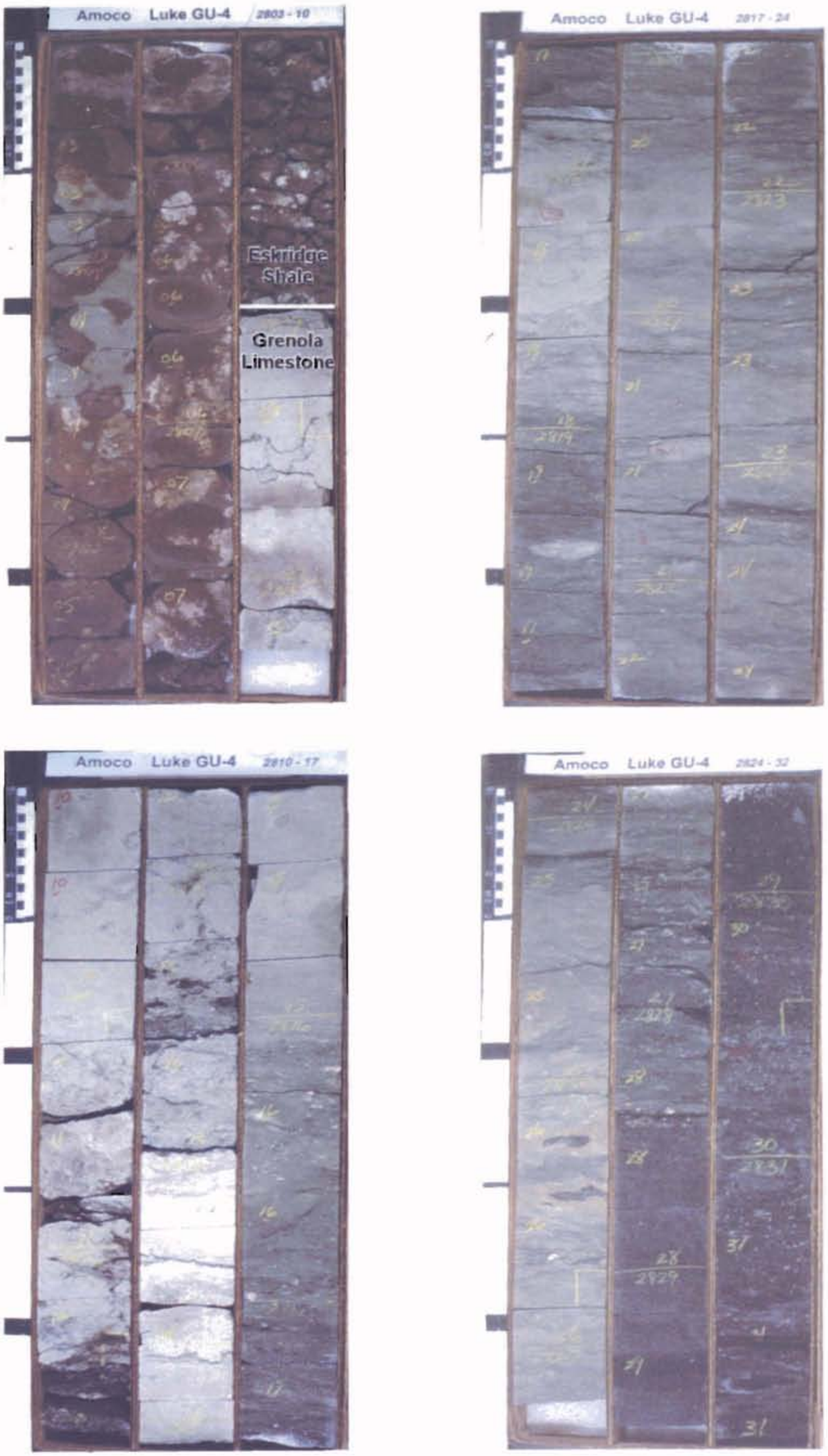

Figure 16. Amoco Luke GU #4 Core 2803-2832

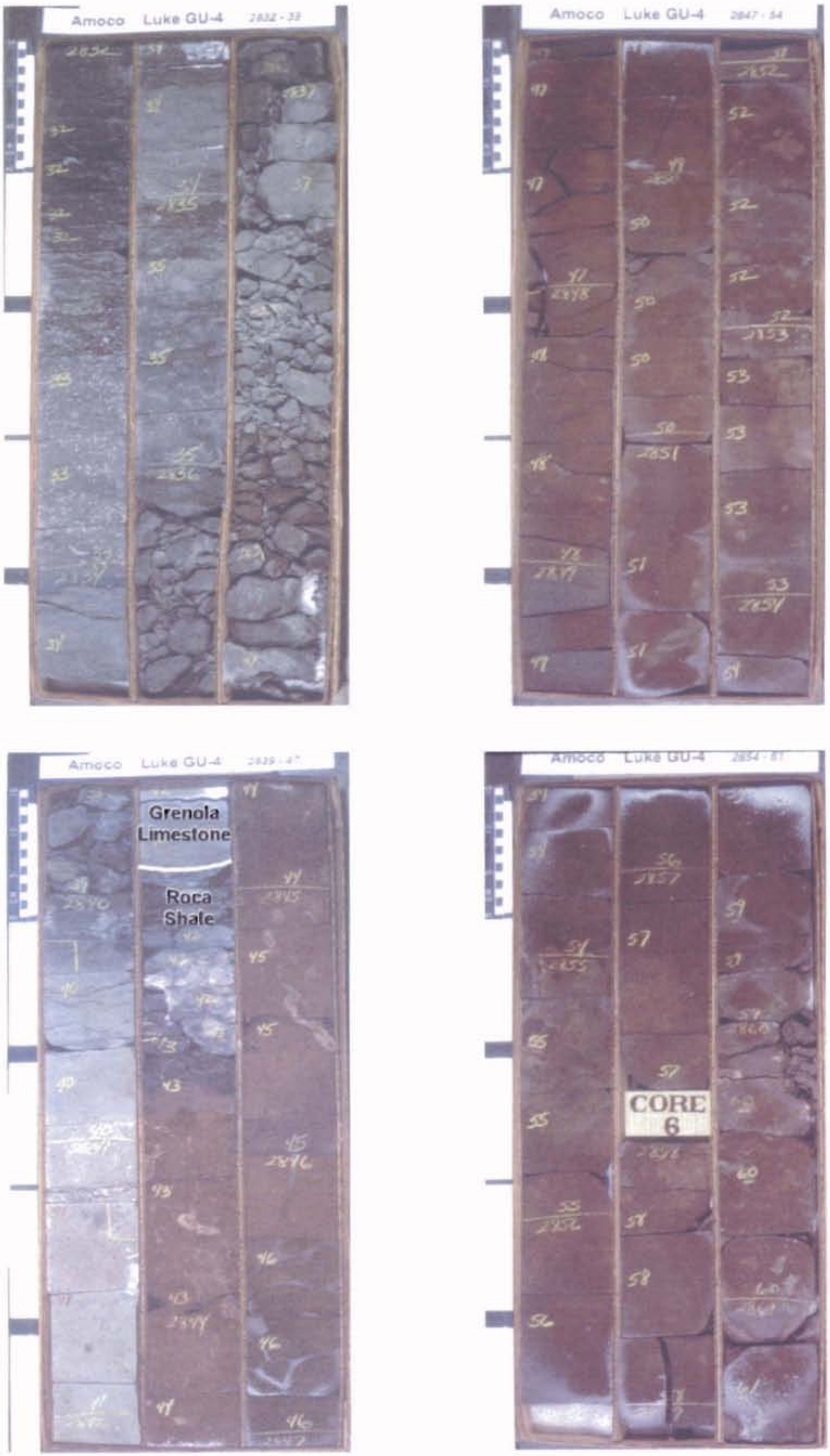

Figure 17. Amoco Luke GU #4 Core 2832-2861

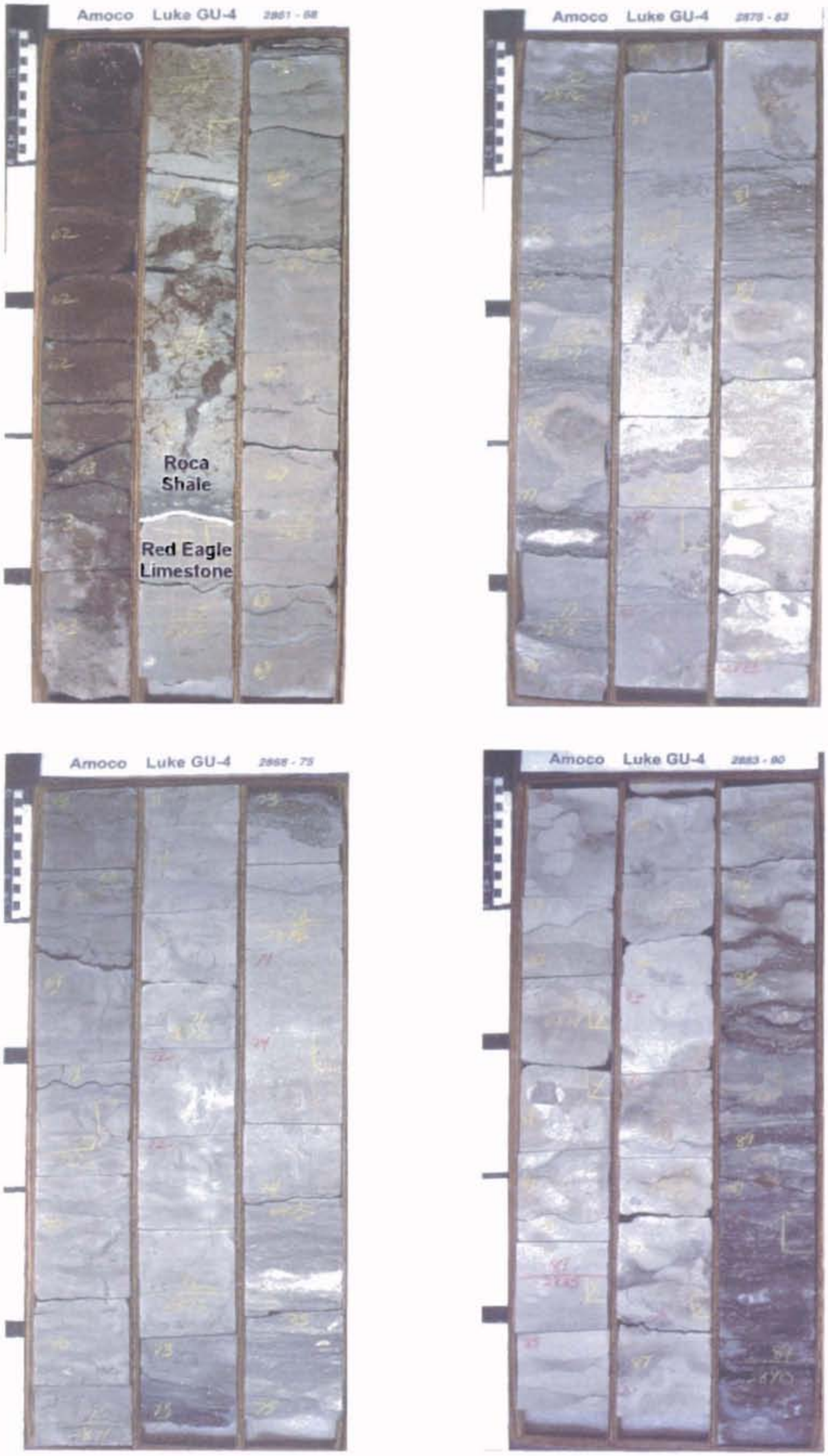

Figure 18. Amoco Luke GU #4 Core 2861-2890

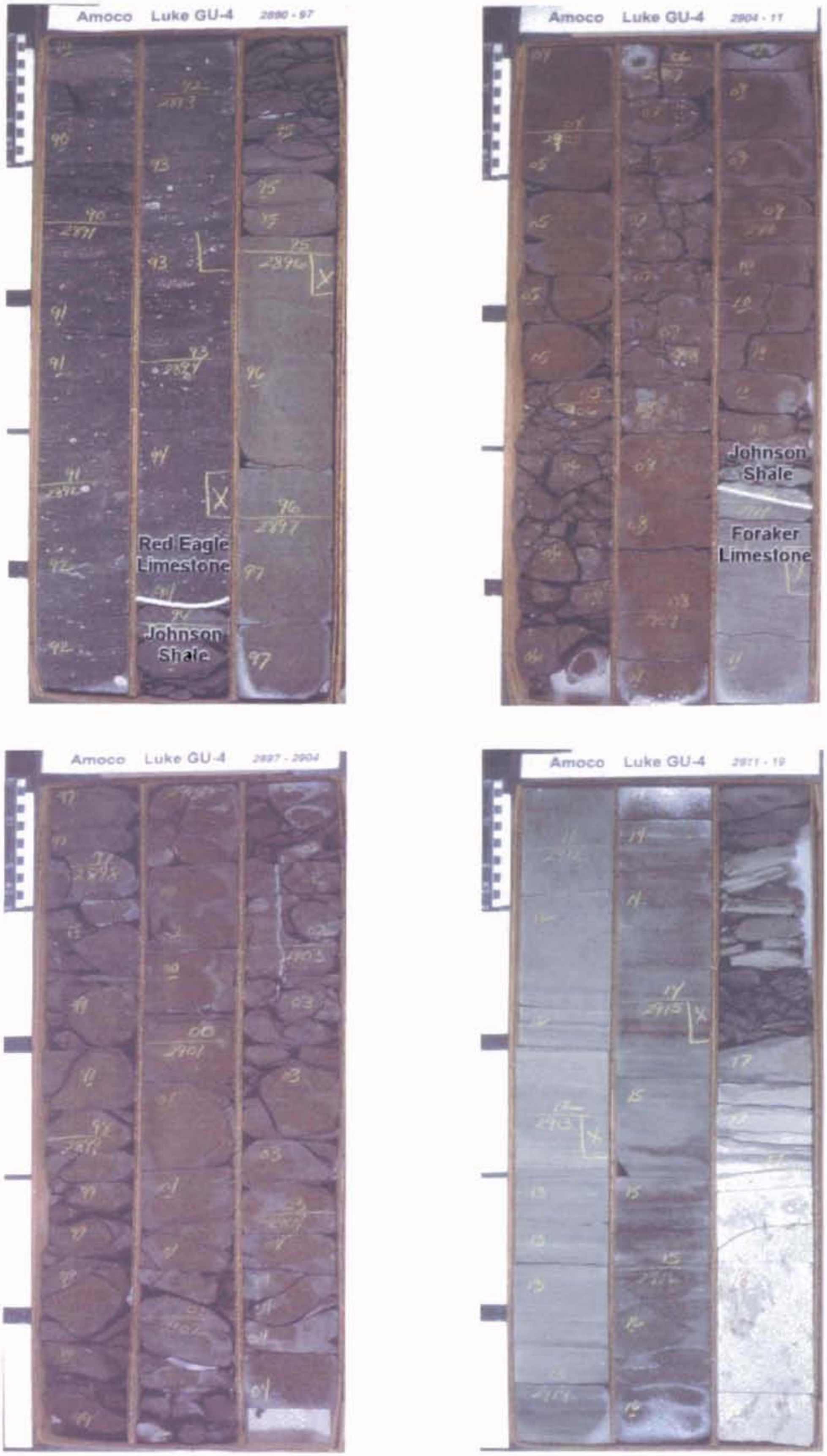

Figure 19. Amoco Luke GU #4 Core 2890-2919

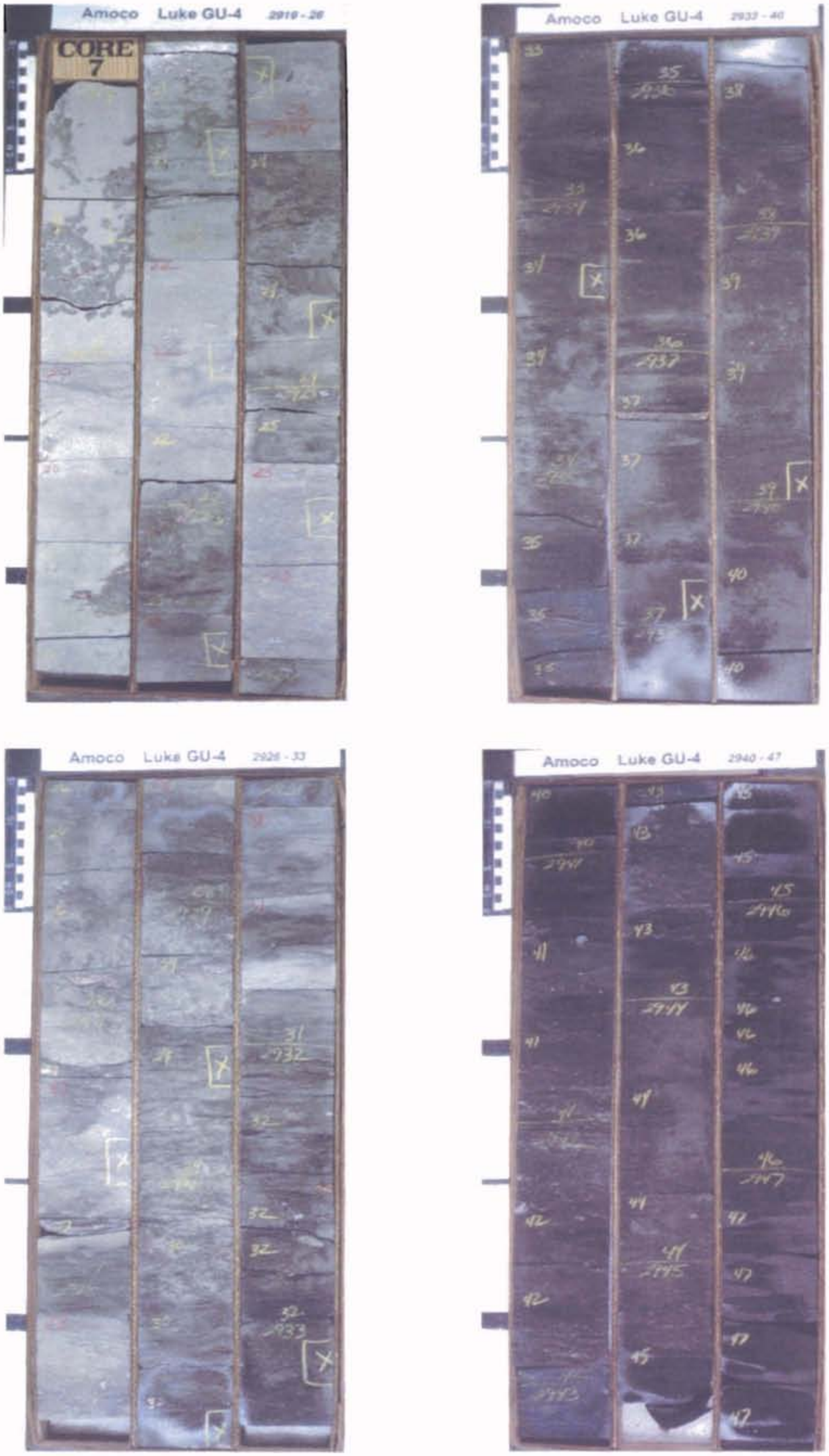

Figure 20. Amoco Luke GU #4 Core 2919-2947

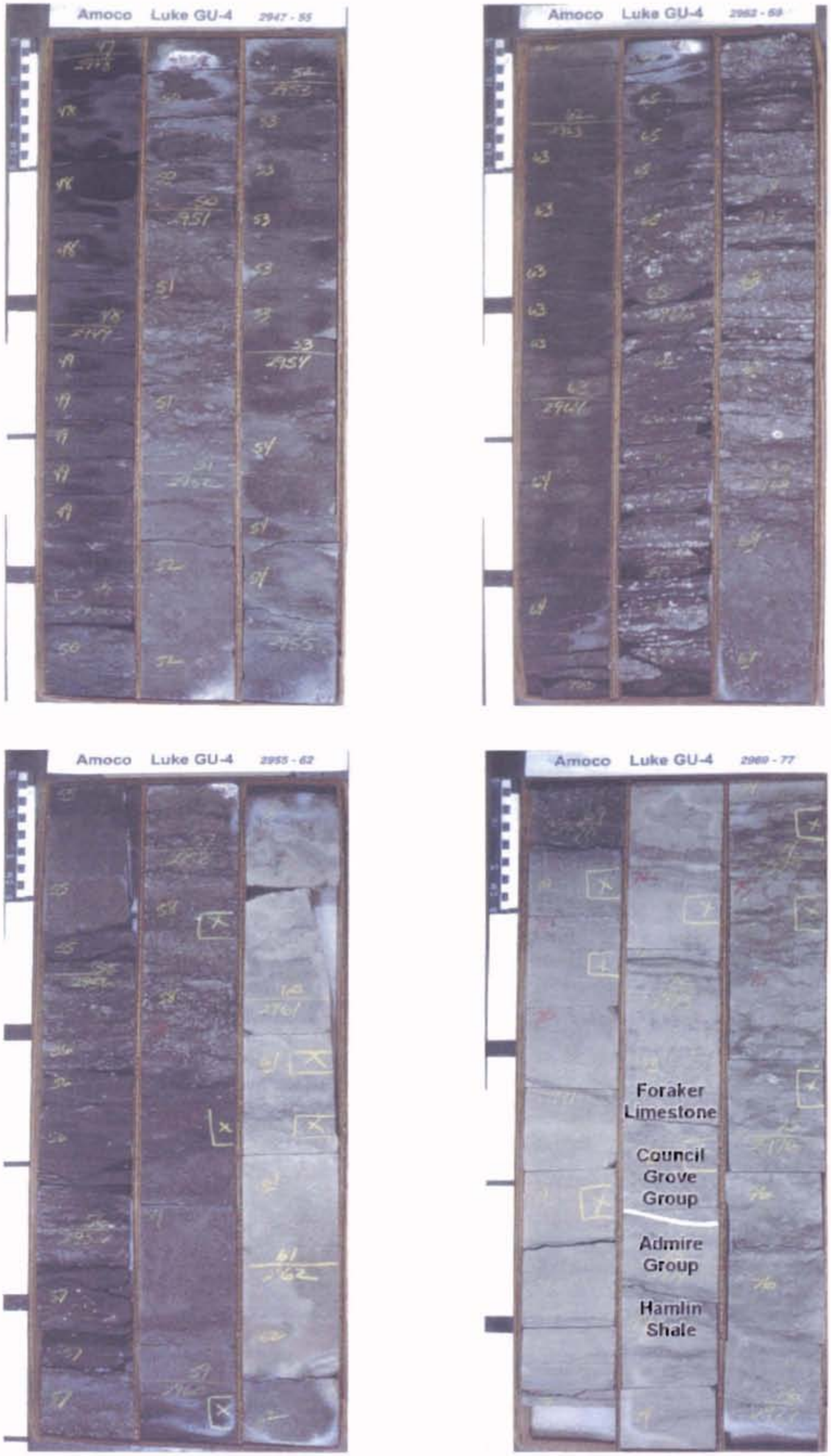

Figure 21. Amoco Luke GU #4 Core 2947-2977

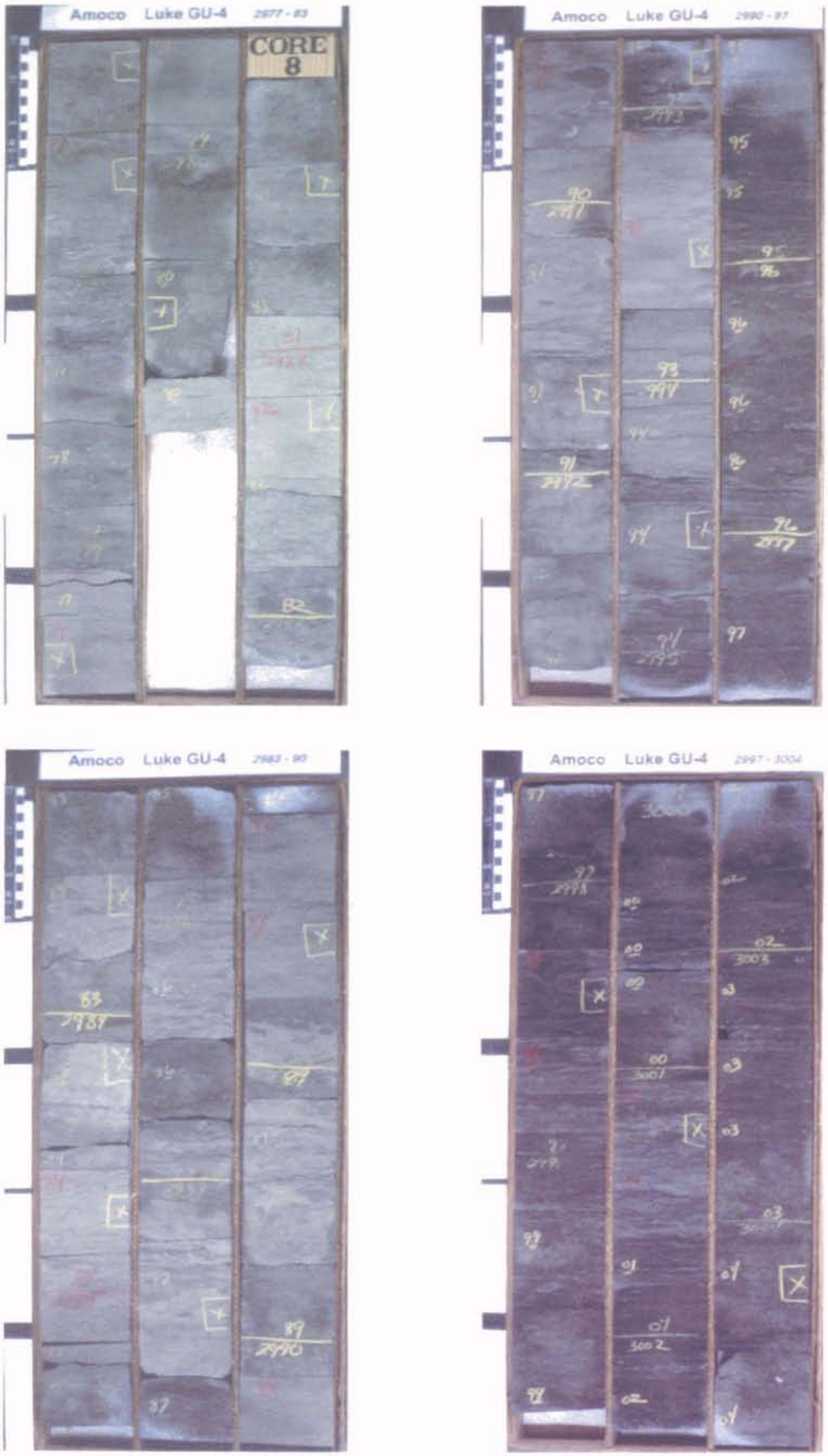

Figure 22. Amoco Luke GU #4 Core 2977-3004

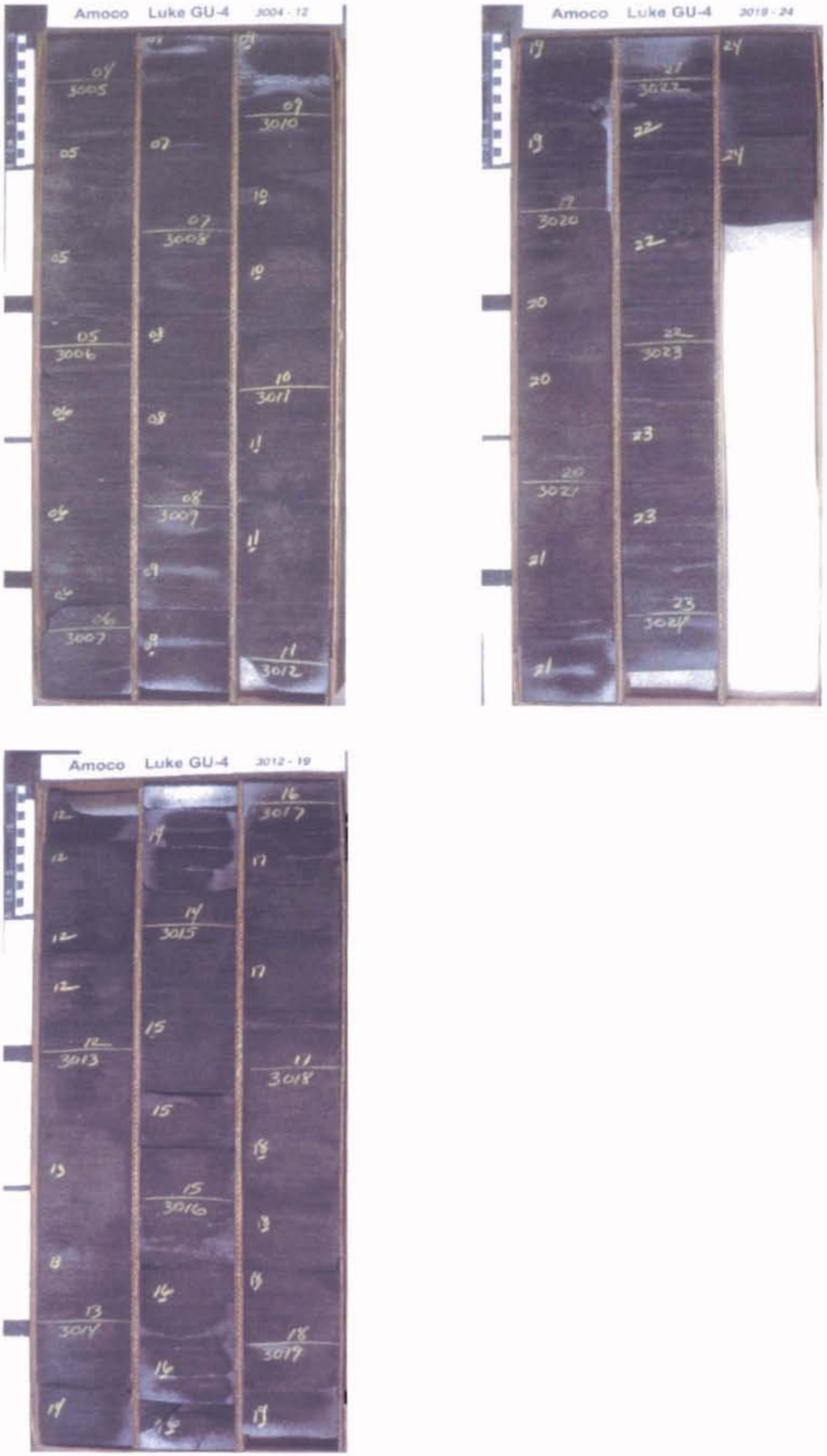

Figure 23. Amoco Luke GU #4 Core 3004-3024

Thin-section Analysis

A total of 8 lithofacies were recognized in the 77 thin-sections: (1) skeletal wackestone, (2) oncoid and skeletal packstone, (3) skeletal packstone, (4) mudstone, (5) silty wackestone, (6) calcareous siltstone, (7) ooid and peloid grainstone, and (8) a dolomite mudstone/wackestone. Table 1 lists lithofacies, formation, unit #, and core depth for each thin-section prepared.

(1) Skeletal Wackestone (SW)

Skeletal fragments, peloids, varying amounts of silt, and minor algal coated grains in a mud matrix (Fig. 24). Spar cement and syntaxial calcite cement are common. Most larger grains are fragmented while smaller grains are whole. Skeletal grains are composed of echinoid, brachiopod, mollusk, foraminifera, trilobite, algae, and minor ostracode. Some grains have been replaced by chalcedony quartz. Minor amounts of anhydrite replacement occurs within the mud. Dolomitization of the mud matrix occurs in some of the thin-sections.

(2) Oncoid and Skeletal Packstone (OSP)

Grain supported oncoids and skeletal fragments with algal coated grains, intraclasts and varying amounts of silt (Fig 25). Spar and syntaxial calcite cement are common. Many grains have been completely micritized. Grain replacement by quartz is common. Minor amounts of mud and grain replacement by anhydrite occurs.

(3) Skeletal Packstone (SP)

Skeletal fragments of echinoid, brachiopod, foraminifera, ostracode, bryozoan, trilobite, and mollusk with minor algal coated grains. Minor amounts of mud and silt (Fig 26). Spar and syntaxial cement are common. Grain replacement by quartz is

Thin-Section	Lithofacies	Formation	Unit	Core Depth
TS-1	SW	Chase GP/Wreford LS	5	2603.5
TS-2	OSP	↑	4	2606.4
TS-3	OSP		3	2606.9
TS-4	OSP	↓	2	2608.0
TS-5	OSP	Chase GP/Wreford LS	1	2610.0
TS-6	M	Funston LS	20	2639.1
TS-7	OSP	↑	19	2639.9
TS-8	M		18	2642.0
TS-9	SP		16	2643.9
TS-10	OSP		14	2647.0
TS-11	OSP		9	2653.8
TS-12	SW		8	2654.2
TS-13	M		5	2661.0
TS-14	M	↓	2	2668.1
TS-15	OSP	Funston LS	1	2670.0
TS-16	OPG	Crouse LS	8	2691.0
TS-17	SW	↑	6	2695.3
TS-18	SW	↓	4	2698.1
TS-19	OSP	Crouse LS	3	2700.2
TS-20	OPG	Bader/Middleburg LS	11	2714.5
TS-21	OSP	Bader/Middleburg LS	10	2716.9
TS-22	OSP	Bader/Middleburg LS	7	2721.9
TS-23	OSP	Bader/Eiss LS	2	2739.3
TS-24	OSP	Bader/Eiss LS	1	2741.3
TS-25	OSP	Stearns SH	2	2755.2
TS-26	M	Stearns SH	2	2757.4
TS-27	OPG	Beattie LS	8	2765.2
TS-28	OPG	↑	7	2766.1
TS-29	DW		6	2768.5
TS-30	DW		4	2772.0
TS-31	OSP		3	2777.0
TS-32	DW	↓	2	2778.8
TS-33	DW	Beattie LS	1	2780.5
TS-34	OSP	Grenola LS	22	2810.4
TS-35	SP	↑	21	2813.0
TS-36	SW		20	2815.5

Table 1. Council Grove Group Thin-Section Lithofacies.

Thin-Section	Lithofacies	Formation	Unit	Core Depth
TS-37	SP		19	2816.4
TS-38	SP		18	2817.4
TS-39	M		15	2823.3
TS-40	SW		14	2827.0
TS-41	SW		12	2828.9
TS-42	SP		9	2831.0
TS-43	SW		7	2833.4
TS-44	SW		6	2834.2
TS-45	OPG	Grenola LS	1	2841.7
TS-46	M	Red Eagle LS	14	2866.0
TS-47	M		14	2871.0
TS-48	SP		13	2873.3
TS-49	SP		11	2875.5
TS-50	SP		10	2877.7
TS-51	SW		9	2878.0
TS-52	SW		6	2879.5
TS-53	SW		4	2881.6
TS-54	STW		3	2882.5
TS-55	SW		3	2886.2
TS-56	STW		1	2889.7
TS-57	STW		1	2893.6
TS-58	STW	Red Eagle LS	1	2894.7
TS-59	OPG	Foraker LS	20	2918.5
TS-60	SP		19	2920.1
TS-61	M		18	2920.6
TS-62	CS		17	2927.3
TS-63	CS		16	2934.6
TS-64	CS		15	2938.0
TS-65	CS		15	2941.9
TS-66	SW		13	2950.0
TS-67	SW		12	2952.5
TS-68	M		11	2954.4
TS-69	SW		10	2955.9
TS-70	OSP		9	2958.0
TS-71	OSP		8	2959.4
TS-72	OSP		7	2960.2

Table 1. Continued. Council Grove Group Thin-Section Lithofacies.

Thin-Section	Lithofacies	Formation	Unit	Core Depth
TS-73	OSP	↓	6	2961.0
TS-74	STW		3	2969.0
TS-75	OSP		2	2970.0
TS-76	OPG		1	2971.0
TS-77	OPG	Foraker LS	1	2973.7

Table 1. Continued. Council Grove Group Thin-Section Lithofacies.

common along with mud and grain replacement by anhydrite. Dolomitization of the mud occurs in TS-9, TS-31, TS-37, TS-38, TS-48, TS-49, and TS-50 (Fig. 27).

(4) Mudstone (M)

Carbonate mud with less than 10% skeletal fragments (Fig. 28). Some mudstones have been dolomitized in thin-sections T5-8, T5-26, T5-39, and T5-47 (Fig. 29).

(5) Silty Wackestone (STW)

Skeletal fragments and silt sized quartz in a carbonate mud matrix (Fig. 30). A minor amount of grains have been replaced by quartz or anhydrite. The dominant skeletal grains are echinoid, brachiopod with a minor amount of fusulinids.

(6) Calcareous siltstone (CS)

Carbonate and mud matrix with quartz silt content ranging from 30-50% (Fig. 31). A minor amount of skeletal grains are present. Skeletal grains are echinoid and brachiopod. This lithofacies is only present in the Foraker Limestone and probably represents the Hughes Creek Shale Member.

(7) Ooid and Peloid Grainstone (OPG)

Ooids and micritized grains cemented by Spar cement (Fig. 32). Intraclasts and skeletal grains are also present. Dominant skeletal grains are echinoids and brachiopods.

(8) Dolomitic Mudstone/Wackestone (DW)

Skeletal grains in a mud matrix which has been replaced by coarse grained dolomite (Fig. 33). Dolomite crystals are euhedral. Dominant skeletal grains are composed of echinoid, bryozoan, and fusulinid. A minor amount of micritized grains are also present.

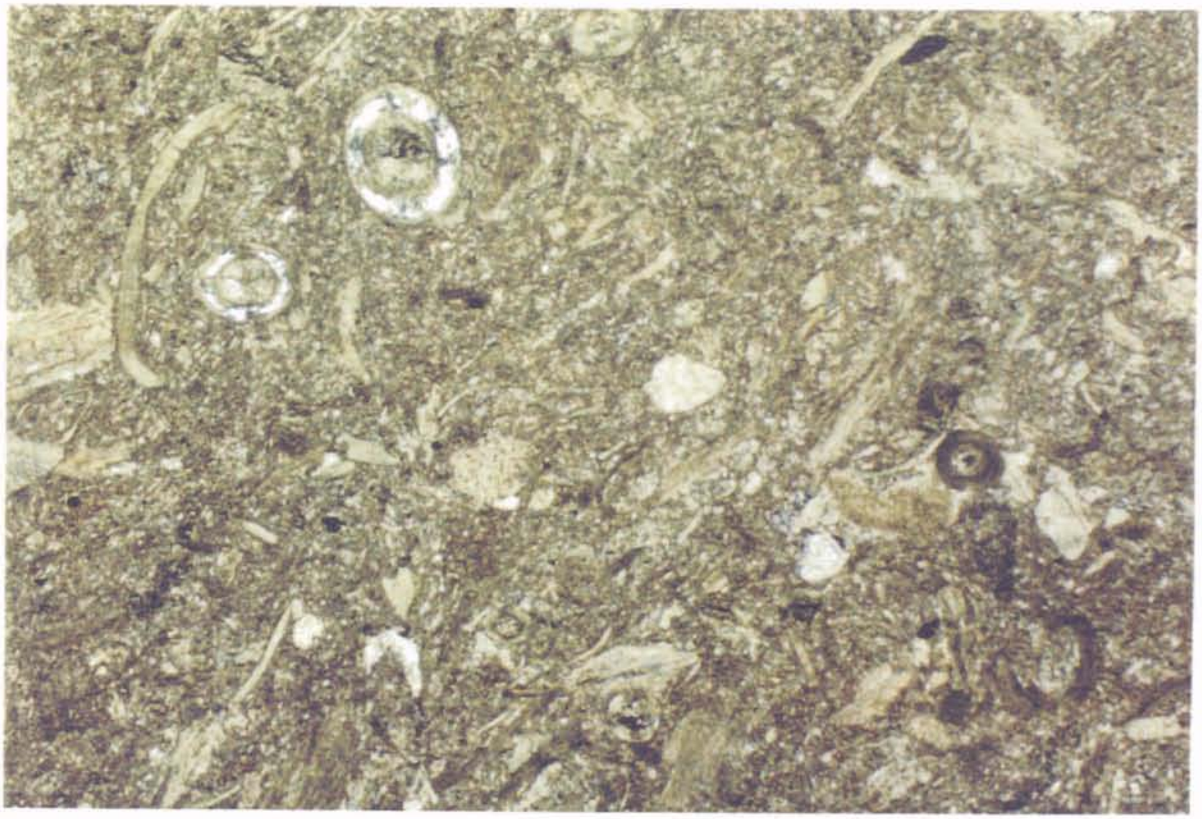

Figure 24. Skeletal Wackestone (SW) with brachiopod, echinoid, and trilobite grains. TS-40

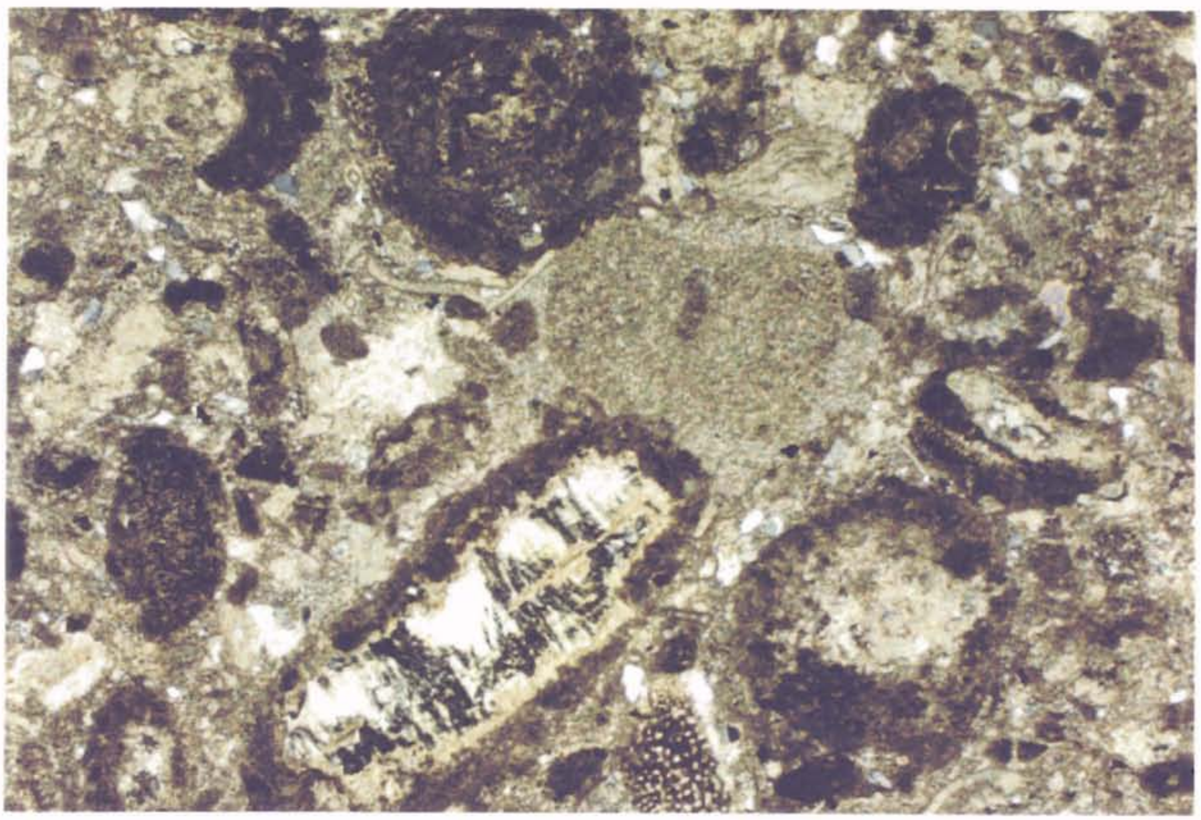

Figure 25. Oncoid and Skeletal Packstone (OSP) with oncoids, echinoid, trilobite, and quartz silt. TS-11

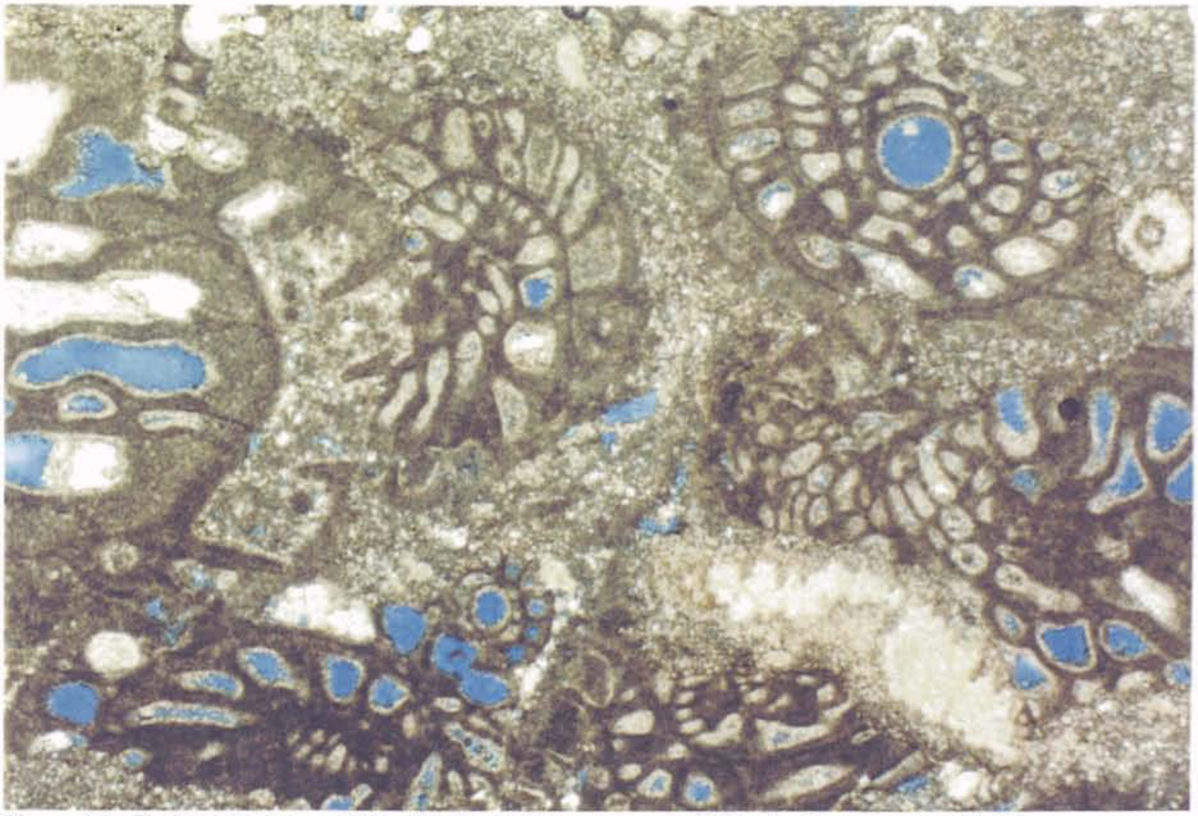

Figure 26. Skeletal Packstone(SP) with fusulinid grains and silicified echinoid grain. TS-60

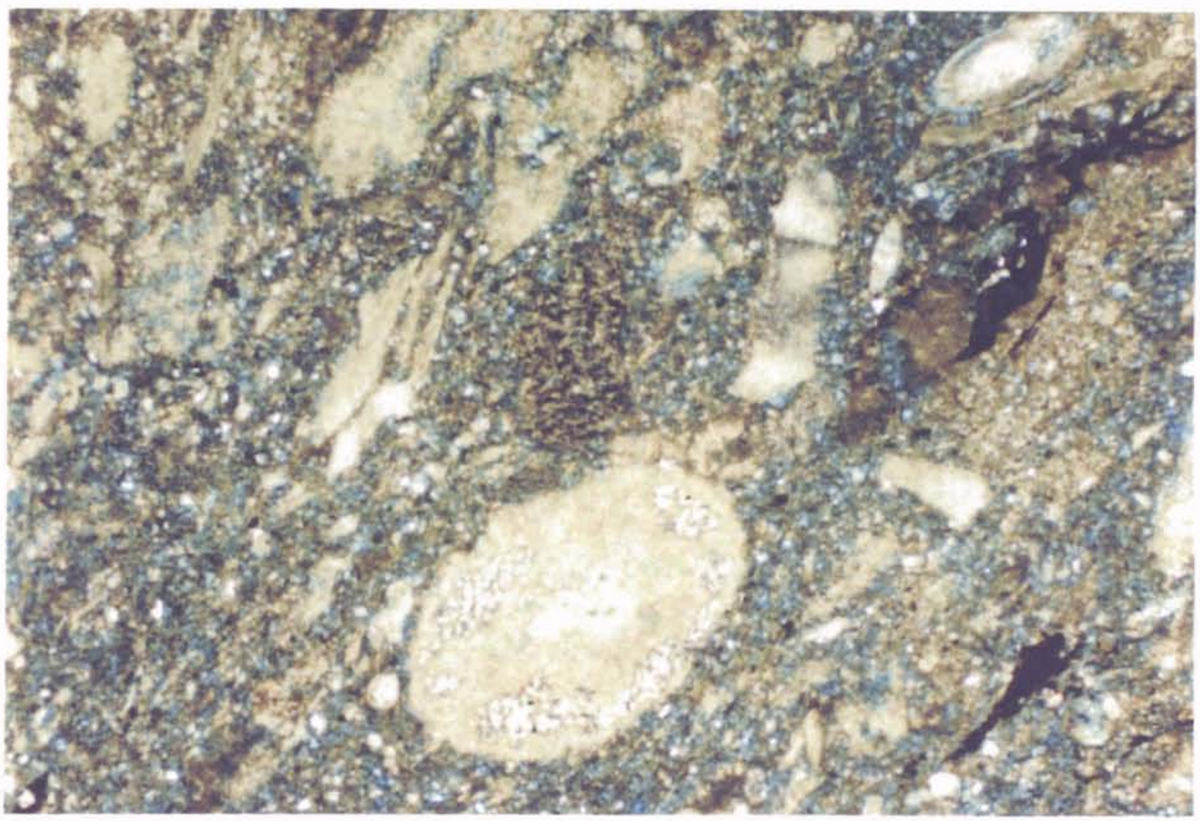

Figure 27. Skeletal Packstone (SP) with dolomite replacement of the mud matrix. TS-38

Figure 28. Mudstone Lithofacies (M), carbonate mud with brachiopod spine and echinoid grains. TS-13

Figure 29. Mudstone Lithofacies (M) dolomitized mud matrix with echinoid grain. TS-26

Figure 30. Silty Wackestone (STW) bryozoan and echinoid grains in mud with 8% silt. TS-56

Figure 31. Calcareous Siltstone (CS) large echinoid grain in carbonate mud with 30-35% silt. TS-62

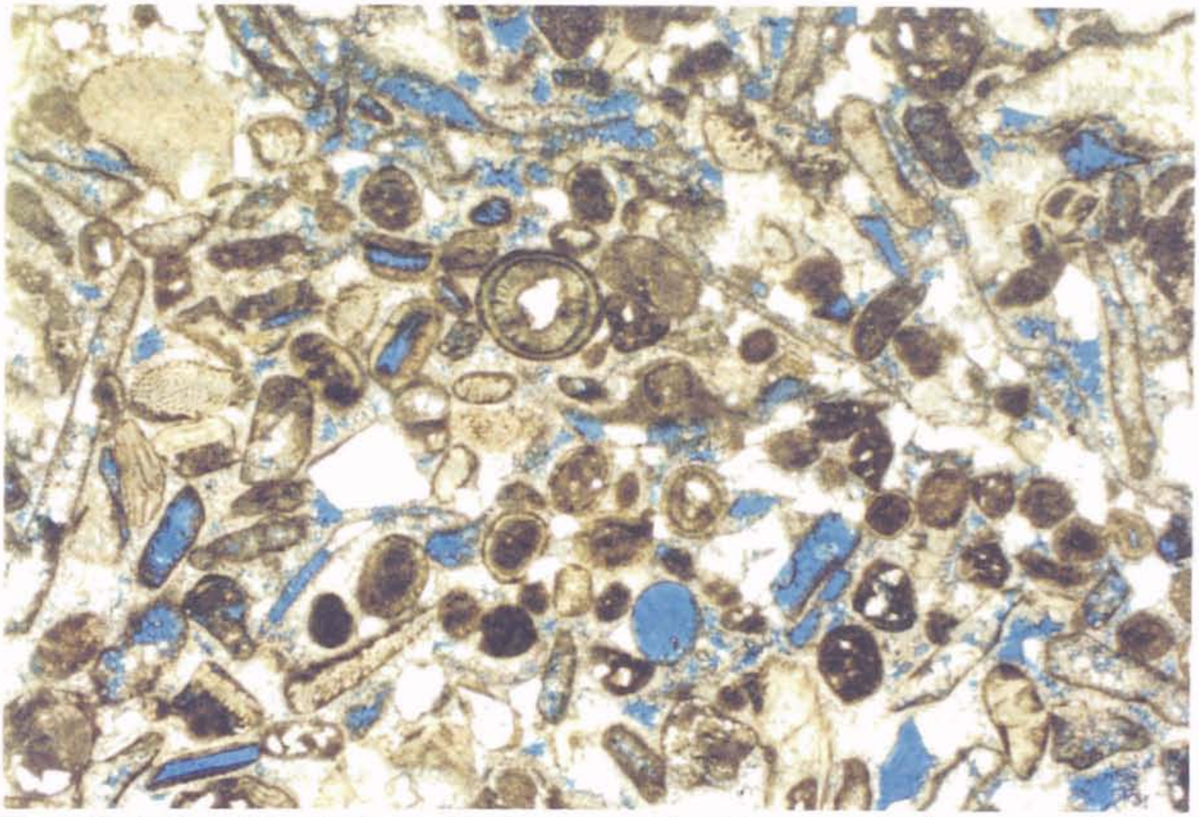

Figure 32. Ooid and Peloid Grainstone (OPG), ooids, peloids, echinoid, brachiopod, spar cement. TS-76

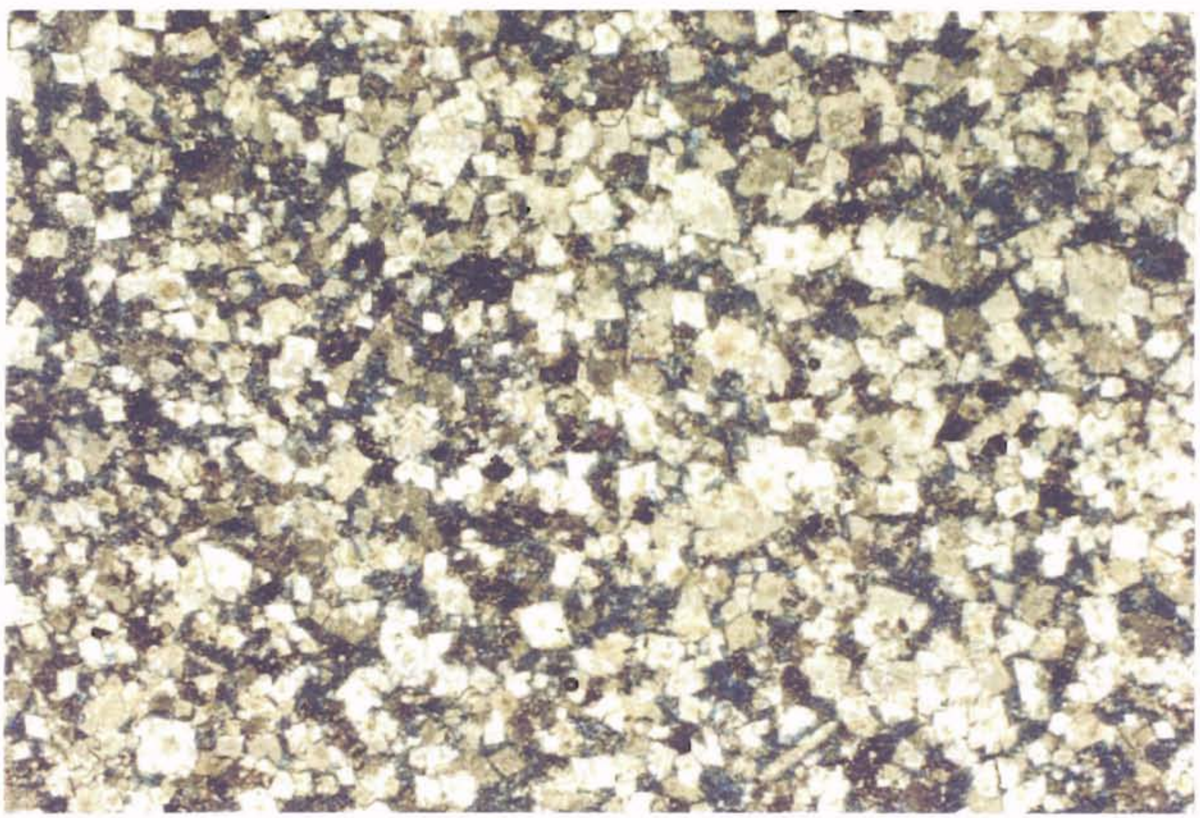

Figure 33. Dolomitic Wackestone (DW) echinoid and brachiopod with coarse dolomite. TS-30

East-West Cross-Sections

A total of 41 wireline logs were used to correlate the Council Grove Group from the Luke GU#4 well in southwestern Kansas to the Spencer No.1 well in southeastern Kansas. These logs were used to construct two stratigraphic cross-sections (Plate 2 and Plate 3). Plate 2 is a wireline log cross section that shows some of the general lithological changes and the associated wireline-log signatures. A total of 11 logs, approximately one per county, were used in the construction of the wireline log cross section (Plate 2). Logs were scanned and kept true to scale, 2.5 in. = 100 ft. Plate 3 is a "stick figure" cross section where thickness data from each formation from all 41 wireline logs was used to construct the stratigraphic cross section.

The datum for both cross sections was the base of the Wreford Limestone of the Chase Group. This datum was chosen because the Wreford Limestone and the overlying Matfield Shale are consistent marker beds throughout southern Kansas.

The Speiser Shale is composed primarily of shale along the entire length of the east-west cross section (Plate 2). Silty zones can be seen and are indicated by slightly lower gamma-ray readings and higher resistivity than the surrounding shale. Along the Plate 3 cross section the thickness of the Speiser Shale decreases between wells 1 and 11 and then remains relatively constant to the east of well 11 (Plate 3). The thinning is probably due to the increase in distance from the siliciclastic source to the west.

The Funston Limestone is predominantly composed of limestone but also contains thin interbeds of shale, silty shale, and possibly minor amounts of siltstone. The Funston Limestone contains a characteristic gamma-ray hot steak or "kick" in the upper most carbonate unit along the entire east-west wireline log cross section (Plate 2). This "kick" does not appear to be related to shale content as the resistivity of the interval remains high. Along the Plate 3 cross section, the thickness of the Funston Limestone is relatively the same between wells 1 and 23. Between wells 23 and 24, the Funston Limestone thins and remains thin until well 32. The thickness of the formation increases between wells 32 and 33 and then remains consistent to the east. The thinning of the Funston Limestone between wells 24 and 32 corresponds to a thickening trend in the underlying Blue Rapids Shale. The decrease in thickness may be due to a paleotopographic high associated with the Blue Rapids Shale.

The Blue Rapids Shale's primarily composed of shale along the western (wells 1-4) and eastern (wells 9-11) areas of the Plate 2 cross section. However, in the central area (well 5-8) the Blue Rapids Shale appears to be composed of interbedded shale and limestone. This area is near the center of the shelf and the limestone beds could be the result of minor transgressions that invaded the center of the shelf but did not reach the outer margins of the shelf area. Along the Plate 3 cross section, the thickness of the Blue Rapids Shale decreases from well 1 to well 14. This decrease in thickness is probably due to an increase in distance from the siliciclastic source to the west. Between wells 14 and 15 the thickness of the Blue Rapids Shale increases and continues to increase to well 24 (Plate 3). The thickness remains relatively constant to well 32 and then decreases between wells 32 and 33. East of well 33, the thickness of the interval shows little variation. The cause of thickening between wells 24 and 32 is unknown, however, this area of the cross section extends over the Pratt Anticline and may be associated with a paleotopographic high in which siliciclastic deposition or soil development was more prominent than surrounding lowland areas (Plate 3).

The Crouse Limestone is composed predominantly of a single limestone unit along the east-west wireline log cross-section (Plate 2). The Crouse Limestone contains a characteristic gamma-ray "kick" that does not appear to be associated with shale. Evidence for this is the fact that the interval with the "kick" generally has a high resistivity reading (Plate 2). Along the Plate 3 cross section, the thickness of the Crouse Limestone increases from west to east towards the center of the shelf. The center of the shelf is interpreted to be between wells 18 and 24 on the Plate 3 cross section. East of well 24 the overall thickness decreases slightly as distance from the center of the shelf increases.

The Easly Creek Shale is composed primarily of shale along the western (wells 1-5) and eastern area (wells 10-11) of the wireline log cross section (Plate 2). However, just like the Blue Rapids Shale above, the Easly Creek Shale appears to be composed of shale and thin limestone beds in the central area of the shelf (wells 6-9). These limestone beds could be the result of minor transgressions that only invaded the central areas of the shelf (Plate 2). Along the Plate 3 cross section, the thickness of the Easly Creek Shale generally decreases from well 1 in the west to well 20 in the center of the shelf. This decrease in thickness is probably caused by an increase in distance from the siliciclastic source to the west. East of well 20, the Easly Creek Shale increases in thickness for the remainder of the length of the cross section (Plate 3).

The Bader Limestone is differentiated into three members, the Eiss Limestone, the Hooser Shale, and the Middleburg Limestone, in ascending order. The Bader Limestone is the only formation in which the associated members were correlated (Plate 2 and 3). This is because all three members are lithologically distinct, consistent over large geographic areas, and contain unique log signatures that are easily identified on wireline logs. The Middleburg Limestone Member is predominately composed of limestone between wells 1 and 8 (Plate 2). From well 9 to 11 the Middleburg is composed of two limestone units separated by a shale unit (Plate 2). The Hooser Shale Member is composed primarily of shale along the entire length of the cross section. However, at wells 7 and 8 a thin unit with a low gamma-ray reading and high resistivity can be seen. This may be a thin limestone unit that is the result of a minor transgression that only affected the central areas of the shelf. The Eiss Limestone is composed entirely of limestone along the entire length of the cross-section. Along the Plate 3 cross section, the thickness of the Bader Limestone shows a general thickening from west to east. In areas where the Middleburg Limestone is relatively thick, the underlying Hooser Shale is thin. In areas where the Middleburg Limestone is thin, the Hooser Shale is thick (Plate 3). Areas where the Middleburg Limestone is thick and the Hooser Shale is thin are thought to be associated with paleotopographic lows during Middleburg Limestone deposition. Areas of Middleburg thinning and Hooser Shale thickening may be associated with paleotopographic highs. The thickness of the Eiss Limestone shows little variation but in areas where the underlying Stearns Shale thickens, the Eiss Limestone tends to thin. These areas may have been paleotopographic highs during Eiss deposition.

The Stearns Shale is composed of both limestone and shale along the entire east-west wireline log cross section (Plate 2). In the western most wells 1 and 2, and eastern most wells 10 and 11, the Stearns Shale is composed of two shale units separated by a thin limestone unit. In the central part of the shelf, wells 3-9, it is composed of approximately equal amounts of limestone and shale. All shale and limestone units are relatively thin bedded in the central area of the shelf (Plate 2). The interbedding of the limestone and shale in the Stearns Shale could be the result of high-frequency transgressive and regressive cycles that affected the inner most areas of the shelf. Along the Plate 3 cross section, the Stearns Shale thickness increases in the central shelf area and thins to the east and west (Plate 3). Thickening of the Stearns Shale in the center shelf area is probably due to a slightly higher rate of subsidence in the center of the shelf and subsequent carbonate production and deposition during minor transgressions.

The Beattie Limestone is composed of a single limestone unit in the western wells 1-3, on the wireline log cross section (Plate 2). Between wells 4 and 11 the Beattie Limestone is composed of multiple interbedded limestone and thin shale units. Some limestone units are "dirtier" or have higher gamma-ray readings than others and some have lower resistivity than others. The shales within the Beattie Limestone remain relatively thin along the east-west wireline log cross section (Plate 2). Along the Plate 3 cross section, the thickness of the Beattie Limestone increases drastically from the edges of the shelf on the east and west toward the center of the cross section (Plate 3). This increase in thickness is interpreted to represent an increase in carbonate production and deposition as the center of the shelf subsided at a faster rate than the edges of the shelf.

The Eskridge Shale is predominantly composed of shale along the entire east-west wireline log cross section (Plate 2). However, similar to shale formations above, thin limestone units can be interpreted in the Eskridge Shale in the central areas of the cross section (Plate 2). These thin limestones have "clean" gamma-ray signatures and high resistivity readings. Along the Plate 3 cross section, the Eskridge Shale thickness generally thins toward the center area of the shelf. This thinning trend is probably due to the increased distance from the siliciclastic source to the west. Thickening of the Eskridge Shale in the eastern part of the cross section appears to correspond to minor thinning of the underlying Grenola Limestone. These areas may be associated with paleotopographic lows that existed during Eskridge Shale deposition.

The Grenola Limestone is composed of interbedded limestone and shale along the east-west wireline log cross section (Plate 2). The upper half of the Grenola Limestone is composed of a relatively massive limestone unit, the Neva Limestone Member, and the lower half is interbedded limestone and shale. The massive upper limestone contains a characteristic gamma-ray "kick" in the lower to middle part of the unit. This "kick" does not appear to be associated with a shale parting. Evidence for this is the fact that the interval tends to have relatively high resistivity and a slight negative SP deflection. Along the Plate 3 cross section, the thickness of the Grenola Limestone increases rapidly just east of the most western well, well 1. The thickness then remains relatively constant along the remainder of the Plate 3 cross section. The thinning of the Grenola Limestone on the western side of the shelf may be due to a slower rate of subsidence on this side of the shelf or it may be due to a paleotopographic high associated with the underlying Roca Shale.

The Roca Shale is composed entirely of shale along the east-west wireline log cross section (Plate 2). A thin bed with a clean gamma-ray signature and high resistivity can be seen in wells 3 and 4 (Plate 2). The boundary between the overlying Grenola Limestone and the Roca Shale is difficult to distinguish between wells 5 and 6, and is therefore inferred from well 5 along the rest of the cross section to the east (Plate 2). Along the Plate 3 cross section, the thickness of the Roca Shale decreases from the west towards the center of the shelf area and then remains relatively constant across the rest of the cross section (Plate 3). The thinning of the Roca Shale in the central and eastern areas of the cross section is possibly due to the increased distance from the siliciclastic source to the west (Plate 3).

The Red Eagle Limestone is composed primarily of limestone and minor amounts of shale along the east-west wireline log cross section (Plate 2). Between wells 1 and 6, it appears to be composed of a single limestone unit (Plate 2). Between wells 7 and 11, it is composed of two limestones separated by a shale unit. The Red Eagle contains a characteristic gamma-ray "kick" in the middle of the unit in the western area of the cross section (wells 1-5). This "kick" does not appear to be associated with shale content. East of well 5 (Plate 2) the Red Eagle Limestone appears to have an overall "dirtier" appearance on gamma-ray logs. The thickness of the Red Eagle Limestone remains relatively constant along the entire length of the east-west cross section (Plate 3).

Along the east-west wireline log cross section (Plate 2), the Johnson Shale is composed primarily of shale. However, beds with low gamma-ray readings and high resistivity appear in well 7 and continue east to well 11. These beds may be limestones deposited by minor transgressions that only affected the central and eastern areas of the shelf. The Johnson Shale decreases in thickness from the west toward the center of the shelf (Plate 3). This thinning is thought to be caused by the increased distance from the siliciclastic source to the west. The Johnson Shale then increases in thickness between wells 22 and 23 (Plate 3). This increase in thickness is thought to be caused by the presence of the limestone unit that appears in wells 7-11 (Plate 2).

The Foraker Limestone contains the most complex lithologies of all the formations within the Council Grove Group. Along the east-west wireline log cross section (Plate 2), the Foraker Limestone is composed of limestone, shales, and siltstones. Limestone appears to be the dominant lithology within the Foraker Limestone along the east-west cross sections. Because of the variability in lithology within the Foraker Limestone, no general wireline log signatures can be seen or identified (Plate 2). The boundary between the Foraker Limestone and the underlying Admire Group is difficult to distinguish as the center of the shelf area is approached between wells 4 and 5 (Plate 2) and is inferred from well 5 to well 11. The thickness of the Foraker Limestone increases as the center of the shelf is approached (Plate 2 and 3). The overall increase in the thickness of the Foraker Limestone in the center of the shelf area is probably due to a higher rate of subsidence.

East-West Cross Section Summary

Both east-west cross sections show a two-dimensional representation of the shelf area during Council Grove Group deposition. Near the edges of the shelf on the east and west sides of the cross sections, the lithologies are approximately equal amounts of limestone and shale (Plate 2 and 3). The thickness of the entire study interval is thinner on the edges of the cross sections when compared to areas near the middle of the shelf. As the center of the shelf is approached, the distance from siliciclastic sources is increased and therefore, the amount of shale compared to limestone decreases (Plate 2 and 3). The overall thickness of the study interval increases by as much as 75 feet in the center of the shelf. This is probably due to a slightly higher rate of subsidence and subsequent increased carbonate production and deposition in the center of the shelf.

North-South Cross Section

A total of 13 wireline logs were used to correlate the Council Grove Group from the southern end to the northern end of the Panoma Field. These logs were used to construct two stratigraphic cross sections (Plate 4 and 5). Plate 4 is a wireline log cross section, which shows the general log signatures of the Council Grove Group. Only 7 of the 13 logs were used to construct the wireline log cross section in Plate 4. All logs were scanned and kept true to scale, 2.5 in. = 100 ft. Plate 5 is a "stick figure" stratigraphic cross section in which trends in thickening and thinning of the formations are shown. The base of the Foraker Limestone, which corresponds to the base of the Council Grove Group, is not shown in well 6 because this well did not penetrate that part of the section.

Similar to the east-west cross sections, the datum for the north-south cross sections is the base of the Wreford Limestone of the overlying Chase Group.

The Speiser Shale is composed predominantly of shale along the north-south wireline log cross section (Plate 4). Lithologies with cleaner gamma-ray readings, higher resistivity and negative SP deflection can be seen in all seven wells along the Plate 4 cross section. In the cored well, well #3, this high resistivity, negative SP deflection interval is associated with an increase in silt content. The thickness of the Speiser Shale remains constant along the entire north-south cross section (Plate 5).

The Funston Limestone is composed primarily of limestone but also contains thin interbeds of shale, siltstone, and silty shale (Plate 4). The Funston Limestone contains a characteristic gamma-ray "kick" near the top of the formation along the Plate 4 cross section. This is the same "kick" that is present in the Funston Limestone along the east-west wireline log cross section (Plate 2). This "kick" does not appear to be associated with shale. The Funston Limestone decreases in thickness from the southern end to the northern end of the cross section. This could be due to increased subsidence to the south, which is closer to the shelf edge.

The Blue Rapids Shale is composed primarily of shale and minor amounts of siltstone or silty shale along the north -south wireline log cross section (Plate 4). Silty zones along the cross section are indicated by clean gamma-ray readings and negative SP deflections. Along the Plate 5 cross section, the thickness of Blue Rapids Shale slightly increases between wells 4 and 5 and then remains relatively constant to the north and south of these two wells.

The Crouse Limestone is composed of a single limestone unit along the north-south wireline log cross section (Plate 4). Along the southern part of the cross section, wells 1-3, the lower part of the limestone has a high gamma-ray reading (Plate 4). North of well 3 this same interval of the Crouse Limestone has a low gamma-ray reading. Along the Plate 5 cross section, the thickness of the Crouse Limestone is relatively constant between wells 1-3, decreases between wells 3 and 4 and remains relatively constant between wells 4 and 9. The thickness decreases again between wells 9 and 10 (Plate 5) and remains thin from wells 10-13. The thinning of the Crouse Limestone from wells 10-13 corresponds with an overall thickening of the underlying Easly Creek Shale in the same wells. The thinning of the Blue Rapids Shale from wells 10-13 may be due to a paleotopographic high on the Easly Creek Shale.

The Easly Creek Shale is composed primarily of shale along the north-south wireline log cross section (Plate 4). Minor zones possibly containing increased silt content are indicated by slightly elevated resistivity readings and minor negative SP deflections. These zones can be seen in wells 3, 6, and 7 (Plate 4). The thickness of the Easly Creek Shale remains relatively constant between wells 1-9 and then increases slightly between wells 9 and 10 and then remains constant along the remainder of the cross section (Plate 5).

The Bader Limestone is composed of the Eiss Limestone, Hooser Shale, and Middleburg Limestone Members, in ascending order. The Bader Limestone is the only formation within the Council Grove Group in which the members can be correlated along the north-south well logs (Plate 4). Along the north-south cross sections, the limestone members are composed primarily of limestone, and the Hooser Shale is primarily shale with minor silty zones (Plate 4). Silty zones within the Hooser Shale are indicated by slightly lower gamma-ray reading and higher resistivity than the surrounding shale. The overall thickness of the Bader Limestone remains constant along the north-south cross section (Plate 5). Minor decreases in the thickness of the Middleburg Limestone from south to north correspond with minor thickening of the underlying Hooser Shale. The thickness of the Eiss Limestone remains relatively constant from south to north (Plate 5).

Along the north-south cross sections, the Stearns Shale is composed of two shale units separated by a thin limestone unit. Possible silty zones within the shales are indicated by slightly lower gamma-ray readings, higher resistivity, and negative SP deflection (Plate 4). The thickness of the Stearns Shale is slightly variable along the north-south cross section and generally thickens to the north (Plate 5).

The Beattie Limestone is composed of a single limestone unit along the north-south wireline log cross section (Plate 4). Along this cross section the Beattie Limestone exhibits a characteristic "kick" on the gamma-ray log which does not appear to be related to shale content (Plate 4). Evidence for this is the fact that although the gamma-ray reading increases dramatically, resistivity remains high and the SP deflection remains negative. The thickness of the Beattie generally decreases from south to north (Plate 5), with a sudden decrease between wells 10 and 11. This thinning trend corresponds to an overall thickening of the overlying Stearns Shale. The thinning of the Beattie Limestone could be due to subaerial exposure, erosion, and soil formation.

The Eskridge Shale is predominantly composed of shale along the north-south wireline log cross section (Plate 4). Minor silty zones are indicated by slightly higher resistivity and lower gamma-ray reading than the surrounding shale (Plate 4). Along the Plate 5 cross section, the thickness of the Eskridge Shale is relatively constant along most of the north-south cross sections. However, between wells 2 and 4, the overall thickness increases rapidly (Plate 5). The thickness decreases between wells 5 and 6 and then remains consistent to the north. This increase in thickness corresponds with an overall thinning of the underlying Grenola Limestone in the same wells. The thickening of the Eskridge Shale and associated thinning of the Grenola Limestone is may be caused by subaerial exposure, erosion, and soil development within the upper part of the Grenola Limestone.

The Grenola Limestone is composed of an upper limestone unit and a lower unit that is composed of interbeds of limestone and shale (Plate 4). The upper limestone is the Neva Limestone Member. The upper limestone contains a characteristic gamma-ray "kick" in the mid to lower part of the unit (Plate 4). This "kick" does not seem to correspond to shale content as resistivity remains high and negative SP deflection can be seen over the same interval (Plate 4). The thickness of the Grenola Limestone is relatively constant from south to north except for the thin area between wells 3, 4, and 5 as previously discussed (Plate 4).

The Roca Shale is composed entirely of shale along the north-south wireline log cross section (Plate 4). Minor increases in silt content may cause slightly higher resistivity than the surrounding shale (Plate 4). The overall thickness of the Roca Shale shows a minor thickening trend from south to north (Plate 5).

The Red Eagle Limestone is composed of a single limestone unit along the north-south wireline log cross section (Plate 4). Along this cross section the Red Eagle Limestone contains a characteristic gamma-ray "kick" in the mid to lower part of the formation. This is the same gamma-ray "kick" that can be seen in the Red Eagle Limestone along the east-west wireline log cross section (Plate 2). This high gamma-ray reading does not appear to be related to shale content as the resistivity of this zone remains high and there is a negative SP deflection (Plate 4). The overall thickness of the Red Eagle Limestone remains constant along the entire length of the north-south cross section (Plate 5). However, minor thinning does occur in well 5.

The Johnson Shale is composed entirely of shale along the north-south wireline log cross section (Plate 4). This formation is characterized by high gamma-ray readings and low resistivity (Plate 4). The overall thickness of the Johnson Shale shows minor thickening from south to north (Plate 5).

The lithology of the Foraker Limestone is highly variable along the north-south wireline log cross section (Plate 4). The Foraker Limestone is composed of limestone, shale, siltstone, and silty shale. The proportions of limestone to siliciclastic units is highly variable from well to well (Plate 4). The top and bottom of Foraker Limestone is characteristically a limestone unit with low gamma-ray readings and high resistivity. The limestone top corresponds to the Long Creek Limestone Member and the base is the Americus Limestone Member. In wells 5-7 (Plate 4), the base of the Foraker Limestone is difficult to identify due to lithological similarities with the underlying Admire Group. The overall thickness of the Foraker Limestone remains relatively constant along the entire north-south cross sections (Plate 5).

North-South Cross Sections Summary

The north-south cross sections show that the Council Grove Group is composed of approximately equal amounts of marine limestone and terrestrial siliciclastic shale. When compared to the central area of the east-west cross sections (Plate 2 and 3) where limestone is the dominant lithology, the north-south cross sections (Plate 4 and 5) show that this areas was much closer to a siliciclastic source and was further landward on the shelf. The overall thinning of the limestones from south to north and the thickening of the shale units in the same direction indicate that transgressions invaded this area of the shelf from the south. This thinning and thickening trend also suggest that the northern area of this cross section was located farther landward than the southern end of the cross section.

Council Grove Group Type Logs

Type Logs for the Council Grove Group have been selected and developed for 16, southern Kansas counties (Fig. 5). These type logs have been separated into two groups, one group is from counties that contain parts of the Panoma Field (Plate 6), and the other group is from counties that lie east of the Panoma Field (Plate 7).

IV

CONCLUSIONS

1. In the Amoco Luke GU #4 core, the seven shale formations of the Council Grove Group represent paleosols developed in coastal plain depositional environment.

2. In the Amoco Luke GU #4 core, the lithologies of the seven limestone formations were deposited in coastal plain, sabkha, intratidal, shoal, and subtidal depositional environments.

3. Eight lithofacies were identified in the 77 thin-sections from the Luke GU #4 core.

4. Shale formations become thinner and limestone formations become thicker as the axis of the Hugoton Embayment is approached from the east and west.

5. Shale formations become thicker and limestone formations become thinner from the southern end to the northern end of the Panoma Field.

6. The boundary between the Council Grove Group and underlying Admire Group was identified on the Luke GU #4 core using lithostratigraphic methods.

7. The boundary between the Council Grove Group and overlying Chase Group was identified on the Luke GU #4 core using lithostratigraphic methods.

8. All 14 formations of the Council Grove Group were identified in all 56 wireline logs used in the study.

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APPENDIX A

Wireline Log Locations and Company Information

County	Well Name	Location
Barber	Douthette No. 1-2A	24-30S-11W C NE NW
Barber	Meairs No. 1	27-30S-12W C NW SE
Barber	Grigsby No. 2	22-30S-13W NE SW NW
Barber	Mills No. 1-20	20-30S-14W SE SW
Barber	Freeman No. 2-21	21-30S-15W SW NE NE
Clark	MC Colm "B" 1	15-30S-21W C NE
Clark	Blau No. 1	23-30S-22W C NE NE
Clark	Pyle Ranch No. 1	13-30S-23W C SW SE
Clark	Espuland No. 1	22-30S-24W C NE SW
Clark	Church No. 1-18	18-30S-25W C S/2 SE
Comanche	Deewall No. 1	22-33S-18W S/2 N/2 NW
Grant	Truesdale No. 3-12	12-30S-35W C SW SW
Grant	H.P. Maxwell No. 2-A	4-29S-36W C SW NE
Grant	Thomason 2-14	14-29S-37W C SE SW
Grant	Goertzen Gas Unit No. 1	5-29S-38W C NW SE
Grant	Gall Area 13 No. 1	16-27S-37W C-NE-SW
Grant	Cassity "A" 1	13-28S-37W C-SE-NW
Harper	Muir "B" 1	16-32S-7W NW-NW-NW
Haskell	Watkins Gas Unit "E" No. 1	20-30S-32W C SW NE
Haskell	E.M. Watkins No. 2	7-30S-33W C NW NW
Haskell	Feedlot No. 1	33-30S-34W C SE SE
Kearny	Miller No. 3	13-21S-35W C-NE-SE
Kearny	Rooney No. 1	4-22S-35W C-NW-NW
Kearny	C.H. Hoover No. 1	23-23S-36W C-SE-NW
Kearny	J.K. Moser No. 1	31-24S-36W C-NW-NW
Kearny	Lee No. 8-2	32-25S-36W C-SW-NE
Kingman	Trousdale No. 1	34-30S-5W C NW SW
Kingman	Callahan No. 1	23-30S-6W C NE SE
Kingman	Kostner #1	13-29S-7W C SW NW SW
Kingman	Pride No. 1	10-29S-8W C NW NE
Kingman	Swinger No. 1	11-30S-9W SW NW NE
Kingman	Morisse Unit No. 1	14-30S-10W NW NW SE
Kiowa	E.D. Robbins	24-30S-16W NE NW SW
Kiowa	Booth No. 1	29-30S-17W 400' W of C-S/2-NE/4
Kiowa	No. 1 Fincham Unit	2-30S-18W C NE SW
Kiowa	Wagner "A" No. 1	2-30S-19W C SW NW
Kiowa	ME Seacat Trustee B-1	1-30S-20W C SW NW
Meade	H. Roberts No. 1	21-30S-26W C SE SW
Meade	Copenhaver No. 1	34-30S-27W C SE
Meade	Merkle No. 1	15-30S-28W C NE NW
Meade	Dale Schmidt No. 1	20-30S-29W C SW SE

County	Well Name	Company
Barber	Douthette No. 1-2A	Kan-Ex, Inc.
Barber	Meairs No. 1	Chief Drilling Co.
Barber	Grigsby No. 2	National Oil Co.
Barber	Mills No. 1-20	Herbert G. Davis Inc.
Barber	Freeman No. 2-21	Sabine Production Co.
Clark	MC Colm "B" 1	Imperial Oil
Clark	Blau No. 1	Mesa Petroleum Co.
Clark	Pyle Ranch No. 1	Oil Property Management Inc.
Clark	Espuland No. 1	Sun Oil Co.
Clark	Church No. 1-18	Ladd Petroleum Corp.
Comanche	Deewall No. 1	Mid Cont. Energy
Grant	Truesdale No. 3-12	Mesa Petroleum Co.
Grant	H.P. Maxwell No. 2-A	Columbian Fuel Corp.
Grant	Thomason 2-14	Hugoton Production Co.
Grant	Goertzen Gas Unit No. 1	Pan American Petroleum Corp.
Grant	Gall Area 13 No. 1	Shell Oil Co.
Grant	Cassity "A" 1	Anadarko Production Co.
Harper	Muir "B" 1	Texas Oil & Gas Corp.
Haskell	Watkins Gas Unit "E" No. 1	Pan American Petroleum Corp.
Haskell	E.M. Watkins No. 2	Pan American Petroleum Corp.
Haskell	Feedlot No. 1	Service Drilling Co.
Kearny	Miller No. 3	Coastal Oil & Gas
Kearny	Rooney No. 1	Keith Tuthill
Kearny	C.H. Hoover No. 1	Pan American Petroleum Corp.
Kearny	J.K. Moser No. 1	Pan American Petroleum Corp.
Kearny	Lee No. 8-2	Kansas Nebraska Gas Co.
Kingman	Trousdale No. 1	Mack Oil Co.
Kingman	Callahan No. 1	Anadarko Production Co.
Kingman	Kostner #1	Gulf Energy & Minerals U.S.
Kingman	Pride No. 1	Mack Oil Co.
Kingman	Swinger No. 1	Sierra Petroleum Co.
Kingman	Morisse Unit No. 1	Sunray DX and Skelly Oil Co.
Kiowa	E.D. Robbins	Shell Oil Co.
Kiowa	Booth No. 1	G.T. Alpin
Kiowa	No. 1 Fincham Unit	K & E Drilling Co.
Kiowa	Wagner "A" No. 1	Anadarko Production Co.
Kiowa	ME Seacat Trustee B-1	KRM Production Corp.
Meade	H. Roberts No. 1	Rains & Williamson
Meade	Copenhaver No. 1	Price Exploration Co.
Meade	Merkle No. 1	C.S.G. Exploration
Meade	Dale Schmidt No. 1	National Oil Co.

County	Well Name	Field
Barber	Douthette No. 1-2A	N/A
Barber	Meairs No. 1	Wildcat
Barber	Grigsby No. 2	Wildcat
Barber	Mills No. 1-20	N/A
Barber	Freeman No. 2-21	East Turkey Greek Abd.
Clark	MC Colm "B" 1	Wildcat
Clark	Blau No. 1	Wildcat
Clark	Pyle Ranch No. 1	Wildcat
Clark	Espuland No. 1	Wildcat
Clark	Church No. 1-18	Wildcat
Comanche	Deewall No. 1	Wildcat
Grant	Truesdale No. 3-12	Ext/Many Creeks
Grant	H.P. Maxwell No. 2-A	Wildcat
Grant	Thomason 2-14	Wildcat
Grant	Goertzen Gas Unit No. 1	Wildcat
Grant	Gall Area 13 No. 1	Wildcat (Hugoton)
Grant	Cassity "A" 1	Wildcat
Harper	Muir "B" 1	Zuercher
Haskell	Watkins Gas Unit "E" No. 1	Wildcat
Haskell	E.M. Watkins No. 2	Lemon N. W.
Haskell	Feedlot No. 1	Wildcat
Kearny	Miller No. 3	Christabelle
Kearny	Rooney No. 1	Wildcat
Kearny	C.H. Hoover No. 1	Wildcat
Kearny	J.K. Moser No. 1	Wildcat
Kearny	Lee No. 8-2	Wildcat
Kingman	Trousdale No. 1	Wildcat
Kingman	Callahan No. 1	Wildcat
Kingman	Kostner #1	N/A
Kingman	Pride No. 1	Wildcat
Kingman	Swinger No. 1	Spivey-Grabs
Kingman	Morisse Unit No. 1	Wildcat
Kiowa	E.D. Robbins	Glick
Kiowa	Booth No. 1	Glick
Kiowa	No. 1 Fincham Unit	Parkin
Kiowa	Wagner "A" No. 1	West Alford
Kiowa	ME Seacat Trustee B-1	Wildcat
Meade	H. Roberts No. 1	Wildcat
Meade	Copenhaver No. 1	Wildcat
Meade	Merkle No. 1	Wildcat
Meade	Dale Schmidt No. 1	Wildcat

County	Well Name	Location
Meade	Hobart No. 1	26-30S-30W C SE
Morton	Tillett Gas Unit "B" No. 1	19-32S-39W C-SW-NE
Sedgewick	D & E No. 37-575	11-29S-1W C NW SE
Sedgewick	St. Clair No. 1	14-29S-4W C SW NW
Seward	Stevens Trust No. 1	20-31S-31W C S/2
Seward	Beck "D" No. 1	4-33S-33W C-SE-SW
Stanton	Luke GU #4	8-30S-39W 1250' FSL & 1250' FWL
Stevens	Hahn Gas Unit "C"	6-31S-38W C-SE-NW
Stevens	Nell A-1	19-33S-37W S/2-NW-NW
Stevens	Creamer No. 1	13-34S-37W C-SW-SW
Stevens	Hubbard #1 Unit, Well 3	20-32S-37W 1250'FSL-330'FWL of SE/4
Sumner	Spencer No. 1	34-31S-2E SE SE NE
Sumner	Carter No. 1	35-30S-1E SE SE NW
Sumner	Riner "A" No. 1	36-30S-2W S/2 SE NE
Sumner	Stephen No. 1	28-30S-3W C SE SE

County	Well Name	Company
Meade	Hobart No. 1	AMPECO
Morton	Tillett Gas Unit "B" No. 1	Pan American Petroleum Corp.
Sedgewick	D & E No. 37-575	Kennedy and Mitchell, Inc.
Sedgewick	St. Clair No. 1	Anadarko Production Co.
Seward	Stevens Trust No. 1	Clinton Oil
Seward	Beck "D" No. 1	Cities Service Oil Co.
Stanton	Luke GU #4	Amoco Production Co.
Stevens	Hahn Gas Unit "C"	Pan American Petroleum Corp.
Stevens	Nell A-1	Anadarko Production Co.
Stevens	Creamer No. 1	Mobil Oil Corp.
Stevens	Hubbard #1 Unit, Well 3	Mobil Oil Corp.
Sumner	Spencer No. 1	McNeish and Gralapp
Sumner	Carter No. 1	Mack Oil Co.
Sumner	Riner "A" No. 1	Beardmore Drilling Co.
Sumner	Stephen No. 1	O.A. Sutton

County	Well Name	Field
Meade	Hobart No. 1	Wildcat
Morton	Tillett Gas Unit "B" No. 1	Kinsler
Sedgewick	D & E No. 37-575	Wildcat
Sedgewick	St. Clair No. 1	Wildcat
Seward	Stevens Trust No. 1	Wildcat
Seward	Beck "D" No. 1	Evelyn
Stanton	Luke GU #4	Hugoton
Stevens	Hahn Gas Unit "C"	Wildcat
Stevens	Nell A-1	Gentzler
Stevens	Creamer No. 1	Voorhees
Stevens	Hubbard #1 Unit, Well 3	Gentzler
Sumner	Spencer No. 1	Wildcat
Sumner	Carter No. 1	Wildcat
Sumner	Riner "A" No. 1	Bates
Sumner	Stephen No. 1	Wildcat

APPENDIX B

Luke GU #4 Core Description

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
Admire Group Hamlin Shale	1	2991.6 - 3024.3	32.7	Gray-dark gray siltstone, calcareous, non-fossiliferous, ripple laminations throughout, vfgr sandy zones, becoming shaly with depth.
Hamilin Shale	2	2973.8 - 2991.6	17.8	Olive, calcareous siltstone, upper 3 feet is burrowed and contains crinoids and minor brachiopods, below this there are only sparse crinoids, siltstone contains ripple laminations throughout, vfgr sandy zones, becoming shaly with depth.
Council Grove Group Foraker Limestone	1	2970.2 - 2973.8	3.6	Light gray-tan packstone-grainstone, massive, crinoids, bioclastic debris, minor molluscs
	2	2969.3 - 2970.2	0.9	Dark gray grainstone, abundant large 3 mm fusulinids, minor brachiopods and crinoids, less fusulinids than overlying unit.
	3	2968.4 - 2969.3	0.9	Dark gray wackestone, abundant large 3 mm fusulinids, minor brachiopods and crinoids.
	4	2965.5 - 2968.4	2.9	Dark gray-black fissile shale, abundant crinoids, calcareous, very brittle.
	5	2962.4 - 2965.5	3.1	Dark gray shale, minor crinoids, slightly calcareous, massive, becoming fissile towards bottom.
	6	2960.3 - 2962.4	2.1	Tan-light gray wackestone-packstone, massive, fusulinids and crinoids.
	7	2960.1 - 2960.3	0.2	Dark gray-black grainstone, fusulinds, brachiopods, crinoids, similar to overlying unit but darker
	8	2958.8 - 2960.1	1.3	Dark gray packstone-grainstone, less abundant fusulinids than overlying unit and grains are smaller, massive.
	9	2957.6 - 2958.8	1.2	Gray-dark gray packstone-grainstone, abundant large 3mm fusulinids, brachiopods, crinoids, minor gastropods, massive.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
Foraker LS Continued	10	2954.9 - 2957.6	2.7	Dark gray interbedded shale and wackestone with abundant fusulinids, shales are fissile, wackestones are massive, minor crinoids.
	11	2953.0 - 2954.9	1.9	Dark gray mudstone, less grains that overlying unit, slightly shaly.
	12	2952.0 - 2953.0	1.0	Dark gray wackestone, brachiopods, massive, well cemented, shaly.
	13	2949.7 - 2952.0	2.3	Dark gray shaly wackestone, brachiopods, minor crinoids, massive.
	14	2945.4 - 2949.7	4.3	Black-dark gray silty shale, calcareous, massive, non-fossiliferous, much less silt than above.
	15	2937.8 - 2945.4	7.6	Dark gray silty shale, minorly calcareous, more abundant crinoids than overlying unit, minor brachiopods, ripple laminations, convoluted bedding, not as dark as above.
	16	2932.4 - 2937.8	5.4	Dark gray silty shale, ripple laminations, minor molluscs, minorly calcareous, thin zones of red anhydrite/quartz?, minor crinoids.
	17	2921.5 - 2932.4	10.9	Olive-dark olive siltstone, only minorly calcareous, ripple laminations, minor molluscs replaced by red anhydrite/quartz?, heavily burrowed in some areas.
	18	2920.3 - 2921.5	1.2	Tan mudstone, massive, red quartz?, dolomitic?, becoming silty with depth.
	19	2920.0 - 2920.3	0.3	Light gray-tan packstone-grainstone, abundant fusulinids, wavy bedded.
	20	2918.0 - 2920.0	2.0	Light gray-tan grainstone, minor crinoids replaced by red quartz.
	21	2917.5 - 2918.0	0.5	Dark gray interbedded shale and gray mudstone.
Foraker LS Continued	22	2916.7 - 2917.5	0.8	Dark gray shale, becoming black near base, fissile, calcareous.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
↓	23	2912.2 - 2916.7	4.5	Gray-red thinly laminated shale, highly calcareous, clean, non-fossiliferous, becoming dirty with depth tidally influenced.
Foraker Limestone	24	2911.0 - 2912.2	1.2	Light gray-gray mudstone, non-fossiliferous, massive.
Johnson Shale ↕	1	2898.4 - 2911.0	12.6	Red siltstone/claystone, calcareous, calich nodules near base, root traces infilled with calcite.
Johnson Shale	2	2894.9 - 2898.4	3.5	Dark olive silty claystone, massive, calcareous, paleosol.
Red Eagle Limestone ↑	1	2889.5 - 2894.9	5.4	Dark gray wackestone, abundant crinoids, massive becoming wavy bedded at top, minor brachiopods and fusulinids, silty.
	2	2888.2 - 2889.5	1.3	Dark tan-gray wackstone-packstone, mottled, burrowed, crinoids, minor fusulinids, anhydrite, silty.
	3	2881.8 - 2888.2	6.4	Tan mudstone-wackstone, heavily burrowed, mottled, minor crinoids and brachiopods, minor anhydrite, silty.
	4	2881.2 - 2881.8	0.6	Dark olive wackestone, shaly, wavy bedded, abundant fusulinids, crinoids and brachiopods
	5	2879.9 - 2881.2	1.3	Tan packstone-grainstone, crinoids, brachiopods, bryozoans, irregular anhydrite zones, fine grained, bioclastic, silty at top
	6	2879.8 - 2879.9	0.1	Olive irregulare zone of wackestone, grains are unbroken, crinoids, minor brachiopods.
	7	2878.6 - 2879.8	1.2	Tan packstone-grainstone, crinoids, brachiopods, bryozoans, irregular anhydrite zones, fine grained, bioclastic, silty at top
	8	2878.3 - 2878.6	0.3	Tan-pink packstone, crinoids, fine grained, very small <1mm black fragments.
	9	2877.8 - 2878.3	0.5	Olive-dark olive wackestone, wavy bedded, burrowed, abundant fusulinids, crinoids, contains irregular dolomotized burrows.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
	10	2877.6 - 2877.8	0.2	Dark olive packstone, shaly, abundant fusulinids.
	11	2875.0 - 2877.6	2.6	Olive-dark olive packstone, wavy bedded, burrowed, abundant fusulinids, crinoids, contains irregular dolomotized burrows.
	12	2873.6 - 2875.0	1.4	Tan wackestone-packstone, crinoids, fusulinids, massive, clean.
	13	2873.1 - 2873.6	0.5	Olive-dark olive wackestone-packstone, wavy bedded, abundant fusulinids and crinoids.
Red Eagle Limestone	14	2865.7 - 2873.1	7.4	Tan-light gray mudstone, minor crinoids, massive with few thin 1mm shale lenses in upper 2 feet, very clean below this, well cemented.
Roca Shale	1	2863.3 - 2865.7	2.4	Red/tan siltstone, contains highly altered intraclasts of underlying limestone, regolith, caliche nodules, calcareous.
	2	2843.0 - 2863.3	20.3	Red siltstone-claystone, increasing silt with depth, massive, minor calich nodules, minor root traces infilled with calcite, becoming less calcareous with depth, irregular pink gypsum/celestite at 2843.0.
Roca Shale	3	2842.4 - 2843.0	0.6	Olive green siltstone, massive, paleosol.
Grenola Limestone	1	2840.6 - 2842.4	1.8	Gray grainstone, massive, crinoids, minor shale parting, irregular anhydrite zones.
	2	2840.1 - 2840.6	0.5	Gray mudstone, dirty, shaly, minor crinoids, altered.
	3	2838.7 - 2840.1	1.4	Olive-dark gray, shale, calcareous, silty, minor crinoids, rubblized.
	4	2838.3 - 2838.7	0.4	Red siltstone/claystone, exposure surface, rubblized.
	5	2836.0 - 2838.3	2.3	Olive-dark gray shale, calcareous, silty, minor crinoids, rubblized.
	6	2834.0 - 2836.0	2.0	Gray-dark gray wackestone, wavy bedded, zones of mud, increasing grain amount with depth.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
Grenola LS Continued	7	2833.0 - 2834.0	1.0	Dark gray wackestone-packstone, massive, highly fossiliferous, 2-3mm fusulinids, minor brachiopod, and crinoids.
	8	2831.4 - 2833.0	1.6	Dark gray shale, calcareous, highly abundant molluscs with unbroken valves, black near top and bottom, lagoonal environment.
	9	2829.8 - 2831.4	1.6	Dark gray wackestone-packstone, massive, crinoids, fusulinids, minor bryozoans, slightly shaly.
	10	2829.5 - 2829.8	0.3	Dark gray wackestone, crinoids, fusulinids, massive highly cemented.
	11	2829.3 - 2829.5	0.2	Black packstone, non-calcareous/siliceous, highly fossiliferous, fusulinids, crinoids, well cemented.
	12	2828.5 - 2829.3	0.8	Dark gray wackestone, crinoids, fusulinids, massive highly cemented.
	13	2827.3 - 2828.5	1.2	Dark olive shale, calcareous, massive, crinoids. fusulinids, brachiopods, minor bryozoans, crinoids have been replaced by anhydrite.
	14	2825.3 - 2827.3	2.0	Tan-gray wackestone, slightly calcareous, crinoids, mottled, burrows filled with chert, well cemented.
	15	2820.0 - 2825.3	5.3	Olive-gray mudstone-wackestone, wavy bedded, minor crinoids and brachiopods, most grains have been replaced by anhydrite, thin 1-2mm darker shaly bands, thin mud zones 1-2".
	16	2818.7 - 2820.0	1.3	Dark olive/moroon packstone, crinoids, wavy bedded.
	17	2818.0 - 2818.7	0.7	Tan wackestone, mottled, large brachiopods replaced by anhydrite.
	18	2817.2 - 2818.0	0.8	Dark olive/moroon packstone, crinoids, wavy bedded.
Grenola LS Continued	19	2816.1 - 2817.2	1.1	Olive packstone, grains have all been repladed by anhydrite, massive.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
	20	2814.0 - 2816.1	2.1	Light tan mudstone-wackestone, massive, thin shaly bands, crinoids, minor brachiopods, minor anhydrite clean towards base.
	21	2811.3 - 2814.0	2.7	Tan packstone with interbeds of red silt and green shaly lenses, crinoids, vugs, terra rosa, more red towards top and more green towards bottom, shale parting at 2813.2.
Grenola Limestone	22	2809.0 - 2811.3	2.3	Tan wackestone-packstone, massive, crinoids, fusulinids?.
Eskridge Shale	1	2804.7 - 2809.0	4.3	Red siltstone/claystone, caliche nodules, calcareous bottom 1' rubblized.
	2	2803.7 - 2804.7	1.0	Red/gray claystone, calcareous, caliche nodules.
	3	2795.5 - 2803.7	8.2	Red siltstone/claystone, mottled, caliche nodules, calcareous.
	4	2784.0 - 2795.5	11.5	Red siltstone/claystone, calcareous, rubblized.
Eskridge Shale	5	2781.7 - 2784.0	2.3	Light green siltstone, massive, calcareous, rubble.
Beattie Limestone	1	2779.9 - 2781.7	1.8	Light gray wackestone, massive, fusulinids and crinoids, thin 1-2mm shale partings.
	2	2778.2 - 2779.9	1.7	Tan wackestone, massive, fusulinids, crinoids, lighter than above, similar to unit below, separated from upper and lower units by stylolites.
	3	2772.4 - 2778.2	5.8	Light tan packstone, massive, anhydrite replaced crinoids, prevalent anhydrite throughout.
	4	2770.6 - 2772.4	1.8	Light tan wackestone with shale streaks, darker than above and below, wavy bedded, non-fossiliferous, anhydrite, 1cm dark gray shale parting at 2771.0.
	5	2769.5 - 2770.6	1.1	Tan mudstone, minor crinoids, prevalent anhydrite, slightly shaly.
	6	2766.7 - 2769.5	2.8	Light tan wackestone-packstone, massive, very small grains, crinoids, brachiopods, shoal deposit.
	7	2765.5 - 2766.7	1.2	Light tan packstone-grainstone, massive, shoal.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
Beattie Limestone	8	2763.9 - 2765.5	1.6	Light tan grainstone, massive, minor crinoids.
Stearns Shale	1	2763.5 - 2763.9	0.4	Light olive-buff silstone, calcareous with intraclasts of the underlying unit, minor anhydrite.
	2	2758.2 - 2763.5	5.3	Red silstone/claystone, minor caliche nodules, calcareous, rubblized in some areas.
	3	2754.9 - 2758.2	3.3	Tan mudstone, massive, anhydrite throughout, minor crinoids, transgressive lag at base.
	4	2754.2 - 2754.9	0.7	Olive/red silstone, slightly fissile, friable.
	5	2753.4 - 2754.2	0.8	Red silstone, caliche nodules , friable.
	6	2747.0 - 2753.4	6.4	Red siltstone, massive, calcareous.
Stearns Shale	7	2741.6 - 2747.0	5.4	Red siltstone, massive, calcareous, caliche nodules.
Bader Limestone Eiss LS Member	1	2740.2 - 2741.6	1.4	Light gray wackestone-packestone, increasing fossil content with depth, terra rosa, shale band at 2741.0, transgressive lag deposit bottom 6".
Eiss LS Member	2	2738.0 - 2740.2	2.2	Light gray packstone, massive, minor crinoids, increasing fusulinids? with depth, minor anhydrite, top 2" contains intraclasts.
Missing Core		2736.9 - 2738.0	1.1	Missing Core
Hooser SH Member	3	2731.8 - 2736.9	5.1	Red silstone/claystone, massive, calcareous, caliche nodules.
	4	2731.0 - 2731.8	0.8	Light gray claystone, caliche nodules, minor red alterations, calcareous.
	5	2730.7 - 2731.0	0.3	Red silstone, massive, calcareous.
Hooser SH Member	6	2722.1 - 2730.7	8.6	Red silstone/claystone, massive, non-calcareous, irregular anhydrite zones, upper 2' rubblized.
Middleburg LS Member	7	2721.3 - 2722.1	0.8	Light gray wackestone-packstone, wavy bedded, abundant crinoids, minor brachiopods, minor fusulinids, transgressive lag at base.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
	8	2720.0 - 2721.3	1.3	Light gray wackestone, brachiopods, thin shale streaks.
	9	2717.6 - 2720.0	2.4	Light gray wackestone-packstone, massive, crinoids fusulinids?, anydrite zones.
	10	2716.3 - 2717.6	1.3	Light gray-buff packstone, massive, increasing crinoids towards top, darker than unit above.
Middleburg LS Member Bader Limestone	11	2712.2 - 2716.3	4.1	Tan grainstone, massive, clean, anhydrite zones, stylolite at 2715.4, 2cm stylolite filled with dark gray mud at very base.
Easly Creek Shale	1	2711.4 - 2712.2	0.8	Light olive shale, silty, intraclasts of underlying unit, regolith, calcareous.
	2	2703.0 - 2711.4	8.4	Red siltstone, massive, caliche nodules, root traces infilled with calcite.
Easly Creek Shale	3	2701.2 - 2703.0	1.8	Gray/red claystone, mottled, caliche nodules, root traces infilled with calcite, calcareous.
Crouse Limestone	1	2700.4 - 2701.2	0.8	Gray packstone-wackestone, crinoids, brachiopods. very grainy at base, becoming muddy at top.
	2	2699.8 - 2700.4	0.6	Light gray packstone, wavy bedded, crinoids, fusulinids, 1-2mm shale parting at very base, moroon shale parting at 2699.9.
	3	2698.3 - 2699.8	1.5	Moroon-gray packstone, shaly, fusulinids, crinoids, brachiopods, minor anhydrite replacement. terra rosa.
	4	2697.0 - 2698.3	1.3	Light gray-moroon mudstone-wackestone, crinoids, minor anhydrite, mottled, terra rosa, massive.
	5	2695.6 - 2697.0	1.4	Light gray-moroon mudstone, wavy bedded, minor brachiopods, terra rosa.
	6	2694.8 - 2695.6	0.8	Tan-moroon wackestone, abundanat fusulinids and crinoids, mottled, terra rosa.
	7	2691.5 - 2694.8	3.3	Gray-moroon mudstone, mottled, massive, silty, minor brachiopods replaced by anhydrite, intraclasts at 2692.0, terra rosa.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
Crouse Limestone	8	2690.5 - 2691.5	1.0	Tan grainstone, massive, fusulinids at base.
Blue Rapids Shale ↑	1	2690.0 - 2690.5	0.5	Light gray claystone, intraclasts, wavy bedded, regolith, altered by paleosol development.
	2	2686.0 - 2690.0	4.0	Red silstone, caliche nodules, massive, calcareous.
	3	2679.3 - 2686.0	6.7	Red-light gray silstone/claystone, calcareous, caliche nodules, regolith.
↓	4	2672.0 - 2679.3	7.3	Red silstone, caliche nodules, root traces.
Blue Rapids Shale	5	2670.6 - 2672.0	1.4	Light olive siltstone, calcareous, rubble, paleosol.
Funston Limestone ↑	1	2669.3 - 2670.6	1.3	Dark gray packstone, massive, crinoids, brachiopods, silty.
	2	2666.7 - 2669.3	2.6	Gray-dark gray mudstone, wavy bedded, crinoids, minor brachiopods, silty zones, lighter in color than overlying unit.
	3	2666.5 - 2666.7	0.2	Dark gray wackestone, wavy bedded, silty, abundant molluscs, lagoonal.
	4	2663.5 - 2666.5	3.0	Dark gray silty shale, fissile towards bottom, massive towards top, minor molluscs at 2664.0
	5	2660.2 - 2663.5	3.3	Gray mudstone, brachiopods, crinoids, minor wavy bedding, lighter in color than above.
	6	2656.5 - 2660.2	3.7	Olive-dark gray silty mudstone, brachiopods, minor crinoids, shaly.
	7	2654.5 - 2656.5	2.0	Dark gray wackestone, massive, brachiopods, fusulinids?, silty.
	8	2653.9 - 2654.5	0.6	Dark gray wackestone-packstone, massive, abundant crinoids and brachiopods.
	9	2652.0 - 2653.9	1.9	Gray packstone, massive, anhydrite replaced crinoids, intraclasts at very base.
	10	2651.6 - 2652.0	0.4	Very dark gray packstone-wackestone, wavy bedded, crinoids, fusulinids, large vertical burrow.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
	11	2649.4 - 2651.6	2.2	Dark gray mudstone, very silty, shaly, few crinoids, massive.
	12	2649.0 - 2649.4	0.4	Dark gray silty shale, angled bedding, non-fossiliferous.
	13	2647.6 - 2649.0	1.4	Dark olive mudstone-wackestone, irregular wavy bedding, shaly, crinoids have been replaced by anhydrite.
	14	2646.0 - 2647.6	1.6	Olive packstone, irregular wavy bedding, zones of mudstone, crinoids, minor molluscs, minor anhydrite replacement, zones of packstone.
	15	2644.5 - 2646.0	1.5	Light gray-olive wackestone, wavy bedded, crinoids, brachiopods, some grains anhydrite replaced.
	16	2643.0 - 2644.5	1.5	Olive-gray packstone, massive, slightly shaly, anhydrite replacement.
	17	2642.2 - 2643.0	0.8	Olive mudstone, massive, shaly.
	18	2640.0 - 2642.2	2.2	Tan mudstone-wackestone, minor crinoids, irregular gray dolomitic zones with minor anhydrite.
	19	2639.3 - 2640.0	0.7	Tan packstone-grainstone, ooids.
Funston Limestone	20	2638.4 - 2639.3	0.9	Tan mudstone, altered by paleosol development, fossil grains replaced by anhydrite, minor dolomite.
Speiser Shale	1	2638.1 - 2638.4	0.3	Olive siltstone, clasts of underlying unit, regolith.
	2	2637.0 - 2638.1	1.1	Olive silstone, calcareous, regolith, paleosol.
	3	2635.5 - 2637.0	1.5	Red claystone/silstone, calcareous, regolith, caliche nodules.
	4	2634.0 - 2635.5	1.5	Red silstone, non-calcareous, massive.
	5	2618 - 2634.0	16.0	Red claystone/silstone, calcareous, caliche nodules, root traces infilled with calcite.
	6	2615.0 - 2618.0	3.0	Red claystone, calcareous, regolith, clasts of altered mudstone.

Formation	Unit	Core Depth (ft)	Thickness (ft)	Unit Description
	7	2613.0 - 2615.0	2.0	Red silstone/claystone, calcareous, caliche nodules.
	8	2612.0 - 2613.0	1.0	Olive silstone, calcareous, caliche nodules.
Speiser Shale	9	2611.3 - 2612.0	0.7	Gray silstone, calcareous, friable, paleosol.
Chase Group Wreford Limestone	1	2608.3 - 2611.3	3.0	Dark gray wackestone-packstone, massive, crinoids. fusulinids, irregular nodules of dark gray dolomite, some crinoids replaced by anhydrite and dolomite?, transgressive lag deposit at bottom 1".
	2	2607.8 - 2608.3	0.5	Very dark gray wackestone-packstone, masssive, fusulinids, shale parting at 2608.3.
	3	2606.6 - 2607.8	1.2	Gray packstone, massive, crinoids, irregular dark gray nodules of dolomite.
	4	2605.5 - 2606.6	1.1	Dark gray packstone, massive, fusulinids, minor crinoids.
Wreford Limestone	5	2600.0 - 2605.5	5.5	Gray wackestone, massive, crinoids, brachiopods, minor horizontal burrows infilled with calcite, dark gray shaly bad at 2600.3-2600.6, minor dolomite replacement towards top.

APPENDIX C

Thin-section Descriptions

Thin-section	Lithofacies	Description
TS-1	SW	Echinoid, brachiopod, minor mollusk, algal coated grains, many grains micritized, minor anhydrite, minor grain replacement by quartz, 2-3% quartz silt.
TS-2	OSP	Echinoid, brachiopod, mollusk, minor bryozoan, abundant algal coated grains, minor fusulinid, many grains micritized, 8-10% quartz silt.
TS-3	OSP	Abundant algal coated grains, fusulinid, minor Echinoid and brachiopod, 3-5% quartz silt.
TS-4	OSP	Algal coated grains, fusulinid, brachiopod, many micritized grains, 1% quartz silt.
TS-5	OSP	Abundant algal coated grains, fusulinid, echinoid and minor brachiopod, many micritized grains, 3-5% quartz silt.
TS-6	M	Minor mollusk grains in a mud matrix. Most grains highly micritized, 1-2% quartz silt.
TS-7	OSP	Abundant algal coated grains, echinoid, brachiopod, mollusk, minor bryozoan, common grain replacement by anhydrite and quartz, trace of silt.
TS-8	M	Minor brachiopod, mollusk, echinoid in a mud matrix, minor anhydrite and quartz replacement, abundant dolomitization of the mud matrix.
TS-9	SW	Brachiopod, echinoid, abundant grain replacement by anhydrite and quartz, abundant dolomitization of the mud matrix.
TS-10	OSP	Abundant algal coated grains, echinoid, brachiopod, mollusk, peloids, many grains micritized, abundant grain replacement by anhydrite and quartz, 5-8% quartz silt.
TS-11	OSP	Algal coated grains, echinoid, fusulinid, mollusk, bryozoan, minor brachiopod, peloids, many grains micritized, minor quartz replacement, 1-2% quartz silt.

Thin-section	Lithofacies	Description
TS-12	SW	Abundant brachiopod, echinoid, minor quartz replacement of grains, dolomitization of the mud matrix.
TS-13	M	Minor bryozoan, mollusk, echinoid, in a mud matrix, 1% quartz silt.
TS-14	M	Minor Echinoid, brachiopod, and peloids in a mud matrix, 15% quartz silt. Mud has been replaced by microspar.
TS-15	OSP	Algal coated grains, echinoid, brachiopod, mollusk, minor fusulinid, many micritized grains, 5-8% quartz silt, intraclasts.
TS-16	OPG	Algal coated grains, ooids, abundant fusulinid, minor Echinoid, 5-8% quartz silt.
TS-17	SW	Echinoid, brachiopod, algal coated grains, 15% quartz silt, minor clay filling fractures.
TS-18	SW	Echinoid, brachiopod, 5% quartz silt.
TS-19	OSP	Algal coated grains, brachiopod, echinoid, fusulinid, intraclasts, spar calcite cement, trace of quartz silt, many micritized grains.
TS-20	OPG	Ooids and peloids with microspar cement, trace of quartz silt, minor quartz replacement of some grains.
TS-21	OSP	Algal coated grains, abundant echinoid, many micritized grains, spar calcite cement, trace of quartz silt.
TS-22	OSP	Algal coated grains, fusulinid, brachiopod, many micritized grains, minor anhydrite, 15-20% quartz silt.
TS-23	OSP	Algal coated grains, fusulinid, brachiopod, echinoid, mollusk, ostracode, spar cement, minor anhydrite, most grains micritized, 10% quartz silt.

Thin-section	Lithofacies	Description
TS-24	OSP	Algal coated grains, mollusk, fusulinid, bryozoan, brachiopod, ostracode, spar calcite cement, 8-10% quartz silt.
TS-25	OSP	Algal coated grains, fusulinid, echinoid, ostracode, many micritized grains, syntaxial calcite cement, abundant anhydrite and quartz replacement.
TS-26	M	Minor mollusk in a mud matrix, dolomitization of the mud matrix.
TS-27	OPG	Echinoid, fusulinid, ostracode, spar cement, minor quartz replacement, many micritized grains, some dolomitization in cement areas.
TS-28	OPG	Algal coated grains, fusulinid, most grains micritized, spar cement, minor dolomitization of cement.
TS-29	DW	Minor bryozoan, fusulinid, and peloids in a coarse dolomite matrix.
TS-30	DW	Minor skeletal fragments in a coarsely dolomitized matrix.
TS-31	OSP	Oncoids, peloids, minor spar cement, many micritized grains, dolomitization of mud matrix.
TS-32	DW	Echinoid, brachiopod, mollusk, bryozoan, minor quartz replacement of some grains, mud matrix is completely dolomitized.
TS-33	DW	Echinoid, bryozoan, fusulinid, algal coated grains, trilobite, trace of quartz silt, dolomitization of mud matrix.
TS-34	OSP	Echinoid, fusulinid, bryozoan, abundant algal coated grains, peloids, spar cement, minor quartz replacement of grains.
TS-35	SP	Echinoid, fusulinid, brachiopod, mollusk, peloids, trilobite, minor vugs filled with dolomite, thin fractures with clay and quartz silt.

Thin-section	Lithofacies	Description
TS-36	SW	Echinoid, bryozoan, brachiopod, fusulinid, trilobite, minor peloids, minor quartz replacement of some grains.
TS-37	SP	Echinoid, brachiopod, trilobite, minor fusulinid, minor quartz replacement of some grains, dolomitization of the mud matrix.
TS-38	SP	Brachiopod, bryozoan, echinoid, trilobite, minor peloids, minor quartz replacement of some grains, minor quartz silt, minor dolomite.
TS-39	M	Echinoid, bryozoan, minor quartz silt, in a mud matrix, most grains replaced by quartz.
TS-40	SW	Brachiopod, echinoid, mollusk, minor fusulinid, bryozoan, spar cement, syntaxial calcite cement, pyrite, minor quartz replacement.
TS-41	SW	Echinoid, fusulinid, brachiopod, trilobite, bryozoan, ostracode, spar cement, trace glauconite, minor quartz replacement.
TS-42	SP	Fusulinid, trilobite, brachiopod, echinoid, minor pyrite, spar cement, trace of quartz silt, minor quartz replacement of grains, trace of clay.
TS-43	SW	Fusulinid, brachiopod, trilobite, echinoid, trace of quartz silt, abundant anhydrite, minor quartz replacement, pyrite.
TS-44	SW	Brachiopod, trilobite, mollusk, echinoid, minor syntaxial calcite cement, minor quartz replacement of some grains.
TS-45	OPG	Algal coated grains, intraclasts, peloids, ooids, echinoid, fusulinid, trilobite, mollusk, spar cement, minor quartz silt.
TS-46	M	Echinoid, fusulinid, in a mud matrix, minor spar, dolomitization of the mud matrix, minor anhydrite and quartz replacement.

Thin-section	Lithofacies	Description
TS-47	M	Carbonate mud, anhydrite, chalcedony quartz, dolomitization of mud.
TS-48	SP	Fusulinid, echinoid, 1% quartz silt, anhydrite and quartz replacement of grains is common.
TS-49	SP	Echinoid, bryozoan, brachiopod, ostracode, quartz replacement of grains common, dolomitization of mud matrix.
TS-50	SP	Fusulinid, brachiopod, echinoid, abundant quartz and anhydrite replacement of grains, pyrite, dolomitization of mud.
TS-51	SW	Brachiopod, echinoid, bryozoan, trilobite, syntaxial calcite cement, minor quartz replacement of some grains.
TS-52	SW	Echinoid, bryozoan, brachiopod, syntaxial calcite cement, quartz replacement of some grains.
TS-53	SW	Echinoid, brachiopod, fusulinid, bryozoan, 3% quartz silt, trace of anhydrite, minor quartz replacement of some grains.
TS-54	STW	Echinoid, brachiopod, in carbonate mud with 12-15% quartz silt, minor quartz replacement of some grains.
TS-55	SW	Bryozoan, brachiopod, echinoid, quartz and minor anhydrite replacement of some grains, 1% quartz silt.
TS-56	STW	Echinoid, brachiopod in carbonate mud with 8-10% quartz silt.
TS-57	STW	Fusulinid, echinoid, brachiopod, trilobite, minor spar, rock fragments, hematite stains, minor quartz replacement of some grains, 10-12% quartz silt.
TS-58	STW	Brachiopod, echinoid, rock fragments, 8-10% quartz silt, minor quartz replacement of some grains.

Thin-section	Lithofacies	Description
TS-59	OPG	Algal coated grains, peloids, echinoid, fusulinid, minor ostracode, spar cement, trace of quartz silt, minor quartz replacement of some grains.
TS-60	SP	Abundant fusulinid, echinoid, brachiopod, spar cement, minor quartz replacement of some grains.
TS-61	M	Carbonate mud with a trace of quartz silt.
TS-62	CS	Minor echinoid fragments in carbonate mud with 30-35% quartz silt, minor anhydrite and quartz.
TS-63	CS	Minor echinoid, brachiopod, in carbonate mud with 50% quartz silt, minor rock fragments, minor glauconite.
TS-64	CS	Echinoid grains in carbonate mud with 30-35% quartz silt, rock fragments.
TS-65	CS	Echinoid, brachiopod in carbonate mud with 30-35% quartz silt, rock fragments, quartz replacement of some grains.
TS-66	SW	Brachiopod, echinoid, minor quartz silt, quartz replacement of some grains.
TS-67	SW	Brachiopod, echinoid, trilobite, trace of quartz silt, quartz replacement of some grains.
TS-68	M	Brachiopod, echinoid, 1-2% quartz silt, minor quartz replacement.
TS-69	SW	Echinoid, brachiopod, bryozoan, fusulinid, spar cement, trace quartz silt, common quartz replacement of grains.
TS-70	OSP	Oncoids, intraclasts, peloids, echinoid, fusulinid, brachiopod, bryozoan, trace quartz silt, spar cement, minor quartz replacement of grains.
TS-71	OSP	Oncoids, intraclasts, echinoid, fusulinid, bryozoan, trilobite, mollusk, peloids, many micritized grains, 1-2% quartz silt, spar cement, minor quartz replacement of some grains.

Thin-section	Lithofacies	Description
TS-72	OSP	Algal coated grains, intraclasts, echinoid, bryozoan, brachiopod, fusulinid, 3-5% quartz silt, common quartz replacement of grains.
TS-73	OSP	Oncoids, intraclasts, echinoid, brachiopod, bryozoan, many micritized grains, 5-8% quartz silt, minor grain replacement by quartz.
TS-74	STW	Intraclasts, fusulinid, echinoid, brachiopod, peloids, minor hematite stains, minor quartz replacement of grains, 10-15% quartz silt.
TS-75	OSP	Oncoid, intraclasts, peloids, bryozoan, fusulinid, echinoid, trilobite, brachiopod, 10-15% quartz silt, minor spar cement.
TS-76	OPG	Echinoid, fusulinid, intraclasts, brachiopod, peloids, ooids, spar calcite cement, trace quartz silt, minor anhydrite filled fracture, minor quartz replacement of grains.
TS-77	OPG	Ooids, peloids, echinoid, brachiopod, intraclasts, fusulinid, bryozoan, syntaxial cement, minor anhydrite and quartz replacement of some grains.

APPENDIX D

Formation Tops, Depths and Thickness for the Council Grove Group

Well Name		**Location**		
Spencer No. 1		34-31S-2E		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		460	9
	Funston LS		469	40
	Blue Rapids SH		509	17
	Crouse LS		526	11
	Easly Creek SH		537	22
	Bader LS	Middleburg LS	559	29
		Hooser SH	588	12
		Eiss LS	600	4
	Stearns SH		604	27
	Beattie LS		631	37
	Eskridge SH		668	27
	Grenola LS		695	68
	Roca SH		763	11
	Red Eagle LS		774	27
	Johnson SH		801	18
Council Grove	Foraker LS		819	45
Top of Admire			864	

Council Grove Thickness (ft) = 404

Well Name		**Location**		
Carter No. 1		35-30S-1E		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		620	9
	Funston LS		629	37
	Blue Rapids SH		666	13
	Crouse LS		679	16
	Easly Creek SH		695	21
	Bader LS	Middleburg LS	716	24
	Bader LS	Hooser SH	740	10
	Bader LS	Eiss LS	750	15
	Stearns SH		755	26
	Beattie LS		781	43
	Eskridge SH		824	14
	Grenola LS		838	65
	Roca SH		903	7
	Red Eagle LS		910	30
	Johnson SH		940	16
Council Grove	Foraker LS		956	40
Top of Admire			996	

Council Grove Thickness (ft) = 376

Well Name D & E No. 37-575

Location 11-29S-1W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		745	9
	Funston LS		754	38
	Blue Rapids SH		792	13
	Crouse LS		805	18
	Easly Creek SH		823	23
	Bader LS	Middleburg LS	846	24
		Hooser SH	870	10
		Eiss LS	880	12
	Stearns SH		892	20
	Beattie LS		912	36
	Eskridge SH		948	13
	Grenola LS		961	80
	Roca SH		1041	3
	Red Eagle LS		1044	26
	Johnson SH		1070	10
Council Grove	Foraker LS		1080	41
Top of Admire			1121	

Council Grove Thickness (ft) = 376

Well Name		**Location**		
Riner "A" No. 1		36-30S-2W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		961	9
	Funston LS		970	40
	Blue Rapids SH		1010	15
	Crouse LS		1025	15
	Easly Creek SH		1040	28
	Bader LS	Middleburg LS	1068	18
		Hooser SH	1086	21
		Eiss LS	1107	7
	Stearns SH		1114	28
	Beattie LS		1142	31
	Eskridge SH		1173	17
	Grenola LS		1190	75
	Roca SH		1265	4
	Red Eagle LS		1269	33
	Johnson SH		1302	13
Council Grove	Foraker LS		1315	45
Top of Admire			1360	

Council Grove Thickness (ft) = 399

Well Name		**Location**		
Stephen No. 1		28-30S-3W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1155	10
	Funston LS		1165	38
	Blue Rapids SH		1203	17
	Crouse LS		1220	15
	Easly Creek SH		1235	28
	Bader LS	Middleburg LS	1263	17
		Hooser SH	1280	16
		Eiss LS	1296	12
	Stearns SH		1308	29
	Beattie LS		1337	33
	Eskridge SH		1370	12
	Grenola LS		1382	84
	Roca SH		1466	8
	Red Eagle LS		1474	40
	Johnson SH		1514	6
Council Grove	Foraker LS		1520	41
Top of Admire			1561	

Council Grove Thickness (ft) = 406

Well Name St. Clair No. 1

Location 14-29S-4W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1212	7
	Funston LS		1219	37
	Blue Rapids SH		1256	15
	Crouse LS		1271	16
	Easly Creek SH		1287	20
	Bader LS	Middleburg LS	1307	18
		Hooser SH	1325	12
		Eiss LS	1337	12
	Stearns SH		1349	31
	Beattie LS		1380	35
	Eskridge SH		1415	19
	Grenola LS		1434	69
	Roca SH		1503	6
	Red Eagle LS		1509	37
	Johnson SH		1546	8
Council Grove	Foraker LS		1554	42
Top of Admire			1596	

Council Grove Thickness (ft) = 384

Well Name | **Location**
Trousdale No. 1 | 34-30S-5W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1454	11
	Funston LS		1465	42
	Blue Rapids SH		1507	17
	Crouse LS		1524	22
	Easly Creek SH		1546	21
	Bader LS	Middleburg LS	1567	15
		Hooser SH	1582	15
		Eiss LS	1597	5
	Stearns SH		1602	33
	Beattie LS		1635	41
	Eskridge SH		1676	24
	Grenola LS		1700	70
	Roca SH		1770	8
	Red Eagle LS		1778	26
	Johnson SH		1804	16
Council Grove	Foraker LS		1820	45
Top of Admire			1865	

Council Grove Thickness (ft) = 411

Well Name		**Location**		
Callahan No. 1		23-30S-6W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1485	14
	Funston LS		1499	38
	Blue Rapids SH		1537	19
	Crouse LS		1556	19
	Easly Creek SH		1575	19
	Bader LS	Middleburg LS	1594	14
		Hooser SH	1608	14
		Eiss LS	1622	9
	Stearns SH		1631	31
	Beattie LS		1662	39
	Eskridge SH		1701	24
	Grenola LS		1725	64
	Roca SH		1789	9
	Red Eagle LS		1798	27
	Johnson SH		1825	14
Council Grove	Foraker LS		1839	49
Top of Admire			1888	

Council Grove Thickness (ft) = 403

Well Name		**Location**		
Kostner #1		13-29S-7W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1650	6
	Funston LS		1656	39
	Blue Rapids SH		1695	18
	Crouse LS		1713	13
	Easly Creek SH		1726	19
	Bader LS	Middleburg LS	1745	25
		Hooser SH	1770	10
		Eiss LS	1780	6
	Stearns SH		1786	33
	Beattie LS		1819	45
	Eskridge SH		1864	26
	Grenola LS		1890	69
	Roca SH		1959	9
	Red Eagle LS		1968	28
	Johnson SH		1996	11
Council Grove	Foraker LS		2007	47
Top of Admire			2054	

Council Grove Thickness (ft) = 404

Well Name		**Location**		
Muir "B" 1		16-32S-7W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1757	11
	Funston LS		1768	43
	Blue Rapids SH		1811	21
	Crouse LS		1832	20
	Easly Creek SH		1852	17
	Bader LS	Middleburg LS	1869	11
		Hooser SH	1880	18
		Eiss LS	1898	9
	Stearns SH		1907	30
	Beattie LS		1937	61
	Eskridge SH		1998	15
	Grenola LS		2013	61
	Roca SH		2074	9
	Red Eagle LS		2083	31
	Johnson SH		2114	7
Council Grove	Foraker LS		2121	54
Top of Admire			2175	

Council Grove Thickness (ft) = 418

Well Name		**Location**		
Pride No. 1		10-29S-8W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1822	9
	Funston LS		1831	21
	Blue Rapids SH		1852	36
	Crouse LS		1888	16
	Easly Creek SH		1904	19
	Bader LS	Middleburg LS	1923	12
		Hooser SH	1935	16
		Eiss LS	1951	13
	Stearns SH		1964	32
	Beattie LS		1996	49
	Eskridge SH		2045	14
	Grenola LS		2059	69
	Roca SH		2128	7
	Red Eagle LS		2135	31
	Johnson SH		2166	10
Council Grove	Foraker LS		2176	43
Top of Admire			2219	

Council Grove Thickness (ft) = 397

Well Name		**Location**		
Swinger No. 1		11-30S-9W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		1889	10
	Funston LS		1899	19
	Blue Rapids SH		1918	39
	Crouse LS		1957	18
	Easly Creek SH		1975	11
	Bader LS	Middleburg LS	1986	27
		Hooser SH	2013	9
		Eiss LS	2022	6
	Stearns SH		2028	34
	Beattie LS		2062	53
	Eskridge SH		2115	13
	Grenola LS		2128	73
	Roca SH		2201	7
	Red Eagle LS		2208	27
	Johnson SH		2235	11
Council Grove	Foraker LS		2246	42
Top of Admire			2288	

Council Grove Thickness (ft) = 399

Well Name		**Location**		
Morisse Unit No. 1		14-30S-10W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2120	10
	Funston LS		2130	27
	Blue Rapids SH		2157	36
	Crouse LS		2193	11
	Easly Creek SH		2204	16
	Bader LS	Middleburg LS	2220	14
		Hooser SH	2234	17
		Eiss LS	2251	1
	Stearns SH		2252	45
	Beattie LS		2297	49
	Eskridge SH		2346	9
	Grenola LS		2355	73
	Roca SH		2428	6
	Red Eagle LS		2434	32
	Johnson SH		2466	11
Council Grove	Foraker LS		2477	47
Top of Admire			2524	

Council Grove Thickness (ft) = 404

Well Name		**Location**		
Douthette No. 1-2A		24-30S-11W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2262	10
	Funston LS		2272	21
	Blue Rapids SH		2293	41
	Crouse LS		2334	16
	Easly Creek SH		2350	15
	Bader LS	Middleburg LS	2365	7
	Bader LS	Hooser SH	2372	24
	Bader LS	Eiss LS	2396	9
	Stearns SH		2405	31
	Beattie LS		2436	44
	Eskridge SH		2480	15
	Grenola LS		2495	70
	Roca SH		2565	6
	Red Eagle LS		2571	31
	Johnson SH		2602	8
Council Grove	Foraker LS		2610	49
Top of Admire			2659	

Council Grove Thickness (ft) = 397

Well Name		**Location**		
Meairs No. 1		27-30S-12W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2236	12
	Funston LS		2248	25
	Blue Rapids SH		2273	43
	Crouse LS		2316	20
	Easly Creek SH		2336	9
	Bader LS	Middleburg LS	2345	6
		Hooser SH	2351	23
		Eiss LS	2374	4
	Stearns SH		2378	45
	Beattie LS		2423	43
	Eskridge SH		2466	12
	Grenola LS		2478	61
	Roca SH		2539	10
	Red Eagle LS		2549	33
	Johnson SH		2582	9
Council Grove	Foraker LS		2591	48
Top of Admire			2639	

Council Grove Thickness (ft) = 403

Well Name		**Location**		
Grigsby No. 2		22-30S-13W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2301	9
	Funston LS		2310	25
	Blue Rapids SH		2335	44
	Crouse LS		2379	21
	Easly Creek SH		2400	7
	Bader LS	Middleburg LS	2407	8
		Hooser SH	2415	21
		Eiss LS	2436	9
	Stearns SH		2445	37
	Beattie LS		2482	49
	Eskridge SH		2531	12
	Grenola LS		2543	57
	Roca SH		2600	6
	Red Eagle LS		2606	29
	Johnson SH		2635	12
Council Grove	Foraker LS		2647	49
Top of Admire			2696	

Council Grove Thickness (ft) = 395

Well Name Mills No. 1-20

Location 20-30S-14W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2391	10
	Funston LS		2401	27
	Blue Rapids SH		2428	42
	Crouse LS		2470	17
	Easly Creek SH		2487	22
	Bader LS	Middleburg LS	2509	7
		Hooser SH	2516	23
		Eiss LS	2539	4
	Stearns SH		2543	37
	Beattie LS		2580	65
	Eskridge SH		2645	15
	Grenola LS		2660	53
	Roca SH		2713	8
	Red Eagle LS		2721	30
	Johnson SH		2751	12
Council Grove	Foraker LS		2763	55
Top of Admire			2818	

Council Grove Thickness (ft) = 427

Well Name		**Location**		
Freeman No. 2-21		21-30S-15W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2460	10
	Funston LS		2470	34
	Blue Rapids SH		2504	41
	Crouse LS		2545	16
	Easly Creek SH		2561	11
	Bader LS	Middleburg LS	2572	8
		Hooser SH	2580	27
		Eiss LS	2607	10
	Stearns SH		2617	30
	Beattie LS		2647	61
	Eskridge SH		2708	11
	Grenola LS		2719	55
	Roca SH		2774	7
	Red Eagle LS		2781	34
	Johnson SH		2815	9
Council Grove	Foraker LS		2824	54
Top of Admire			2878	

Council Grove Thickness (ft) = 418

Well Name		**Location**		
E.D. Robbins		24-30S-16W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2400	13
	Funston LS		2413	35
	Blue Rapids SH		2448	42
	Crouse LS		2490	18
	Easly Creek SH		2508	15
	Bader LS	Middleburg LS	2523	9
		Hooser SH	2532	15
		Eiss LS	2547	8
	Stearns SH		2555	31
	Beattie LS		2586	66
	Eskridge SH		2652	19
	Grenola LS		2671	59
	Roca SH		2730	5
	Red Eagle LS		2735	33
	Johnson SH		2768	6
Council Grove	Foraker LS		2774	59
Top of Admire			2833	

Council Grove Thickness (ft) = 433

Well Name | **Location**
Booth No. 1 | 29-30S-17W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2821	9
	Funston LS		2830	42
	Blue Rapids SH		2872	30
	Crouse LS		2902	22
	Easly Creek SH		2924	15
	Bader LS	Middleburg LS	2939	16
		Hooser SH	2955	10
		Eiss LS	2965	10
	Stearns SH		2975	37
	Beattie LS		3012	71
	Eskridge SH		3083	12
	Grenola LS		3095	59
	Roca SH		3154	3
	Red Eagle LS		3157	35
	Johnson SH		3192	8
Council Grove	Foraker LS		3200	62
Top of Admire			3262	

Council Grove Thickness (ft) = 441

Well Name		**Location**		
No. 1 Fincham Unit		2-30S-18W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2761	7
	Funston LS		2768	42
	Blue Rapids SH		2810	27
	Crouse LS		2837	22
	Easly Creek SH		2859	16
	Bader LS	Middleburg LS	2875	8
		Hooser SH	2883	19
		Eiss LS	2902	8
	Stearns SH		2910	34
	Beattie LS		2944	68
	Eskridge SH		3012	12
	Grenola LS		3024	61
	Roca SH		3085	3
	Red Eagle LS		3088	42
	Johnson SH		3130	2
Council Grove	Foraker LS		3132	62
Top of Admire			3194	

Council Grove Thickness (ft) = 433

Well Name		**Location**		
Deewall no.1		22-33S-18W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2893	6
	Funston LS		2899	33
	Blue Rapids SH		2932	43
	Crouse LS		2975	15
	Easly Creek SH		2990	18
	Bader LS	Middleburg LS	3008	20
		Hooser SH	3028	8
		Eiss LS	3036	8
	Stearns SH		3044	29
	Beattie LS		3073	67
	Eskridge SH		3140	20
	Grenola LS		3160	69
	Roca SH		3229	11
	Red Eagle LS		3240	37
	Johnson SH		3277	5
Council Grove	Foraker LS		3282	74
Top of Admire			3356	

Council Grove Thickness (ft) = 463

Well Name		**Location**		
Wagner "A" No. 1		2-30S-19W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2916	7
	Funston LS		2923	50
	Blue Rapids SH		2973	23
	Crouse LS		2996	24
	Easly Creek SH		3020	14
	Bader LS	Middleburg LS	3034	21
		Hooser SH	3055	9
		Eiss LS	3064	6
	Stearns SH		3070	31
	Beattie LS		3101	78
	Eskridge SH		3179	11
	Grenola LS		3190	50
	Roca SH		3240	5
	Red Eagle LS		3245	34
	Johnson SH		3279	4
Council Grove	Foraker LS		3283	71
Top of Admire			3354	

Council Grove Thickness (ft) = 438

Well Name		**Location**
ME Seacat Trustee B-1		1-30S-20W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2956	11
	Funston LS		2967	48
	Blue Rapids SH		3015	21
	Crouse LS		3036	18
	Easly Creek SH		3054	6
	Bader LS	Middleburg LS	3060	27
	Bader LS	Hooser SH	3087	12
	Bader LS	Eiss LS	3099	7
	Stearns SH		3106	33
	Beattie LS		3139	71
	Eskridge SH		3210	17
	Grenola LS		3227	55
	Roca SH		3282	7
	Red Eagle LS		3289	34
	Johnson SH		3323	3
Council Grove	Foraker LS		3326	72
Top of Admire			3398	

Council Grove Thickness (ft) = 442

Well Name		**Location**		
MC Colm "B" 1		15-30S-21W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2951	8
	Funston LS		2959	52
	Blue Rapids SH		3011	23
	Crouse LS		3034	24
	Easly Creek SH		3058	9
	Bader LS	Middleburg LS	3067	16
		Hooser SH	3083	15
		Eiss LS	3098	9
	Stearns SH		3107	34
	Beattie LS		3141	70
	Eskridge SH		3211	11
	Grenola LS		3222	53
	Roca SH		3275	5
	Red Eagle LS		3280	22
	Johnson SH		3302	7
Council Grove	Foraker LS		3309	86
Top of Admire			3395	

Council Grove Thickness (ft) = 444

Well Name Blau No. 1

Location 23-30S-22W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3042	9
	Funston LS		3051	48
	Blue Rapids SH		3099	18
	Crouse LS		3117	25
	Easly Creek SH		3142	6
	Bader LS	Middleburg LS	3148	14
		Hooser SH	3162	13
		Eiss LS	3175	9
	Stearns SH		3184	35
	Beattie LS		3219	71
	Eskridge SH		3290	9
	Grenola LS		3299	55
	Roca SH		3354	4
	Red Eagle LS		3358	27
	Johnson SH		3385	5
Council Grove	Foraker LS		3390	86
Top of Admire			3476	

Council Grove Thickness (ft) = 434

Well Name		**Location**
Pyle Ranch No. 1		13-30S-23W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2937	11
	Funston LS		2948	48
	Blue Rapids SH		2996	20
	Crouse LS		3016	26
	Easly Creek SH		3042	7
	Bader LS	Middleburg LS	3049	11
		Hooser SH	3060	13
		Eiss LS	3073	9
	Stearns SH		3082	28
	Beattie LS		3110	62
	Eskridge SH		3172	11
	Grenola LS		3183	59
	Roca SH		3242	6
	Red Eagle LS		3248	33
	Johnson SH		3281	6
Council Grove	Foraker LS		3287	79
Top of Admire			3366	

Council Grove Thickness (ft) = 429

Well Name Espuland No. 1

Location 22-30S-24W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3088	12
	Funston LS		3100	37
	Blue Rapids SH		3137	23
	Crouse LS		3160	24
	Easly Creek SH		3184	11
	Bader LS	Middleburg LS	3195	13
		Hooser SH	3208	10
		Eiss LS	3218	15
	Stearns SH		3233	42
	Beattie LS		3275	49
	Eskridge SH		3324	14
	Grenola LS		3338	50
	Roca SH		3388	4
	Red Eagle LS		3392	32
	Johnson SH		3424	3
Council Grove	Foraker LS		3427	75
Top of Admire			3502	

Council Grove Thickness (ft) = 414

Well Name		**Location**		
Church No. 1-18		18-30S-25W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3066	8
	Funston LS		3074	40
	Blue Rapids SH		3114	18
	Crouse LS		3132	18
	Easly Creek SH		3150	7
	Bader LS	Middleburg LS	3157	15
		Hooser SH	3172	12
		Eiss LS	3184	15
	Stearns SH		3199	31
	Beattie LS		3230	52
	Eskridge SH		3282	14
	Grenola LS		3296	63
	Roca SH		3359	8
	Red Eagle LS		3367	33
	Johnson SH		3400	8
Council Grove	Foraker LS		3408	72
Top of Admire			3480	

Council Grove Thickness (ft) = 414

Well Name		**Location**		
H. Roberts No. 1		21-30S-26W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2987	8
	Funston LS		2995	42
	Blue Rapids SH		3037	9
	Crouse LS		3046	16
	Easly Creek SH		3062	16
	Bader LS	Middleburg LS	3078	8
		Hooser SH	3086	14
		Eiss LS	3100	9
	Stearns SH		3109	40
	Beattie LS		3149	56
	Eskridge SH		3205	18
	Grenola LS		3223	61
	Roca SH		3284	12
	Red Eagle LS		3296	24
	Johnson SH		3320	8
Council Grove	Foraker LS		3328	64
Top of Admire			3392	

Council Grove Thickness (ft) = 405

Well Name		**Location**		
Copenhaver No. 1		34-30S-27W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2918	10
	Funston LS		2928	42
	Blue Rapids SH		2970	13
	Crouse LS		2983	15
	Easly Creek SH		2998	8
	Bader LS	Middleburg LS	3006	14
		Hooser SH	3020	10
		Eiss LS	3030	13
	Stearns SH		3043	40
	Beattie LS		3083	53
	Eskridge SH		3136	9
	Grenola LS		3145	65
	Roca SH		3210	8
	Red Eagle LS		3218	13
	Johnson SH		3231	23
Council Grove	Foraker LS		3254	61
Top of Admire			3315	

Council Grove Thickness (ft) = 397

Well Name		**Location**		
Merkle No. 1		15-30S-28W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2975	8
	Funston LS		2983	39
	Blue Rapids SH		3022	10
	Crouse LS		3032	18
	Easly Creek SH		3050	5
	Bader LS	Middleburg LS	3055	11
		Hooser SH	3066	7
		Eiss LS	3073	9
	Stearns SH		3082	37
	Beattie LS		3119	45
	Eskridge SH		3164	4
	Grenola LS		3168	78
	Roca SH		3246	12
	Red Eagle LS		3258	27
	Johnson SH		3285	15
Council Grove	Foraker LS		3300	57
Top of Admire			3357	

Council Grove Thickness (ft) = 382

Well Name		**Location**		
Dale Schmidt No. 1		20-30S-29W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3057	13
	Funston LS		3070	36
	Blue Rapids SH		3106	14
	Crouse LS		3120	14
	Easly Creek SH		3134	8
	Bader LS	Middleburg LS	3142	6
		Hooser SH	3148	5
		Eiss LS	3153	11
	Stearns SH		3164	38
	Beattie LS		3202	34
	Eskridge SH		3236	19
	Grenola LS		3255	77
	Roca SH		3332	16
	Red Eagle LS		3348	24
	Johnson SH		3372	6
Council Grove	Foraker LS		3378	72
Top of Admire			3450	

Council Grove Thickness (ft) = 393

Well Name		**Location**		
Hobart No. 1		26-30S-30W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3035	9
	Funston LS		3044	38
	Blue Rapids SH		3082	10
	Crouse LS		3092	15
	Easly Creek SH		3107	9
	Bader LS	Middleburg LS	3116	10
	Bader LS	Hooser SH	3126	9
	Bader LS	Eiss LS	3135	10
	Stearns SH		3145	37
	Beattie LS		3182	34
	Eskridge SH		3216	16
	Grenola LS		3232	78
	Roca SH		3310	17
	Red Eagle LS		3327	27
	Johnson SH		3354	16
Council Grove	Foraker LS		3370	65
Top of Admire			3435	

Council Grove Thickness (ft) = 400

Well Name	**Location**
Stevens Trust No. 1	20-31S-31W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2981	13
	Funston LS		2994	37
	Blue Rapids SH		3031	13
	Crouse LS		3044	14
	Easly Creek SH		3058	6
	Bader LS	Middleburg LS	3064	11
		Hooser SH	3075	7
		Eiss LS	3082	9
	Stearns SH		3091	39
	Beattie LS		3130	38
	Eskridge SH		3168	12
	Grenola LS		3180	67
	Roca SH		3247	16
	Red Eagle LS		3263	31
	Johnson SH		3294	6
Council Grove	Foraker LS		3300	65
Top of Admire			3365	

Council Grove Thickness (ft) = 384

Well Name		**Location**		
Watkins Gas Unit "E" No. 1		20-30S-32W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2952	14
	Funston LS		2966	38
	Blue Rapids SH		3004	16
	Crouse LS		3020	18
	Easly Creek SH		3038	10
	Bader LS	Middleburg LS	3048	10
		Hooser SH	3058	12
		Eiss LS	3070	8
	Stearns SH		3078	27
	Beattie LS		3105	23
	Eskridge SH		3128	11
	Grenola LS		3139	78
	Roca SH		3217	11
	Red Eagle LS		3228	26
	Johnson SH		3254	13
Council Grove	Foraker LS		3267	63
Top of Admire			3330	

Council Grove Thickness (ft) = 378

Well Name		**Location**		
Beck "D" no.1		4-33S-33W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2877	10
	Funston LS		2887	51
	Blue Rapids SH		2938	14
	Crouse LS		2952	19
	Easly Creek SH		2971	6
	Bader LS	Middleburg LS	2977	18
		Hooser SH	2995	11
		Eiss LS	3006	11
	Stearns SH		3017	33
	Beattie LS		3050	47
	Eskridge SH		3097	15
	Grenola LS		3112	52
	Roca SH		3164	14
	Red Eagle LS		3178	32
	Johnson SH		3210	5
Council Grove	Foraker LS		3215	62
Top of Admire			3277	

Council Grove Thickness (ft) = 400

Well Name		**Location**		
E.M. Watkins No. 2		7-30S-33W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2906	20
	Funston LS		2926	34
	Blue Rapids SH		2960	14
	Crouse LS		2974	14
	Easly Creek SH		2988	11
	Bader LS	Middleburg LS	2999	9
		Hooser SH	3008	12
		Eiss LS	3020	5
	Stearns SH		3025	19
	Beattie LS		3044	26
	Eskridge SH		3070	14
	Grenola LS		3084	60
	Roca SH		3144	21
	Red Eagle LS		3165	25
	Johnson SH		3190	10
Council Grove	Foraker LS		3200	65
Top of Admire			3265	

Council Grove Thickness (ft) = 359

Well Name Feedlot No. 1

Location 33-30S-34W

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2720	18
	Funston LS		2738	36
	Blue Rapids SH		2774	14
	Crouse LS		2788	17
	Easly Creek SH		2805	9
	Bader LS	Middleburg LS	2814	14
		Hooser SH	2828	9
		Eiss LS	2837	7
	Stearns SH		2844	24
	Beattie LS		2868	24
	Eskridge SH		2892	18
	Grenola LS		2910	66
	Roca SH		2976	16
	Red Eagle LS		2992	31
	Johnson SH		3023	7
Council Grove	Foraker LS		3030	70
Top of Admire			3100	

Council Grove Thickness (ft) = 380

Well Name		**Location**		
Truesdale No. 3-12		12-30S-35W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2795	21
	Funston LS		2816	39
	Blue Rapids SH		2855	17
	Crouse LS		2872	13
	Easly Creek SH		2885	9
	Bader LS	Middleburg LS	2894	12
		Hooser SH	2906	17
		Eiss LS	2923	5
	Stearns SH		2928	16
	Beattie LS		2944	22
	Eskridge SH		2966	14
	Grenola LS		2980	66
	Roca SH		3046	16
	Red Eagle LS		3062	26
	Johnson SH		3088	13
Council Grove	Foraker LS		3101	66
Top of Admire			3167	

Council Grove Thickness (ft) = 372

Well Name		**Location**		
Miller No. 3		13-21S-35W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2904	23
	Funston LS		2927	24
	Blue Rapids SH		2951	23
	Crouse LS		2974	6
	Easly Creek SH		2980	17
	Bader LS	Middleburg LS	2997	5
	Bader LS	Hooser SH	3002	21
	Bader LS	Eiss LS	3023	8
	Stearns SH		3031	35
	Beattie LS		3066	9
	Eskridge SH		3075	25
	Grenola LS		3100	46
	Roca SH		3146	28
	Red Eagle LS		3174	37
	Johnson SH		3211	21
Council Grove	Foraker LS		3232	73
Top of Admire			3305	

Council Grove Thickness (ft) = 401

Well Name		**Location**		
Rooney No. 1		4-22S-35W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2910	24
	Funston LS		2934	27
	Blue Rapids SH		2961	19
	Crouse LS		2980	5
	Easly Creek SH		2985	17
	Bader LS	Middleburg LS	3002	7
		Hooser SH	3009	14
		Eiss LS	3025	12
	Stearns SH		3037	32
	Beattie LS		3069	12
	Eskridge SH		3081	17
	Grenola LS		3098	55
	Roca SH		3153	26
	Red Eagle LS		3179	41
	Johnson SH		3220	23
Council Grove	Foraker LS		3243	67
Top of Admire			3310	

Council Grove Thickness (ft) = 400

Well Name		**Location**		
H.P. Maxwell No. 2-A		4-29S-36W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2803	19
	Funston LS		2822	32
	Blue Rapids SH		2854	18
	Crouse LS		2872	12
	Easly Creek SH		2884	8
	Bader LS	Middleburg LS	2892	10
		Hooser SH	2902	13
		Eiss LS	2915	3
	Stearns SH		2918	20
	Beattie LS		2938	14
	Eskridge SH		2952	21
	Grenola LS		2973	62
	Roca SH		3035	17
	Red Eagle LS		3052	35
	Johnson SH		3087	16
Council Grove	Foraker LS		3103	45
Top of Admire			3148	

Council Grove Thickness (ft) = 345

Well Name		**Location**		
C.H. Hoover No. 1		23-23S-36W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2805	27
	Funston LS		2832	23
	Blue Rapids SH		2855	22
	Crouse LS		2877	6
	Easly Creek SH		2883	18
	Bader LS	Middleburg LS	2901	5
		Hooser SH	2906	19
		Eiss LS	2925	4
	Stearns SH		2929	29
	Beattie LS		2958	8
	Eskridge SH		2966	28
	Grenola LS		2994	49
	Roca SH		3043	21
	Red Eagle LS		3064	40
	Johnson SH		3104	22
Council Grove	Foraker LS		3126	67
Top of Admire			3193	

Council Grove Thickness (ft) = 388

Well Name		**Location**		
J.K. Moser No. 1		31-24S-36W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2753	27
	Funston LS		2780	25
	Blue Rapids SH		2805	21
	Crouse LS		2826	9
	Easly Creek SH		2835	13
	Bader LS	Middleburg LS	2848	7
		Hooser SH	2855	19
		Eiss LS	2874	6
	Stearns SH		2880	22
	Beattie LS		2902	15
	Eskridge SH		2917	27
	Grenola LS		2944	46
	Roca SH		2990	23
	Red Eagle LS		3013	33
	Johnson SH		3046	18
Council Grove	Foraker LS		3064	76
Top of Admire			3140	

Council Grove Thickness (ft) = 387

Well Name		**Location**		
Lee No 8-2		32-25S-36W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2636	25
	Funston LS		2661	29
	Blue Rapids SH		2690	21
	Crouse LS		2711	13
	Easly Creek SH		2724	9
	Bader LS	Middleburg LS	2733	7
		Hooser SH	2740	9
		Eiss LS	2749	8
	Stearns SH		2757	26
	Beattie LS		2783	15
	Eskridge SH		2798	29
	Grenola LS		2827	44
	Roca SH		2871	25
	Red Eagle LS		2896	36
	Johnson SH		2932	19
Council Grove	Foraker LS		2951	67
Top of Admire			3018	

Council Grove Thickness (ft) = 382

Well Name		**Location**		
Gall Area 13		16-27S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2632	25
	Funston LS		2657	26
	Blue Rapids SH		2683	24
	Crouse LS		2707	11
	Easly Creek SH		2718	13
	Bader LS	Middleburg LS	2731	8
		Hooser SH	2739	16
		Eiss LS	2755	5
	Stearns SH		2760	22
	Beattie LS		2782	16
	Eskridge SH		2798	24
	Grenola LS		2822	49
	Roca SH		2871	24
	Red Eagle LS		2895	32
	Johnson SH		2927	22
Council Grove	Foraker LS		2949	76
Top of Admire			3025	

Council Grove Thickness (ft) = 393

Well Name		**Location**		
Cassity "A" No. 1		13-28S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2631	21
	Funston LS		2652	33
	Blue Rapids SH		2685	18
	Crouse LS		2703	10
	Easly Creek SH		2713	13
	Bader LS	Middleburg LS	2726	10
		Hooser SH	2736	12
		Eiss LS	2748	6
	Stearns SH		2754	17
	Beattie LS		2771	14
	Eskridge SH		2785	29
	Grenola LS		2814	54
	Roca SH		2868	17
	Red Eagle LS		2885	38
	Johnson SH		2923	20
Council Grove	Foraker LS		2943	70
Top of Admire			3013	

Council Grove Thickness (ft) = 382

Well Name		**Location**		
Thomason 2-14		14-29S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2748	21
	Funston LS		2769	35
	Blue Rapids SH		2804	18
	Crouse LS		2822	12
	Easly Creek SH		2834	10
	Bader LS	Middleburg LS	2844	10
	Bader LS	Hooser SH	2954	17
	Bader LS	Eiss LS	2971	9
	Stearns SH		2880	15
	Beattie LS		2895	11
	Eskridge SH		2906	24
	Grenola LS		2930	54
	Roca SH		2984	18
	Red Eagle LS		3002	38
	Johnson SH		3040	18
Council Grove	Foraker LS		3058	70
Top of Admire			3128	

Council Grove Thickness (ft) = 380

Well Name		**Location**		
Hubbard #1 unit, well #3		30-32S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2888	25
	Funston LS		2913	41
	Blue Rapids SH		2954	13
	Crouse LS		2967	17
	Easly Creek SH		2984	10
	Bader LS	Middleburg LS	2994	10
		Hooser SH	3004	12
		Eiss LS	3016	6
	Stearns SH		3022	23
	Beattie LS		3045	21
	Eskridge SH		3066	25
	Grenola LS		3091	47
	Roca SH		3138	18
	Red Eagle LS		3156	32
	Johnson SH		3188	16
Council Grove	Foraker LS		3204	58
Top of Admire			3262	

Council Grove Thickness (ft) = 374

Well Name		**Location**		
Nell A-1		19-33S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2852	26
	Funston LS		2878	39
	Blue Rapids SH		2917	14
	Crouse LS		2931	15
	Easly Creek SH		2946	10
	Bader LS	Middleburg LS	2956	10
		Hooser SH	2966	10
		Eiss LS	2978	5
	Stearns SH		2983	19
	Beattie LS		3002	24
	Eskridge SH		3026	16
	Grenola LS		3042	47
	Roca SH		3089	16
	Red Eagle LS		3105	30
	Johnson SH		3135	16
Council Grove	Foraker LS		3151	81
Top of Admire			3232	

Council Grove Thickness (ft) = 380

Well Name		**Location**		
Creamer No. 1		33-34S-37W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		3034	15
	Funston LS		3049	48
	Blue Rapids SH		3097	16
	Crouse LS		3113	16
	Easly Creek SH		3129	9
	Bader LS	Middleburg LS	3138	14
	Bader LS	Hooser SH	3152	10
	Bader LS	Eiss LS	3162	6
	Stearns SH		3168	26
	Beattie LS		3194	22
	Eskridge SH		3216	19
	Grenola LS		3235	55
	Roca SH		3290	12
	Red Eagle LS		3302	28
	Johnson SH		3330	14
Council Grove	Foraker LS		3344	65
Top of Admire			3409	

Council Grove Thickness (ft) = 375

Well Name		**Location**		
Goertzen Gas Unit No. 1		5-29S-38W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2639	18
	Funston LS		2657	40
	Blue Rapids SH		2697	20
	Crouse LS		2717	11
	Easly Creek SH		2728	13
	Bader LS	Middleburg LS	2741	11
		Hooser SH	2752	16
		Eiss LS	2768	5
	Stearns SH		2773	26
	Beattie LS		2799	15
	Eskridge SH		2814	22
	Grenola LS		2836	40
	Roca SH		2876	23
	Red Eagle LS		2899	31
	Johnson SH		2930	20
Council Grove	Foraker LS		2950	N/A
Top of Admire				

Council Grove Thickness (ft) = N/A

Well Name		**Location**		
Hahn Gas Unit "C"		6-31S-38W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2767	25
	Funston LS		2792	42
	Blue Rapids SH		2834	15
	Crouse LS		2849	13
	Easly Creek SH		2862	10
	Bader LS	Middleburg LS	2872	9
		Hooser SH	2881	16
		Eiss LS	2897	6
	Stearns SH		2903	24
	Beattie LS		2927	16
	Eskridge SH		2943	40
	Grenola LS		2983	29
	Roca SH		3012	21
	Red Eagle LS		3033	31
	Johnson SH		3064	19
Council Grove	Foraker LS		3083	66
Top of Admire			3149	

Council Grove Thickness (ft) = 382

Well Name		**Location**		
Tillett Gas Unit "B" no.1		19-32S-39W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2684	31
	Funston LS		2715	30
	Blue Rapids SH		2745	28
	Crouse LS		2773	14
	Easly Creek SH		2787	11
	Bader LS	Middleburg LS	2798	8
	Bader LS	Hooser SH	2806	14
	Bader LS	Eiss LS	2820	3
	Stearns SH		2823	29
	Beattie LS		2852	14
	Eskridge SH		2866	26
	Grenola LS		2892	38
	Roca SH		2930	13
	Red Eagle LS		2943	28
	Johnson SH		2971	27
Council Grove	Foraker LS		2998	61
Top of Admire			3059	

Council Grove Thickness (ft) = 375

Well Name		**Location**		
Luke GU #4		8-30S-39W		

Group	Formation	Member	Log Depth (ft)	Formation Thickness (ft)
Base of Chase	Wreford LS			
Council Grove	Speiser SH		2614	29
	Funston LS		2643	31
	Blue Rapids SH		2674	20
	Crouse LS		2694	11
	Easly Creek SH		2705	12
	Bader LS	Middleburg LS	2717	10
		Hooser SH	2727	17
		Eiss LS	2744	4
	Stearns SH		2748	22
	Beattie LS		2770	18
	Eskridge SH		2788	28
	Grenola LS		2816	34
	Roca SH		2850	23
	Red Eagle LS		2873	29
	Johnson SH		2902	18
Council Grove	Foraker LS		2920	64
Top of Admire			2984	

Council Grove Thickness (ft) = 370

PLATES

1, 2, 3, 4, 5, 6, and 7

Plate 1

Core Description

Amoco Luke GU #4 Core

Oklahoma State University

Masters Thesis

Chris M. Amador

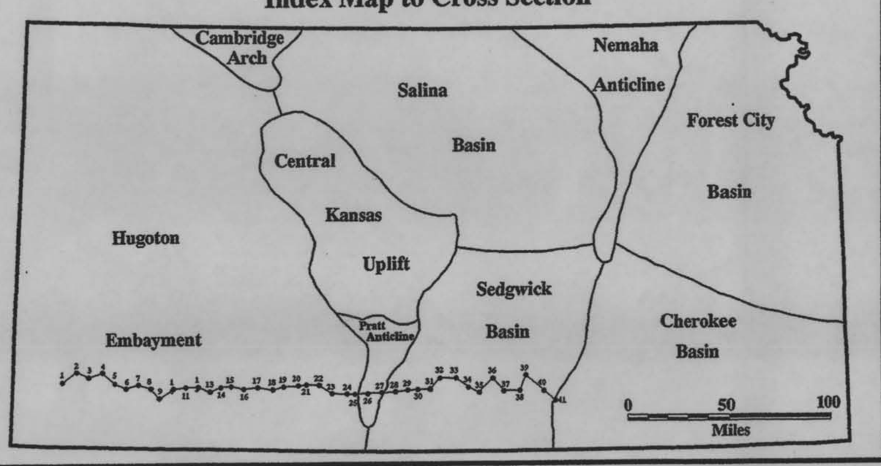
May 2000

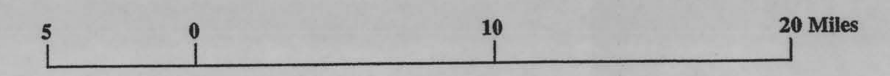
Plate 2
East-West Wireline Log Stratigraphic Cross Section
Oklahoma State University
Master's Thesis
Chris M. Amador
May 2000

East - West Stratigraphic Cross Section

1. Luke GU #4 - Amoco Prod. Co.
2. Goertzen Gas Unit No. 1 - Pan American Petroleum Corp.
3. Thomason 2-14 - Hugoton Prod. Co.
4. H.P. Maxwell No. 2-A - Columbian Fuel Corp.
5. Truesdale No. 3-12 - Mesa Petroleum Co.
6. Feedlot No. 1 - Service Drilling Co.
7. E.M. Watkins No. 2 - Pan American Petroleum Corp.
8. Watkins Gas Unit "E" No. 1 - Pan American Petroleum Corp.
9. Stevens Trust No. 1 - Clinton Oil
10. Hobart No. 1 - AMPECO
11. Dale Schmidt No. 1 - National Oil Co.
12. Merkle No. 1 - C.S.G. Exploration
13. Copenhaver No. 1 - Price Exploration Co.
14. H. Roberts No. 1 - Rains & Williamson
15. Church No. 1-18 - Ladd Petroleum Co.
16. Espuland No. 1 - Sun Oil Co.
17. Pyle Ranch No. 1 - Oil Property Management Inc.
18. Blau No. 1 - Mesa Petroleum Co.
19. MC Colm "B" 1 - Imperial Oil
20. ME Seacat Trustee B-1 - KRM Production Corp.
21. Wagner "A" No. 1 - Anadarko Petroleum Co.
22. No. 1 Fincham Unit - K & E Drilling Co.
23. Booth No. 1 - G.T. Alpin
24. E.D. Robbins - Shell Oil Co.
25. Freeman No. 2-21 - Sabine Production Co.
26. Mills No. 1-20 - Herbert G. Davis Inc.
27. Grigsby No. 2 - Nation Oil Co.
28. Meairs No. 1 - Chief Drilling Co.
29. Douthette No. 1-2A - Kan-Ex, Inc
30. Morisse Unit No. 1 - Sunray DX and Skelly Oil Co.
31. Swinger No. 1 - Sierra Petroleum Co.
32. Pride No. 1 - Mack Oil Co.
33. Kostner #1 - Gulf Energy & Minerals U.S.
34. Callahan No. 1 - Anadarko Production Co.
35. Trousdale No. 1 - Mack Oil Co.
36. St. Clair No. 1 - Anadarko Production Co.
37. Stephen No. 1 - O.A. Sutton
38. Riner "A" No. 1 - Beardmore Drilling Co.
39. D & E No. 37-575 - Kennedy and Mitchell, Inc.
40. Carter No. 1 - Mack Oil Co.
41. Spencer No. 1 - McNeish and Gralapp

Index Map to Cross Section





Horizontal Scale

Legend

- Lithologic Boundary
- Inferred Lithologic Boundary
- Shale Formations and Members
- Limestone Formations and Members

Plate 3

East-West Stratigraphic Cross Section

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Master's Thesis

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May 2000

South
North
1
Mobil Oil Corp.
Creamer No. 1
13-34S-37W
2
Mobil Oil Corp.
Hubbard #1 Unit, Well #3
20-32S-37W
3
Amoco Production Co.
Luke GU # 4
8-30S-39W
4
Shell Oil Co.
Gall Area 13
16-27S-37W
5
Pan American Petroleum Corp.
J.K. Moser No. 1
31-24S-36W
6
Pan American Petroleum Corp.
C.H. Hoover No. 1
23-23S-36W
7
Coastal Oil & Gas
Miller No. 3
13-21S-35W
Datum: Base of Chase Group
Speiser Shale
Funston Limestone
Blue Rapids Shale
Crouse Limestone
Easly Creek Shale
Middleburg LS
Bader Limestone
Hooser SH
Eiss LS
Stearns Shale
Beattie Limestone
Eskridge Shale
Grenola Limestone
Roca Shale
Red Eagle Limestone
Johnson Shale
Foraker Limestone
Admire Group
GR
SP
Cal.
Res.
Rxo/Rt
Cond.
Feet
100
50
0
Scale
2.5
5
Miles
Index Map to Cross Section
Panoma Field
Colorado
KS
OK
North - South Wireline Log Stratigraphic Cross Section
Legend
Lithologic Boundary
Inferred Lithologic Boundary
Cal. - Caliper
GR - Gamma-ray
Res. - Resistivity
SP - Spontaneous Potential
Cond. - Conductivity
Plate 4
North-South Wireline Log
Stratigraphic Cross Section
Oklahoma State University
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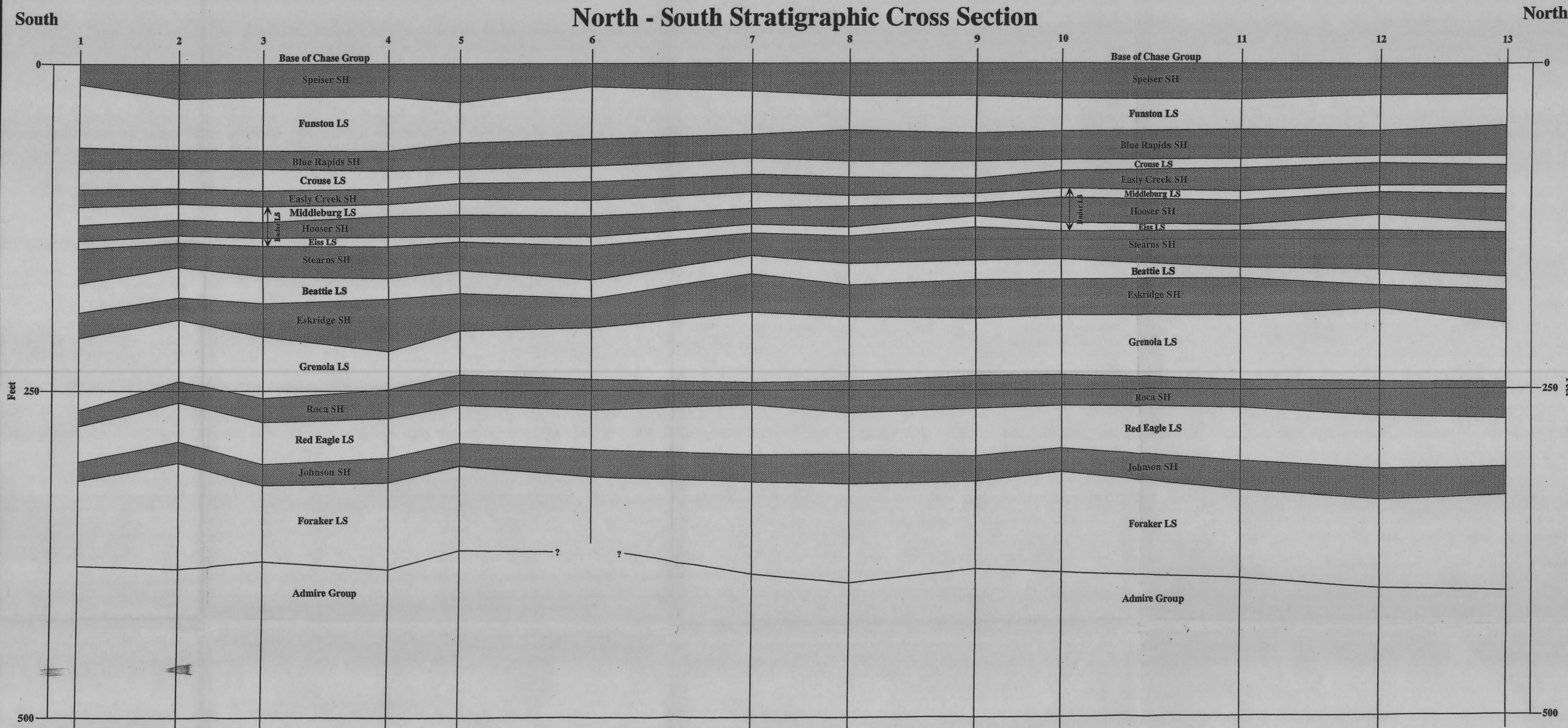
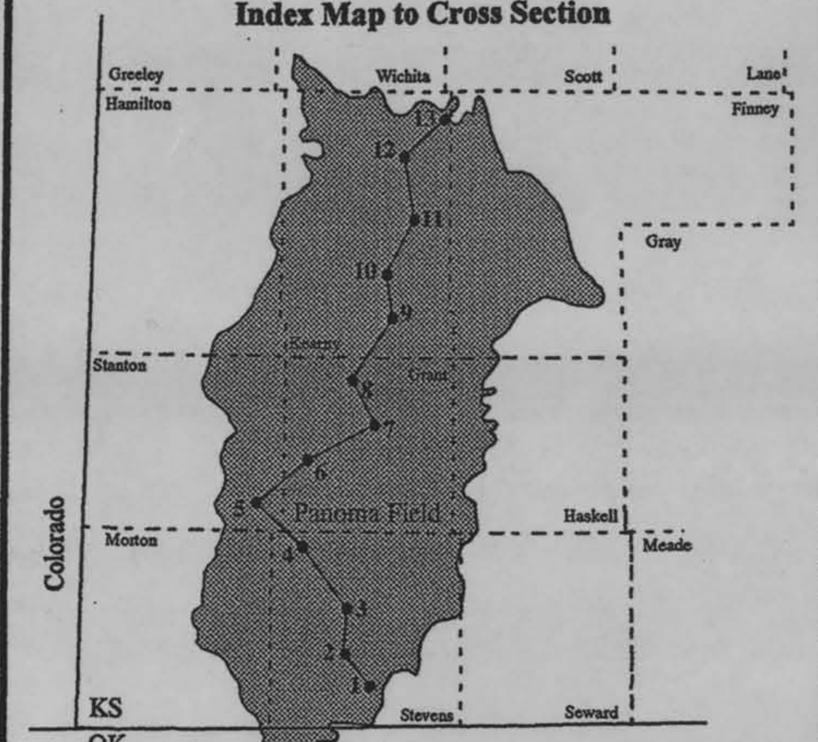
May 2000

North - South Stratigraphic Cross Section



1. Creamer No. 1 - Mobil Oil Corp.
2. Nell A-1 - Anadarko Production Co.
3. Hubbard No. 1 Unit, Well #3 - Mobil Oil Corp.
4. Hahn Gas Unit "C" - Pan American Petroleum Corp.
5. Luke GU #4 - Amoco Production Co.
6. Goertzen Gas Unit No. 1 - Pan American Petroleum Corp.
7. Cassity "A" 1 - Anadarko Production Co.
8. Gall Area 13 - Shell Oil Co.
9. Lee No. 8-2 - Kansas Nebraska Natural Gas Co.
10. J.K. Moser No. 1 - Pan American Petroleum Corp.
11. C.H. Hoover No. 1 - Pan American Petroleum Corp.
12. Rooney No. 1 - Keith Tuthill
13. Miller No. 3 - Coastal Oil & Gas

Index Map to Cross Section



5 0 10 20 Miles

Horizontal Scale

Legend

- Lithologic Boundary
- Shale Formations and Members
- Limestone Formations and Members

Plate 5

North - South Stratigraphic Cross Section

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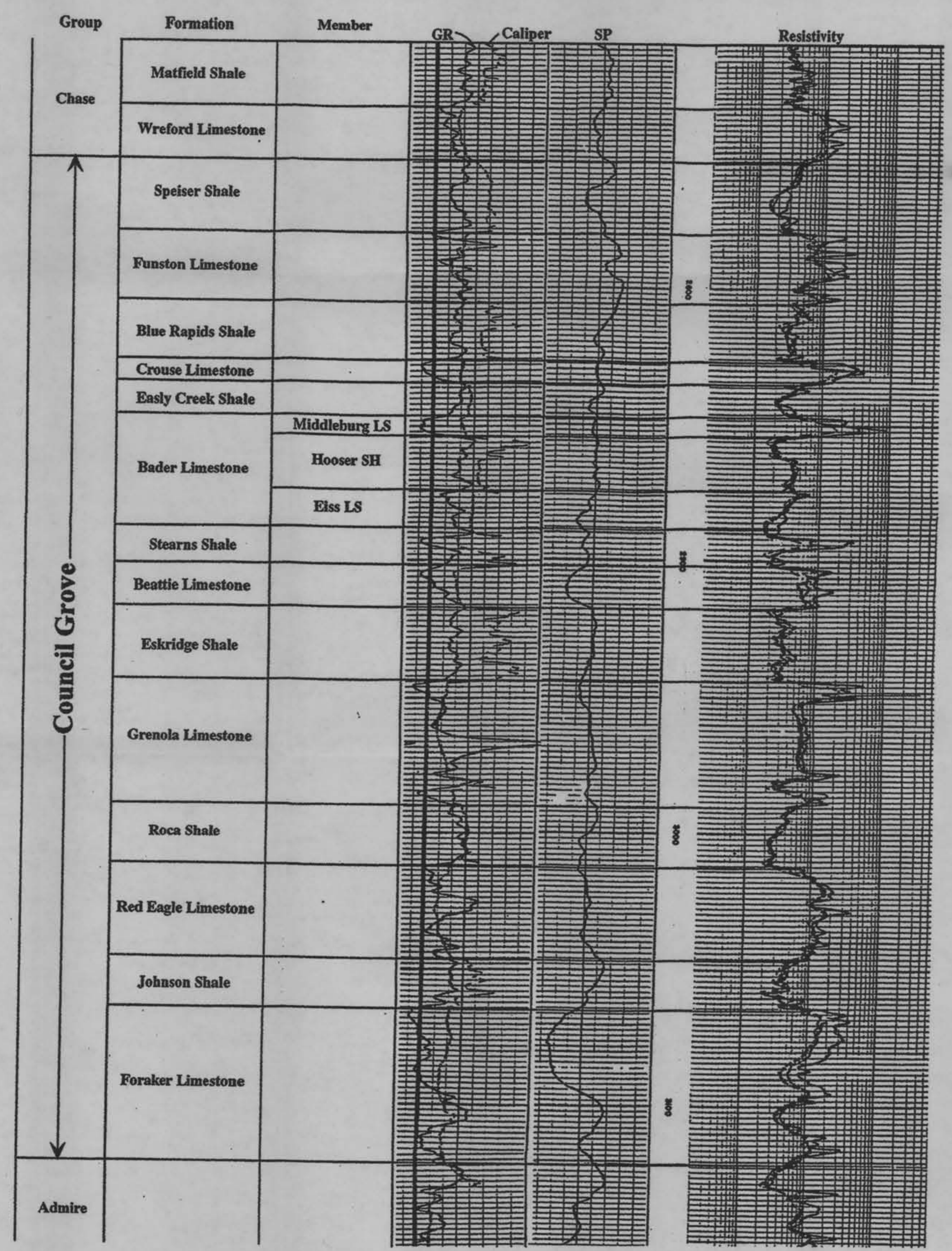
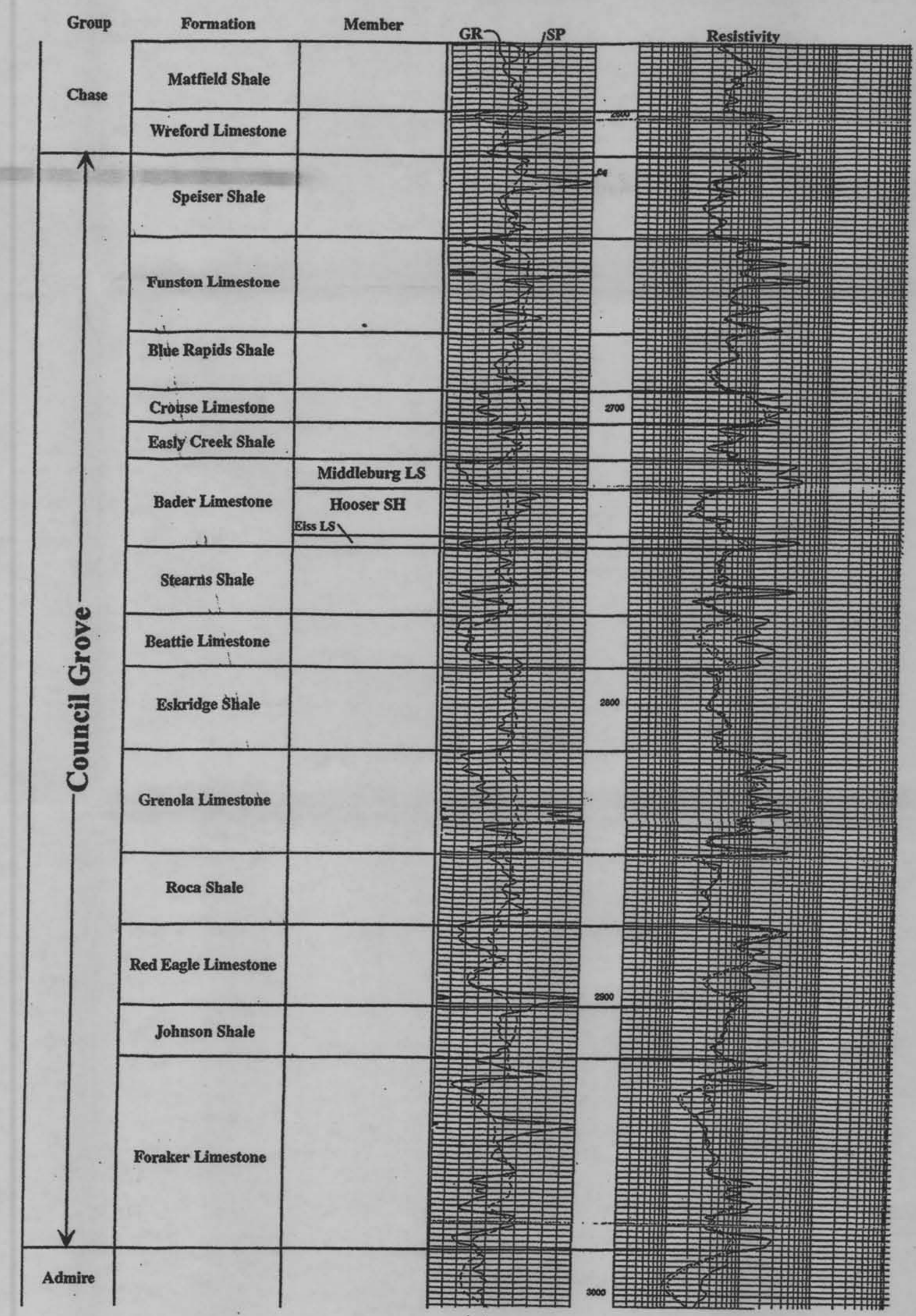
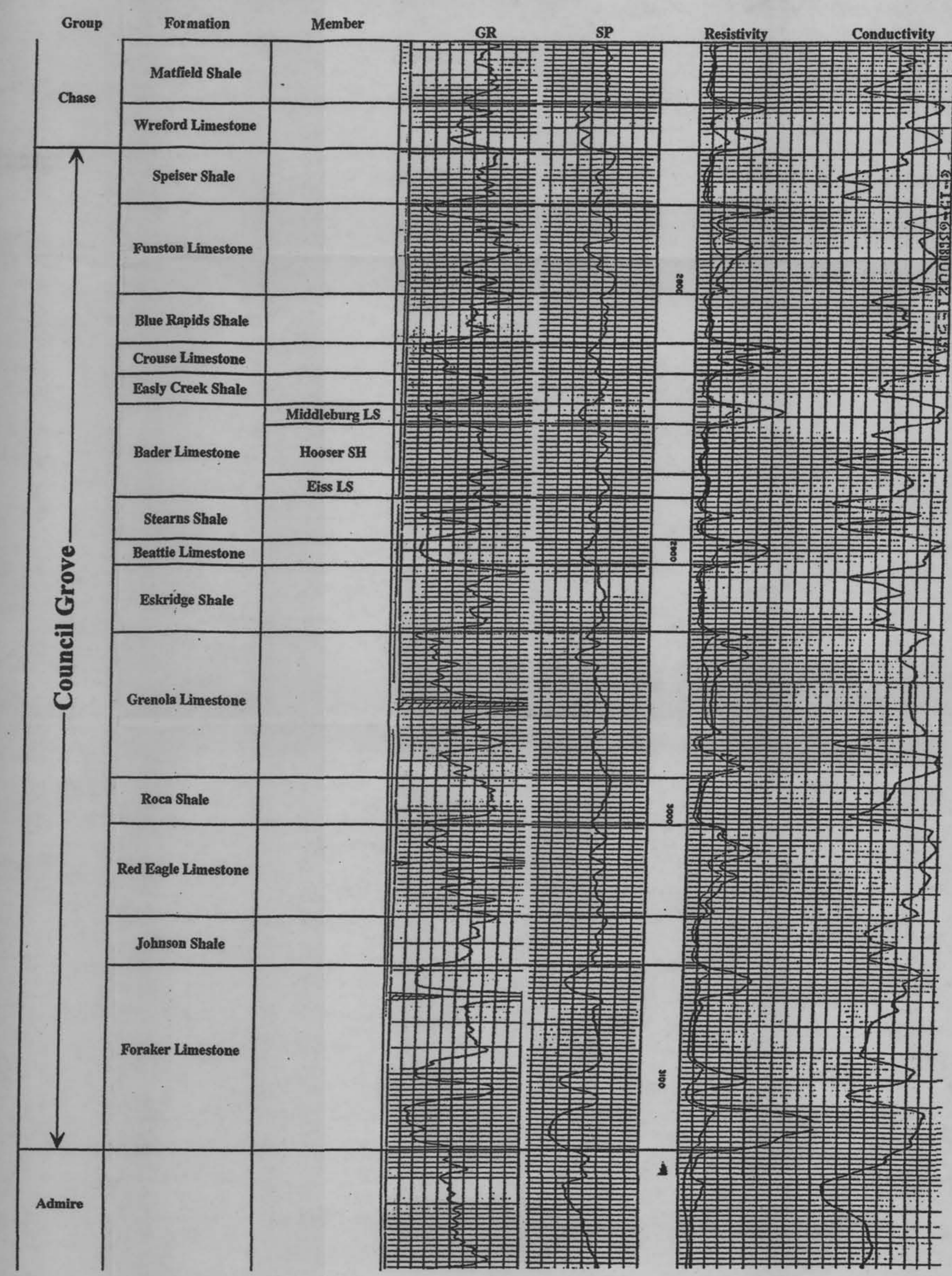
Kearny County, Kansas
31-24S-36W
J.K. Moser No. 1



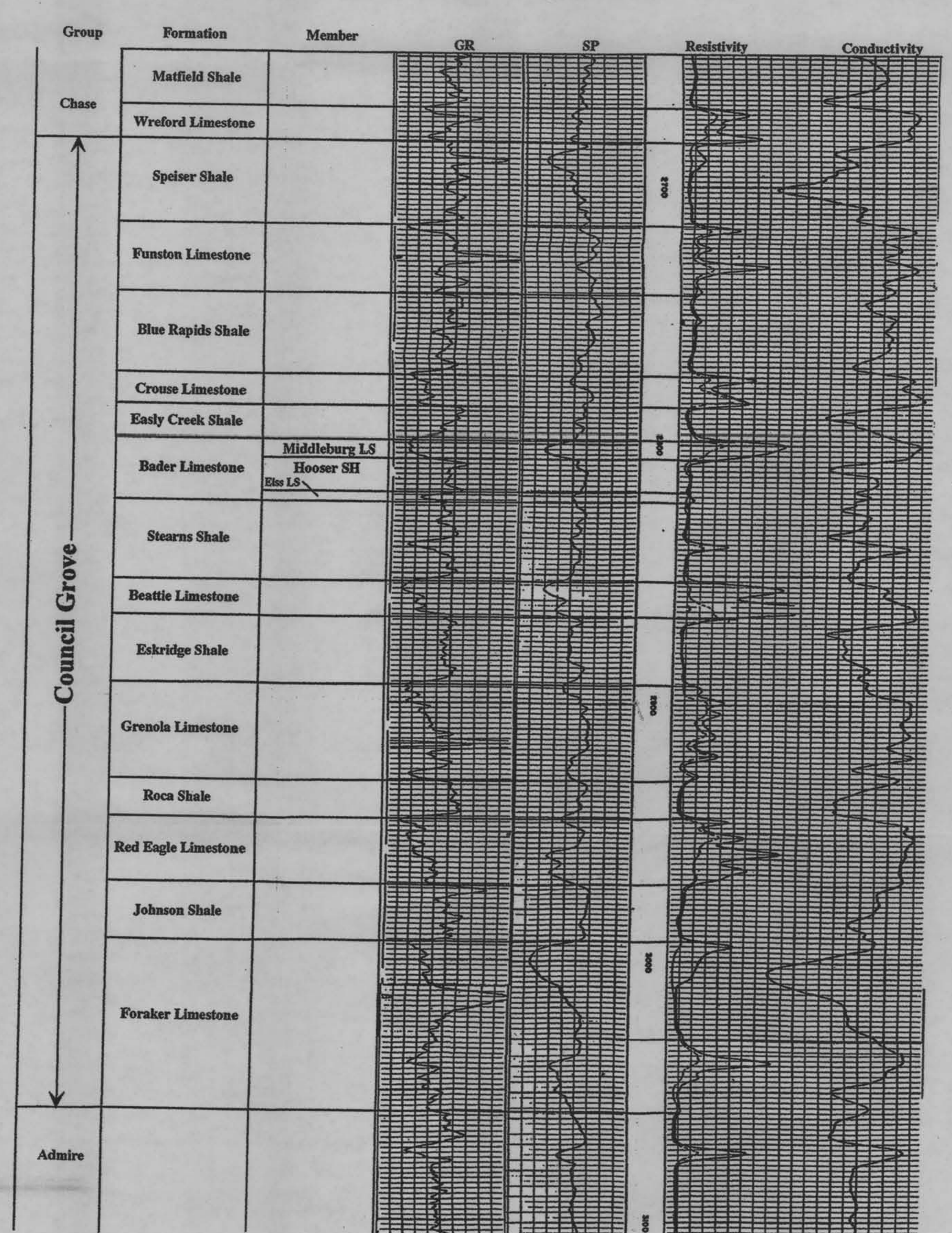
Stanton County
8-30S-39W
Luke GU #4



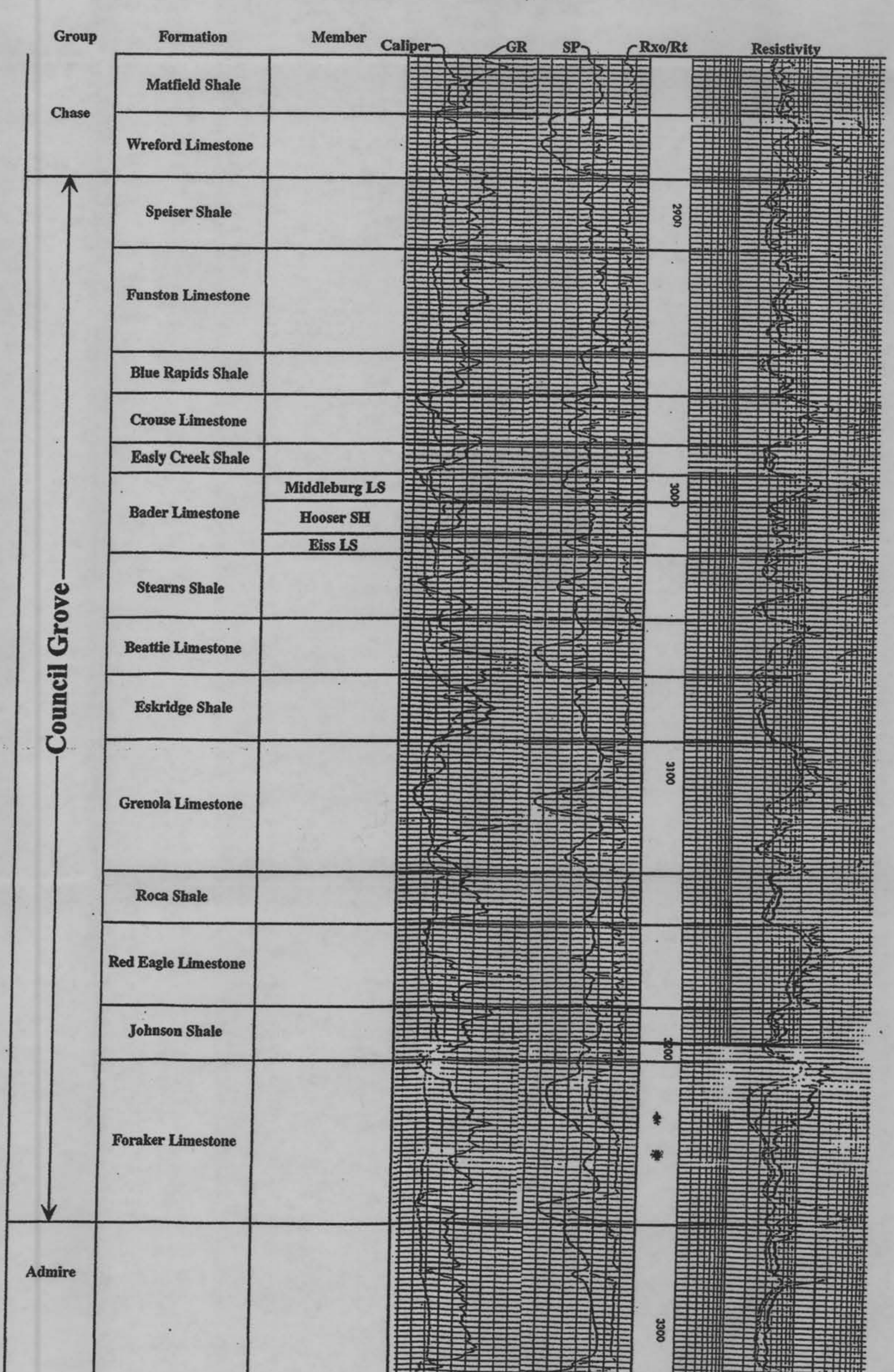
Grant County
14-29S-37W
Thomason No. 2



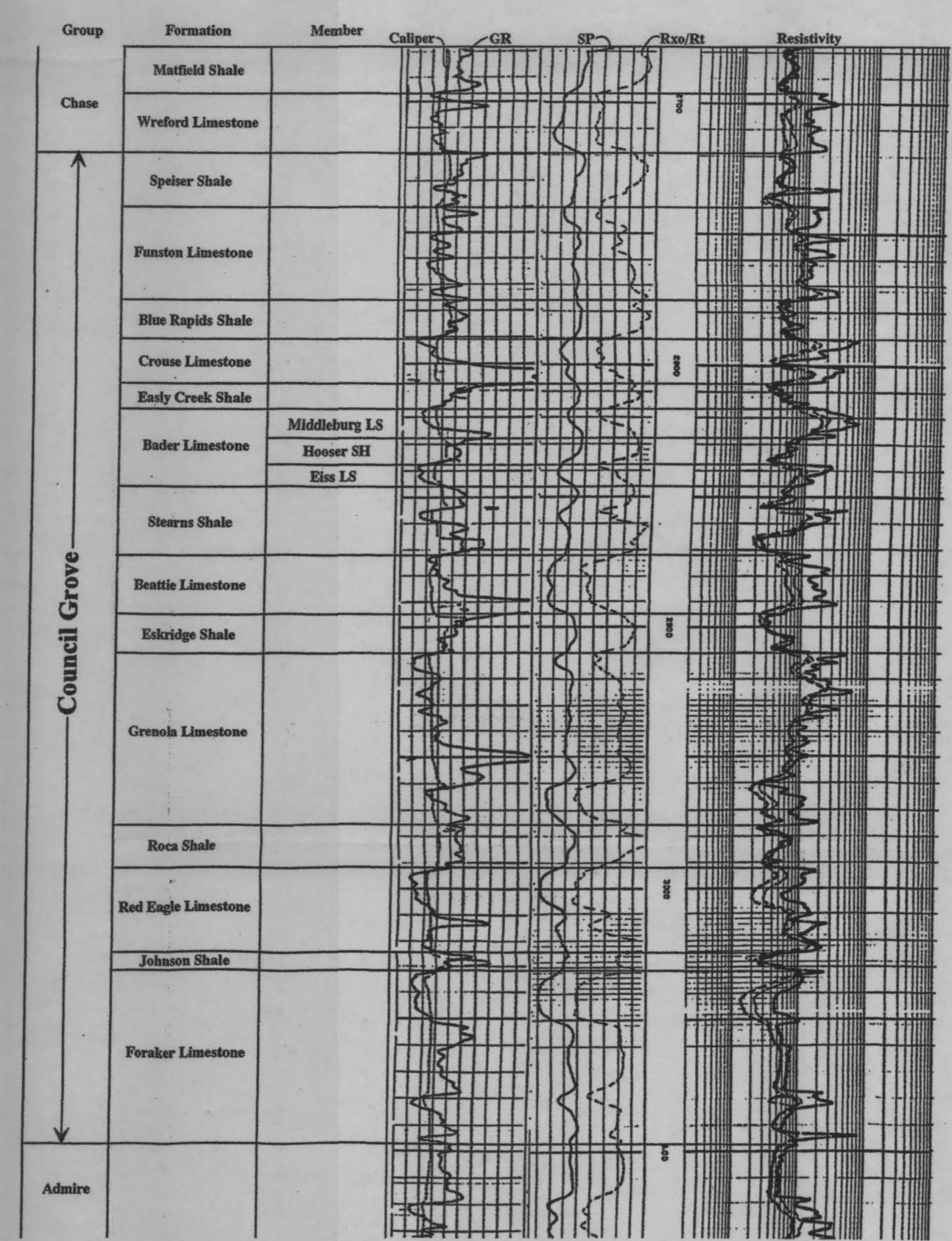
Morton County
19-32S-39W
Tillett Gas Unit "B" No. 1



Stevens County
20-32S-37W
Hubbard #1 Unit, Well #3



Haskell County
33-30S-34W
Feedlot No. 1



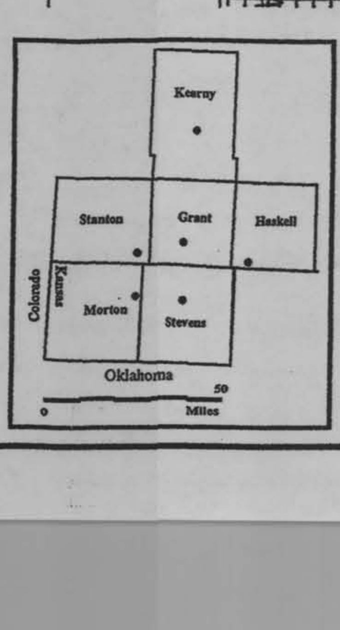


Plate 6
Council Grove Group Type Logs
Panoma Field Counties
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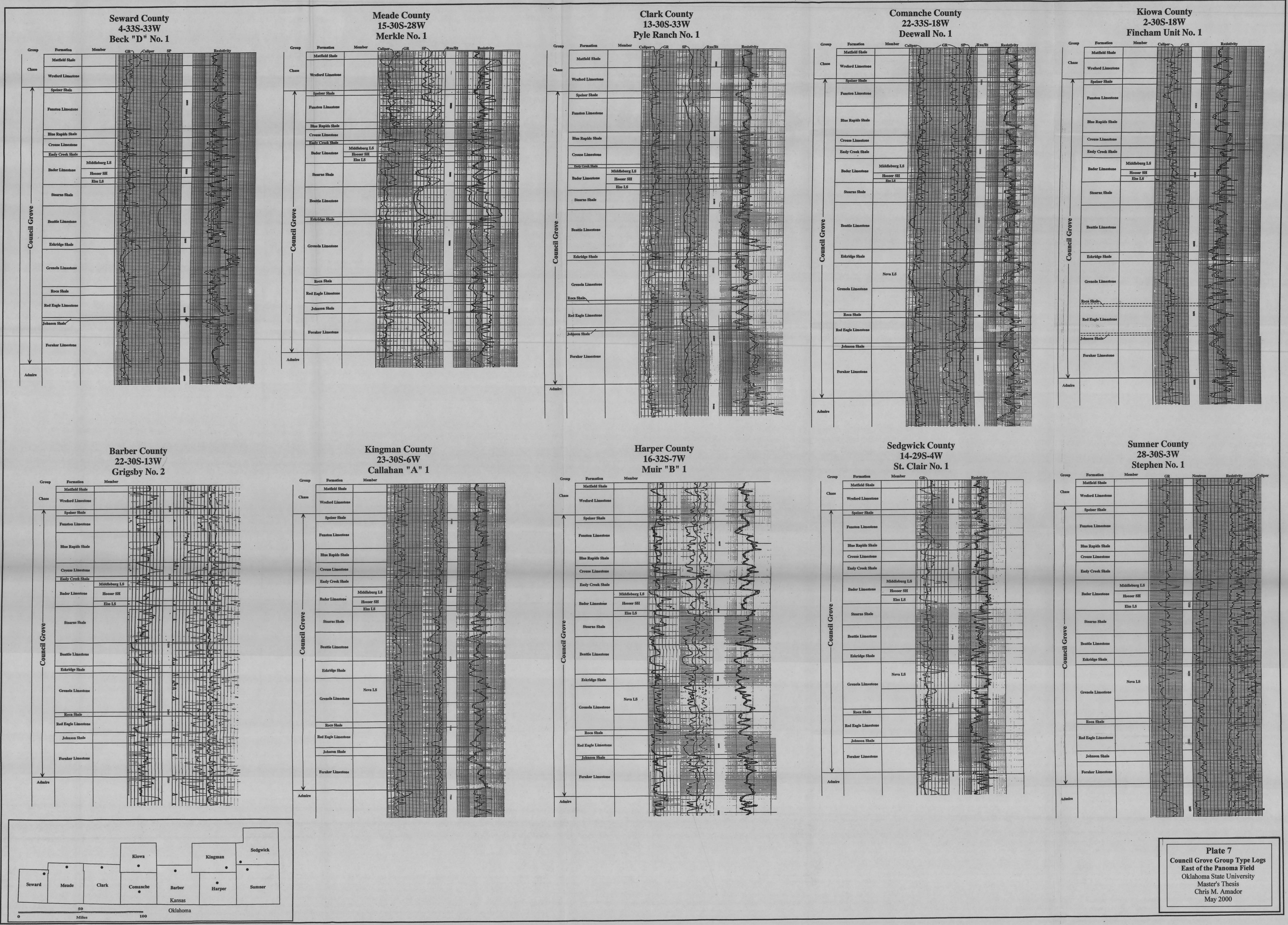

Plate 7
Council Grove Group Type Logs
East of the Panoma Field
Oklahoma State University
Master's Thesis
Chris M. Amador
May 2000

VITA 2

Chris M. Amador

Candidate for the Degree of

Master of Science

Thesis: HIGH-RESOLUTION CORRELATION AND TYPE LOG DEVELOPMENT OF THE COUNCIL GROVE GROUP IN SOUTHERN KANSAS

Major Field: Geology

Biographical:

Education: Taos High School, Taos, New Mexico, 1989. Bachelor of Geological Sciences, New Mexico State University, December, 1994. Completed requirements for the Master of Science degree with a major in Geology at Oklahoma State University, School of Geology, in July 2000.

Experience: Reclamation Scientist/Geologist with Buchanan Consultants, Ltd. in Farmington, NM, from July 1995 to February 2000. Subcontracted well-site geologist by BHP World Minerals from April 1998 to August 1998. Taught structural, historical and introductory geology laboratory courses while attending Oklahoma State University between August 1998 and May 2000.

Professional Memberships: Associate Member of the American Association of Petroleum Geologist

Academic Honors: Graduated PHI KAPPA PHI, Oklahoma State University
Recipient of AAPG Grants-In-Aid award
Skinner Fellowship, OSU, 1998-2000
Graduated Deans Honor List, New Mexico State University