Stratigraphy, petrology, and paleogeography of the upper portion of the **Cherokee Group** (Middle Pennsylvanian), eastern Kansas and northeastern Oklahoma

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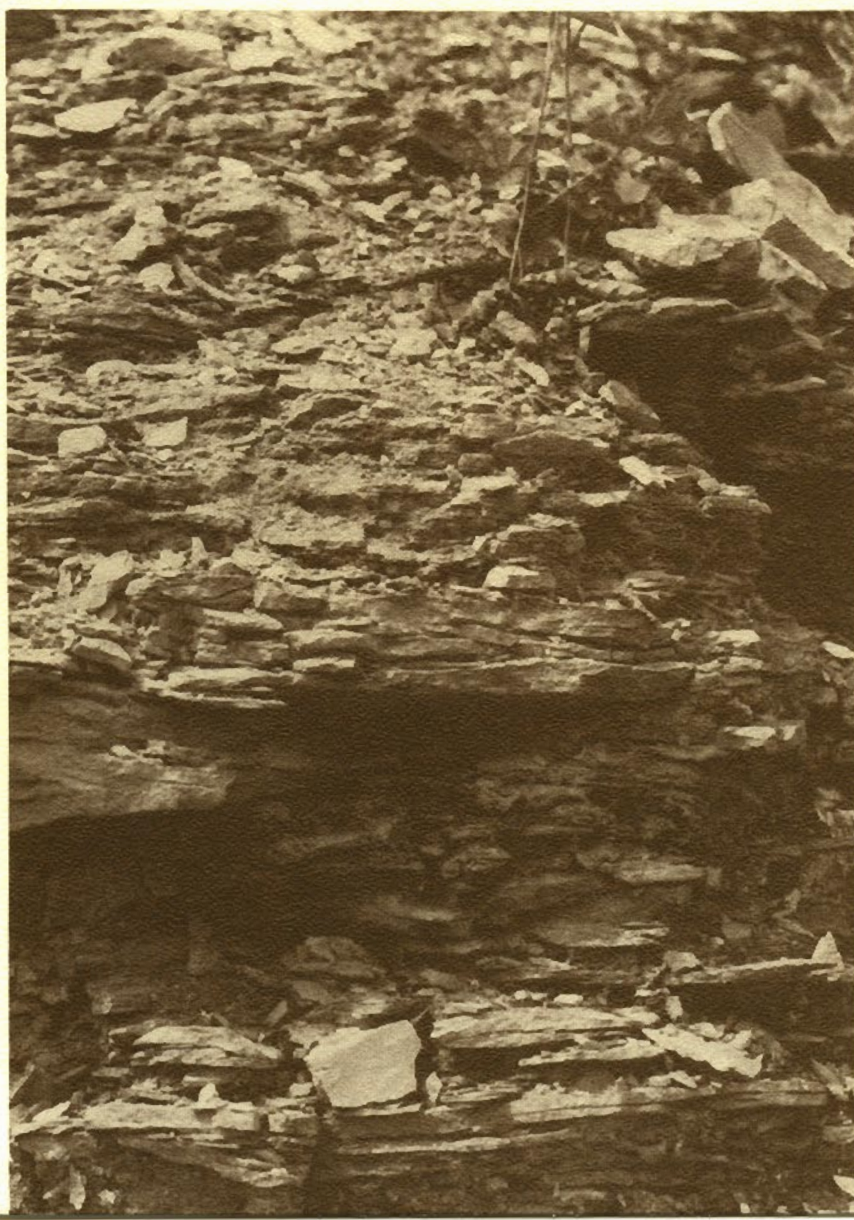
Geology Series 3 1989
Kansas Geological Survey



Stratigraphy, petrology, and paleogeography of the upper portion of the Cherokee Group (Middle Pennsylvanian), eastern Kansas and northeastern Oklahoma

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Executive summary

The upper portion of the Cherokee Group serves as host for petroleum-bearing sandstone and coal deposits that have contributed significantly to the economy of eastern Kansas and northeastern Oklahoma. Published studies of these rocks consist of regional studies based on outcrop observations and local studies based on subsurface data, usually centered upon a petroleum field. In this paper, I integrate surface and subsurface data that five graduate students and I collected and use this information to reconstruct the depositional and post-depositional (diagenetic) histories of these petroleum and coal-producing rocks.

This paper uses maps and cross sections to show the characteristics and distributions of rock types between two widespread black shale marker units. Sandstone bodies, which host most of the petroleum deposits of the upper portion of the Cherokee, form northeastward-trending "shoestrings" within lobate complexes that rim the margins of the Forest City basin and the Cherokee shelf. These complexes were formed by delta systems that prograded across the Pennsylvanian epeiric sea margin during times of low sea levels (i.e. eustatic regression). Coal beds represent swamps that covered major portions of delta plains and some interdeltaic areas. Overextending of delta-distributary channels resulted in channel diversion, the creation of new delta lobes, and the abandonment of previously active lobes. Marine environment covered abandoned lobes, burying swamp areas and channel sands with marine muds, thus protecting peat deposits and later serving as seals for underlying petroleum-bearing sandstones. During times of rising sea levels (i.e. eustatic transgressions), river mouths were shifted hundreds of kilometers northward and eastward, effectively cutting off the supplies of sand and mud to the sea that covered the study area. Depositional rates in the study area were extremely low during this time, resulting in very thin marine units that cover large portions of the area.

The locations of petroleum accumulations were determined by the distributions and characteristics of Pennsylvanian deltaic sedimentary complexes and the post-depositional (diagenetic) histories of the sandstone bodies within these complexes. Some diagenetic alterations destroyed the reservoir properties of sandstones by filling their void spaces (pores) with mineral cements. Other alterations enhanced these properties by dissolving previously deposited cements and, in some cases, portions of original sand grains. The distributions and intensities of diagenetic alterations seem to be controlled to a large extent by sandstone depositional environments and the sea-level changes that followed. Details of these and other possible mechanisms will be better understood as study of the petrology of Cherokee Group sandstones continues. Ultimately, depositional and diagenetic models will be developed that will be used to predict the locations and sizes of petroleum accumulations.

Contents

Table

Figures

Abstract

The Desmoinesian Cherokee Group of eastern Kansas and adjacent states consists of cyclic sequences of mudrock, thin carbonates, and lenticular sandstones. This study focuses upon the upper portion of the Cherokee Group between two widespread black shale markers: 1) the Oakley shale which underlies the Ardmore limestone and 2) the Excello shale which overlies the Cherokee and forms the base of the Marmaton Group. The study area extends from the Nebraska–Kansas border south through the northern tier of counties in Oklahoma, and from the Kansas–Missouri border west to the Nemaha uplift.

Stratigraphic and sedimentologic interpretations were based on outcrops, well cores, and a grid of geophysical logs from over 1,200 wells. Petrologic interpretations were made primarily from thin sections of well-core specimens, augmented by outcrop specimens. This integrated approach allowed lithologic facies to be identified and mapped. It also helped to demonstrate that the stratigraphic-nomenclature schemes currently in use in eastern Kansas and northeastern Oklahoma are inadequate to describe the three-dimensional stratigraphy of the region. An informal stratigraphic scheme is used to avoid confusion.

Sedimentologic analysis using all available data shows that sandstones are concentrated as shoestring-shaped and thin sheetlike bodies within lobate sediment thicks. These thicks were deposited as deltaic complexes which included fluvial and distributary channel sands, interdistributary muds and marshes, crevasse-splay sands and muds, flood-basin muds and swamps, delta-front sands, and prodeltaic muds. These facies were deposited as delta lobes prograded across the margins of the Pennsylvanian epeiric sea during times of eustatic regression. When lobes were abandoned as distributary channels over-extended themselves, waves and currents reworked their upper portions, winnowing out muds and leaving thin sheetlike lenses of sand. These local transgressive units, lying above the regressive sequences formed by prograding delta lobes, form autocycles within eustatic regressive hemicycles.

During eustatic transgressions, shorelines were shifted northward and eastward very rapidly, moving siliciclastic point sources away from the study area. As a result, transgressing hemicycles are represented by thin, reworked sandstone lenses, laterally extensive thin mudrock units, marine limestones, or black phosphatic shales.

Diagenetic alterations profoundly affected petroleum reservoir characteristics of Banzet sandstones. Thin marine sandstone units that were sampled are pervasively cemented, caused by an early stage of carbonate cementation. Some distributary-channel sandstone units have partial chlorite grain coatings, while other units that lack these coatings have well-developed quartz overgrowths that severely reduce both porosity and permeability. Fluvial and distributary-channel sandstones in northeastern Kansas seem to have undergone stages of late-carbonate cementation and concomitant silicate dissolution, followed by dissolution of carbonates. This sequence of events caused the development of significant volumes of secondary porosity, thus enhancing the reservoir characteristics of these sandstone units.

Introduction

The Cherokee Group (Desmoinesian) in eastern Kansas and northeastern Oklahoma consists predominantly of siliciclastic mudrocks with lesser amounts of lenticular sandstones, thin limestones, and coals. These lithologies occur in repetitive sequences that are exposed in a belt trending southwestward through the study area from western Missouri, through the southeastern corner of Kansas, and through the northeastern portion of Oklahoma (fig. 1). The stratigraphic interval studied consists of the upper portion of the Cherokee between the top of the Verdigris limestone and the base of the Excello shale (fig. 2).

Purposes of investigation

The purposes of this investigation were to 1) work out the regional stratigraphic relationships within the upper portion of the Cherokee Group, 2) reconstruct the paleogeography of eastern Kansas and adjoining areas during the Desmoinesian, and 3) describe the petrographic characteristics and potential reservoir characteristics of sandstone units within the upper Cherokee.

Tectonic setting and regional structure

Desmoinesian strata were deposited upon the Cherokee shelf, a tectonically stable depositional platform. The shelf is bounded to the west by the Nemaha uplift, to the east by the Ozark uplift, and to the south by the Arkoma basin (fig. 3). During the Early Pennsylvanian, the shelf was divided into two depositional elements: the

Cherokee shelf in southeastern Kansas and northeastern Oklahoma and the Forest City basin in northeastern Kansas, southeastern Nebraska, northwestern Missouri, and southwestern Iowa, separated from each other by the Bourbon arch, a low-relief feature which trends northwest-southeast through east-central Kansas into Missouri (Merriam, 1963). A north-south well-log traverse shows that both the Cherokee shelf and the Forest City basin were filled to such an extent that by the time upper Cherokee sediments were deposited, the Bourbon arch was no longer a depositional barrier (fig. 4).

The Nemaha uplift is a north-south-trending belt of faulted anticlines which extends from Nebraska to central Oklahoma (McElroy, 1961). Wells and Anderson (1968) suggest that movements along the uplift may have begun as early as late Early Ordovician, but major tectonic movements attained a peak in post-Mississippian, pre-Desmoinesian time, or more specifically, post-Morrowan, pre-Atokan time (Berryhill, 1960).

In Oklahoma, complete burial of the Nemaha uplift was achieved by the beginning of upper Cherokee sedimentation (Krumme, 1981). However, throughout most of its trace in southeastern Kansas, the uplift was a positive feature during the Middle Pennsylvanian, as shown by the onlapping of upper Cherokee beds upon it.

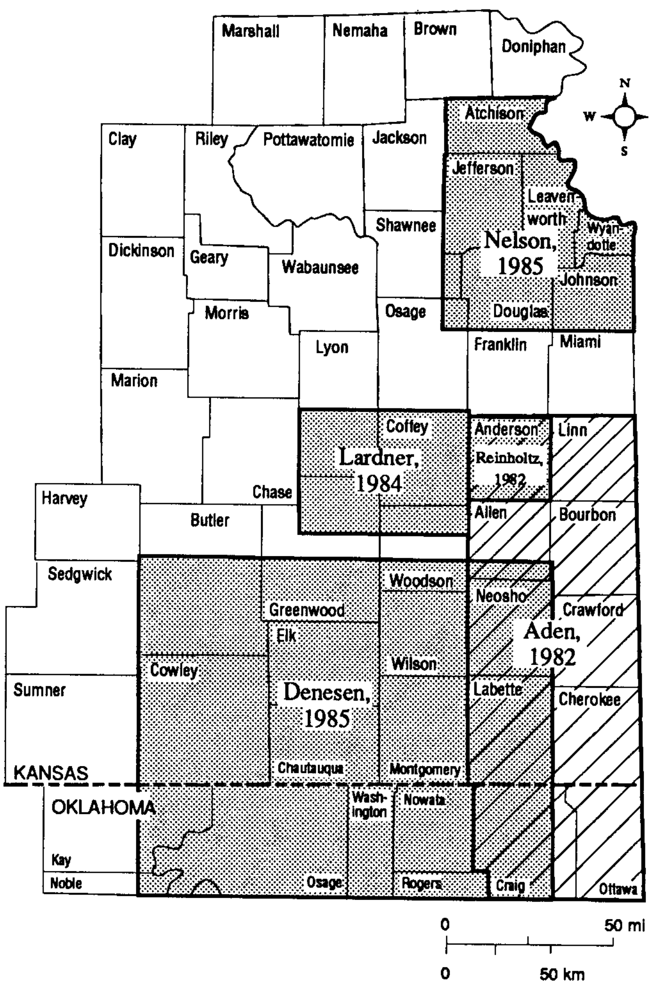


FIGURE 1—MAP OF EASTERN KANSAS AND ADJACENT AREAS SHOWING OUTCROP BELT OF CHEROKEE GROUP and locations of study areas of University of Iowa master of science students. The years are thesis-completion dates.

To the east of the Cherokee shelf lies the Ozark uplift, which persisted as a positive feature during the Paleozoic Era. The latest pre-upper Cherokee tectonic movements in the Ozark area seem to have begun prior to deposition of Cabaniss sediments (Branson and Huffman, 1965). Any effect that this uplift might have had on Cherokee sedimentation cannot be determined due to post-Desmoinesian erosion between the study areas and the Ozark uplift.

The regional strike of Desmoinesian strata varies from northeast-southwest along the outcrop belt, to north-south through the center, and northwest-southeast in the southwest corner of the study area (fig. 5) in proximity to the hinge line of the Anadarko basin.

The region forms part of the Prairie Plains homocline, a post-Permian structure (Berryhill, 1960). Beds dip westward at about 3-9 m/km (30-50 ft/mi). Near the Nemaha uplift, the dip changes as beds flatten and then reverse to the east as a result of post-Cherokee tectonic movements along the uplift.

Smith (1955) documented several folds in Cowley County, Kansas, and Kay County, Oklahoma, which trend parallel to the Nemaha uplift. Denesen (1985) reported that evidence for tectonic movements involving the upper portion of the Cherokee was observed in Butler and Cowley counties, Kansas, and Kay, Osage, and Washington counties, Oklahoma. These structures have not as yet been analyzed; however, they appear to have had little influence on Middle Pennsylvanian sedimentation.

Previous work

Although the Cherokee shelf has been subjected to oil exploration over the last 120 yrs, only during the previous 50 years has there been much published information about the nature of Desmoinesian strata. Investigations of these rocks on the surface have been summarized by Howe (1956) for Kansas and Branson and Huffman (1965) for northeastern Oklahoma.

Subsurface studies of Desmoinesian strata in Oklahoma are more numerous than those in Kansas due to a large extent to theses done at the University of Oklahoma. Many of these theses deal with the nature of lenticular sandstones and persistent marker horizons as they relate to the geologic history of the region. These studies include those by Ware (1955), Smith (1955), Graves (1958), Kirk (1958), Querry (1958), Stringer (1958), Baker (1958), Sartin (1958), Berryhill (1960), McElroy (1961), Strong (1961), Clayton (1967), Hanke (1967), Cole (1970), and Scott (1970). In addition, similar theses were done by students from Oklahoma State University and Tulsa University. These authors include Berry (1967), Dogan (1970), Astarita (1975), Candler (1979), and Shipley (1979).

Krumme (1981) examined strata between the base of the Verdigris Limestone Member and the top of the Checkerboard Limestone (Missourian Series) and delineated the paleoenvironment of the shelf by examining the depositional trends and characteristics of limestones, sandstones, and key marker horizons. He also attempted to make correlations between strata on the Cherokee shelf and the Arkoma basin strata.

Very little information about the subsurface stratigraphic nature of the Cherokee Group in southeastern Kansas has been published. Smith (1955) correlated Kansas and Oklahoma strata by the use of electric-log cross sections from Cowley County, Kansas, to Kay County, Oklahoma. Correlations of various prominent Cherokee sandstones were achieved in Bourbon, Cherokee, and Crawford counties by Ebanks and others (1977), and in Greenwood County by Hulse (1978). Woody (1983) and Harris (1984) examined the sedimentology, diagenesis, and petrophysics of sandstones from various intervals within the Cherokee.

To date, the most comprehensive studies of the stratigraphic relationships and depositional environments of prominent lithologies within the upper portion of the Cherokee Group have come from master of science theses at the University of Iowa, in part supported by the Kansas Geological Survey. Sedimentologic and stratigraphic studies include those by Aden (1982), Reinholtz (1982), Lardner (1984), Denesen (1985), and Nelson (1985). The major contributions made in these theses are incorporated into this report.

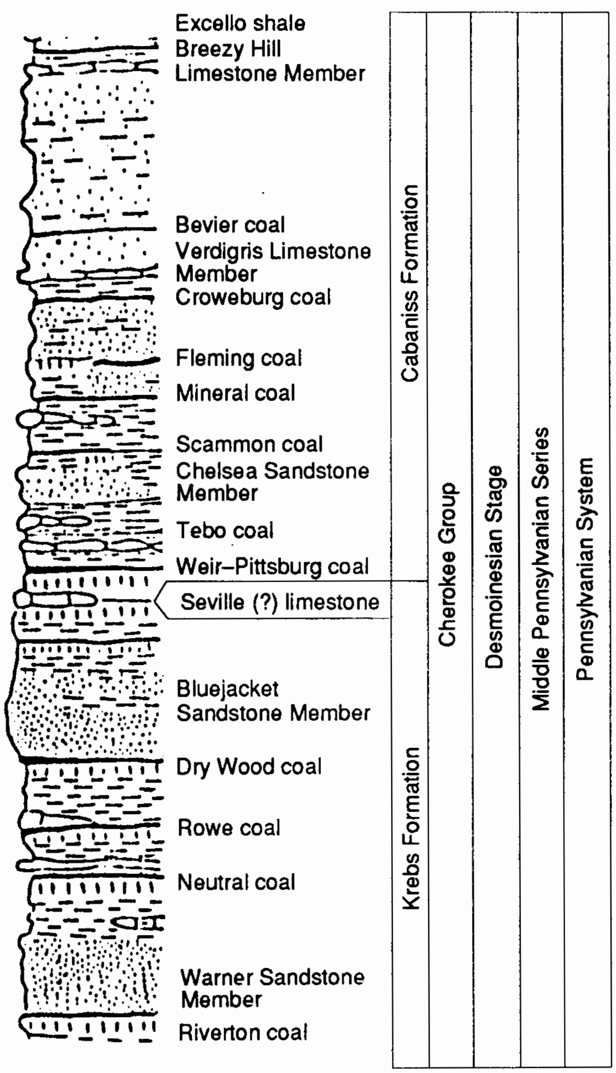


FIGURE 2—Traditional stratigraphic terms used for Cherokee Group in Kansas; modified from Zeller, 1968.

Methods of study

Geophysical well logs from 1,293 wells were examined (fig. 6 and appendix A), mostly from the well-log libraries at the Kansas Geological Survey in Lawrence and the Oklahoma Geological Survey in Norman. Where available, an average density of three well logs per township was used in an attempt to secure adequate representation of strata within the study area. After eliminating logs that did not record data from the interval of study, logs from 1,229 wells were used in this study. Gamma-ray, neutron, and density well logs were used because of their high bed resolution, which facilitates the differentiation of black shales, coals, and gross geometries of sandstone bodies. Electric logs (SP and resistivity) were used where other logs were not available. Bed resolution is not as precise in electric logs as it is in gamma-ray logs.

Acknowledgments—Although I am solely responsible for the interpretations made in this manuscript, many people contributed data and ideas. Much of the data used in this study was collected and analyzed by the following individuals while they were geology graduate students at the University of Iowa: Leon J. Aden, Stephen L. Denesen, James E. Lardner, Murray R. Nelson, and Philip N. Reinholtz. These students also contributed interpretations and ideas that I have cited and freely drawn upon in this manuscript. Professor Philip H. Heckel of the Geology Department of the University of Iowa first

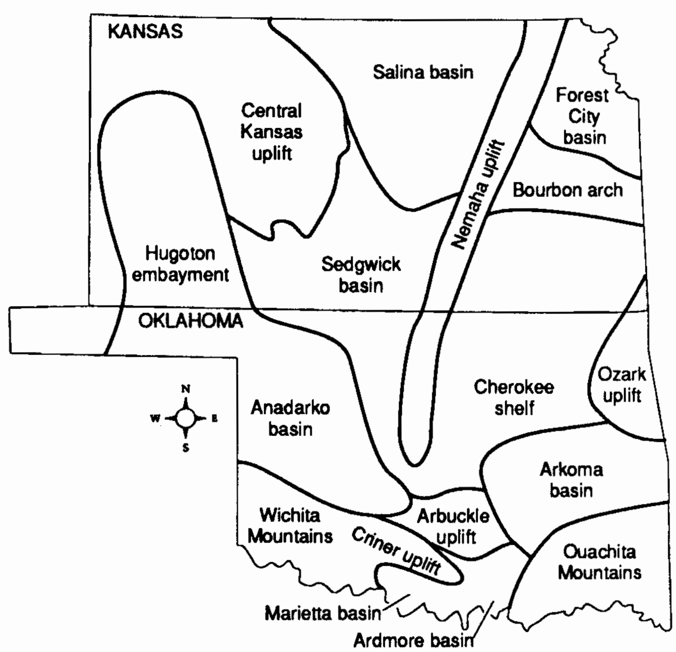


FIGURE 3—Pennsylvanian tectonic settings in Kansas and Oklahoma; modified from Lardner, 1984; Merriam, 1963.

rekindled my interest in the Pennsylvanian of the midcontinent. Dr. W. J. Ebanks, formerly the chief of the subsurface division of the Kansas Geological Survey, introduced me to the Cherokee outcrop belt in western Missouri, southeastern Kansas, and northeastern Oklahoma. He also provided me with aid while working in the Kansas Geological Survey facilities in Lawrence. Aid and guidance were continued by Dr. W. Lynn Watney, chief of the Petroleum Research Section of the Kansas Geological Survey, who also reviewed early drafts of this manuscript. I would like also to thank the other individuals who critically reviewed various drafts of this manuscript. Other employees and past employees of the Kansas Geological Survey provided logistical support to my students and me. Professor Anthony W. Walton of the University of Kansas discussed with me observations and interpretations that he and his students made in the lower portion of the Cherokee Group.

Finally, I wish to thank the many landowners, drillers, and loggers that helped my students and me obtain critical pieces of information during the course of our studies.

Stratigraphy

Abrupt lateral facies changes within the Cherokee Group complicate its stratigraphy. The relatively narrow, poorly exposed outcrop belt of the Cherokee does not reveal enough of the lateral and vertical relationships to adequately determine regional stratigraphy. Therefore, the stratigraphy of the Cherokee Group must be based on subsurface data, as well as surface exposures. Unfortunately, this integrative approach has not yet been applied to the entire Cherokee on a regional basis. Stratigraphic nomenclature schemes used by various workers not only do not agree with one another, but also have caused numerous miscorrelations between distant outcrops and between outcrops and subsurface sections. Resolution of the stratigraphic nomenclature problems within the Cherokee must wait until regional analysis of this entire rock package has been completed.

In this report, I will define an informal stratigraphic term, the "Banzet formation," to include the uppermost Cherokee rocks. This unit is spelled with a lower-case "f" to distinguish it from formally defined formations. Likewise, I will use informal members, each spelled with a lower-case "m" to ease rock descriptions. To help establish the stratigraphic framework for the Banzet, I will review the history and current usage of the stratigraphic nomenclature of Cherokee rocks.

History of stratigraphic nomenclature

The Pennsylvanian System of the midcontinent has traditionally been divided into five series based on biostratigraphic zones. In ascending order, these are the Morrowan, Atokan, Desmoinesian, Missourian, and Virgilian series. Morrowan and Atokan rocks are preserved in the Arkoma basin of Oklahoma, while rocks belonging to the latter three series are found on the Cherokee shelf and in the Forest City basin (Krumme, 1981). In the study area, the Cherokee Group traditionally has been classified as the lower part of the Desmoinesian Series. It unconformably overlies rocks of the Mississippian System and conformably underlies rocks of the Marmaton Group, which form the upper portion of the Desmoinesian. However, Ravn and others (1984) have reported Atokan fossils in the lower part of the Cherokee in Iowa.

The Desmoinesian was originally called the Des Moines Group by the U.S. Geological Survey, and according to Condra (1949), it included the interval between the Hertha Limestone and the top of the

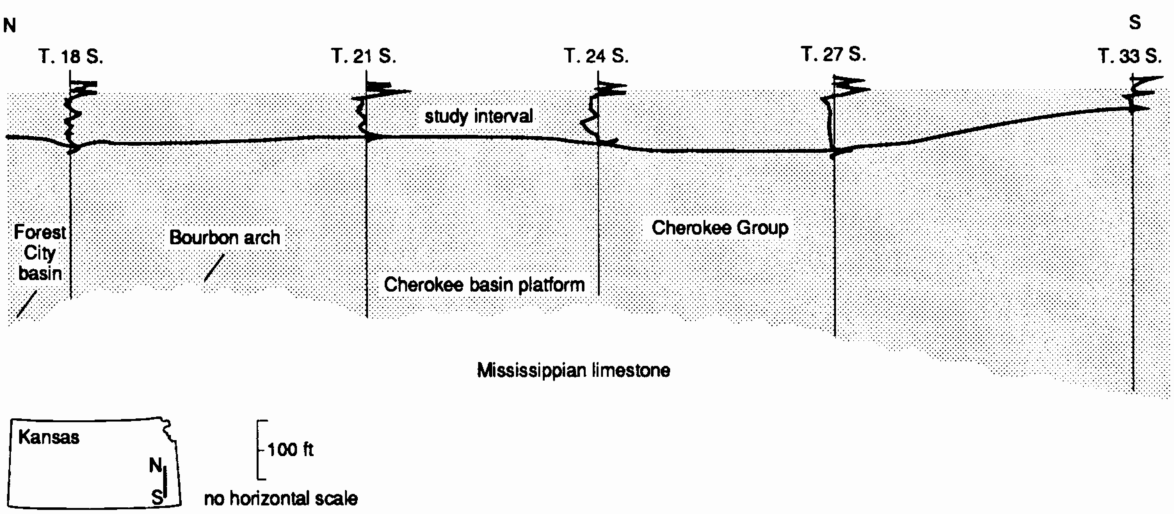


FIGURE 4—Generalized north-south cross section across Bourbon arch (line N-S on fig. 6), showing thickness variations of Cherokee Group and of upper Cherokee study interval.

Mississippian System in northwest Missouri and southeast Iowa. Included within this group were the "Cherokee shales," a term coined by Haworth and Kirk (1894) to designate shale, sandstone, coal, and thin limestone in Cherokee County, Kansas. Moore (1932, 1936) redefined the Desmoinesian as a series to include the Marmaton and Cherokee groups.

At a conference held in Nevada, Missouri, March 31-April 1, 1953, representatives from Iowa, Kansas, Missouri, Nebraska, and Oklahoma reached an agreement on division, classification, and nomenclature of Desmoinesian beds in these states. Older established names were retained with some redefinition, and new names were introduced to complete the classification.

Because of paleontological changes at the top of the Seville limestone (Kansas) or Inola limestone (Oklahoma), two substages, the Ventran and Cygnian, were adopted as time-stratigraphic divisions of the Desmoinesian. Two group names, Krebs and Cabaniss, were adopted to replace Cherokee (Howe, 1956). However, the term Cherokee was readopted by the Kansas Geological Survey, with the Krebs and Cabaniss being reclassified as subgroups. Because of the cyclic nature of Pennsylvanian rocks in the region, the representatives of the Nevada conference decided that the two new

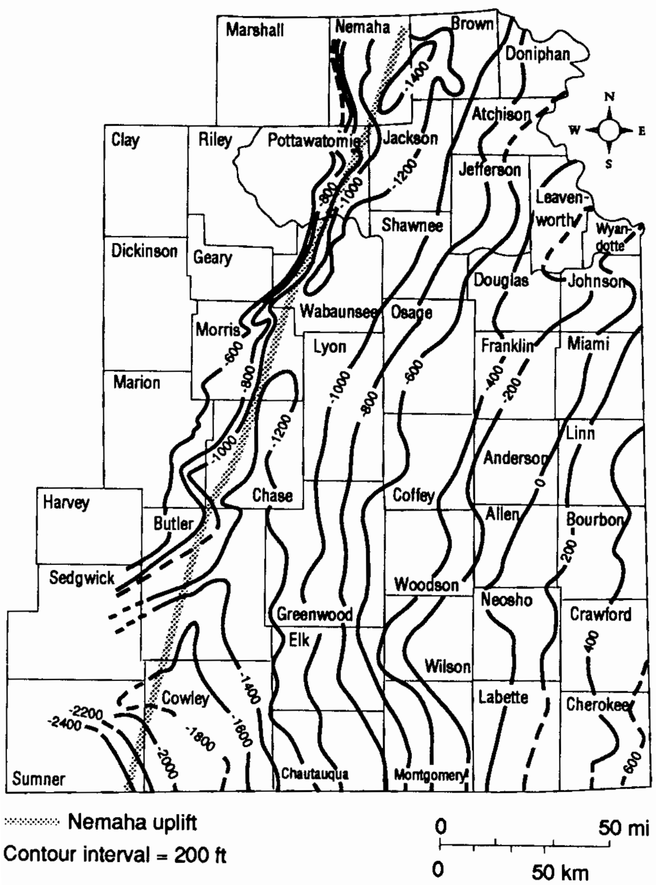


FIGURE 5—Structure contour map of eastern Kansas from Nemaha uplift eastward.

subgroups would be subdivided into formations, each consisting of strata between the top of a coal bed and the top of the next higher coal bed with four exceptions. These were named after the unit judged to be the most distinctive within the formation, regardless of the lithology. Usage of these formational units was restricted to areas where shelf conditions prevailed. However, at the present time, Missouri is the only state of the five which still subdivides the Desmoinesian Series by the guidelines set up at the Nevada conference.

Current stratigraphic nomenclature

Oklahoma

The term *Cherokee* is not recognized as a formal stratigraphic term in Oklahoma. Soon after the Nevada conference, the Oklahoma Geological Survey replaced it with the terms *Krebs* and *Cabaniss*, which were elevated from subgroup to group status. The boundary between the two was originally defined in the Arkoma basin, where a distinct paleontological break, change in character of sediments, and structural discordance occur at the Krebs–Cabaniss boundary (Oakes, 1953). This paleontological break was placed at the Inola limestone on the shelf, but because of the discontinuous nature of this limestone, the boundary is placed at the top of the Weir–Pittsburg coal, which overlies the Inola limestone on the shelf (Branson, 1957).

The Krebs Group is the lowest group in the Desmoinesian and includes all rocks between the top of the Atoka Formation and the top of the Boggy Formation (fig. 7). It contains the following formations in ascending order: Hartshorne, McAlester, Savanna, and Boggy.

Krebs Group thickness varies from 2,438 m (8,000 ft) in the basin to 104 m (340 ft) near the Kansas–Oklahoma border (Oakes, 1953). On the shelf, the Krebs contains prominent sandstones, limestones, and coals. These include the Warner, Bluejacket, and Taft sandstones (Warner, Bartlesville, and Red Fork sandstones of the subsurface), Sam Creek and Spaniard limestones (Brown limestone of the subsurface), Inola limestone, and the Riverton, Rowe, Drywood, and Weir–Pittsburg coals (fig. 7).

The Cabaniss Group contains all rocks between the top of the Krebs Group and base of the Marmaton Group. Its boundaries are marked by the top of the Weir–Pittsburg coal, below, and the top of the Excello shale, above. In the Arkoma basin, the Cabaniss is approximately 305 m (1,000 ft) thick, but thins to about 49 m (160 ft) near the Kansas–Oklahoma border (Oakes, 1953). The Cabaniss contains the following formations in ascending order: Thurman Sandstone, Stuart Shale, and Senora formation (fig. 7). From the basin northward, the Thurman Sandstone is overlapped by the Stuart Shale at a point near the Canadian River. In turn, the Stuart Shale is overlapped by the Senora formation in the vicinity of T. 13 N., R. 16 E. From this point, the Senora formation rests unconformably upon the Boggy Formation of the Krebs Group northward into Kansas (Ware, 1955).

Lithologically, the Senora formation resembles the Krebs Group in that it contains shale; discontinuous, lenticular sandstones; and several thin, persistent limestones and economically important coals. Prominent beds include the Chelsea, Goldenrod, and Lagonda sandstones (lower Skinner, upper Skinner, and Prue or "squirrel" sandstones of the subsurface); Tiawah limestone (pink lime of subsurface), Verdigris and Breezy Hill limestones; Tebo, Mineral, Croweburg, and Iron Post coals, and the black shales beneath the Tiawah and Verdigris limestones (fig. 7).

Kansas

The term Cherokee Group is recognized as a formal stratigraphic unit in Kansas. The type locality of the Cherokee Group is in Cherokee County, Kansas (Howe, 1956). The Krebs and Cabaniss subgroups were renamed as formations by Jewett (1959), with prominent coals, limestones, and sandstones used to define members of these two formations (Zeller, 1968).

The Krebs Formation was defined as consisting of rocks lying above the top of the Atoka Formation in the

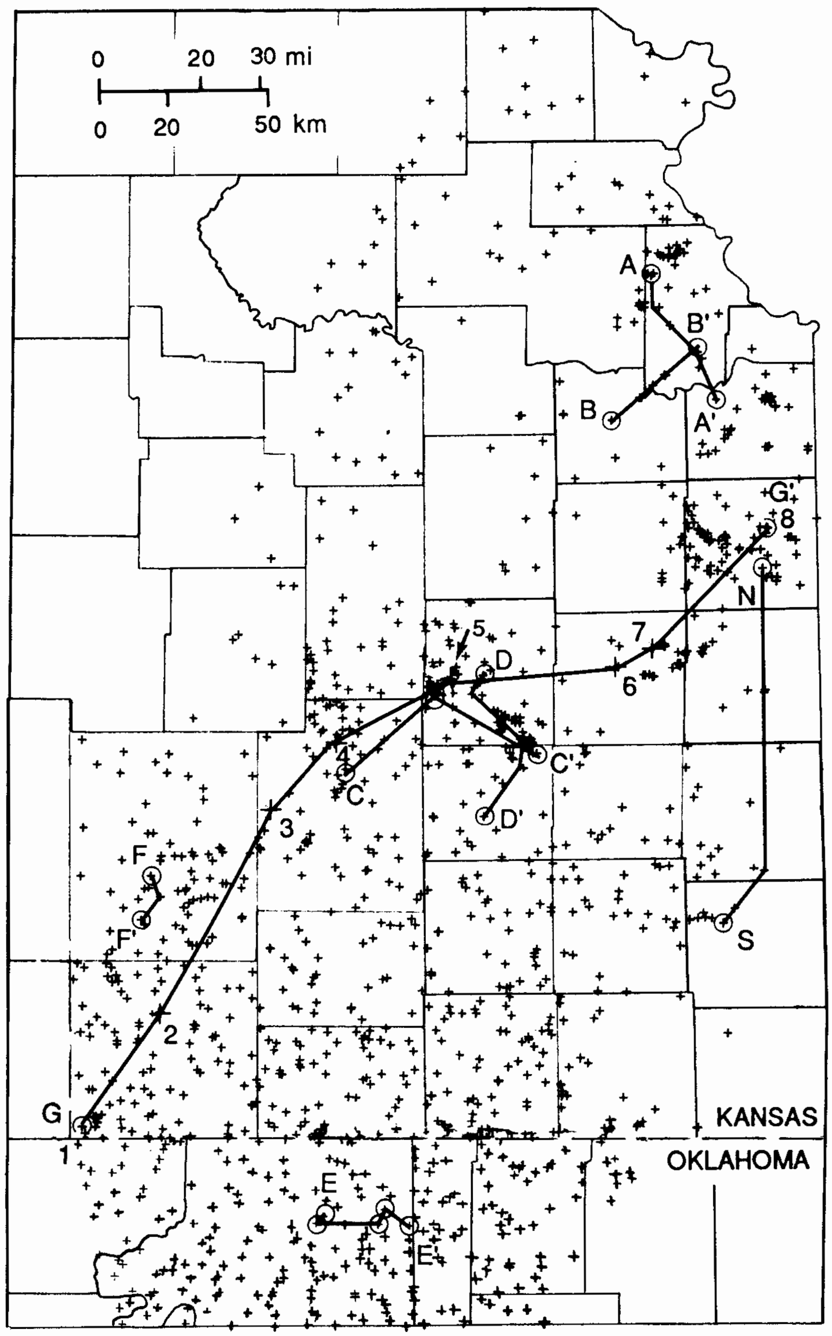


FIGURE 6—Distribution of well logs and locations of stratigraphic cross sections in Kansas and Oklahoma; see appendix A for listing of each well.

Arkoma basin of southern Oklahoma, and below the top of the Seville limestone (fig. 7). In sections where Atokan fossils have not been found and where the Seville has an erratic distribution over southeastern Kansas, the lower Krebs boundary is generally regarded as the top of the Mississippian System, while its upper boundary has been placed at the top of the Bluejacket Sandstone Member, which underlies the Seville. Krebs thickness on outcrops varies from 61 to 76 m (200-250 ft; Zeller, 1968). Listed in ascending order, prominent members of this formation include the Riverton coal, Drywood coal, Bluejacket Sandstone Member, and Seville limestone.

Rocks lying above the Seville or Bluejacket and below the top of the Excello shale belong to the Cabaniss Formation. On outcrop, the formation thickness averages 67 m (220 ft; Zeller, 1968). Prominent members include the Weir–Pittsburg, Tebo, Scammon, Mineral, Croweburg, and Bevier coals; Chelsea and Lagonda sandstones; and the Verdigris and Breezy Hill limestones (fig. 7).

The Banzet formation —an informal rock unit

The Verdigris Limestone Member of Oklahoma is traceable into Missouri where it has been named the Ardmore limestone by Gordon (1896). The black shale beneath the Verdigris–Ardmore limestone can be traced throughout the study area using gamma-ray logs. It can be traced along outcrop and in the subsurface from Oklahoma through eastern Kansas and western Missouri and into Iowa, where it recently has been named the Oakley Shale (Ravn and others, 1984). The lateral persistence of the Verdigris–Ardmore limestone and the Oakley Shale throughout the region establishes them as reliable lithostratigraphic markers. Following the historic precedent set by Gordon (1896) and the Missouri Geological Survey, I will refer to this unit as the Verdigris Formation, which includes the Ardmore Limestone Member above, and the Oakley Shale Member below (fig. 8). The lithologies that overlie the Verdigris will be referred to as the Banzet formation, an informal rock-stratigraphic unit. The lithologies below the Oakley Shale and above the Croweburg coal can be placed as a lower member of the Verdigris Formation.

The informal Banzet formation lies between the top of the Verdigris Formation and the base of the Excello shale. This stratigraphic interval, which has been the focus of the studies reported in this bulletin, was named after the ghost town of Banzet in Craig County, Oklahoma. An informal "type section" for the Banzet formation is in SWSW sec. 30, T. 28 N., R. 20 E., Craig County, Oklahoma, where a section of the Verdigris and Banzet formations, and the Excello shale, between the base of the Oakley Shale and the base of the Blackjack Creek limestone, is exposed in a roadcut along OK–10 (fig. 9). Denesen (1985) was able to divide the Banzet into four members along and adjacent to the outcrop belt. For simplicity in describing the Banzet, I will use Denesen's members as informal units.

If the Banzet formation were to be made into a formal rock-stratigraphic unit, it would necessitate major revisions in Kansas and Oklahoma stratigraphic-nomenclature schemes. However, more detailed subsurface stratigraphic studies of rocks below the Banzet must be completed before revisions of Cherokee stratigraphic terminology can be intelligently attempted. After this is done, the stratigraphic nomenclature for the entire Cherokee Group in the midcontinent needs to be reevaluated by representatives from all states involved. A nomenclature-correlation scheme should be agreed upon that takes into account all data from both surface exposures and subsurface wells. Until these studies are completed and a nomenclature-correlation scheme is agreed upon, I will use the Banzet formation, as defined above, as an informal formation within the Cabaniss subgroup.

Outcrop descriptions

The upper Cherokee outcrop belt trends across the southeastern portion of the study area from Bates County, Missouri, through portions of Bourbon, Crawford, Cherokee, and Labette counties, Kansas, and through Craig and Rogers counties, Oklahoma. Exposures are discontinuous and rarely contain the entire Verdigris–Banzet section. However, composite sections have been constructed using two or more nearby exposures. The stratigraphic positions and lithologic characteristics of the Oakley and Excello black shales and the Ardmore limestone are consistent throughout the outcrop belt. On the

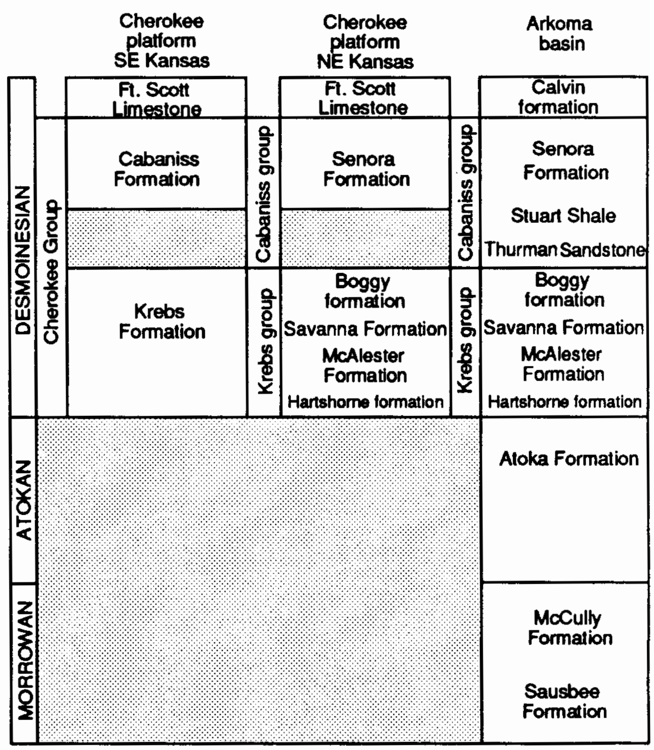


FIGURE 7—COMPARISON OF CHEROKEE STRATIGRAPHIC TERMS USED ON CHEROKEE SHELF OF EASTERN KANSAS AND NORTHEASTERN OKLAHOMA AND TERMS USED IN ARKOMA BASIN; modified from Krumme, 1981.

other hand, the gray shales, coals, sandstones, and the Breezy Hill Limestone Member of the Banzet formation vary considerably in lithology and thickness from the northeast to the southwest along the outcrop belt.

Oakley shale of the Verdigris Formation

The Oakley shale member of the Verdigris Formation consists of very dark gray to black, fissile clay shale that overlies dark-gray shale. The unit ranges in thickness from 0.5 m (1.5 ft) to 1.8 m (5 ft). The black shale contains oblate spheroidal, dark-gray phosphate nodules with maximum diameters of less than 1 cm. Conodonts were observed in the black shale and other marine fossils in gray shales of the Oakley.

Ardmore limestone of the Verdigris Formation

The Ardmore limestone member of the Verdigris Formation consists of an olive-gray to dark-olive-gray, dense biomicrite containing marine brachiopods, bryozoa, echinoderm debris, corals, and algal fragments. Its thickness has been reported to vary from 0.6 m (2 ft) to 4.3 m (14 ft) (Denesen, 1985), but ranges between 1.1 m (3.5 ft) and 1.5 m (4.8 ft) in the exposures where they were measured along the outcrop belt. The southernmost exposure studied was in the spillway of the Lake Bixhoma dam in sec. 2, T. 16 N., R. 14 E., Wagoner County, Oklahoma. At that locality, the limestone is split into two 0.3-m (1-ft)-thick beds by a 0.3-m (1-ft)-thick bed of dark-gray shale (fig. 10). This shale pinches out northward, so that exposures of the Ardmore in Craig County, Oklahoma, consist of a single limestone unit. Howe (1956) reported that the Ardmore splits into three limestone units separated by dark-gray shale in Cherokee and Crawford counties, Kansas. Unfortunately, many of these were exposed in coal pits that have since been covered. Two pits that were still accessible in the early 1980's showed a single 1.5-m-thick biomicrite in Cherokee County (NE sec. 13, T. 32 S., R. 22 E.) and three thin limestone units separated by dark-gray shale in a 3-m (10-ft) interval in northern Crawford County (SE sec. 9, T. 28 S., R. 25 E.) (fig. 11).

Bevier member of the Banzet formation

The interval between the top of the Ardmore limestone and the Bevier coal consists of a thin, dark-gray shale overlain by a medium-gray seatrock beneath the coal. Accessible exposures are poor; however, the Bevier member can be seen in several exposures in Craig County, Oklahoma, in southeastern Kansas, and in Bates County, Missouri. This member is generally less than 8 m (26 ft)

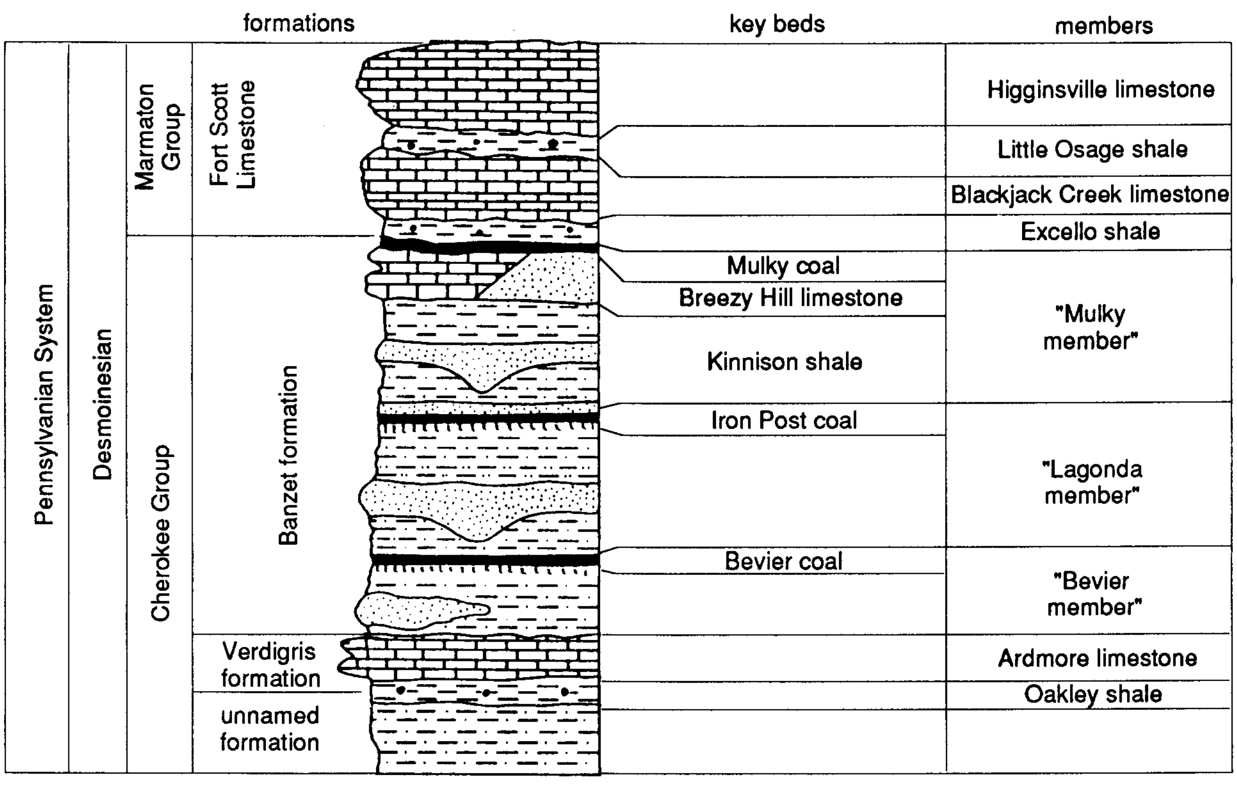


FIGURE 8—INFORMAL STRATIGRAPHIC NOMENCLATURE USED IN THIS STUDY FOR UPPER PORTION OF CHEROKEE GROUP ON THE CHEROKEE SHELF AND KANSAS PORTION OF FOREST CITY BASIN. Formations can be traced over the entire region. Members and key beds are recognized only in southern portion of study area; modified from Denesen, 1985.

thick along the outcrop belt. South of Craig County, the Bevier coal is not exposed (Denesen, 1985). In Craig County, Oklahoma, this member consists of a coarsening-upward sequence of clay shale, silt shale, and fine-grained sandstone, capped by a clayey seatrock and the Bevier coal.

Two types of sandstone occur within the Bevier member in Oklahoma. One type is a light-gray to medium-brownish-gray, fine-grained, ripple-laminated sandstone that is interstratified with light-to-medium-gray siltstone. The other type is a light-olive-gray, medium-grained, crossbedded sandstone with cross sets dipping southward at 15–20°. This sandstone has a sharp, erosional basal contact with underlying silt shales.

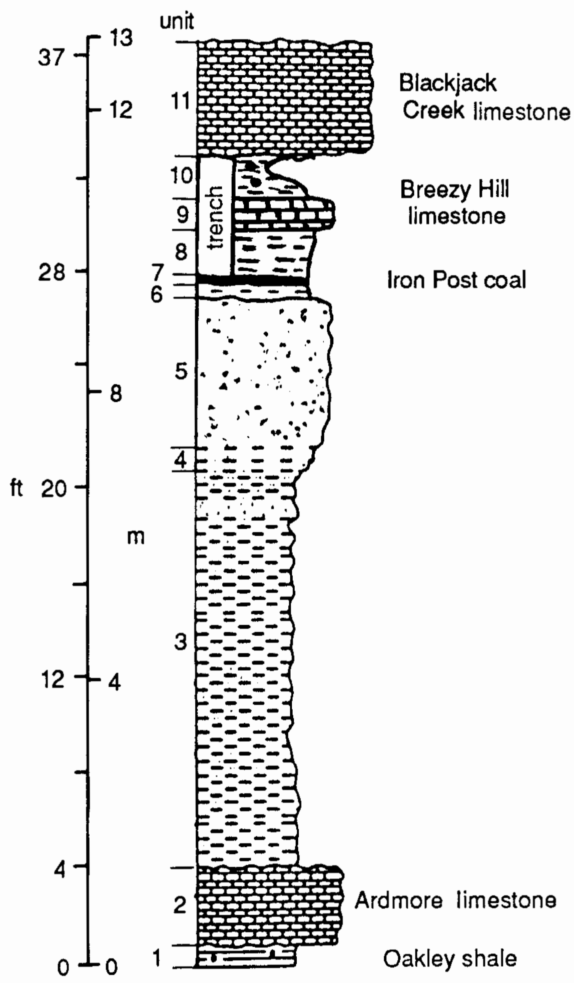
In Labette County, Kansas, the Bevier member consists of 2.5 m (8.3 ft) of thin-bedded, fine-grained sandstone. Further to the northeast in Bourbon and Crawford counties, Kansas, the Bevier coal and its clayey seatrock lie directly above the Ardmore limestone.

Along the Marais des Cygnes River northeast of Foster in Bates County, Missouri, the Bevier coal is a thin seam that can only be observed at low river levels.

Lagonda member of the Banzet formation

In Craig County, Oklahoma, the Lagonda member consists of a fining-upward sequence of sandstone, siltstone, and silt shale that lies directly upon the Bevier coal. This member thins from 6.2 m (20 ft) in the north in sec. 29, T. 27 N., R. 19 E. to 1.1 m (3.5 ft) in the south in sec. 28, T. 25 N., R. 18 E. (Denesen, 1985). The sandstone units are medium-to-fine grained, micaceous, platy subarkose. The basal contacts commonly show load features, and the upper portions of the sandstone units are ripple-laminated and interstratified with medium-gray silt shale.

The lower portion of the interval between the top of the Bevier coal and the base of the Breezy Hill Lime-



SWSWSW sec. 30, T. 28 N., R. 20 E.
Craig County, Oklahoma

Measured in roadcut along OK–10 by Robert L. Brenner, 1980; trenched in 1982

Type section of the Banzet formation and principal reference section of the Verdigris formation

Unit 11	11.3–13.0 m (36.2–41.6 ft)	Fossiliferous limestone
Unit 10	10.9–11.3 m (34.9–36.2 ft)	Black phosphatic clay shale
Unit 9	10.3–10.9 m (33.0–34.9 ft)	Fossiliferous limestone
Unit 8	9.7–10.3 m (31.0–33.0 ft)	Slightly calcareous light shale, medium-dark gray
Unit 7	9.6–9.7 m (30.7–31.0 ft)	Coal, poorly exposed
Unit 6	9.4–9.6 m (30.1–30.7 ft)	Claystone, medium-light-gray
Unit 5	7.3–9.4 m (23.3–30.1 ft)	Sandstone, fine- to medium-grained; regular laminae at base, mottled toward top; central part poorly exposed
Unit 4	7.0–7.3 m (22.4–23.3 ft)	Interstratified sandstone and siltshale; fissile beds less than 1 cm thick; gradational lower contact
Unit 3	1.4–7.0 m (4.4–22.4 ft)	Siltshale, medium-gray; contains some thin siltstone and sandstone beds which increase in frequency upward
Unit 2	0.3–1.4 m (0.9–4.4 ft)	Limestone; wacke-packstone
Unit 1	0–0.3 m (0–0.9 ft)	Clayshale, black; contains phosphate nodules.

FIGURE 9—DESCRIPTION OF "TYPE SECTION" OF BANZET FORMATION WEST OF WELCH (SWSW sec. 30, T. 28 N, R. 20 E.), Craig County, Oklahoma.

stone, corresponding to the Lagonda member, consists mostly of dark-gray clay shale with thin limestone beds that contain fossil brachiopods, pelecypods, and gastropods. Lenses and nodules of argillaceous micritic carbonate occur locally in some shale units. The interval, which includes the Lagonda and Mulky members, thickens northward from 9.5 m (31 ft) in sec. 16, T. 31 S., R. 23 E., Crawford County, to 23 m (77 ft) in sec. 32, T. 27 S., R. 25 E., Crawford County. The outcrop of this interval in Bates County, Missouri, is at least 11 m (37 ft) thick. It consists of dark-gray shales with thin, fossiliferous limestone units in its lower portion. Thin, fine-grained sandstones are restricted to the upper portion of the interval (Mulky member) on Kansas and Missouri exposures.

Mulky member of the Banzet formation

Above the Iron Post coal in northeastern Oklahoma, a wedge of dark-gray clay shale, named the Kinnison shale by Howe (1951), comprises the bulk of the Mulky member. The Kinnison thins northward in Craig County, Oklahoma, to less than 0.6 m (2 ft). This unit cannot be recognized in Kansas or Missouri exposures. This is due to an increase in silt content of the shales and the inclusion of thin sandstone units within the Mulky member in northernmost Craig County (e.g., Banzet type section; fig. 9) and into Kansas and Missouri.

The sandstone units exposed in the Neosho River section, Labette County, Kansas (fig. 12) consist of three beds, the thickest of which is 0.4 m (1.3 ft) thick. The sandstones are well sorted, very fine grained, and horizontal and ripple cross laminated, with sharp basal contacts that form load casts into the underlying shale (fig. 13). In the McCollum farm (fig. 14) and the Osage cemetery (fig. 15) sections in southern Crawford County, Kansas, 5 m (16.4 ft) of very fine grained, wavy-laminated sandstone crop out just below the Breezy Hill Limestone Member. The sandstone is similar in nature to those observed in Labette County but is higher in the section. The best exposures of Mulky member sandstones are in the Breezy Hill area of northern Crawford County in the North Arma (fig. 16) and West Croweburg sections. The sandstone units in each of these sections are 3 m (10 ft) thick and lie directly below the Breezy Hill Limestone Member. On both outcrops, the sandstones are horizontally laminated, wavy, and ripple cross laminated, with prominent load casts where sandstone over shale contacts are exposed (fig. 17). In this area, the sandstone units are capped by the Breezy Hill Limestone Member.

In Missouri, the Mulky member sandstones vary considerably between exposures. At the Northeast Foster section (fig. 18), the sandstone lies at the top of the interval and appears similar to the sandstone exposures in northern Crawford County, Kansas. At the Lawrence cemetery composite section (fig. 19) in Vernon County, Missouri, the sandstone is found in a 5-m (16.4-ft) sequence of interbedded, mottled and ripple-laminated sandstone and medium-dark-gray shale. The sequence seems to become more sandy up to a point 3 m (10 ft) below the top of the section. Above that level, the section is mostly shale with a few thin, very fine grained sandstone beds (Aden, 1982).

FIGURE 10—Contact between Oakley shale and Ardmore limestone which forms a ledge in the Lake Bixhoma spillway, south of Tulsa, Oklahoma; note a thin shale break within the Ardmore.

FIGURE 11—Contact between Oakley shale and Ardmore limestone in coal-pit headwall west of Croweburg (SWSESE sec. 9, T. 28 S., R. 25 E.), Crawford County, Kansas. This headwall has since been covered by a reclamation project.

Breezy Hill Limestone Member of Banzet formation

The Breezy Hill Limestone Member was named by Pierce and Courtier (1937) from a coal-pit headwall in northeastern Crawford County, Kansas, where a 1-m (3.3-ft)-thick fossiliferous marine limestone was exposed. North of this area, the Breezy Hill becomes a mottled caliche or rhizolite (Knight, 1985). This can be seen at the North Arma section (fig. 20). From eastern Crawford County southwestward into northeastern Oklahoma, the Breezy Hill Limestone Member is a skeletal calcilutite and calcarenite with marine fossils. The maximum thickness of the Breezy Hill Limestone Member observed was 3 m (10 ft) in sec. 14, T. 21 N., R. 15 E., Rogers County, Oklahoma, and sec. 25, T. 26 N., R. 18 E., Craig County, Oklahoma (Denesen, 1985).

Excello shale

The Excello shale can be traced the entire length of the outcrop in the study area. It consists of fissile, phosphatic, black-clay shale with conodonts that are visible on the outcrop. Calcareous concretions are concentrated in layers in some Excello outcrops. Along the north side of US–160 in SESE sec. 16, T. 31 S., R. 23 E., Crawford County, Kansas, these concretions merge forming a limestone bed having a maximum thickness of about 0.5 m (1.3 ft). This bed cannot be traced laterally between outcrops nor could it be recognized in the subsurface on well logs. The Excello shale is 1.5-2.0 m (5-6.2 ft) thick in northeastern Oklahoma and up to 2.5 m (8.6 ft) in southeastern Kansas.

Core descriptions

Many of the wells that were drilled to test the petroleum potential of Banzet sandstone units were cored. Unfortunately, due to lack of storage facilities, most of the core materials were lost after they were analyzed by their owners. Fortunately, some cores were given to and stored by the Kansas Geological Survey, and other cores were made available by various drillers. These cores, which were clustered in three Kansas counties, provided representative samples of sandstone units from several horizons within the Banzet formation. However, mudrock units were poorly represented since only mudrock associated with sandstones was cored. Fig. 21 summarizes the lateral and stratigraphic positions of core samples that were analyzed.

Leavenworth County cores

In northern Kansas, available cores were confined to Leavenworth County. Nelson (1985) analyzed these cores and recognized five lithofacies: 1) homogeneous pebble-to-boulder conglomerate; 2) fine- to medium-grained litharenites that are homogeneous to thickly horizontally bedded; 3) fine- to medium-grained litharenites

Oswego–Neosho River section
Riverside Park Road—SWSWNE sec. 15, 33 S. 21E.,
Labette County, Kansas

Measured by R. L. Brenner, May 25, 1980

Unit 8*	19.0–20.0 m (60.89–64.09 ft)	Limestone; wackestone-packstone grains appear to be mostly crinoidal debris; basal contact sharp
Unit 7*	18.5–19.0 m (59.2–60.8 ft)	Clay shale, black, with phosphate nodules; fissile; base not exposed
Unit 6	13.9–18.5 m (44.5–59.2 ft)	Shale; with scattered thin, ripple-laminated beds; sharp basal contact; top partially covered
Unit 5	13.7–13.9 m (43.9–44.5 ft)	Sandstone, very fine grained, ripple laminated; shale partings near gradational base
Unit 4	13.0–13.7 m (41.6–43.9 ft)	Clayey shale with silty beds near top, medium-gray, very fissile; abruptly gradational base
Unit 3	12.6–13.0 m (40.3–41.6 ft)	Sandstone, fine-grained, micaceous quartz arenite; load structure at base causes unit thickness to vary; calcite cemented in places; no visible stratigraphy(homogenous); basal contact sharp–no evidence of erosion
Unit 2	3.6–12.6 m (11.5–40.3 ft)	Interbedded shale (50% clay, 50% silt) and clayey shale, both medium-gray, noncalcareous; some carbonaceous (plant) fragments on stratified planes
	3.0–3.6 m (9.6–11.5 ft)	Covered interval
Unit 1	0–3.0 m (0–9.6 ft)	Clay shale, medium-gray, tan-weathering

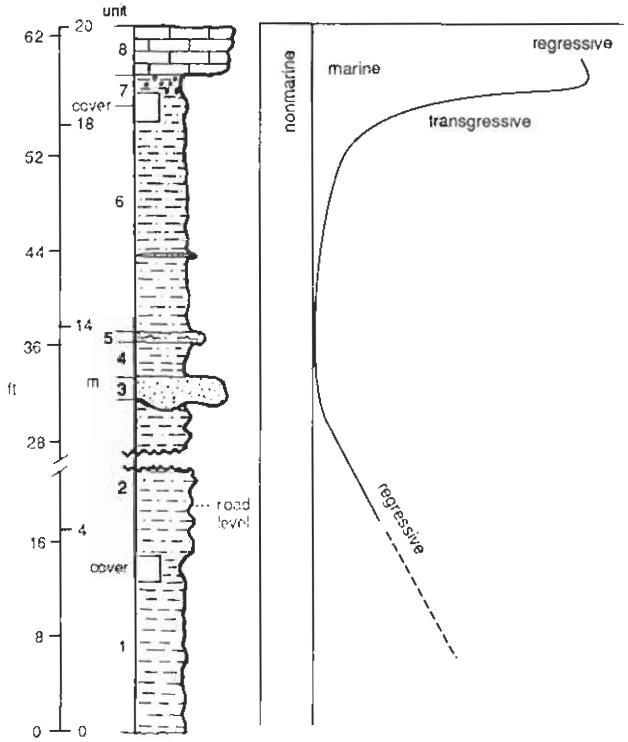
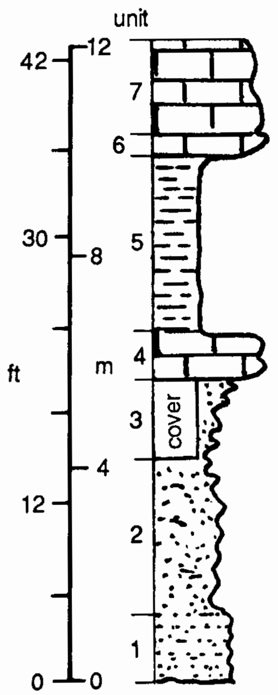


FIGURE 12—Description of Neosho River Park section, Oswego (SWSWNE sec. 15, T. 33 S., R. 21 E.), Labette County, Kansas.

FIGURE 13—Load structures at base of lowest sandstone bed in Neosho River Park section.



McCollum Farm section
Center SE sec. 36, T. 30 S., R. 22 E., Crawford County, Kansas

Measured by R. L. Brenner, May 1980

Unit 7	8.6–10.0 m (27.56–32.04 ft)	Limestone; skeletal packstone-grainstone; sharp basal contact
Unit 6	8.3–8.6 m (26.59–27.56 ft)	Limestone; fossil; wackestone; sharp basal contact
Unit 5	6.0–8.3 m (19.22–26.59 ft)	Clay shale; black, fissile, with phosphate nodules in upper 1.5 m; lower 0.8 m is partially covered; basal contact is not exposed
Unit 4	5.4–6.0 m (17.62–19.22 ft)	Limestone; fossil; wackestone; mottled; rusty-weathering; basal contact not exposed
	4.4–5.5 m (14.10–17.62 ft)	Covered interval; trenched and found fine-grained, regular-to-irregular lamination; slabby sandstone
Unit 3	2.2–4.4 m (7.05–14.10 ft)	Sandstone, very fine grained, regular lamination, slabby aspect; gradational basal contact
Unit 2	1.5–2.2 m (4.80–7.05 ft)	Sandstone, fine-grained, irregular-wavy thin beds and lamination, slightly calcereous; abruptly gradational basal contact
Unit 1	0.0–1.5 m (0–4.80 ft)	Very fine grained sandstone and siltstone; regular-irregular thin beds and lamination, slightly calcereous, some coaly partings; basal contact not exposed

Interval beneath this section is covered

FIGURE 14—DESCRIPTION OF MCCOLLUM FARM SECTION (center SE sec. 36, T. 30 S., R. 22 E., Crawford County, Kansas).

with unimodel, large-scale cross stratification; 4) ripple cross stratified, fine-grained litharenite; and 5) interlaminated shale and siltstone with thin coal seams.

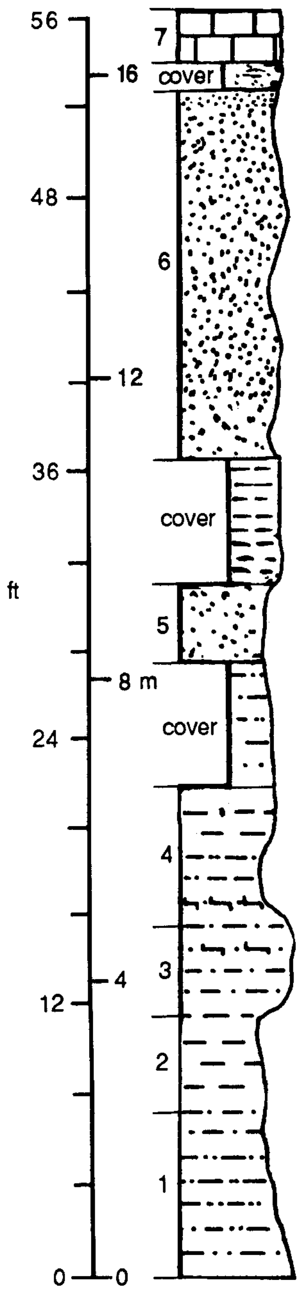
Conglomerate units have sharp, erosional basal contacts and overlie either sandstone or siltstone-shale units. They form the basal units of fining-upward sequences that may contain any or all of the lithofacies listed above (fig. 22). The fine- to medium-grained sandstone units that commonly overlie the conglomerates are oil stained and micaceous, with mica flakes concentrated on some bedding planes. These sandstones are the most porous and permeable and seem to have the lowest amounts of clay minerals (Nelson, 1985). Overlying cross stratified and rippled sandstones also are oil stained, but not to the degree that the horizontally bedded units are. The upper portions of ripple cross stratified units are flaser bedded with thick laminae and thin beds of mudstone separating sets of ripples. Siltstone or very fine grained sandstone lenses and starved ripples commonly occur in the lower portions of the interlaminated shale and siltstone units. This lithofacies also is marked by concentrations of mica flakes and carbonized plant debris on bedding planes as well as thin coal seams and iron-carbonate-rich claystone laminae.

Anderson County cores

Lithologies associated with sandstone trends in Anderson County, Kansas, were studied by Reinholtz (1982). He recognized five lithofacies: 1) homogenous, fine-grained, micaceous sandstone; 2) fine-grained sandstone interstratified with lesser amounts of silt and clay shales; 3) subequal amounts of interstratified fine-grained sandstone and shale; 4) interstratified siltstone and silty shale; and 5) clayey shales with minor lenticular laminae of siltstone.

The homogenous, fine-grained, micaceous sandstone facies is often thick, having been observed in 4.6 m (15.1 ft) of continuous core in the Bailey–Lohrenpel 18 core (fig. 23). The base of this unit is marked by a thin shale-chip conglomerate that is similar to, but finer grained than the conglomeratic units described in the Leavenworth County cores.

The interstratified sandstone and mudrock facies contain a variety of stratification types including regular and irregular wavy-thin beds, ripple cross lamination, thin sets of high-angle tabular crossbeds, flaser bedding, and minor bioturbation structures (Reinholtz, 1982). Clay shales exhibit faint irregular to regular lamination, commonly disturbed by soft-sediment deformation

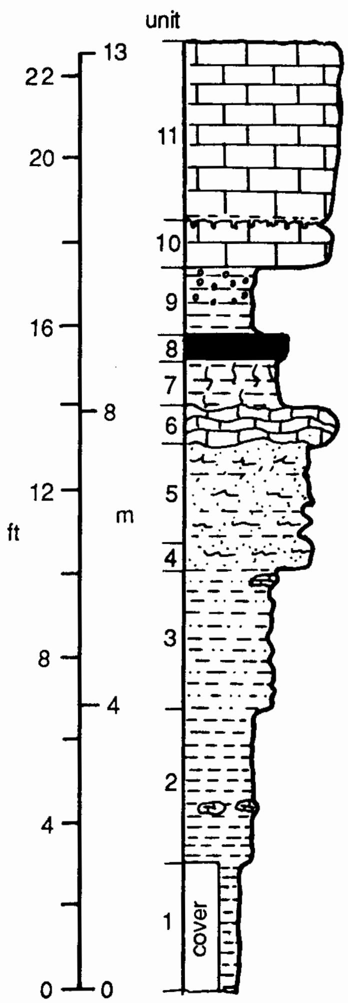


Osage cemetery section
NWNWSW sec. 30, T. 30 S., R. 22 E.
Crawford County, Kansas

Lower 14.9 m (47.75 ft) measured by R. L. Brenner, May 1980; upper 3.1 m (9.93 ft) measured by L. J. Aden, May, 1981

Unit 7	17.4–18.0 m (55.7–57.6 ft)	Fossiliferous limestone; wackestone, mottled; basal contact not exposed
	14.9–17.4 m (47.7–55.7 ft)	Covered interval; sandstone and shale float
Unit 6	10.5–14.9 m (33.6–47.7 ft)	Sandstone, fine-grained, regular lamination with some bioturbation, calcareous along some strata; upper 3.4 m (10.8 ft) poorly exposed due to increasing shale interbeds; base not exposed
	9.0–10.5 m (28.8–33.6 ft)	Covered interval; dark-gray shale float
Unit 5	8.0–9.0 m (25.6–28.8 ft)	Sandstone, fine-grained, mottled (exterior bioturbation), with some irregular lamination; calcareous cementing along some strata gives slabby outcrop appearance; base not exposed
	6.5–8.0 m (20.8–25.6 ft)	Covered interval; dark-gray clay shale float
Unit 4	4.7–6.5 m (15.0–20.8 ft)	Silty shale, olive-gray, slightly calcareous, regular lamination and thin beds (1–2 cm; .39–.78 in); abruptly gradating basal contact
Unit 3	3.4–4.7 m (10.8–15.0 ft)	Silty shale-silt shale; olive-gray calcite, iron-stained strata form slabby ledges; gradational basal contact
Unit 2	2.3–3.4 m (7.3–10.8 ft)	Interstratifed calcareous siltstone and clay shale, light-gray and dark-gray; increasing siltstone upward; gradational basal contact
Unit 1	0.0–2.3 m (0.0–7.3 ft)	Clay shale, medium-dark-gray, with flattened limestone lenses up to 10 cm (3.93 in) thick scattered through interval

FIGURE 15—DESCRIPTION OF OSAGE CEMETERY SECTION (NESE SEC. 25, T. 30 S., R. 22 E.), CRAWFORD COUNTY, KANSAS.



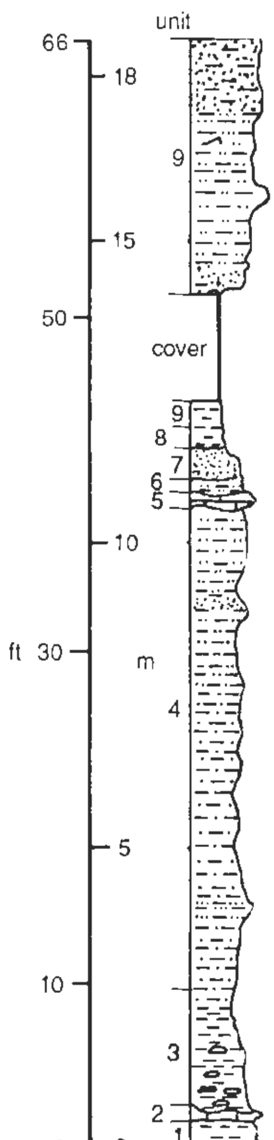
North Arma section—US-69
SWNWSW sec. 5, T. 28 S., R. 25 E. and SWSWSW sec. 32, T. 27 S., R. 25 E., Crawford County, Kansas

Measured by R. L. Brenner, May 22, 1980

Unit 11	10.65–13.2 m (34.–42.3 ft)	Limestone-skeletal packstone-grainstone; chaetetid heads, forams, crinoids; sharp basal contact
Unit 10	10.0–10.65 m (29.1–34.1 ft)	Limestone-biomicrite, corroded upper surface; sharp basal contact
Unit 9	9.1–10.0 m (29.1–29.1 ft)	Clay shale, black, highly fissile; abundant phosphatic nodules; upper 0.55 m (1.76 ft); sharp basal contact
Unit 8	8.75–9.1 m (28.0–29.1 ft)	Coal
Unit 7	8.2–8.75 m (24.3–28.0 ft)	Claystone, mottled, medium-gray; mottled, increasing coaly fragments upward, contact sharp (poorly exposed)
Unit 6	7.6–8.2 m (24.3–24.3 ft)	Micritic limestone, gray with red-brown (rusty) weathering, mottled; sharp irregular basal contact
Unit 5	6.2–7.6 m (19.8–24.3 ft)	Sandstone, fine-medium-grained, ripple laminated, slabby; some thin clay shale lamination; calcite and iron-oxide cement; gradational basal contacts
Unit 4	5.9–6.2 m (18.9–19.8 ft)	Sandstone, fine-medium-grained, massive-to-rippled; cemented with calcite and iron-oxide; sharp basal contact
Unit 3	3.9–5.9 m (12.4–18.9 ft)	Interbedded (thin) laminated medium-light-gray clay shale and very fine grained siltstone slightly calcareous contact in upper 0.5 m (1.6 ft); sharp (nonerosion) contact marked by color change on outcrop
Unit 2	1.8–3.9 m (5.7–12.4 ft)	Clayey shale, slightly calcareous, slabby, medium-olive-gray on fresh surfaces; unidentified fossil imprints and pyrite cubes on stratified surface; argillaceous calcitic concretions 10–70 cm (3.9–27.5 in) thick, form discontinuous layer at 2.5–2.7 m (8.0–8.6 ft); gradational basal contact
Unit 1	0.0–1.8 m (0.0–5.7 ft)	Clay shale, medium-dark medium-olive-gray; exposed in trench dug through cover

FIGURE 16—Description of North Arma section (SWSW sec. 32, T. 27 S., R. 25 E.), Crawford County, Kansas.

FIGURE 17—LOAD FEATURES IN SANDSTONE-SHALE SEQUENCE IN ROAD CUT 200 M (667 FT) WEST OF COAL-PIT HEADWALL PICTURED IN FIG. 11; pencil is 18 cm long.



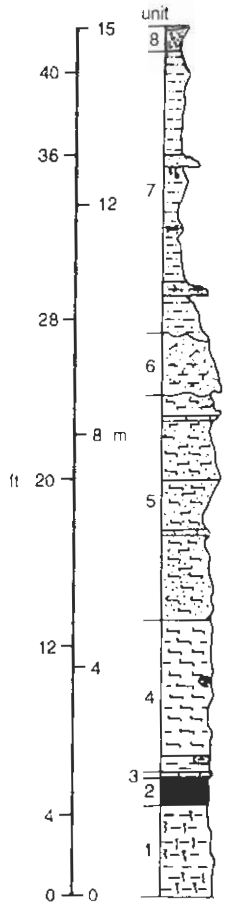
Northeast Foster section
SE sec. 6, T. 39 N., R. 32 W., Bates County, Missouri

Measured by L. J. Aden, May 1981

Unit 9	14.0–17.5 m (44.8–56.0 ft)	Interstratified sandstone, siltstone, and shale; increasing sandstone upward; sandstone (?) beds are ripple-laminated; basal contact not exposed
	12.2–14.0 (39.0–44.8 ft)	Covered interval; shale float
Unit 8	11.22–12.2 (35.95–39.0 ft)	Mudstone; very fossiliferous, with ostracodes and productid brachiopods well preserved
Unit 7	10.9–11.22 m (34.9–35.95 ft)	Mudstone; not fossiliferous
Unit 6	10.6–10.9 m (33.9–34.9 ft)	Sandstone, fine-grained, very fossiliferous
Unit 5	10.4–10.6 m (33.3–33.9 ft)	Limestone; fossiliferous wackestone
Unit 4	2.5–10.4 m (8.0–33.3 ft)	Shale with interstratified siltstone beds that are up to 1.0 m (3.2 ft) thick; siltstone is irregular-wavy laminated with some ripple cross lamination; poorly preserved productid brachiopod spines are common at base of interval and decreasing upward
Unit 3	0.6–2.5 m (1.92–8.01 ft)	Interstratified shale and silty shale, medium-dark-gray; lenses of iron-rich carbonate mudstone occur between 0.7 and 2.0 m (8.0–6.4 ft)
Unit 2	0.5–0.6 m (1.6–1.9 ft)	Limestone, wavy-bedded, fossiliferous
Unit 1	0.0–05 m (0.0–1.6 ft)	Silty shale

Base of section underlain by a coal bed that lies beneath river waters except at low-water stages

FIGURE 18—DESCRIPTION OF NORTHEAST FOSTER SECTION (SE sec. 6, T. 39 N., R. 32 W., Bates County, Missouri).



Lawrence Cemetery section
SENE sec. 5, T. 37 N., R. 33 W., Vernon County, Missouri

Measured by L. J. Aden, May 1981

Unit 8	13.8–14.3 m (44.2–45.8 ft)	Sandstone, fine-grained; ripple cross lamination, mottled (burrows)
Unit 7	9.3–13.8m (29.8–44.2 ft)	Clay shale with thin beds of very fine grained sandstone; sharp basal contact
Unit 6	8.3–9.3 m (26.5–29.8 ft)	Sandstone, very fine grained; lower portion calcareous; sharp basal contact
Unit 5	4.4–8.3 m (14.1–26.5 ft)	Interstratified calcerous shale and siltstone; ostracodes in shale
Unit 4	2.0–4.4 m (6.4–14.1 ft)	Shale, medium-gray, calcareous; echindoderm fragments; contains at least two stratigraphic horizons with lenses of carbonate nodules

FIGURE 19—Description of Lawrence Cemetery section (SENE sec. 5, T. 37 N., R. 33 W.), Vernon County, Missouri.

FIGURE 20—Mottled Breezy Hill limestone in upper portion of North Arma section; scale in lower left hand corner is in centimeters.

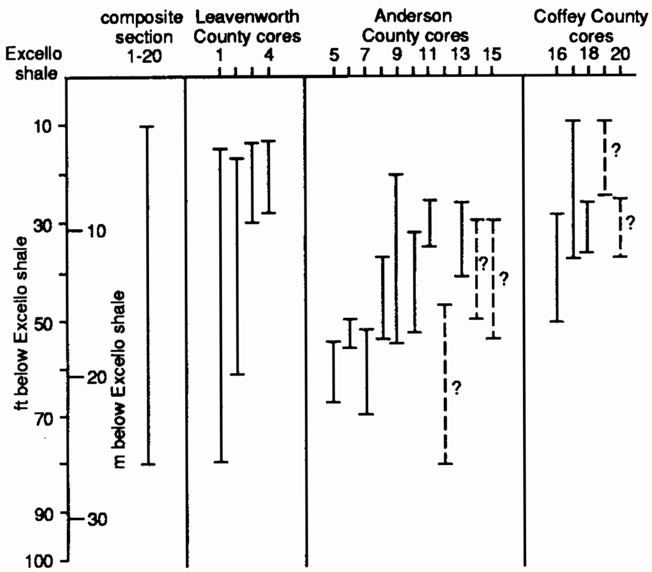


FIGURE 21—CHART SHOWING RELATIVE STRATIGRAPHIC POSITIONS OF CORE SAMPLES USED IN THIS STUDY.

1=HAR	6=BL-18	11=H-20	16=IM-8
2=HEM	7=BL-16	12=J-22	17=LB-3
3=IR-2	8=K-31	13=HB	18=KB-1
4=GR-1	9=H-8-2	14=L-36-2	19=LP-6
5=BB-1	10=O4A	15=BEN	20=LWB-4

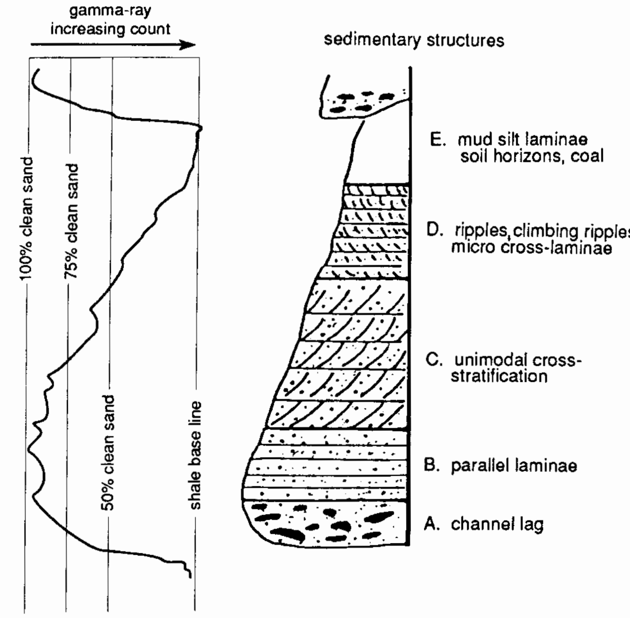


FIGURE 22—LITHOFACIES RECOGNIZED IN CORE SAMPLES FROM LEAVENWORTH COUNTY, KANSAS, and deduced from well-log signatures in northeastern Kansas; from Nelson, 1985.

structures and rarely by distinct burrows. Carbonized and pyritized plant remains commonly are concentrated on stratification planes.

Coffey County cores

Lardner's (1984) study of the 11 cores that were available in Coffey County, Kansas, also resulted in the establishment of five distinct lithofacies. These facies are 1) interlaminated siltstone and shale; 2) ripple-laminated to low-angle crossbedded sandstone with a basal conglomerate; 3) interstratified contorted and convoluted sandstone, siltstone, and shale; 4) calcite-cemented, fossiliferous sandstone; and 5) thinly laminated, dark-gray clay shale with marine fossils and carbonized plant fragments (fig. 24).

Sandstones interstratified with shales are very fine grained, while the cross-stratified sandstone units are fine grained and seem to fine upwards. The upper portions of cross-stratified units have siltstone and clayey shale interstratified with sandstone. Fining-upwards sequences of units are capped with calcite-cemented, fossiliferous, fine-grained sandstone in some cores (fig. 24).

Discussion

The localities from which cores were obtained form a linear trend from Leavenworth County in northeastern Kansas, southwestward to Coffey County, Kansas (fig. 1). The lithofacies recognized in each of the three areas are similar, except that the cores in Leavenworth County contain less mudrock interstrata, and the sandstones from these cores generally are coarser grained. Fining-upward sequences of lithologies, having sharp bases overlain by shale-chip conglomerates, were found in all three areas. Only in Coffey County was fossiliferous, calcite-cemented sandstone found in cores. However, geophysical well-log analysis indicates that this lithology is widespread across most of the study area and occurs at several different stratigraphic horizons within the Banzet formation. The basis for extrapolating this and other lithologies to wells where cores were not available will be discussed in the following sections.

Geophysical well-log analyses

During the course of this study, geophysical well logs from 1,293 wells were examined. Of these, 1,231 penetrated at least a portion of the Banzet formation. The gamma-ray and neutron logs were found to be the most useful logs for determining the lithologies penetrated.

Unit 1 186.2–184.4 m (611.0–605.0 ft) Micaceous, slightly calcareous, clay-chip conglomerate at 188 m (605 ft)

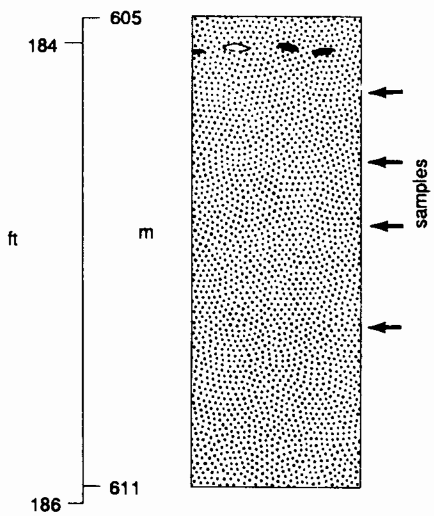


FIGURE 23—Core description from Bailey–Lohrengel 18 well in Anderson County, Kansas; from Reinholtz, 1982.

Spontaneous-potential/resistivity logs lacked the resolution shown by these radioactivity logs, and they also were affected by electrolytic contrasts between formation and drilling fluids. For these reasons, the gamma-ray log, supplemented by neutron and density logs, was used as the primary lithology indicator in wells without cores. Electrical logs were used only in the few wells where radioactivity logs were not made.

Comparisons with cored intervals

In each of the three areas where cores were available and in several other cores that I described in eastern Kansas, gamma-ray/neutron log signatures for repetitive rock sequences were consistent. Sandstone sequences and interstratified sandstone and mudstone sequences that were observed in cores form four distinctive gamma-ray log signatures. Fining-upwards sandstones with sharp bases are characterized by a gamma-ray signature that is bell-shaped (fig. 25A). Thinly interbedded sandstone and shale sequences are represented by a serrate to cylinder-shaped gamma-ray log signature (fig. 25B). Thin, calcite-cemented sandstones show low gamma-count spikes (fig. 25C), which are accompanied by symmetrical spikes on neutron and density log curves. Coarsening-upward sandstone sequences with gradational bases have funnel-shaped

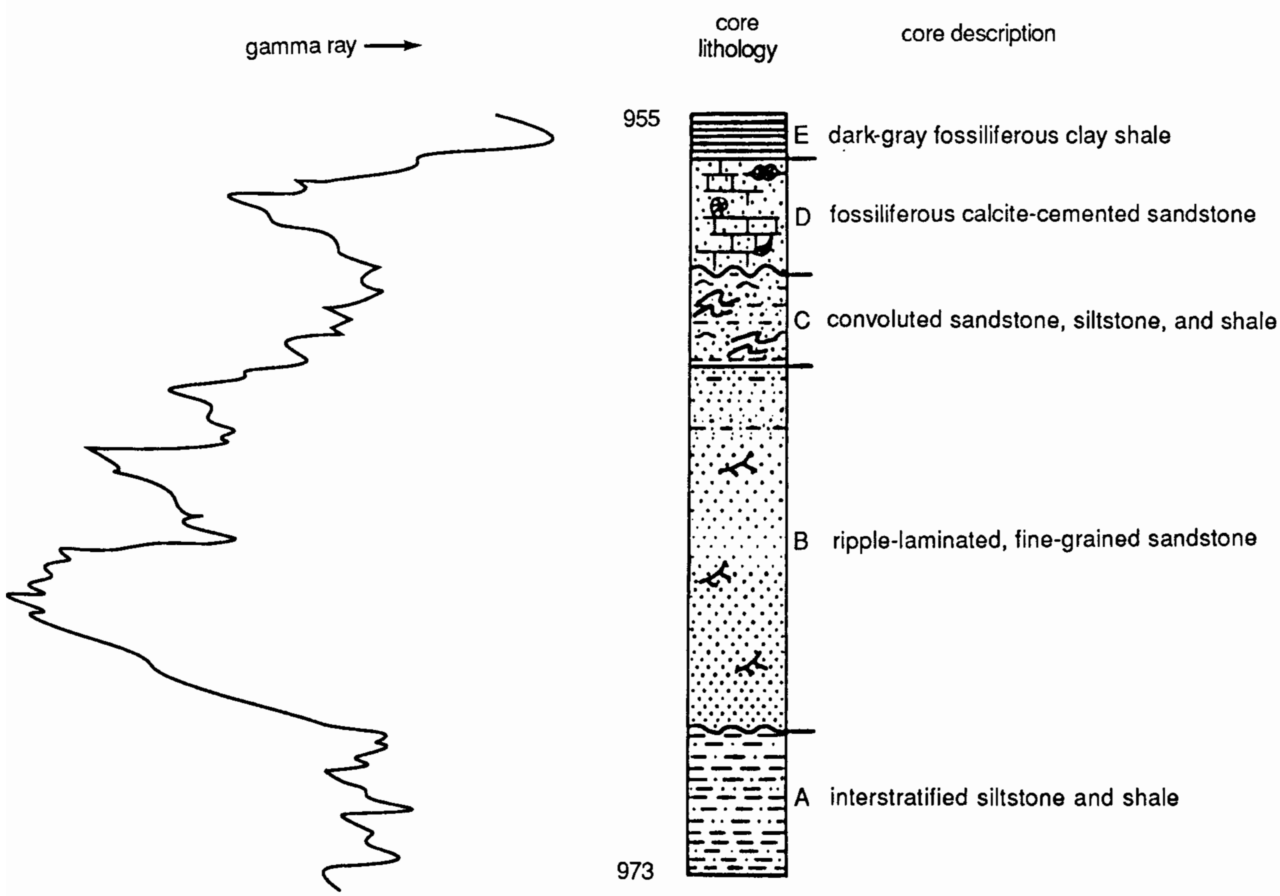


FIGURE 24—Lithofacies recognized in core samples from Coffey County, Kansas, and deduced from well-log signatures in east-central Kansas; from Lardner, 1984.

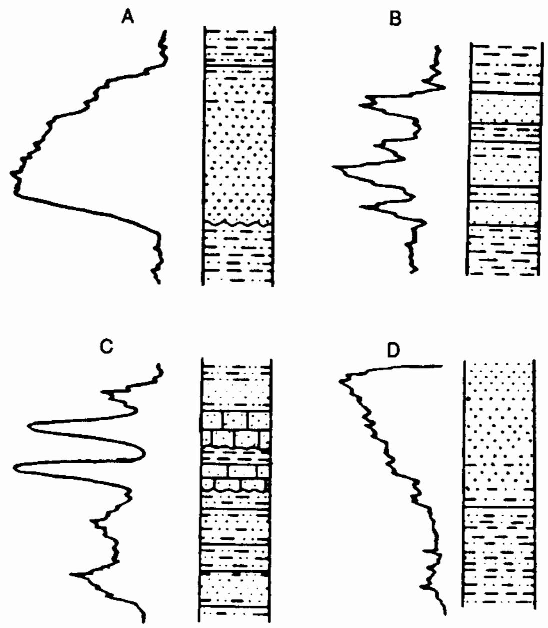


FIGURE 25—CHARACTERISTIC GAMMA-RAY LOG PATTERNS AND THEIR LITHOLOGIC INTERPRETATIONS: A) bell-shaped pattern formed by a fining-upward sequence of sandstone to shale lying with sharp contact over shale; B) serrate pattern formed by interstratified sandstone and shale; C) spiked pattern produced by thin, calcite-cemented sandstone beds; and D) funnel-shaped pattern formed by coarsening-upward shale to sandstone sequence with gradational base and sharp upper contact; from Lardner, 1984.

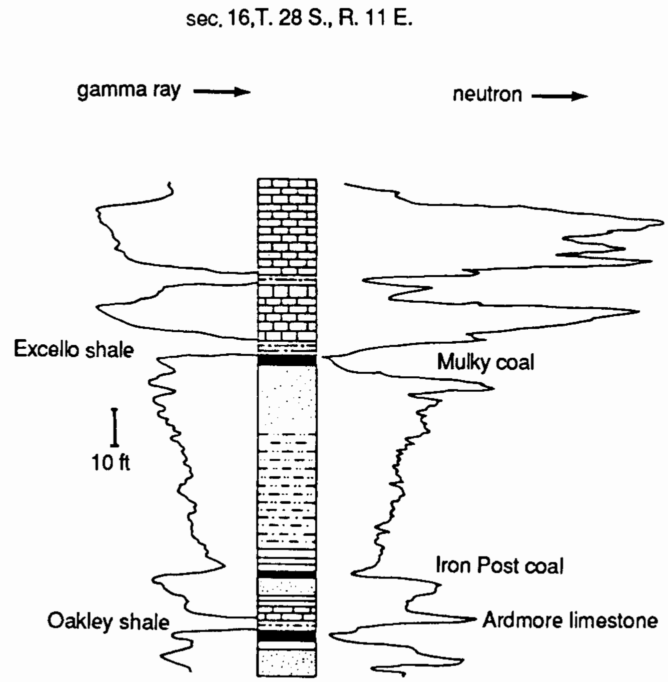


FIGURE 26—GAMMA-RAY AND NEUTRON-LOG SIGNATURES OF BLACK, PHOSPHATIC CLAY SHALES AND OTHER LITHOLOGIES; modified from Denesen, 1985.

gamma-ray log signatures with serrated lower portions, which represent shale interbeds and abrupt upper boundaries (fig. 25D). Coal beds that are in excess of 0.6 m (2 ft) are represented by low gamma-ray spikes resembling those formed by sandstone and thin carbonate units. However, coal beds are represented on neutron and density logs by low neutron-density spikes that mimic rather than mirror the gamma-ray spike. Black, phosphatic clay shales are represented by extremely high gamma-ray spikes and accompanying low neutron spikes (fig. 26). This signature is so distinctive and the gamma-ray counts are so high that these black shales can be readily identified even where the unit thickness drops slightly below the resolution limit of about 0.6 m (2 ft).

Sandstone determinations

In order to map the distribution of sandstone bodies within the Banzet formation, the amount of sandstone had to be determined for each well. In uncored wells, this was accomplished by constructing *shale-base lines, 100% sandstone lines*, and a *50% sandstone line* midway between the first two lines. The shale-base line was drawn at the gamma-ray values recorded by gray shales on each log. The 100% sandstone line was drawn at the lowest gamma-ray value produced by a known sandstone unit. All portions of the logged interval that had gamma-ray counts lower than the 50% sandstone line were counted as sandstones (fig. 27). Spontaneous-potential logs were handled in a similar way in wells that were not logged with a gamma-ray tool. On these logs, maximum SP deflection caused by a known sandstone was used as the 100% sandstone line and 0 deflection was used as the shale-base line.

Although using a 50% sandstone line as the maximum gamma-ray value for labeling an interval a sandstone may seem arbitrary, comparisons between logs and cores from the same wells indicate that this is a good approximation. I experimented with other sandstone-percentage lines and found that if lines closer to the shale-base line were used, then sandstone counts came out significantly higher than amounts measured in cores, while using lines closer to the clean-sandstone lines yielded sandstone counts that were too low. In addition, the 50% sandstone line is mechanically easy to establish, thus data generated in this fashion are more easily reproduced. To verify reproducibility, two operators (a student and I) independently determined sandstone thicknesses in randomly selected wells. Deviations were generally within the 0.3-m (1-ft) to 0.6-m (2-ft) range, which is minimal when one considers that the resolution of the logs is 0.6 m (2 ft) at best.

Distributions and log characteristics of rock units

Extent of black shale markers

The Excello shale, a black, phosphatic clay shale, overlies the Banzet formation. This shale was observed in all the gamma-ray logs and most of the SP logs that were studied. In addition, the Excello shale was either observed directly, or its float was dug out above Banzet outcrops in Kansas and Oklahoma. Studies done in Oklahoma (Krumme, 1981) and Iowa (Ravn and others, 1984) also show that the Excello shale is widespread over the entire region. This unit was deposited over the Banzet formation as a thin, continuous sheet.

Extent of the Verdigris Formation

The Ardmore limestone and Oakley shale members of the Verdigris Formation form a couplet that can be traced throughout the region. The Oakley shale can be observed on all gamma-ray logs that penetrate it, except where the Verdigris has been cut out by sandstone units at the base of the Banzet formation. The Ardmore limestone, which can be traced easily on the surface, is not as easy to trace in the subsurface using geophysical well logs. On the outcrop, this unit thins to a little over 1 m (3 ft) in Crawford County, Kansas. Conceivably, this limestone unit may drop below the limits of resolution in some of the wells that penetrate it. For this reason, the Ardmore limestone member of the Verdigris Formation was lumped with the Banzet formation in the construction of an isopach map. This allowed the isopach interval containing the Banzet formation to extend between two easily identifiable, widespread, black phosphatic clay-shale units.

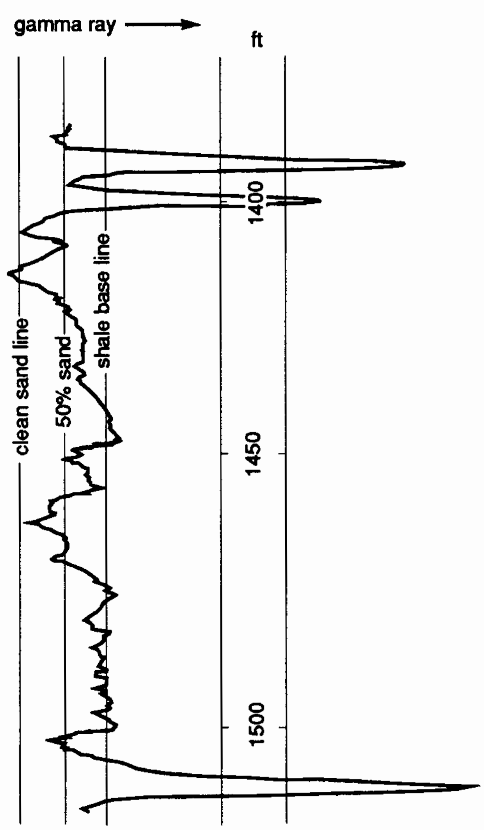


FIGURE 27—Illustration of method used to determine positions and thicknesses of sandstones within Banzet formation. Sandstone-unit contacts were placed where gamma-ray curve values dropped below the "50% sand" line. Intervals whose curves are to the left of this line were counted as sandstone. Same procedure was used with SP curves in wells that did not have gamma-ray logs available; modified from Lardner, 1984.

Extent of the Banzet–Ardmore interval

An isopach map constructed for the interval between the widespread Oakley and Excello shales shows a range of thicknesses from 9.1 m (30 ft) in the southwestern portion of the study area in Kay County, Oklahoma, to a thick of more than 60.7 m (199 ft) in sec. 34, T. 34 S., R. 17 E., Montgomery County, Kansas, where the base of a sandstone channel that cuts down through the Ardmore and underlying units is used as the interval base. However, most of the Kansas portion of the study area lies between 24.4 and 33.5 m (80 and 110 ft) (fig. 28). Although the interval thins to the southwest, thickness trends are not confined to the northeastern portion of the study area. In addition to a thick centered in Leavenworth County, lobate and linear thicks are found in Brown, Jackson, and Pottawatomie counties in the northwestern portion of the study area; Nowata County, Oklahoma, in the southeastern portion of the area; Lyon, Chase, and Coffey counties in the west-central portion of the area; and Crawford, Bourbon, Neosho, Labette, and northeastern Montgomery counties, Kansas, in the east-central portion of the study area (fig. 28). Each of these thicks is in excess of 30 m (100 ft).

Distribution and log characteristics of Banzet sandstone units

A gross sandstone-isolith map of the Banzet formation in the study area shows high sandstone patterns (fig. 29) corresponding to most of the thicks on the interval isopach map (fig. 28). This is to be expected because volume change in sand bodies due to compaction is much less than those in muds. Fig. 30 shows Ardmore–Banzet interval well-log signatures for various isopach thicks and thins. Some sandstone highs do not relate directly to isopach thicks. One such case is in northeastern Brown and western Doniphan counties, Kansas. The sandstone here seems to be part of a channel system that extends southwestward from southern Nebraska. The channels apparently cut out previously deposited muds, thus reducing the total sediment accumulation in this area.

The sandstone isolith map for the Banzet shows a blurred picture of sandstone geometries because the

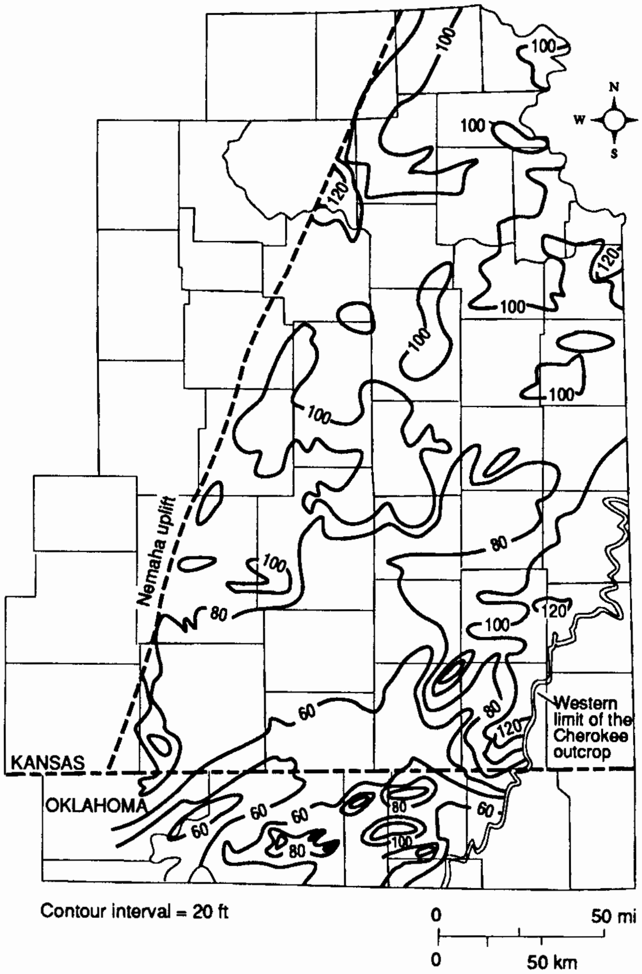


FIGURE 28—Isopach map of Ardmore–Banzet interval (Banzet formation plus Ardmore Limestone Member of Verdigris Formation), consisting of strata between top of the Oakley Shale and base of the Excello shale.

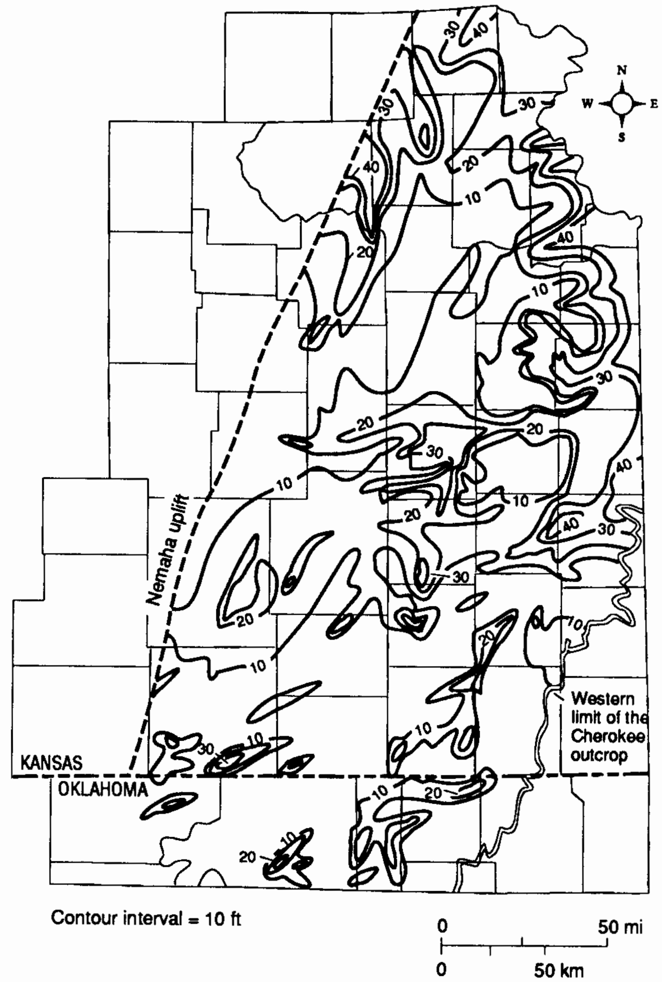


FIGURE 29—Sandstone-isolith map of Banzet formation.

sandstone bodies occur in several different horizons. Because no markers within the Banzet were observable throughout the study area, producing reliable isolith maps for stratigraphic portions of the formation was not possible. In local areas, however, sandstone isoliths were constructed for vertical subdivisions of the Banzet. These maps, along with cross sections, were useful for reconstructing the geologic history of the study area. In the following paragraphs, I will present these maps and discuss the nature of rock-body distributions in four portions in the study area.

Sandstones in northeastern Kansas—In northeastern Kansas, Nelson (1985) was able to divide the sandstone units of the Banzet formation into two genetically related sets. In the northern portion of his study area, all the gamma-ray/neutron well logs showed the presence of a coal near the middle of the formation. Well logs and cores south of a line through the northwest corner of Wyandotte County through Leavenworth, Jefferson, and Douglas counties and into the central portion of Shawnee County, do not contain this coal bed (fig. 31). Nelson (1985) suggests that the coal was removed by erosion as later channels cut into the subaerially exposed surface. As will be shown later, a regional analysis of coal beds and overlying transgressive lithologies supports his contention that the sandstone units in this area lie within an upper and lower portion of the Banzet, with the units within each being genetically related.

Fig. 31 is a sandstone-isolith map for the lower portion of the Banzet. It shows that discontinuous, lenticular sandstone thicks trend northeast-southwest. The thickest sandstone forms a lobate trend in the northwestern portion of the map area across the Atchison–Jefferson County border. The sandstone-isolith map for the upper interval shows similar trending thicks, with the thickest sandstones forming a lobate trend centered in the south-central portion of Leavenworth County (fig. 32).

Two cross sections from Leavenworth and Douglas counties illustrate the spatial relationships between sandstone units in the Banzet formation in northeastern Kansas. Northwest to southeast, strike-

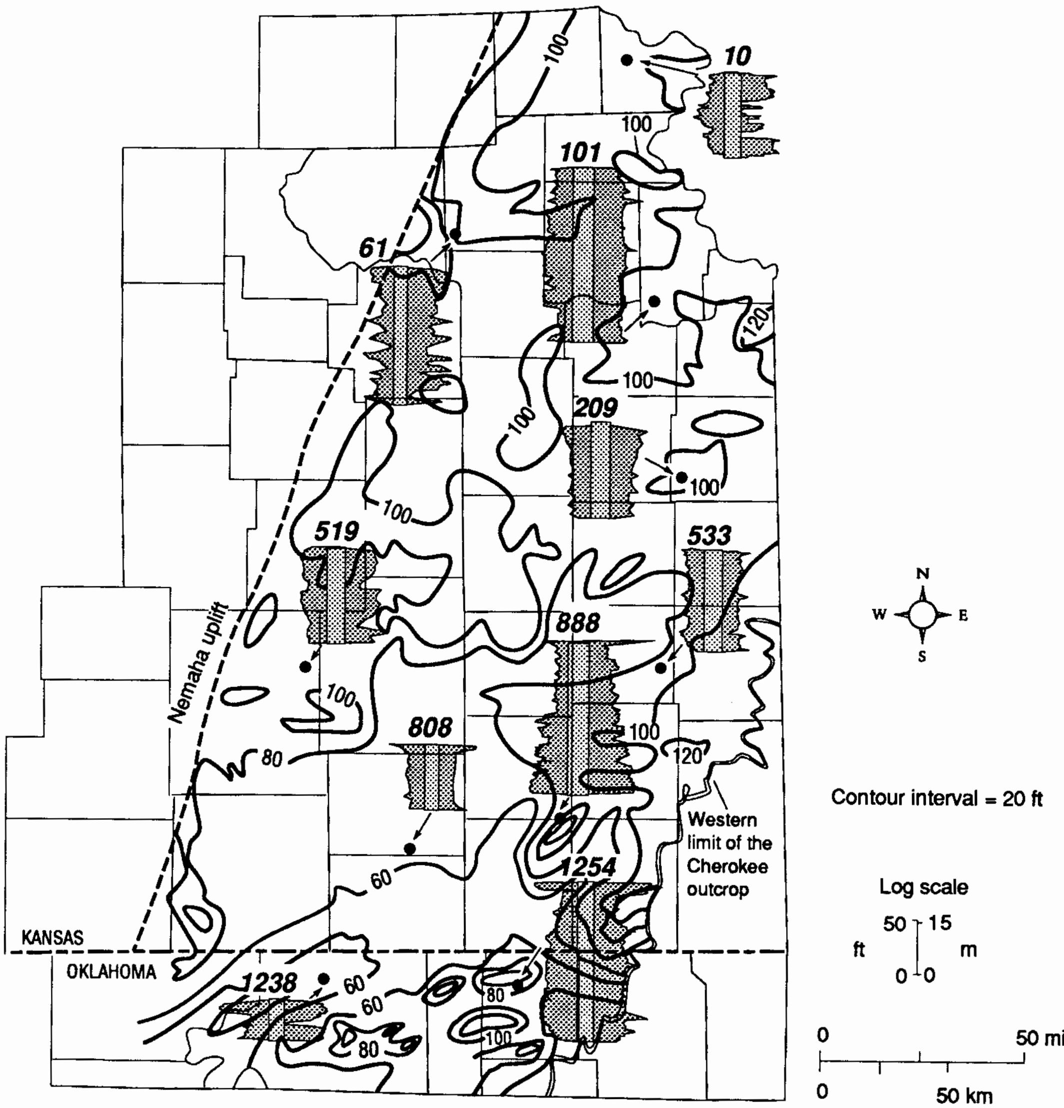


FIGURE 30—TYPICAL ARDMORE–BANZET WELL-LOG SIGNATURES THAT RELATE TO ISOPACH THICKS AND THINS. SP and resistivity curves are shown for well 519, gamma-ray and density curves are shown for well 1238, gamma-ray and neutron curves are shown for all other wells. Well numbers relate to data listing in appendix A.

oriented cross section A–A′ (modification of Nelson's B–B′) shows seven sandstone units at four different horizons (fig. 33). This section also shows the coal bed that was used to divide the Banzet into upper and lower portions. Two different types of sandstone body morphologies are shown on this cross section: 1) laterally continuous, thin, sheetlike bodies and 2) thick, laterally discontinuous bodies. The thick, laterally discontinuous sandstone bodies seem to truncate the underlying units. The well-log signatures of these units are bell shaped, indicating fining-upward sequences. The thin, more laterally continuous units have block, spike, or funnel-shaped signatures, indicating either thin, relatively clean sandstones, or coarsening-upward sequences.

Dip-oriented cross section B–B′ (modification of Nelson's E–E′) was constructed along one of the thicker northeast-southwest sandstone thicks (fig. 34). This section illustrates the laterally continuous nature of stacked sandstone bodies within lobate sandstone thicks. Signatures are bell shaped, funnel shaped, and blocky, with bell-shaped signatures being more prevalent towards the northeast. Bell-shaped and blocky signatures represent fining-upward sequences and well-sorted relatively coarse-grained units, respectively. Towards the southwest, the Banzet becomes increasingly shalier and thinner; well-log signatures of sandstone units between isolith thicks are more irregular, indicating interstratification of sandstone and shale.

SANDSTONES IN EAST-CENTRAL KANSAS—Lardner (1984) divided the Banzet into upper and lower sandstone-rich intervals. A sandstone-isolith map of the lower interval shows a lobate sandstone pattern which appears to radiate from an easterly source (fig. 35). The thickest sandstone concentration is in the center of the map area and seems to form a hub from which other sandstone trends radiate.

Cross section C–C′ (modified from Lardner's A–A′) shows an east-west section along the axis of a lower-interval sandstone trend (fig. 36). The lower sandstones are characterized by irregular signatures with

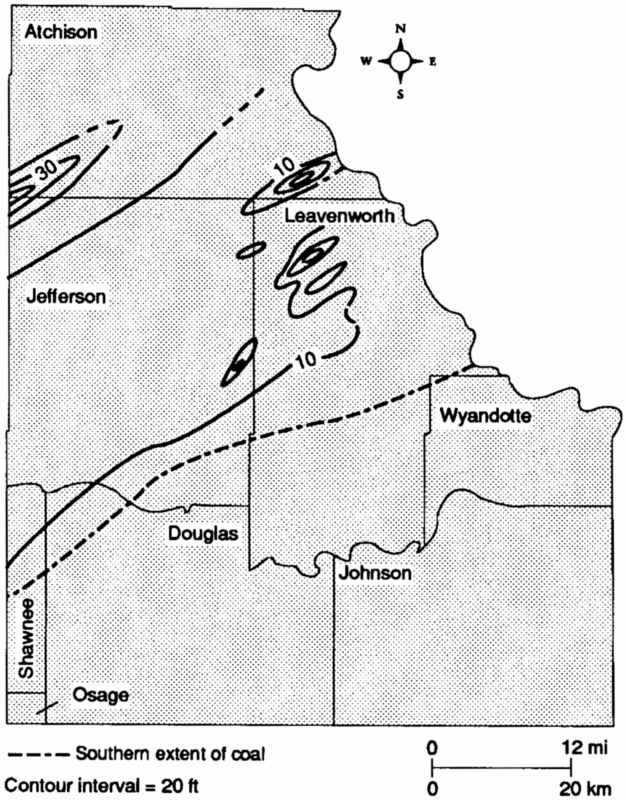


FIGURE 31—Sandstone-isolith map of lower portion of Banzet formation in northeastern Kansas; from Nelson, 1985.

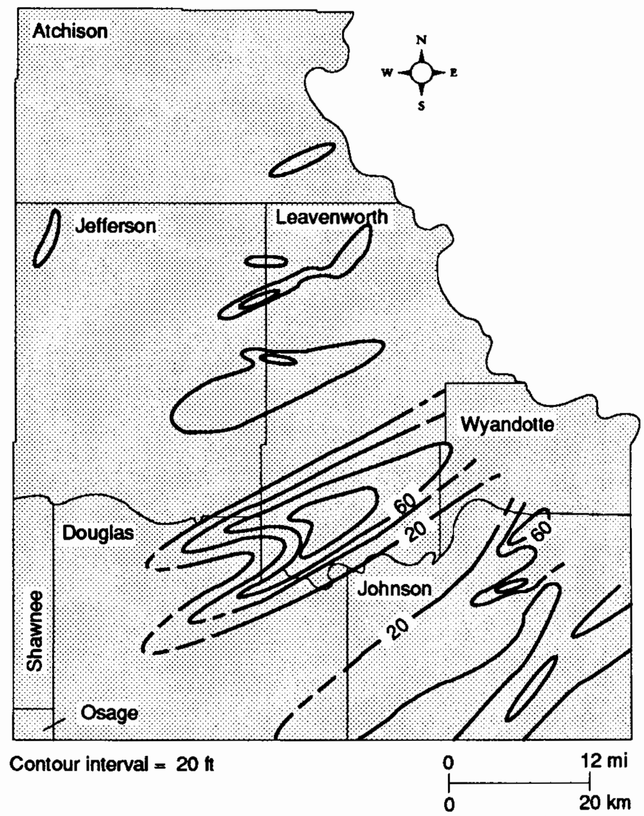


FIGURE 32—Sandstone-isolith map of upper portion of Banzet formation in northeastern Kansas; from Nelson, 1985.

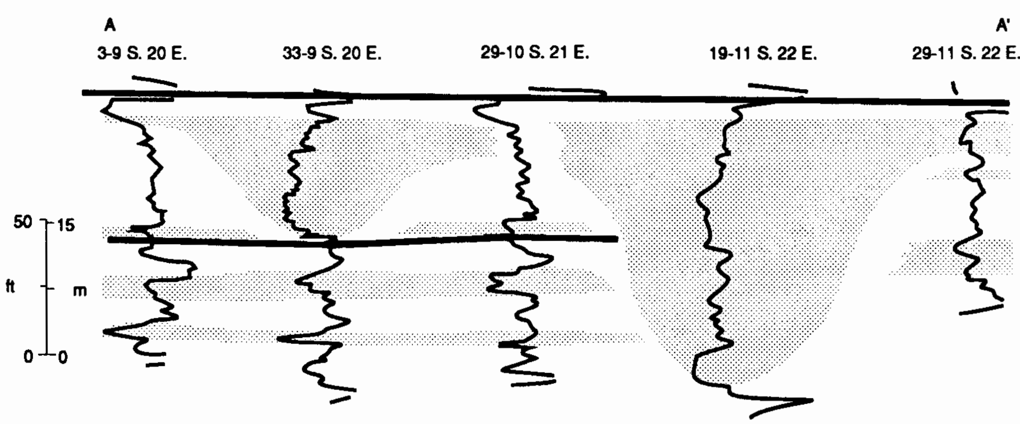


FIGURE 33—Cross section A–A′, strike-oriented view of Banzet sandstone bodies in northeastern Kansas. See fig. 6 for location; modified from Nelson, 1985,

sharp bases and gradational upper contacts. Cores of sandstone units in this interval verify that these signatures represent fining-upward sandstone to interstratified sandstone, siltstone, and shale, with a sharp, possibly erosional, basal contact over underlying shales and siltstones.

Cross section D–D′ (modified from Lardner's B–B′) shows a north-south section perpendicular to a linear sandstone trend (fig. 37). The thickest sandstones along the axis of the sandstone trend are identical to the fining-upward sequence seen in cross section C–C′. However, away from the axis, the well-log signatures become more irregular and the sandstone unit thins abruptly. These changes indicate that the sandstone grades to interstratified sandstone and shale, and then to siltstone and shale.

The sandstone of the upper interval is thinner and more widespread than the sandstone of the lower interval (fig. 38). The well-log signatures in cross sections C–C′ and D–D′ (figs. 36 and 37) are funnel shaped with gradational bases. These signatures seem to represent coarsening-upward sequences, although core samples were not available to verify this.

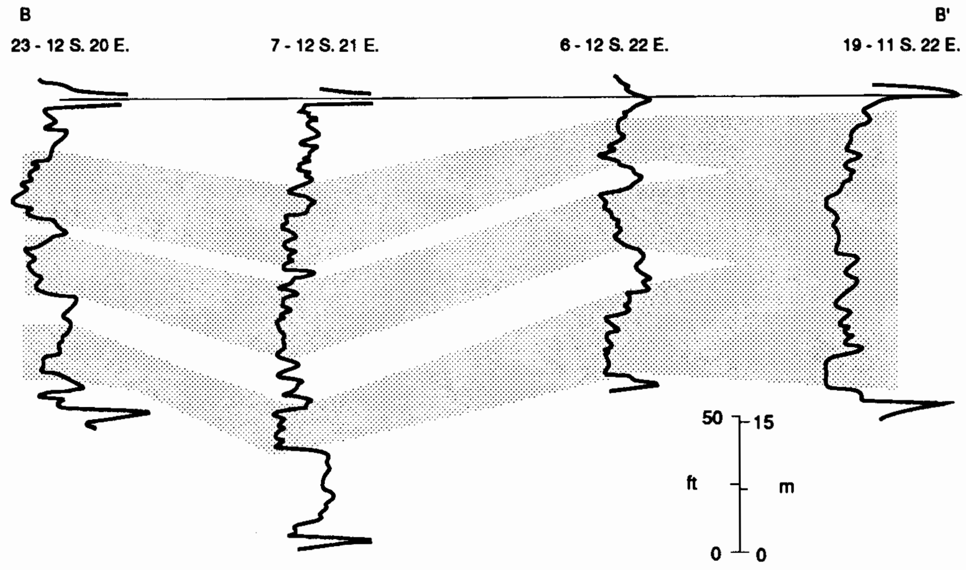


FIGURE 34—Cross section B–B′, dip-oriented view of Banzet sandstone bodies in northeastern Kansas. See fig. 6 for location; modified from Nelson, 1985,

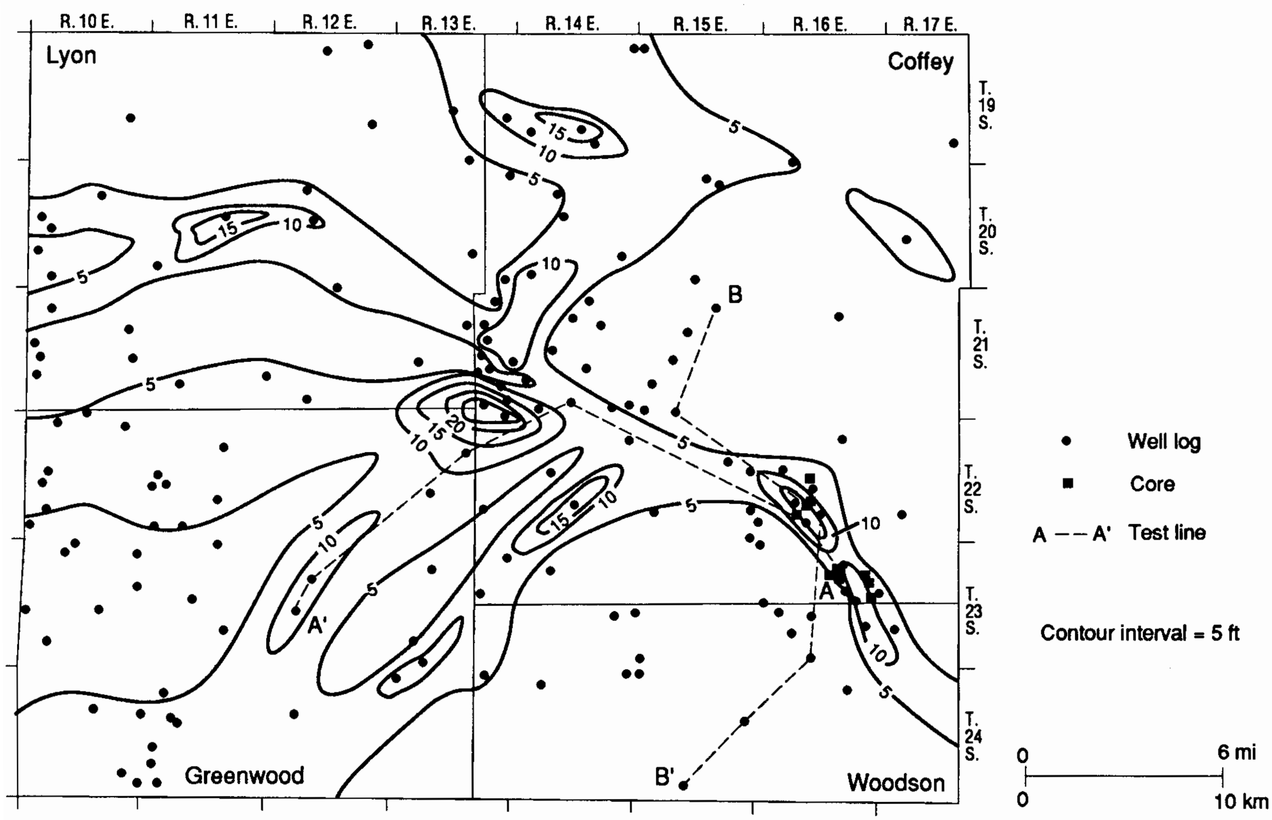


FIGURE 35—Sandstone-isolith map of lower portion of Banzet formation in east-central Kansas; from Lardner, 1984.

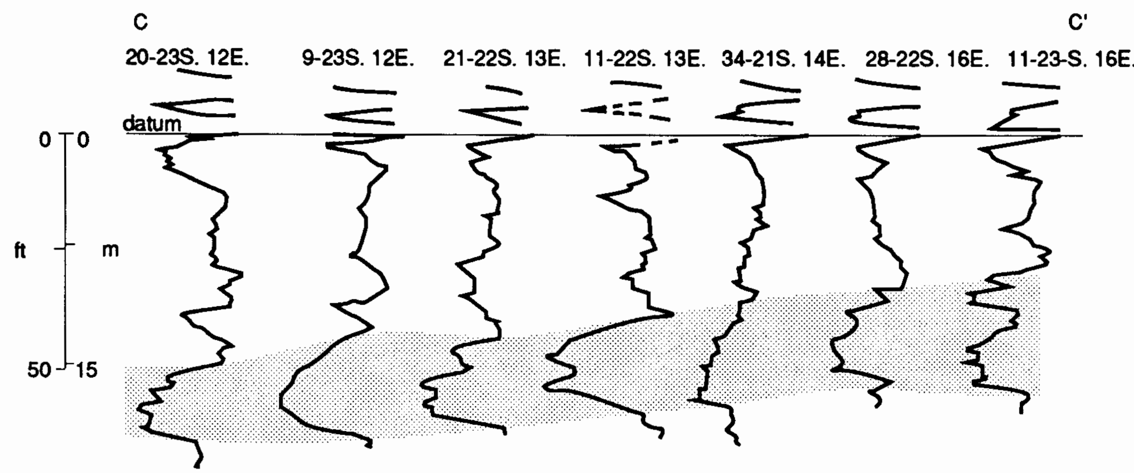


FIGURE 36—Cross section C–C′, dip-oriented view of Banzet sandstone bodies in east-central Kansas. See fig. 6 for location; modified from Lardner, 1984.

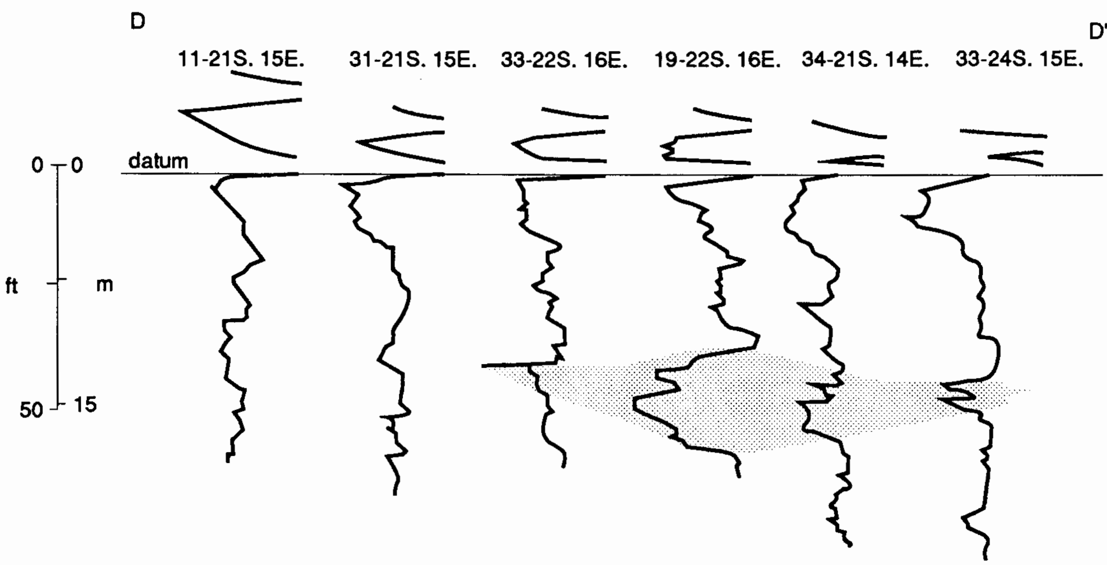


FIGURE 37—Cross section D–D′, strike-oriented view of Banzet sandstone bodies in east-central Kansas. See fig.6 for location; modified from Lardner, 1984.

Sandstones in southeastern Kansas and northeastern Oklahoma—In the southeastern Kansas-northeastern Oklahoma portion of the study area, Denesen (1985) was able to divide the Banzet formation into four members, as was discussed in the previous discussion on stratigraphy. However, in the subsurface, coal beds that were used as marker beds for these members are difficult to trace. Some of those beds are discontinuous, while others thin to below the resolution of geophysical well logs. By tracing coal beds to their resolution limits and then picking up on other signatures, Denesen (1985) was able to place Banzet sandstone units into several intervals.

The interval between the top of the Ardmore limestone and the base of the Iron Post coal contains thick "shoestring" sandstone bodies which trend northeast-southwest (fig. 39). Some of these sandstone bodies cut down through the Ardmore limestone and underlying Oakley shale in Nowata, Washington, and Osage counties, Oklahoma. This relationship is illustrated in cross section E–E′ (fig. 40; modified from Denesen's F–F′), and its effects are shown both on the sandstone isolith map of this part of the study area for the Ardmore–Iron Post interval (fig. 39) and on the Banzet–Ardmore isopach map (fig. 28).

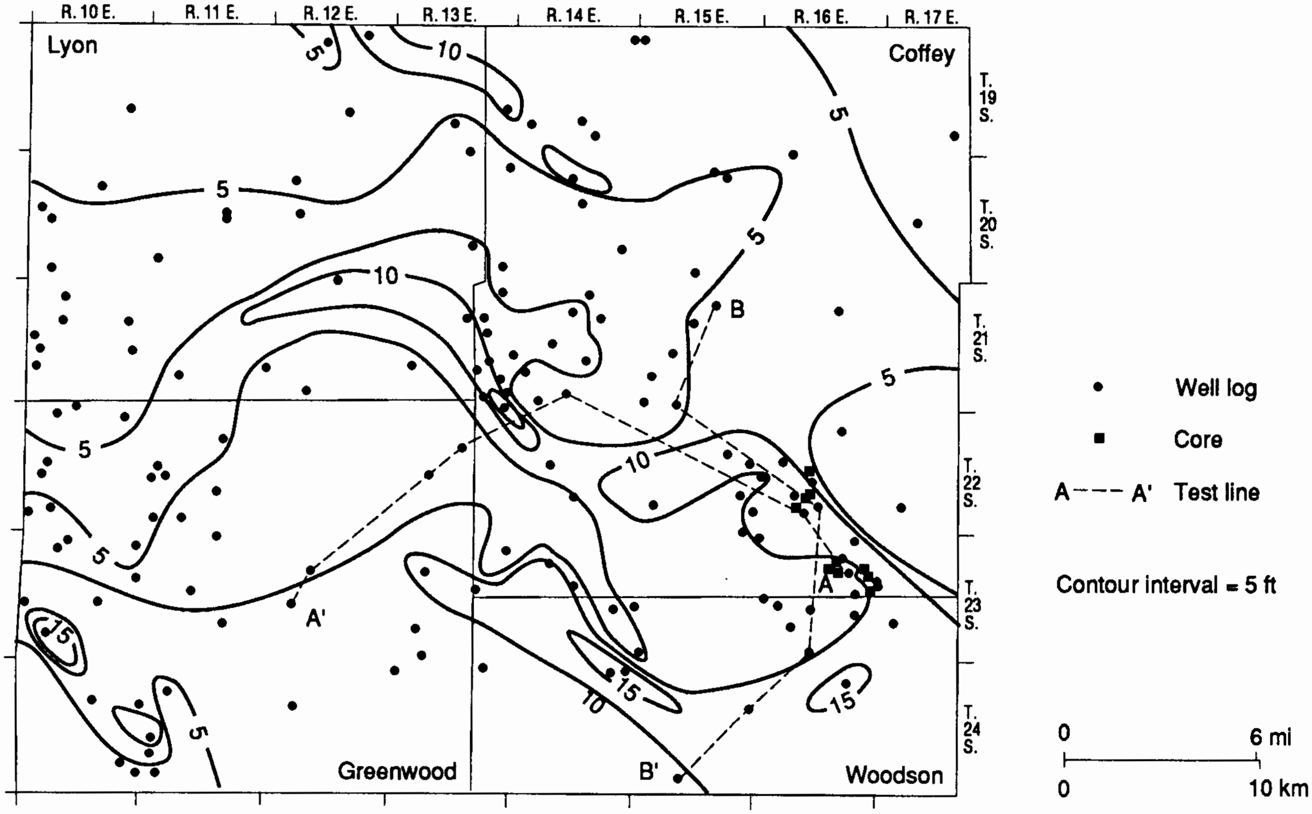


FIGURE 38—Sandstone-isolith map of upper portion of Banzet formation in east-central Kansas; from Lardner, 1984.

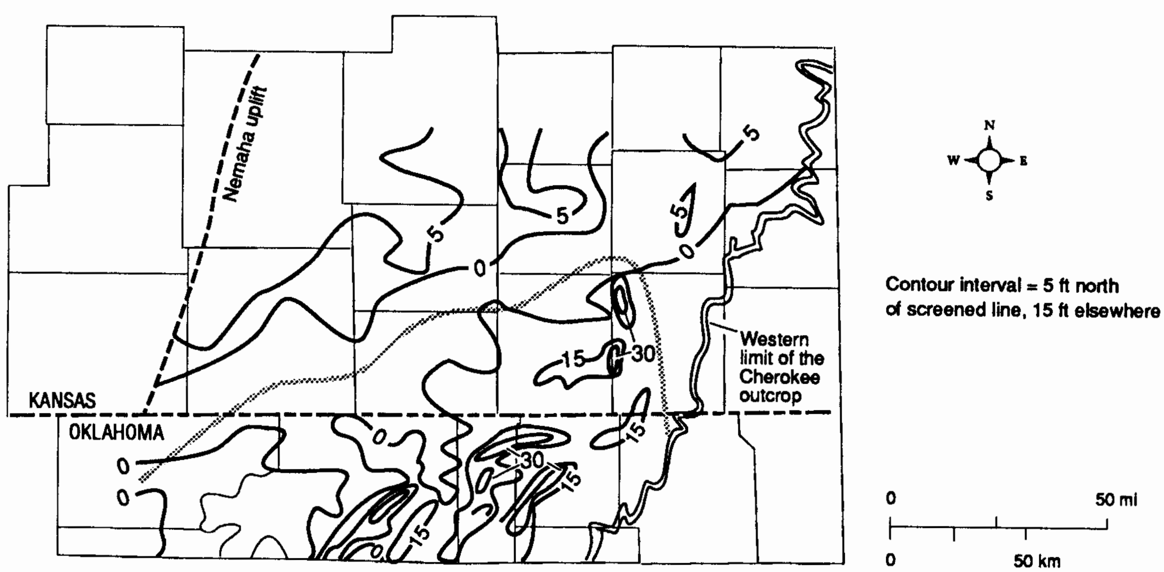


FIGURE 39—Sandstone-isolith map of Ardmore–Iron Post interval of Banzet formation in southeastern Kansas and northeastern Oklahoma; from Denesen, 1985.

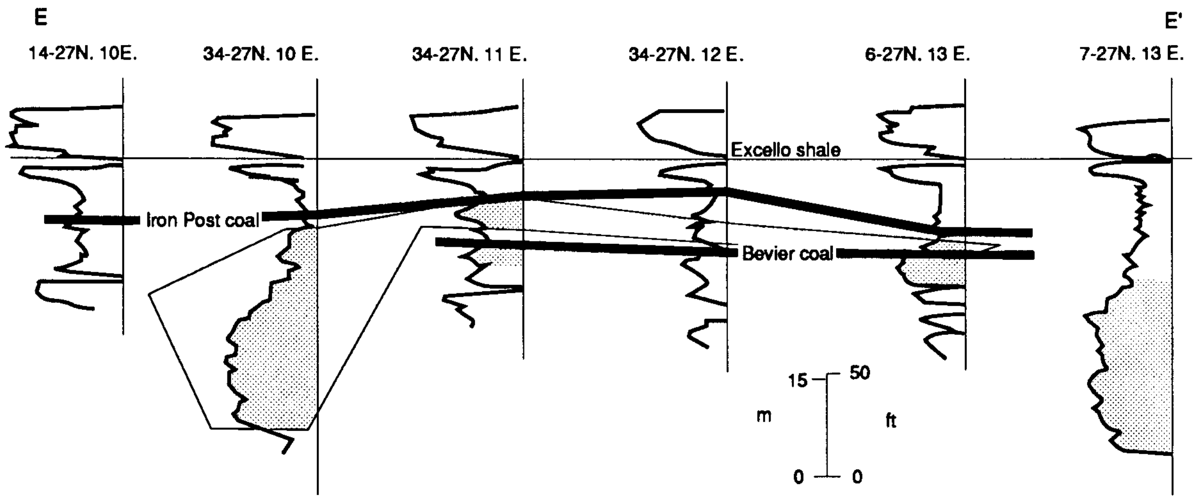


FIGURE 40—Cross section E–E′, east-west view of Banzet sandstone bodies in northeastern Oklahoma. See fig. 6 for location; modified from Denesen, 1985.

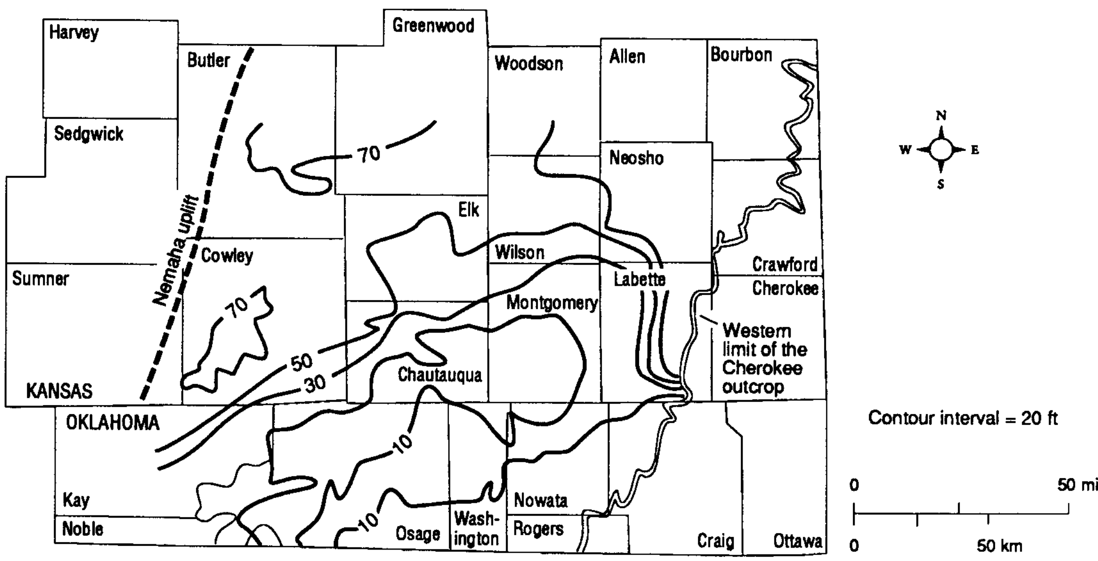


FIGURE 41—Isopach map of Kinnison shale interval of Banzet formation; from Denesen, 1985.

Above the Iron Post coal lies the Kinnison shale, which is considerably thicker in the subsurface than it is along the outcrop belt. The Kinnison thickens northward (fig. 41) as the amount of sandstone increases. Denesen (1985) was able to recognize two sandstone-rich zones within this interval. The lower of the two, which he referred to as the "middle sandstone zone," consists of thin, laterally discontinuous units, forming two major sandstone trends (fig. 29). The thickest trend lies parallel to the Nemaha uplift, extending from western Greenwood County and eastern Butler County southward to southeastern Sumner County, Kansas. Another trend extends southwestward from Woodson County, Wilson County, northwest Montgomery County, and into central Chautauqua County, Kansas (fig. 29). A north-south cross section, F–F′ in Butler County, Kansas, shows that Denesen's "middle sandstone zone" consists of two separate bodies, the lower of which is more continuous than the upper body (fig. 42; modified from Denesen's cross section C–C′).

The uppermost sandstones in the Kinnison shale and in the Banzet in general were referred to as the "upper sandstone zone" by Denesen (1985). These sandstone bodies are restricted to Kansas, pinching out in the southern tier of Kansas counties (fig. 29). Their well-log signatures consist of spike or funnel-shaped gamma-ray curves that indicate either thin, well-sorted sandstone or a coarsening-upward sequence with a gradational basal contact (fig. 42).

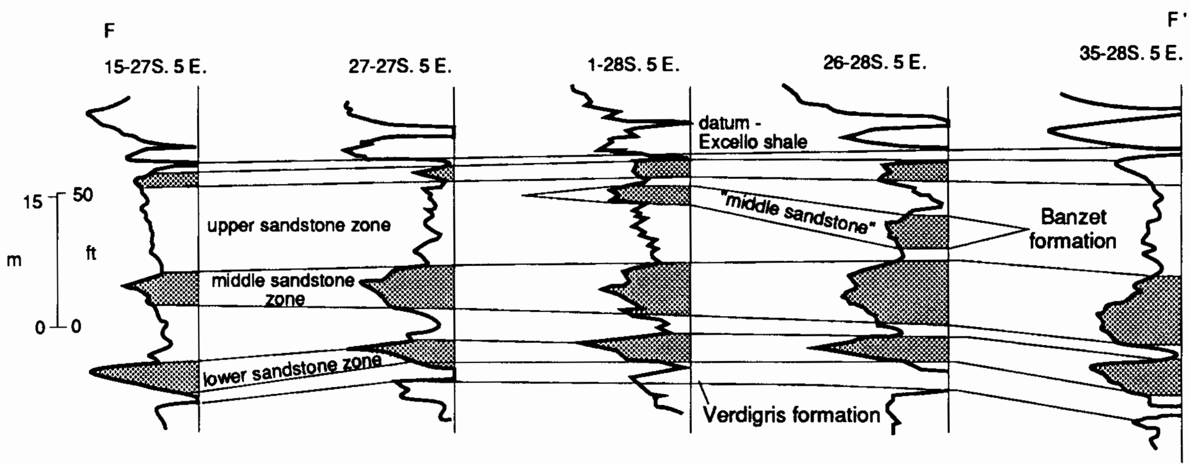


FIGURE 42—CROSS SECTION F–F′, NORTH-SOUTH VIEW OF BANZET SANDSTONE BODIES IN NORTHEASTERN OKLAHOMA. See fig. 6 for location; modified from Denesen, 1985.

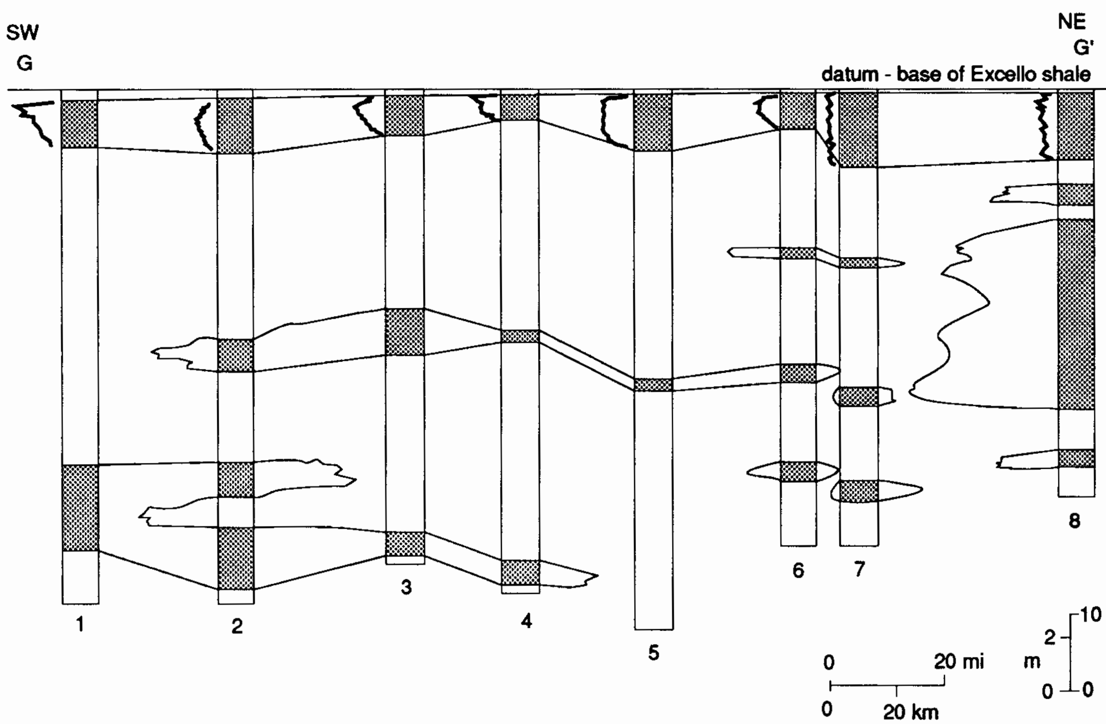


FIGURE 43—CROSS SECTION G–G′, NORTHEAST-SOUTHWEST VIEW OF BANZET SANDSTONE BODIES BETWEEN MIAMI AND COWLEY COUNTIES, KANSAS, showing stratigraphic positions of sandstone bodies in Banzet formation. See fig. 6 for location of cross section and of wells 1–8.

Discussion

Following consideration of the distributions and well-log characteristics of Banzet lithologies in three map areas within the study area, several regional similarities and differences are apparent. First of all, individual sandstone bodies cannot be traced over areas more than a few counties in extent. Cross section G–G' (fig. 43) extends along the trend of a sandstone-rich thick from Miami County in the northeast, to Cowley County, Kansas, near the Oklahoma border in the southwest. Although most sandstone units are not traceable for the 270 km (168 mi) of the section, this cross section shows that they occur within definite zones or intervals.

Thicker sandstone units in all map areas tend to have sharp basal contacts and either bell-shaped or blocky log signatures. Thinner units have either spike or funnel-shaped log signatures. When complex sequences of log signatures occur, spiked or funnel-shaped signatures occur overlying blocky or bell-shaped signatures. When sandstone units are traced laterally, the signatures grade into irregular serrated-curve patterns. Blocky and bell-shaped signatures change rapidly in strike-oriented cross sections and gradually in dip-oriented sections.

These vertical and lateral patterns of well-log signatures suggest that the thick, northeast-southwest-trending sandstones represent sharp-based channel complexes. The thinner, more extensive sandstone units with spike and funnel-shaped signatures seem to be upward-coarsening bar complexes. Irregular well-log patterns, into which the sandstone signatures tend to grade, represent interstratified sandstone and mudrocks. As mentioned earlier, cores from Leavenworth, Anderson, and Coffey counties, Kansas, confirm these interpretations when cored lithologies are compared with corresponding geophysical well logs.

Petrology of Banzet lithologies

The petrographic characteristics of sandstone and shale units vary between core samples collected in northeastern Kansas and those of southeastern Kansas and northeastern Oklahoma. The outcrop samples, collected from western Missouri through southeastern Kansas and into northeastern Oklahoma, show some of these variations. In general, mudrocks become clayier southwestward from northeastern Kansas as kaolinite-rich silty shales give way to illite-rich clay shales, as determined by Aden (1982) using x-ray diffraction analyses. Likewise, sandstone bodies tend to be medium-grained lithic arenites in northeastern Kansas (Leavenworth County cores) and become more quartzose and finer grained to the south and west (fig. 44).

Clay mineralogy of mudrocks

By combining clay-mineral variation with paleontologic considerations, Aden (1982) recognized three distinct mudrock facies, which he interpreted to be related to depositional settings. Considering the clay components of these facies, it can be seen that the clay mineralogies vary as one moves vertically within measured surface sections and laterally along the outcrop belt and into the subsurface.

The "prodeltaic mud facies" of Aden (1982) is characterized by 1) high illite-crystallinity values, 2) mud percentages of 75% or greater, 3) kaolinite percentages less than 10%, and 4) mixed-layer clay percentages of less than 20%. These characteristics are best observed in the Neosho River Park section (fig. 45). In the units immediately below thin sandstone bodies, illite-crystallinity values drop and mixed-layer clay-mineral percentages increase upward, perhaps indicating short-lived increases in sedimentation rates (Aden, 1982).

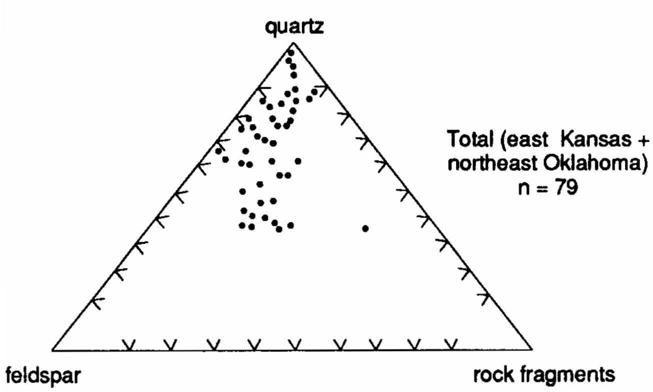


FIGURE 44—TERNARY DIAGRAM SHOWING COMPOSITION OF SANDSTONE UNITS IN BANZET FORMATION SAMPLED FROM ENTIRE STUDY AREA; see appendix B for data summary.

Aden's (1982) "shoreline-coastal facies" include coal beds with underlying seatrocks, as well as relatively high percentages of siltstone and sandstone units. The clays in this facies are characterized by 1) illites with low crystallinity values, 2) kaolinite percentages ranging from 15% to 55%, and 3) mixed-layered clays accounting for 20-60% of clays. In addition, total clay content is generally less than 30% of rock samples. This facies is best exposed at the northeast Foster section in Bates County, Missouri (figs. 18 and 46).

A transition facies that Aden (1982) referred to as the "delta front facies" is found as thin units at several localities including the upper 2 m (6.6 ft) at the North Arma section in Crawford County, Kansas (figs. 16 and 47), and the lower 4 m (13.1 ft) of the type-Banzet section west of Walsh in Craig County, Oklahoma (figs. 9 and 48). Of the three mudrock facies recognized by Aden, the transitional facies is laterally more widespread than the others, occurring in many of the surface sections and in the cores he analyzed.

Sandstone petrography

The petrographic characteristics of sandstone units along the outcrop belt from western Missouri to northeastern Oklahoma seem to be similar. The textures vary within a narrow range from very fine grained to fine-grained sandstone. Mineralogically these units are quartzose with varying amounts of feldspar, chert, and mica. However, as mentioned and illustrated earlier (fig. 44), analyses of samples from subsurface cores show marked textural and mineralogical differences between northeast Kansas (Leavenworth County) and the southwestern portion of the study area in Coffee County, Kansas. With the exception of some of the subsurface specimens from Anderson County, Kansas, surface samples are more quartzose than those collected from subsurface cores. Diagenetic alterations are similar in all areas but vary in relative timing and extent between sandstone units.

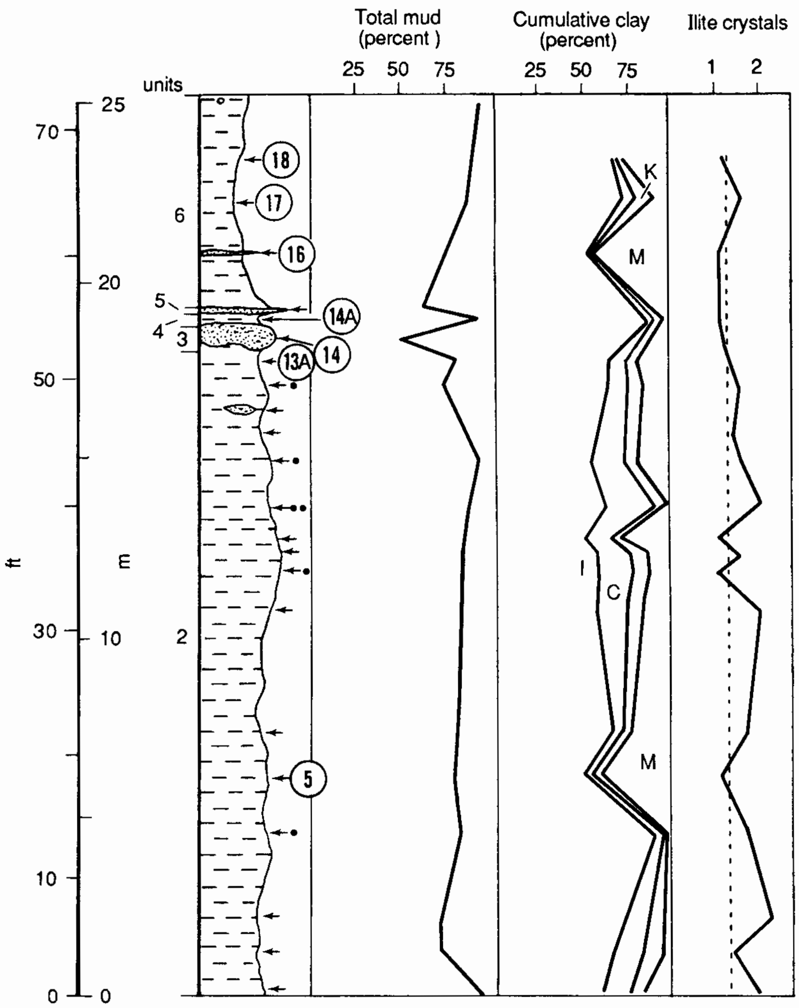


FIGURE 45—COMPOSITIONAL VARIATIONS IN MUDROCK PORTIONS OF BANZET FORMATION AT NEOSHO RIVER PARK SECTION, LABETTE COUNTY, KANSAS. Sample points and numbers are shown by arrows. Dots show relative abundances of eurytopic fossils (productid brachiopods plus ostracodes). I, illite; C, chlorite; K, kaolinite; and M, mixed-layer clays. Dashed line in right-hand column is placed at illite-crystallinity value = 1.2. See fig. 12 for exact location; from Aden, 1982.

Leavenworth County sandstones

DETRITAL MINERALOGY—The sandstones analyzed from the Leavenworth County cores are predominantly lithic arkoses (fig. 49), which range in grain size up to medium-grained sandstone (Nelson, 1985). Potassium feldspar ranges from 15% to 20% of the bulk sandstone, and albitic plagioclase constitutes 2-3%. Siltstone, shale, schistose metamorphic, and chert fragments account for 6-16% of bulk sandstone. Shale and sandstone fragments occur as rip-up clasts near the bases of upward-fining sandstone units, while the other rock fragments occur as sand-sized grains. Minor amounts of muscovite, biotite, and chlorite coarse-silt- to coarse-sand-sized grains are found throughout the sandstone units in this part of the study area. However, these micas are found in higher concentrations towards the top of fining-upwards sequences (Nelson, 1985). In addition to detrital minerals, seams of coalified plant debris and blebs of petroleum were common in the sandstones sampled from the Leavenworth County cores.

DIAGENETIC ALTERATIONS—The general sequence of diagenetic alterations reported by Nelson (1985) is as follows: 1) pyrite formation as a product from reduction of organic matter, 2) crystallization of chlorite coatings on detrital grain surfaces, 3) formation of kaolinite pore fillings, 4) formation of quartz overgrowths on detrital quartz grains, 5) calcite cementation and partial replacement of authigenic quartz and detrital quartz and feldspars, 6) precipitation of iron carbonate, and 7) nearly continuous formation of illite and smectite clays (table 1). Many of these alterations took place prior to extensive sediment compaction. Nelson (1985) reported a separate late phase of potassium feldspar dissolution. However, feldspar dissolution more likely took place in conjunction with earlier carbonate replacement, followed by a phase of carbonate dissolution due to exposure to acidic fluids. This phase of dissolution was probably responsible for the creation of secondary porosity, which enhances the reservoir properties of the sandstone units throughout the study area.

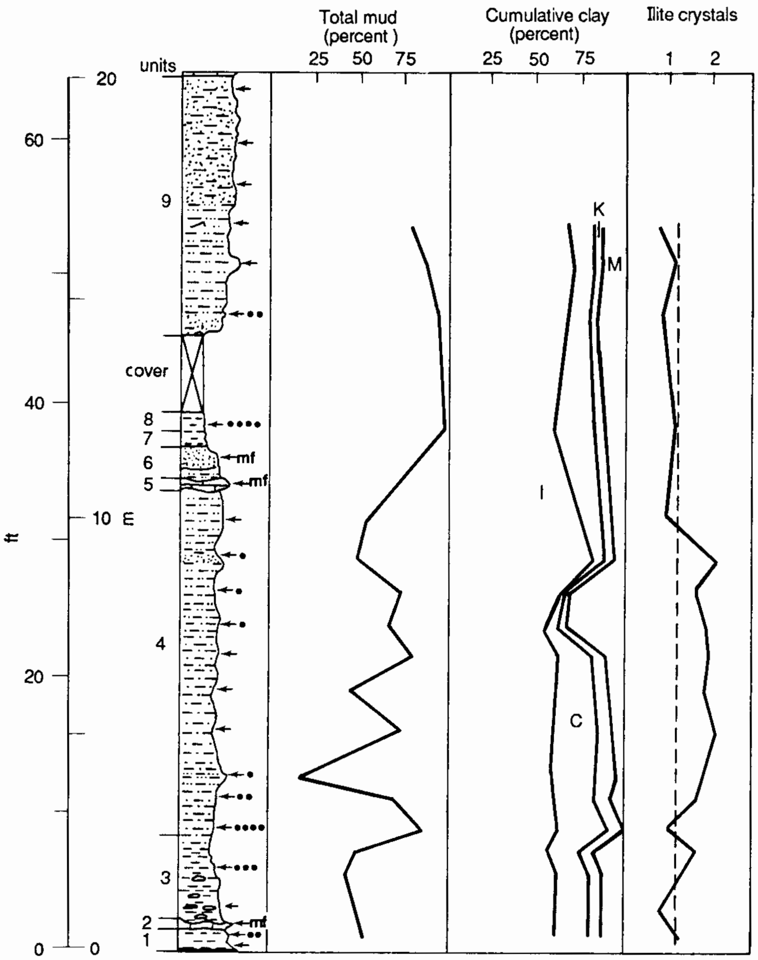


FIGURE 46—Compositional variations in mudrock portions of Banzet formation at Northeast Foster section, Bates County, Missouri. Sample points are shown by arrows. Dots show relative abundances of eurytopic fossils (productid brachiopods plus ostracodes), and mf, other marine fossils found. I, illite; C, chlorite; K, kaolinite; and M, mixed-layer clays. Dashed line in right-hand column is placed at illite-crystallinity value = 1.2. See fig. 18 for exact location; from Aden, 1982.

Bush City and Centerville sandstones

Detrital mineralogy—The 39 sandstone specimens from the Bush City and Centerville trends of Anderson County, Kansas, form the most quartzose assemblage in the study area. According to Reinholtz (1982), the Bush City sandstones average 94% total quartz (monocrystalline [92%], and polycrystalline quartz [2%]), and the Centerville sandstones average 89% total quartz (85% monocrystalline, 4% polycrystalline). This, coupled with small amounts of feldspars and rock fragments (appendix B), puts these rocks into the quartz arenite and subarkose compositional fields (fig. 50).

The Bush City sandstones are very fine to fine-grained, while the Centerville is somewhat coarser grained and more arkosic (Reinholtz, 1982). However, the sandstone samples from the Bush City are from three lithofacies: 1) subequal amounts of interstratified, very fine grained sandstone and shale; 2) thin, ripple-laminated siltstone and very fine grained sandstone and silty shale; and 3) a mostly mudrock facies containing isolated lenses of siltstone and very fine grained sandstones. These samples only represent the finest grained sandstones found in the Bush City trend. On the other hand, the Centerville sandstone samples are from two lithofacies consisting of massive, fine-grained micaceous sandstone and fine-grained sandstone with lesser amounts of silt and clay shales. These samples represent a somewhat coarser portion of this trend. Thus, the differences between the two groups of samples may be due entirely to textural and environmental differences.

Diagenetic alterations—The diagenetic alterations reported by Reinholtz (1982) for the Bush City and Centerville sandstones are similar to those observed in Leavenworth County and elsewhere in the study area. However, Reinholtz suggested that sediments in Anderson County underwent some degree of compaction before any authigenic materials were found. In addition, he recognized two phases of carbonate precipitation, one of which preceded the formation of authigenic chlorite coatings on quartz grains (table 1).

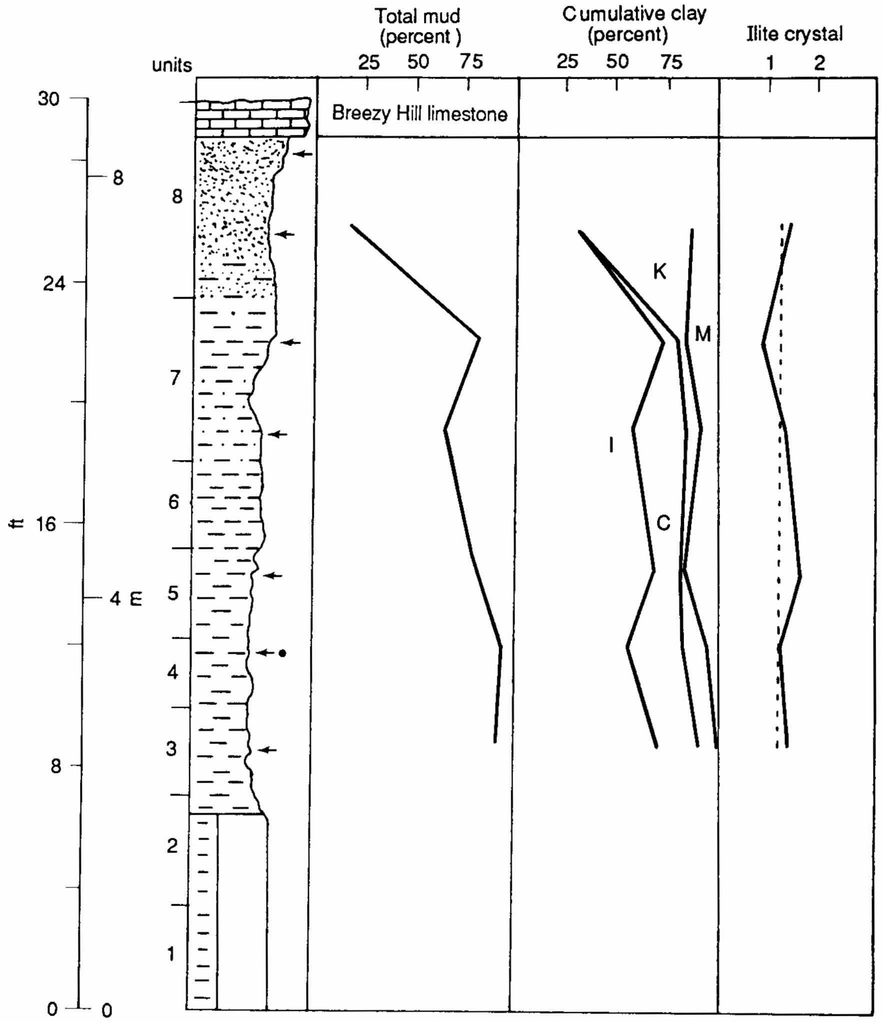


FIGURE 47—Compositional variations in mudrock portions of Banzet formation at North Arma section, Crawford County, Kansas. Sample points are shown by arrows. Dots show relative abundances of eurytopic fossils (productid brachiopods plus ostracodes). I, illite; C, chlorite; K, kaolinite; and M, mixed-layer clays. Dashed line in right-hand column is placed at illite-crystallinity value = 1.2. See fig. 16 for exact location; from Aden, 1982.

As mentioned above in our discussion of the detrital components of the Bush City and Centerville sandstones, these specimens are more quartzose than sandstones studied in adjacent areas. This may be due to more pervasive early-phase carbonate cementation that may have been synchronous with, or preceded by, feldspar dissolution.

One observation made by Reinholtz (1982), neither I nor other workers in the area have confirmed. This is a late phase of gypsum cementation. The minor amounts of gypsum observed by Reinholtz may have formed as a by-product from the late oxidation of pyrite to iron oxide. This reaction releases sulfur in the form of sulfate ions which combine with calcium ions in formation waters to form gypsum.

Coffey County sandstones

Detrital mineralogy—Core samples available from wells in Coffey County, Kansas, contained two distinct sandstone-rich lithofacies (fig. 24) which were analyzed by Lardner (1984). The stratigraphically lowest of them consists of fine-grained, ripple-laminated, subarkoses and arkoses. The higher lithofacies consists of fine- to medium-grained, fossiliferous subarkoses and arkoses. The ripple-laminated sandstones are moderately well-sorted, angular to subangular, with detrital minerals consisting of 36-44% monocrystalline quartz, 9-16% potassium feldspars, 1-4% plagioclase, 1-2% rock fragments, and 4-15% micas (biotite plus muscovite; fig. 51A). The fossiliferous sandstones contain 20-45% quartz and similar amounts of the other constituents with the exception of detrital micas, which are much less abundant in this lithofacies (fig. 51B).

Diagenetic alterations—Lardner (1984) reported similar diagenetic alterations in both of the sandstone lithofacies that he studied (table 1). As in the other sandstone samples analyzed, the Coffey County sandstones contain early authigenic pyrite, clay coatings, and quartz overgrowths. The primary difference between these sandstones and others may be the distributions and timing

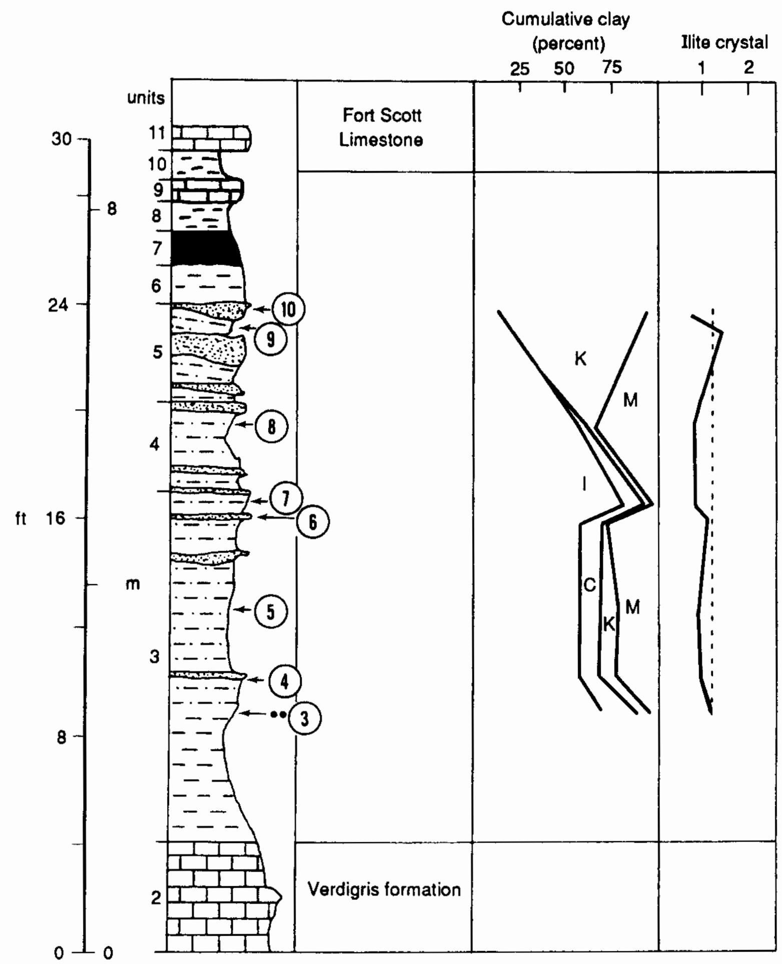


FIGURE 48—COMPOSITIONAL VARIATIONS IN MUDROCK PORTIONS OF BANZET FORMATION AT TYPE BANZET SECTION, CRAIG COUNTY, OKLAHOMA. Sample points are shown by arrows. Dots show relative abundances of eurytopic fossils (productid brachiopods plus ostracodes). I, illite; C, chlorite; K, kaolinite; and M, mixed-layer clays. Dashed line in right-hand column is placed at illite-crystallinity value = 1.2. See fig. 9 for exact location; from Aden, 1982.

TABLE 1—DIAGENETIC SEQUENCES.

Lardner, 1984	**Nelson, 1985**	**Reinholtz, 1982**
pyrite formation	pyrite formation	sediment compaction
clay coatings	chlorite coatings	pyrite formation
silica overgrowths	kaolinite fillings	siderite precipitation
illitization of smectite	quartz overgrowths	clay coatings
period of compaction	calcite precipitation and replacement	quartz overgrowths
dissolution of feldspars	siderite precipitation and replacement	iron-calcite precipitation and replacement
kaolinite pore fillings	illite formation	precipitation of gypsum
iron-calcite precipitation and replacement	smectite formation	kaolinite sericite
seritization of feldspars	sediment compaction	oxidation of pyrite
hydrocarbon migration	feldspar (k) dissolution	
	hydrocarbon migration	

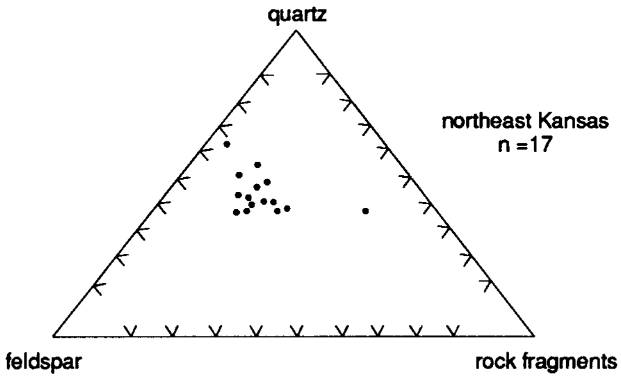


FIGURE 49—TERNARY DIAGRAM SHOWING COMPOSITION OF SANDSTONE UNITS IN BANZET FORMATION SAMPLED IN LEAVENWORTH COUNTY, KANSAS; see appendix B for data summary.

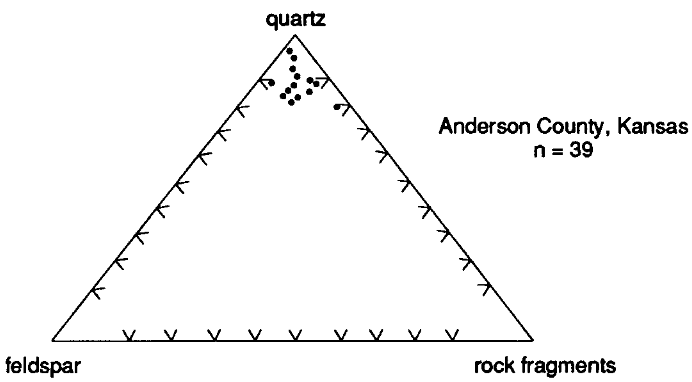


FIGURE 50—TERNARY DIAGRAM SHOWING COMPOSITION OF SANDSTONE UNITS IN BANZET FORMATION SAMPLED IN ANDERSON COUNTY, KANSAS; see appendix B for data summary.

of carbonate cements. Lardner (1984) observed evidence of appreciable compaction prior to carbonate cementation in both sandstone lithofacies, indicating that only a late phase of carbonate cementation affected these rocks. The pervasiveness of iron-rich calcite cement varies considerably between the ripple-laminated and the fossiliferous lithofacies. The former is characterized by minor carbonate cementation and, as a result, has up to 25% preserved porosity. The latter has only trace amounts of porosity with pervasive calcite cement filling what may have been pore spaces at one time.

Sandstones from the southeastern Kansas–northeastern Oklahoma outcrop belt

DETRITAL MINERALOGY—Denesen (1985) concentrated his petrographic analysis on the sandstones below the stratigraphic horizon of the Iron Post coal. These sandstones are subarkosic and are the most quartzose of the sandstones studied except those that were discussed earlier from Anderson County, Kansas (fig. 52). Two types of subarkoses are present. One is fine grained,

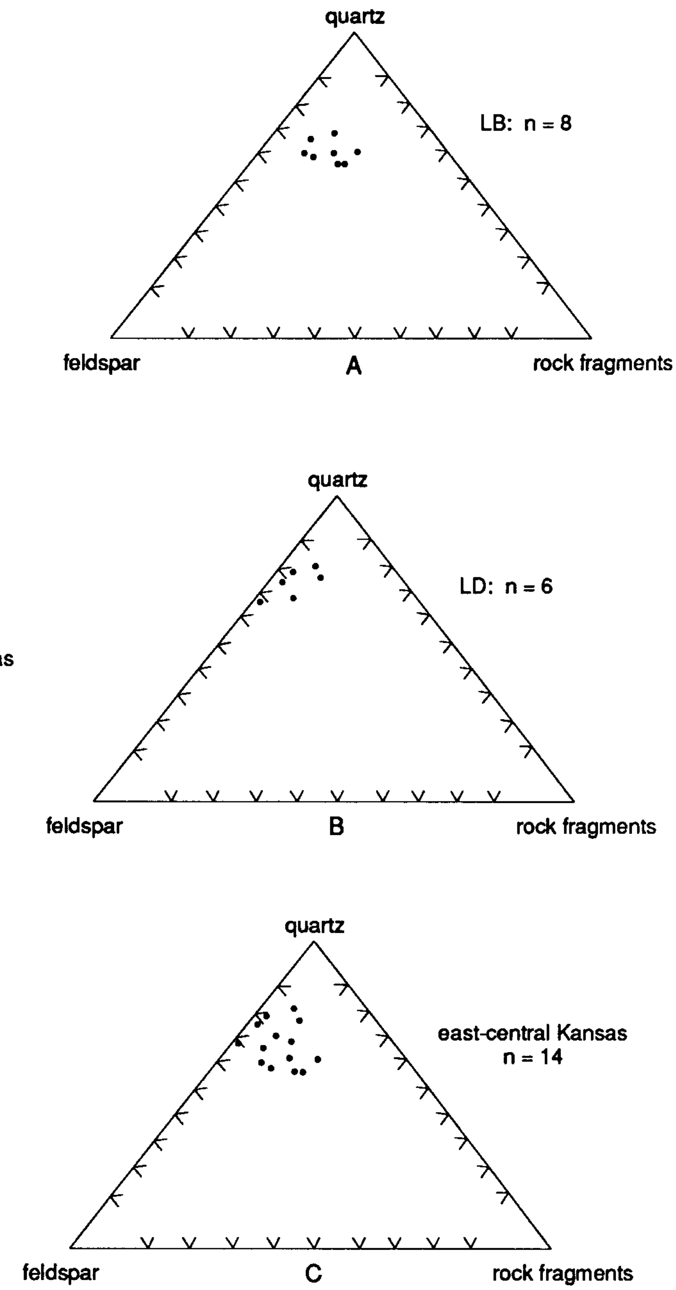


FIGURE 51—TERNARY DIAGRAM SHOWING COMPOSITION OF SANDSTONE UNITS IN BANZET FORMATION SAMPLED IN COFFEY COUNTY, KANSAS. A) lower sandstones (lithofacies "B" on fig. 22); B) upper sandstones (lithofacies "D" on fig. 22); C) total Coffey County samples; see appendix B for data summary.

moderately well sorted, ripple stratified, and lies with a gradational basal contact above silty shales. The other is medium grained, moderately sorted, micaceous, and cross-bedded with sharp contacts with underlying mudrocks. Potassium feldspar constitutes from 6% to 13% of bulk sandstone samples, while albitic plagioclase constitutes less than 2% of the bulk sandstones.

Denesen (1985) made an interesting observation concerning the condition of feldspar grains. The majority of potassium-feldspar grains are partially altered, while the albitic-plagioclase grains are clean. This argues against

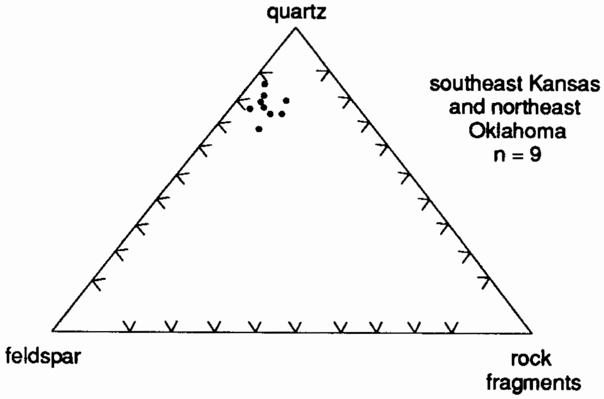


FIGURE 52—Ternary diagram showing composition of sandstone units in Banzet formation sampled along outcrop belt in southeastern Kansas and northeastern Oklahoma; see appendix B for data summary.

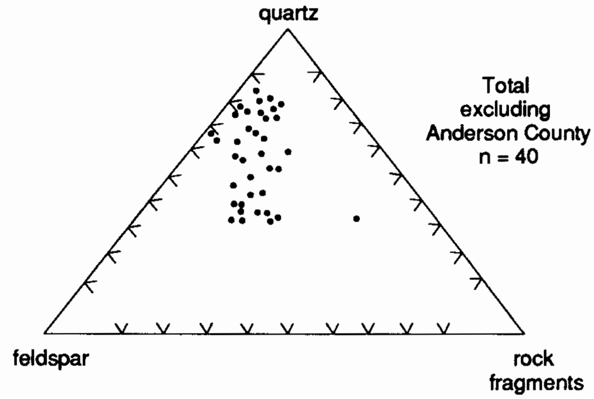


FIGURE 53—Ternary diagram showing composition of sandstone units in Banzet formation sampled from entire study area, excluding Anderson County, Kansas; see appendix B for data summary.

the contention that plagioclase grains are less abundant due to their more extensive diagenetic alteration or weathering than the potassium feldspars. Apparently, the siliciclastic source contained a high ratio of potassium to plagioclase feldspar.

Diagenetic alterations—Although the detrital mineralogies of the subarkoses in the southern portion of the study area are similar, the bulk compositions vary. The two sandstone types that Denesen (1985) recognized have two distinct diagenetic styles. The moderately well-sorted, fine-grained sandstone consists of up to 5% clay matrix. Sandstone units of this type have authigenic kaolinite, chlorite (?), minor amounts of quartz overgrowths, and point-counted porosities up to 13%. Some of these units have pervasive calcite cement and show no pore space. The second type of subarkose, which has up to 5% muscovite, has similar diagenetic alterations except that it has significant amounts of pyrite and iron oxides and lacks carbonate cements. This sandstone type showed up to 17% point-counted porosity.

The fine-grained, rippled sandstone seems to be marine influenced, perhaps accounting for the pervasive calcite cementation of some of its units. The medium-grained, crossbedded sandstone with sharp basal contacts may have been more influenced by freshwaters that were not chemically suited for pervasive calcite precipitation.

Discussion

The sandstone specimens Reinholtz (1982), Lardner (1984), Denesen (1985), Nelson (1985) and I studied represent sands that were deposited in a variety of depositional environments at slightly different times. They have in common a tectonic setting along the margins of an epicontinental seaway and mineralogically similar siliciclastic source areas. When comparing the compositional data from the detailed study areas just discussed, we see a sequence from lithic arkoses in the northeast (Leavenworth County, Kansas) to subarkoses in the southwest (Coffey County, Kansas) and south and along the outcrop belt of southeastern Kansas and northeastern Oklahoma (fig. 53). The exception to this trend seems to be the Bush City and Centerville trends of Anderson County, Kansas, where sandstones are sometimes quartz arenites as well as subarkoses (fig. 50).

Diagenetic styles also varied depending upon original sediment composition and the position of sandstone units within stratigraphic sequences. These factors, along with their impact upon the distribution of petroleum within the upper portion of the Cherokee Group, will be discussed after we consider the depositional environments that hosted sandstone deposition.

Paleontological observations

Fossils are scarce in the gray shales of the Banzet formation. The fossils that were found by Aden (1982) form low-diversity faunal assemblages. A common assemblage consists of poorly preserved productid brachiopods. The only genus identified was *Desmoinesia* sp. Some samples also contained the ostracode *Cavellina* sp. Only one outcrop section contained what is considered a normal marine assemblage. This is the Lawrence Cemetery section in Bates County, Missouri, where Aden (1982) collected the fossils of sea-cucumber scalerites and crinoid columnals, as well as productid brachiopods and ostracodes. He also recovered phosphatic fish scales from shale samples in the Neosho River Park section in Labette County, Kansas. In addition, carbonate concretions in the shale form around nuclei of brachiopod and gastropod remains.

The generally low abundances and diversity of fossils in the Banzet formation along its outcrop belt indicate deposition in restricted environments that underwent rapid changes. The productid brachiopods and ostracodes found may represent an eurytropic assemblage that was able to withstand broad salinity and turbidity fluctuations (Aden, 1982).

Depositional environments

Depositional environments are interpreted by integrating data and observations gathered from surface exposures, well cores, and geophysical well logs. Any one of these sources of information alone is inadequate to either interpret depositional environments or delineate paleodepositional systems. However, outcrops and cores provide relationships that allow geophysical well-log signatures to be interpreted in terms of lithologies and sequences of lithologies. The grid of well-log data is used to delineate both the vertical and lateral distributions of rock facies through their well-log signatures.

The interpreted rock sequences record a variety of sedimentary processes which were active within the Middle Pennsylvanian epeiric seaway. These process elements delineate areas of sand deposition in narrow "shoestring" bodies that form trends spatially associated with lobate sediment thicks (fig. 28) and high sandstone concentrations (fig. 29). Most of these lobes seem to be areas where sand and mud entered the seaway as river systems reached the seaway margins. The lateral and vertical progressions of process elements are similar to those found within fluvially dominated delta systems and associated environments.

Deltaic complexes

Upward-fining sequences of sandstones and silty mudstones characterize the central portions of lobate sandstone thicks. These always have sharp basal contacts, and core samples show that at least some of these have basal shale-chip conglomerates. The lateral distribution of these sequences shows them to form northeast-southwest-trending channels, as illustrated in cross sections A–A′ (fig. 33) and B–B′ (fig. 34). Off the sandstone trends, sandstones thin abruptly and grade into interstratified siltstone and shale as illustrated in the lower portion of cross section D–D′ (fig. 37). The upper portions of sandstone channels are often associated with or overlain by coal beds such as shown in fig. 40. This pattern is repeated in both the upper and lower portions of the Banzet formation over the eastern and northwestern margins of the study area.

Each lobate pattern on the sandstone-isolith map represents one or more complexes of elongate delta lobes that formed during times that the shoreline encroached upon the study area. The northeast-southwest trends of relatively thick sandstone bodies represent main distributary-channel complexes of delta systems. Smaller divergent trends of fining-upward sandstones represent complexes of minor distributary channels and crevasse splays (fig. 54). Although many of the sandstone patterns appear lobate on the isolith map, individual sandstone trends are linear, indicating that individual lobes were elongate (fig. 54).

Thicknesses of delta-lobe complexes are generally less than 9 m (30 ft). This reflects the relatively low rates of subsidence in the Forest City basin and the Cherokee shelf compared to present-day situations along continental margins. In northeastern Kansas, the delta-distributary channel complexes are thicker than elsewhere and may include the lower portions of fluvial valleys. Rates of deposition probably exceeded accumulation rates by wide margins in this portion of the study area. Shifting channels resulted in a form of sedimentary cannibalism, where prograding channels eroded preexisting deposits and redeposited them in more basinward positions. Core samples from this area contain shale and coal chips at the bases of thick sandstone units (fig. 22).

Coal beds overlie mottled, light-gray to tan, clayey mudstone units where they were observed on outcrops and in cores. Although some coal beds are easily recognized on gamma-ray and neutron logs, many coaly horizons and underlying mudstone units are too thin to be recognized in this manner. The mudrocks are Pennsylvanian paleosols, or seatrock, that represent soils upon which coal-swamp vegetation grew.

Prodelta and interdistributary environments

Between and adjacent to sandstone thicks, the Banzet section consists primarily of mudrock with a thin strata of siltstone and very fine grained sandstone. The lithologic characteristics and positions relative to interpreted deltaic lobes, as well as the clay mineralogies of sampled mudrocks and the distributions of fossil assemblages, all indicate prodelta and interdistributary environments of deposition.

Thin lenticular siltstone and sandstone beds encased within the mudrock sequences resulted from short periods of high-energy activities, which caused transportation of silts and sands from delta-distributary mouths to adjacent muddy-shelf areas. Evidence for this includes the sharp, nonerosional bases and upward fining of thin sandstones observed in cores and outcrops, such as those exposed at the Neosho River Park section in Labette County, Kansas (figs. 12 and 13). High-energy events were probably in the form of unusually severe fluvial floods caused by intense storm systems, similar to typhoons that rake equitorial areas today during monsoon seasons. A short-term increase in a deltaic, plane-jet flow could cause sands and silts, which were deposited earlier as distributary mouth-bar deposits, to be swept seaward into normally low-energy prodeltaic settings.

Crevasse-splay deposits also may have been deposited into interdistributary bays during floods. However, most of these deposits were later incorporated into the delta-lobe complex as distributary channels shifted within lobes. Only a splay formed along the outer edge of a lobe when it is occupying an extreme position relative to its lateral shifting would be identifiable as a splay in a delta-margin setting.

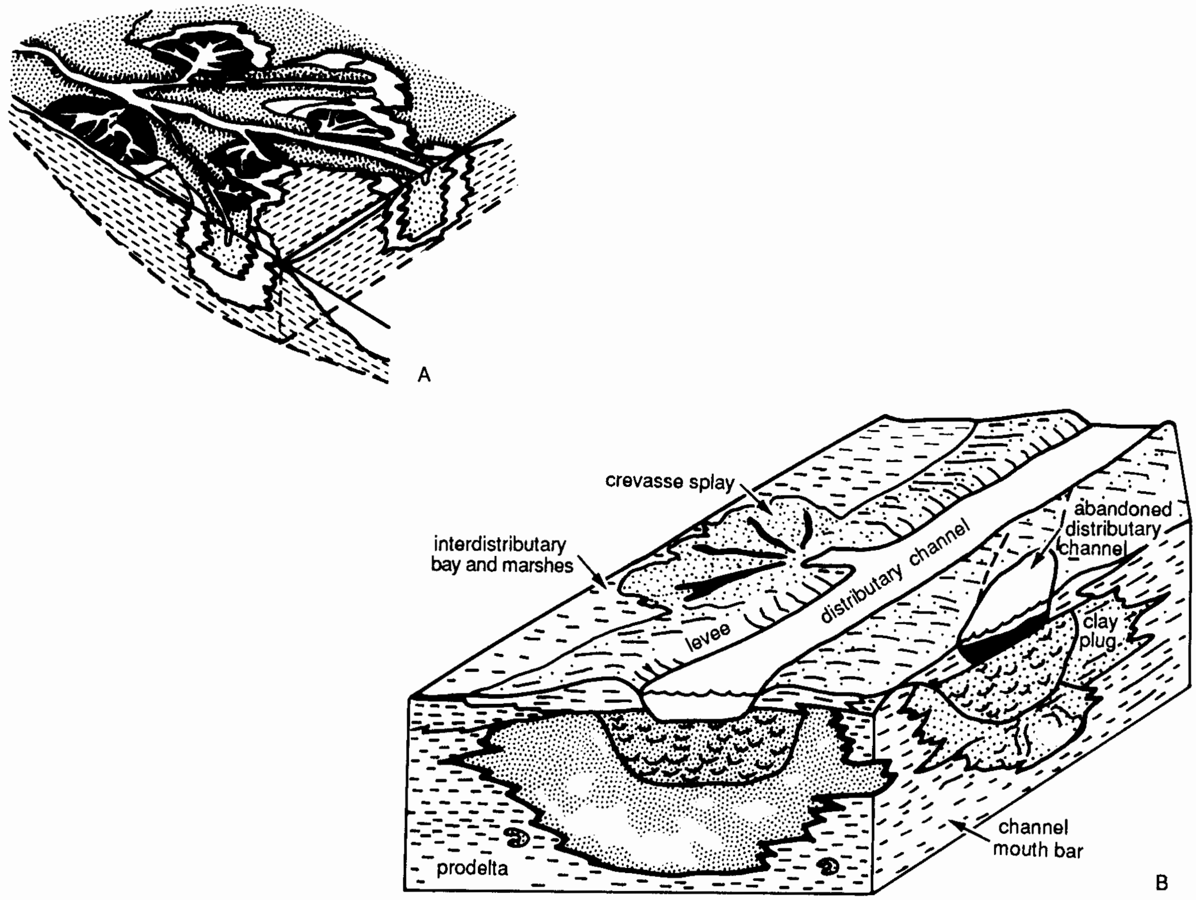


FIGURE 54—DIAGRAMS SHOWING SPATIAL RELATIONSHIPS BETWEEN DEPOSITIONAL ENVIRONMENTS IN A HIGH-CONSTRUCTIVE, ELONGATE, FLUVIALLY DOMINATED DELTA LOBE. A) overall view of lobe, B) facies relationships associated with distributary channel; modified from Brown, 1979.

Marine-shelf environments

Portions of the Banzet formation are essentially sandstone-free and seem to represent low-energy shelf environments. For the most part, these intervals consist of clayey shale containing a diverse assemblage of fossils, relatively low proportions of kaolinite, and some calcareous units. The most extensive of these sandstone-free intervals are in the upper part of the Banzet in the southern half of the study area. These include the Kinnison shale and the Breezy Hill Limestone Member of the Mulky member of the Banzet formation.

The characteristics of these intervals show either more marine influence or greater distance from siliciclastic point sources than do the other portions of the Banzet. Energy levels were low with most sedimentation coming from suspension. The Breezy Hill member is a marine-carbonate unit that lacks any significant amounts of siliciclastic components. It reaches a maximum thickness in excess of 4.9 m (16 ft) in northern Washington and Nowata counties, Oklahoma, and southern Montgomery County, Kansas (fig. 55). It pinches out northward where it is underlain by prodeltaic mudstones and sandstones and overlain by a seat rock and the overlying Mulky coal.

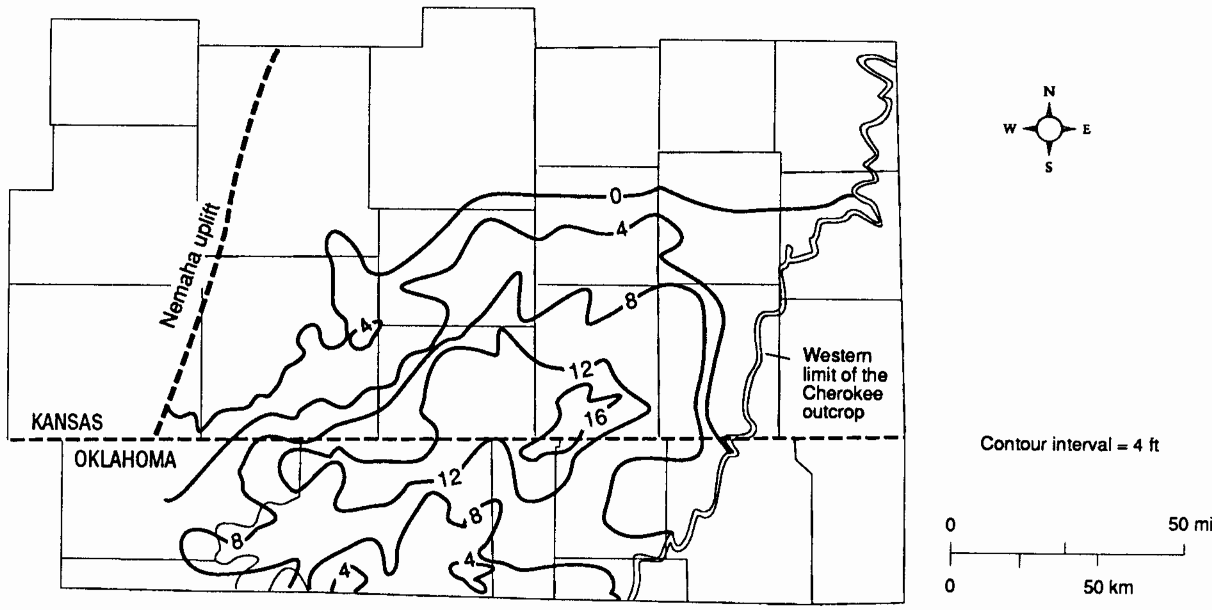


FIGURE 55—ISOPACH MAP OF BREEZY HILL LIMESTONE MEMBER; FROM DENESEN, 1985.

The Breezy Hill Limestone Member seems to represent shelf environments far removed from siliciclastic deposition. It probably was deposited during a widespread marine transgression when shorelines and delta systems were shifted to the north and east of the study area.

Lenses of sandstone, generally less than 3 m (10 ft) thick, occur in portions of shelf areas adjacent to deltaic and prodeltaic deposits. These upward-coarsening units seem to represent sand-bar fields that were the reworked remnants of previously deposited delta lobes. The seawardmost prograded delta lobes would have been the thinnest of these sequences deposited and would be more thoroughly reworked by marine currents and waves during subsequent transgressions. Initial concentrations of sands in distributary channels and channel-mouth bars were reshaped into bars that formed elliptical sandsheets with long axes approximately parallel to the former channel trends. Examples of the sandstone bodies can be seen on the sandstone-isolith map in Neosho, Elk, Chautauqua, and Cowley counties, Kansas (fig. 29).

Paleogeographic reconstruction

Distribution of depositional complexes

The midcontinent of the United States straddled the Pennsylvanian paleoequator (Heckel, 1977). Warm equatorial seas were conducive to carbonate-sediment production through inorganic precipitation as well as by biochemical processes. This setting persisted throughout the Carboniferous. However, siliciclastic sediments transported into an equatorial basin quickly overwhelmed the carbonate-producing agents. This occurred during regressions when fluvial systems drained nearby cratonic areas and more distant marginal orogenic belts.

The isopach and sandstone-isolith maps for the Banzet formation (figs. 28 and 29) outline the positions of preserved deltaic complexes. Isolated sandstone lenses on the isolith map probably represent the reworked remnants of relatively short-lived delta lobes. The well-log signatures that are associated with isopach thicks show that these thicks consist of blocky channel complexes and coarsening-upward sandstone bars (fig. 30). Using these interpretations as guides, two paleogeographic reconstructions were made showing the positions of delta complexes during the deposition of the upper and lower portions of the Banzet (figs. 56 and 57).

An unpublished study made by Staton in Butler County, Kansas, indicates that there may be some thin limestone units in the lower portion of the Banzet (Brady, personal communication, 1987). This part of the study area is adjacent to the southern extension of the Nemaha uplift, which was apparently not a positive feature during this time. It is possible that some of the limestone-producing environments that existed at this time west of the uplift extended into the southwestern portion of the study area. If this were the case, then several feet of limestone may be present in the lower portion of the Banzet where I have placed some tightly cemented sandstone units. These possible limestone beds are not accounted for on the maps or cross sections in this report, but their presence would not significantly affect the interpretations made here.

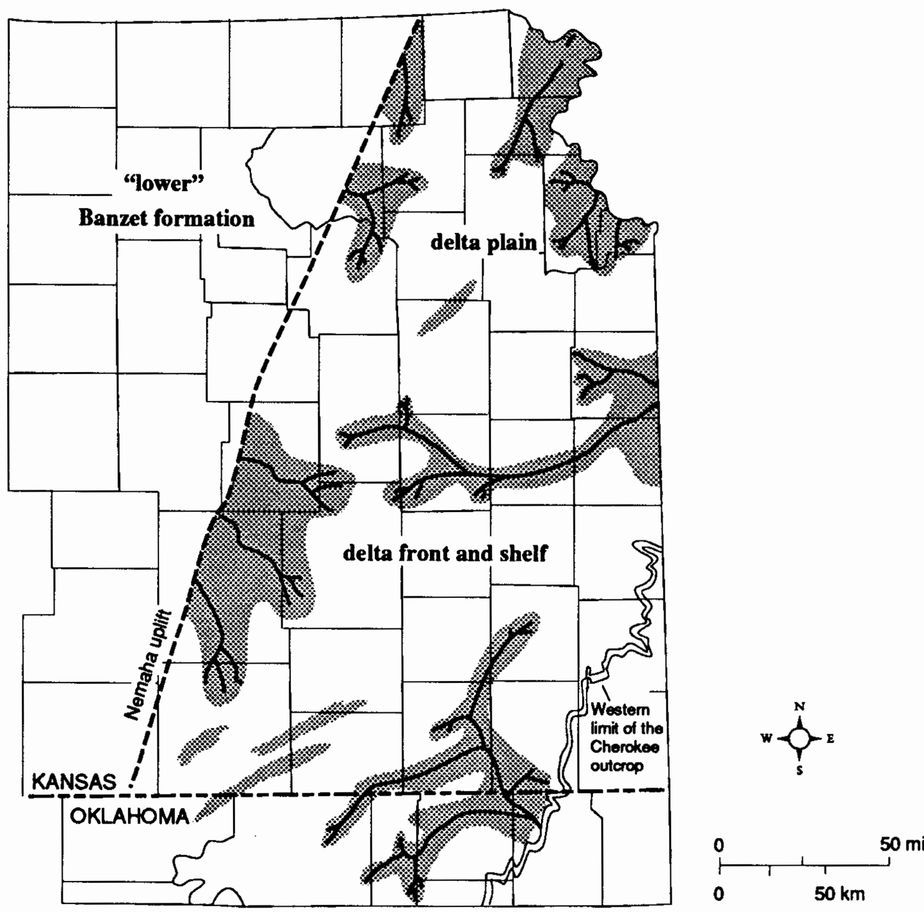


FIGURE 56—Paleogeographic reconstruction of study area at time that lower portion of Banzet formation was being deposited.

Two mechanisms seem to control the distribution of sandstone bodies. First of all, well-documented eustatic fluctuations in sea level (e.g., Heckel, 1986) determine the positions of shorelines and siliciclastic point sources relative to the study area. Only during periods of eustatic regression were shorelines and deltaic systems located within the study area. During times of eustatic transgressions, shorelines and deltas were displaced to the north and east. Heckel (1986) has shown that at least two cycles of sea-level change are recorded within the Banzet.

The second mechanism that controlled sand-body distribution was delta-lobe shifting. As distributary channels overextended themselves seaward, they shifted laterally through the diversion of flow through crevasses formed during floods and storms. Abandoned portions of a delta system subsided as lobal sediments consisting mostly of mud became compact. Local transgressions occurred as marine waters reoccupied submergent lobes.

Eustatic changes and autocycles

Nature of transgressive and regressive sequences

Many transgressive and regressive sequences are found in the Banzet formation. Transgressive sequences commonly consist of sandstones overlain by marine shales. In some cases the sandstones fine upward, then coarsen upward, and are then capped with shale. This sequence represents delta-progradational sands, delta-destructive sands, and prodeltaic and shelf muds respectively. Similar sequences have been observed in the lower portion of the Cherokee Group and have been interpreted as being parts of deltaic complexes (e.g., Visher and others, 1971). In the upper part of the Banzet, delta-front marine sandstones are capped by the Breezy Hill Limestone Member, representing a time when siliciclastic point sources were displaced northward and eastward. The end of Banzet deposition is marked by a widespread, black, phosphatic shale, the Excello shale.

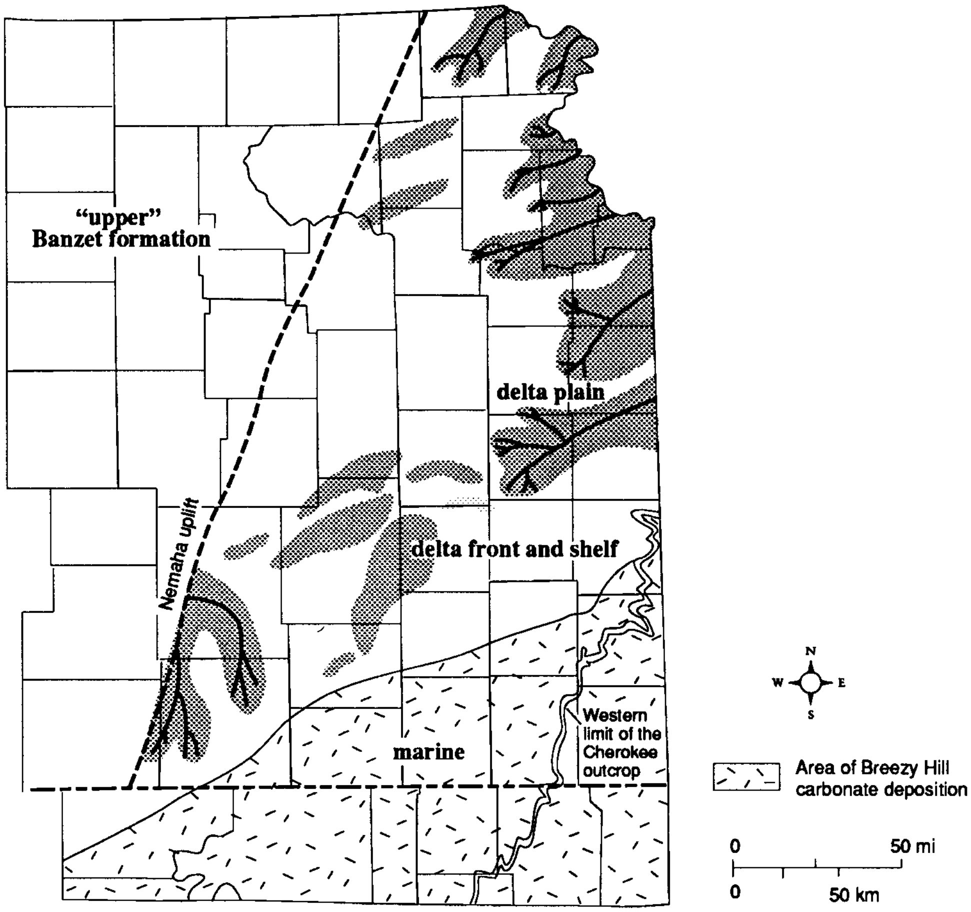


FIGURE 57—PALEOGEOGRAPHIC RECONSTRUCTION OF STUDY AREA AT TIME THAT UPPER PORTION OF BANZET FORMATION WAS BEING DEPOSITED.

This shale, as well as the Oakley shale of the Verdigris Formation, represents deep-water anoxic conditions that covered the study area during times of widespread transgression (Heckel, 1977).

Regressive sequences commonly consist of delta-distributary sandstones that overlie marine shales and are sometimes capped with seatrocks and coal beds. These sequences generally are thicker than the transgressive sequence. Some transgressive sequences are extremely thin, such as the uppermost sequence that only consists of the Excello black shale that directly overlies the Mulky coal (fig. 58). Thin transgressive sequences are caused by low rates of sedimentation that accompanied rapid landward shifting of siliciclastic point sources.

Eustatic cycles

Two widespread transgressive events are recorded by the Oakley shale, which marks the base of the Ardmore–Banzet interval, and the Excello shale, which marks the top of the interval. These units were observed on outcrops in nearly all wells and can be traced laterally throughout the midcontinent region and into the Appalachian basin to the east (e.g., see Ravn and others, 1984, for a summary of previous work). These two units represent transgressions that affected areas beyond the study area and were eustatic in nature.

The question arises as to whether other eustatic events can be observed within the Ardmore–Banzet interval, or whether the Banzet formation represents one eustatic regression between the two well-marked transgressions. When individual wells and cross sections made from closely spaced well logs are analyzed, several regressive-transgressive sequences can be delineated. The Bevier, Iron Post, and Mulky coal beds appear to mark the tops of regressive sequences that are each capped by transgressive marine shales (T_3, T_4, T_7 on fig. 58). The transgressive-regressive cycle formed above the Iron Post coal and below the Breezy Hill Limestone Member by the marine shales of the Kinnison (T_4 on fig. 58) and on the overlying generally coarsening-upward sequence of silty mudrocks and thin sandstones has not been previously described as an allocycle. Therefore, there are five regressive-transgressive cycles within the upper Cherokee interval that seem to be regional in extent (fig. 58): 1) between

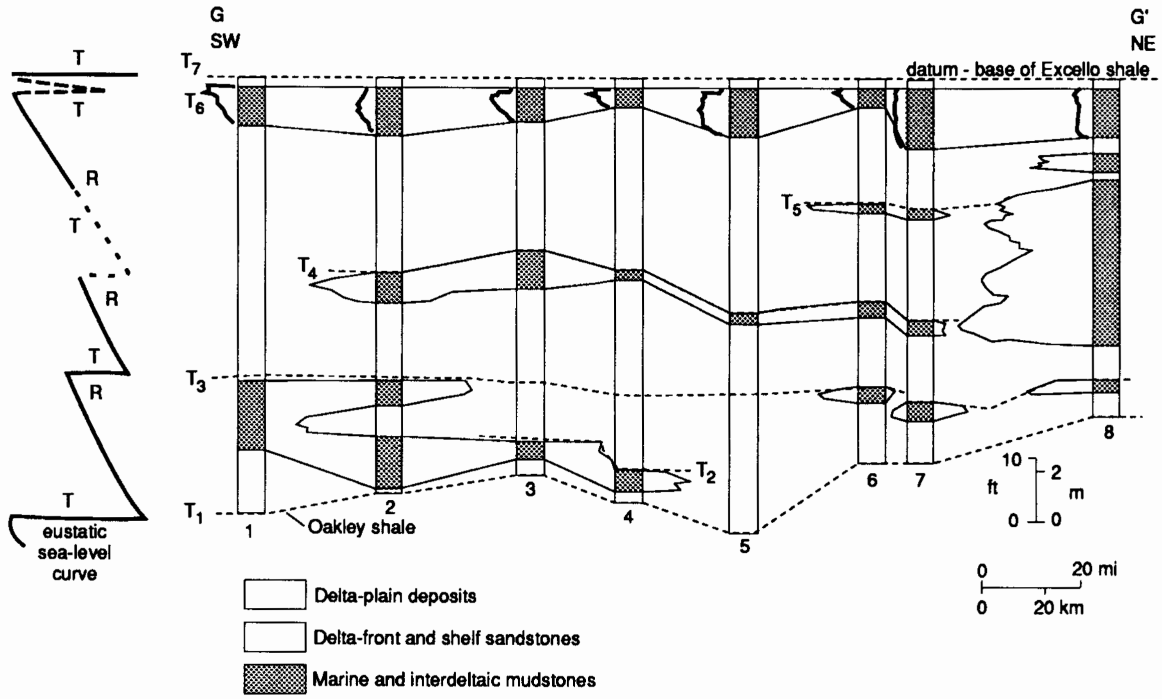


FIGURE 58—Eustatic cycles and autocycles as they were recorded along cross section G–G′. Only initial transgressive events are labeled (T_{1-8}). T_1, T_3, T_6, and T_7 seem to record eustatic transgressions, while others record abandonment and subsequent submergence of deltaic lobes.

the top of the Oakley shale (T_1) through the Ardmore limestone; 2) between the base of the mudrock-sandstone sequence that lies above the Ardmore limestone to the top of the marine shales (T_3) that overlie the Bevier coal; 3) between the base of the coarsening-upward sequence that contains the Iron Post coal to the top of the Kinnison shale (T_4); 4) between the base of the mudrocks and sandstones that overlie the Kinnison shale to the top of the Breezy Hill limestone (T_6); and 5) the rocks above the Breezy Hill, including the Mulky coal, to the base of the Excello shale (T_7). With the exception of cycle 3, these cycles correspond to those observed by Heckel (1986) to be interregional.

Autocycles

Within the widespread eustatic regressive hemicycles, many local regressive-transgressive cycles can be observed. These cycles correspond to the progradation, abandonment, and submergence of deltaic lobes and associated shoreline features. Autocycles are restricted to eustatic regressive hemicycles because of the removal of siliciclastic point sources from the study area as shorelines were displaced landward during eustatic transgressions. Therefore, during transgressions, the only sediments deposited on the Cherokee shelf and adjacent areas consisted of thin layers of pelagic clays and carbonates—rock units that are observable on geophysical well logs. Eustatic regressions allowed siliciclastic depositional systems associated with shorelines and river mouths to reestablish themselves, and autocyclic processes resumed. The resulting siliciclastic sequences are dominantly regressive or upward-shoaling in character and are often capped by thin, destructional (reworked) sandstone sheets or pelagic shelf muds. Although their characteristics were determined by local fluvial and deltaic processes, stratigraphic distribution of autocycles was controlled by interregional mechanisms, most likely eustatic sea-level changes caused by climatic fluctuations.

Implications for petroleum exploration and production

Effective porosity and varying diagenetic styles

Many of the Banzet sandstone thicks illustrated on a sandstone-isolith map (fig. 29) are areas of petroleum production (fig. 59). However, not all the sandstone bodies within these sandstone thicks produce petroleum. In order for petroleum to accumulate in any rock, all the following conditions must be met: 1) the potential reservoir rock must have had communication with a hydrocarbon source rock at the time that petroleum was being generated, 2) the potential reservoir must have had effective porosity at the time that petroleum was migrating, and 3) a seal must be in place to prevent petroleum from migrating completely through the reservoir without accumulation.

The marine mudrock units of the Cherokee Group have been shown to be rich in organic carbon and have been interpreted as the most likely source rocks for the encased sandstone units on the Cherokee shelf (Baker, 1962). Organic geochemical data from Cherokee mudrocks provided by Hatch and others (1984) show that gray shales commonly have organic carbonate contents of 4–5%, and black shales often have more than 12% organic carbon. However, maturation modeling by time-temperature index calculations indicates that Pennsylvanian mudrocks in the Forest City basin should be immature, and that shales lower in the Paleozoic are more likely to be the source of oil in the Cherokee (Newell and others, 1986). It is possible that Cherokee oils have different sources depending upon whether they were generated in the more deeply buried portions of the Cherokee shelf or the shallower Forest City basin. Further analyses and petroleum-source-rock fingerprinting will ultimately allow the petroleum contribution of each Paleozoic mudrock interval to be evaluated across the study area.

Marine and delta-plain mudrocks seem to form the updip seals needed to form traps in the upper Cherokee. The main difference between petroleum-producing Banzet sandstone units and those that do not produce is the existence or nonexistence of effective porosity. In general, the thin delta-destructive sandstones have very little porosity. Most pore spaces are filled with carbonate cements that were precipitated early during the sediment's burial history. On the other hand, distributary-channel shoestring sandstone bodies are the most prolific petroleum producers in the study area. These units generally have greater than 15% porosity, a significant portion of which is secondary in origin.

While sands deposited in marine environments during the Pennsylvanian had interstitial waters saturated with respect to calcite, sands deposited in fluvial and delta-distributary channels were probably acidic and not saturated. As a result, channel sands were not pervasively calcite cemented during the early phases of their diagenetic histories. Instead, some grains were coated with chlorite. As burial continued and silica-saturated fluids entered channel sands from adjacent compacting mudrocks, silica overgrowths formed on detrital grains not coated with chlorite. Rocks with extensive chlorite coatings have very small amounts of silica overgrowth with resulting higher porosities and permeabilities (Woody, 1983; Lardner, 1984; Nelson, 1985).

Pore spaces that survived early stages of carbonate and silica cementation were subjected to at least one stage of carbonate cementation. Concomitant with, or just prior to late-stage carbonate cementation, silica grains and overgrowths were etched and significant volumes of silica were removed from the affected sandstone units. Secondary pores were formed prior to hydrocarbon migration as formation waters became acidic once more, dissolving much of the late-stage carbonates from some units.

Processes affecting reservoir properties

Depositional and early diagenetic conditions

Sandstone porosities and permeabilities are related to their depositional environments and diagenetic histories. Geochemical conditions at depositional sites seem to have controlled the nature and extent of early precompaction diagenetic processes. As a result, the well-sorted, reworked delta-destructional sandstones may have had high original porosities and permeabilities, but they also were more susceptible to early carbonate cementation. In this case, the free movement of carbonate-saturated waters under alkaline conditions led to the rapid, pervasive cementation of these rocks.

Another factor which may have contributed to early cementation was the interlayering of mud with thin sands. As muds began compacting, first carbonate-saturated and later silica-saturated fluids were flushed through the porous sand layers. Sandstones that were not pervasively cemented with carbonate were later subjected to silica cementation as diagenetic alterations of silt-sized and smaller feldspar grains and grains of unstable clay minerals released silica into waters that were being expelled during compaction.

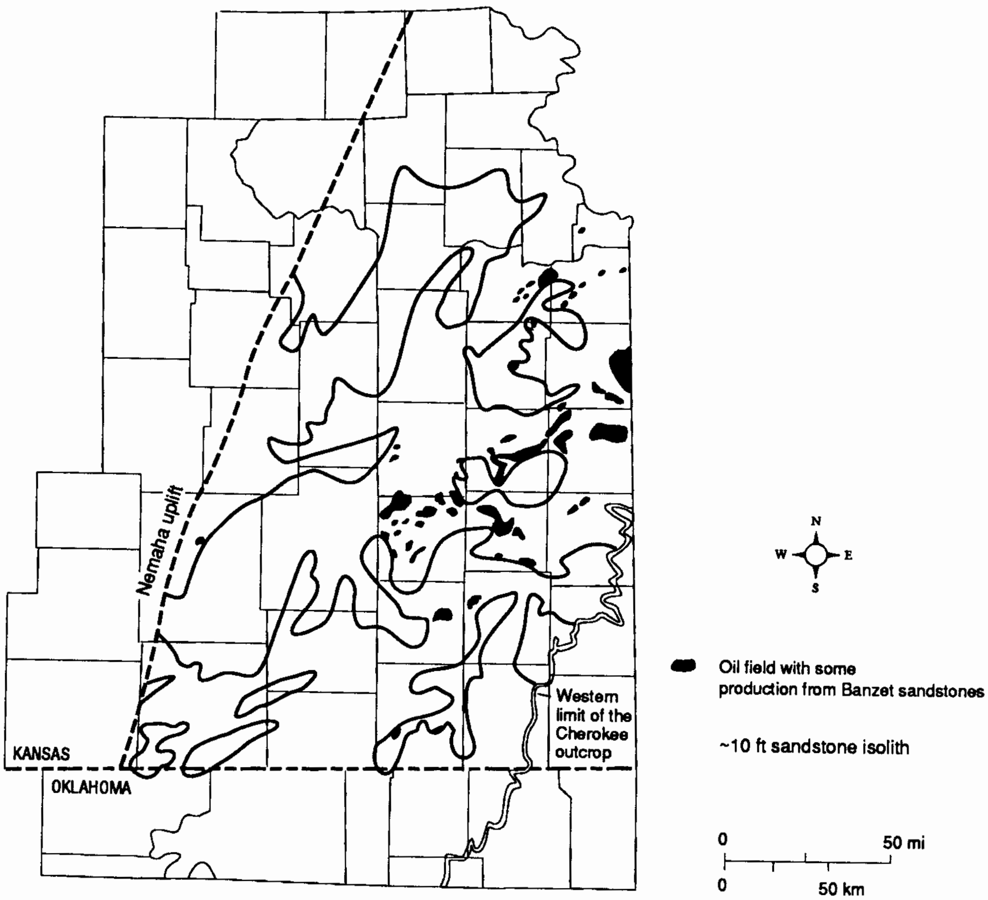


FIGURE 59—MAP OF EASTERN KANSAS SHOWING DISTRIBUTION OF OIL FIELDS THAT PRODUCE FROM POOLS IN THE BANZET FORMATION. Dashed line is 10-ft (3-m) sandstone isolith from map on fig. 29. Note that some fields produce also from pools not in the Banzet. Data from Kansas Geological Survey oil production files updated through 1985.

Enhancement of reservoir properties

Channel-sandstone units have the highest porosities and probably the highest permeabilities within the Banzet formation. Significant portions of pore spaces in these units are secondary in origin (see appendix B). This type of porosity was recognized by noting the geometries of pores and by the presence of remnant grain particles. Secondary pores either have cross sectional shapes and sizes similar to those of grains or they form embayments into remnant grains. Because all sandstone samples were impregnated with blue-dyed polyester resin before thin sections were cut and ground, all naturally occurring pores appear blue in thin sections. Any materials that were removed during thin-section manufacture are colorless in thin sections. Therefore, secondary pores recognized using geometric criteria could not be misinterpreted as plucked particles or vice versa.

Secondary pores formed as a result of dissolution of feldspars and other unstable constituents and replacement of detrital and authigenic silica by late-phase carbonate cements, followed by still later dissolution of the carbonate cement. Both mechanisms of secondary porosity development seem to have taken place. Some specimens show secondary pores in rocks that have no evidence that carbonate cements were present (fig. 60). Other specimens have secondary pores that clearly were developed by dissolution of carbonate cements that had previously replaced parts of siliciclastic grains and siliceous overgrowths (fig. 61). The two phases of dissolution were mutually exclusive, since the chemistry required to dissolve carbonates (e.g., low pH or low temperature) is much different than that required to dissolve silicates (e.g., high pH or elevated temperatures). However, silicate dissolution possibly was concomitant with carbonate replacement of silicates.

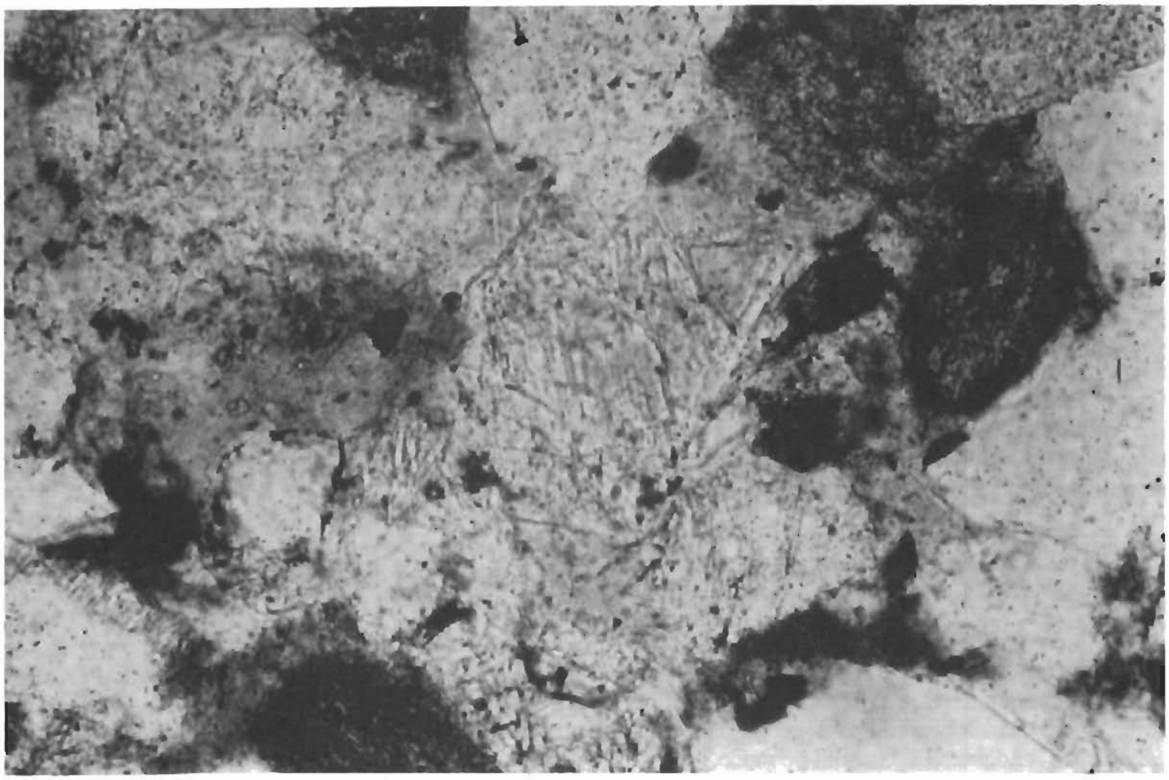


FIGURE 60—Photomicrograph showing secondary pore spaces (P) formed as a result of feldspar (F) dissolution in a sample that does not show evidence of previous carbonate cementation. Sample 16.6, Bailey–Lohrengel 18 core (core #6 on fig. 21), Anderson County, Kansas. Plain polarized light; bar = 0.1 mm.

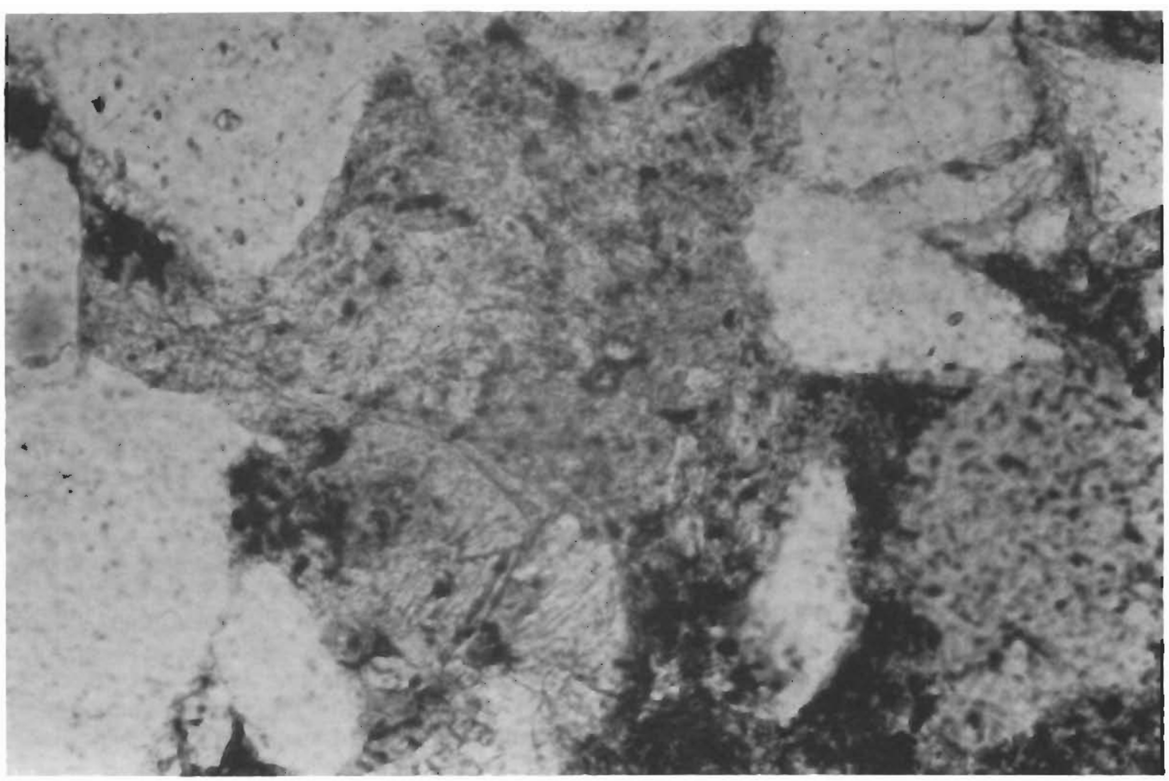


FIGURE 61—Photomicrograph of secondary pores (P) formed by dissolution of carbonate cements (C). Sample 1037.8, M. C. Colt–W. Lauber–101A well, Woodson County, Kansas. Plain polarized light; bar = 0.1 mm.

Keys to predicting quality of reservoir characteristics

The depositional styles depicted in this study show that potential reservoir rocks trend primarily northeast-southwest and, to a lesser extent, northwest-southeast. These are not new observations in that many authors, including Bass (1936) and Hulse (1979), have shown that these trends are common throughout the Cherokee Group. However, once sandstone trends are either delineated or predicted, high-quality reservoir characteristics are not always assured. Walton and others (in press) show that cross-bedded channel sandstones have the highest porosities and permeabilities among the Cherokee units they analyzed. Although this study does not include permeability measurements, point-counted porosities indicate that these relationships hold for the Banzet sandstone units analyzed. Reservoir characteristics vary within these units because of changes in the nature and intensities of diagenetic alterations. Therefore, the key to finding sandstone bodies with high porosities and permeabilities lies in the interpretations of the rock's diagenetic history in relation to depositional settings and subsidence history.

Because the tectonic setting for this portion of the midcontinent was one of relative stability during the time that the Banzet formation was being deposited, eustatic sea-level changes may have been the only significant cause of perturbations in sediment-accumulation rates. Therefore, the positions of sandstone bodies at the time of Desmoinesian and post-Desmoinesian eustatic transgressions and regressions may be an important key in determining which diagenetic alterations affected each sandstone body. This phase of the study is still in progress at this time and will be discussed more fully in a future paper.

Summary and conclusions

The integration of surface and subsurface geological and geophysical data has provided the basis from which stratigraphic, petrologic, and paleogeographic interpretations and reconstructions could be made.

The attempts by earlier workers to extend the established stratigraphic terminology from the Arkoma basin northward to the Cherokee shelf and the Forest City basin have led to confusion and miscorrelations. These miscorrelations must be corrected and the stratigraphic nomenclature for the entire Cherokee should be revised by an interstate committee. For ease of communication, this study uses a stratigraphic scheme devised as a result of work done primarily by Denesen (1985). This scheme consists of the following features:

1) The terms "Krebs," "Cabaniss," and "Senora" are not used in this report except to refer to the study interval as being within the Cabaniss subgroup as it is defined in Kansas, and the term "Cherokee Group" is used throughout the region as a formal term.
2) The Verdigris Formation is used throughout the region as it is currently used in Missouri with three members: the lower unnamed shale member, the Oakley shale member, and the Ardmore limestone member.
3) An informal formation, the "Banzet formation," is used to refer to the lithologies that occur between the top of the Ardmore limestone and the base of the Excello shale.
4) The Breezy Hill Limestone Member is used as a thin marker bed within the Banzet formation in Kansas and as a member of the Banzet formation in northeastern Oklahoma where it thickens to over 4 m (13 ft).
5) The Excello shale is used as the basal unit of the Marmaton Group.

Sedimentologic analysis of all available data shows that sands were deposited predominantly as northeast-southwestward-trending channels within elongated, fluvially dominated deltaic lobes. These lobes prograded across the margins of the Pennsylvanian epeiric sea during times of eustatic regression. Autocycles were formed as lobes shifted laterally. During times of eustatic transgression, siliciclastic point sources were shifted northward and eastward, removing most of them from the study area. Thin shales and carbonate units were deposited at slow rates during these times, resulting in thin transgressive hemicycles.

Petrographic analysis shows that sandstones are predominantly subarkoses, and they become quartzose and finer grained southwestward along a trend from which core specimens were obtained. Diagenetic alterations within these sandstones vary depending upon original sediment characteristics of the sites of deposition and on the sea-level changes that followed deposition. Marine-sandstone, sheetlike lenses are often pervasively cemented with iron-rich carbonate cement. Channel sandstones underwent chlorite coating of grains and silica cementation in the form of quartz overgrowths prior to extensive compaction due to burial. Late carbonate cementation, which was concomitant with or preceded by silica dissolution, set the stage for porosity and permeability enhancement during a still-later stage of carbonate dissolution. Petroleum generation and migration followed these stages of diagenetic alterations.

Continued study of Cherokee Group sandstones will ultimately result in the establishment of depositional and diagenetic models that can be used to predict the distributions and reservoir characteristics of potential petroleum-bearing sandstones within the Pennsylvanian epeiric sea and similar geologic settings.

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Appendix A—Banzet formation well-log data

1) Quarter-section data are coded so that 0 = center, 1 = NW 1/4, 2 = NE 1/4, 3 = SW 1/4, and 4 = SE 1/4.
2) All townships in Kansas are south; all townships in Oklahoma are north.
3) Log types are coded so that D = density, E = electric logs (SP, resistivity, laterologs, etc.), G = gamma ray, M = miscellaneous logs (e.g., temperature, dipmeter), N = neutron, P = porosity measurements, and S = sonic.
4) All measurements are in ft. Depths are in ft below kelley bushing.
5) Heading abbreviations are SE = section, TP = township, RGE = range, OAKL = Oakley shale, EXCE = Excello shale, INT THK = interval thickness, LO = sandstone in the lower portion of the Banzet formation, UP = sandstone in the upper portion of the Banzet formation, and TOT = sandstone.

Well	Qtr						Log	Total	Top	Base	INT		Sandstone	
Num	Sec	SE	Tp	Rge	County	State	Type	Depth	OAKL	EXCE	THK	LO	UP	TOT
1	021	03	01	15E	BROWN	KS	EMG	3028	1850	1748	102	20	15	35
2	334	31	01	17E	BROWN	KS	GNE	3312	1446	1348	98	14	26	40
3	021	07	02	16E	BROWN	KS	GE	2948	1754	1648	106	2	12	14
4	033	14	02	20E	DONIPHAN	KS	EGD	1779	1126	1028	98	24	15	39
5	013	25	03	13E	NEMAHA	KS	GNDEM	2999	1294	1210	84	20	18	38
8	224	34	03	17E	BROWN	KS	E	3365	1438	1354	84	0	0	0
9	013	27	03	18E	BROWN	KS	E	3270	2275	2160	115	0	0	0
10	024	04	03	20E	DONIPHAN	KS	EGND	1720	1120	1040	80	24	12	36
11	042	35	03	21E	DONIPHAN	KS	EGND	1620	1045	944	101	11	24	35
12	112	34	04	13E	NEMAHA	KS	E	3933	2280	2185	95	15	0	15
13	444	26	04	14E	NEMAHA	KS	GNE	3063	1900	1795	105	10	22	32
14	333	01	04	16E	BROWN	KS	E	3249	1495	1422	73	0	0	0
15	021	05	04	16E	BROWN	KS	GN	2875	1686	1597	89	15	19	34
16	114	25	05	12E	NEMAHA	KS	GNDEM	3522	1630	1518	112	9	24	33
17	333	20	05	13E	NEMAHA	KS	GNEM	3587	1992	1908	84	27	9	36
18	234	01	06	12E	JACKSON	KS	GDE	3539	1942	1836	106	16	22	38
19	014	20	06	14E	JACKSON	KS	GNE	3636	1852	1762	90	7	12	19
20	022	13	06	17E	ATCHISON	KS	EGD	2346	1360	1270	90	9	16	25
21	041	05	06	18E	ATCHISON	KS	GDE	2337	1380	1290	90	14	8	22
22	213	10	06	19E	ATCHISON	KS	E	2945	1290	1192	98	20	12	32
23	21	10	06	19E	ATCHISON	KS	GN	0	1232	1148	84	14	3	17
24	22	27	6	20E	ATCHISON	KS	GDNE	1522	1003	914	89	4	16	20
25	022	06	07	12E	POTTAWATOMIE	KS	GN	3016	1944	1870	74	0	0	0
26	333	09	07	12E	POTTAMATOMIE	KS	EMGD	3597	1370	1260	110	12	6	18
27	011	21	07	13E	JACKSON	KS	GEM	3322	1944	1842	102	15	18	33
28	021	24	07	16E	JEFFERSON	KS	GEM	2972	1326	1222	117	40	11	51
29	344	27	7	17E	JEFFERSON	KS	GNDE	2489	1438	1338	100	12	17	29
30	032	04	07	18E	ATCHISON	KS	GDE	2306	1344	1250	94	15	9	24
31	242	26	7	18E	JEFFERSON	KS	GNDE	2852	1270	1186	84	10	6	16
32	034	02	07	20E	ATCHISON	KS	GDE	1695	1183	1078	105	2	25	27
33	401	5	7	21E	ATCHISON	KS	GNDE	1525	1002	912	90	8	21	29
34	313	18	7	21E	ATCHISON	KS	GNDE	1597	1114	1004	110	29	10	39
35	424	18	07	21E	ATCHISON	KS	GDE	1603	1326	1218	108	37	18	55
36	032	18	07	22E	ATCHISON	KS	EM	2846	848	750	98	0	15	15
37	344	23	08	10E	POTTAWATOMIE	KS	IGD	1539	856	740	116	18	30	48
38	012	26	08	11E	POTTAWATOMIE	KS	GDE	3528	2002	1920	82	22	11	33
39	023	06	08	13E	JACKSON	KS	GN	3533	2008	1913	95	12	5	17
40	111	14	8	15E	JACKSON	KS	GN	2579	1400	1316	84	0	0	0
42	111	35	8	16E	JACKSON	KS	GN	0	1487	1385	102	16	10	26
43	323	16	08	17E	JEFFERSON	KS	GN	1944	1322	1224	92	10	17	27
44	042	16	08	20E	JEFFERSON	KS	GN	1650	1390	1263	98	12	19	31
45	42	16	8	20E	JEFFERSON	KS	GN	1640	1174	1076	105	17	20	37
46	12	24	8	20E	LEAVENWORTH	KS	GN	1385	932	830	102	0	28	28
47	332	24	8	20E	LEAVENWORTH	KS	GND	1554	954	828	126	2	121	4
48	331	9	8	21E	LEAVENWORTH	KS	GND	1679	1076	978	98	12	11	23
49	12	11	8	21E	LEAVENWORTH	KS	GDE	1691	1030	935	96	4	31	35
50	111	15	8	21E	LEAVENWORTH	KS	GD	1584	1086	987	99	16	32	48
51	444	15	8	21E	LEAVENWORTH	KS	GND	1494	950	850	100	9	15	26
52	431	17	8	21E	LEAVENWORTH	KS	GD	1536	1042	944	98	16	13	29
53	013	19	08	21E	LEAVENWORTH	KS	GND	1515	1056	956	100	10	29	39
54	411	20	8	21E	LEAVENWORTH	KS	GN	1432	1034	930	104	17	13	30
55	423	20	8	21E	LEAVENWORTH	KS	GD	1484	906	806	100	11	21	32
56	131	21	8	21E	LEAVENWORTH	KS	GD	1534	1056	957	99	16	8	24
57	222	21	8	21E	LEAVENWORTH	KS	GDN	1478	1012	914	98	21	15	36

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
58	232	21	8	21E	LEAVENWORTH	KS	GDN	1456	996	894	100	20	21	41
59	21	33	8	21E	LEAVENWORTH	KS	GDE	2353	1050	948	102	19	13	32
60	023	16	09	10E	POTTAWATOMIE	KS	IGD	1579	899	770	129	30	22	52
61	011	25	09	12E	JACKSON	KS	GN	3263	1879	1786	93	24	17	41
62	021	12	09	13E	JACKSON	KS	IE	3168	1744	1640	104	26	32	58
63	001	02	09	20E	LEAVENWORTH	KS	GND	1700	850	760	90	0	12	12
64	24	3	9	20E	LEAVENWORTH	KS	GD	1554	994	906	88	3	17	20
65	231	3	9	20E	LEAVENWORTH	KS	GND	1490	1110	1012	98	5	14	19
66	10	20	9	20E	LEAVENWORTH	KS	GND	1672	1078	987	89	10	10	20
67	34	32	9	20E	LEAVENWORTH	KS	G	1449	1102	1012	90	10	12	22
68	4	33	9	20E	LEAVENWORTH	KS	GND	1870	1088	995	93	5	40	45
69	333	17	9	21E	LEAVENWORTH	KS	GNDE	1447	976	886	90	5	12	17
70	2	25	9	21E	LEAVENWORTH	KS	GNDE	1399	926	818	108	10	25	35
71	232	20	9	22E	LEAVENWORTH	KS	GDE	1528	904	804	100	15	10	25
72	424	30	10	12E	WABAUNSEE	KS	GN	3080	1720	1629	91	6	19	25
73	431	30	10	12E	WABAUNSEE	KS	GNI	3120	1797	1692	105	8	5	13
74	024	14	10	14E	SHAWNEE	KS	E	3027	1703	1607	96	3	2	5
75	423	15	10	19E	JEFFERSON	KS	E	2256		1070	98	0	0	0
76	021	27	10	19E	JEFFERSON	KS	E	2270	1318	1220	98	6	3	9
77	243	1	10	20E	LEAVENWORTH	KS	GN	1728	1072	970	102	11	22	33
78	134	4	10	20E	JEFFERSON	KS	GNES	1808	1070	974	96	6	32	38
79	241	5	10	20E	JEFFERSON	KS	GN	1739	1176	1088	88	21	27	48
80	322	5	10	20E	JEFFERSON	KS	GN	1862	1130	1038	92	0	30	30
81	442	5	10	20E	JEFFERSON	KS	GNES	1825	1077	982	95	2	21	23
82	332	19	10	20E	JEFFERSON	KS	E	1760	1157	1042	115	15	6	21
83	21	29	10	21E	LEAVENWORTH	KS	GNDE	1777	922	820	102	9	12	21
84	222	15	10	22E	LEAVENWORTH	KS	GN	1765	840	748	113	7	19	26
85	223	14	11	10E	WABAUNSEE	KS	GN	3384	2236	2127	109	6	15	21
86	432	16	11	11E	WABAUNSEE	KS	GN	3072	2046	1959	87	6	10	16
87	132	26	11	12E	WABAUNSEE	KS	GNP	3030	1855	1743	112	25	20	45
88	041	20	11	13E	WABAUNSEE	KS	E	3035	1925	1850	75	0	6	6
89	2	19	11	22E	LEAVENWORTH	KS	GNDE	778	728	615	113	0	76	76
90	41	29	11	22E	LEAVENWORTH	KS	GNDE	785	724	644	80	0	5	5
91	211	23	11	23E	WYANDOTTE	KS	GE	567	466	370	96	0	20	20
94	444	25	12	10E	WABAUNSEE	KS	GN	3307	2298	2221	77	5	15	20
95	344	18	12	11E	WABAUNSEE	KS	EGN	3453	2030	1944	86	12	8	20
96	013	06	12	13E	WABAUNSEE	KS	IGN	2994	1668	1582	86	10	14	24
97	411	13	12	17E	DOUGLAS	KS	ENGDS	2973	1295	1204	91	3	18	21
98	21	23	12	20E	LEAVENWORTH	KS	GNDE	894	830	722	108	0	32	32
100	123	33	12	20E	DOUGLAS	KS	(REP)	1270	750	640	110	0	62	62
101	14	7	12	21E	LEAVENWORTH	KS	GND	1375	854	692	164	0	88	88
102	41	7	12	21E	LEAVENWORTH	KS	GN	697		683	+14	0	0	0
103	422	06	12	22E	LEAVENWORTH	KS	GN	1875	812	707	100	0	61	61
104	332	26	12	23E	JOHNSON	KS	GN	546	550	448	102	0	20	20
106	43	7	12	24E	JOHNSON	KS	GD	863	852	730	122	0	67	67
107	0	31	12	24E	JOHNSON	KS	GE	863	604	490	114	0	24	24
108	144	31	12	24E	JOHNSON	KS	GN	720	686	576	110	0	59	59
109	34	32	12	24E	JOHNSON	KS	GN	689	686	572	114	0	55	55
110	333	32	12	24E	JOHNSON	KS	GN	708	710	598	112	0	46	46
111	334	32	12	24E	JOHNSON	KS	GN	727	716	609	112	0	53	53
112	134	35	13	08E	WABAUNSEE	KS	EIP	3516	2305	2225	80	0	0	0
113	232	33	13	10E	WABAUNSEE	KS	GN	3262	2188	2104	84	4	6	10
114	0	15	13	16E	SHAWNEE	KS	E	2375	1253	1170	83	0	0	0
115	441	15	13	16E	SHAWNEE	KS	E	2376	1342	1240	102	16	5	21
116	141	05	13	17E	DOUGLAS	KS	E	1315		1270	+45	0	0	0
117	341	5	13	17E	DOUGLAS	KS	E	1715	1258	1166	92	0	0	0
118	0	21	13	19E	DOUGLAS	KS	E	1832	800	702	98	0	5	5
119	222	03	13	22E	JOHNSON	KS	E	1542	687	597	90	0	0	0
120	443	36	13	22E	JOHNSON	KS	GND	876	717	632	85	0	24	24
121	222	1	13	23E	JOHNSON	KS	GN	590	572	468	104	0	23	23
122	22	17	13	23E	JOHNSON	KS	GN	708	706	610	96	0	27	27
123	0	31	13	23E	JOHNSON	KS	GN	799	694	602	92	0	15	15
124	43	31	13	23E	JOHNSON	KS	GN	772	658	570	88	0	29	29
125	123	5	13	24E	JOHNSON	KS	GN	688	674	571	113	0	19	19
126	133	5	13	24E	JOHNSON	KS	GN	638	628	520	108	0	30	30
127	213	5	13	24E	JOHNSON	KS	GN	670	644	536	108	0	24	24
128	413	5	13	24E	JOHNSON	KS	GN	724	705	598	107	0	17	17
129	431	6	13	24E	JOHNSON	KS	GN	692	670	566	104	0	31	31
131	113	09	13	25E	JOHNSON	KS	GN	494			+17	4	13	17

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
132	444	11	13	25E	JOHNSON	KS	GN	526	522	429	93	0	57	57
133	024	08	14	07E	MORRIS	KS	GN	2120	1270	1258	12	0	0	0
134	022	04	14	08E	MORRIS	KS	ES	2422	1861	1848	13	0	0	0
135	043	24	14	10E	WABAUNSEE	KS	GSNE	3470	2314	2218	96	8	5	13
136	233	27	14	11E	WABAUNSEE	KS	GNE	3398	2267	2178	89	2	5	7
137	044	20	14	12E	WABAUNSEE	KS	GNES	3157	2047	1960	87	13	12	25
138	331	14	14	15E	OSAGE	KS	E	2532	1445	1360	85	12	0	12
139	022	08	14	17E	OSAGE	KS	E	1956	1206	1108	98	0	0	0
140	013	27	14	19E	DOUGLAS	KS	ES	1474	1062	960	102	4	7	11
141	444	1	14	22E	JOHNSON	KS	GE	777	701	601	100	0	31	31
142	031	12	14	22E	JOHNSON	KS	EGN	1468	830	734	96	5	20	25
143	141	17	14	22E	JOHNSON	KS	GN	873	736	632	104	0	22	22
144	134	22	14	22E	JOHNSON	KS	GN	850	736	644	92	0	8	8
145	11	28	14	22E	JOHNSON	KS	GN	914	682	577	105	0	14	14
146	2	30	14	22E	JOHNSON	KS	GNE	910	769	664	105	0	22	22
147	1	19	14	24E	JOHNSON	KS	GN	761	720	625	95	0	34	34
148	2	19	14	24E	JOHNSON	KS	GN	763	752	658	94	0	46	46
149	111	20	14	24E	JOHNSON	KS	GN	722	696	604	92	0	28	28
150	221	21	14	25E	JOHNSON	KS	GNDE	552	530	423	107	2	4	6
151	343	21	14	25E	JOHNSON	KS	GNDE	551	527	431	96	0	11	11
152	214	02	15	07E	MORRIS	KS	GN	2606	1954	1892	62	0	0	0
153	012	22	15	08E	MORRIS	KS	GNE	3210	2217	2130	87	0	5	5
154	444	33	15	10E	LYON	KS	GN	3189	2288	2180	108	18	3	21
155	031	11	15	12E	WABAUNSEE	KS	IE	3084	1953	1820	133	13	6	19
156	334	04	15	13E	WABAUNSEE	KS	IEGS	2232	1782	1686	96	4	2	6
157	113	07	15	17E	OSAGE	KS	E	2195	1282	1182	100	2	2	4
158	012	17	15	18E	DOUGLAS	KS	IS	2117	1195	1103	92	8	4	12
159	241	01	15	20E	FRANKLIN	KS	IED	2021	1202	1120	82	10	4	14
160	14	24	15	20E	DOUGLAS	KS	GN	861	861	787	74	0	0	0
161	134	32	15	21E	FRANKLIN	KS	GN	747	747	712	35	0	0	0
162	014	34	15	22E	MIAMI	KS	GN	1461	670	568	102	0	5	5
163	141	31	15	24E	MIAMI	KS	GN	847	648	546	102	6	18	24
164	344	18	15	25E	MIAMI	KS	GN	697	697	611	86	0	0	0
165	433	13	16	07E	MORRIS	KS	IE	3128	2374	2304	70	0	0	0
166	214	09	16	11E	LYON	KS	IE	3200	2138	2040	98	0	5	5
167	421	23	16	16E	OSAGE	KS	GN	2075	1262	1158	104	11	9	20
168	312	15	16	17E	OSAGE	KS	EM	1958	1207	1105	102	6	2	8
169	034	17	16	18E	FRANKLIN	KS	EM	1918	1186	1092	94	12	5	17
171	331	11	16	21E	MIAMI	KS	GN	733	733	659	74	11	21	32
172	23	12	16	21E	MIAMI	KS	GN	732	732	676	56	0	25	25
174	11	24	16	21E	MIAMI	KS	GN	735	735	669	66	8	18	26
175	0	25	16	21E	MIAMI	KS	GN	729	705	636	69	2	12	14
176	13	26	16	21E	MIAMI	KS	GN	740	699	649	50	1	18	19
177	0	35	16	21E	MIAMI	KS	GN	679	679	638	41	0	0	0
178	13	12	16	22E	MIAMI	KS	GN	736	736	666	70	0	0	0
179	3	31	16	22E	MIAMI	KS	GN	753	753	656	97	2	26	28
180	4	31	16	22E	MIAMI	KS	GN	725	725	646	79	0	0	0
181	123	31	16	22E	MIAMI	KS	GN	757	757	673	84	4	20	24
182	0	22	16	23E	MIAMI	KS	GN	841	573	475	98	8	16	24
183	0	36	16	23E	MIAMI	KS	GN	730	631	539	92	21	13	34
184	424	11	16	24E	MIAMI	KS	GN	930	632	549	83	37	17	54
185	22	20	16	24E	MIAMI	KS	GN	531	510	476	34	5	10	15
186	0	31	16	24E	MIAMI	KS	GN	665	576	479	97	25	23	48
187	324	31	16	24E	MIAMI	KS	GN	606	560	465	95	25	23	48
188	1	26	16	25E	MIAMI	KS	GND	1190	497	422	75	30	3	33
189	000	22	17	06E	MORRIS	KS	GN	2148	1925	1888	37	0	0	0
190	022	25	17	08E	MORRIS	KS	EIG	3370	2530	2454	76	4	3	7
191	114	04	17	10E	LYON	KS	E	3050	2050	1946	104	0	0	0
192	033	07	17	12E	LYON	KS	GNE	2740	1884	1788	96	3	9	12
193	113	31	17	16E	OSAGE	KS	E	2160	1340	1240	100	12	2	14
194	311	10	17	21E	FRANKLIN	KS	GN	697	697	598	99	0	0	0
195	321	10	17	21E	FRANKLIN	KS	GN	640	640	602	38	0	0	0
196	44	14	17	21E	MIAMI	KS	GN	579	579	548	31	0	0	0
197	2	16	17	21E	FRANKLIN	KS	GN	990	588	480	108	10	17	27
198	311	20	17	21E	FRANKLIN	KS	G	623	623	578	45	0	0	0
199	44	25	17	21E	MIAMI	KS	GN	546	546	480	66	0	0	0
200	343	26	17	21E	MIAMI	KS	GN	564	564	462	102	0	0	0
201	3	1	17	22E	MIAMI	KS	GN	654	604	504	100	3	7	10
202	333	1	17	22E	MIAMI	KS	GN	649	594	502	92	3	3	6

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	Sandstone UP	Sandstone TOT
203	44	3	17	22E	MIAMI	KS	GN	930	649	540	109	11	12	23
204	113	4	17	22E	MIAMI	KS	GN	710	710	669	41	0	0	0
205	13	5	17	22E	MIAMI	KS	GN	761	756	657	99	0	0	0
206	42	5	17	22E	MIAMI	KS	GN	753	740	674	66	0	0	0
207	0	6	17	22E	MIAMI	KS	GN	719	719	650	69	6	13	19
208	2	6	17	22E	MIAMI	KS	GN	719	719	649	70	6	13	19
209	21	8	17	22E	MIAMI	KS	GN	762	762	676	86	11	26	37
210	1	12	17	22E	MIAMI	KS	GN	906	599	519	80	15	24	39
211	111	12	17	22E	MIAMI	KS	GN	615	590	498	92	15	17	32
212	0	13	17	22E	MIAMI	KS	GN	712	646	570	76	32	4	36
213	111	16	17	22E	MIAMI	KS	GDP	1568	772	660	112	4	38	42
214	12	23	17	22E	MIAMI	KS	GN	664	588	539	49	13	5	18
215	0	25	17	22E	MIAMI	KS	GN	553	553	521	32	0	0	0
216	11	31	17	22E	MIAMI	KS	GN	522	522	480	42	0	0	0
217	134	35	17	22E	MIAMI	KS	CGND	736	588	527	61	19	23	42
218	1	11	17	23E	MIAMI	KS	GR	864	626	547	79	26	6	32
219	0	20	17	23E	MIAMI	KS	GN	866	560	471	89	21	3	24
220	12	20	17	23E	MIAMI	KS	G	732	500	406	94	5	12	17
221	0	22	17	23E	MIAMI	KS	GN	750	538	448	90	17	1	18
222	424	22	17	23E	MIAMI	KS	GN	835	499	408	91	17	1	18
223	0	24	17	23E	MIAMI	KS	GSPR	1326	548	466	82	11	12	23
224	0	6	17	24E	MIAMI	KS	GN	730	606	510	96	18	3	21
227	4	30	17	24E	MIAMI	KS	GN	867	610	532	78	21	2	23
229	13	30	17	25E	MIAMI	KS	GN	867	610	531	79	36	2	38
230	022	07	18	07E	CHASE	KS	GND	2157	1970	1932	38	0	0	0
231	141	20	18	09E	CHASE	KS	GNIP	3065	2194	2090	104	8	0	8
232	232	22	18	09E	CHASE	KS	E	3151	2197	2093	104	3	0	3
233	214	31	18	11E	LYON	KS	GN	2773	1898	1804	94	3	3	6
234	423	6	18	16E	OSAGE	KS	GN	1909	1172	1079	93	9	27	36
235	011	06	18	17E	OSAGE	KS	GNEID	2545	1060	964	96	10	4	14
236	0	12	18	20E	FRANKLIN	KS	GN	741	741	642	99	0	0	0
237	114	13	18	20E	FRANKLIN	KS	GN	764	764	666	98	0	0	0
238	221	24	18	20E	FRANKLIN	KS	GN	754	754	670	84	0	0	0
239	0	1	18	21E	MIAMI	KS	GN	547	547	490	57	0	0	0
240	3	23	18	21E	MIAMI	KS	GN	593	587	482	105	0	0	0
241	0	27	18	21E	FRANKLIN	KS	GN	625	624	549	75	0	0	0
242	1	4	18	22E	MIAMI	KS	GN	746	528	428	100	9	14	23
243	2	8	18	22E	MIAMI	KS	GN	679	586	483	103	10	23	33
244	233	9	18	22E	MIAMI	KS	GSPR	671	552	451	101	4	16	20
245	2	10	18	22E	MIAMI	KS	GN	574	531	434	97	4	25	29
246	0	12	18	22E	MIAMI	KS	GN	572	514	440	74	25	13	38
247	344	1	18	23E	MIAMI	KS	GN	601	500	432	68	0	9	9
248	434	18	18	23E	MIAMI	KS	GNEID	2188	506	406	100	4	2	6
250	323	16	18	24E	MIAMI	KS	GN	554	554	478	76	0	0	0
251	0	17	18	24E	MIAMI	KS	GN	510	478	408	70	14	15	29
252	0	18	18	24E	MIAMI	KS	GN	492	475	404	71	8	21	29
253	321	21	18	24E	MIAMI	KS	GN	522	512	444	68	0	0	0
254	222	31	18	25E	MIAMI	KS	GN	1035	728	631	97	10	29	39
255	111	20	19	06E	CHASE	KS	GN	3100	2183	2102	81	24	9	33
257	444	11	19	10E	LYON	KS	EM	2800	1855	1780	75	6	5	11
258	444	23	19	10E	LYON	KS	GN	2838	1884	1794	90	4	4	8
259	232	2	19	12E	LYON	KS	GN	1945	1664	1564	100	4	6	10
260	314	4	19	12E	LYON	KS	GN	2043	1721	1627	94	4	12	16
261	212	26	19	12E	LYON	KS	GN	2480	1586	1489	97	10	10	20
262	334	24	19	13E	COFFEY	KS	GN	2291	1538	1422	116	12	11	23
263	113	27	19	13E	LYON	KS	GN	2301	1550	1444	106	5	6	11
264	424	34	19	13E	LYON	KS	GN	2288	1508	1404	104	4	7	11
265	442	1	19	14E	COFFEY	KS	GN	1729	1418	1325	93	6	6	12
266	331	27	19	14E	COFFEY	KS	GN	2258	1453	1350	103	16	6	22
267	114	30	19	14E	COFFEY	KS	GN	2288	1478	1371	107	10	12	22
268	112	34	19	14E	COFFEY	KS	GN	2299	1443	1340	103	14	6	20
269	131	6	19	15E	COFFEY	KS	GN	2286	1394	1306	88	8	7	15
270	331	06	19	15E	COFFEY	KS	GN	2290	1392	1304	88	8	7	15
271	112	34	19	17E	COFFEY	KS	GN	1882	169	90	79	14	5	19
272	013	23	19	21E	LINN	KS	GN	808	808	722	86	0	8	8
273	0	14	19	22E	MIAMI	KS	GN	622	556	466	90	5	9	14
274	0	35	19	22E	LINN	KS	GN	915	630	542	88	13	10	23
275	222	01	20	07E	CHASE	KS	E	2830	2120	2030	90	0	0	0
277	434	28	20	08E	CHASE	KS	EM	2503	2136	2036	100	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
278	334	36	20	08E	CHASE	KS	GN	3097	2218	2138	80	6	8	14
279	411	29	20	10E	LYON	KS	GN	2320	2225	2120	105	6	6	12
280	14	10	20	10E	LYON	KS	E	2834	1970	1864	106	6	3	9
281	314	18	20	10E	LYON	KS	GN	2383	2130	2025	105	6	3	9
282	111	20	20	10E	LYON	KS	GN	2409	2160	2058	102	3	2	5
284	443	30	20	10E	LYON	KS	GN	2490	2211	2102	109	0	0	0
285	332	32	20	10E	LYON	KS	GN	2370	2172	2074	98	3	2	5
286	224	15	20	11E	LYON	KS	EGN	2648	1812	1700	112	17	4	21
287	224	8	20	12E	LYON	KS	GN	2532	1703	1598	105	5	4	9
288	024	17	20	12E	LYON	KS	GN	2612	1485	1364	121	26	26	52
289	132	27	20	13E	LYON	KS	GN	2241	1492	1392	100	3	6	9
290	313	36	20	13E	COFFEY	KS	GN	2208	1468	1372	96	5	9	14
291	331	9	20	14E	COFFEY	KS	GN	2176	1408	1299	109	5	5	10
292	441	16	20	14E	COFFEY	KS	GN	2175	1407	1300	107	4	7	11
293	431	25	20	14E	COFFEY	KS	GN	2181	1330	1234	96	6	6	12
294	000	31	20	14E	COFFEY	KS	EI	2179	1334	1232	102	4	6	10
295	334	3	20	15E	COFFEY	KS	GN	2154	1376	1273	103	9	17	26
296	111	11	20	15E	COFFEY	KS	GN	2158	1376	1290	86	10	6	16
297	114	33	20	15E	COFFEY	KS	GN	2062	1301	1210	91	11	26	37
298	221	5	20	16E	COFFEY	KS	GN	2093	1340	1255	85	12	13	25
299	442	19	20	17E	COFFEY	KS	GN	1988	1210	1128	82	16	15	31
300	144	08	20	19E	ANDERSON	KS	GN	1844	851	764	87	6	7	13
301	433	15	20	19E	ANDERSON	KS	GN	853	820	+33	0	0	0	
302	134	13	20	20E	ANDERSON	KS	GN	819	760	666	94	9	12	21
303	223	13	20	20E	ANDERSON	KS	GN	843	788	695	93	9	10	19
304	313	13	20	20E	ANDERSON	KS	GN	819	728	637	91	4	10	14
305	324	13	20	20E	ANDERSON	KS	GN	759	713	622	91	9	4	13
306	324	13	20	20E	ANDERSON	KS	GN	801	758	664	94	7	6	13
307	344	13	20	20E	ANDERSON	KS	GN	853	810	716	94	6	4	10
308	444	13	20	20E	ANDERSON	KS	GN	878	824	726	98	5	3	8
309	000	22	20	20E	ANDERSON	KS	G	708		631	+77	17	17	
310	441	22	20	20E	ANDERSON	KS	GN	706		639	+67	15	15	
311	000	27	20	21E	ANDERSON	KS	GN	621		555	+66	4	4	
312	122	27	20	21E	ANDERSON	KS	GN	621		544	+77	3	3	
313	222	27	20	21E	ANDERSON	KS	GN	615		545	+70	4	4	
314	314	27	20	21E	ANDERSON	KS	GN	641		564	+77	3	3	
315	131	33	20	21E	ANDERSON	KS	DEI	685	680	585	95	0	10	10
316	000	16	20	22E	LINN	KS	GN	625	610	518	92	15	3	18
317	000	19	20	22E	LINN	KS	GN	626		555	+71		14	14
318	131	20	20	22E	LINN	KS	GN	642	634	550	84	20	4	24
319	000	30	20	22E	LINN	KS	G	579		494	+85	14	0	14
320	211	30	20	22E	LINN	KS	GN	579		494	+85		8	8
321	430	17	21	05E	MARION	KS	GN	2345	2086	1982	104	0	0	0
322	111	8	21	10E	LYON	KS	GN	2286	2078	1978	100	23	0	23
323	333	12	21	10E	LYON	KS	GN	2629	1940	1842	98	6	3	9
324	34	18	21	10E	LYON	KS	GN	2273	2104	2009	95	2	2	4
325	142	19	21	10E	LYON	KS	GN	2175	2020	1927	93	5	3	8
326	134	24	21	10E	LYON	KS	GN	2540	1870	1770	100	2	2	4
327	11	30	21	10E	LYON	KS	GN	2298	2120	2027	93	2	2	4
328	212	25	21	11E	LYON	KS	GN	2559	1818	1718	100	5	5	10
329	0	29	21	11E	LYON	KS	GN	1971	1790	1692	98	6	6	12
330	221	3	21	12E	LYON	KS	GN	2482	1680	1576	104	1	6	7
331	2	32	21	12E	LYON	KS	GN	2111	1732	1635	97	7	2	9
332	332	1	21	13E	COFFEY	KS	GN	2226	1486	1374	112	4	17	21
333	144	11	21	13E	COFFEY	KS	GN	2283	1546	1429	117	2	11	13
334	142	14	21	13E	COFFEY	KS	GN	1846	1564	1463	101	1	13	14
335	223	20	21	13E	LYON	KS	GN	2384	1636	1536	100	1	10	11
336	422	23	21	13E	COFFEY	KS	GN	2256	1496	1390	106	4	11	15
337	333	24	21	13E	COFFEY	KS	GN	2252	1516	1410	106	2	15	17
338	441	25	21	13E	COFFEY	KS	GN	2245	1512	1406	106	3	16	19
339	122	26	21	13E	COFFEY	KS	GN	2246	1518	1410	108	4	8	12
340	232	35	21	13E	COFFEY	KS	GN	2232	1561	1443	118	26	10	36
341	444	36	21	13E	COFFEY	KS	GN	2241	1542	1428	114	25	35	60
342	442	3	21	14E	COFFEY	KS	GN	2010	1392	1286	106	2	6	8
343	231	10	21	14E	COFFEY	KS	GN	1995	1394	1298	96	2	35	37
344	243	11	21	14E	COFFEY	KS	GN	195	1325	1223	102	5	10	15
345	333	16	21	14E	COFFEY	KS	GN	2300	1470	1365	105	7	8	15
346	123	19	21	14E	COFFEY	KS	GN	2220	1480	1379	101	5	9	14
347	441	22	21	14E	COFFEY	KS	GN	2175	1414	1310	104	3	11	14

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
348	142	30	21	14E	COFFEY	KS	GN	2238	1508	1400	108	3	7	10
349	441	31	21	14E	COFFEY	KS	GN	2249	1510	1408	102	2	30	32
350	423	32	21	14E	COFFEY	KS	GN	1607	1499	1389	110	0	22	22
351	131	34	21	14E	COFFEY	KS	GN	2248	1374	1362	112	3	9	12
352	111	11	21	15E	COFFEY	KS	GN	1990	1276	1176	100	9	12	21
353	122	16	21	15E	COFFEY	KS	GN	1888	1227	1133	94	7	12	19
354	331	21	21	15E	COFFEY	KS	GN	2022	1280	1178	102	7	12	19
355	331	29	21	15E	COFFEY	KS	GN	2090	1302	1208	94	3	10	13
356	414	31	21	15E	COFFEY	KS	GN	2119	1342	1236	106	22	28	50
357	334	33	21	15E	COFFEY	KS	GN	1998	1294	1196	98	10	27	37
358	113	11	21	16E	COFFEY	KS	GN	1853	1198	1092	106	9	12	21
359	221	24	21	17E	ANDERSON	KS	GN	1385	1017	928	89	10	19	29
360	004	03	21	19E	ANDERSON	KS	EIGN	1111	810	726	84	10	11	21
361	113	14	21	20E	ANDERSON	KS	GN	857		766	+91		28	28
362	124	15	21	20E	ANDERSON	KS	GN	849		792	+57		7	7
363	411	15	21	20E	ANDERSON	KS	GN	866	605	515	90	4	7	11
364	131	16	21	20E	ANDERSON	KS	GN	859		784	+75		20	20
365	241	16	21	20E	ANDERSON	KS	GN	853	786		+67		13	13
366	001	04	21	21E	ANDERSON	KS	GN	755	643	553	90	12	16	28
367	100	04	21	21E	ANDERSON	KS	GN	741	638	548	90	20	22	42
368	104	04	21	21E	ANDERSON	KS	GN	749	640	550	90	10	20	30
369	323	04	21	21E	ANDERSON	KS	GN	746	640	550	90	22	18	40
370	021	08	21	21E	ANDERSON	KS	GN	637		592	+45		20	20
372	222	31	21	24E	LINN	KS	EIGN	865	270	165	105	14	22	36
373	304	31	21	24E	LINN	KS	GN	882	266	152	114	30	26	56
374	113	23	22	06E	CHASE	KS	EI	3238	2654	2567	87	6	6	12
375	332	29	22	09E	CHASE	KS	EI	2729	2460	2340	120	11	4	15
376	443	1	22	10E	GREENWOOD	KS	GN	2037	1879	1782	97	5	18	23
377	222	4	22	10E	GREENWOOD	KS	GN	2234	1950	1855	95	6	3	9
378	0	5	22	10E	GREENWOOD	KS	GN	2370	2113	2024	89	8	12	20
379	0	10	22	10E	GREENWOOD	KS	GN	2381	2141	2046	95	3	3	6
380	122	11	22	10E	GREENWOOD	KS	GN	2143	1957	1860	97	0	0	0
381	333	17	22	10E	GREENWOOD	KS	GN	2384	2227	2133	94	10	18	28
382	442	19	22	10E	GREENWOOD	KS	E	2369	2170	2078	92	0	18	18
383	123	29	22	10E	GREENWOOD	KS	EG	2368	2222	2137	85	10	4	14
384	424	33	22	10E	GREENWOOD	KS	EI	2323	2018	1938	80	5	6	11
385	113	07	22	11E	GREENWOOD	KS	GN	2137	1975	1886	89	6	0	6
386	141	07	22	11E	GREENWOOD	KS	EI	2741	1988	1890	98	6	2	8
387	424	10	22	11E	GREENWOOD	KS	GN	1810	1675	1577	98	7	8	15
388	0	19	22	11E	GREENWOOD	KS	GN	0	1972	1877	95	7	16	23
389	412	27	22	11E	GREENWOOD	KS	GN	2121	1826	1730	96	7	11	18
390	0	31	22	11E	GREENWOOD	KS	GN	1750	1879	1796	83	5	14	19
391	42	32	22	11E	GREENWOOD	KS	GN	1997	1813	1718	95	6	1	7
392	121	26	22	12E	GREENWOOD	KS	EI	1780	1540	1460	80	25	0	25
393	233	11	22	13E	COFFEY	KS	GN	2250	1552	1446	106	14	32	46
394	133	10	22	14E	COFFEY	KS	GN	2183	1432	1326	106	10	23	33
395	0	27	22	14E	COFFEY	KS	GN	2172	1404	1299	105	18	2	20
396	123	27	22	14E	COFFEY	KS	GN	2172	1404	1298	106	22	5	27
397	224	13	22	15E	COFFEY	KS	GN	1894	1209	1116	93	8	27	35
398	242	14	22	15E	COFFEY	KS	GN	2006	1258	1162	96	2	13	15
399	442	25	22	15E	COFFEY	KS	GN	1126	1128	1036	92	0	32	32
400	123	29	22	15E	COFFEY	KS	GN	2080	1344	1232	112	2	16	18
401	444	36	22	15E	COFFEY	KS	GN	1093	0	1047	+46	0	8	8
402	221	11	22	16E	COFFEY	KS	GN	1780	1086	996	90	8	24	32
403	124	19	22	16E	COFFEY	KS	GN	1102		1004	+98	0	19	19
404	142	19	22	16E	COFFEY	KS	GN	1067		1004	+63		19	19
405	224	19	22	16E	COFFEY	KS	GN	1064	1010		+54		19	19
406	342	19	22	16E	COFFEY	KS	GN	1099	1003		+96		16	16
407	423	19	22	16E	COFFEY	KS	GN	1113	1095	999	96	23	12	35
408	424	19	22	16E	COFFEY	KS	GN	1099		1005	+94	3	37	40
409	124	21	22	16E	COFFEY	KS	GN	1037	0	980	+57	0	12	12
410	13	22	22	16E	COFFEY	KS	GN	1021	0	972	+49	0	8	8
411	323	27	22	16E	COFFEY	KS	GN	1012	0	958	+46	0	15	15
412	1	28	22	16E	COFFEY	KS	GN	1010	0	958	+52	0	26	26
413	124	28	22	16E	COFFEY	KS	GN	1023		964	+59		26	26
414	442	28	22	16E	COFFEY	KS	GN	1037	0	964	+73	2	38	40
415	333	30	22	16E	COFFEY	KS	GN	1052	0	1028	+24	0	13	13
416	113	31	22	16E	COFFEY	KS	GN	1416	1157	1050	107	1	13	14

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
417	113	29	22	17E	COFFEY	KS	GN	1003		937	+66	1	0	1
418	344	29	22	17E	COFFEY	KS	E	1004		935	+69	20	14	34
419	031	13	22	22E	LINN	KS	EI	749	544	440	104	9	14	23
422	243	08	23	04E	BUTLER	KS	GN	2455	2358	2334	24	7	9	16
423	034	22	23	04E	BUTLER	KS	EI	2450	2418		+32		14	14
424	443	34	23	05E	BUTLER	KS	EIGN	2546	2422	2369	53	1	5	6
426	022	11	23	08E	GREENWOOD	KS	ISE	2814	2572	2487	85	12	0	12
427	222	30	23	08E	BUTLER	KS	EI	2802	2576	2492	84	10	7	17
428	234	1	23	10E	GREENWOOD	KS	GN	2135	1966	1872	94	4	11	15
429	312	4	23	10E	GREENWOOD	KS	GN	2216	2090	1996	94	4	0	4
430	222	12	23	10E	GREENWOOD	KS	GN	2099	1910	1810	100	0	6	6
431	223	13	23	10E	GREENWOOD	KS	GN	2150	1942	1848	94	5	0	5
432	131	19	23	10E	GREENWOOD	KS	GN	2317	2187	2094	93	5	6	11
433	422	22	23	10E	GREENWOOD	KS	GN	2152	1975	1880	95	0	6	6
434	143	29	23	10E	GREENWOOD	KS	GN	2375	2220	2124	96	8	20	28
435	132	3	23	11E	GREENWOOD	KS	GN	1880	1786	1690	96	3	7	10
436	314	16	23	11E	GREENWOOD	KS	GN	2006	1836	1738	98	4	0	4
437	131	26	23	11E	GREENWOOD	KS	GN	1861	1690	1580	110	5	5	10
438	0	9	23	12E	GREENWOOD	KS	EIGD	2294	1588	1481	107	0	14	14
439	0	20	23	12E	GREENWOOD	KS	GD	2346	1645	1537	108	0	21	21
440	441	9	23	13E	GREENWOOD	KS	GN	1919	1255	1144	111	3	14	17
441	023	15	23	13E	GREENWOOD	KS	EIGN	2215	1459	1357	102	7	2	9
442	124	29	23	13E	GREENWOOD	KS	GD	2275	1485	1380	105	4	4	8
443	331	9	23	14E	COFFEY	KS	GN	2083	1394	1292	102	4	14	18
444	431	24	23	14E	WOODSON	KS	GN	1993	1304	1198	106	3	2	5
445	343	09	23	15E	COFFEY	KS	GN	1968	1282	1170	112	2	34	36
446	141	19	23	15E	WOODSON	KS	GN	1560	1280	1175	105	6	9	15
447	1	1	23	16E	COFFEY	KS	GN	1566	1277	1169	108	2	10	12
448	121	6	23	16E	COFFEY	KS	GN	1075	0	1020	+55	0	14	14
449	434	10	23	16E	COFFEY	KS	GN	994	0	922	+72	1	0	1
450	213	11	23	16E	COFFEY	KS	GN	996	0	918	+78	4	0	4
451	333	11	23	16E	COFFEY	KS	GN	992	0	922	+70	4	0	4
452	441	11	23	16E	COFFEY	KS	GN	993	0	936	+57	2	0	2
453	243	12	23	16E	COFFEY	KS	GN	967	0	902	+65	2	0	2
454	323	12	23	16E	COFFEY	KS	GN	983	0	905	+78	4	0	4
455	343	12	23	16E	COFFEY	KS	GN	961	0	903	+58	0	0	0
456	132	13	23	16E	COFFEY	KS	GN	949	0	902	+47	5	0	5
457	224	13	23	16E	COFFEY	KS	GN	991	0	904	+87	9	0	9
458	332	13	23	16E	COFFEY	KS	GN	949	0	905	+44	8	11	19
459	431	13	23	16E	COFFEY	KS	GN	972	0	897	+75	7	0	7
460	442	13	23	16E	COFFEY	KS	GN	983	0	902	+81	0	0	0
461	111	14	23	16E	COFFEY	KS	GN	976	0	908	+68	1	0	1
462	131	14	23	16E	COFFEY	KS	GN	973	0	920	+53	0	0	0
463	144	14	23	16E	COFFEY	KS	GN	985	0	904	+81	7	0	7
464	411	20	23	16E	WOODSON	KS	GN	1043	0	1020	+23	0	0	0
465	124	21	23	16E	WOODSON	KS	GN	1037	0	978	+59	3	0	3
466	443	24	23	16E	WOODSON	KS	GN	950	0	904	+46	0	19	19
467	422	29	23	16E	WOODSON	KS	GN	1055	0	1030	+25	0	0	0
468	111	33	23	16E	WOODSON	KS	E	1468	1169	1075	94	0	13	13
469	142	33	23	16E	WOODSON	KS	GN	1383	1114	1004	110	6	16	22
470	001	30	23	17E	WOODSON	KS	GN	906		872	+24			0
471	222	30	23	17E	WOODSON	KS	GN	921	0	872	+39	0	0	0
472	141	06	23	18E	ANDERSON	KS	GN	857		812	+45		10	10
473	131	22	23	18E	ALLEN	KS	G	873		818	+55	0	5	5
474	142	27	23	18E	ALLEN	KS	GN	1541	870	784	86	0	0	0
475	143	27	23	18E	ALLEN	KS	GN	1541	870	784	86	7	30	37
476	000	06	23	19E	ANDERSON	KS	E	891	779	112	0	0	0	
477	000	23	23	21E	ALLEN	KS	E	658	468	389	79	6	0	6
478	214	27	23	24E	BOURBON	KS	GN	445	176	74	102	23	24	47
483	033	10	24	04E	BUTLER	KS	GDE	2565	2492	2453	39	0	5	5
484	344	12	24	05E	BUTLER	KS	EIGS	2659	2460	2395	65	3	0	3
485	432	15	24	06E	BUTLER	KS	E	3084	2566	2488	78	0	0	0
486	223	30	24	07E	BUTLER	KS	EIGS	2859	2592	2492	100	10	13	23
487	441	16	24	08E	BUTLER	KS	EID	3065	2291	2208	83	8	7	15
488	313	34	24	09E	GREENWOOD	KS	EIM	2367	2185	2091	94	13	2	15
489	444	10	24	10E	GREENWOOD	KS	GN	2757	2058	1958	100	4	16	20
490	22	13	24	10E	GREENWOOD	KS	GN	2141	1890	1784	106	5	11	16
491	343	25	24	10E	GREENWOOD	KS	GN	1928	1888	1792	96	3	4	7

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	Sandstone UP	Sandstone TOT
492	42	36	24	10E	GREENWOOD	KS	G	1917	1862	1772	90	4	8	12
493	231	8	24	11E	GREENWOOD	KS	GN	2576	1892	1794	98	4	6	10
494	4	19	24	11E	GREENWOOD	KS	GE	1934	1820	1721	99	8	14	22
495	142	23	24	11E	GREENWOOD	KS	GN	1857	1562	1478	84	3	8	11
496	0	30	24	11E	GREENWOOD	KS	GN	1827	1772	1674	98	4	13	17
497	002	14	24	12E	GREENWOOD	KS	E	1806	1692	1580	112	2	10	12
498	42	2	24	13E	WOODSON	KS	GN	0	1580	1488	92	0	20	20
499	0	6	24	13E	GREENWOOD	KS	GN	1621	1348	1238	110	2	23	25
500	222	1	24	14E	WOODSON	KS	GN	1573	1172	1161	111	8	17	25
501	002	06	24	14E	WOODSON	KS	E	1765	1428	1330	98	8	17	25
502	121	6	24	15E	WOODSON	KS	GN	1544	1263	1153	110	0	16	16
503	413	13	24	15E	WOODSON	KS	GN	1204	1217	1110	107	0	15	15
504	332	33	24	15E	WOODSON	KS	GN	1494	1214	1110	104	2	9	11
505	134	2	24	16E	WOODSON	KS	GN	1039		984	+55	0	23	23
506	014	19	24	16E	WOODSON	KS	EI		1126	1012	114	2	8	10
507	2	36	24	17E	ALLEN	KS	GN	852	0	810	+42	0	13	13
508	000	04	24	18E	ALLEN	KS	E	1190	898	802	96	0	15	15
509	442	10	24	21E	ALLEN	KS	EIGD	881	598	498	100	11	20	31
510	133	30	24	22E	BOURBON	KS	GN	820	558	468	90	18	16	34
511	002	13	24	25E	BOURBON	KS	GN	368	122	30	92	3	8	11
512	202	22	24	25E	BOURBON	KS	GD	443	186	92	94	6	8	14
513	303	35	24	25E	BOURBON	KS	GD	393	140	39	101	4	16	20
517	423	25	25	04E	BUTLER	KS	GNIM	2657	2480	2425	55	9	4	13
519	323	25	25	06E	BUTLER	KS	EI	2812	2566	2476	90	12	20	32
520	223	06	25	07E	BUTLER	KS	EI	2757	2564	2464	100	20	5	25
521	132	13	25	08E	GREENWOOD	KS	E	2287	2316	2224	92	24	2	26
522	313	13	25	09E	GREENWOOD	KS	EM	2449	2270	2180	90	14	10	24
523	221	01	25	10E	GREENWOOD	KS	GN	1864	1812	1717	95	4	6	10
524	333	32	25	11E	GREENWOOD	KS	GN	2353	1721	1642	79	3	20	23
525	121	07	25	12E	GREENWOOD	KS	GN	1864	1697	1601	96	6	12	18
526	114	24	25	13E	WOODSON	KS	E	1281	1254	1172	82	4	10	14
527	414	24	25	13E	WOODSON	KS	G	565	1272	1191	81	2	15	17
528	231	12	25	14E	WOODSON	KS	GN	1576	1288	1183	105	13	8	21
529	024	21	25	15E	WOODSON	KS	EI	1521	1192	1095	97	25	13	38
530	042	20	25	17E	WOODSON	KS	GN	926		876	+50		18	18
531	411	14	25	19E	ALLEN	KS	E	903	716	624	92	2	15	17
532	003	01	25	21E	BOURBON	KS	E	704	580	482	98	0	0	0
533	144	18	25	21E	ALLEN	KS	GN	767	654	556	98	37	29	66
535	043	16	25	25E	BOURBON	KS	GN	422	173	74	99	6	10	16
538	223	34	26	04E	BUTLER	KS	E	3240	3204	3128	76	0	14	14
539	341	03	26	05E	BUTLER	KS	GN	3972	2458	2384	74	6	8	14
540	323	04	26	05E	BUTLER	KS	EID	2522	2409	2339	70	5	0	5
541	244	26	26	05E	BUTLER	KS	GN	3972	2612	2528	84	6	2	8
542	414	35	26	05E	BUTLER	KS	GN	2740	2589	2499	90	4	0	4
543	441	18	26	06E	BUTLER	KS	E	3363	2631	2531	100	8	14	22
544	112	26	26	06E	BUTLER	KS	GN	2843	2635	2543	92	7	5	12
545	424	26	26	06E	BUTLER	KS	M	2848	2628	2552	76	0	0	0
546	003	28	26	06E	BUTLER	KS	GD		2640	2547	93	6	6	12
547	003	29	26	06E	BUTLER	KS	GN	2832	2611	2514	97	6	16	22
548	241	22	26	07E	BUTLER	KS	M	2812	2577	2491	86	0	0	0
549	432	22	26	07E	BUTLER	KS	GN	2798	2592	2493	99	6	4	10
550	111	26	26	07E	BUTLER	KS	EIGD	2793	2561	2458	103	6	0	6
551	223	29	26	07E	BUTLER	KS	GN	2776	2610	2515	95	5	5	10
552	233	33	26	07E	BUTLER	KS	E	3097	2552	2464	88	0	18	18
553	112	02	26	08E	GREENWOOD	KS	E	2475	2288	2184	104	10	7	17
554	341	10	26	08E	GREENWOOD	KS	GN	2536	2350	2254	96	7	9	16
555	001	22	26	08E	GREENWOOD	KS	GN	2471	2248	2150	98	2	8	10
556	441	22	26	08E	GREENWOOD	KS	GN	2904	2236	2138	98	7	17	24
557	411	29	26	08E	BUTLER	KS	GN	2729	2539	2438	101	2	10	12
558	114	13	26	09E	GREENWOOD	KS	GN	2160	1852	1750	102	3	17	20
559	144	23	26	09E	GREENWOOD	KS	GN	2176	1916	1815	101	5	7	12
560	001	33	26	09E	GREENWOOD	KS	GN	2748	2122	2017	105	2	8	10
561	144	06	26	10E	GREENWOOD	KS	GN	2164	1870	1772	98	4	0	4
562	144	06	26	10E	GREENWOOD	KS	GN	2164	1870	1772	98	4	13	17
563	333	07	26	10E	GREENWOOD	KS	GD	2195	1890	1792	98	5	12	17
564	411	18	26	10E	GREENWOOD	KS	GN	2140	1845	1748	97	5	7	12
565	214	08	26	11E	GREENWOOD	KS	GN	1750	1623	1549	74	4	4	8
566	223	24	26	11E	GREENWOOD	KS	GN	1864	1598	1530	68	3	11	14

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
567	321	08	26	12E	GREENWOOD	KS	GN	2163	1545	1473	72	3	12	15
568	321	08	26	12E	GREENWOOD	KS	GN	2163	1545	1473	72	0	0	0
569	441	11	26	12E	GREENWOOD	KS	GN	2023	1363	1291	72	3	14	17
570	332	30	26	12E	GREENWOOD	KS	GN	2254	1609	1532	77	3	12	15
571	021	36	26	12E	GREENWOOD	KS	IG	2056	1388	1324	64	2	11	13
572	033	26	26	13E	WOODSON	KS	E	2522	1217	1146	71	0	0	0
573	142	26	26	13E	WOODSON	KS	GN	1453	1224	1152	72	5	4	9
574	132	02	26	14E	WOODSON	KS	EG	1559	1256	1190	66	3	0	3
575	242	13	26	14E	WOODSON	KS	GN	1304	1073	0992	81	3	0	3
576	002	27	26	14E	WOODSON	KS	GN	1432	1137	1064	73	3	6	9
577	002	27	26	14E	WOODSON	KS	GN	1432	1137	1064	73	3	6	9
578	121	01	26	15E	WOODSON	KS	EIMS	1432	1050	974	76	22	12	34
579	142	19	26	15E	WOODSON	KS	G	1366	1173	1094	79	3	0	3
580	001	31	26	16E	WOODSON	KS	E	1556	935	827	108	35	5	40
581	000	22	26	17E	ALLEN	KS	GD	0901	0719	0626	93	0	8	8
582	422	24	26	17E	ALLEN	KS	GN		0780	0679	101	2	10	12
583	221	30	26	17E	WOODSON	KS	EIM	1989	884	787	97	0	5	5
584	443	02	26	18E	ALLEN	KS	GN	1092	0692	0602	90	0	9	9
585	212	13	26	18E	ALLEN	KS	GN	864	730	641	89	9	16	25
586	222	05	26	19E	ALLEN	KS	GN	1142	0726	0635	91	3	3	6
587	321	07	26	19E	ALLEN	KS	G	861	699	611	88	6	7	13
588	231	16	26	20E	ALLEN	KS	GN	910	607	510	97	0	11	11
589	413	18	26	21E	ALLEN	KS	GN	0864	0594	0493	101	0	11	11
590	221	21	26	21E	ALLEN	KS	GN	710	610	517	93	5	8	13
591	000	19	26	22E	BOURBON	KS	GN	675	0564	0451	113	0	0	0
592	122	27	26	22E	BOURBON	KS	GN	0461	0363	0245	118	0	4	4
593	423	33	26	22E	BOURBON	KS	E	973	484	392	92	0	4	4
595	313	15	27	02E	SEDGWICK	KS	EIM	1791	1116	1041	75	0	0	0
597	442	14	27	03E	BUTLER	KS	ES	3035	2532	2435	97	0	21	21
598	241	35	27	04E	BUTLER	KS	GM	2587	2500	2427	73	7	0	7
599	242	15	27	05E	BUTLER	KS	GD	2816	2660	2572	88	6	2	8
600	134	26	27	05E	BUTLER	KS	G	2715	2564	2484	80	6	0	6
601	000	27	27	05E	BUTLER	KS	GN	2769	2671	2591	80	4	10	14
602	213	08	27	06E	BUTLER	KS	GN	2777	2622	2531	91	6	11	17
603	111	20	27	06E	BUTLER	KS	EM	2750	2572		74	0	15	15
604	023	28	27	06E	BUTLER	KS	GD	3080	2552	2470	82	5	6	11
605	221	33	27	06E	BUTLER	KS	GN	3097	2620	2532	88	6	3	9
606	022	35	27	06E	BUTLER	KS	GN	2486	2276	2185	91	4	0	4
607	324	14	27	07E	BUTLER	KS	GN	2722	2562	2478	84	5	14	19
608	313	20	27	07E	BUTLER	KS	GD	2810	2604	2524	80	5	18	23
609	414	20	27	07E	BUTLER	KS	EIGD	2822	2605	2514	91	12	8	20
610	424	13	27	08E	BUTLER	KS	GN	2453	2209	2114	95	17	6	23
611	341	25	27	08E	BUTLER	KS	GN	2442	2236	2144	92	10	15	25
612	141	18	27	09E	GREENWOOD	KS	GN	2433	2198	2104	94	27	17	44
613	043	06	27	10E	GREENWOOD	KS	ID	3320	1956	1877	79	4	9	13
614	013	07	27	11E	GREENWOOD	KS	GN	1988	1651	1576	75	0	9	9
615	332	07	27	11E	GREENWOOD	KS	E	1909	1680	1605	75	0	8	8
616	000	31	27	11E	GREENWOOD	KS	GN	1986	1747	1677	70	4	10	14
617	223	21	27	12E	GREENWOOD	KS	GN	1745	1378	1312	66	4	11	15
618	432	30	27	12E	GREENWOOD	KS	E	2198	1573	1504	69	0	9	9
619	034	29	27	13E	WILSON	KS	GN	1580	1300	1232	68	5	8	13
620	023	33	27	13E	GREENWOOD	KS	EIGND	2081	1228	1155	73	10	12	22
621	333	18	27	14E	WILSON	KS	I	1791	1116	1041	75	0	24	24
622	314	20	27	14E	WILSON	KS	GN	1357	1100	1020	80	3	10	13
623	032	30	27	14E	WILSON	KS	GN	1415	1124	1050	74	2	10	12
624	002	14	27	15E	WILSON	KS	GN	0928	0867	0770	97	2	7	9
625	333	27	27	15E	WILSON	KS	E	1207	922	812	110	19	27	46
626	121	06	27	16E	NEOSHO	KS	GN	1064	887	787	100	0	14	14
627	232	18	27	16E	WILSON	KS	GN	1027	0917	0827	90	0	0	0
628	000	04	27	17E	WILSON	KS	GN	1190	0862	0762	100	0	6	6
629	041	19	27	17E	WILSON	KS	GN		0888	0793	95	0	0	0
630	131	21	27	17E	WILSON	KS	GD	1173	778	690	88	0	15	15
631	121	11	27	18E	NEOSHO	KS	G	1307	0652	0558	94	0	5	5
632	131	22	27	18E	NEOSHO	KS	GNE	873	636	546	90	0	6	6
633	131	22	27	18E	NEOSHO	KS	GD	873	0636	0546	90	0	0	0
634	000	19	27	19E	NEOSHO	KS	GN	0940	0676	0582	94	0	0	0
635	000	33	27	19E	NEOSHO	KS	GN	56	599	494	105	15	40	55
636	133	05	27	20E	NEOSHO	KS	EI	934	612	506	106	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	Sandstone UP	Sandstone TOT
637	242	08	27	20E	NEOSHO	KS	GN	0834	0628	0524	104	0	8	8
638	112	12	27	21E	NEOSHO	KS	GN	823	494	376	118	0	5	5
639	322	19	27	21E	BOURBON	KS	GN	0674	0565	0462	103	0	4	4
640	121	35	27	21E	NEOSHO	KS	GN	0674	0598	0486	112	0	0	0
641	114	12	27	22E	BOURBON	KS	GN	0665	0364	0250	114	0	15	15
642	113	16	27	22E	BOURBON	KS	EI	728	442	325	117	0	9	9
643	343	08	27	23E	BOURBON	KS	GN	0597	0340	0231	109	0	0	0
648	000	01	28	05E	BUTLER	KS	GD	2862	2670	2588	82	7	15	22
649	112	05	28	05E	BUTLER	KS	MGN	2781	2686	2608	78	8	14	22
650	331	26	28	05E	BUTLER	KS	GN	2801	2712	2635	77	7	5	12
651	412	35	28	05E	BUTLER	KS	GN	2793	2699	2604	95	4	10	14
652	004	05	28	06E	BUTLER	KS	GD	3115	2627	2540	87	6	12	18
653	242	09	28	06E	BUTLER	KS	GN	3090	2585	2496	89	6	8	14
654	222	15	28	06E	BUTLER	KS	GN	2992	2528	2440	88	8	12	20
655	232	21	28	06E	BUTLER	KS	GN	3173	2628	2544	84	0	0	0
656	441	35	28	06E	BUTLER	KS	GN	2883	2686	2603	83	5	10	15
657	331	01	28	07E	BUTLER	KS	GD	2889	2616	2530	86	4	7	11
658	221	02	28	07E	BUTLER	KS	GN	2789	2575	2487	88	6	10	16
659	332	03	28	07E	BUTLER	KS	IGD	2921	2626	2538	88	7	11	18
660	314	24	28	08E	BUTLER	KS	GN	2936	2353	2276	77	5	21	26
661	433	24	28	08E	BUTLER	KS	E	2926	2340	2280	60	0	0	0
662	313	20	28	09E	ELK	KS	IE	2843	2355	2281	74	0	4	4
663	334	17	28	10E	ELK	KS	E	2600	2012	1947	65	0	6	6
665	111	16	28	11E	GREENWOOD	KS	GN	1999	1666	1596	70	5	9	14
666	444	26	28	12E	ELK	KS	GN	1619	1359	1283	76	4	10	14
667	000	31	28	12E	ELK	KS	GN	1053	0885	0810	75	0	0	0
668	332	33	28	12E	ELK	KS	E	1984	1454	1378	76	0	12	12
669	000	03	28	13E	GREENWOOD	KS	GDEI	1803	1227	1161	66	5	4	9
670	212	26	28	13E	ELK	KS	GN	1556	1092	1081	11	0	9	9
671	431	34	28	13E	ELK	KS	GN	1491	1142	1068	74	2	8	10
672	000	04	28	15E	WILSON	KS	GN	1067	887	798	89	5	28	33
673	111	09	28	15E	WILSON	KS	EGN	1105	908	814	94	12	19	31
674	114	24	28	15E	WILSON	KS	GN	1000	0817	0734	83	2	6	8
675	111	31	28	15E	WILSON	KS	GN	1073	0892	0803	89	2	13	15
676	001	19	28	16E	WILSON	KS	GN	1046	0833	0750	83	2	6	8
677	111	23	28	16E	WILSON	KS	EIGD	1200	827	739	88	0	10	10
678	431	11	28	17E	WILSON	KS	E	1095	752	678	74	0	8	8
679	111	16	28	17E	WILSON	KS	G		0795	0712	83	0	0	0
680	333	16	28	17E	WILSON	KS	GN	0954	0777	0692	85	0	4	4
681	433	04	28	18E	NEOSHO	KS	GN	0950	0716	0614	102	0	4	4
682	222	18	28	18E	NEOSHO	KS	G	839	715	628	87	3	6	9
683	222	24	28	18E	NEOSHO	KS	GN	0760	0634	0531	103	0	5	5
684	003	04	28	19E	NEOSHO	KS	GN	1116	0531	0429	102	0	0	0
685	331	19	28	19E	NEOSHO	KS	GN	0725	0630	0526	104	0	5	5
686	443	22	28	19E	NEOSHO	KS	GN	632	507	419	88	44	0	44
687	004	22	28	20E	NEOSHO	KS	GN	0539	0432	0316	116	0	22	22
688	112	30	28	20E	NEOSHO	KS	GN	0338	0448	0338	110	0	4	4
691	024	30	28	21E	CRAWFORD	KS	GN	0572	0347	0248	99	5	16	21
692	112	35	28	21E	NEOSHO	KS	GN	0450	0357	0245	112	1	16	17
693	442	24	28	22E	CRAWFORD	KS	GN	0638	0359	0233	126	0	0	0
694	001	26	28	22E	CRAWFORD	KS	G	0394	0313	0196	117	0	0	0
695	000	27	28	22E	CRAWFORD	KS	GN	409	310	203	107	0	0	0
696	000	32	28	22E	CRAWFORD	KS	GN	0400	0342	0227	115	0	0	0
697	334	13	28	23E	CRAWFORD	KS	E	589	260	150	110	0	0	0
700	111	24	29	03E	BUTLER	KS	GN	3029	3022	2950	72	4	20	24
701	000	02	29	04E	BUTLER	KS	EIGN	3100	2673	2594	79	4	6	10
702	334	23	29	04E	BUTLER	KS	GN	2995	2834	2753	81	5	9	14
703	324	25	29	04E	BUTLER	KS	M		2766	2698	68	0	0	0
704	011	18	29	05E	BUTLER	KS	GN		2811	2734	77	3	11	14
705	000	25	29	05E	BUTLER	KS	GN	2827	2671	2586	85	5	8	13
706	003	29	29	05E	BUTLER	KS	GN	2792	2737	2651	86	5	16	21
707	344	31	29	05E	BUTLER	KS	EI	2803	2734	2654	80	0	5	5
708	122	03	29	06E	BUTLER	KS	GN	2913	2700	2617	83	6	6	12
709	214	16	29	06E	BUTLER	KS	GN	2823	2634	2562	72	12	22	34
710	121	19	29	06E	BUTLER	KS	M		2679	2607	72	0	0	0
711	312	20	29	06E	BUTLER	KS	GN	2821	2657	2568	89	7	13	20
712	023	10	29	07E	BUTLER	KS	GN	2891	2672	2596	76	5	8	13

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
713	003	14	29	07E	BUTLER	KS	GN	2785	2577	2497	80	8	10	18
714	000	19	29	08E	ELK	KS	GN	2838	2559	2481	78	4	13	17
715	114	19	29	08E	ELK	KS	EIG	2891	2542	2464	78	2	1	3
716	422	05	29	09E	ELK	KS	EGD	2723	2162	2090	72	4	3	7
717	231	34	29	09E	ELK	KS	GN	2051	2071	2001	70	2	5	7
718	031	13	29	10E	ELK	KS	GD	2469	1807	1733	74	3	6	9
719	421	34	29	10E	ELK	KS	GN	2339	1744	1670	74	5	5	10
720	114	17	29	11E	ELK	KS	GN	1974	1722	1652	70	4	8	12
721	314	12	29	12E	ELK	KS	GN	1725	1392	1321	71	2	5	7
722	000	20	29	13E	WILSON	KS	GN	1676	1468	1398	70	0	5	5
723	022	23	29	13E	ELK	KS	GN	1599	1184	1112	72	0	10	10
724	000	01	29	14E	WILSON	KS	E	1119	883	808	75	0	12	12
725	332	01	29	14E	WILSON	KS	GN	1099	0883	0808	75	0	11	11
726	223	28	29	15E	WILSON	KS	E	1345	1006	938	68	0	4	4
727	441	02	29	16E	WILSON	KS	GN	1072		988	+84	0	10	10
728	134	24	29	17E	WILSON	KS	GN	0927	0708	0612	96	0	2	2
730	341	30	29	17E	NEOSHO	KS	GN	0931	0790	0630	160	47	2	49
731	311	36	29	17E	WILSON	KS	GN		0758	0662	96	0	0	0
732	444	25	29	18E	NEOSHO	KS	E	1075	676	592	84	0	16	16
733	002	02	29	20E	NEOSHO	KS	GN	0545	442	0338	104	0	0	0
734	321	02	29	21E	NEOSHO	KS	E	1039	338	253	85	0	12	12
739	441	02	30	03E	COWLEY	KS	GN	3183	3061	2978	83	11	14	25
740	312	10	30	03E	COWLEY	KS	GD	2903	2744	2675	69	3	14	17
741	032	24	30	03E	COWLEY	KS	EIGN	3481	2996	2928	68	7	14	21
742	332	01	30	04E	COWLEY	KS	GN	2956	2746	2664	82	7	19	26
743	312	11	30	04E	COWLEY	KS	GN	3311	2734	2651	83	3	22	25
744	244	13	30	04E	COWLEY	KS	GD	3512	2813	2730	83	5	7	12
745	000	15	30	04E	COWLEY	KS	GN	2813	2768	2689	79	5	12	17
746	224	22	30	04E	COWLEY	KS	GN	3334	2780	2700	80	9	4	13
747	004	23	30	04E	COWLEY	KS	GD	2965	2830	2750	80	4	15	19
748	423	33	30	04E	COWLEY	KS	GN	3280	2809	2730	79	6	16	22
749	031	08	30	05E	COWLEY	KS	GN	2869	2745	2664	81	5	4	9
750	223	13	30	05E	COWLEY	KS	EI	2914	2717	2637	80	2	8	10
751	324	20	30	05E	COWLEY	KS	IGD	2976	2684	2600	84	5	6	11
752	114	33	30	05E	COWLEY	KS	GN	2956	2775	2689	86	0	0	0
753	444	03	30	06E	COWLEY	KS	GNE	3324	2676	2602	74	5	5	10
754	111	19	30	06E	COWLEY	KS	GD	2925	2716	2632	84	8	16	24
755	342	31	30	06E	COWLEY	KS	GD	3002	2782	2693	89	8	11	19
756	321	12	30	07E	COWLEY	KS	GD	2857	2542	2465	77	3	9	12
757	444	29	30	07E	COWLEY	KS	GDE	2912	2680	2606	74	3	8	11
758	443	10	30	08E	COWLEY	KS	GN	3152	2600	2530	70	4	10	14
759	033	25	30	08E	COWLEY	KS	GD	2948	2332	2258	74	4	5	9
760	112	09	30	09E	ELK	KS	GN	3594	2212	2142	70	6	5	11
761	324	09	30	09E	ELK	KS	GN	2588	2332	2260	72	0	21	21
762	412	35	30	09E	ELK	KS	GN	2686	2085	2017	68	3	4	7
763	442	14	30	10E	ELK	KS	GN	2354	1755	1680	75	0	0	0
764	443	14	30	10E	ELK	KS	GN	2354	1755	1680	75	0	9	9
765	111	26	30	10E	ELK	KS	GN	2047	1756	1706	50	6	2	8
766	043	30	30	11E	ELK	KS	EIGN	2273	1679	1614	65	0	5	5
767	444	15	30	12E	ELK	KS	GN	1846	1333	1263	70	2	7	9
768	131	22	30	12E	ELK	KS	E	2000	1494	1440	54	0	0	0
769	133	07	30	13E	WILSON	KS	GN	1551	1307	1236	71	0	0	0
770	131	18	30	13E	WILSON	KS	GN	1588	1258	1187	71	0	0	0
771	421	33	30	13E	ELK	KS	GN	1545	1222	1154	68	2	8	10
772	441	34	30	14E	WILSON	KS	G	1684	1055	984	71	3	0	3
773	000	8	30	15E	WILSON	KS	GN	1314	1047	0971	76	0	0	0
774	022	01	30	16E	WILSON	KS	GN	0899	0766	0689	77	0	0	0
775	000	21	30	16E	WILSON	KS	E	972	756	688	68	0	4	4
776	244	25	30	16E	WILSON	KS	GN	0935	0746	686	60	0	0	0
777	332	26	30	16E	WILSON	KS	GN	0819	0706	0651	55	0	0	0
778	243	01	30	17E	WILSON	KS	GN	0950	0780	0702	78	0	0	0
779	311	22	30	17E	WILSON	KS	GN	0996	0784	0718	66	0	0	0
780	431	26	30	17E	NEOSHO	KS	E	659	524	466	58	0	0	0
781	234	18	30	18E	NEOSHO	KS	EI	1373	733	678	55	0	0	0
782	000	31	30	18E	NEOSHO	KS	GN	0799	0660	0600	60	5	0	5
783	134	32	30	19E	NEOSHO	KS	GN	0715	0587	0476	111	5	0	5
787	022	29	31	03E	COWLEY	KS	GN	3129	3038	2966	72	7	13	20

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
788	000	33	31	03E	COWLEY	KS	GN	3100	2944	2874	70	0	0	0
789	343	05	31	04E	COWLEY	KS	EI	3300	2808	2746	62	0	24	24
790	213	36	31	04E	COWLEY	KS	GD	3007	2836	2752	84	9	8	17
791	241	20	31	05E	COWLEY	KS	GN	2918	2741	2657	84	9	7	16
792	113	21	31	05E	COWLEY	KS	EIGD	3061	2846	2761	85	8	7	15
793	002	36	31	05E	COWLEY	KS	GN	3008	2836	2752	84	5	0	5
794	034	36	31	05E	COWLEY	KS	GD	3110	2900	2812	88	4	7	11
795	444	07	31	06E	COWLEY	KS	GN	2964	2738	2652	86	10	5	15
796	313	31	31	06E	COWLEY	KS	GN	3062	2892	2807	85	0	4	4
797	342	32	31	06E	COWLEY	KS	EI	3450	2794	2723	71	0	3	3
798	223	14	31	07E	COWLEY	KS	GD	2872	2634	2555	79	3	0	3
799	241	30	31	07E	COWLEY	KS	EI	2933	2710	2634	76	0	4	4
800	233	03	31	08E	ELK	KS	GN	2695	2475	2407	68	3	4	7
801	124	16	31	08E	COWLEY	KS	GDN	2888	2524	2448	76	3	0	3
802	322	16	31	09E	ELK	KS	GN	2269	2055	1983	72	0	6	6
803	314	17	31	09E	ELK	KS	GN	2292	2076	2004	72	0	10	10
804	113	10	31	10E	ELK	KS	GN	2014	1756	1694	62	0	0	0
805	000	23	31	10E	ELK	KS	G	1407	1128	1065	63	1	5	6
806	141	15	31	11E	ELK	KS	GN	2146	1634	1568	66	0	3	3
807	143	15	31	11E	ELK	KS	GN	2146	1634	1568	66	0	0	0
808	123	29	31	11E	ELK	KS	GDN	2275	1742	1676	66	2	0	2
809	412	17	31	13E	MONTGOMERY	KS	GD	1926	1360	1292	68	0	0	0
810	000	23	31	13E	MONTGOMERY	KS	G	1406	1129	1054	75	2	0	2
811	221	15	31	14E	MONTGOMERY	KS	GN	1434	1104	1040	64	0	0	0
812	032	20	31	14E	MONTGOMERY	KS	GDEI	1482	1115	1066	49	0	4	4
813	032	22	31	14E	MONTGOMERY	KS	GN	1482	1115	1066	49	0	4	4
814	441	26	31	14E	MONTGOMERY	KS	GN	1458	1102	1048	54	0	0	0
815	311	10	31	15E	MONTGOMERY	KS	GN	1097	0812	0757	55	0	3	3
816	113	14	31	15E	MONTGOMERY	KS	GN	772	633	579	54	0	2	2
817	341	23	31	15E	MONTGOMERY	KS	GN	1085	0836	0779	57	0	3	3
818	000	02	31	16E	MONTGOMERY	KS	GN	0872	0682	0629	53	0	0	0
819	122	13	31	16E	MONTGOMERY	KS	GN	978	809	755	54	3	0	3
820	234	23	31	16E	MONTGOMERY	KS	GN	1122	0715	0660	55	2	0	2
821	000	05	31	17E	LABETTE	KS	GN	1005	849	0714	135	19	0	19
822	023	08	31	17E	LABETTE	KS	GD	1513	0772	0716	56	2	0	2
823	422	27	31	17E	MONTGOMERY	KS	GN	1000	0667	0530	137	53	0	53
824	133	30	31	17E	LABETTE	KS	GN	1045	692	640	52	4	0	4
825	133	30	31	17E	LABETTE	KS	GN	1046	0692	0640	52	3	0	3
826	000	34	31	17E	MONTGOMERY	KS	GN		0710	0511	199	99	21	120
827	212	19	31	18E	LABETTE	KS	GN	0804	0643	0580	63	4	0	4
828	032	29	31	18E	LABETTE	KS	GN	1197	577	514	63	3	0	3
829	023	03	31	21E	LABETTE	KS	GN	0289	0164	0057	107	6	4	10
833	343	26	32	02E	SUMNER	KS	GN	3605	3055	3000	55	2	25	27
834	344	27	32	02E	SUMNER	KS	EIG	3300	3225	3162	63	2	17	19
835	314	36	32	02E	SUMNER	KS	GD	3472	3140	3070	70	5	22	27
836	344	02	32	03E	COWLEY	KS	GD	3117	3020	2938	82	0	15	15
837	314	09	32	03E	COWLEY	KS	GD	3412	3027	2951	76	0	0	0
838	131	12	32	03E	COWLEY	KS	E	3405	2958	2888	70	0	4	4
839	433	03	32	04E	COWLEY	KS	EI	3476	2878	2812	66	0	14	14
840	332	15	32	04E	COWLEY	KS	GN	3010	2864	2778	86	0	0	0
841	012	22	32	04E	COWLEY	KS	GN	3291	2852	2769	83	0	0	0
842	003	13	32	05E	COWLEY	KS	GD	3148	2880	2792	88	0	12	12
843	112	13	32	05E	COWLEY	KS	GN	3459	2854	2770	84	0	0	0
844	321	33	32	05E	COWLEY	KS	GD	3135	2920	2830	90	3	2	5
845	142	05	32	06E	COWLEY	KS	GD	3064	2836	2751	85	0	8	8
846	444	16	32	06E	COWLEY	KS	GNEI	3146	2897	2815	82	0	16	16
847	323	32	32	06E	COWLEY	KS	GN	3231	2927	2840	87	0	2	2
848	143	10	32	07E	COWLEY	KS	GN	2902	2691	2614	77	3	14	17
849	442	10	32	07E	COWLEY	KS	E	3025	2708	2638	70	0	6	6
850	224	21	32	07E	COWLEY	KS	GD	2907	2682	2604	78	0	6	6
851	022	04	32	08E	CHAUTAUQUA	KS	GN	3140	2540	2463	77	2	0	2
852	411	18	32	08E	CHAUTAUQUA	KS	GN	1657	1366	1311	55	4	8	12
853	211	34	32	08E	CHAUTAUQUA	KS	GN	2428	2169	2096	73	2	18	20
854	134	13	32	09E	CHAUTAUQUA	KS	EGD	2420	1923	1852	71	0	0	0
855	323	17	32	09E	CHAUTAUQUA	KS	GN	2268	2057	1985	72	0	0	0
856	442	20	32	09E	CHAUTAUQUA	KS	GD	2290	2038	1963	75	0	4	4
857	111	25	32	09E	CHAUTAUQUA	KS	EI	2559	1996	1922	74	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
858	444	32	32	09E	CHAUTAUQUA	KS	GN	2125	2049	1985	64	0	3	3
859	113	02	32	10E	CHAUTAUQUA	KS	GN	2045	1790	1726	64	0	6	6
860	444	04	32	10E	CHAUTAUQUA	KS	GD	2077	1819	1753	66	0	0	0
861	114	18	32	10E	CHAUTAUQUA	KS	EI	2580	1828	1763	65	0	0	0
862	004	28	32	10E	CHAUTAUQUA	KS	GN	2014	1745	1684	61	0	0	0
863	233	04	32	11E	CHAUTAUQUA	KS	GN	1962	1705	1642	63	1	0	1
864	214	06	32	11E	CHAUTAUQUA	KS	GD	1964	1668	1603	65	0	0	0
865	124	08	32	11E	CHAUTAUQUA	KS	GN	2526	1668	1604	64	0	0	0
866	124	08	32	11E	CHAUTAUQUA	KS	GN	2526	1668	1604	64	0	0	0
867	121	17	32	11E	CHAUTAUQUA	KS	GN	2238	1685	1622	63	0	0	0
868	312	18	32	11E	CHAUTAUQUA	KS	GN	1960	1686	1622	64	1	0	1
869	134	20	32	11E	CHAUTAUQUA	KS	GD	1903	1628	1567	61	0	1	1
870	232	31	32	11E	CHAUTAUQUA	KS	GN	2030	1706	1646	60	0	8	8
871	211	03	32	12E	CHAUTAUQUA	KS	GN	1569	1322	1258	64	0	0	0
872	032	14	32	12E	CHAUTAUQUA	KS	GN	1795	1256	1210	46	0	3	3
873	032	14	32	12E	CHAUTAUQUA	KS	GN	1795	1256	1210	46	0	0	0
874	312	21	32	12E	CHAUTAUQUA	KS	GNE	1565	1516	1460	56	0	0	0
875	441	06	32	13E	MONTGOMERY	KS	GN	1594	1318	1257	61	3	6	9
876	442	13	32	13E	CHAUTAUQUA	KS	E	1301	1178	1100	78	0	0	0
877	322	26	32	13E	CHAUTAUQUA	KS	GN	1910	0918	0873	45	2	0	2
878	442	13	32	14E	MONTGOMERY	KS	EGN	1073	917	872	45	0	0	0
879	211	32	32	14E	MONTGOMERY	KS	GD	1746	1090	1044	46	4	0	4
880	014	06	32	15E	MONTGOMERY	KS	GN	1300	1049	1001	48	0	0	0
881	014	06	32	15E	MONTGOMERY	KS	GN	1300	1049	1011	38	0	0	0
882	234	35	32	15E	MONTGOMERY	KS	GN	1128	0844	0794	50	2	0	2
883	004	01	32	16E	MONTGOMERY	KS	GN	0887	0735	0682	53	0	0	0
884	004	08	32	16E	MONTGOMERY	KS	G		667	620	47	10	0	10
885	114	16	32	16E	MONTGOMERY	KS	GN	1536	0795	0745	50	5	0	5
886	422	17	32	16E	MONTGOMERY	KS	GN	0966	0728	0677	51	10	0	10
887	442	19	32	16E	MONTGOMERY	KS	GN	0572	722	672	50	10	0	10
888	123	02	32	17E	MONTGOMERY	KS	GN		0673	524	149	55	0	55
889	332	03	32	17E	MONTGOMERY	KS	GN	0754	0613	0515	98	66	0	66
890	311	09	32	17E	MONTGOMERY	KS	GN	0765	0610	0546	64	2	0	2
891	000	26	32	17E	MONTGOMERY	KS	GN	1198	591	518	73	2	4	6
892	000	26	32	17E	MONTGOMERY	KS	GN	1198	0588	0520	68	4	0	4
893	113	34	32	18E	LABETTE	KS	GN	0785	0539	0463	76	5	0	5
894	422	08	32	22E	CHEROKEE	KS	GN	0	108	0006	102	0	0	0
895	042	07	33	01E	LABETTE	KS	EIGN	4229	3632	3580	52	12	14	26
896	323	10	33	02E	LABETTE	KS	EI	3554	3177	3110	67	2	3	5
897	234	14	33	03E	LABETTE	KS	EIG	3330	3208	3117	91	0	0	0
898	141	32	33	03E	COWLEY	KS	EI	3378	3195	3123	72	0	21	21
89o	112	33	33	03E	LABETTE	KS	GN	3331	3191	3107	84	2	8	10
900	221	13	33	04E	LABETTE	KS	GD	3113	2960	2845	115	6	0	6
901	004	23	33	04E	LABETTE	KS	IG	3133	2935	2836	99	0	0	0
902	131	31	33	04E	COWLEY	KS	EI	3376	3247	3132	115	0	12	12
903	442	10	33	05E	COWLEY	KS	IGD	3150	2913	2822	91	4	4	8
904	021	14	33	05E	LABETTE	KS	GD	3091	2872	2782	90	0	0	0
905	012	35	33	05E	LABETTE	KS	GD	3169	2948	2860	88	0	2	2
906	023	07	33	06E	COWLEY	KS	GD	3131	2894	2808	86	0	0	0
907	322	18	33	06E	LABETTE	KS	EIGD	3160	2919	2832	87	0	4	4
908	421	36	33	06E	LABETTE	KS	GD	2847	2566	2486	80	0	6	6
909	241	04	33	07E	COWLEY	KS	EI	2839	2622	2550	72	0	3	3
910	332	06	33	07E	LABETTE	KS	GD	2953	2714	2634	80	0	6	6
911	021	18	33	07E	LABETTE	KS	GN	2721	2524	2444	80	0	5	5
912	432	08	33	08E	COWLEY	KS	GD	2493	2280	2207	73	0	6	6
913	331	21	33	08E	LABETTE	KS	IGD	2766	2531	2459	72	4	6	10
914	442	25	33	08E	CHAUTAUQUA	KS	GD	2319	2098	2032	66	0	9	9
915	124	28	33	08E	COWLEY	KS	GN	2373	2307	2239	68	0	8	8
916	004	05	33	09E	CHAUTAUQUA	KS	GD	2350	2018	1948	70	0	4	4
917	131	07	33	09E	CHAUTAUQUA	KS	GD	2302	2102	2028	74	0	6	6
918	323	11	33	09E	CHAUTAUQUA	KS	E	83	2028	1968	60	0	6	6
919	001	14	33	09E	CHAUTAUQUA	KS	GD	2274	1991	1935	56	0	1	1
920	023	14	33	09E	CHAUTAUQUA	KS	EG	2754	2088	2022	66	0	0	0
921	114	02	33	10E	CHAUTAUQUA	KS	GN	2078	1768	1707	61	4	0	4
922	332	16	33	10E	CHAUTAUQUA	KS	EID	1935	1710	1660	50	0	0	0
923	111	19	33	11E	CHAUTAUQUA	KS	GN	1947	1639	1590	49	1	0	1
924	331	20	33	11E	CHAUTAUQUA	KS	EIGN	2301	1682	1638	44	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
925	322	30	33	11E	CHAUTAUQUA	KS	GN	2012	1653	1606	47	0	3	3
926	002	14	33	12E	CHAUTAUQUA	KS	GN	1781	1266	1220	46	0	0	0
927	224	18	33	12E	CHAUTAUQUA	KS	EID	1930	1354	1300	54	0	0	0
928	113	10	33	13E	CHAUTAUQUA	KS	GN	1904	1228	1182	46	5	10	15
929	421	25	33	13E	MONTGOMERY	KS	EG	2868	1164	1120	44	0	0	0
930	334	13	33	14E	MONTGOMERY	KS	G	1205	0987	0940	47	0	0	0
931	442	35	33	14E	MONTGOMERY	KS	GN	1748	1046	0998	48	0	0	0
932	241	11	33	15E	MONTGOMERY	KS	GN	1091	0864	0813	51	1	0	1
933	031	19	33	15E	MONTGOMERY	KS	G	1187	0956	0908	48	0	0	0
934	213	19	33	15E	MONTGOMERY	KS	GN	1154	934	886	48	2	6	8
935	431	19	33	15E	MONTGOMERY	KS	G	1171	955	906	49	4	0	4
937	111	11	33	16E	MONTGOMERY	KS	GNS	1124	641	591	50	6	0	6
938	000	19	33	16E	MONTGOMERY	KS	GN		0849	0794	55	8	0	8
939	242	07	33	17E	LABETTE	KS	GN	1405	512	448	64	2	8	10
940	222	12	33	17E	LABETTE	KS	GN	0744	0544	0482	62	3	0	3
941	444	23	33	17E	MONTGOMERY	KS	GN	1158	0861	0808	53	9	0	9
942	334	29	33	17E	MONTGOMERY	KS	GN	0621	0576	0440	136	72	0	72
943	443	29	33	17E	MONTGOMERY	KS	GN	0604	0576	0437	139	66	0	66
944	024	32	33	17E	MONTGOMERY	KS	GN	0633	0527	0422	105	40	0	40
945	000	04	33	18E	LABETTE	KS	GN	596	494	421	73	4	0	4
947	324	07	34	02E	LABETTE	KS	E	3998	3475	3376	99	0	0	0
948	311	29	34	02E	LABETTE	KS	EIGD	3516	3411	3342	69	4	5	9
949	344	19	34	03E	COWLEY	KS	EID	3831	3286	3192	94	0	0	0
950	141	29	34	03E	COWLEY	KS	E	3396	3258	3166	92	0	40	40
951	214	29	34	03E	COWLEY	KS	GD	3881	3263	3175	88	0	11	11
952	412	29	34	03E	COWLEY	KS	ES	3370	3264	3166	98	0	12	12
953	422	32	34	03E	COWLEY	KS	GN	3910	3270	3181	89	0	13	13
954	244	07	34	04E	COWLEY	KS	GD	3824	3058	2972	86	0	4	4
955	001	09	34	04E	COWLEY	KS	GN	3371	3147	3059	88	0	3	3
956	121	14	34	04E	COWLEY	KS	GN	3269	3060	2973	87	3	6	9
957	413	28	34	04E	COWLEY	KS	GN	3372	3169	3078	91	0	15	15
958	032	03	34	05E	COWLEY	KS	GD	3097	2877	2790	87	0	1	1
959	013	21	34	05E	COWLEY	KS	GN	3244	3045	2958	87	0	0	0
960	121	27	34	05E	COWLEY	KS	GN	3140	2946	2860	86	1	2	3
961	102	03	34	06E	COWLEY	KS	E	3186	2862	2767	95	0	50	50
962	342	35	34	06E	COWLEY	KS	GD	3152	2925	2853	72	0	0	0
963	244	32	34	07E	COWLEY	KS	EIG	3144	2768	2705	63	0	0	0
964	331	09	34	08E	COWLEY	KS	GD	2274	2223	2158	65	0	9	9
965	333	10	34	08E	CHAUTAUQUA	KS	GN	2185	2159	2095	64	0	0	0
966	231	15	34	08E	CHAUTAUQUA	KS	GD	2997	2335	2280	55	0	5	5
967	242	18	34	08E	COWLEY	KS	GD	2640	2407	2325	82	0	5	5
968	001	31	34	08E	CHAUTAUQUA	KS	E	2844	2647	2597	50	3	27	30
969	444	18	34	09E	CHAUTAUQUA	KS	GD	2229	1967	1920	47	0	1	1
970	041	22	34	09E	CHAUTAUQUA	KS	EIGD	2192	1906	1863	43	2	0	2
971	222	31	34	09E	CHAUTAUQUA	KS	GD	2223	1988	1945	43	0	0	0
972	333	31	34	09E	CHAUTAUQUA	KS	GD	2223	1988	1945	43	0	0	0
973	334	10	34	10E	CHAUTAUQUA	KS	GN	2013	1679	1632	47	0	0	0
974	223	33	34	10E	CHAUTAUQUA	KS	GNE	2471	1882	1838	44	0	8	8
975	432	02	34	11E	CHAUTAUQUA	KS	GN	1698	1406	1359	47	0	0	0
976	113	04	34	11E	CHAUTAUQUA	KS	GN	2088	1498	1450	48	7	0	7
977	333	06	34	12E	CHAUTAUQUA	KS	GD	1807	1393	1346	47	2	0	2
978	241	17	34	12E	CHAUTAUQUA	KS	GN	1982	1351	1300	51	3	0	3
979	333	21	34	12E	CHAUTAUQUA	KS	E	2120	1442	1393	49	0	0	0
981	211	06	34	13E	MONTGOMERY	KS	GN	2224	1447	1402	45	0	0	0
982	003	08	34	13E	MONTGOMERY	KS	GN	1748	1208	1160	48	2	0	2
983	002	07	34	14E	MONTGOMERY	KS	GD	1887	1089	1044	45	3	0	3
984	133	25	34	14E	MONTGOMERY	KS	GN	1412	1164	1109	55	11	0	11
985	113	35	34	14E	MONTGOMERY	KS	GN	1368	1121	1069	52	4	0	4
986	414	01	34	15E	MONTGOMERY	KS	GN	0865	0865	0794	71	14	0	14
987	024	04	34	15E	MONTGOMERY	KS	GN	1163	0900	0844	56	18	0	18
988	423	11	34	15E	MONTGOMERY	KS	GN	1290	0822	0769	53	4	0	4
989	332	20	34	15E	MONTGOMERY	KS	GN	1252	0933	0883	50	4	0	4
990	000	24	34	15E	MONTGOMERY	KS	GN	1672	0788	0730	58	10	0	10
991	003	25	34	15E	MONTGOMERY	KS	GN	1037	0768	0715	53	17	0	17
992	000	08	34	16E	MONTGOMERY	KS	GN	1122	0838	0783	55	12	0	12
993	421	17	34	16E	MONTGOMERY	KS	GN	1571	803	744	59	9	0	9
994	022	05	34	17E	MONTGOMERY	KS	GN	0693	0494	0390	104	39	0	39

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
995	442	05	34	17E	MONTGOMERY	KS	GN	0966	0508	0400	108	17	0	17
996	442	06	34	17E	MONTGOMERY	KS	GN	1154	0424	0362	62	10	0	10
997	441	17	34	17E	MONTGOMERY	KS	GN	0728	0526	0460	66	3	0	3
998	434	04	34	19E	LABETTE	KS	GN	0603	0374	0248	126	7	2	9
999	044	26	34	19E	LABETTE	KS	GN	0716	0290	0158	132	3	3	6
1000	221	21	34	20E	LABETTE	KS	GD	0405	0154	0030	124	6	0	6
1001	001	34	34	20E	LABETTE	KS	E	605	140	50	90	0	6	6
1002	003	36	34	20E	LABETTE	KS	GN	1056	0067		67	0	0	0
1004	013	01	35	01E	SUMNER	KS	EI	3546	3396	3324	72	0	7	7
1005	234	01	35	02E	SUMNER	KS	EIGD	3574	3421	3343	78	0	5	5
1006	424	08	35	02E	SUMNER	KS	GN	3400	3288	3217	71	0	2	2
1007	444	15	35	02E	SUMNER	KS	GN	3477	3362	3291	71	0	9	9
1008	011	03	35	03E	COWLEY	KS	GN	3401	3235	3140	95	0	10	10
1009	421	05	35	03E	COWLEY	KS	GN	3832	3298	3208	90	0	6	6
1010	332	10	35	03E	COWLEY	KS	GN	3477	3351	3276	75	3	13	16
1011	241	18	35	03E	COWLEY	KS	GD	3542	3339	3262	77	3	8	11
1012	341	04	35	04E	COWLEY	KS	GN	3212	3010	2934	76	0	5	5
1013	112	07	35	04E	COWLEY	KS	GN	3266	3173	3073	100	0	6	6
1014	224	05	35	05E	COWLEY	KS	EM	3145	2950	2875	75	0	14	14
1015	033	15	35	05E	COWLEY	KS	EIGN	3185	2992	2912	80	0	0	0
1016	331	15	35	05E	COWLEY	KS	G	3171	2978	2900	78	0	4	4
1017	221	17	35	05E	COWLEY	KS	E	3068	2946	2864	82	0	0	0
1018	333	08	35	06E	COWLEY	KS	E	3020	2938	2874	64	0	0	0
1019	113	13	35	06E	COWLEY	KS	E	3265	2780	2734	46	0	0	0
1020	442	08	35	07E	COWLEY	KS	EIGD	2976	2765	2714	51	0	0	0
1021	014	17	35	07E	COWLEY	KS	EI	2587	2670	2624	46	0	0	0
1022	222	17	35	07E	COWLEY	KS	GD	3036	2691	2648	43	0	0	0
1023	333	02	35	08E	CHAUTAUQUA	KS	E	2739	2150	2100	50	0	0	0
1024	111	01	35	09E	CHAUTAUQUA	KS	GN	1953	1682	1640	42	0	0	0
1025	123	08	35	09E	CHAUTAUQUA	KS	EM	2758	2142	2106	36	0	0	0
1206	041	15	35	09E	CHAUTAUQUA	KS	EIGD	2317	2020	1982	38	0	0	0
1027	142	11	35	10E	CHAUTAUQUA	KS	GN	1967	1970	1624	46	5	0	5
1028	412	13	35	10E	CHAUTAUQUA	KS	GN	1793	1520	1475	45	0	0	0
1029	421	14	35	10E	CHAUTAUQUA	KS	GN	1890	1579	1536	43	1	0	1
1030	444	03	35	11E	CHAUTAUQUA	KS	GD	1823	1552	1506	46	1	2	3
1031	234	09	35	11E	CHAUTAUQUA	KS	GN	2076	1488	1443	45	4	0	4
1032	003	13	35	11E	CHAUTAUQUA	KS	GN	2129	1542	1494	48	10	0	10
1033	313	14	35	11E	CHAUTAUQUA	KS	GN	1818	1457	1411	46	0	0	0
1034	443	04	35	12E	CHAUTAUQUA	KS	GN	1468	1396	1346	50	0	0	0
1036	334	04	35	13E	CHAUTAUQUA	KS	EM	2059	1294	1250	44	0	0	0
1037	034	11	35	13E	CHAUTAUQUA	KS	E	2837	1134	1075	59	0	0	0
1038	213	03	35	14E	MONTGOMERY	KS	GN	1361	1092	1037	55	8	0	8
1039	000	08	35	14E	MONTGOMERY	KS	GN	1514	1152	1100	52	4	0	4
1040	024	12	35	14E	MONTGOMERY	KS	GN	1603	1158	1106	52	0	0	0
1041	042	18	35	14E	MONTGOMERY	KS	GD	1604	1152	1098	54	2	0	2
1042	042	34	35	14E	MONTGOMERY	KS	GN	1364	1163	1060	103	0	0	0
1043	001	03	35	15E	MONTGOMERY	KS	GN	1255	0884	0838	46	3	0	3
1044	000	04	35	15E	MONTGOMERY	KS	GN	1232	0945	0899	46	0	0	0
1045	432	06	35	15E	MONTGOMERY	KS	GD	1734	0954	0900	54	0	0	0
1046	244	10	35	15E	MONTGOMERY	KS	GN	1407	0893	0840	53	4	0	4
1047	044	12	35	15E	MONTGOMERY	KS	GN	1129	0823	0778	45	0	0	0
1048	000	18	35	15E	MONTGOMERY	KS	GN	1254	0984	0938	46	0	0	0
1049	011	08	35	16E	MONTGOMERY	KS	GD	1155	0759	0707	52	0	0	0
1050	122	12	35	16E	MONTGOMERY	KS	GN	1316	0440	0378	62	7	0	7
1051	141	18	35	16E	MONTGOMERY	KS	GN	1121	0799	0752	47	0	0	0
1052	343	04	35	17E	MONTGOMERY	KS	GN	1321	0497	0448	49	5	0	5
1053	004	06	35	17E	MONTGOMERY	KS	GN		0500	0450	50	3	1	4
1054	443	18	35	18E	LABETTE	KS	GN	0892	0459	0406	53	10	0	10
1055	231	01	35	19E	LABETTE	KS	GN	0953	0177	0043	134	0	0	0
1056	013	02	35	19E	LABETTE	KS	E		0224	0100	124	0	0	0
1057	000	12	35	19E	LABETTE	KS	GN	0980	0187	0074	113	0	0	0
1061	041	08	24	03E	NOBLE	OK	GD	3934	3650	3610	40	0	0	0
1062	341	15	24	03E	NOBLE	OK	GD	3744	3458	3416	42	2	0	2
1063	042	34	24	03E	OSAGE	OK	GD	4236	3572	3523	49	4	0	4
1064	111	03	24	04E	OSAGE	OK	GD	3534	3216	3180	36	3	0	3
1065	312	16	24	04E	OSAGE	OK	GD	3674	3274	3234	40	0	0	0
1066	314	23	24	04E	OSAGE	OK	GD	3617	3242	3194	48	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
1067	043	05	24	05E	OSAGE	OK	GD	3274	2925	2887	38	3	0	3
1068	013	16	24	05E	PAWNEE	OK	GD	3241	2918	2879	39	0	0	0
1069	322	34	24	05E	PAWNEE	OK	GD	3685	2824	2783	41	0	0	0
1070	122	03	24	06E	OSAGE	OK	GD	2782	2664	2628	36	3	0	3
1071	012	24	24	06E	OSAGE	OK	GD	2773	2498	2461	37	0	0	0
1072	003	31	24	06E	OSAGE	OK	GD	3534	2784	2746	38	3	0	3
1073	421	22	24	07E	OSAGE	OK	GD	2670	2288	2240	48	0	0	0
1074	212	01	24	08E	OSAGE	OK	GD	2822	2190	2146	44	6	0	6
1075	003	12	24	08E	OSAGE	OK	GD	2381	2045	2002	43	0	0	0
1076	023	23	24	08E	OSAGE	OK	GN	2393	2060	2015	45	5	0	5
1077	333	35	24	08E	OSAGE	OK	GN	2308	1995	1946	49	6	0	6
1078	113	03	24	09E	OSAGE	OK	GN	2149	1824	1778	46	2	0	2
1079	343	15	24	09E	OSAGE	OK	GD	2567	1855	1804	51	0	0	0
1080	013	21	24	09E	OSAGE	OK	GN	2220	2034	1982	52	0	0	0
1081	441	35	24	09E	OSAGE	OK	GD	2383	1927	1869	58	0	0	0
1082	001	05	24	10E	OSAGE	OK	GD	2466	1733	1675	58	9	0	9
1083	223	21	24	10E	OSAGE	OK	GD	2069	1676	1614	62	4	0	4
1084	242	30	24	10E	OSAGE	OK	GD	2273	1867	1809	58	3	0	3
1085	032	36	24	10E	OSAGE	OK	GN	1850	1376	1328	48	1	0	1
1086	233	04	24	11E	OSAGE	OK	GN	1904	1549	1490	59	2	0	2
1087	004	09	24	11E	OSAGE	OK	GN	1526	1418	1356	62	0	0	0
1088	444	16	24	11E	OSAGE	OK	GN	1809	1378	1313	65	5	0	5
1089	004	29	24	11E	OSAGE	OK	GN	1644	1262	1196	66	4	0	4
1090	443	04	24	12E	OSAGE	OK	GN	1641	1265	1184	81	34	0	34
1091	002	22	24	12E	OSAGE	OK	GN	1663	1284	1219	65	9	0	9
1092	124	31	24	12E	OSAGE	OK	GN	1752	1344	1276	68	7	0	7
1093	000	35	24	12E	WAGONEER	OK	GN	1342	1311	1242	69	0	0	0
1094	311	19	24	13E	WAGONEER	OK	GN		1017	934	83	5	0	5
1095	211	21	24	13E	WAGONEER	OK	GN	1397	1009	926	83	0	0	0
1096	321	08	24	14E	WAGONEER	OK	GN	1441	732	662	70	11	0	11
1097	142	18	24	14E	WAGONEER	OK	GD	1338	702	634	68	7	0	7
1098	311	35	24	14E	ROGERS	OK	GN	1270	536	470	66	3	0	3
1099	311	21	24	15E	ROGERS	OK	GD	1485	497	439	58	4	0	4
1100	322	24	24	16E	ROGERS	OK	GN	472	54	3	51	8	0	8
1101	124	33	24	16E	ROGERS	OK	GD	1450	444	387	57	2	0	2
1102	332	04	25	03E	OSAGE	OK	G	3644	3347	3310	37	2	3	5
1103	000	14	25	03E	OSAGE	OK	GD	4209	3392	3355	37	3	1	4
1104	422	32	25	03E	OSAGE	OK	GD	3841	3466	3428	38	0	0	0
1105	014	08	25	04E	OSAGE	OK	G	3537	3279	3244	35	0	0	0
1107	042	34	25	04E	OSAGE	OK	GD	3488	3191	3156	35	0	0	0
1108	214	03	25	05E	OSAGE	OK	GD	3199	2877	2841	36	0	0	0
1109	004	06	25	05E	OSAGE	OK	E	3299	2922	2886	36	0	0	0
1110	213	12	25	05E	OSAGE	OK	GD	3168	2863	2827	36	4	0	4
1111	312	21	25	05E	OSAGE	OK	GD	3255	2900	2866	34	3	0	3
1112	231	34	25	05E	OSAGE	OK	GD	3269	2954	2916	38	0	0	0
1113	324	04	25	06E	OSAGE	OK	GD	2864	2639	2606	33	2	0	2
1114	004	15	25	06E	OSAGE	OK	GN	2767	2616	2580	36	8	0	8
1115	321	22	25	06E	OSAGE	OK	GN	2838	2698	2664	34	4	0	4
1116	224	34	25	06E	OSAGE	OK	GD	2793	2676	2639	37	6	0	6
1117	444	13	25	07E	OSAGE	OK	GD	2553	2277	2232	45	2	0	2
1118	433	32	25	07E	OSAGE	OK	GD	2738	2508	2468	40	3	0	3
1119	442	10	25	08E	OSAGE	OK	GN	2624	2076	2027	49	2	0	2
1120	333	16	25	08E	OSAGE	OK	GD	2363	2081	2033	48	0	0	0
1121	004	23	25	08E	OSAGE	OK	GN	2358	2027	1966	61	0	0	0
1122	442	36	25	08E	OSAGE	OK	GD	2423	2112	2068	44	0	0	0
1123	112	03	25	09E	OSAGE	OK	G	2081	1808	1663	145	94	0	94
1124	000	10	25	09E	OSAGE	OK	GN	2048	1740	1639	101	37	0	37
1125	223	17	25	09E	OSAGE	OK	GN	2404	2028	1989	39	28	0	28
1126	001	21	25	09E	OSAGE	OK	GDN	2329	2022	1972	50	2	0	2
1127	114	34	25	09E	OSAGE	OK	GN	2148	1842	1795	47	0	0	0
1128	443	03	25	10E	OSAGE	OK	GN	2315	1674	1620	54	2	0	2
1129	123	13	25	10E	OSAGE	OK	GD		1575	1515	60	10	1	11
1130	413	32	25	10E	OSAGE	OK	GD	2141	1776	1715	61	6	0	6
1131	002	01	25	11E	OSAGE	OK	GD	1720	1420	1358	62	3	0	3
1132	004	11	25	11E	OSAGE	OK	GN	1936	1474	1404	70	9	0	9
1133	011	18	25	11E	OSAGE	OKGD		1921	1601	1544	57	2	0	2
1134	331	35	25	11E	OSAGE	OK	GD	2049	1512	1447	65	3	0	3

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
1135	000	10	25	12E	OSAGE	OK	GN	1634	1303	1240	63	3	0	3
1136	001	28	25	12E	OSAGE	OK	GN	1753	1333	1266	67	10	0	10
1137	002	33	25	12E	OSAGE	OK	GN	2120	1397	1274	123	0	0	0
1138	113	04	25	13E	WAGONEER	OK	GD	1392	900	832	68	5	0	5
1139	002	06	25	14E	WAGONEER	OK	GN	1078	768	691	77	37	0	37
1140	143	07	25	14E	WAGONEER	OK	GN	1106	801	715	86	0	0	0
1141	031	21	25	14E	WAGONEER	OK	GN	1104	738	663	75	20	0	20
1142	443	04	25	15E	NOWATA	OK	GN	1229	672	602	70	9	0	9
1143	000	09	25	15E	NOWATA	OK	GN	967	662	560	102	5	0	5
1144	111	31	25	15E	NOWATA	OK	GD	1135	411	364	47	0	0	0
1145	343	35	25	15E	NOWATA	OK	GD	1157	464	407	57	1	0	1
1146	441	09	25	16E	NOWATA	OK	GN	724	343	290	53	5	0	5
1147	431	22	25	16E	NOWATA	OK	GN	743	344	298	46	3	0	3
1148	032	33	25	16E	NOWATA	OK	GD	1359	344	296	48	8	0	8
1149	324	29	26	02E	KAY	OK	GD	4179	3547	3509	38	0	4	4
1150	002	16	26	03E	KAY	OK	GD	3722	3405	3368	37	3	4	7
1151	334	34	26	03E	OSAGE	OK	GD	3313	3242	3207	35	4	1	5
1152	313	24	26	04E	OSAGE	OK	GD	3138	3168	3138	30	2	0	2
1153	004	18	26	05E	OSAGE	OK	GD	3213	2933	2902	31	0	0	0
1154	000	36	26	05E	OSAGE	OK	GN	2857	2711	2676	35	0	0	0
1155	413	11	26	06E	OSAGE	OK	GD	2917	2729	2690	39	5	0	5
1156	421	26	26	06E	OSAGE	OK	GD	2955	2740	2706	34	5	0	5
1157	141	06	26	07E	OSAGE	OK	GD	3032	2747	2711	36	3	0	3
1158	411	15	26	07E	OSAGE	OK	GD	3874	2461	2423	38	0	0	0
1159	001	35	26	07E	OSAGE	OK	GD	3055	2432	2396	36	0	0	0
1160	134	07	26	08E	OSAGE	OK	GD	2541	2216	2177	39	3	0	3
1161	422	17	26	08E	OSAGE	OK	GD	2469	2150	2114	36	2	0	2
1162	001	36	26	08E	OSAGE	OK	GN	2286	1989	1945	44	0	0	0
1163	231	22	26	09E	OSAGE	OK	GD	2230	1966	1922	44	0	0	0
1164	224	36	26	09E	OSAGE	OK	E	2277	1862	1676	186	72	0	72
1165	433	07	26	10E	OSAGE	OK	GD	2066	1786	1618	168	30	0	30
1166	004	19	26	10E	OSAGE	OK	GD	2159	743	690	53	0	0	0
1167	412	24	26	10E	OSAGE	OK	GN	1756	1549	1483	66	2	0	2
1168	431	31	26	10E	OSAGE	OK	GD	2167	1892	1725	167	0	0	0
1169	004	09	26	11E	OSAGE	OK	GN	1947	1556	1493	63	1	0	1
1170	001	12	26	11E	OSAGE	OK	GN	1500	1255	1189	66	1	0	1
1171	424	24	26	11E	OSAGE	OK	GN	1623	1281	1216	65	4	0	4
1172	014	33	26	11E	OSAGE	OK	GN	1868	1490	1434	56	4	0	4
1173	004	06	26	12E	OSAGE	OK	GN	1528	1170	1096	74	0	0	0
1174	001	15	26	12E	OSAGE	OK	GN	1685	903	835	68	8	0	8
1175	001	27	26	12E	OSAGE	OK	GN	1346	1056	992	64	14	0	14
1176	000	03	26	13E	WAGONEER	OK	GN		972	892	80	18	0	18
1177	000	07	26	13E	WAGONEER	OK	GN	1388	958	889	69	5	0	5
1178	332	14	26	13E	WAGONEER	OK	GN	1382	1056	966	90	47	0	47
1179	003	34	26	13E	OSAGE	OK	GN	1661	1293	1226	67	9	0	9
1180	002	01	26	14E	NOWATA	OK	GN	1099	926	825	101	35	0	35
1181	000	34	26	14E	WAGONEER	OK	GN	1120	791	724	67	11	0	11
1182	000	06	26	15E	NOWATA	OK	GN	1160	846	781	65	7	0	7
1183	001	10	26	15E	NOWATA	OK	GN	923	598	544	54	0	0	0
1184	043	33	26	16E	NOWATA	OK	GN	744	408	351	57	9	0	9
1185	014	33	26	17E	NOWATA	OK	GN	469	101	63	38	4	0	4
1186	414	08	27	02E	KAY	OK	GD	3631	3463	3386	77	0	24	24
1187	034	29	27	02E	KAY	OK	GN	4334	3490	3447	43	4	3	7
1188	121	22	27	03E	KAY	OK	GD	3242	3066	3027	39	0	5	5
1189	341	01	27	04E	KAY	OK	GD	3160	2973	2934	39	1	2	3
1190	322	28	27	04E	KAY	OK	GD	3328	3123	3089	34	0	3	3
1191	133	13	27	05E	OSAGE	OK	GD	3007	2859	2822	37	2	0	2
1192	141	32	27	05E	OSAGE	OK	GD	3102	2942	2910	32	3	1	4
1193	032	14	27	06E	OSAGE	OK	GD	3334	2669	2634	35	5	0	5
1194	334	34	27	06E	OSAGE	OK	GN	2808	2647	2615	32	1	0	1
1195	000	12	27	07E	OSAGE	OK	GN	2523	2293	2234	59	2	0	2
1196	233	32	27	07E	OSAGE	OK	GN	3004	2674	2638	36	3	0	3
1197	224	05	27	08E	OSAGE	OK	GD	2522	2200	2164	36	1	0	
1198	341	12	27	08E	OSAGE	OK	GD	2321	2000	1962	38	0	0	0
1199	434	32	27	08E	OSAGE	OK	GD	2617	2268	2230	38	0	0	0
1200	111	07	27	09E	OSAGE	OK	GD	2376	2099	2059	40	0	0	0
1201	344	20	27	09E	OSAGE	OK	GN	2261	1940	1900	40	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
1202	321	33	27	09E	OSAGE	OK	GD	2245	976	934	42	0	0	0
1203	223	06	27	10E	OSAGE	OK	GN	2057	1790	1742	48	0	0	0
1204	001	14	27	10E	OSAGE	OK	GN	1929	1628	1570	58	0	0	0
1205	432	34	27	10E	OSAGE	OK	GN	1821	1678	1538	140	61	0	61
1206	232	05	27	11E	OSAGE	OK	GD	2303	1522	1465	57	3	0	3
1207	004	16	27	11E	OSAGE	OK	GN	1961	1558	1500	58	0	0	0
1208	000	34	27	11E	OSAGE	OK	GN	1736	1514	1448	66	6	0	6
1209	342	07	27	12E	OSAGE	OK	GD	1672	1427	1361	66	3	0	3
1210	002	28	27	12E	OSAGE	OK	GN	1635	1358	1281	77	0	0	0
1211	003	34	27	12E	OSAGE	OK	GN	1325	1063	990	73	2	0	2
1212	423	05	27	13E	WAGONEER	OK	GN	1400	941	872	69	12	0	12
1213	121	06	27	13E	WAGONEER	OK	GD	1549	1026	949	77	12	0	12
1214	413	09	27	13E	WAGONEER	OK	GN	1342	1036	891	145	12	0	12
1215	000	35	27	13E	WAGONEER	OK	GN	1270	1002	932	70	0	0	0
1216	244	12	27	14E	NOWATA	OK	D	1265	923	860	63	0	0	0
1217	000	17	27	14E	WAGONEER	OK	GN	1273	988	912	76	10	0	10
1218	312	13	27	15E	NOWATA	OK	GN	1286	965	823	142	88	0	88
1219	123	22	27	15E	NOWATA	OK	GN	960	656	553	103	43	0	43
1220	000	28	27	15E	NOWATA	OK	GN	1030	636	572	64	0	0	0
1221	424	35	27	15E	NOWATA	OK	GN	832	523	470	53	5	0	5
1222	444	17	27	16E	NOWATA	OK	GD	1016	504	452	52	4	0	4
1223	044	35	27	16E	NOWATA	OK	GN	647	312	267	45	0	0	0
1224	443	04	27	17E	NOWATA	OK	GN	1153	336	285	51	0	0	0
1225	000	08	27	18E	CRAIG	OK	GD	799	171	108	63	6	0	6
1226	000	02	28	02E	KAY	OK	GN	3633	3392	3313	79	0	3	3
1227	032	09	28	02E	KAY	OK	E	3612	3383	3302	81	0	0	0
1228	221	27	28	02E	KAY	OK	GN	3451	3392	3318	74	0	5	5
1229	024	03	28	03E	KAY	OK	GD	3325	3082	3006	76	0	0	0
1230	333	11	28	03E	KAY	OK	GN	3231	2985	2920	65	0	6	6
1231	432	35	28	03E	KAY	OK	GD	3448	3014	2967	47	2	4	6
1232	411	09	28	04E	KAY	OK	E	3637	3042	3000	42	0	0	0
1233	144	25	28	04E	KAY	OK	E	3144	2933	2886	47	0	0	0
1234	242	28	28	05E	KAY	OK	GD	3120	2892	2853	39	1	0	1
1235	414	29	28	06E	OSAGE	OK	GD	3529	2835	2797	38	0	0	0
1236	333	09	28	07E	OSAGE	OK	GDN	3212	2576	2539	37	0	0	0
1237	332	36	28	07E	OSAGE	OK	GN	2701	2420	2384	36	0	0	0
1238	003	13	28	08E	OSAGE	OK	GD	3353	2694	2654	40	0	0	0
1239	112	16	28	08E	OSAGE	OK	GD	2513	2186	2150	36	0	0	0
1240	411	33	28	08E	OSAGE	OK	GD	2523	2212	2175	37	0	0	0
1241	222	34	28	09E	OSAGE	OK	GN	2227	1892	1848	44	0	3	3
1242	421	03	28	10E	OSAGE	OK	GN	1698	1391	1344	47	0	0	0
1243	422	16	28	10E	OSAGE	OK	GN	1961	1603	1552	51	1	0	1
1244	144	29	28	10E	OSAGE	OK	GD	2191	1754	1704	50	1	0	1
1245	001	13	28	11E	OSAGE	OK	GD	1871	1444	1388	56	0	0	0
1246	423	28	28	11E	OSAGE	OK	GN	2191	1450	1394	56	0	0	0
1247	001	08	28	12E	OSAGE	OK	GN	1640	1212	1150	62	6	0	6
1248	003	33	28	12E	OSAGE	OK	GD	1864	1353	1290	63	0	0	0
1249	002	02	28	13E	WAGONEER	OK	GN	1392	1064	1009	55	3	0	3
1250	444	12	28	13E	WAGONEER	OK	GN	1595	1149	991	158	2	0	2
1251	000	36	28	13E	WAGONEER	OK	GN	1447	1126	1055	71	0	0	0
1252	000	08	28	14E	WAGONEER	OK	GN	1422	1176	1024	152	66	0	66
1253	324	30	28	14E	WAGONEER	OK	GN	1340	1006	943	63	0	0	0
1254	143	05	28	15E	NOWATA	OK	GN	1178	935	788	147	71	0	71
1255	444	06	28	15E	NOWATA	OK	GN	1149	974	798	176	86	0	86
1256	421	07	28	15E	NOWATA	OK	GN	1161	985	826	159	41	0	41
1257	000	17	28	15E	NOWATA	OK	GN		898	824	74	6	0	6
1258	323	06	28	16E	NOWATA	OK	GD	1135	649	578	71	11	0	11
1259	002	08	28	16E	NOWATA	OK	GD	1079	555	493	62	4	0	4
1260	241	15	28	16E	NOWATA	OK	GN	901	407	357	50	2	0	2
1261	044	24	28	16E	NOWATA	OK	GN	970	438	384	54	5	0	5
1262	113	07	28	17E	NOWATA	OK	GN		442	381	61	16	0	16
1263	111	30	28	17E	NOWATA	OK	GN	1208	438	379	59	2	0	2
1264	442	04	28	18E	CRAIG	OK	GD	374	257	202	55	2	0	2
1265	000	18	28	18E	CRAIG	OK	GN	1161	298	229	69	5	0	5
1266	000	30	28	18E	CRAIG	OK	GN	757	275	219	56	4	0	4
1267	113	15	28	19E	CRAIG	OK	GN	364	131	70	61	1	0	1
1268	041	22	28	19E	CRAIG	OK	GN	587	116	56	60	0	0	0

Well Num	Qtr Sec	SE	Tp	Rge	County	State	Log Type	Total Depth	Top OAKL	Base EXCE	INT THK	Sandstone LO	UP	TOT
1269	234	13	29	02E	KAY	OK	GD		3107	3022	85	0	5	5
1270	112	21	29	03E	KAY	OK	GD	3356	3103	3018	85	0	5	5
1271	424	17	29	04E	KAY	OK	E	3246	2994	2920	74	0	0	0
1272	000	20	29	04E	KAY	OK	E	3610	3052	2992	60	0	0	0
1273	342	33	29	04E	KAY	OK	E	3296	3064	3004	60	0	0	0
1274	011	13	29	05E	CRAIG	OK	GD	3042	2763	2715	48	0	0	0
1275	032	14	29	05E	CRAIG	OK	GD	3056	2746	2699	47	2	1	3
1276	444	22	29	06E	OSAGE	OK	GD	3456	2746	2706	40	0	1	1
1277	443	32	29	06E	OSAGE	OK	GD		2707	2667	40	3	2	5
1278	421	17	29	07E	OSAGE	OK	GD	3239	2612	2573	39	0	0	0
1279	223	35	29	07E	OSAGE	OK	GD	2905	2565	2530	35	0	0	0
1280	224	34	29	08E	OSAGE	OK	GN	2573	2052	2013	39	1	0	1
1281	432	16	29	09E	OSAGE	OK	GD	2588	1856	1813	43	0	0	0
1282	241	31	29	09E	OSAGE	OK	GD	2234	1960	1923	37	3	0	3
1283	000	16	29	10E	OSAGE	OK	GN	1834	1420	1374	46	6	0	6
1284	344	36	29	10E	OSAGE	OK	GD	1735	1361	1314	47	2	0	2
1285	133	21	29	12E	OSAGE	OK	EGD	2029	1266	1207	59	0	0	0
1286	231	33	29	12E	OSAGE	OK	GN	1680	1243	1182	61	0	0	0
1287	222	24	29	13E	WAGONEER	OK	GN	1234	977	924	53	4	4	8
1288	434	34	29	13E	WAGONEER	OK	GN	1394	1051	996	55	0	0	0
1289	433	16	29	14E	WAGONEER	OK	GD	1377	1104	1050	54	1	3	4
1290	000	29	29	14E	NOWATA	OK	GD	1252	988	927	61	11	0	11
1291	421	35	29	15E	NOWATA	OK	GD	1166	642	572	70	2	1	3
1292	412	25	29	17E	NOWATA	OK	GD	790	346	294	52	11	0	11
1293	244	33	29	18E	CRAIG	OK	GD	754	254	200	54	5	0	5

Appendix B—Petrographic data for the Banzet formation

1) JEL = Lardner, 1984; PNR = Reinholtz, 1982; SLD = Denesen, 1985; MRN = Nelson, 1985.
2) See text for explanation of facies designations.
3) All samples are from well cores except those by SLD.

Thin Section	Ternary Composition			Porosity				Data
Sample Number	Quar	Feld	R.Fr.	Prim	Sec	Total	Facies	Source
IM-8:948.9	62.0	28.0	10.0	07.0	15.0	22.0	LB	JEL
IM-8:949.9	63.0	29.0	09.0	08.0	15.0	23.0	LB	JEL
KB-1:967.0	59.0	24.0	17.0	06.0	15.0	21.0	LB	JEL
KB-1:973.2	58.0	23.0	18.0	03.0	08.0	11.0	LB	JEL
LB-3:959.5	63.0	18.0	19.0	10.0	08.0	18.0	LB	JEL
LB-3:961.1	63.0	23.0	14.0	05.0	08.0	13.0	LB	JEL
LB-3:966.8	69.0	20.0	11.0	08.0	05.0	13.0	LB	JEL
LB-3:967.8	66.0	27.0	07.0	05.0	08.0	13.0	LB	JEL
KB-1:955.4	76.0	22.0	02.0	0	0	0	LD	JEL
KB-1:955.9	79.0	19.0	02.0	01.0	04.0	05.0	LD	JEL
KB-1:956.7	67.0	32.0	01.0	03.0	10.0	13.0	LD	JEL
KB-1:957.3	71.0	22.0	07.0	01.0	05.0	06.0	LD	JEL
LP-6:976.4	78.0	13.0	09.0	0	0	0	LD	JEL
LWB-4:941.3	81.0	12.0	07.0	0	0	0	LD	JEL
BB-3:21.5	88.0	03.0	09.0	Not Measured			CC	PNR
BB-5:21.2	90.0	06.0	04.0	Not Measured			CC	PNR
BB-7:21.0	83.0	09.0	08.0	Not Measured			CC	PNR
BB-9:20.5	89.0	09.0	02.0	Not Measured			CC	PNR
BB-11:20.2	85.0	08.0	07.0	Not Measured			CC	PNR
BB-13:19.8	82.0	09.0	09.0	Not Measured			CC	PNR
BB-15:19.6	90.0	05.0	05.0	Not Measured			CC	PNR
BB-17:19.0	81.0	12.0	07.0	Not Measured			CC	PNR
BB-20:18.7	83.0	08.0	09.0	Not Measured			CC	PNR
BB-22:18.6	87.0	07.0	06.0	Not Measured			CC	PNR
BB-24:18.0	85.0	08.0	07.0	Not Measured			CC	PNR
BB-26:17.9	89.0	04.0	07.0	Not Measured			CC	PNR
BB-28:17.6	90.0	06.0	04.0	Not Measured			CC	PNR
BB-30:17.3	82.0	12.0	06.0	Not Measured			CC	PNR
BB-32:17.0	83.0	10.0	07.0	Not Measured			CC	PNR
BB-34:16.5	86.0	07.0	07.0	Not Measured			CC	PNR
18-2:16.3	80.0	11.0	09.0	Not Measured			CC	PNR
18-5:15.2	85.0	05.0	10.0	Not Measured			CC	PNR
16-2:19.8	85.0	09.0	06.0	Not Measured			CC	PNR
16-6:18.4	85.0	09.0	06.0	Not Measured			CC	PNR
16-8:17.2	83.0	10.0	07.0	Not Measured			CC	PNR
16-10:15.8	88.0	06.0	06.0	Not Measured			CC	PNR
K-1:18.5	84.0	06.0	10.0	Not Measured			BC	PNR
K-3:18.1	79.0	03.0	18.0	Not Measured			BC	PNR
K-5:17.3	81.0	10.0	09.0	Not Measured			BC	PNR
K-9:14.4	92.0	05.0	03.0	Not Measured			BC	PNR
K-11:13.2	95.0	03.0	02.0	Not Measured			BC	PNR
K-17:10.4	98.0	02.0	00.0	Not Measured			BC	PNR
HB:742.1	92.0	04.0	04.0	Not Measured			BC	PNR
HB:729.7	89.0	05.0	06.0	Not Measured			BC	PNR
H8-2:657.0	89.0	05.0	06.0	Not Measured			BC	PNR
H8-2:648.6	94.0	04.0	02.0	Not Measured			BC	PNR
L-36:694.1	92.0	05.0	03.0	Not Measured			BC	PNR
L-36:689.0	90.0	05.0	05.0	Not Measured			BC	PNR
H-20:694.3	96.0	02.0	02.0	Not Measured			BC	PNR
H-20:685.0	90.0	04.0	06.0	Not Measured			BC	PNR
H-20:679.7	92.0	05.0	03.0	Not Measured			BC	PNR
J-22:682.5	91.0	05.0	04.0	Not Measured			BC	PNR

Thin Section Sample Number	Ternary Composition Quar	Feld	R.Fr.	Porosity Prim	Sec	Total	Facies	Data Source
J-22:671.6	95.0	04.0	01.0	Not Measured			BC	PNR
9-4	85.0	12.0	03.0	Not Measured			A	SLD
9-6	81.0	14.0	05.0	Not Measured			A	SLD
6-2	79.0	11.0	10.0	Not Measured			A	SLD
4-2	77.0	19.0	04.0	Not Measured			A	SLD
8-4	80.0	15.0	05.0	Not Measured			A	SLD
7-2:3.3	70.0	21.0	09.0	Not Measured			B	SLD
7-2:6.2	75.0	16.0	09.0	Not Measured			B	SLD
9-2:0.6	75.0	14.0	11.0	Not Measured			B	SLD
9-2:4.0	77.0	16.0	07.0	Not Measured			B	SLD
HAR-2:694.0	42.0	15.0	43.0	03.0	04.0	07.0	AC	MRN
HAR-3:692.2	56.0	29.0	15.0	04.0	09.0	13.0	AC	MRN
HAR-4:688.7	43.0	30.0	27.0	02.0	08.0	10.0	AC	MRN
HAR-8:677.5	47.0	37.0	16.0	03.0	05.0	08.0	DS	MRN
HAR-10:669.0	45.0	33.0	22.0	03.0	08.0	11.0	BC	MRN
HAR-12:661.0	42.0	40.0	18.0	02.0	08.0	10.0	BC	MRN
HAR-13:658.5	42.0	38.0	20.0	01.0	04.0	05.0	BC	MRN
HAR-15:652.3	51.0	29.0	20.0	03.0	08.0	11.0	CB	MRN
HAR-16:647.7	53.0	34.0	13.0	03.0	06.0	09.0	CB	MRN
HEM-1:782.2	46.0	36.0	18.0	04.0	05.0	09.0	AC	MRN
HEM-2:781.1	45.0	33.0	22.0	00.0	02.0	02.0	DS	MRN
HEM-3:780.6	44.0	32.0	24.0	03.0	06.0	09.0	AC	MRN
HEM-5:778.0	42.0	32.0	26.0	01.0	03.0	04.0	DS	MRN
HEM-9:770.3	47.0	36.0	17.0	06.0	05.0	11.0	CB	MRN
HEM-13:757.5	45.0	36.0	19.0	04.0	05.0	09.0	BC	MRN
HEM-14:751.5	64.0	32.0	04.0	04.0	05.0	09.0	CB	MRN
HEM-18:744.0	50.0	32.0	18.0	04.0	04.0	08.0	BC	MRN

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