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Stratigraphy and Depositional Environments of the

Cherokee Group (Middle Pennsylvanian),

Sedgwick Basin, Southcentral Kansas

by

David B. Killen

KANSAS GEOLOGICAL SURVEY
1930 Constant Avenue
University of Kansas
Lawrence, KS 66047

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STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS OF THE CHEROKEE GROUP (MIDDLE PENNSYLVANIAN), SEDGWICK BASIN, SOUTHCENTRAL KANSAS

by

David B. Killen

B.S., University of Kansas, 1983

Submitted to the Department of Geology and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Science.

Anthony W. Walton
Professor in Charge

Ernest E. Angino

Lawrence L. Brady
Committee Members

Ernest E. Angino
For the Department

Table of Contents

List of Figures

List of Plates
(Plates in pocket in back cover)

Plate

Plate

ABSTRACT

Interpretation of data from geophysical well logs, cores, and well cuttings provided detailed stratigraphic correlation of the Cherokee Group in the Sedgwick basin. The development of isopach and lithofacies maps allowed interpretation of Middle Pennsylvanian depositional environments.

Stratigraphic correlation of radioactive black shales from southeastern Kansas to the Sedgwick basin confirmed that black shales are laterally widespread throughout the Sedgwick basin, as well as extending into the Cherokee and Forest City basins. It is possible to divide the Cherokee Group into eight stratigraphic intervals on the basis of these markers. Cross sections indicate that the Sedgwick basin subsided during deposition of the Krebs Formation. Stratigraphic intervals in the Cabaniss Formation are relatively constant in thickness, suggesting little or no differential subsidence during deposition. The Cabaniss has a higher percentage of limestone than the Krebs interval.

Lithofacies mapping indicates the Sedgwick basin evolved from a mud-dominated basin to a carbonate shelf. Three lithofacies were distinguished through use of the limestone percentage maps: the limestone facies (60% and greater of limestone), the limestone-and-shale facies (30-59% limestone), and the shale facies (less than 29% limestone). A gradual increase in percentage of limestone and decrease in percentage of shale is observed in successively younger intervals. Siliciclastic mud was derived from the Central Kansas uplift, Nemaha uplift, Anadarko basin, and possibly the Ouachita Mountains and southeast Kansas. Between the base of the Mineral interval and the top of the Cherokee, the Cabaniss Formation is predominately limestone. The continuous nature of the limestone facies in those intervals reflects a shallow, stable setting and widespread carbonate precipitation.

ACKNOWLEDGEMENTS

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This thesis is dedicated to my parents Don and Elaine Killen. Without their moral and financial support my education would not have been possible.

INTRODUCTION

The Cherokee Group is the lower group in the Desmoinesian Stage, Middle Pennsylvanian Series. In Kansas, the Cherokee Group has been divided into the Cabaniss Formation (lower) and the Krebs Formation (Jewett, O'Connor, and Zeller, 1968). The Cherokee Group consists of shale, limestone, sandstone, and thin coal beds (Adkinson, 1963; Lee, 1949).

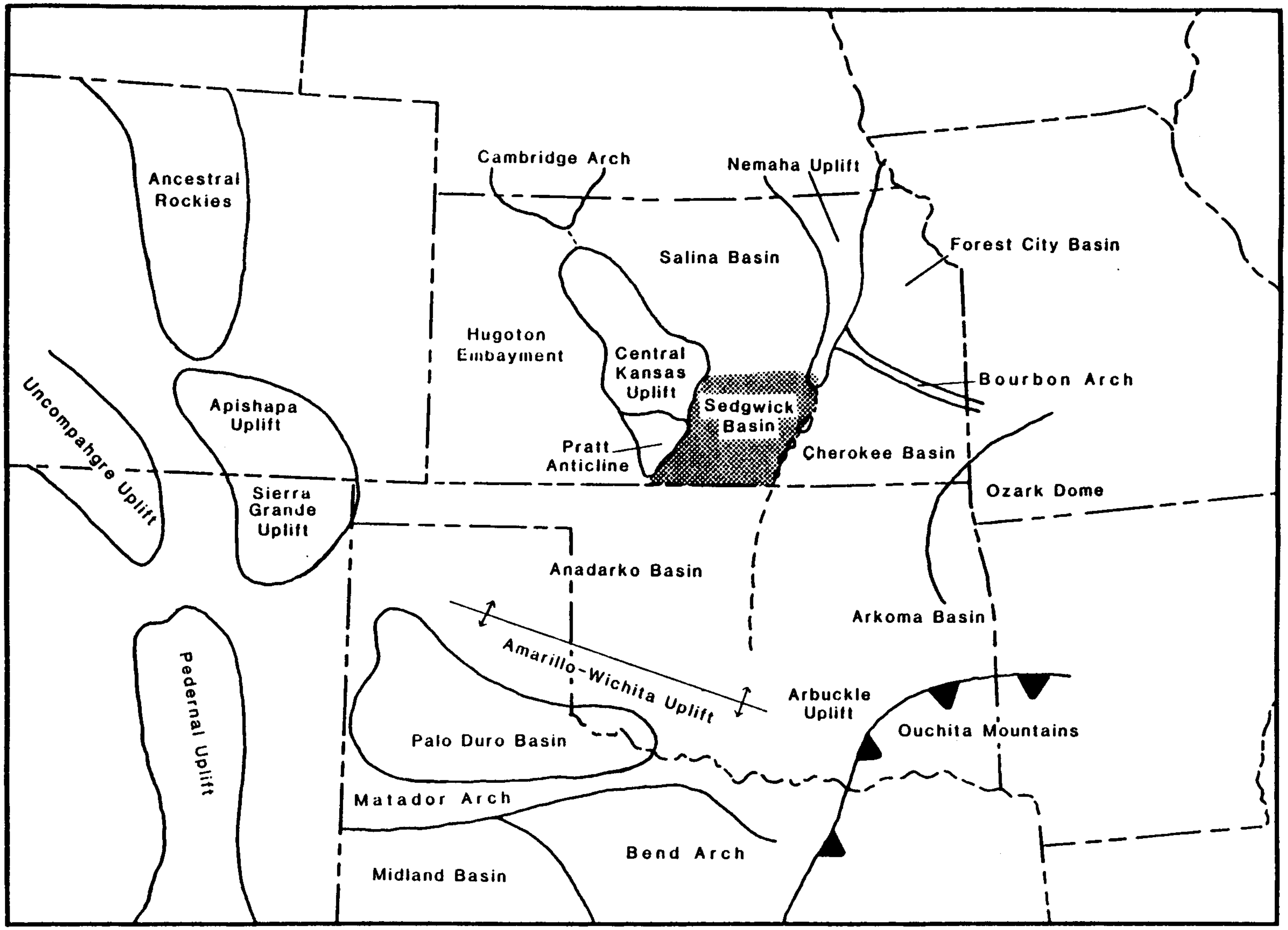
Purpose and Significance of Study

The primary objectives of this study are (1) to provide detailed stratigraphic correlation of the Cherokee Group in the Sedgwick basin, and (2) to interpret depositional environments and examine lateral facies distribution in the Cherokee with emphasis on changes with time and regional setting. The importance of this study is to extend detailed work on the Cherokee Group from southeastern Kansas to the Sedgwick basin where little stratigraphic information is available. Examination of the depositional environments and facies distribution within the study area will better define the regional setting of the midcontinent in Middle Pennsylvanian time. This research is part of a project to study Kansas sedimentary basins and their depositional and tectonic history. Information from this study will be used to provide data on coal resource distribution in the Sedgwick basin as part of a broader effort by the Kansas Geological Survey in conjunction with the United States Geological Survey.

Area of Investigation

The study area covers approximately 8,100 square miles (approximately 21,000 square kilometers) within a 12-county area in southcentral Kansas (Fig. 1). Specifically, the study includes the area between Township 20 South, Range 4 East to 7 West on the north side, to Township 35 South, Range 1 East to 14 West on the south side. Thickness of the Cherokee in the Sedgwick basin ranges from 0 m along the eastern flank of the Central Kansas Uplift (Rice, Reno, Pratt, and Barber counties, Kansas) and northeast portions of the study area along the west flank of the Nemaha uplift (Marion and Butler counties, Kansas) to nearly 90 m in Harper County, Kansas.

Figure 1 - Location of study area and Pennsylvanian structural features of the midcontinent.



Ancestral Rockies
Cambridge Arch
Nemaha Uplift
Forest City Basin
Salina Basin
Hugoton Embayment
Central Kansas Uplift
Bourbon Arch
Uncompahgre Uplift
Apishapa Uplift
Sedgwick Basin
Pratt Anticline
Cherokee Basin
Sierra Grande Uplift
Ozark Dome
Anadarko Basin
Arkoma Basin
Amarillo-Wichita Uplift
Arbuckle Uplift
Pedernal Uplift
Ouchita Mountains
Palo Duro Basin
Matador Arch
Bend Arch
Midland Basin

Previous Investigations

The Cherokee Group was originally mentioned by Haworth and Kirk (1894) following description of a section along the banks of the Neosho River in southeastern Kansas. Since then, the Cherokee Group has undergone significant change in its stratigraphic nomenclature. Early stratigraphic classification schemes were based upon coal bed or sandstone distribution (Abernathy, 1937; Searight and others, 1953; Howe, 1956; and Branson, 1957). Moore (et al., 1951) classified the rocks of the Cherokee Group on the basis of cyclothems. Detailed study by Howe (1956) led to the division of the Cherokee into 18 formations. Rock units between one coal bed and the top of the next overlying coal bed were classified as one formation. The bottom six formations were grouped into the Krebs Subgroup and the upper eleven into the Cabaniss Subgroup. Practical considerations of mapping led Jewett (1959) to change the rank of the Cabaniss and Krebs from subgroup to formation.

A generalized overview of the Cherokee Group has been presented by Ebanks, Brady, and others (1979). Seevers (1975) published a description of surficial rocks in Cherokee County, Kansas. Preliminary work on the Lagonda interval (uppermost Cherokee) and the redefining of the stratigraphic nomenclature of the upper Cabaniss Formation is underway (Brenner, in review; Lardner, 1984; and Denesen, 1985). Harris (1984) studied the stratigraphy and depositional environments of the Krebs Formation in southeastern Kansas. Aden (1982) studied clay mineralogy and depositional environments of the Lagonda interval in eastern Kansas, western Missouri, and northeastern Oklahoma. Murphy (1978) studied outcropping Middle Cherokee (lower Cabaniss) facies in detail in Kansas, Missouri, and Oklahoma, and compared them with facies of modern depositional environments.

The Cherokee Group in southeastern Kansas is an important source of oil, gas, and coal. Estimates of cumulative production from Cherokee rocks in Kansas (Brady, 1985, personal communication) are approximately 0.7 billion barrels of oil, more than 0.6 trillion cubic feet of natural gas, and 278 million tons of coal. Ebanks and James (1974), Ebanks, James, and Livingston (1977), and Ebanks (1979), have evaluated the heavy oil and tar sands potential of southeast Kansas and the tri-state district of Kansas, Missouri, and Oklahoma. A detailed account of resources, strippable coal reserves, and stratigraphy of coal-bearing units for Kansas has been discussed by Brady, Livingston, and Adams (1976).

Detailed work on the Cherokee Group in the Sedgwick basin has not been attempted prior to this study. The need for such a study was identified by L. H. Lukert (1949 p.132) "since the Cherokee presents stratigraphic problems which warrant separate study..." Correlations through the Sedgwick basin that include the Cherokee Group have been published by Lee (1949), Lukert (1949), Lee and Merriam (1954), Goebel and Merriam (1957), and Adkison (1963). Jewett (1951), Kelly (1961), Merriam (1963), and Kelly and Merriam (1964) studied the character and structural evolution of the Sedgwick basin in detail. Other authors have discussed the Cherokee Group and the Sedgwick basin in reference to the more significant Anadarko basin to the south (Gibbons, 1962; Stanbro, 1960; McElroy, 1961; Rascoe, 1962; Berg, 1969; and Rascoe and Adler, 1983).

The lowermost Pennsylvanian deposit unconformably overlying the Mississippian limestone is the Pennsylvanian basal conglomerate or "Burgess sand". The Pennsylvanian basal conglomerate is one of the more significant oil-and-gas bearing units in the Sedgwick basin. Its origin and significance have been discussed by Lee (1939), Merriam (1960 and 1963), and Nodine-Zeller (1981 and 1985).

METHODS OF INVESTIGATION

The Cherokee Group has been inconsistantly identified in the Sedgwick basin. This is due to the very different depositional history and lithologies represented in the Cherokee section of the Sedgwick basin compared to the better known Cherokee stratigraphy in southeastern Kansas. Use of all available information was critical to this study to ensure accurate results. Sources of information include scout cards, geophysical well logs, cores, well cuttings, and sample logs.

Geophysical well logs

The majority of data for this study stems from analysis of geophysical well logs. Two hundred and sixteen well logs were examined with a spacing of one well per township (36 square miles; 93.3 square kilometers) (Fig. 2). Gamma ray, neutron, and density logs were used because of their reliability in correlating, identifying lithologies, and calculating volume of shale. If a suitable gamma ray-neutron log

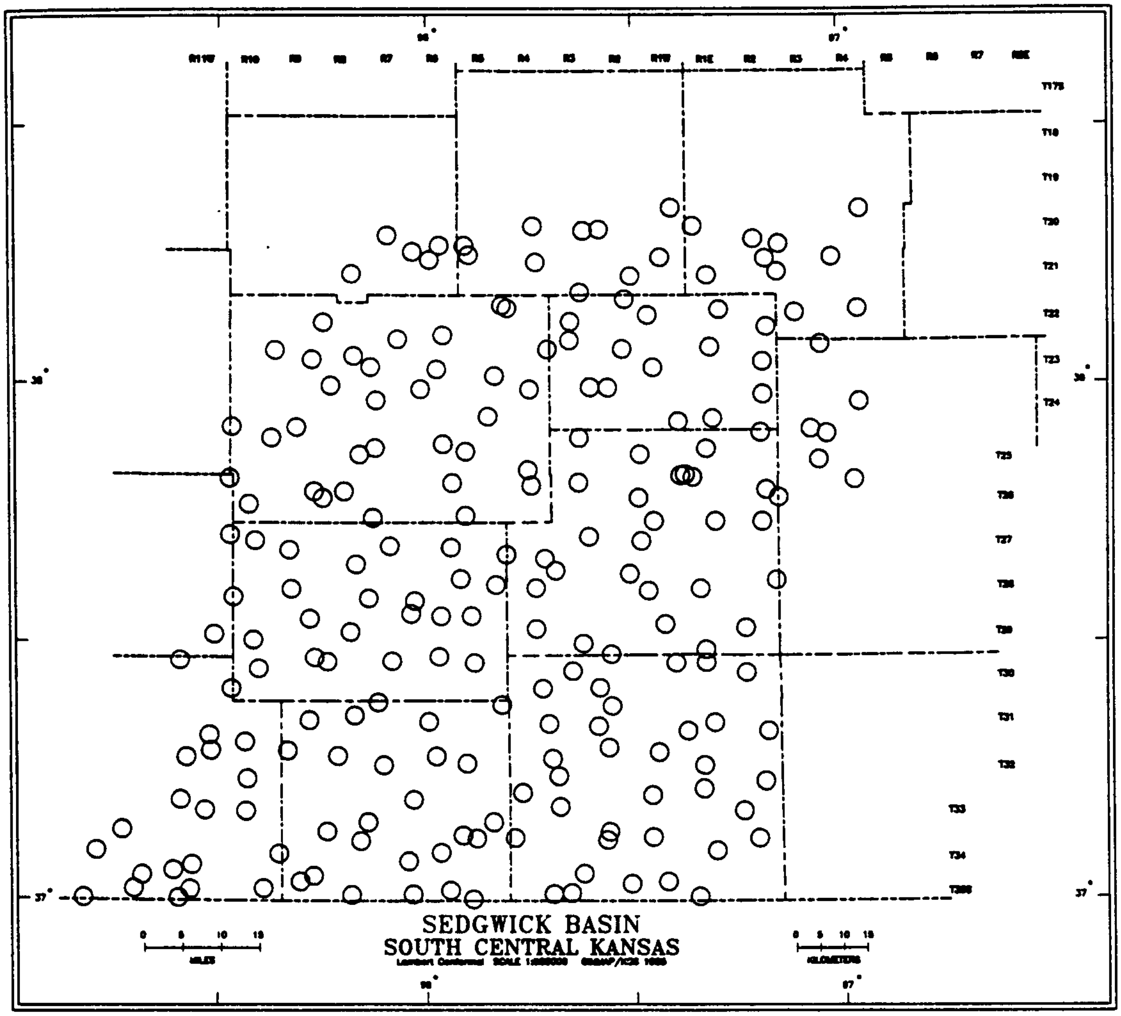


Figure 2 – Location of geophysical logs examined in study area.

was not available for a township, a spontaneous potential-resistivity log was used, but only for identifying the top of the Mississippian limestone.

Shale abundance

Gamma ray logs record the natural radioactivity of rocks. Most natural radioactivity is from ^{40}K in clays and isotopes of the uranium series. Highly radioactive shales are characteristically black or very dark gray, and respond with a sharp deflection of increasing API gamma ray units on the gamma ray log.

Percentage of shale present in the formation was calculated from gamma ray logs. Sandstone or limestone versus shale was determined by a 50% (actually 50% clay) shale line drawn on gamma ray logs. Calculation of the 50% shale line begins with the determination of the maximum gamma ray count for a non-black shale (GRmax), and the minimum gamma ray count for a clean sand or carbonate (GRmin). Following Dresser Atlas (1979), older, consolidated rocks with 50% clay have a gamma ray index (Igr) of 0.64. Substitution into the formula;

$$Igr = \frac{GRlog - GRmin}{GRmax - GRmin} \quad \text{(Schlumberger, 1974)}$$

will yield the gamma ray count where the 50% shale line should be drawn (GRlog).

Sandstones vs. Limestones

It is frequently difficult to distinguish between sandstones and limestones because of their similar log response on gamma ray and neutron logs (Fig. 3). The geologist's familiarity with the geology and stratigraphy of the area along with log analysis experience can resolve the problem. Clean limestones are typically less radioactive than clean, non-feldspathic sandstones (figures 4 and 5). Neutron response depends upon formation fluids. Water-bearing limestones tend to have a higher neutron response (i.e. higher apparent density) on the API scale than non-feldspathic, water-bearing sandstones. Thin, clean limestones usually leave a telltale sharp deflection to the right (indicating greater density) on the neutron log. Where the gamma ray curve may not conclusively identify the thin unit as a limestone or sandstone because of tool resolution, the neutron log can sharply increase over 750 API units in a limestone of less than 3 feet (0.91 meters) in thickness. If gamma ray-neutron logs do not conclusively identify

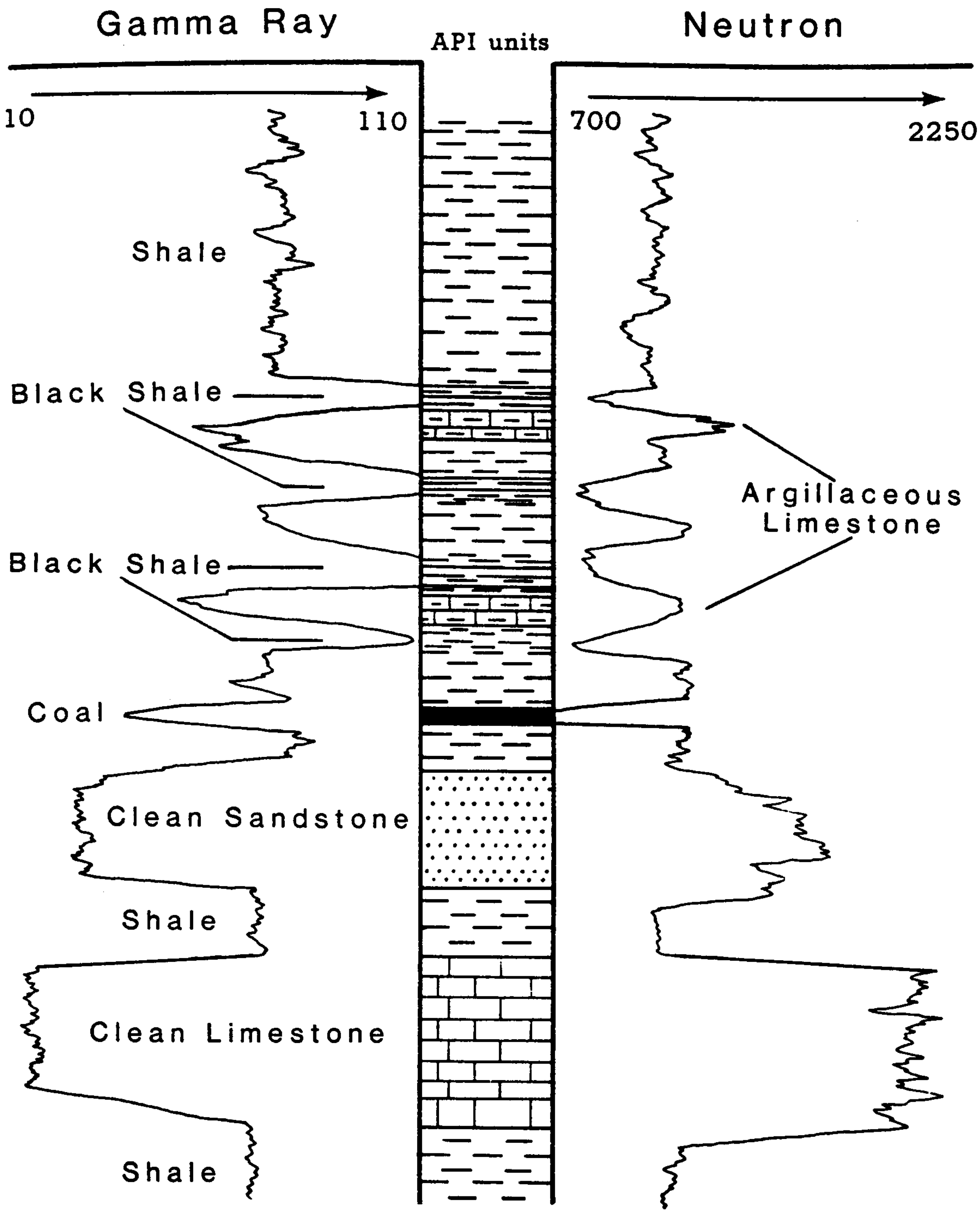
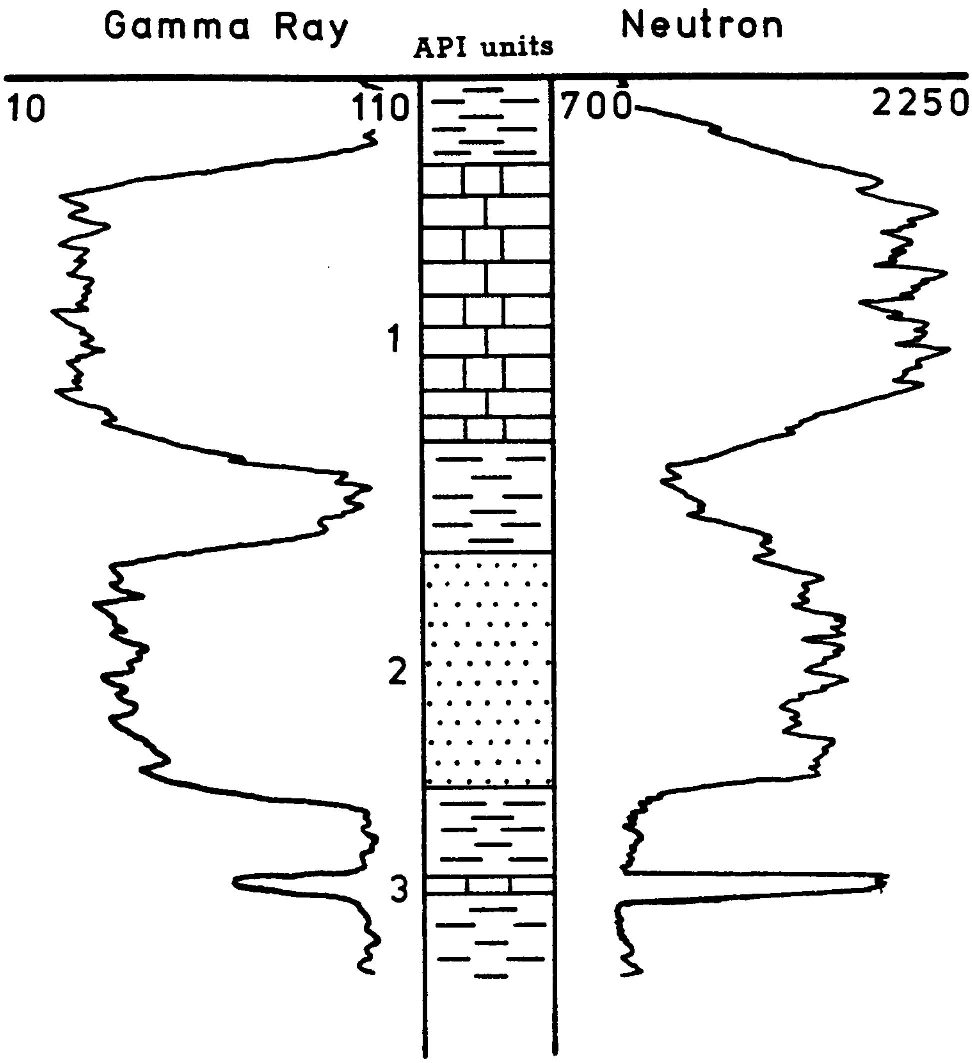


Figure 3 – Lithologic responses on a typical gamma ray – neutron geophysical log.

Lithology	GR API units (average)	Neutron API units (average)
clean limestone	20 - 40	variable but high
clean sandstone	30 - 50	variable but high
shale	60 - 90	930 - 1100
black shale	100 - 170	700 - 950
coal	30 - 60	775 - 860

Figure 4 - Average API numerical values for lithologies on a gamma ray - neutron log.



1 clean limestone

2 clean, non—feldspathic sandstone

3 thin, clean limestone

Figure 5 – Gamma ray – neutron response for sandstone and limestone.

the lithology, other types of geophysical logs and well cuttings can.

Physical Analysis

Stratigraphic and sedimentologic data were obtained from eight cores and cuttings from thirteen wells (Fig. 6). Cores were obtained from the Kansas Geological Survey core repository in Lawrence, Kansas. The cores were examined and described wet, noting depth, color, lithology, sedimentary structures, fossils, and diagenesis. Because the Cherokee Group is not a significant producer of oil or gas in the Sedgwick basin, few cores are available. Only the upper Cherokee interval and the Pennsylvanian basal conglomerate interval have been cored. The upper Cherokee interval (part of the Cabaniss Formation) has been cored only along the flanks of the Sedgwick basin where the interval rests unconformably upon the Pennsylvanian basal conglomerate. The majority of the cores described are of the Pennsylvanian basal conglomerate. Because of the few cores available in the Sedgwick basin, two cores located outside, but within six miles (9.6 km.) of the study area

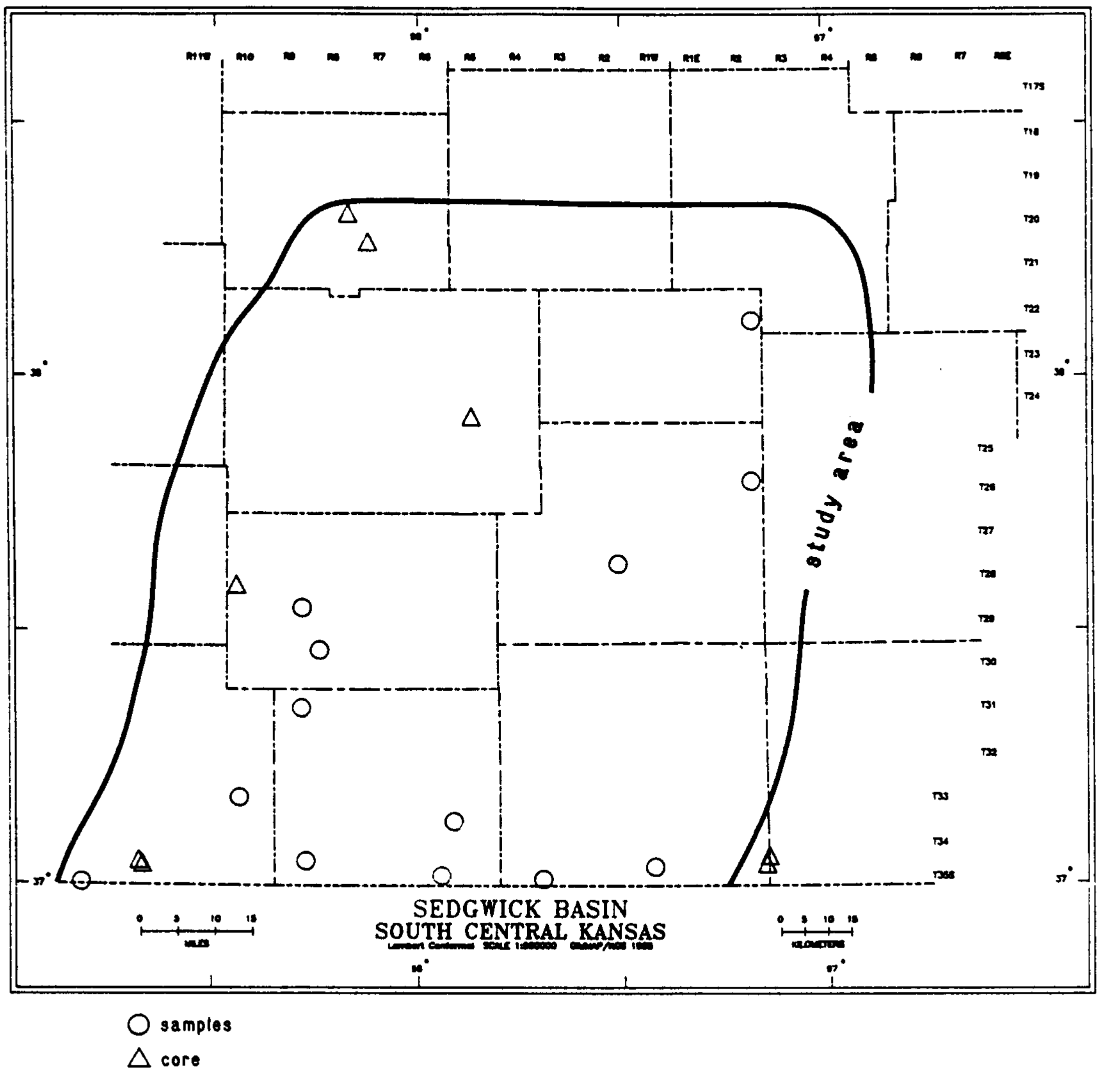


Figure 6 - Location of examined cores and well cuttings.

were also examined for additional information on thickness and distribution of sandstone and basal conglomerate.

Drill cuttings were obtained from the Kansas Geological Survey sample library in Wichita, Kansas. Thirteen wells and their corresponding geophysical logs were selected for sample examination (appendix C). The primary reasons for the well selection was to confirm presence of sandstone and basal conglomerate that was suspected from geophysical log picks, and to look for any indication of coal in the samples. Sample spacing was commonly at five foot (1.5 meters) or ten foot (3.1 meters) intervals with sandstone and basal conglomerate sections at one foot intervals (0.3 meters). Samples were examined and described following Low (1977).

Detailed sample logs constructed by the Kansas Sample Log Service in Wichita, Kansas, and on file at the Kansas Geological Survey, in conjunction with cuttings, provided lithologic observations over the entire study area (appendix C). The sample logs were selected to match a geophysical log used for correlation or to be as close as possible to the location of one of the correlation logs. Use of sample logs aided the accuracy of mapping of Pennsylvanian basal conglomerate. Twenty-two sample logs corresponded to the logs used in the study.

Computer Applications

Locations of the geophysical well logs were plotted on standard United States Geological Survey 7.5 minute topographic maps. The locations were digitized using a Tektronix computer system to translate section, township, and range to longitude and latitude. This information, along with other data collected from the geophysical logs, was entered into two databases on the Data General MV-8000 mainframe computer at the Kansas Geological Survey. The purpose of the databases are to organize and access pertinent information efficiently for this study and future studies.

The first database consists of the basic information found on the cover page of well logs, longitude, latitude, elevation, and the well identification number used for this study (Fig. 7A). The second database (Fig. 7B) contains the information necessary for computer posting of data and contour mapping. Information in the database includes identification numbers of the correlation marker, depth of markers, thickness to the

```
                              -- SEDGWICK BASIN --
PLEASE ENTER THE DECIMAL POINT, IF ANY, AT THE POSITION POINTED BY ^.

 WELL ID             WELL NAME
  ( 53)      (CHAVEZ #1            )

          COMPANY                              FIELD
 (E. H. ADAIR OIL COMPANY  )  (WILDCAT                 )

                      QUAD.
   LOG      CNTY      MAP       SEC     TWN      RNG       LOCATION
 (RG    )   (HV)     (0938)    (26)   (S24)    (W 1)     ( C)(SE)(SE)


  LONGITUDE     LATITUDE       ELEV.(GL)         X             Y
 (-97.39223)  ( 37.92891)    (1419.0)     ( 12.19748)   ( 10.10844)
      ^            ^             ^             ^             ^

     GEOLOGIST                    COMMENT
 (D. KILLEN      )     (                                )

ENTERING EDIT MODE     CTRL-C: send    CTRL-R: panic
```

A. Database #1

```
                              -- SEDGWICK BASIN --
PLEASE ENTER THE DECIMAL POINT, IF ANY, AT THE POSITION POINTED BY ^.

WELL ID#              GEOLOGIST                        COMMENT
 (053)            (D. KILLEN     )     (0640 TO 0590 LIMEY                  )

      -- MARKER --                -- LITHOLOGIC THICKNESS --
   ID    DEPTH       THK           SHALE   S. S.    L. S.    COAL
 (1000) (3038.0) (    .0)         (      ) (      ) (      ) (     )
 (0780) (3078.0) ( 40.0)          ( 30.0) (      ) ( 10.0) (     )
 (0720) (3108.0) ( 30.0)          ( 30.0) (      ) (      ) (     )
 (0640) (3117.0) (  9.0)          (  9.0) (      ) (      ) (     )
 (0590) (3143.0) ( 26.0)          ( 26.0) (      ) (      ) (     )
 (0100) (3144.0) (  1.0)          (  1.0) (      ) (      ) (     )
 (0000) (3152.0) (  8.0)          (  8.0) (      ) (      ) (     )
               ^       ^                ^        ^        ^       ^
                   TOTAL           TOTAL   TOTAL    TOTAL    TOTAL     CONTINUE TO
                  (114.0)         (104.0) (   .0) ( 10.0) (   .0)     NEW CARD ( )
                       ^                ^        ^        ^       ^
 NEW RESPECTIVE TOTALS WILL BE CALCULATED AFTER YOU SEND THIS CARD.

ENTERING EDIT MODE     CTRL-C: send    CTRL-R: panic
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B. Database #2

Figure 7 – Terminal display of databases.

next deepest identified marker, and lithologic breakdown of the section into thickness (in feet) of shale, sandstone, limestone, and coal.

The Surface II graphics system (Sampson, 1978), available at the Kansas Geological Survey, was used to contour structure, isopach, isolith, and facies maps of the Cherokee Group. Data from the second database provided the bulk of information for mapping. Three-dimensional block diagrams, or "fishnet" plots, were also made for each contoured map. Although quantitative information cannot be obtained from the block diagram, it is useful for three-dimensional interpretation.

The computer offers a number of advantages for this kind of study. The data from a large area including a few hundred wells cannot be manipulated quickly by hand (Jones and Johnson, 1983). Posting of points or data and contouring of a number of stratigraphic horizons can be effectively handled by the computer. Because of the large databases created and the number of horizons studied, the computer was used as a time-saving instrument.

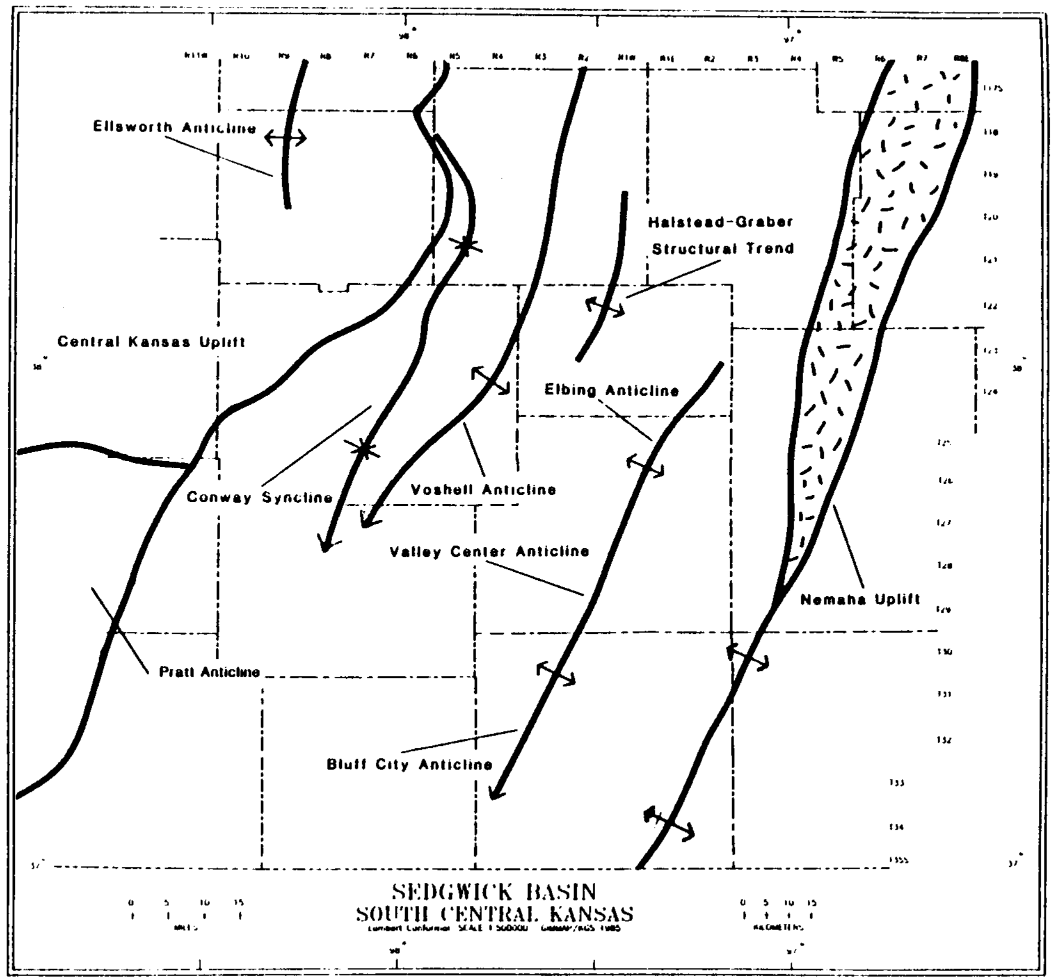
REGIONAL GEOLOGIC SETTING

Structural Setting

The Sedgwick basin is regarded as one of the major pre-Desmoinesian post-Mississippian structural features of Kansas (Jewett, 1951; Merriam, 1963). It is bounded to the east by the Nemaha anticline (Moore and Haynes, 1917), to the west by the Central Kansas uplift (Morgan, 1932) and the Pratt anticline (Merriam, 1955), to the north by the Salina basin (Barwick, 1928), and to the south by the Anadarko basin. The boundary between the Sedgwick and Salina basins is a low, indistinct arch that extends northwest-southeast through Ellsworth, McPherson, and Marion counties (Jewett, 1951; Lee, 1956; Adkison, 1963). Erosional thinning of Mississippian rocks there indicates post-Mississippian detachment of the Sedgwick and Salina basins (Lee, Leatherock, and Botinelly, 1948; Jewett, 1951). E. A. Koester (1935) is credited for naming this feature the Wilson-Burns element.

Interest in the geology of southcentral Kansas began as early as 1915 with the discovery of the El Dorado oil field in Butler County. Continued petroleum exploration helped define the structural features in Kansas. The Sedgwick basin was named by Moore and Jewett in 1942. Several minor structures that roughly parallel the Nemaha uplift have been recognized in the Sedgwick basin (Jewett, 1951; Merriam, 1963). They are the Bluff City anticline, Conway syncline, Elbing anticline, Halstead-Graber structural trend, Valley Center anticline, and the Voshell anticline (Fig. 8).

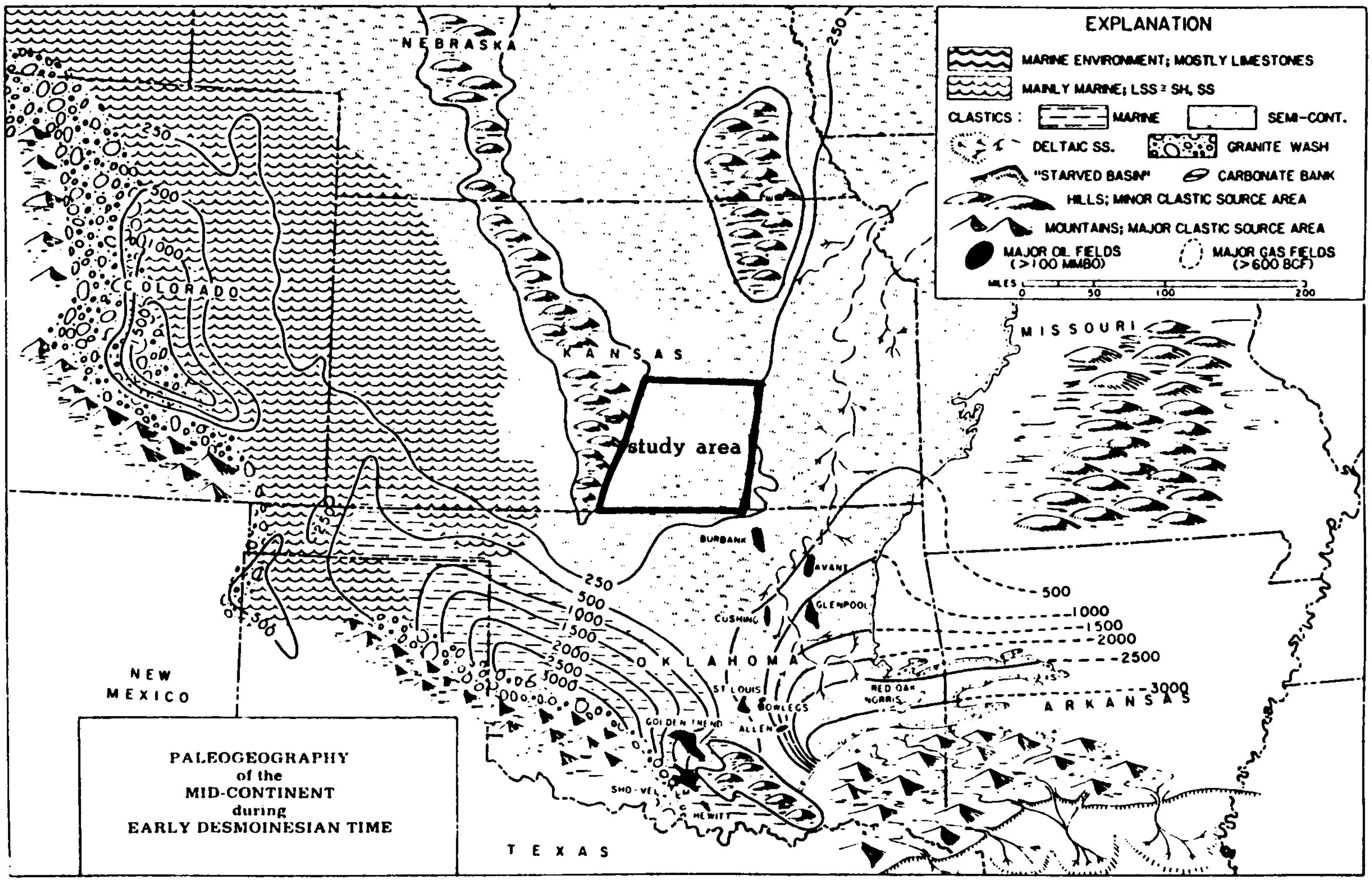
The Sedgwick basin has been described structurally as a southward plunging, shelflike, northward extension of the Anadarko basin by Jewett and Merriam (1959), Kelly (1961), and Rascoe (1962; Fig. 9). The edge of the shelf in Early Desmoinesian time was in Canadian County, Oklahoma (Kimberlin, 1954), approximately 100 miles (160 km.) south of the Kansas-Oklahoma state line. The Sedgwick basin is in a structural relationship to the Anadarko basin similar to that of the Hugoton Embayment, but is less than one-third as large. The Hugoton Embayment covers approximately 28,600 square miles (74,100 square kilometers) (Merriam, 1963) or roughly one-third of the state of Kansas.



Subcrop of Precambrian rock on the basal Pennsylvanian unconformity along the crest of the Nemaha uplift

Figure 8 - Structural features in the Sedgwick basin

Figure 9 - Paleogeography of the mid-continent during the early Desmoinesian and isopachs of lower Desmoinesian rocks, includes Atokan in Anadarko basin (modified from Rascoe and Adler, 1983). The semi-continental conditions in the Sedgwick basin interpreted by Rascoe and Adler are not supported in this study.



PALEOGEOGRAPHY
of the
MID-CONTINENT
during
EARLY DESMOINESIAN TIME

The structural and depositional framework of the North American continent is basically inherited from the Pennsylvanian Period (Moore, 1979). Tectonic instability during this time profoundly shaped the region as well as the Sedgwick basin.

The Ouachita orogeny has been interpreted as the result of suturing of the North American and South American continents (Dewey and Bird, 1970) during the Early and Middle Pennsylvanian. Graham and others (1975) interpreted the progressive, southwestward migration of the orogen and sedimentation to the growth of the continental suture. As the suture lengthened to the southwest, the midcontinent as well as the Ouachitas experienced increased deformation (Kluth and Coney, 1981).

Sedimentological study of flysch and pre-flysch strata in the Ouachita Mountains by Lowe (1985), however, indicates deposition in a narrow, two-sided basin (the Ouachita trough) from the Early Ordovician through the late Carboniferous as a result of a failed Cambrian rift system. Lowe (1985) suggests that the Ouachita trough was bounded to the north by the North American craton and to the south by the uplifted passive margin sequence (Morris, 1974) or the converging Gondwana craton.

Recurrent uplift of the passive margin complex provided quartzose sedimentary and metasedimentary debris to the trough. This debris is contained in flysch and pre-flysch units derived from sources to the south. The Ouachita trough is considered by Lowe to be one of several sedimentary basins that formed in the southern and southeastern portion of the North American craton associated with the failed Cambrian rift system. Lowe concludes that the Ouachita trough never formed the southern, passive margin of the North American craton. This is consistent with the small amount of volcanism in the Ouachitas and the Sabine Uplift of Texas (Walton, 1985, personal communication).

Continental collision during the Middle Pennsylvanian led to the structural activity in the Ancestral Rocky Mountains, the Marathon region, and the Anadarko region (Goldstein, 1961; Molnar and Tapponier, 1975; Kluth and Coney, 1981). The Central Kansas uplift and the Nemaha uplift, major pre-Desmoinesian post-Mississippian structural features of Kansas, also resulted from the continental collision. Rapid uplift also took place in the Uncompaghre and Apishapa uplifts (Mallory, 1975). The similarity in timing of deformation in the Ouachita and Marathon regions, and the Ancestral Rocky Mountains indicates that they all resulted from the same plate tectonic event (Morris, 1974; Coney, 1978; and Kluth and Coney, 1981).

Structural activity of the Ancestral Rocky Mountains and the midcontinent continued through the Late Pennsylvanian and Early Permian, but with much less intensity (Mallory, 1975; DeVoto, 1980). Deformation in the Anadarko area was still rapid, particularly along the Amarillo-Wichita Uplift (Tomlinson and McBee, 1959). The Marathon area experienced intense thrusting and folding during the Late Pennsylvanian and Early Permian (Kluth and Coney, 1981).

REGIONAL PENNSYLVANIAN STRATIGRAPHY

Springeran Stage

Towards the end of the Mississippian, the midcontinent experienced a major regression of the sea. Pennsylvanian deposition associated with latter stages of the regression are represented by the Springer Series (Huffman, 1959). The name Springer is derived from the town in the Ardmore basin in southcentral Oklahoma (Tomlinson, 1929) where thicknesses range from 3,000 to 5,000 feet (914 to 1,524 meters). No Springeran rocks are present in the Sedgwick basin.

Morrowan Stage

Much of the midcontinent was an area of exposed, low-lying Mississippian and older Paleozoic rocks during the Morrowan. Tectonic features formed during late Mississippian and early Pennsylvanian time began to influence depositional patterns during the Morrowan marine transgression (Moore, 1979; and Swanson, 1979).

Identification of the Morrow is based primarily on the fusilinid Millerella (Thompson, 1944; and Wanless, 1969). The Morrowan is the oldest Pennsylvanian unit present in Kansas and is restricted to the subsurface of western Kansas. The entire stage has been grouped into the Kearney Formation in Kansas by Thompson and includes as much as 600 feet (183 meters) of shale, limestone, and sandstone (Huffman, 1959; Moore, 1979; Rascoe, 1962; Wanless, 1969; and Zeller, 1968).

Atokan Stage

By the beginning of Atokan time, the major Pennsylvanian tectonic features of the midcontinent had reached their full extent, with continued minor movement into early Permian (Moore, 1979). In Kansas, the Atokan Stage is again present in the subsurface of the western portion of the state and may be present in the Forest City basin in northeastern Kansas (Searight and Howe, 1961). Thickness of Atokan rocks range from 0 to 500 (0 to 152 meters) feet in the Hugoton embayment. A widespread coal bed is common at the base of the Atokan (Zeller, 1968).

Desmoinesian Stage

Much of the midcontinent region was inundated by epicontinental seas during the Desmoinesian and widespread deltic systems deposited sediment into them. Desmoinesian strata are more widely distributed in North America than any other Upper Carboniferous interval. The Cherokee Group is the lowermost unit in the Desmoinesian Stage in Kansas. The maximum thickness of Desmoinesian rocks occurs in the Anadarko basin where over 8,000 feet (2,438 meters) are preserved (Wanless, 1969). The greatest thickness of Desmoinesian rocks in Kansas is in the Forest City basin with over 1,000 feet (305 meters) of shale, sandstone, limestone, and coal (Anderson and Wells, 1968).

Because of the extended period of time that the northern midcontinent was exposed before the Desmoinesian, much of the area had been eroded to a flat surface (Stewart, 1975) leaving only major pre-Pennsylvanian highlands (Central Kansas uplift and the Nemaha uplift). Minor transgressions and regressions or progradations allowed the sea to inundate and reexpose extensive areas of land (McKee, 1975). Wanless (1969) estimates strand line shifts in excess of 800 km.

Missourian Stage

Marine transgression continued through the Late Pennsylvanian, inundating the Central Kansas uplift and the Nemaha uplift (Rascoe and Adler, 1983). Most of Kansas was a broad carbonate shelf during the Missourian, where the classic cyclothem is well represented in outcrop and the subsurface (Heckel, 1977). The carbonates thicken to the south at the expense of the shales. Extensive work on the Lansing and Kansas City Groups was done by Watney (1980, 1985), emphasizing stratigraphy and sedimentology in northwestern Kansas and southwestern Nebraska in relation to the distribution and predictability of hydrocarbon reservoirs in the carbonate rocks.

Virgilian Stage

The Lower Virgilian consists predominantely of terrigenous sediments (the Douglas Group) throughout the midcontinent. The overlying Oread Limestone of the Shawnee Group contains the Heebner Shale, an offshore shale. The Heebner can be identified and correlated in Kansas, southeastern Nebraska, eastern Colorado, the Texas Panhandle and most of Oklahoma. Its great regional extent suggests that the Heebner marks a major rise in sea level (Heckel, 1977) and may be the greatest marine transgression during the Pennsylvanian (Rascoe, 1978).

STRATIGRAPHY

Correlations carried from southeastern Kansas to the Sedgwick basin revealed that important subsurface stratigraphic markers of the Cherokee Group used in correlating throughout the eastern third of the state could be used in the Sedgwick basin as well. Markers used for correlation in southeast Kansas are very dark gray to black carbonaceous shales and associated coal beds. In the Cherokee and Forest City basins, black shales characteristically overlie coal beds or seat earth. They extend laterally into areas where coal is not present. Coals common in eastern Kansas are not present in the Sedgwick basin. The dark gray to black shales have high uranium contents and are easy to recognize on gamma ray logs. Many of these radioactive black shales in the Cherokee are quite widespread and serve as stratigraphic markers. The "hot shales" used in this study were correlated throughout the Sedgwick basin after constructing an east-to-west cross-section from a type Cherokee Group log in Crawford County, Kansas (Harris, 1984), to the study area (Fig. 10). Development of a

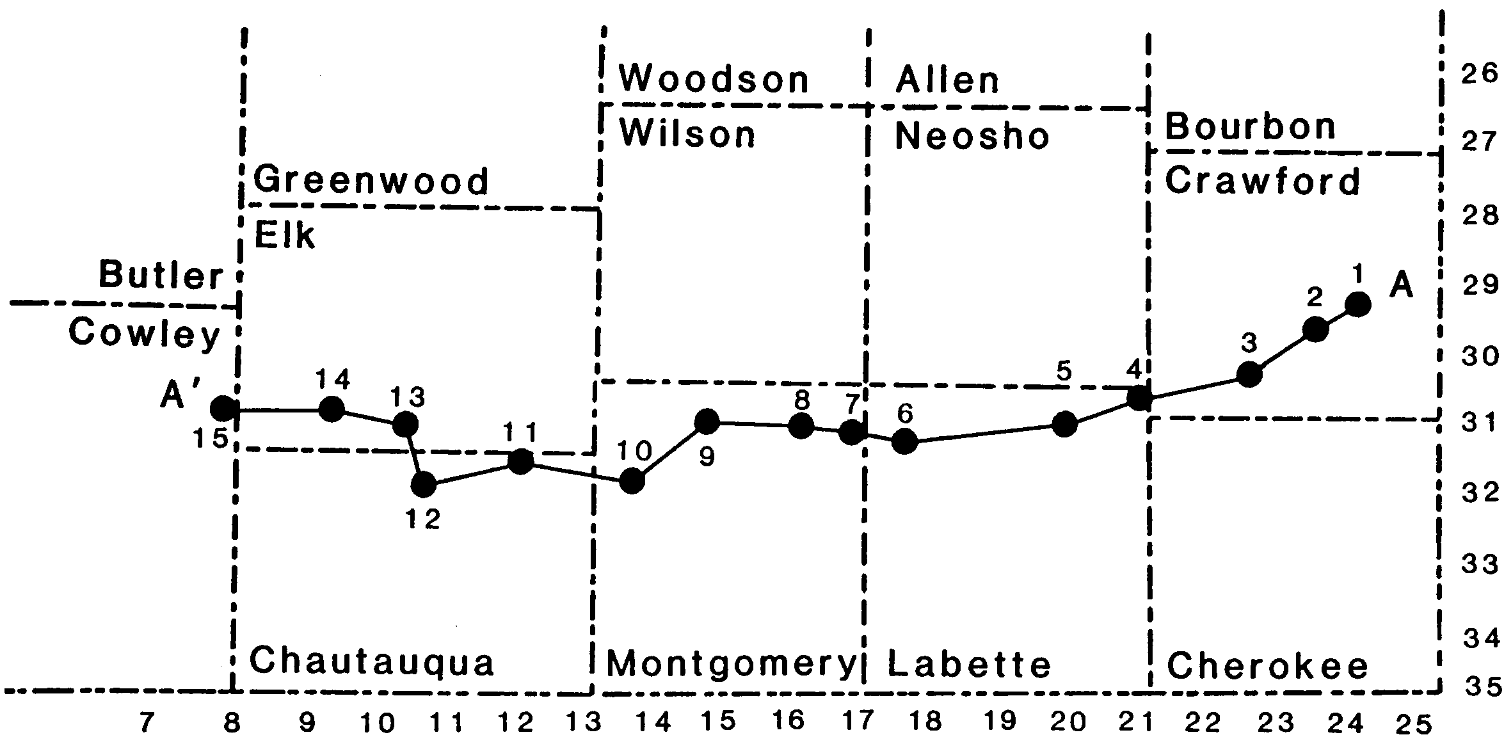


Figure 10 – Location of cross-section A–A'.

closed loop network of cross-sections throughout the study area helped prevent miscorrelation of markers (Fig. 11).

Recently students and staff of the University of Iowa have suggested revision of stratigraphic nomenclature of the Cherokee Group in Iowa, Kansas, and northeast Oklahoma. Denesen (1985) recommends abandonment of the Krebs and Cabaniss formations because they are based upon paleontological and lithic variation in the Arkoma basin. Denesen proposes applying shelf terminology used in other states in the midcontinent to the Cherokee Group of Kansas and Oklahoma.

The stratigraphy and correlation of the Cherokee Group in Kansas and throughout the midcontinent is difficult because of varied depositional environments and discontinuous beds and marker horizons. Denesen is correct in stating that highly radioactive black shales (such as the Excello and "V" shales) and limestones are best for widespread correlations, but his proposed nomenclature only complicates Cherokee Group stratigraphy. Creation of new formations is not possible without further study throughout the state of Kansas and additional work in adjoining states of the more difficult lower Cherokee Group (sub-"V" shale). Establishing sub-

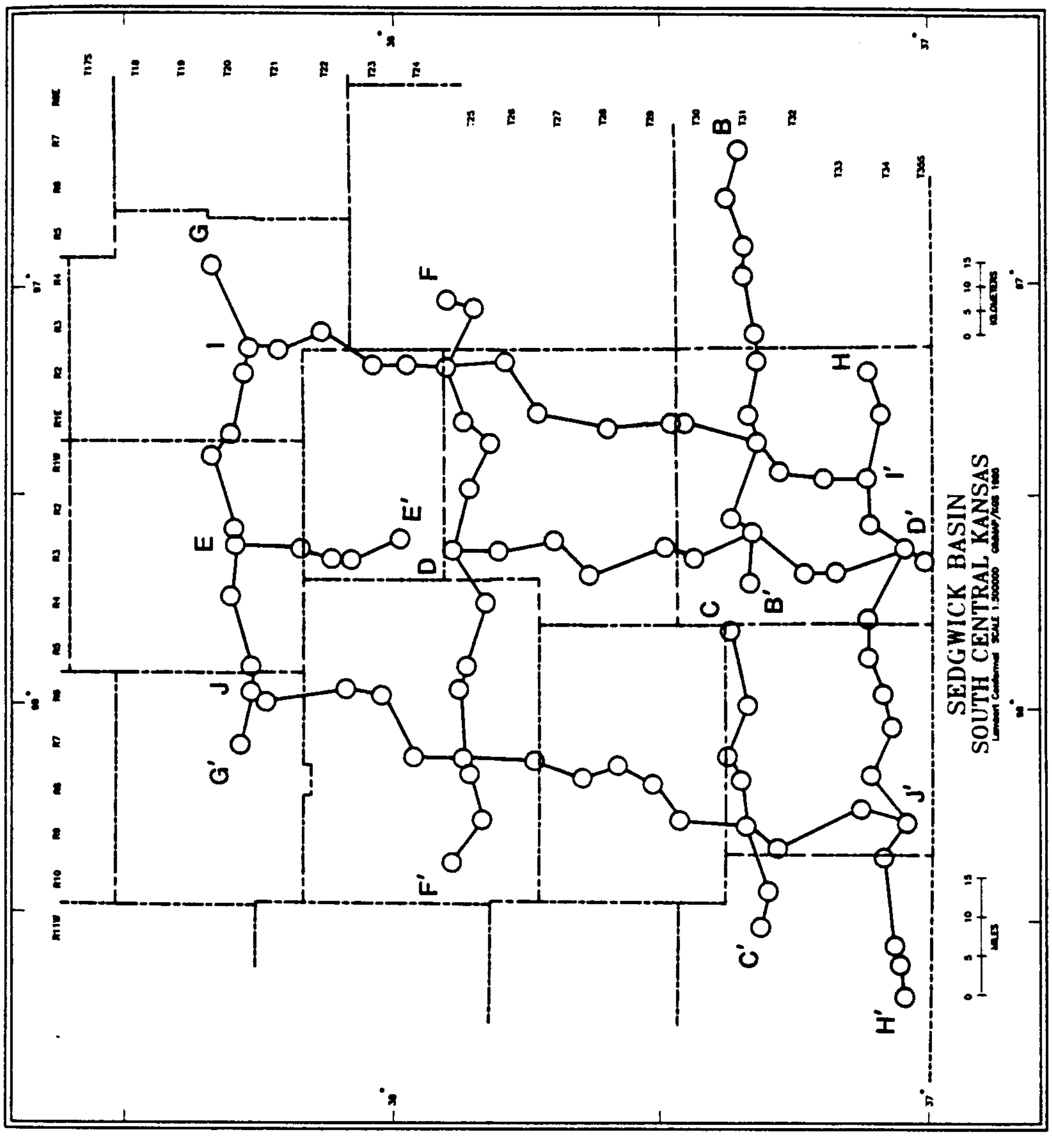


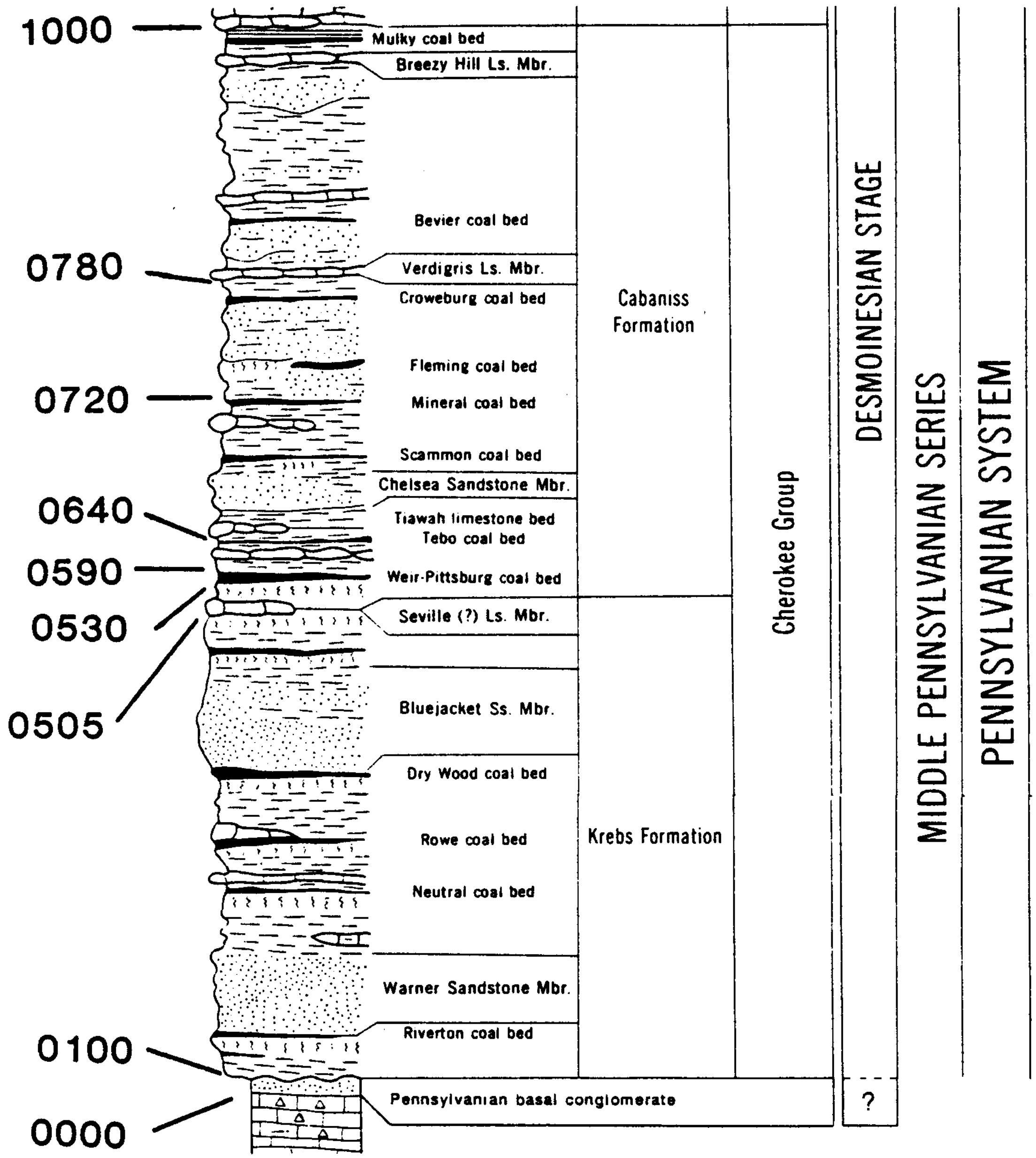
Figure 11– Closed loop network of cross-sections constructed in study area.

"V" shale formations with black shale or limestone boundaries (Denesen, 1985) may not prove advantageous. Lateral distribution of markers or beds over widespread areas are not definite. An unneccessary number of formations in an already complex geological unit can only confuse stratigraphic understanding and hinder mapping efforts. A difference in continuity of markers between the Cabaniss and Krebs groups (Walton, 1986, personal communication) and the lack of extensive detailed correlations between adjoining states in the midcontinent does not permit serious consideration of proposed stratigraphic redefinition of the Cherokee Group at this time.

Nine stratigraphic markers were used in this study: (1) the top of the Cherokee Group (top of the Excello (black) shale), (2) the "V shale" (black shale below the Verdigris limestone and above the Croweburg coal, equivalent to the Oakley Shale of Iowa; Denesen, 1985), (3) the black shale above the Mineral coal, (4) the black shale above the Tebo coal, (5) the black shale above the Weir-Pittsburg coal, (6) the Bluejacket B shale (black shale above the Bluejacket B coal; Harris, 1984), (7) the black shale found between the Bluejacket B and Bluejacket C coals (the lower Bluejacket marker; Harris, 1984), (8) the top of the Pennsylvanian basal conglomerate, and (9) the top of the Mississippian limestone. Harris (1984) placed the top of the Krebs Formation at the Seville Limestone. It was not possible to correlate the Seville Limestone from southeast Kansas to the Sedgwick basin.

To provide identification numbers for the second database, the markers were assigned sequential numbers. The top of the Cherokee Group was assigned the number 1,000 and the base of the Cherokee (or base of the Pennsylvanian basal conglomerate) as 0000. The remaining markers were assigned a number corresponding roughly to their location within the Cherokee: "V shale" - 0780, Mineral shale - 0720, Tebo shale - 0640, Weir-Pittsburg shale - 0590, Bluejacket B shale - 0530, the shale between the Bluejacket B and Bluejacket C shales - 0505 and the Pennsylvanian basal conglomerate - 0100 (Fig. 12). The Burgmeier #2 log (SW-SE-SE, sec. 36 - T33S - R6W) serves as a type log for correlation in the Sedgwick basin and shows the normal log responses (Fig. 13).

Major lithologies present in the Cherokee Group include shales of various colors, siltstone, sandstone, and limestone. Based on the combined thickness of the wells studied, the percentage of the lithologies in the study are approximately; mudrock - 73%, sandstone - less



(modified after Zeller, 1968)

Figure 1.2 - Identification numbers used in database #2 for correlation horizons.

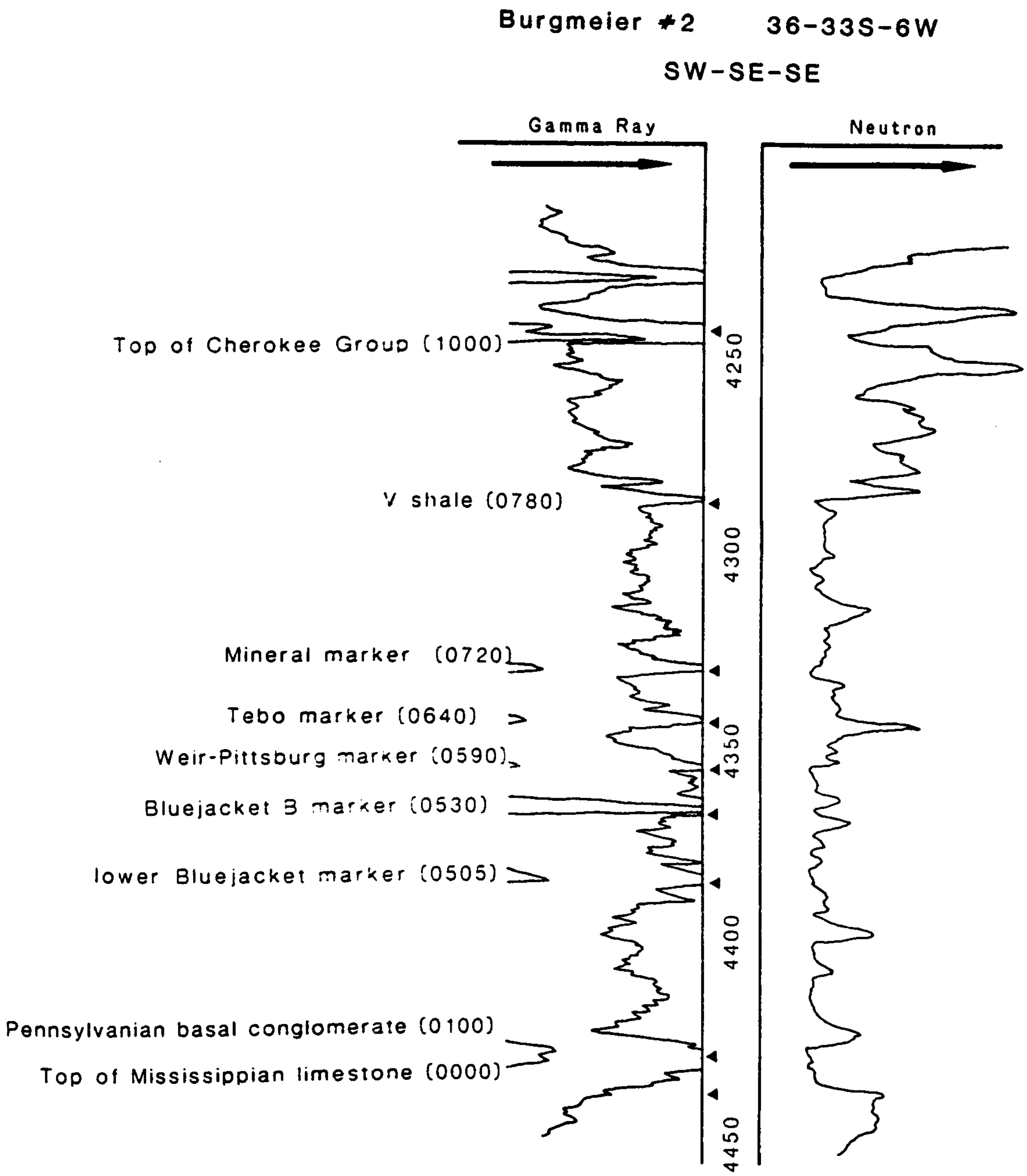


Figure 13 - Type gamma ray - neutron log for the Cherokee Group in the Sedgwick basin.

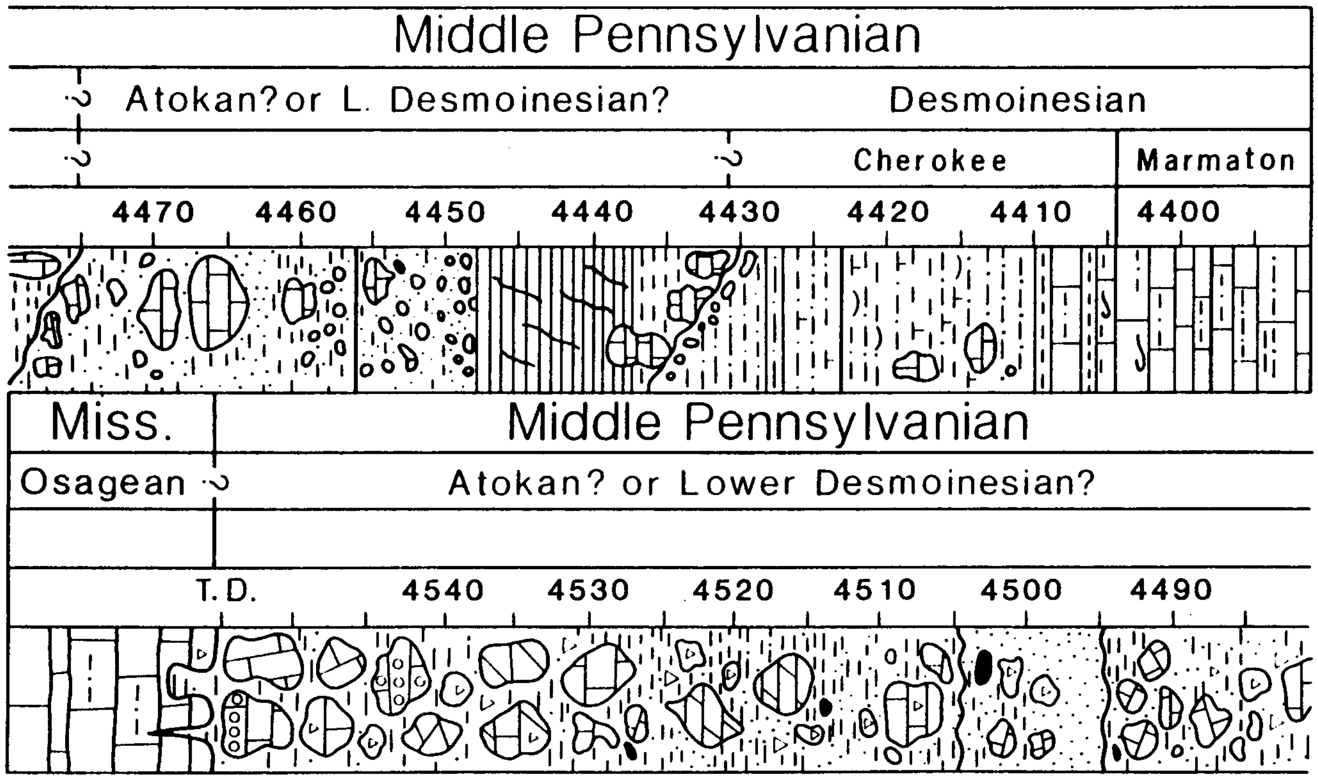
than 1%, and limestone - 26%. The percentage for siltstone was not calculated separately from shale (clay shale and claystone) because of the difficulty in distinguishing siltstone from either clayey sandstone or sandy shale.

No coal was observed in cores or samples and no distinct coal responses were identified on any of the geophysical logs. Very thin and discontinuous coals may be present, but due to the logging speed and tool spacing used in oil and gas exploration, their presence cannot be detected. Unpublished work by the Kansas Geological Survey estimates bed resolution from two to three feet for neutron logs. Through comparison of cores and density and neutron logs, it was determined that the thickness of coals could be identified accurately to not less than 10 inches.

Pennsylvanian basal conglomerate interval - (0100 - 0000)

Major structural movement in the late Mississippian that formed the prominent structural features of central Kansas and regression of midcontinent seas allowed a karst terrain to form in early Pennsylvanian time (Nodine-Zeller, 1981). The exposed Mississippian limestones and dolomites were leached, leaving residual chert, clay, silt, and sand (Nodine-Zeller, 1985). This material was reworked by marine and fluvial processes to form the Pennsylvanian basal conglomerate. Paleontological studies (Nodine-Zeller, 1981) suggest that the conglomerate is of early Desmoinesian or Atokan age (Fig. 14). The Pennsylvanian basal conglomerate, where clean, is a significant oil and gas producing unit in the Sedgwick basin.

The important areas of basal conglomerate production in Kansas are the Sedgwick basin, Pratt anticline, Central Kansas uplift, and the Nemaha uplift. The western flank of the Central Kansas uplift is the most prolific producing area in the state (Merriam and Goebel, 1959; Nodine-Zeller, 1981). Pennsylvanian basal conglomerate production is scattered in the Sedgwick basin because of the inconsistant nature of the karst surface developed on the top of the Mississippian limestone, and areas of reworked conglomerate where porosity and permeability trends have been preserved by depositional processes. Numerous basal conglomerate fields and pools have been discovered in the Sedgwick basin since the late 1900's. A few of the fields are: the Gingrass field (T24S - R2E), DeMoss (T28S - R7E), Leon (T27S - R1E), Canfield (T34S - R3E), Mahannah (T30S



(Nodine—Zeller, 1981)

Figure 14 - Geologic section encountered in the Mid-Continent No. 1 Collins core, C-NW-NW, Sec. 24, T20S, R26W, Ness County, Kansas.

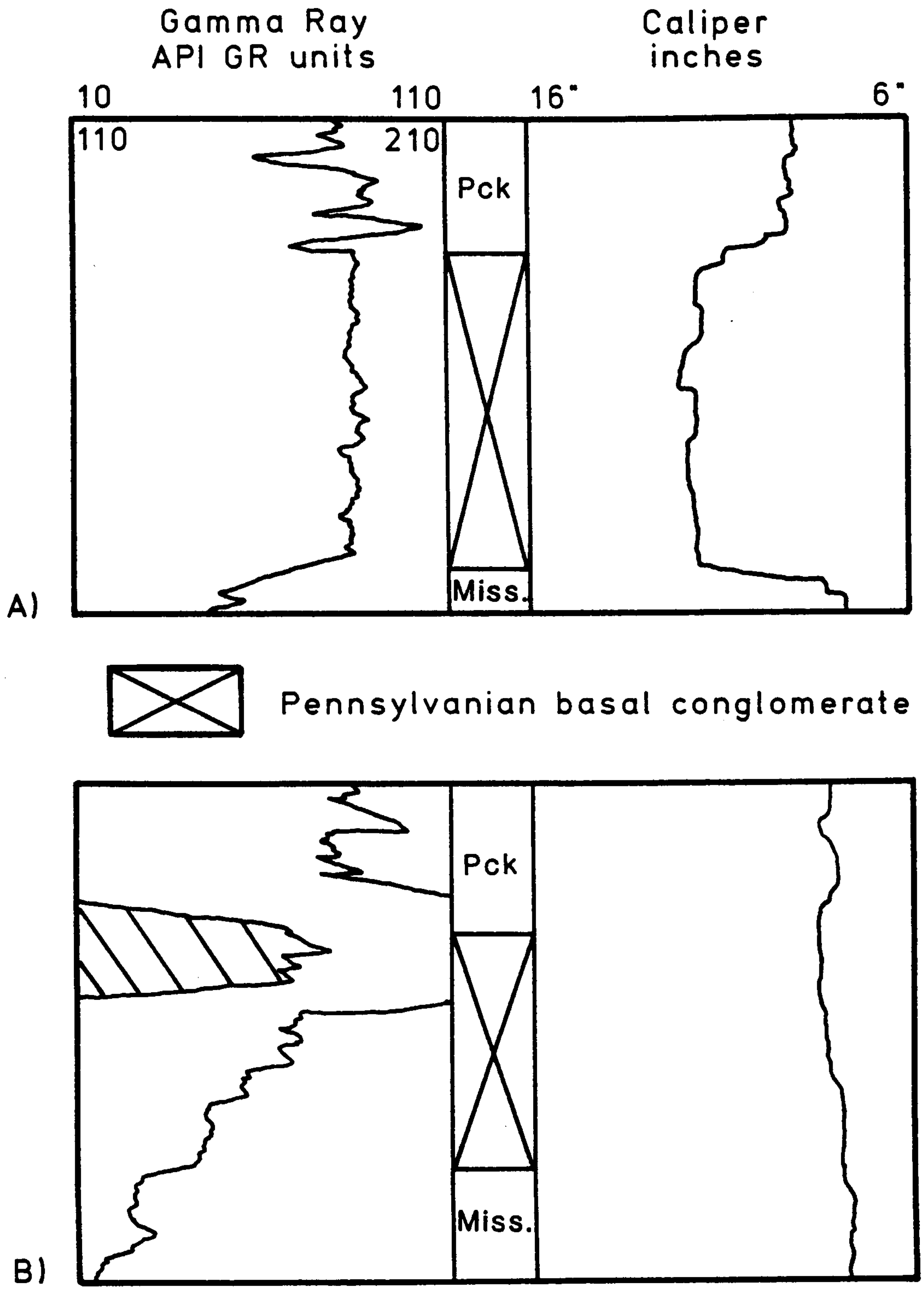
- R8E), Goodrich (T25S - R1E), Peabody (T22S - R4E), and Hardtner (T35S - R12W) (Jewett, 1954; Kansas Geological Society, 1960). Initial production in the oil wells range from a few bbls a day to 1,750 bbls a day (Jewett, 1954).

The Pennsylvanian basal conglomerate is unconformably overlain by normal Cherokee sediments that are usually lithologically distinct (Lee, 1939; Nodine-Zeller, 1985). Differentiating the Pennsylvanian basal conglomerate where upper basal conglomerate sediments are lithologically similar to lower normal Cherokee sediments can be difficult. On gamma ray logs the top of the Pennsylvanian basal conglomerate shows most clearly a highly radioactive shale interval ranging from 5 feet (1.5 meters) to 20 feet (6.1 meters) thick. Association with the high gamma ray response and a sharp increase in the borehole diameter on the caliper log at the same depth is confirmation of the basal conglomerate (Fig. 15). The contact is drawn at the midpoint of the upper deflection on the gamma ray curve. Other areas may only display a moderately radioactive zone highly variable in thickness from well to well. The top of the basal conglomerate is more difficult to identify where the

Figure 15 - Typical gamma ray - caliper response in the Pennsylvanian basal conglomerate interval.

A. Little to no gamma ray evidence for the top of the Pennsylvanian basal conglomerate, strong caliper respose to the unconsolidated interval.

B. Strong gamma ray respose for the top of the Pennsylvanian basal conglomerate interval, little to no caliper response.


Gamma Ray
API GR units
Caliper
inches
10
110
16"
6"
110
210
Pck
Miss.
A)
Pennsylvanian basal conglomerate
Pck
Miss.
B)

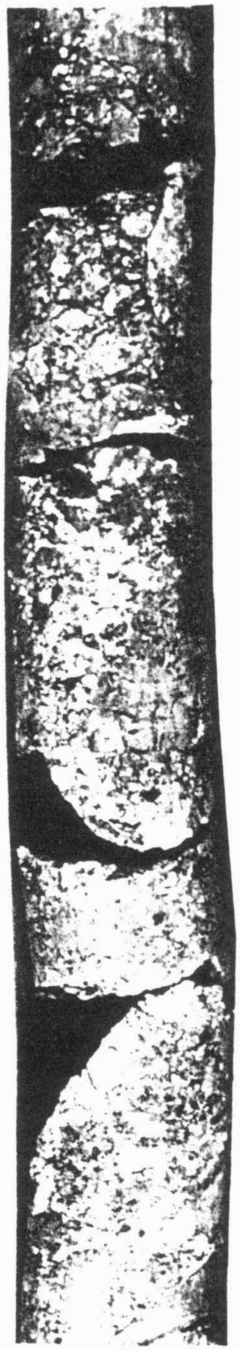
shale is less radioactive. Accurate recognition and mapping of the Pennsylvanian basal conglomerate must utilize all available drillers logs, well samples, and cores.

Cores and samples show that the most common Pennsylvanian basal conglomerate is reworked residuum composed of pebbles and cobbles of weathered Mississippian limestones and cherts in a matrix of shale, silt, and glauconitic sand (figures 16-19; Nodine-Zeller, 1981). The basal conglomerate was also found to be composed of well sorted, fine grained sandstone (figures 20 and 21) ranging from dark yellowish brown (10 YR 4/2) to light olive gray (5 Y 5/2) (Goddard and others, 1980). Sandstone in the Pennsylvanian basal conglomerate is commonly referred to as the Burgess sand. Paleontological evidence suggests that the heterogeneous conglomerate is largely derived from weathering of Mississippian formations ranging from the Osagian through Chesteran stages (Nodine-Zeller, 1985).

Silty shale and siltstone predominate in basal conglomerate cores studied (figures 22 and 23). Colors range from dusky red (5 R 3/4) to grayish black (N2), depending upon clay and mud content. The silty shales

Figure 16 - Pennsylvanian basal conglomerate; cobbles and pebbles of limestone and chert in a silty shale matrix (4812.0 - 4816.0 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.

Figure 17 - Pennsylvanian basal conglomerate; close-up of figure 16, (4812.0 - 4813.0 ft.).



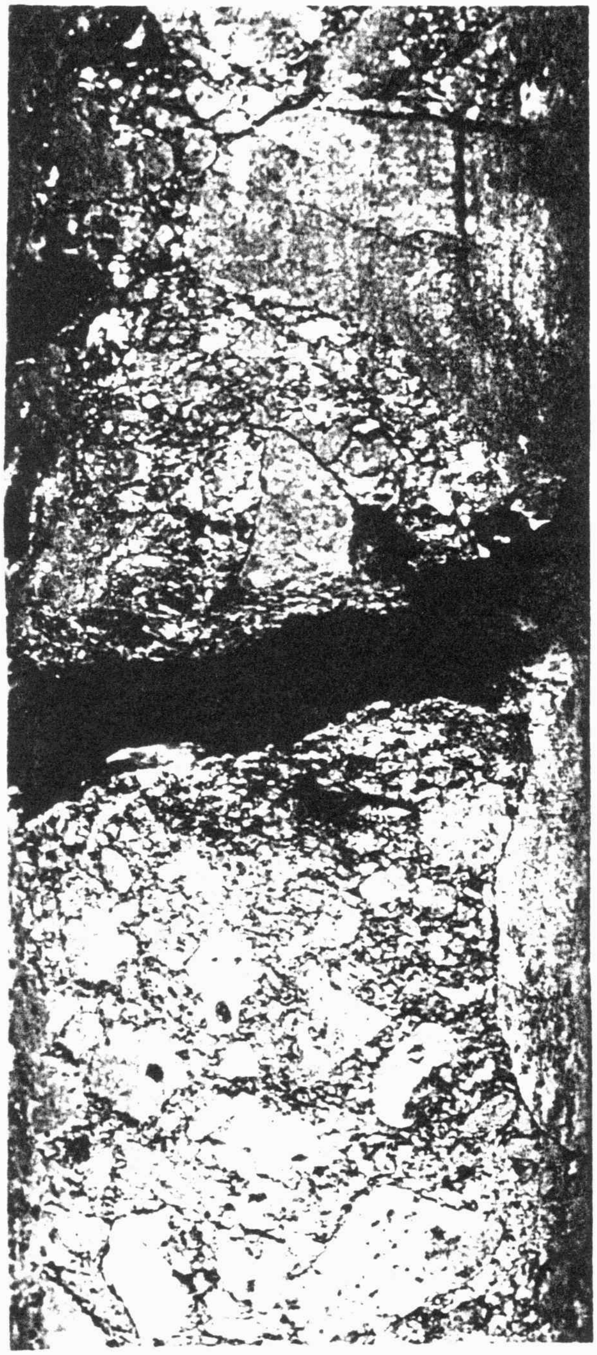


Figure 18 - Oil-stained Pennsylvanian basal conglomerate; cobbles and pebbles of limestone and chert in a silty shale matrix (4816.0 - 4816.5 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.

Figure 19 - Oil-stained Pennsylvanian basal conglomerate; cobbles and pebbles of limestone and chert in a silty shale matrix (4818.0 - 4820.1 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.

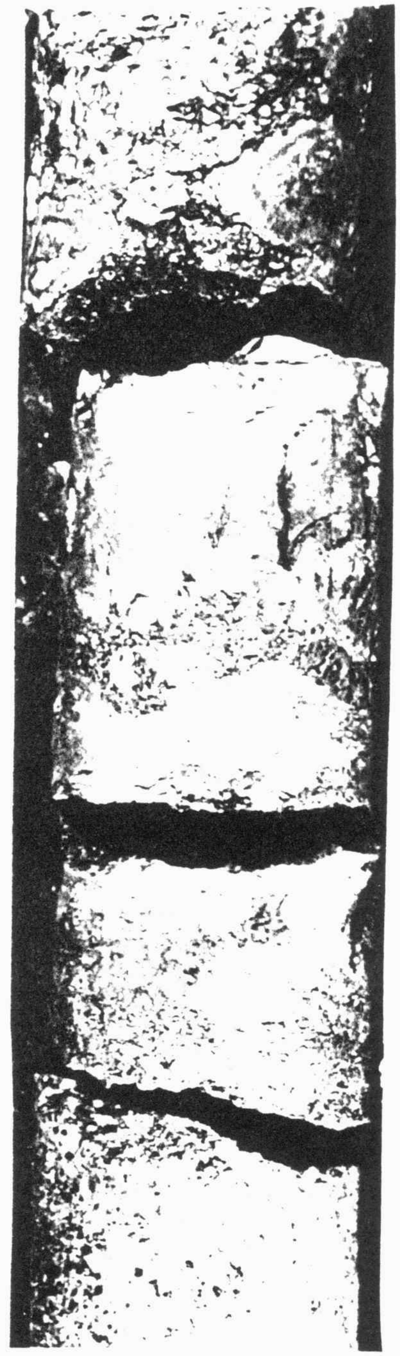


Figure 20 - Pennsylvanian basal conglomerate interval; fine grained sandstone (3501.1 - 3503.2 ft.). Laughlin #3, NE - NW - NE, 1 - 35S - 2E, Sumner County, Kansas.

Figure 21 - Pennsylvanian basal conglomerate interval; representative samples from interval 3474.0 - 3500.0 ft., predominately fine grained sandstone. Laughlin #3, NE - NW - NE, 1 - 35S - 2E, Sumner County, Kansas.

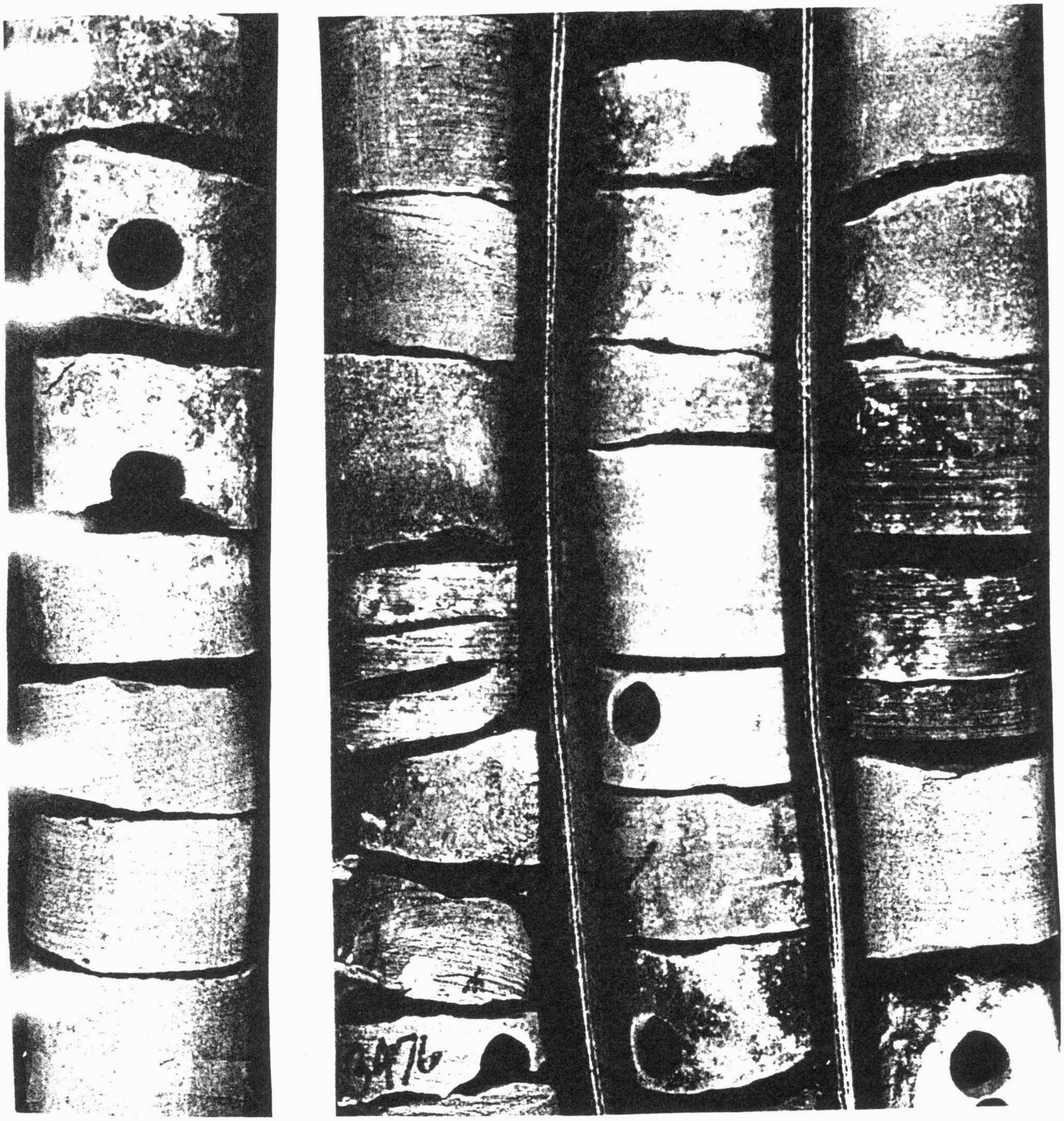
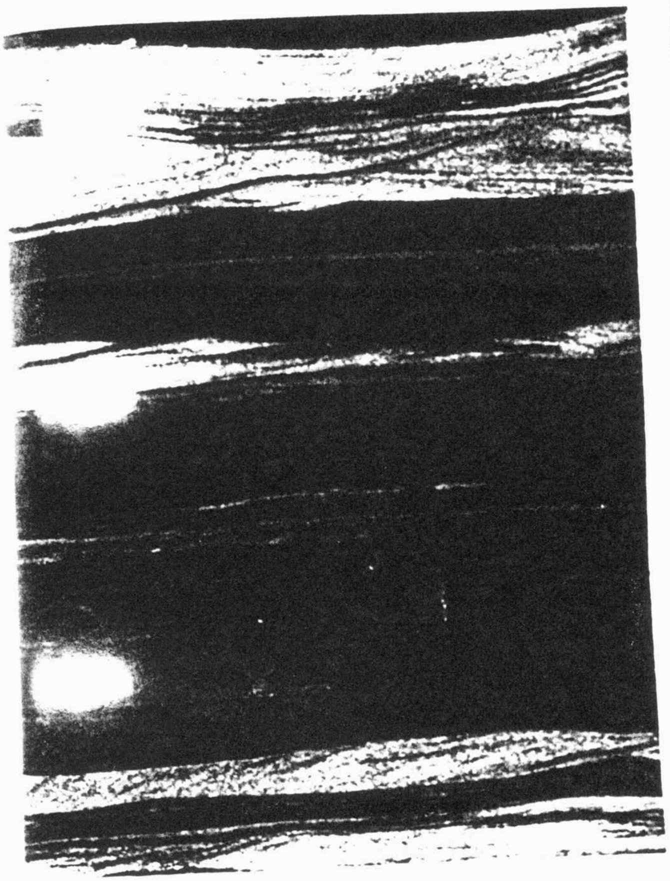
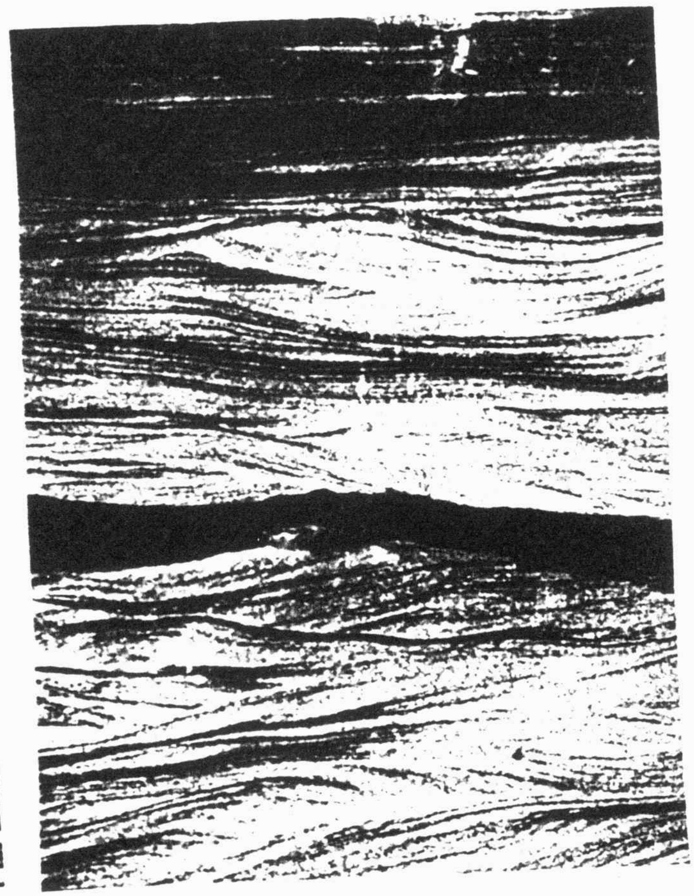


Figure 22 - Pennsylvanian basal conglomerate interval; laminated and slightly rippled silty shale (3434.0 - 3435.0 ft.). Slabbed core, Weir #1, SW - SW - SW, 30 - 34S - 3E, Cowley County, Kansas.

Figure 23 - Pennsylvanian basal conglomerate interval; rippled and laminated shaley sandstone (3430.0 - 3430.3 ft.). Slabbed core, Weir #1, SW - SW - SW, 30 - 34S - 3E, Cowley County, Kansas.





tend to be laminated and slightly rippled, whereas siltstones display some laminations and distinctive rippling.

Shales in the basal conglomerate interval range in color from very dark red (5 R 2/6) to dusky green (5 G 3/2). The shales are slightly calcareous, and vertically burrowed with carbonaceous matter. Limestone pebbles and cobbles in a very dark red (5 R 2/6) shale were observed in the Weatherall #1 core (figures 24 and 25). Shale intervals in the cores grade above and below into silty shales to siltstones, and below to conglomerate. Chert pebble conglomerates are common in combination with one or all of the previously discussed lithologies found in the Pennsylvanian basal conglomerate interval. Colors in chert pebble beds vary considerably, depending on the clay content. The Maughlin #1 (sec. 11 - T20S - R8W) displays slightly laminated, cherty siltstone (Fig. 26). Cherty basal conglomerate in the Sterling-D is stained by oil (Fig. 27).

<u>Krebs</u> <u>interval</u> - (0505 - 0100)

Lower Cherokee sediments (not including the Pennsylvanian basal conglomerate) are believed to have been deposited on a nearly flat surface. The basal

Figure 24 - Pennsylvanian basal conglomerate; limestone pebbles in shale matrix (4095.5 - 4097.5 ft.). Weatherall #1, NE - C - SW, 20 - 28S - 10W, Kingman County, Kansas.

Figure 25 - Pennsylvanian basal conglomerate; closeup of figure 24 (4097.0 - 4098.0 ft.).

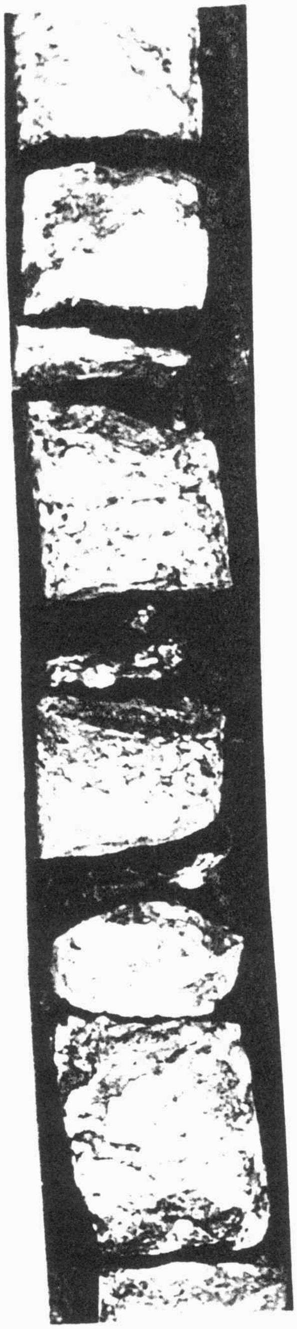
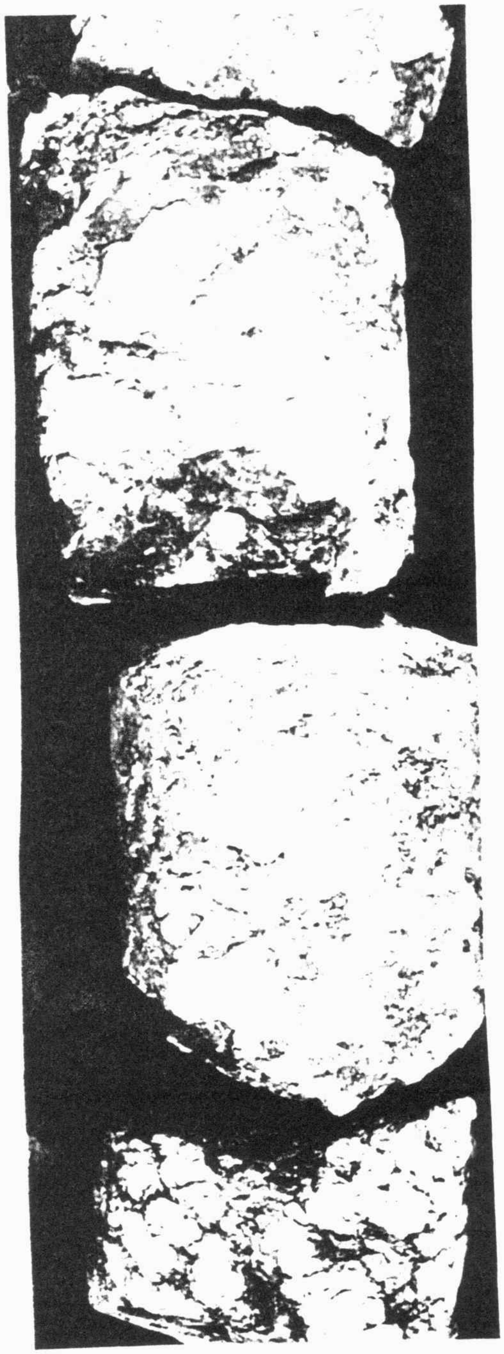
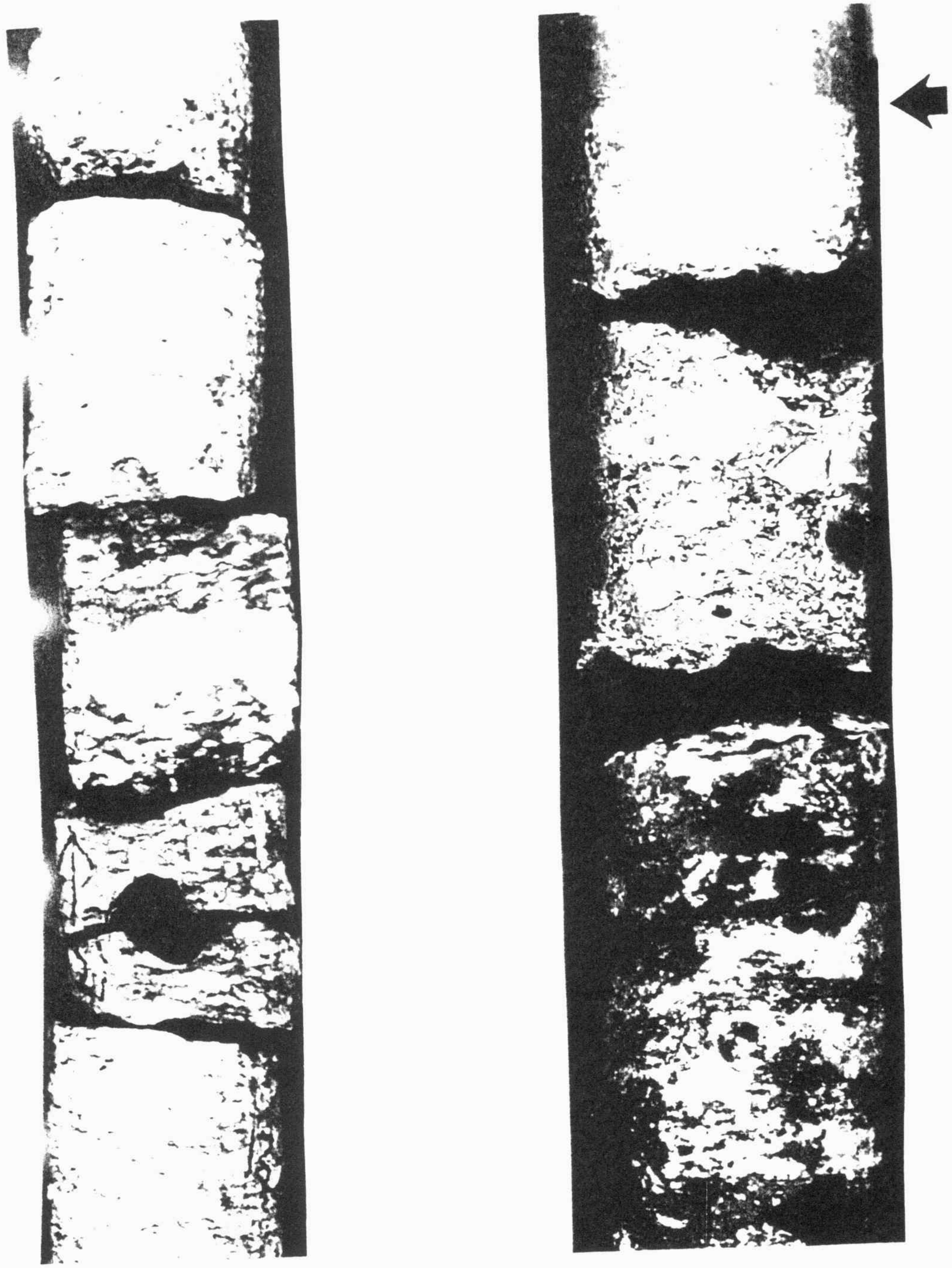



Figure 26 - Pennsylvanian basal conglomerate; cherty siltstone (3209.0 - 3213.0 ft.). Maughlin #1, NE - NW - SW, 11 - 20S - 8W, Rice County, Kansas.

Figure 27 - Upper Cherokee interval and oil stained Pennsylvanian basal conglomerate; unconformable contact (indicated by arrow) at 4810.2 feet (4810.0 - 4812.0 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.



conglomerate filled topographic lows, allowing the Early Desmoinesian trangression to cover low-lying areas evenly. The lower Bluejacket marker (0505) at the top of the Krebs interval is difficult to correlate. The character of the marker varies widely from a black shale (100-140 API GR units) to a drab shale (70-90 API GR units).

The Krebs interval consists mainly of dark gray, light gray, and green shale. Examination of the samples from the Hagar "A" #1 well (sec. 4 - T35S - R1W) revealed a light gray, slightly silty shale 37 feet thick (11.3 meters) in the interval. As many as four limestones and argillaceous limestones are developed in the Krebs interval. They are discontinuous but widely distributed.

Upper Bluejacket interval - (0530 - 0505)

The interval between the Krebs and the upper Bluejacket is one of the thinner intervals studied. The Bluejacket B marker (0530) is a consistant highly radioactive shale throughout most of the study area and an excellent marker. As previously mentioned, the bottom marker (0505) for the interval is difficult to pick.

Colors of black, light gray, dark gray and green shale predominate in the upper Bluejacket interval.

Drillers logs for a few of the southernmost logs indicate some silty shale. Minor limestone is found in the upper Bluejacket interval. The Seville Limestone, a thin limestone in southeast Kansas, is not correlative to the Sedgwick basin, but is likely present. The Seville occurs locally in Crawford County (Zeller, 1968), but Harris (1984), noted the widespread presence of the limestone in Cherokee County. Many gamma ray logs indicate marginal limestone-calcareous shale for the interval. However, because the gamma-ray count is slightly above the 50% shale line, the interval was recorded as shale.

<u>Weir</u> - <u>Pittsburg</u> <u>interval</u> - (0590 - 0530)

The Weir-Pittsburg marker displays a fairly strong gamma-ray response throughout the study area. Because the Bluejacket B marker is easily indentified, it aided in the identification of the Weir-Pittsburg marker. The Weir-Pittsburg interval consists of light gray, dark gray and green shale and white to light gray limestone. The one limestone developed in the interval, directly above the Bluejacket B marker, varied widely in its thickness. Fragments of crinoid stems were found in samples from the Stringer #1 (sec. 11 - T28S - R2W).

<u>Tebo interval</u> - (0640 - 0590)

The Tebo marker (0640) is moderately to highly radioactive on the gamma ray log (80-130 API GR units). Lithologies for the Tebo interval below the marker include light gray, dark gray, and green shale and very little silty shale. The one limestone in the interval between the Tebo and Weir-Pittsburg marker varies considerably in thickness, but is relatively consistant in its lateral distribution. The limestone, where present, is located directly below the Tebo marker. This observation aided in the identification of the top of the Tebo interval where the radioactivity of the shale marker was low.

<u>Mineral interval</u> - (0720 - 0640)

The Mineral shale marker displays fairly high radioactivity throughout much of the study area (90-130 API GR units). The Mineral interval is composed of light gray, dark gray, and green shale and white to gray limestone and argillaceous limestone. Two limestones are developed in the interval and are irregularly distributed. The Tiawah limestone of southeast Kansas is directly above the Tebo coal bed or Tebo marker in the Sedgwick basin. In southeast Kansas the Tiawah limestone is abundantly fossiliferous containing gastropods and brachiopods (Zeller, 1968).

<u>"V" shale interval</u> - (0780 - 0720)

The "V" shale interval is a highly radioactive black shale (110-150 API GR units). The "V" shale is the most widespread and consistantly distributed marker, except for the Excello shale at the top of the Cherokee Group. Because of this consistancy, the "V" shale was used as the datum for the cross sections.

The "V" shale (Oakley shale of Iowa, Denesen, 1985) has been traced throughout the Sedgwick, Cherokee, and Forest City basins and correlated with the Mecca Quarry Shale in Indiana (Wright, 1975), which extends as far east as western Indiana and Kentucky. The shale is a "black, fissle, thinly laminated, fossiliferous shale which contains limestone and phosphatic concretions" (Wright, 1975). The black shale is unnamed in the midcontinent but has been designated as the Mecca Quarry Shale in Indiana by Zangerl and Richardson (1963). Recently, workers of the Cherokee Group in Kansas have informally referred to the black shale as the "V" shale (Angino and others, 1981) because it lies below the Verdigris Limestone.

Dominant lithologies in the "V" shale interval are light gray to gray argillaceous limestone and light gray, dark gray, and green shale. Clean limestones are thin and discontinuous. Geophysical logs indicate that up to four clean limestones are irregularly developed in the study area. Fragments of crinoid stems were found in argillaceous limestone samples from the Klassen #1 well (sec. 26 - T27S - R2E).

<u>Upper Cherokee interval</u> - (1000 - 0780)

The upper Cherokee interval is customarily referred to as the "Lagonda interval" in the "oil patch" in southeastern Kansas and western Missouri, and in a variety of publications (Charles, 1927, 1941; Bass, 1936; Reinholtz, 1982; Denesen, 1985). The Excello shale marks the top of this interval and of the Cherokee Group. It is a highly radioactive shale (130-160 API GR units) that can be correlated throughout the eastern one-half of Kansas (Harris, 1984; unpublished Kansas Geological Survey cross-sections) and into the Illinois basin. The core from the Sterling - D well (sec. 36 - T34S - R13W) is the only one available that includes the upper Cherokee interval. Grayish olive (10 Y 4/2), slightly laminated silty shale with carbonaceous matter and light olive gray (5 Y 5/2) to dusky yellow green (5 GY 5/2) shale are represented in the Sterling - D core (figures 28 and 29).

White to light gray limestone and gray argillaceous limestone containing brachiopods and crinoid stems dominate well cuttings from the upper Cherokee interval. Up to three limestones are developed in the interval. The lowermost limestone in the interval (directly above the "V" shale marker) is most likely the Verdigris Limestone. The Verdigris Limestone has been studied and described from outcrops in southeast Kansas. Heckel and others (1979) view the Verdigris as a regressive gray to light brown fossiliferous micrite. Denesen (1985) describes the Verdigris from outcrops in southeast Kansas and northeast Oklahoma as a gray to dark gray, finely crystalline, fossiliferous limestone containing algal debris (Schell, 1955), brachiopods, bryozoans, corals, and echinoderms. The uppermost limestone may correlate to the Breezy Hill Limestone. The Breezy Hill Limestone is a transgressive, medium calcilutite in southeast Kansas (Bennison, 1984). Light gray, dark gray, and green shale and minor dark yellowish brown (10 YR 4/2) siltstone are also present in the interval.

Figure 28 - Upper Cherokee interval; silty shale with abundant carbonaceous material (4788.0 - 4790.0 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.

Figure 29 - Upper Cherokee interval; laminated shale with streaks of carbonaceous material (4794.0 - 4795.0 ft.). Sterling - D #1, SW - NE - NE, 36 - 34S - 13W, Barber County, Kansas.


ISOPACH AND LITHOFACIES MAPPING

The lithofacies of each interval were mapped in an attempt to determine their areal distribution. An individual lithofacies is a rock unit defined on the basis of its distinctive lithologic features, which include composition, bedding characteristics, sedimentary structures, and grain size (Miall, 1984). Because the Cherokee Group in the study area consists essentially of shale and limestone, the percentage of limestone for the total thickness of each interval was mapped in 10% increments. Three facies types were distinguished through the limestone percentage maps following Rascoe (1962). The limestone facies (more than 60% of the thickness of the interval is limestone), the limestone-and-shale facies (limestone constitutes 30-59% of the interval), and the shale facies (limestone makes up less than 30% of the interval).

<u>Pennsylvanian basal conglomerate interval</u> - (0100 - 0000) Lithofacies maps were not constructed for the Pennsylvanian basal conglomerate interval because of the

highly variable depositional controls associated with the conglomerate. Basal conglomerate deposits on the basin floor range from 0 to 61 feet (18.6 meters), with the thickest section in the Klassen #1 (sec. 26-T22S-R2E) well in the northeast portion of the basin.

Krebs interval - (0505 - 0100)

Isopach thickness and limestone percentage roughly parallel each other in the Krebs interval. Krebs sediments gradually increase in thickness from north to south and decrease away from the axis of the basin (Fig. 30). Krebs deposition is confined to the central portion of the Sedgwick basin with the greatest thickness of the interval in the Unruh #1 well (SE-NE-SE, sec. 3 - T35S - R2W). This distribution suggests that early Cherokee transgression inundated only the low lying areas of the basin, possibly an early-formed axis of the basin. The flanks of the Sedgwick basin may have been at or above sea level. The limestone percentage map (Plate 5) shows less than 10% limestone for most of the western one-half of the Sedgwick basin with only one well above 30%. The eastern one-half of the data points vary from 10% to slightly over 40%. The areas with increased limestone

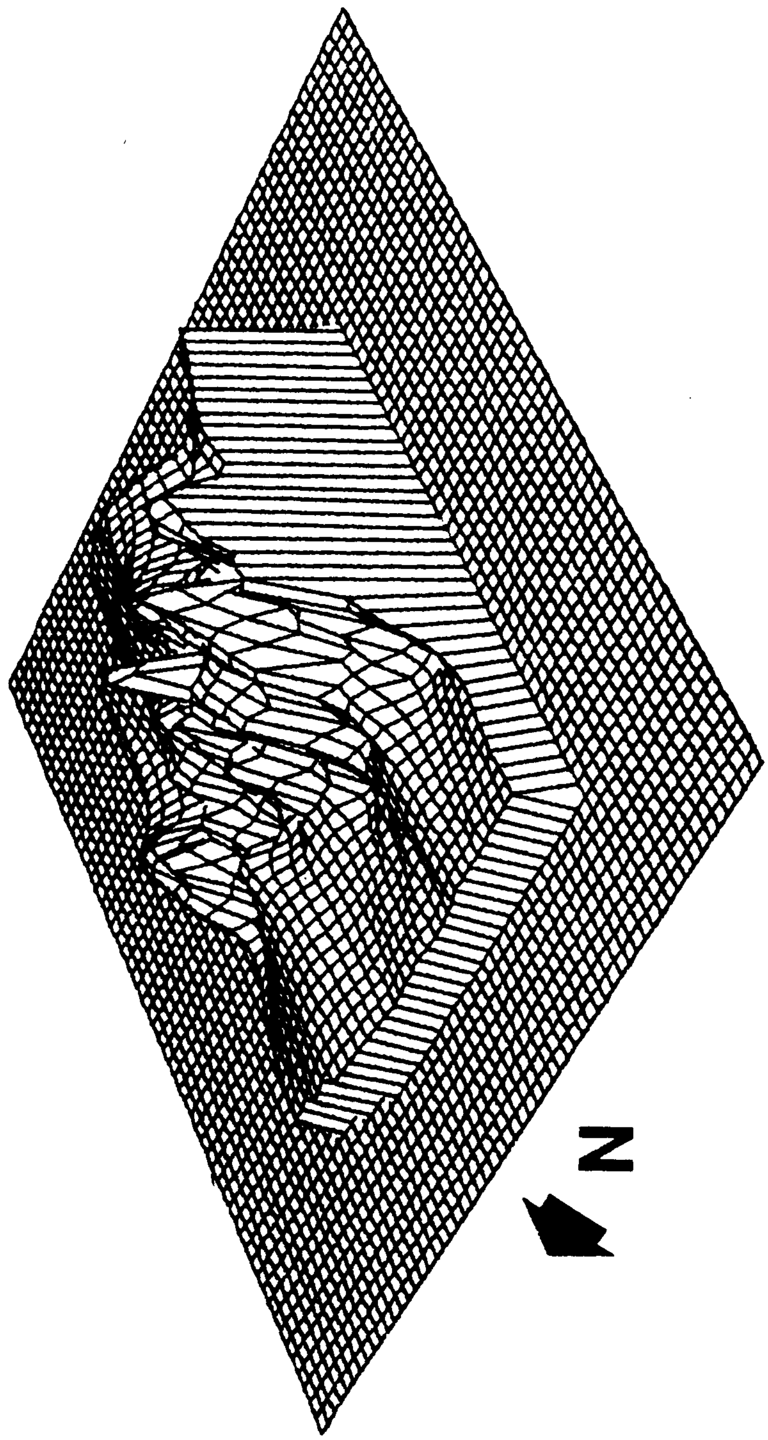


Figure 30 - Transect diagram of the Krebs interval thickness.

percentage in southern Sumner County and western Sedgwick County are also small, consisting of one to two data points.

Upper Bluejacket interval - (0530 - 0505)

Interval thickness and limestone percentage show opposite trends in the upper Bluejacket interval. Thickness distribution is relatively constant for the northern two-thirds of the study area, varying around 5 to 10 feet (1.5 - 3.1 meters) (Plate 6). Interval thickness increases steadily for the southern one-third of the study area from 10 to slightly greater than 30 feet (3.1 - 9.1 meters). The limestone percentage increases south to north, but the flanks of the basin have higher and more widespread limestone development (10-20%) than the axis of the basin (less than 10%; Plate 7). Only two wells, the no. 1 Wall (sec. 15 - T20S - R4W) and the Weins-C #1 (sec. 11 - T21S - R4W) in McPherson County, are in the limestone-and-shale facies, the remainder of the study area is in the shale facies. The complete upper Bluejacket interval is present in relatively the same area as the Krebs interval.

Weir - Pittsburg interval - (0590 - 0530)

The Weir - Pittsburg interval increases in thickness to the east-southeast, with a distinct increase marked by the 15 foot contour, trending approximately north - south through the study area (Plate 8). Minor movement of the Voshell anticline may have controlled this variation. The interval thins to the southeast past the thick area in northeastern Sumner County. The Weir - Pittsburg isopach map shows two areas with thicknesses greater than 30 feet (9.1 meters). The two areas lie in small places where the Bluejacket B marker is flat lying (Plate 9).

The Weir-Pittsburg interval has small, randomly distributed patches of limestone-and-shale facies. The areas are located in central Harper and Sumner counties and southwestern McPherson County and occupy one to two well locations. Comparison of the Weir-Pittsburg isopach map and the limestone percentage map (Plate 10) suggest that high limestone percentages lie adjacent to areas of low interval thickness, but lower limestone percentage coincides with areas of thickest sediment. This finding indicates that areas with rapid sedimentation, where mudstones and shales accummulate were too turbid for carbonate production or were in depositional lows. Areas adjacent to the greater thicknesses of mud deposition and accumulation may prove to have had clearer waters or were depositional highs, allowing better limestone development.

Tebo interval - (0640 - 0590)

The isopach (Plate 11) and limestone percentage map (Plate 12) coincide to a reasonable degree in the Tebo interval. They exhibit a northeast-southwest trending complex of high interval thickness (37 feet - 11.3 m - in southern Sedgwick County) and high limestone percentages across Sedgwick and Harper counties with decreasing values to the northwest and southeast. The Seltzer #1 well in McPherson County (sec. 2 - T20S - R1W) has over 50% limestone. Increased interval thickness may again be attributed to the structurally flat area in the same general area on the structure map drawn on the top of the Weir-Pittsburg marker. The limestone-and-shale facies is more widespread in the Tebo interval than lower intervals.

Mineral interval - (0720 - 0640)

The Mineral interval is thin (less than 25 feet; 7.6 meters) and fairly evenly distributed throughout the Sedgwick basin. Thickness gradually increases southeast of southeastern Kingman County (Plate 13). The limestone facies develops for the first time in the Mineral interval (Plate 14). The M. A. Brown #4 well in Sedgwick County (sec. 20 - T28S - R1E) has a value slightly over 60% limestone in the interval. The limestone-and-shale facies is sporadically distributed and not as widespread as in the Tebo interval. Because the interval is so thin it is difficult to determine any particular depositional control.

There is distinct similarity in the style of interval thickening and thinning for the Mineral, Tebo, and Weir-Pittsburg intervals. Each isopach map indicates greatest interval thickness in a line trending approximately northeast from T35S, R7W to T27S, R1E with interval thinning to the southeast and northwest of the line.

"V" shale interval - (0780 - 0720)

The "V" shale interval is similar to the Mineral, Tebo, and Weir - Pittsburg intervals where isopach contours trend northeast to southwest. The "V" shale interval, however, does not thin to the southeast. The interval increases in thickness fairly regularly to the southeast from less than 15 feet (4.6 meters) in southeastern Rice county to over 40 feet (12.2 meters) in Harper and Sumner counties (Plate 15).

Limestone percentages are much higher in the "V" shale interval than in underlying intervals. Limestone percentages greater than 50% concentrate in the southern one-half of the Sedgwick basin (Plate 16) with two wells in northwestern Harper County, #1 Boyt's A (sec. 17 - T32S - R7W) and Hadsall #1 (sec. 8 - T32S - R8W), posting values greater than 70% limestone. Greater limestone percentages characterize areas with interval thickness less than 30 feet (9.1 meters). Where interval thickness excedes 30 feet (southern Harper and Sumner counties) the limestone percentage decreases with increasing interval thickness. Limestone percentage averages 30% for the northern one-half of the study area.

Upper Cherokee interval - (1000 - 0780)

The upper Cherokee interval also displays thickness trends running northwest to southeast, similar to previously mentioned intervals (Plate 17). Interval thickness, approximately 35 to 40 feet (10.7 - 12.2 meters), is fairly consistant from southeastern Rice County to northwestern Sumner County. The interval increases in thickness to the southeast at a rate of approximately 1 foot per mile (20 cm/Km) from northwest Sumner County to southeast Sumner County.

The upper Cherokee interval records development of a carbonate shelf across nearly the entire Sedgwick basin (Plate 18). Only very small parts of the study area remain in the shale facies. The southern one-half of the basin ranges from slightly less than 30% to nearly 90% limestone; the northern half ranges from less than 10% to over 70%.

ENVIRONMENTAL INTERPRETATIONS

Lithofacies distribution indicates the gradual transition of the Sedgwick basin from a mud-dominated basin to a carbonate shelf (figures 31 and 32). A progressive shift in distribution of limestone from the extreme eastern and southern margins of the Sedgwick basin to approximately the southeastern one-half of the study area is apparent in progressively younger intervals. Figure 33 depicts the overall paleogeography of the Cherokee Group with a restricted shelf to the north-northwest and a carbonate shoal to the south and east. Relative rise or fall of sea level resulted in migration of these facies in the Sedgwick basin.

The development of the mud-dominated, restricted shelf facies is due to basin restriction. The Sedgwick basin was confined to the east, west, and, to a lesser extent to the north by topographically prominant features during deposition of the Cherokee. Wave action and currents were minimal in a shallow basin with low relief. Poor circulation in shallow water may result in abnormal salinity, depleted nutrients, abnormally high

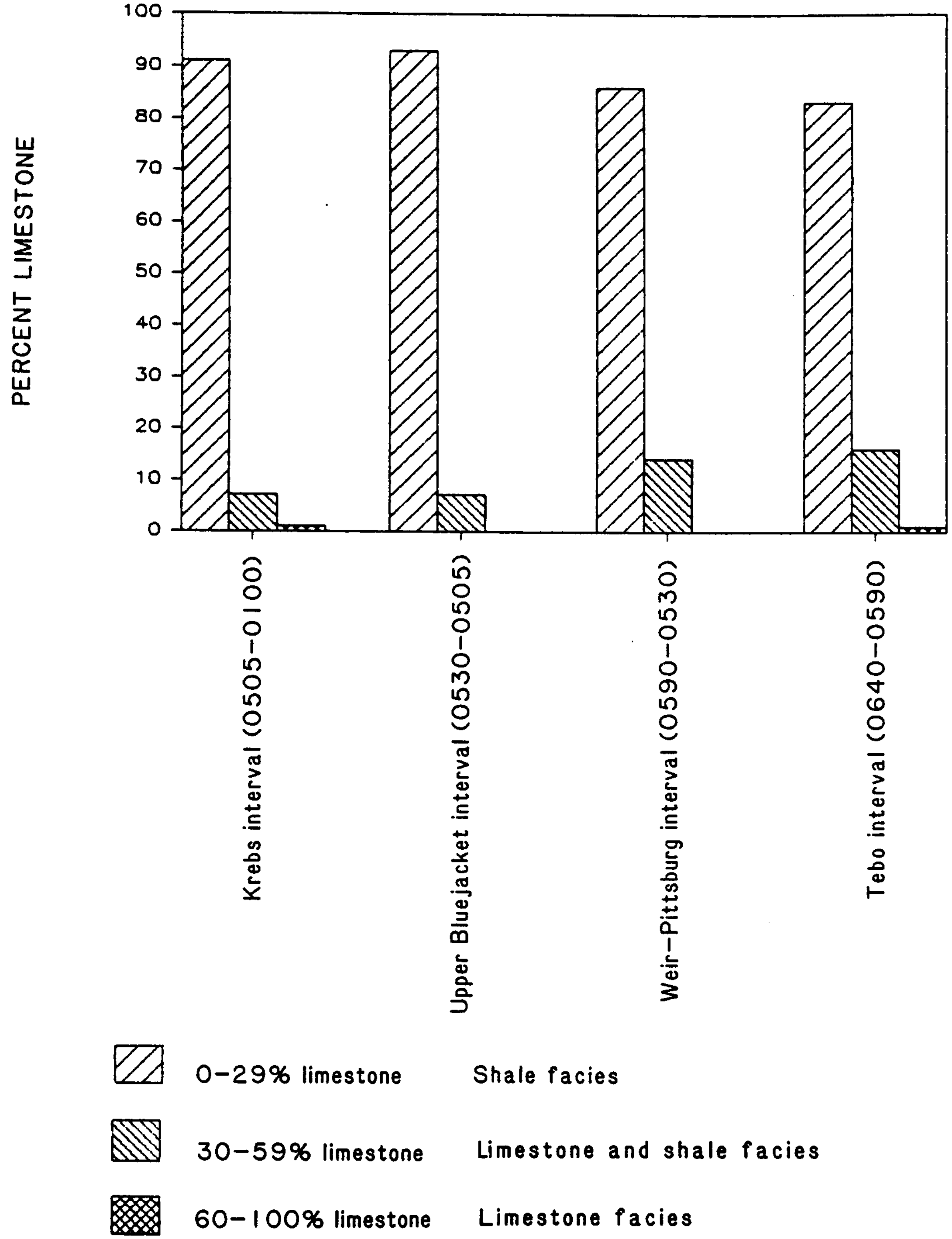


Figure 31-Lithofacies dominance by interval.

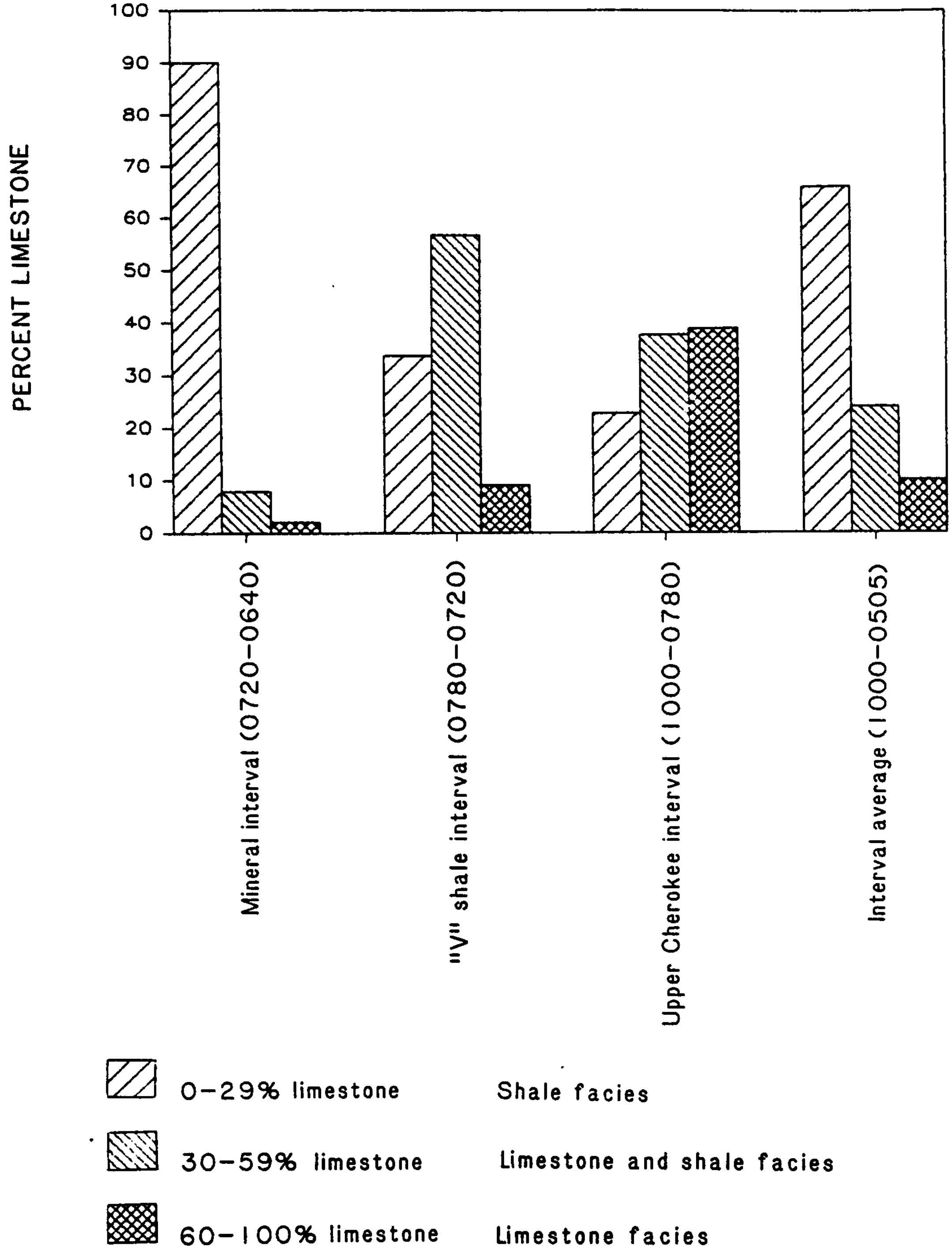


Figure 32-Lithofacies dominance by interval.

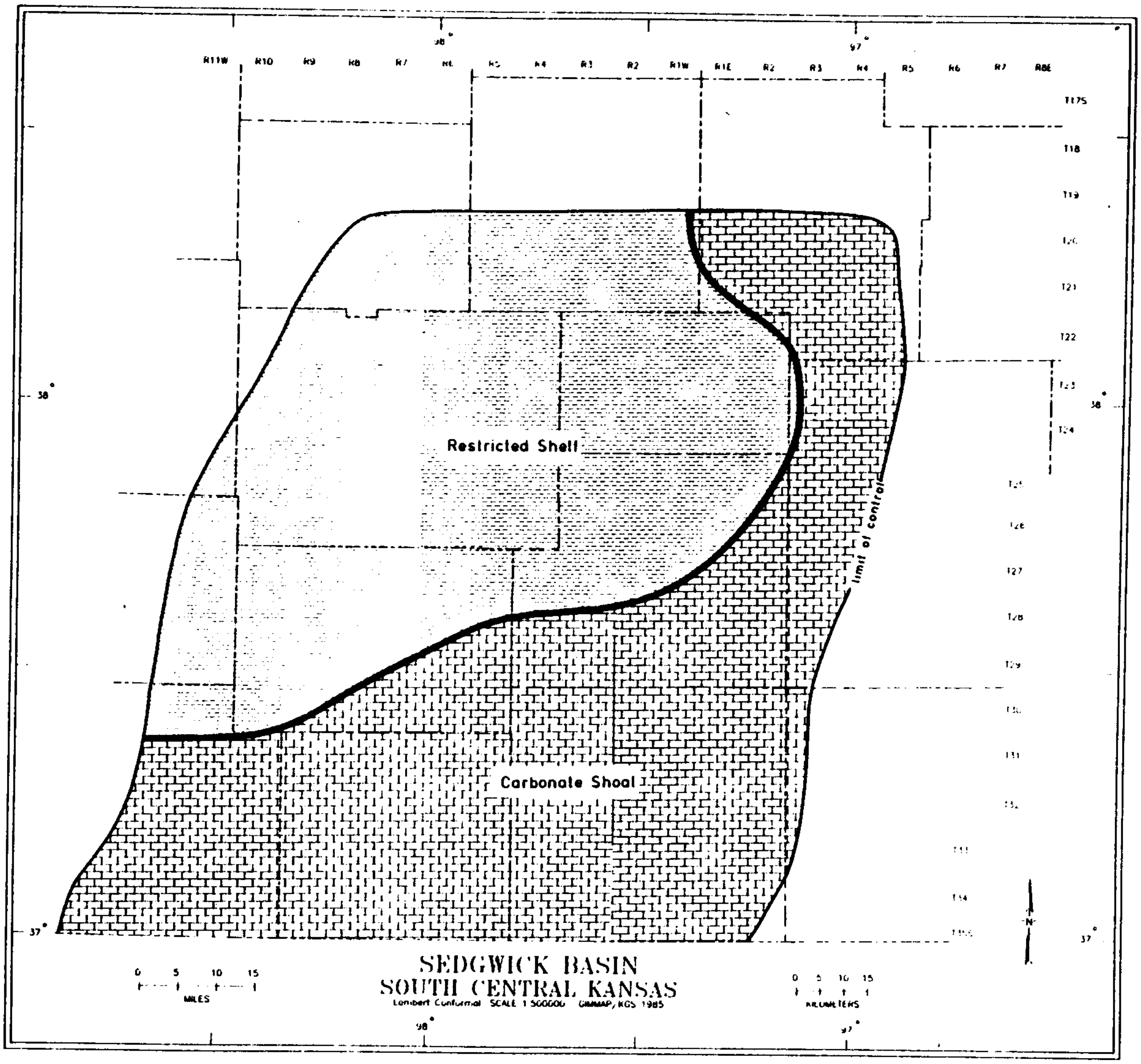


Figure 33 – Paleogeography of the Cherokee Group.

temperatures (Enos, 1983), and produces mud-supported facies landward of higher-energy facies. Watney (1980) described a similar depositional setting for the Lansing-Kansas City Groups in northwestern Kansas and southwestern Nebraska.

The mud constituent of the intervals above the Bluejacket B marker are primarily carbonate mud with moderate amounts of aluminosilicate mud. Intervals below the Bluejacket B marker are composed predominately of siliciclastic mud. Siliciclastic mud-dominated shelf deposits accumulate most rapidly in areas of low wave and current agitation where suspended sediment concentrations are high. Sedimentation of muddy shelf deposits is controlled by the concentration of fine-grained suspended sediment entering shelf seas and by the intensity of shelf hydraulic processes (Drake, 1976; and Johnson, 1978).

Because shale is the dominant lithology in the Cherokee Group, source of the mud is important in interpreting depositional environments. A variety of siliciclastic mud sources exist, however, it is difficult to establish the degree of influence of each source. The Central Kansas uplift and the Nemaha uplift which were structurally positive features during deposition of the

Cherokee Group contributed variegated muds to the Sedgwick basin (Wright, 1975). Transgressions provide an important mechanism for transporting sediment to the shelf (Johnson, 1978) and the Anadarko basin may have been a significant source since marine transgressions are thought to have approached Kansas from the south (Aden, 1982). A significant problem with this notion is that there is no process during transgressions to effectively stir up sediment and place it into suspension for transport. Sediment eroded from the Ouachita Mountains may have remained in suspension and transported by epicontinental sea circulation patterns to the Sedgwick basin. Murphy (1978) has suggested that Cherokee distributary channels associated with the deltaic system in southeast Kansas cut through the prodeltaic muds transporting large amounts of mud to the sea. Some of the mud was likely to have been transported by shelf circulation currents to the Sedgwick basin. Settling of suspended material will tend to concentrate the sediment towards the shoreline, or the most restricted portion of the basin due to the lack of transport energy. The lack of sand in the Cherokee Group implies no major direct input of mud into the Sedgwick basin. No hypothesis can be confirmed to be the dominant siliciclastic source and each mechanism may have contributed a portion of the sediment to the Sedgwick basin.

The understanding of both sediment transport mechanics and of the mechanics of sediment transporting flows is important in understanding the physical characteristics of a particular environment. Numerous modern studies of shelf sedimentation and transport have been completed on Atlantic and Pacific shelf areas of the United States. Study of the continental shelf off of Washington and Oregon by Smith and Hopkins (1972), and of the northeastern Atlantic shelf areas (Buss and Rodolfo, 1972; Meade, 1972; and Schubel and Okubo, 1972), all stress the significance of wind and wave driven currents and periodic intense storms as important mechanisms of transport of fine sediment. Most authors on shelf sedimentation believe that some of the major sources of suspended matter are biogenic detritus from shelf organisms (Meade, 1972), continental sources (McCave, 1972), and resuspended shelf bottom sediments (Meade, 1972; Schubel and Okubo, 1972). Concentration of terrigenous material in shallow areas of the shelf and along shorelines, similar to what has been found in this study, has been documented by Buss and Rodolfo (1972), Meade (1972), Schubel and Okubo (1972), and Smith and

Hopkins (1972). These authors have been unable to substantiate mechanisms of suspending sediment other than rivers and intense storms.

Thinness of the black shales in conjunction with great lateral persistance implies very slow sedimentation away from detrital influx and offshore in deeper water (Heckel, 1977). The quasi-estuarine circulation thought to have occurred in the Pennsylvanian mid-continent sea allows black, phosphatic, organic-rich shales to be deposited during high stands of sea-level across vast areas (Brongersma-Sanders, 1971; Heckel, 1977). This model may help explain the lateral continuity of black shales such as the Mecca Quarry (Oakley or "V" shale) and Excello shales.

Limestones of the Cherokee Group in the Sedgwick basin are typically argillaceous, less than 10 feet (3.1 meters) thick, and not widespread. The limestones in the Upper Cherokee interval, however, are less argillaceous and more widespread. Sample logs from by the Kansas Geological Society describes Cherokee limestones as fossiliferous, finely crystalline, or "lithographic". Stanbro (1960) descibes the Cherokee limestones as gray to tan and microcrystalline. Enos (1983) states that one of the most typical limestones deposited in epeiric seas of broad, flat interiors are fossiliferous lime mudstones.

Carbonates of the Cherokee Group accumulated during inundation of the Sedgwick basin and during the clearing of the water or regressions. Maximum organic productivity is generally associated with shallow agitated environments (Watney, 1980), frequently referred to as the aerobic zone. The aerobic zone is an oxygen-saturated zone not restictive to any group of marine invertebrates. Mixing of surface waters by the wind, waves, and currents, oxygenate the water with atmospheric oxygen (Cluff and others, 1981; and Heckel, 1984). Byers (1977) concluded that the minimum depth for the base of the aerobic zone is approximately 50 meters (164 feet). The aerobic zone is characterized by its fossil content and bioturbation. Variation in sea level and subsidence caused migration of this zone of maximum productivity across the Sedgwick basin during transgressions and regressions. Such factors as temperature, carbonate saturation, light penetration, water turbidity, salinity, and nature of currents, are also important in carbonate sedimentation (Enos, 1983; Wilson and Jordan, 1983; and Miall, 1984). Sea-bottom configuration, water circulation patterns, and other factors (Watney, 1980) also affect the trends and development of carbonate units. Marine transgressions during deposition of the Marmaton Group (directly above the Cherokee Group) are thought to have been much more extensive than marine transgressions during deposition of the Cherokee Group (below the "V" shale), resulting in the dominance of limestone in the Marmaton Group. The increase of limestone in the "V" shale interval and upper Cherokee interval may reflect the beginning of these transgressions.

Deposition and reworking of the Pennsylvanian basal conglomerate is due to ancient streams (Nodine-Zeller, 1981). Rippled sandstone, siltstone, and scoured conglomerate found in the examined cores are typical sedimentary structures expected from fluvial deposition by streams (Collinson, 1978; Nodine-Zeller, 1985). Transgression of Cherokee seas allowed further reworking of the basal conglomerate in a marine environment. Nodine-Zeller (1981) recognizes shale beds of the Pennsylvanian basal conglomerate as weathered clay from the soil profile. An abundance of weathered white chert found in the cores and samples is evidence of a long-term exposure and weathering common in karst regimes (Nodine-

Zeller, 1985). Depending on the clay content of the conglomerate, the extent of reworking can be envisioned. Shaley conglomerates received little reworking while silt and sand represent increasing degrees of sorting and removal of fine grains.

The Central Kansas uplift and the Nemaha uplift were topographically prominant structural features flanking the Sedgwick basin during Atokan and earliest Desmoinesian time. Nodine-Zeller (1981) has interpreted the flanks of the Central Kansas uplift as sea cliffs with thicker deposition of the Pennsylvanian basal conglomerate adjacent to the prominent cliffs in a quasi-marine environment.

The Pennsylvanian basal conglomerate isopach map (Plate 19) for the Sedgwick basin does not support Nodine-Zeller's interpretation. Thicker accummulations, up to 61 feet (18.6 meters, Klassen #1 well, sec. 26 - T22S - R2E) of the Pennsylvanian basal conglomerate are present on the northwest flank of the Nemaha uplift and the northeast flank of the Central Kansas uplift, but the deposits are not continuous along strike on the flank of each structural feature. The elongate and linear pattern of basal conglomerate accumulation may reflect stream deposition. A stream depositional mode has also been considered by Nodine-Zeller (1981) for the Pennsylvanian basal conglomerate in southwestern Ness County, Kansas, and by Guinan (1966) who studied a Wolfcampian conglomerate of chert and limestone pebbles in a shaly matrix. Isolated thicker deposits may reflect deposition in sinkholes developed on the karst surface (Nodine-Zeller, 1981, 1985).

BASIN DEVELOPMENT

In an effort to define basin setting and subsidence, a map was prepared showing the area where thickness in each interval exceded 70% of the maximum for that interval. Two trends were observed. The first is the similarity of areas of maximum interval thickness from the Krebs, upper Bluejacket, Weir-Pittsburg, and Tebo intervals (figure 34). Each interval records greatest thickness in the eastern and southeastern portion of the Sedgwick basin, but are confined to specific areas. A very subtle arch, not recognizable on structure maps, may have been present along the Kansas - Oklahoma border during early Cherokee deposition. The second trend is observed in the Mineral, Verdigris, and upper Cherokee intervals (figure 35). Greatest interval thicknesses are in the south and southeastern area of the Sedgwick basin, are more laterally continuous, and may extend into Oklahoma.

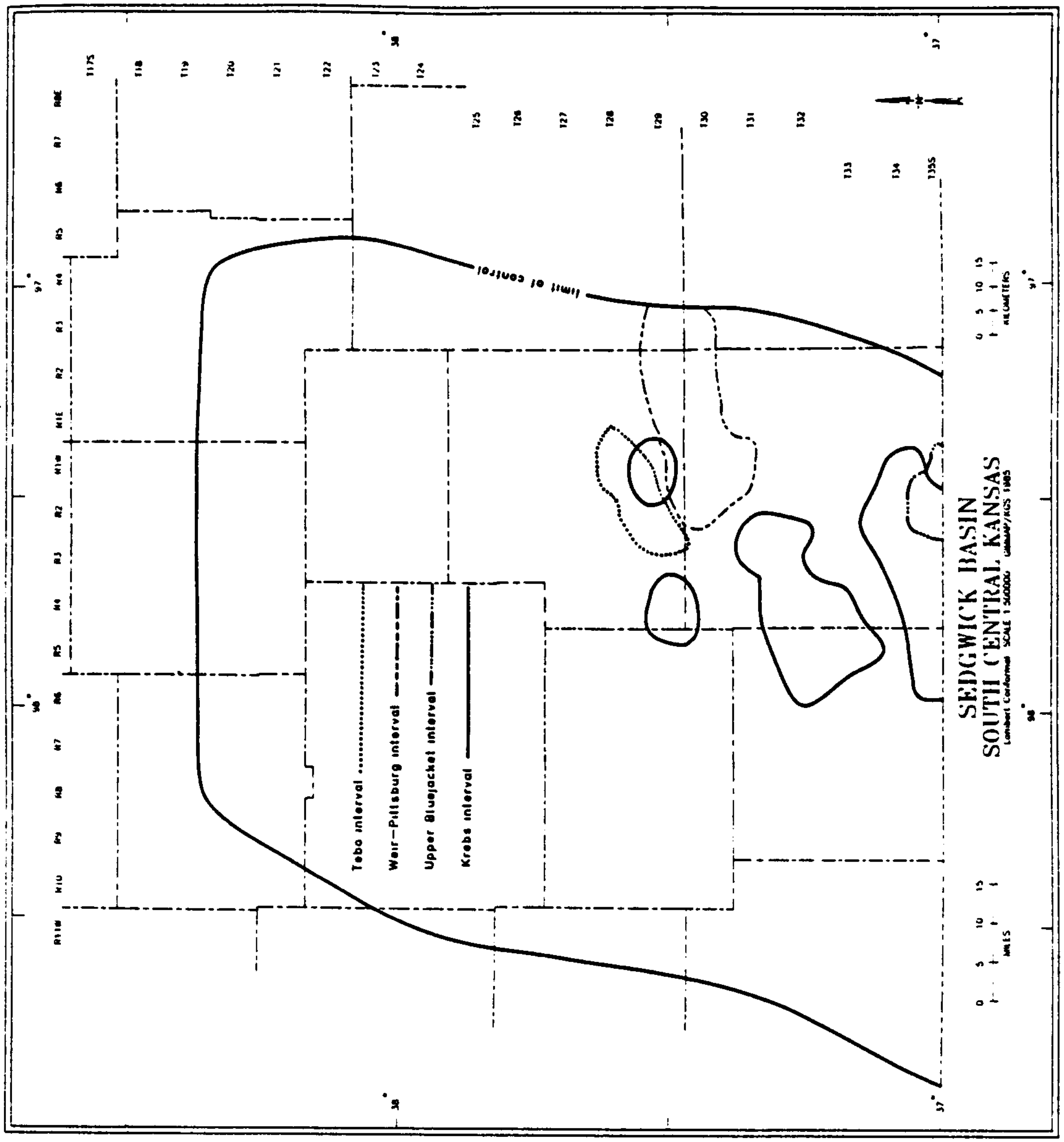


Figure 34 – Map of the greater than seventy percent of interval thickess.

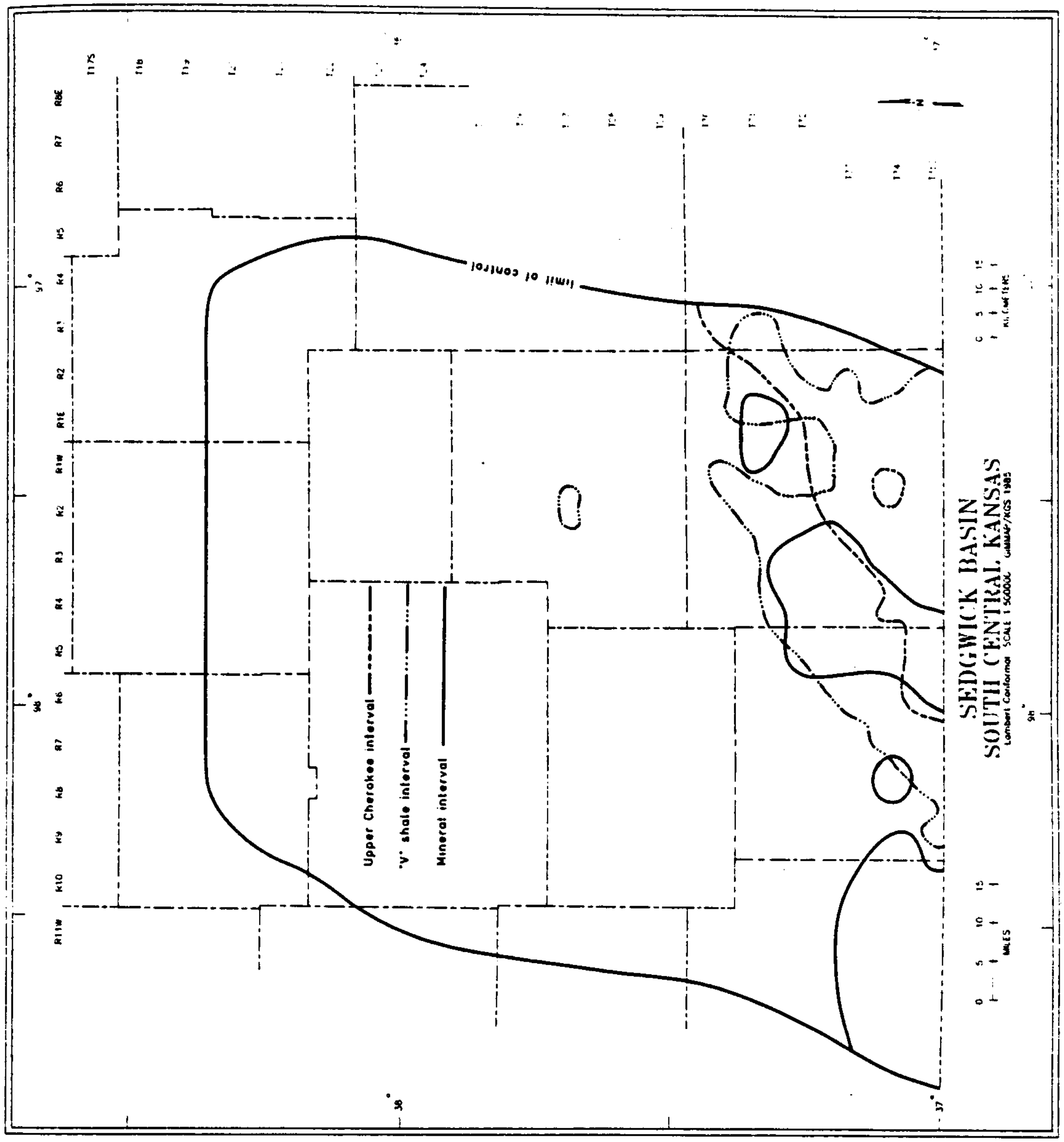


Figure 35 – Map of the greater than seventy percent of interval thickness.

SUMMARY

Detailed stratigraphic correlations have shown that it is possible to correlate the Cherokee Group and some of its distinctive interval markers (those used in this study) from southeastern Kansas to the Sedgwick basin. Markers used for correlation are black shales that are laterally widespread throughout the Sedgwick basin as well as extending into the Cherokee and Forest City basins, and the top and bottom of the Pennsylvanian basal conglomerate. It is possible to divide the Cherokee Group of the Sedgwick basin into eight stratigraphic intervals on the basis of these markers.

Cross sections show that the Sedgwick basin subsided during deposition of the Krebs interval. Other intervals are relatively constant in thickness across the basin suggesting little or no differential subsidence during deposition. This also implies that the Sedgwick basin may have been developing in early Desmoinesian time.

Lithofacies maps drawn from lithologic data from geophysical logs depict the transition of the Sedgwick basin from a mud-dominated basin to a carbonate shelf. A gradual increase in percentage of limestone and gradual decrease in percentage of shale is observed in successively younger intervals.

The Krebs through Tebo intervals are predominately shale. Siliciclastic mud may have been derived from the Central Kansas uplift, Nemaha uplift, Anadarko basin, Ouachita Mountains, or southeast Kansas. The Mineral through upper Cherokee intervals are predominately limestone. The more continuous nature of the limestone facies for the upper three intervals reflects a shallow, stable setting for widespread carbonate growth.

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APPENDIX A

LIST OF CORES USED IN THIS STUDY

Location	Spot	Well Name	Operator	County
32-20S-7W	SW-SE-NW	Lantz #1	Shell	Rice
11-20S-8W	NE-NW-SE	Maughlin #1	Shell	Rice
33-24S-5W	NE-C-NE	Bontrager #1	Marathon	Reno
20-28S-10W	NE-C-SW	Weatherall #1	Kingman	Kingman
30-34S-3E	SW-SW-NW	Weir #1	Sinclair	Cowley
31-34S-12W	SW-NE-SW	Sterling-C #1	Atlantic	Barber
36-34S-13W	SW-NE-NE	Sterling-D #1	Atlantic	Barber
1-35S-2E	NE-NW-NE	McLaughlin #3	Sinclair	Sumner

All cores are in the collection of the Kansas Geological Survey, Lawrence, Kansas.

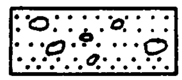
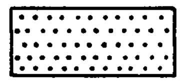
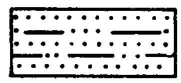
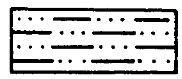
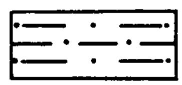
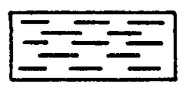
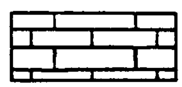
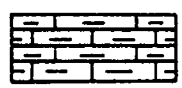
APPENDIX B

Graphic descriptions of cores used in this study

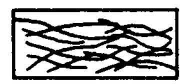
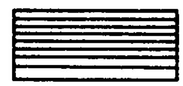
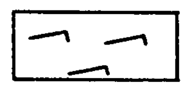
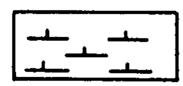
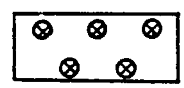
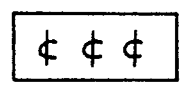
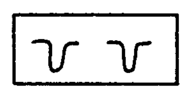
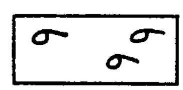
Cores described wet

Rock colors follow Goddard and others, 1980

Lithologic Symbols

Conglomerate	
Sandstone	
Argillaceous Sandstone	
Siltstone	
Silty Shale	
Shale	
Limestone	
Argillaceous Limestone	
Chert or Cherty	

Accessory Symbols

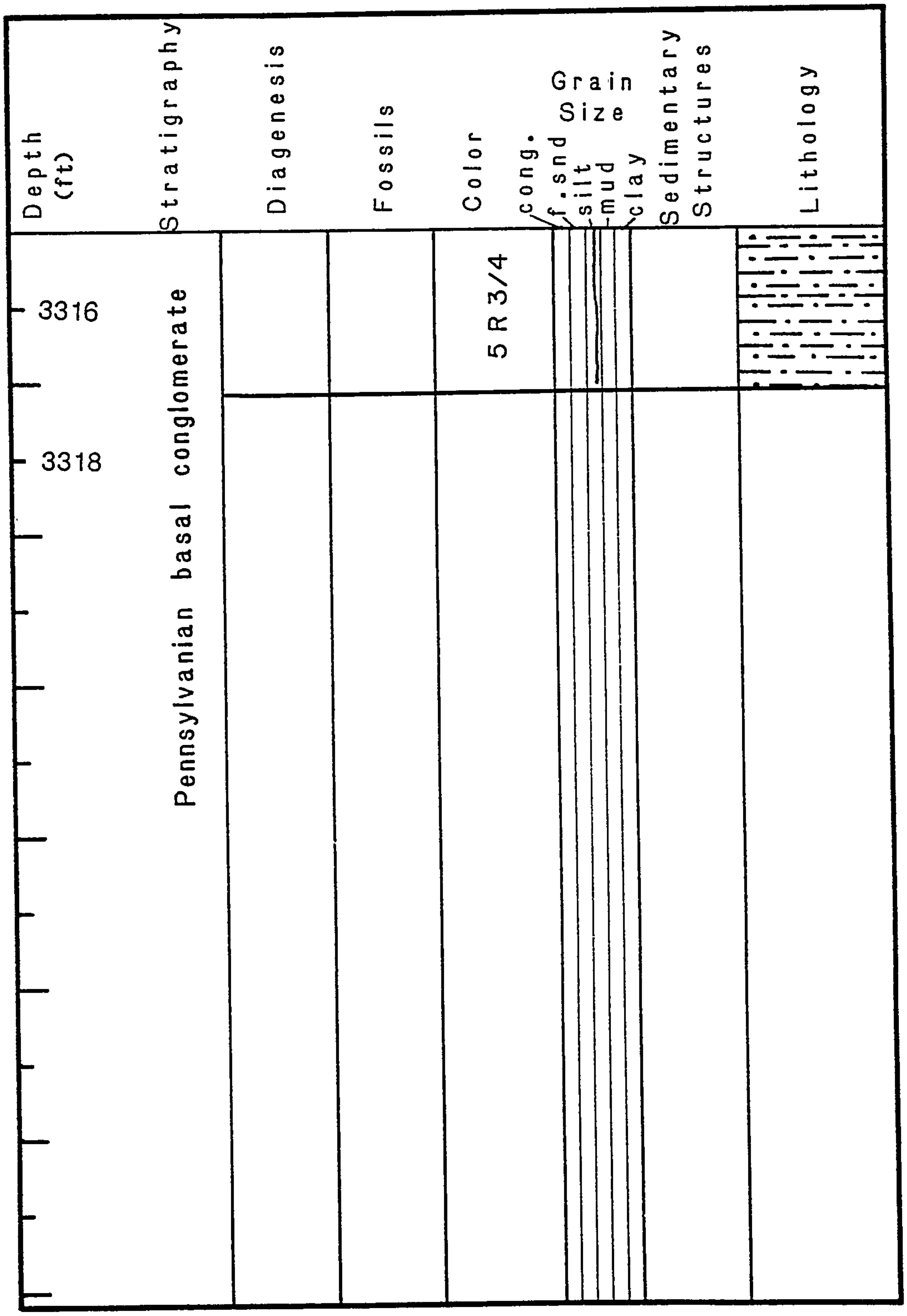
Flaser bedding	
Lamination	
Ripples	
Calcareous	
Pyrite Concretion	
Carbonaceous material	
Vertical burrow	
Brachiopod	
No core recovery	

Rock Color

Color	Munsell Classification
Dusky red	5 R 3/4
Very dark red	5 R 2/6
Dark yellowish brown	10 YR 4/2
Light olive gray	5 Y 6/1
Light olive gray	5 Y 5/2
Olive gray	5 Y 3/2
Pale olive	10 Y 6/2
Grayish olive	10 Y 4/2
Dusky yellow green	5 GY 5/2
Grayish green	5 G 5/2
Dusky green	5 G 3/2
Brownish black	5 YR 2/1
Greenish black	5 G 2/1
Grayish black	N2
Black	N1

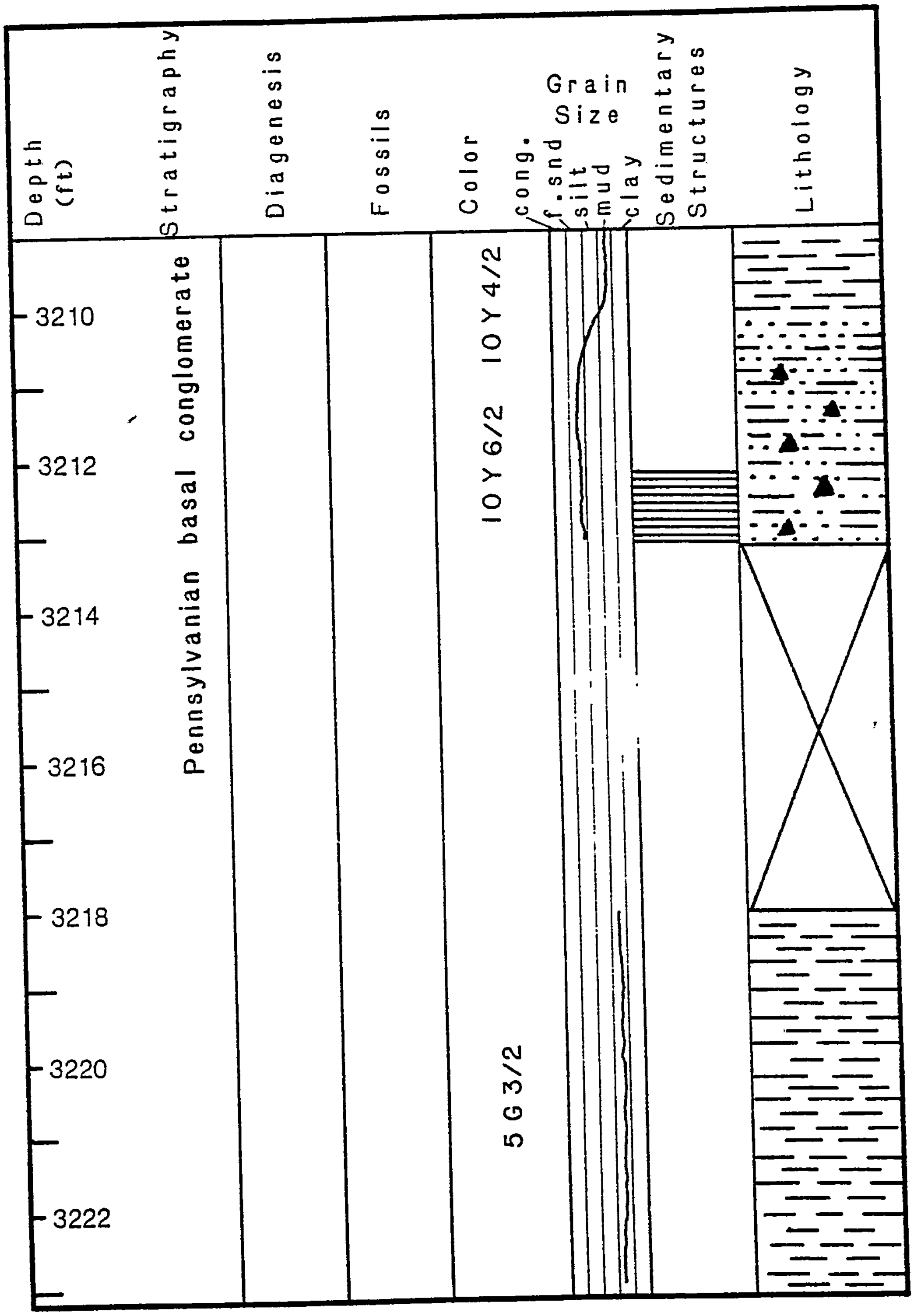
Lantz#1 32-20S-7W SW-SE-NW

Rice County, Kansas



Maughlin#1 11-20S-8W NE-NW-SW

Rice County, Kansas



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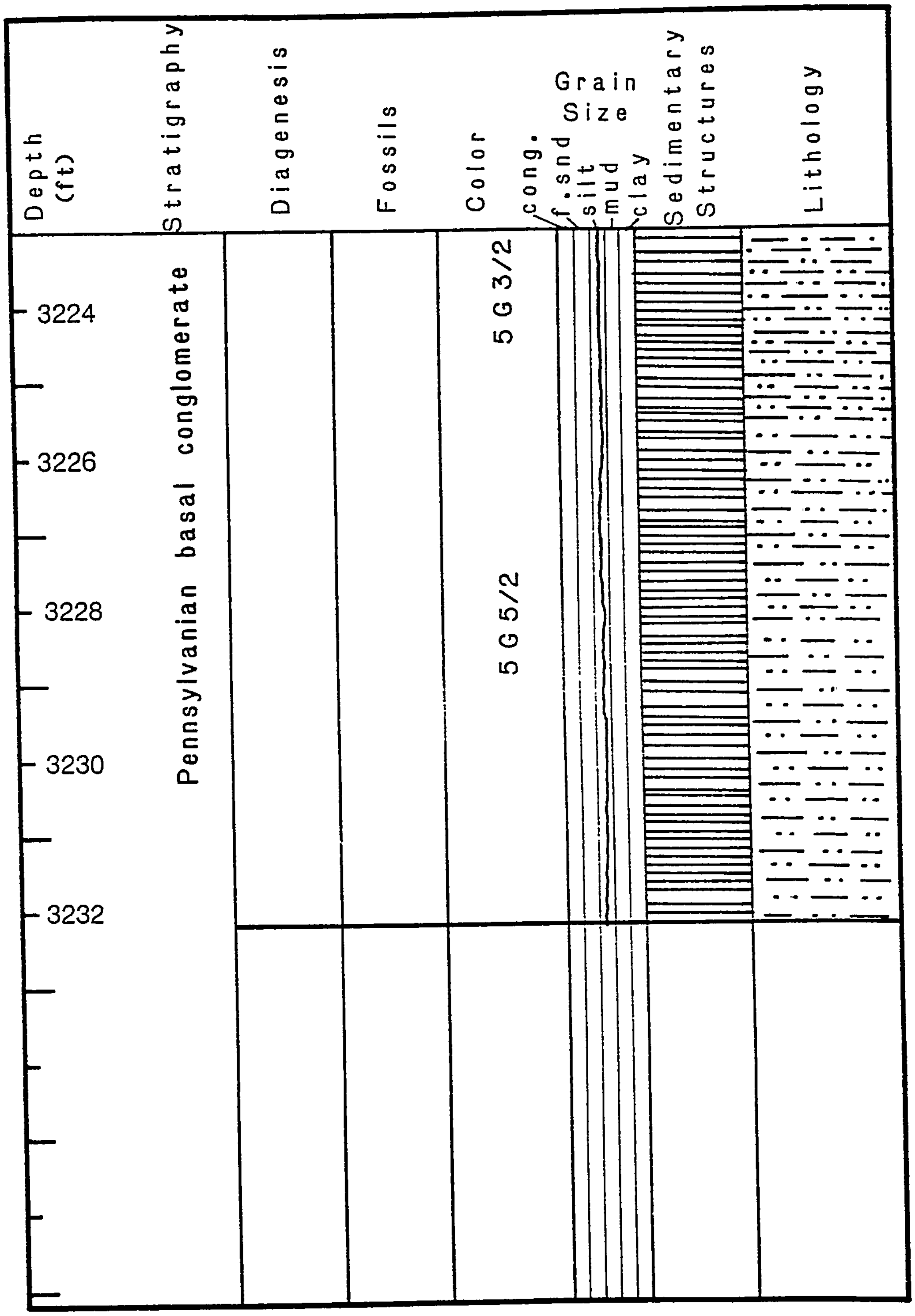
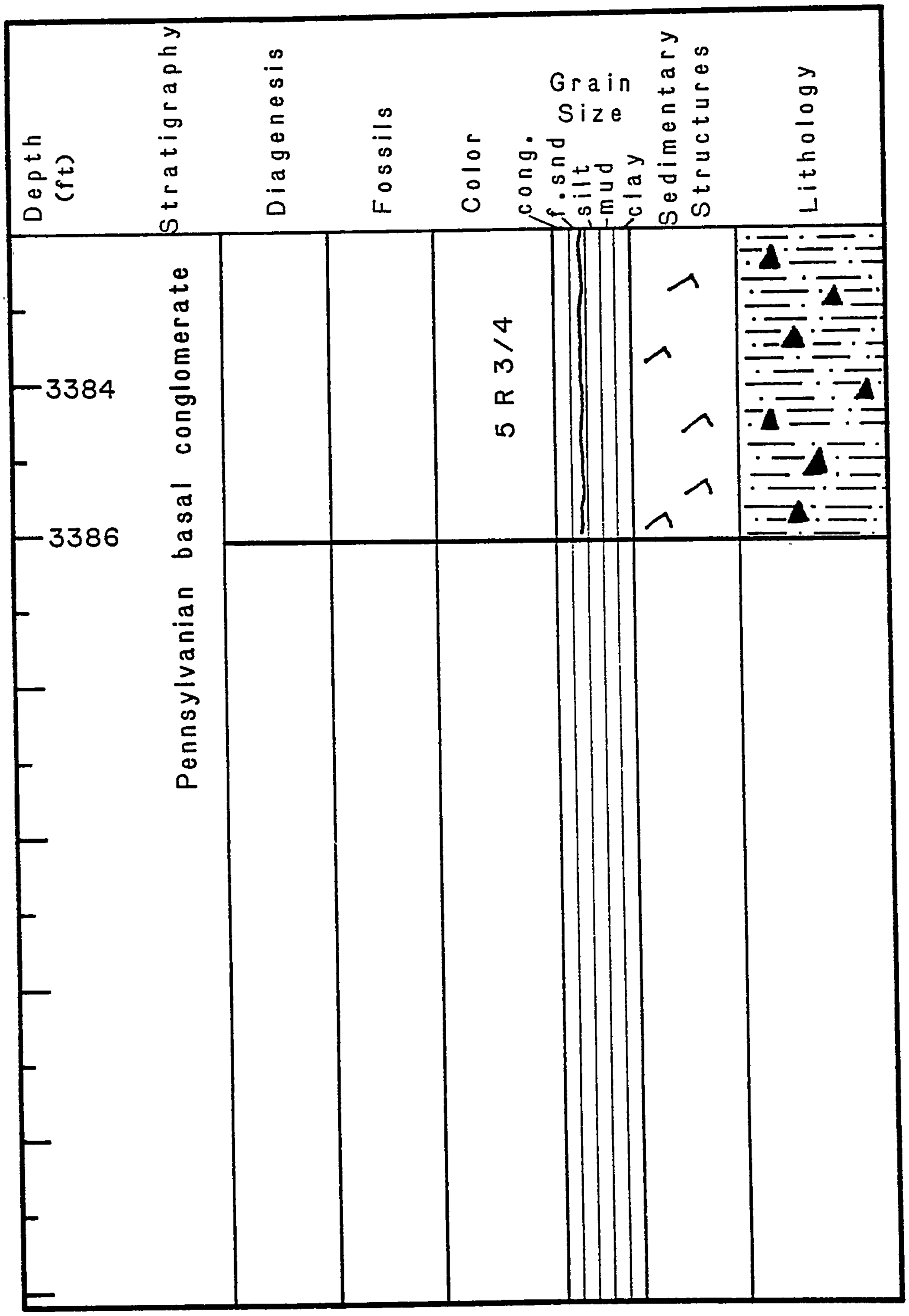
Rice County, Kansas

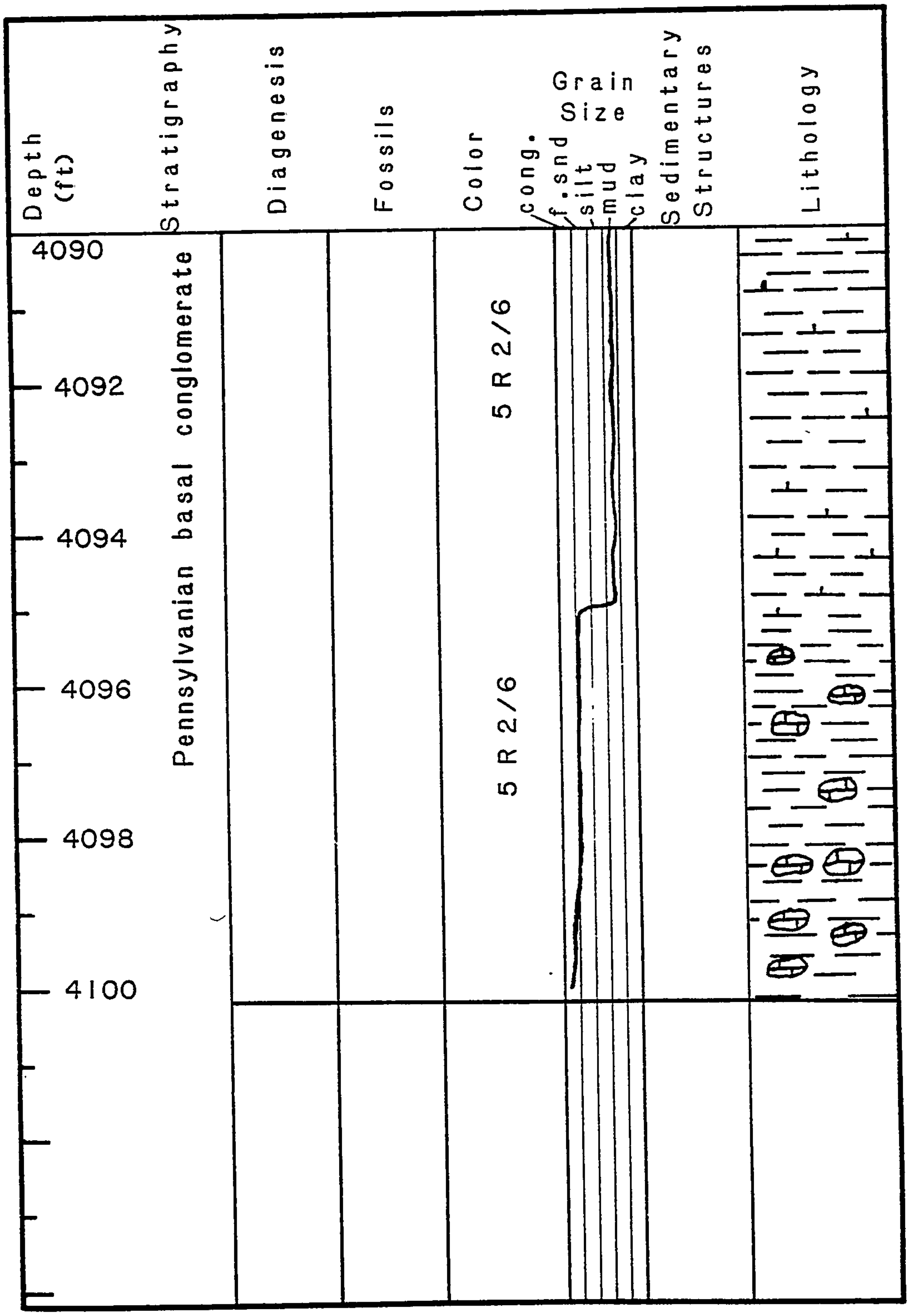


Bontrager#1 33-24S-5W NE-C-NE
Reno County



Weatherall#1 20-28S-10W NE-C-SW

Kingman County



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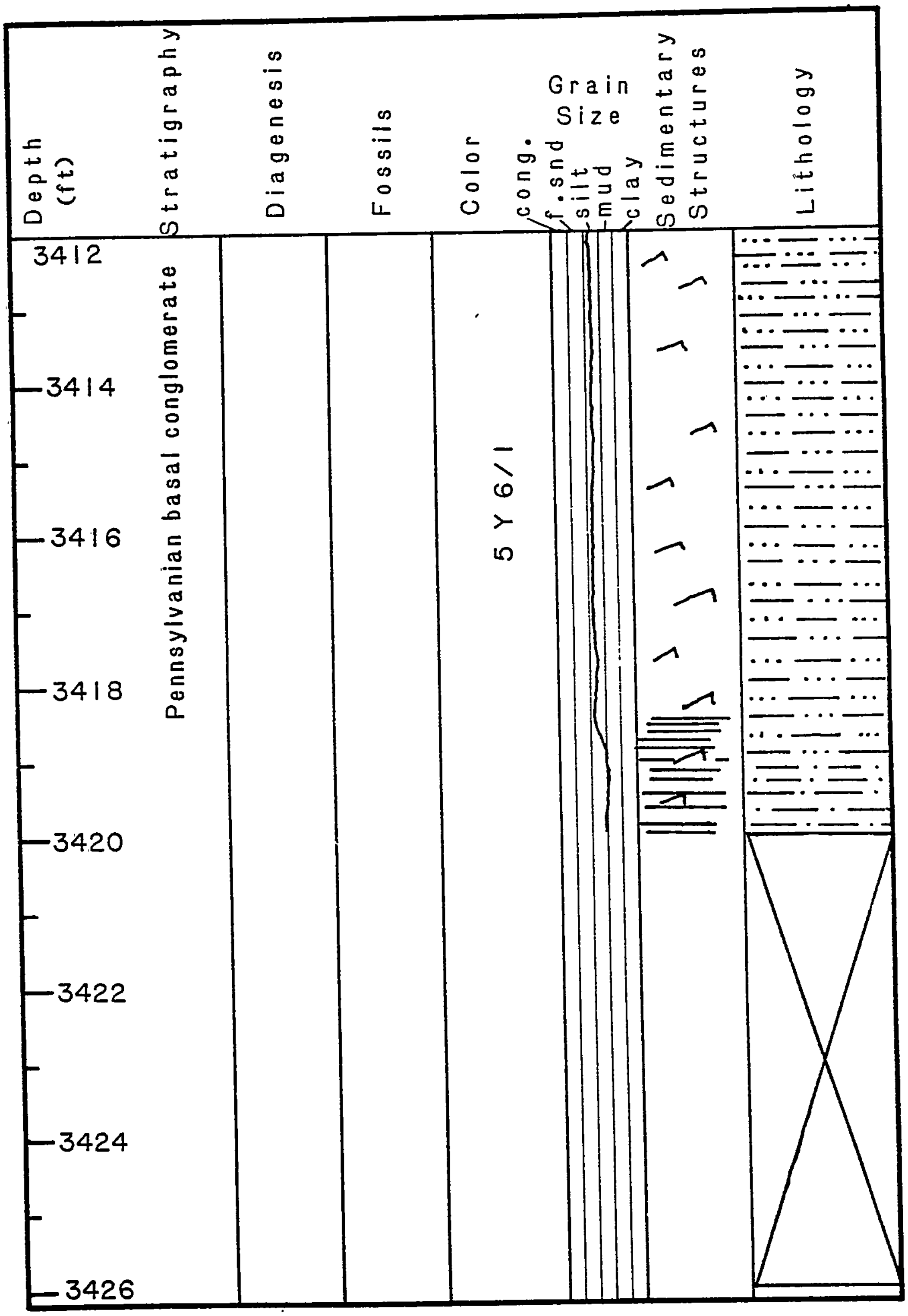
Cowley County



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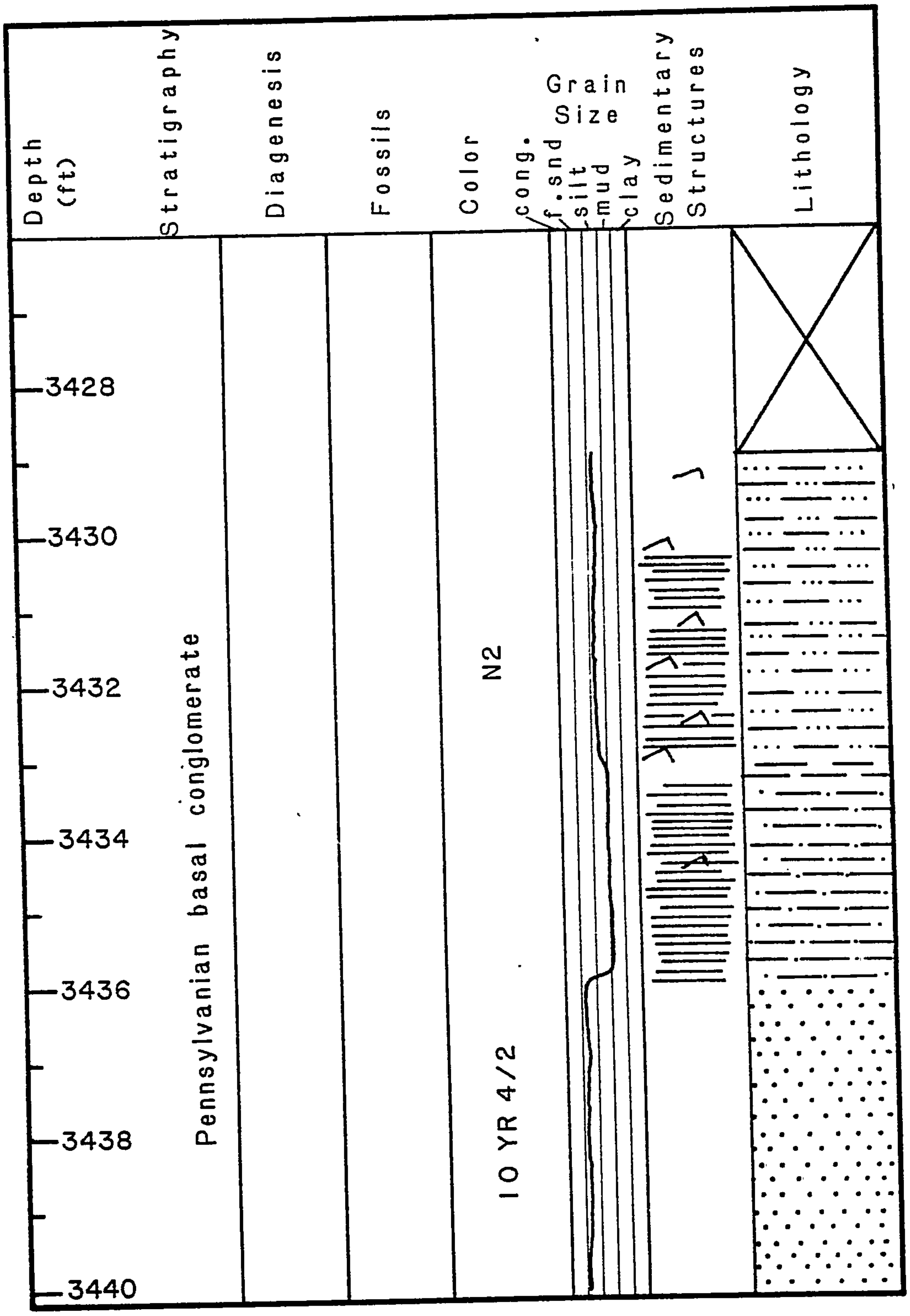
Cowley County



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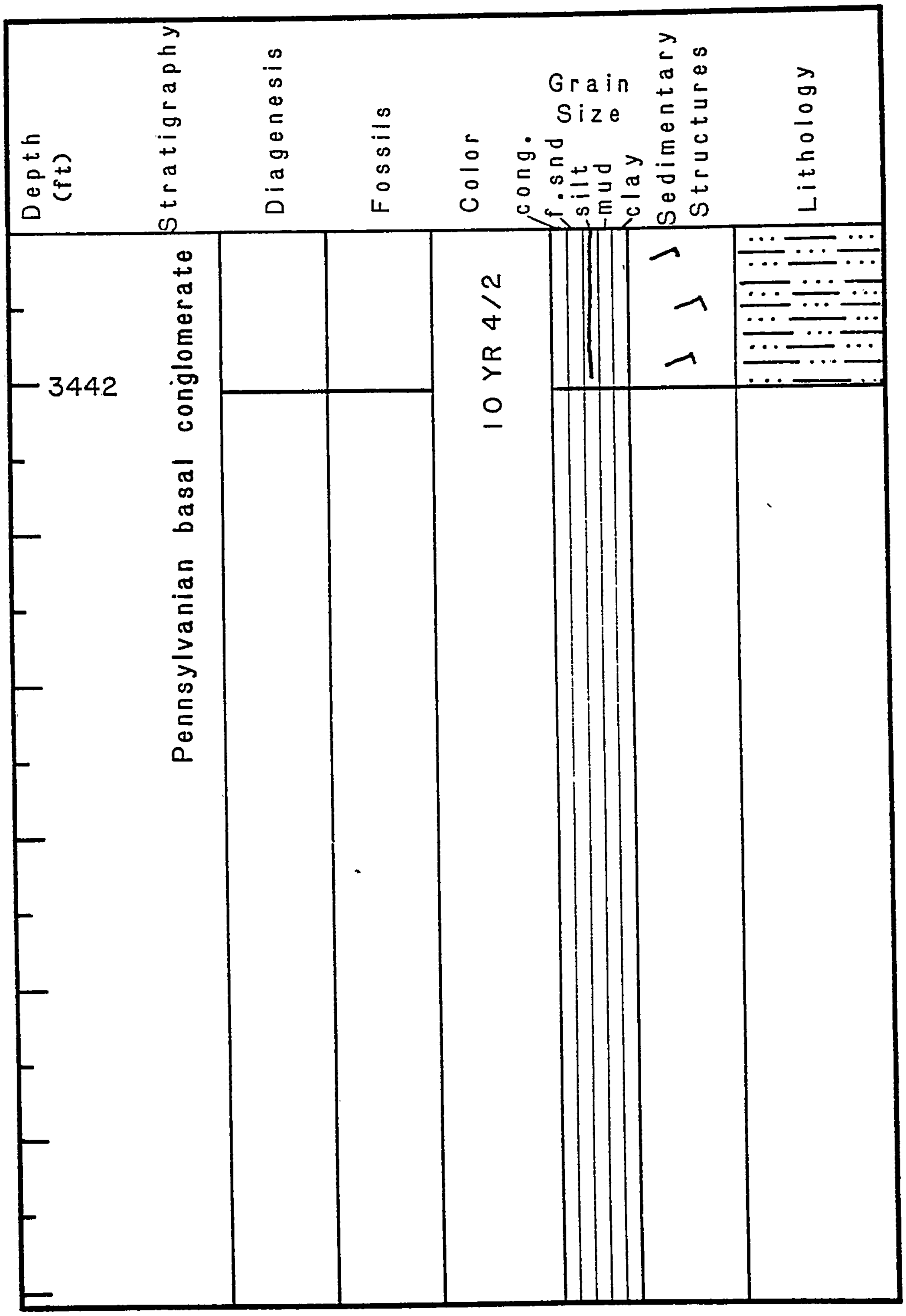
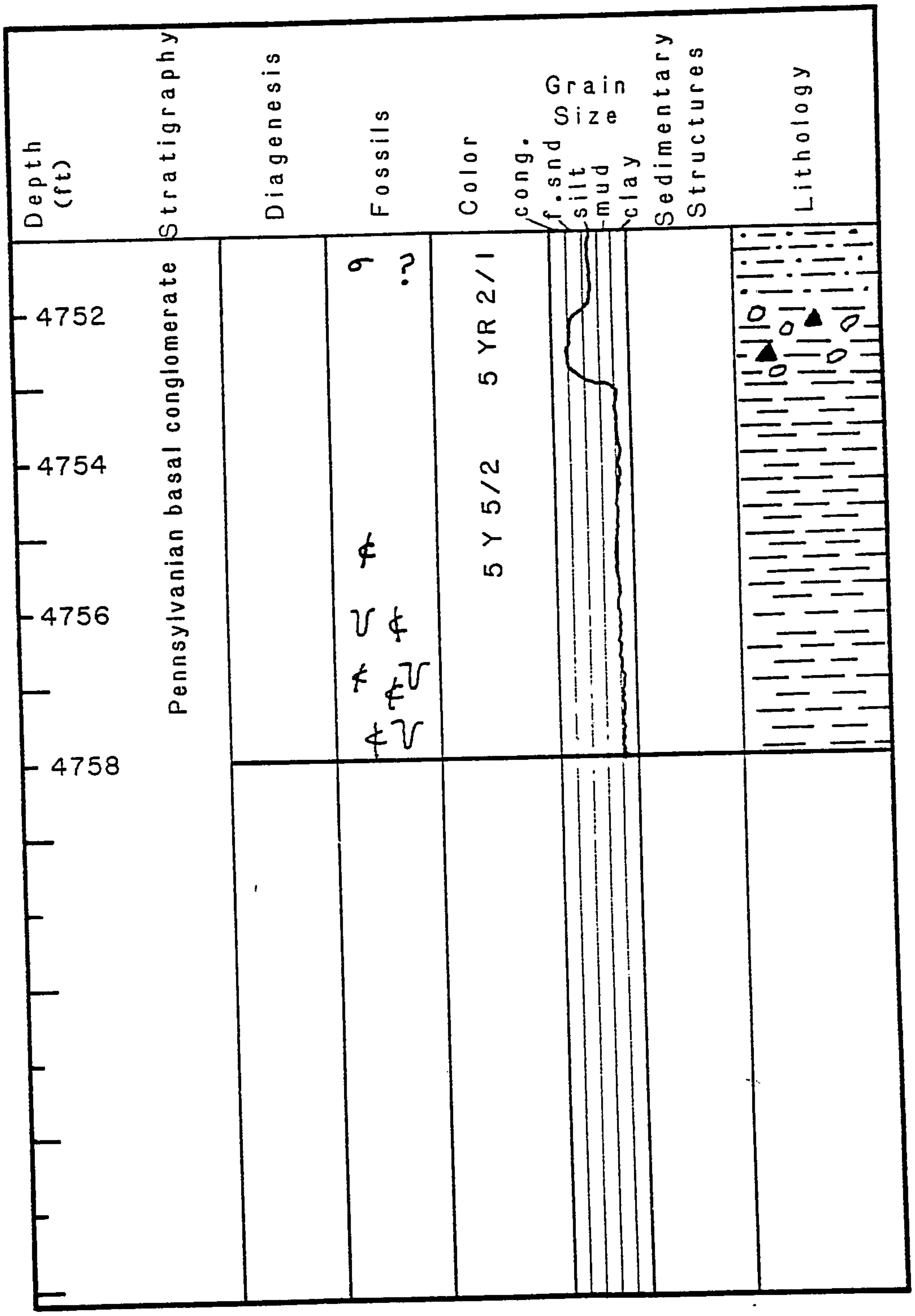
Cowley County



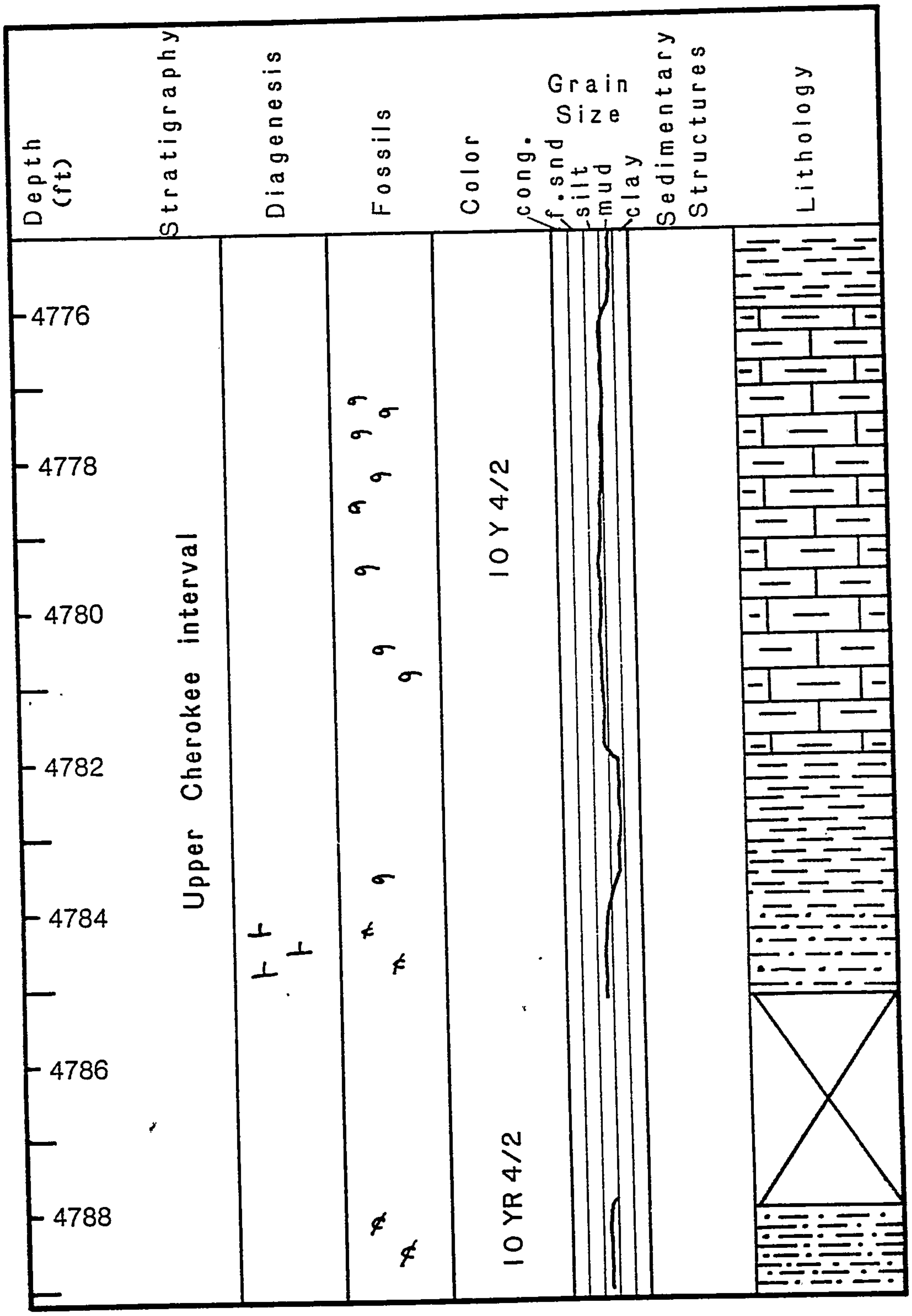
Sterling-C#1   31-34S-12W   SW-NE-SW

Barber County



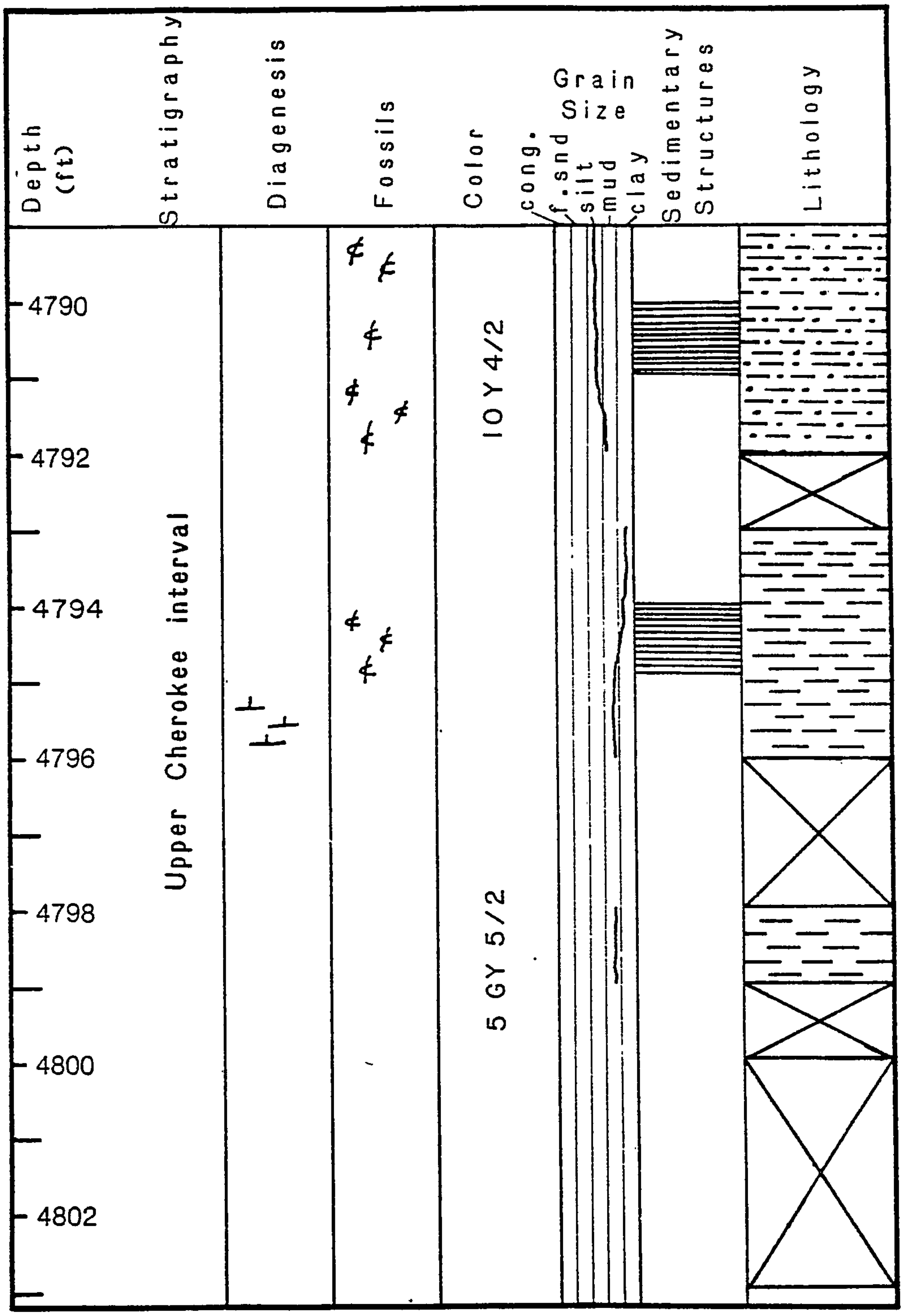
Sterling-D#1 36-34S-13W SW-NE-NE

Barber County, Kansas



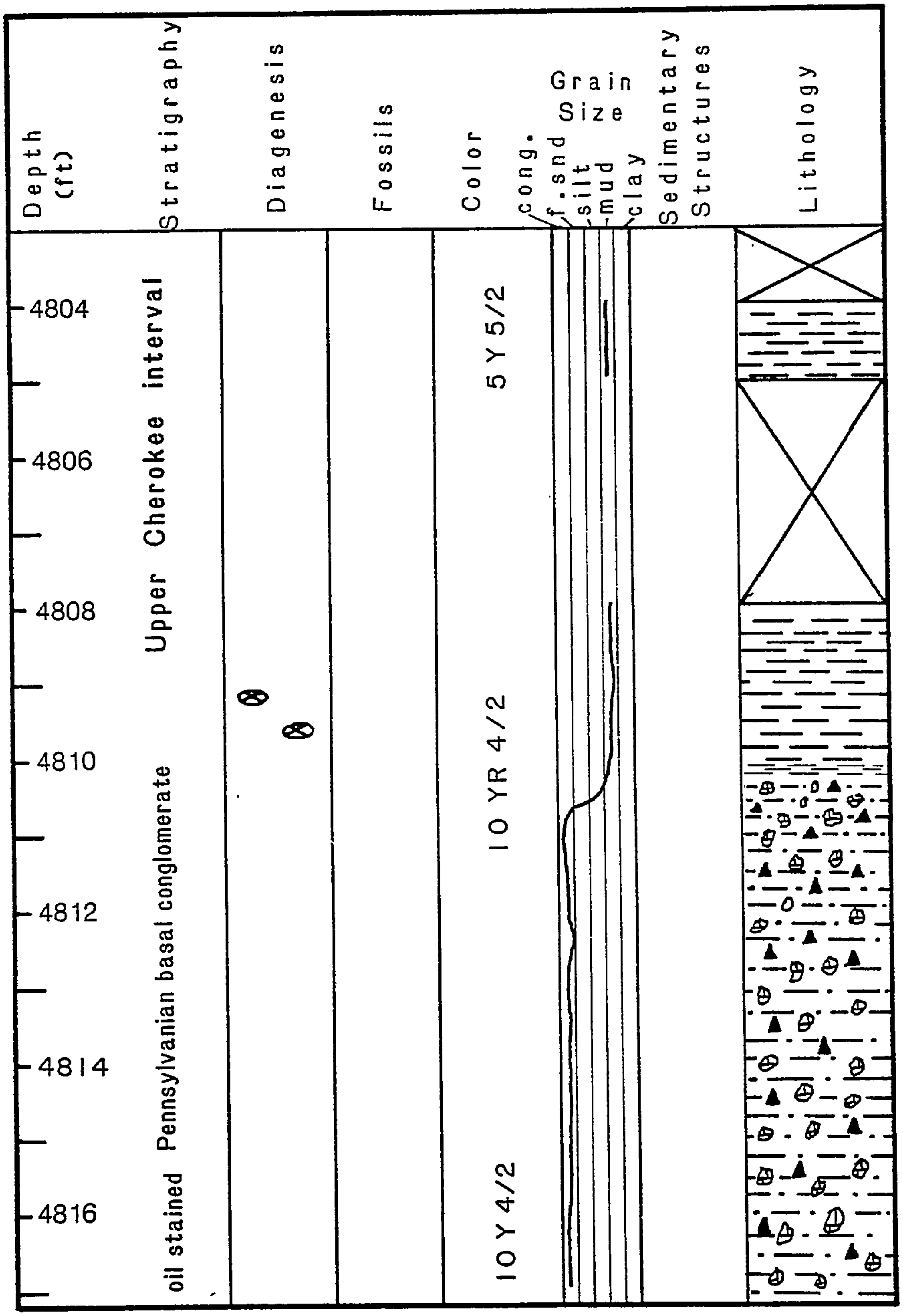
Sterling-D#1 36-34S-13W SW-NE-NE

Barber County, Kansas



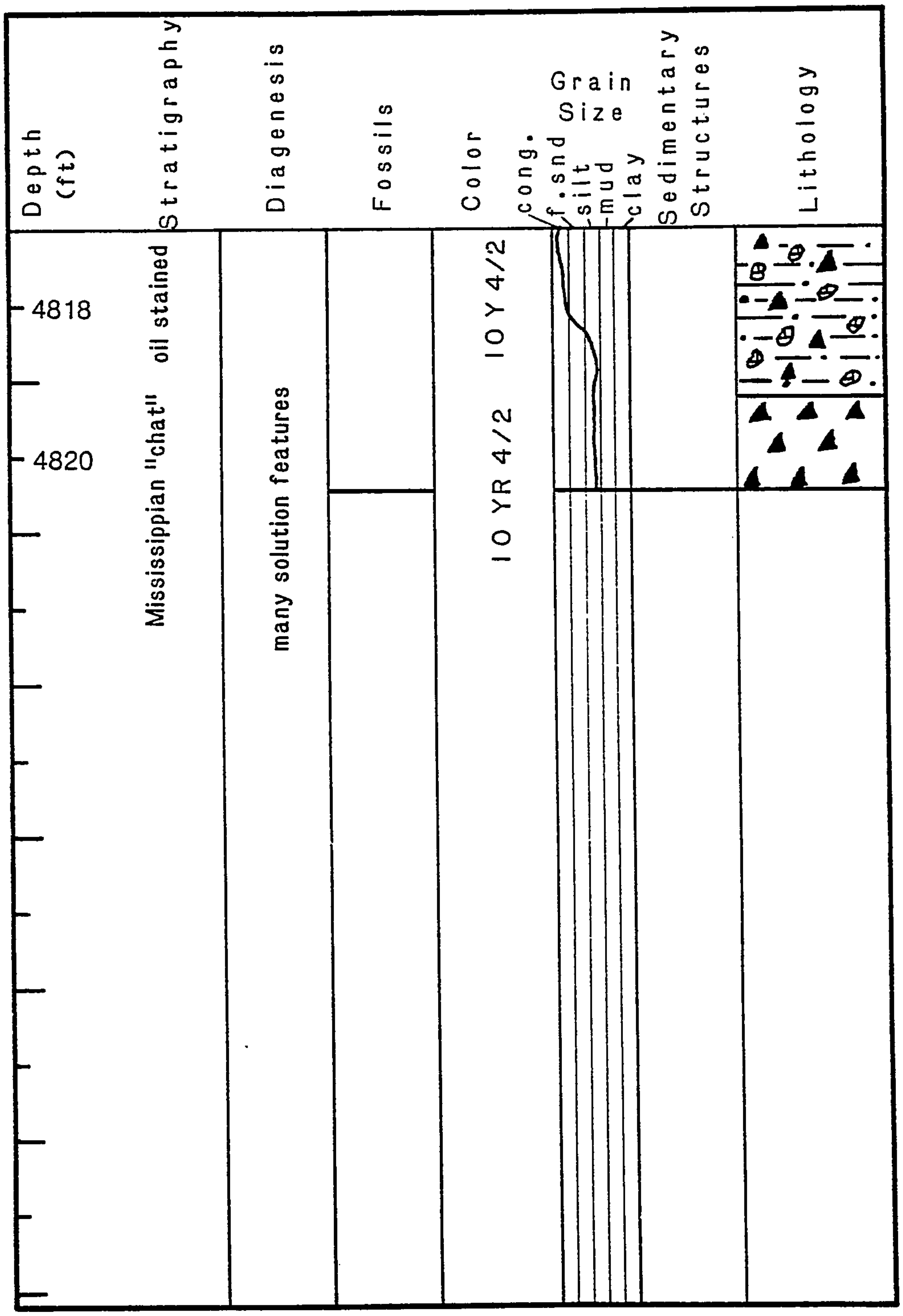
Sterling-D#1 36-34S-13W SW-NE-NE

Barber County, Kansas



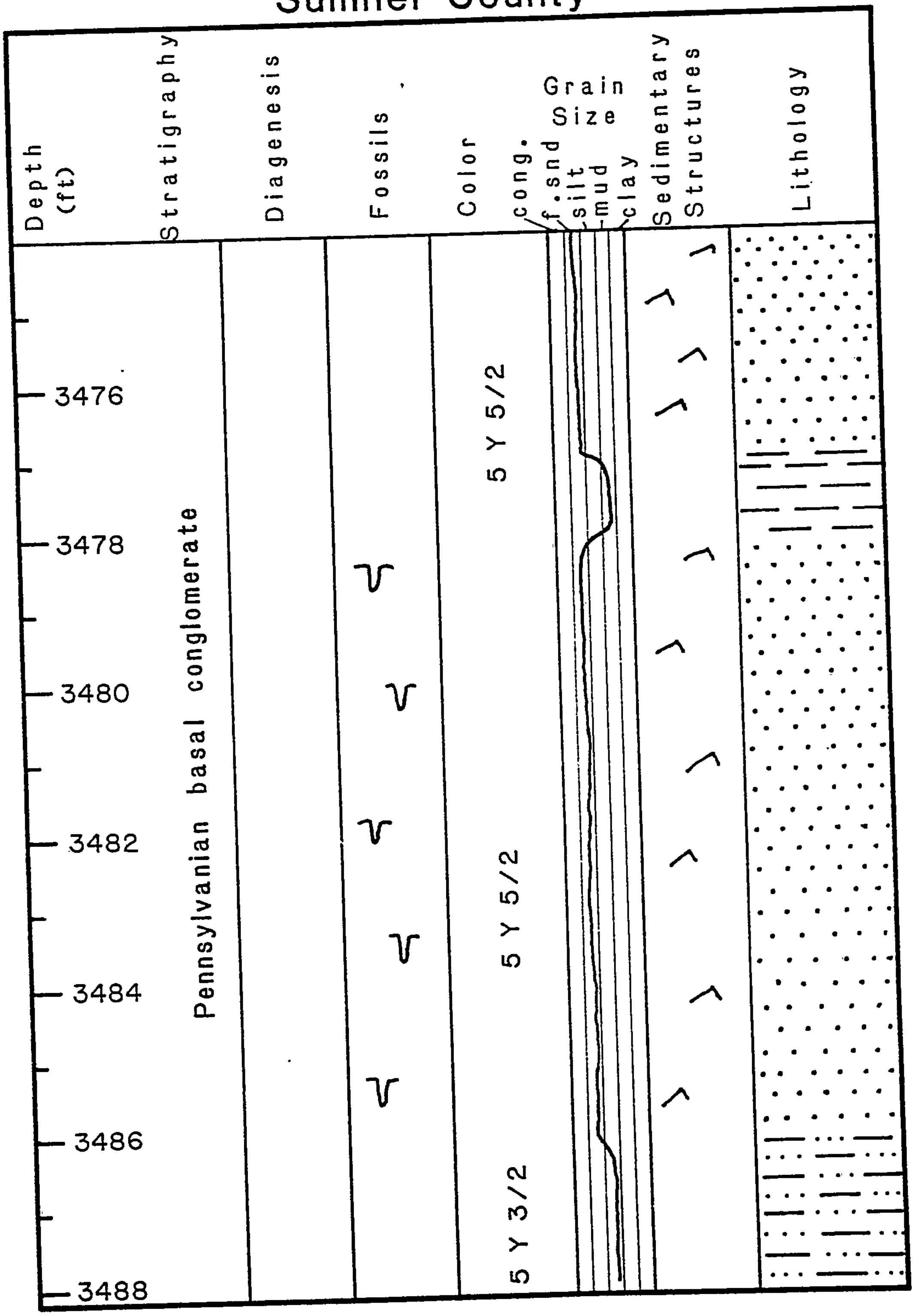
Sterling-D#1 36-34S-13W SW-NE-NE

Barber County, Kansas



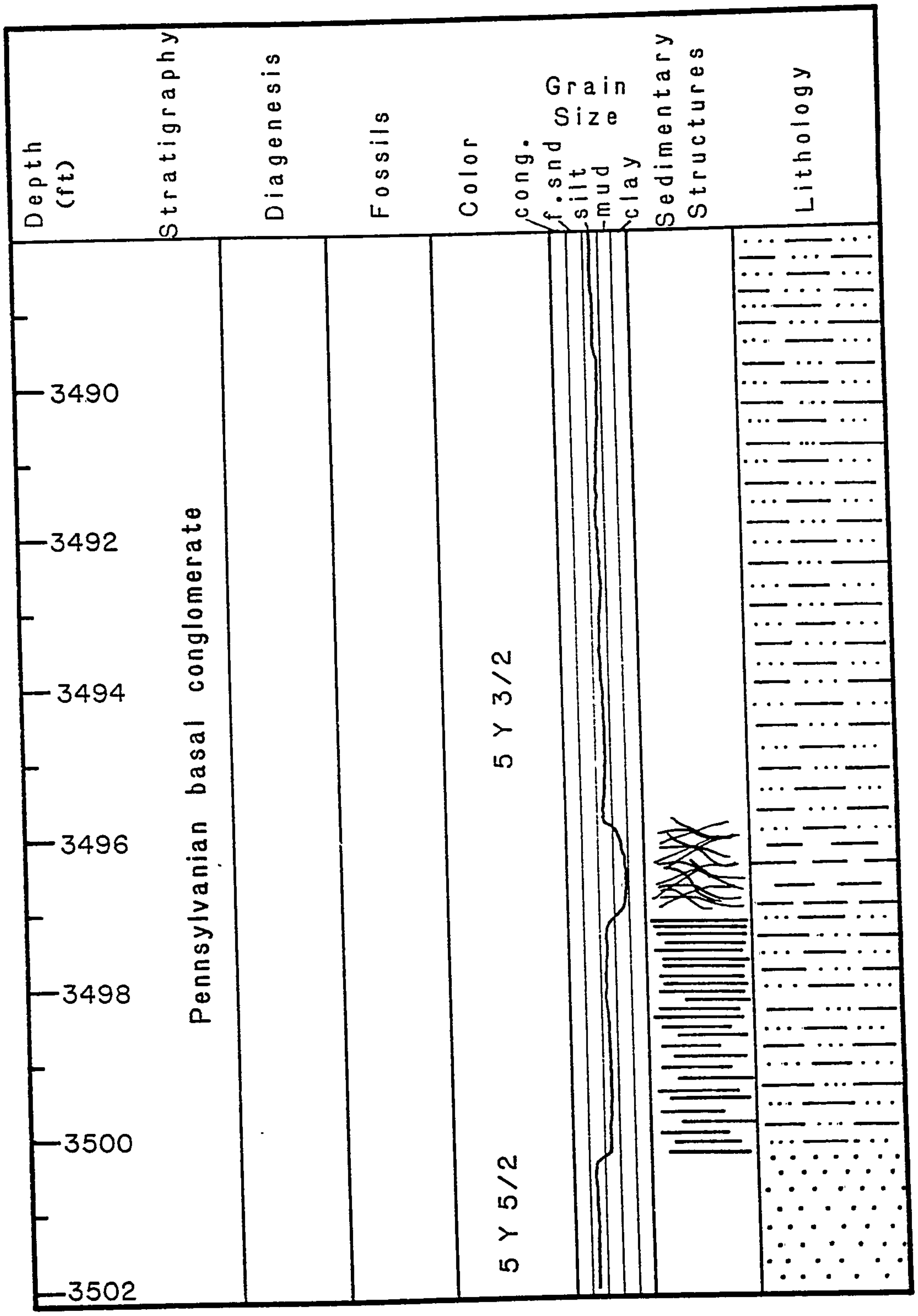
Laughlin#3 1-35S-2E NE-NW-NE

Sumner County



Laughlin#3 1-35S-2E NE-NW-NE

Sumner County, Kansas



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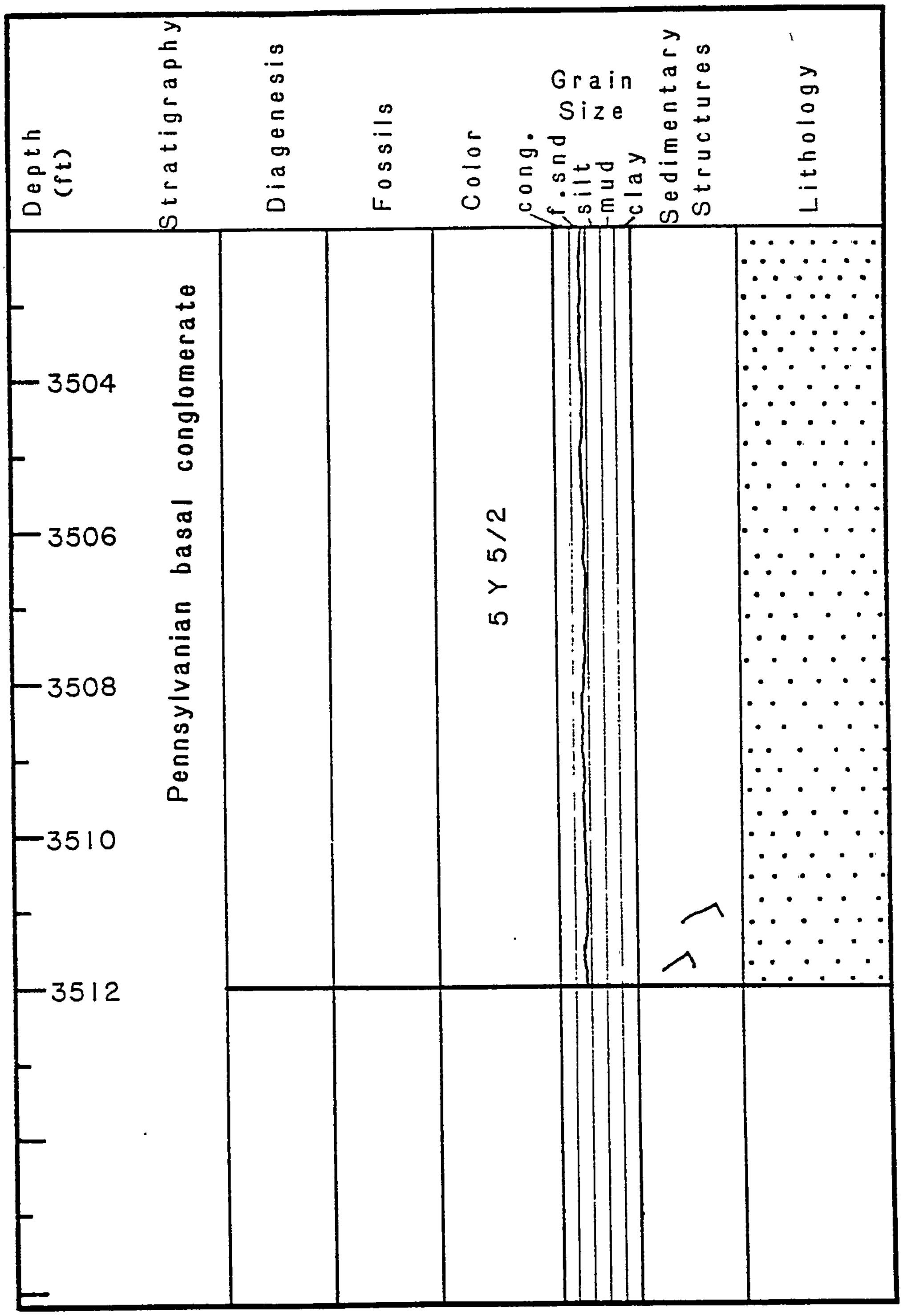
Sumner County, Kansas



APPENDIX C

WELL CUTTINGS

LIST OF WELL CUTTINGS EXAMINED AND USED IN THIS STUDY

Examined Well Cuttings

Location	Spot	Well Name	Operator	County
26-22S-2E	NE-SW-NE	Klassen #1	National	Harvey
11-26S-2E	SE-SE-SW	Mitchell #2	Vincent	Sedgwick
11-28S-2W	W2-NE-NW	Stringer #1	Gear	Sedgwick
2-29S-9W	SW-SW-SW	Govert #1	Lit. George	Kingman
6-30S-8W	C-NE-SW	Whitmer-C #1	McCoy	Kingman
15-31S-9W	NE-NW-SE	Kennedy #1	Magnolia	Harper
36-33S-6W	SW-SE-SE	Burgmeier #2	National	Harper
17-33S-10W	C-NE-SW	Stewart-A #2	Range	Barber
35-34S-9W	C-SW-NW	Chain-Burke #1	Pet. Cons.	Harper
4-35S-1W	E2-W2-E2	Hagar-A #1	Cities	Sumner
12-35S-4W	SE-SW-SE	#1 Moss	National	Sumner
11-35S-6W	C-SW-NW	Smith #1	Sanders	Harper
14-35S-14W	C-E2-NW	Snyder #1	Reach	Barber

Cuttings obtained from the Kansas Geological Society collection, Wichita, Kansas.

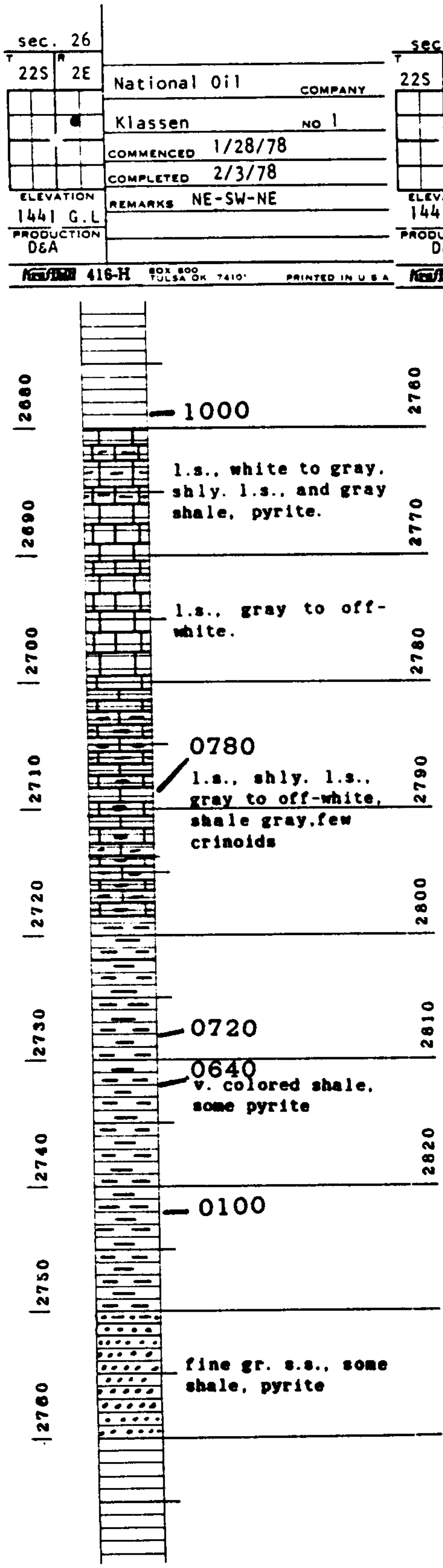
Well Cuttings Described by the Kansas Sample Log Service

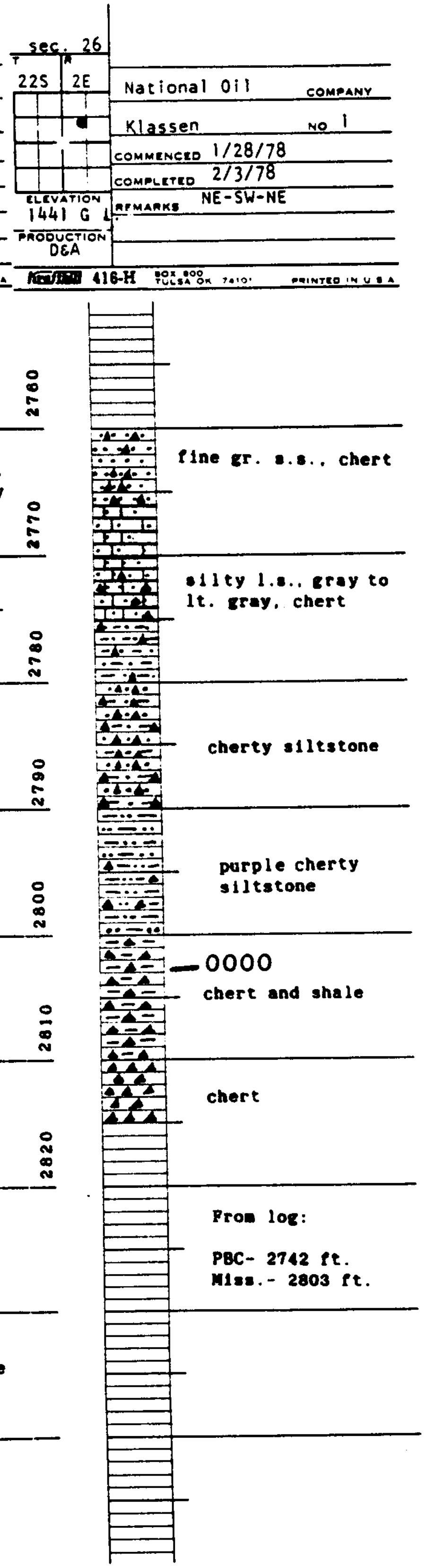
Location	Spot	Well Name	Operator	County
6-24S-6W	NW-NW-SE	Benton #1	Osage	Reno
10-25S-3W	NW-NE-NE	Jorgenson #1	Rupp & Sin.	Sedgwick
18-25S-7W	SE-SE-NE	Trembley #1	Thunderbird	Reno
12-25S-10W	N2-NE-NW	Morris #1	Schermrhrn.	Reno
31-26S-5W	C-NW-NE	White #1	Brad's Pet.	Reno
31-26S-7W	C-SE-NW	Bruch-E #1	Pickrell	Reno
21-26S-10W	NW-NW-SW	Hayes #1	Bennett	Reno
1-26S-11W	SW-SW-NE	Slater #1	Deep Rock	Pratt
14-27S-3W	NE-NE-NE	Klausmeyer #1	Aurora	Sedgwick
21-27S-7W	SW-NW-NE	Wooldridge	Kathol	Kingman
20-27S-9W	C-NE-SW	Boswell #1	Bander	Kingman
15-28S-4W	C-SE-SE	Spurrier #1	Mull Drlg.	Sedgwick
25-28S-7W	C-NE-SE	#1 Reida	Mall & Mah.	Kingman
5-29S-5W	SW-NE-SW	Kinkaid #1	Keener	Kingman
1-29S-7W	C-SE-NW	Shrag-L #1	Pickrell	Kingman
1-30S-12W	C-SW-NW	Knop #1	Beacon	Barber
1-31S-5W	C-NW-SW	Simmons #1	Mull Drlg.	Harper
18-32S-5W	SE-SE-NW	Hallman #2	Robinson	Harper
32-33S-2W	C-NW-SW	Builta A-1	Anadarko	Sumner

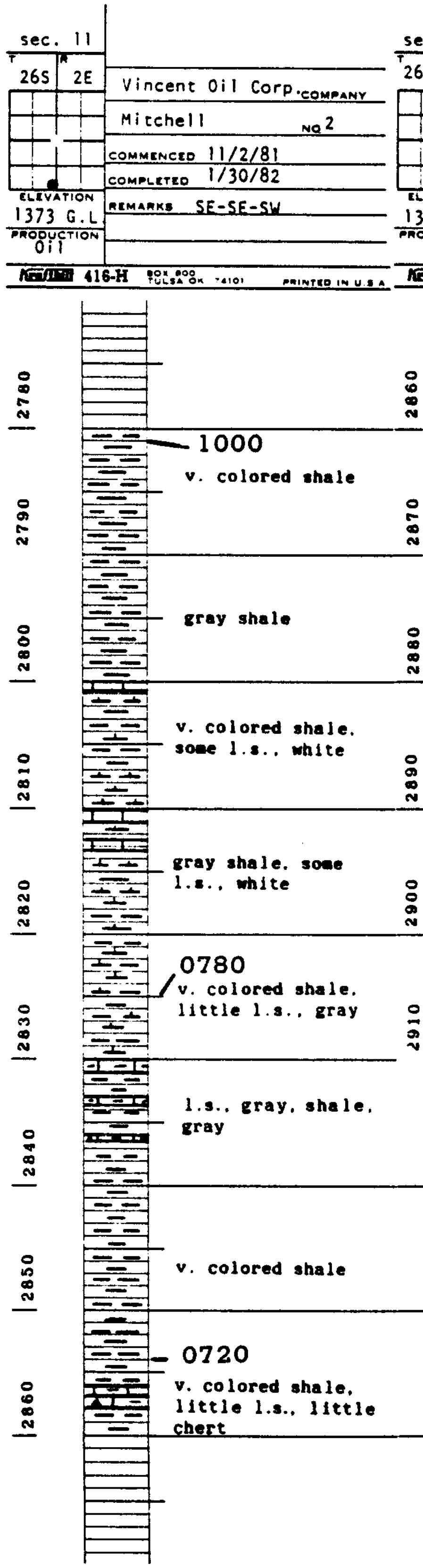
5-34S-5W	C-SW-NE	Equity #1	Int. Hdcbn.	Harper
10-35S-8W	SW-SW-SW	Zellers #1	Aurora	Harper
10-35S-10W	NW-NW-NE	Gudeman #1	Aurora	Barber

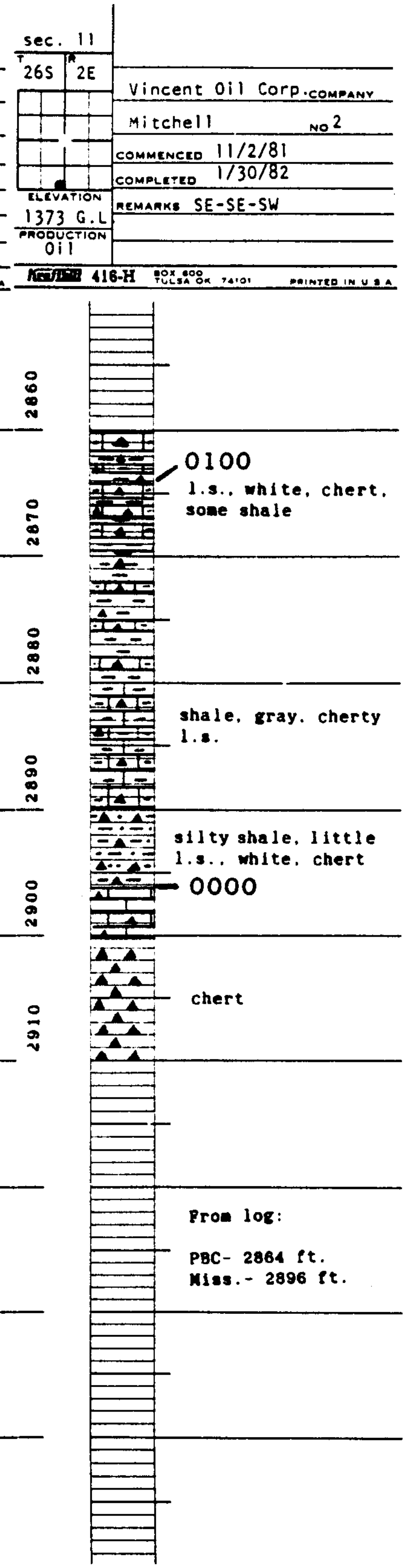
APPENDIX D

Description of Well Cuttings

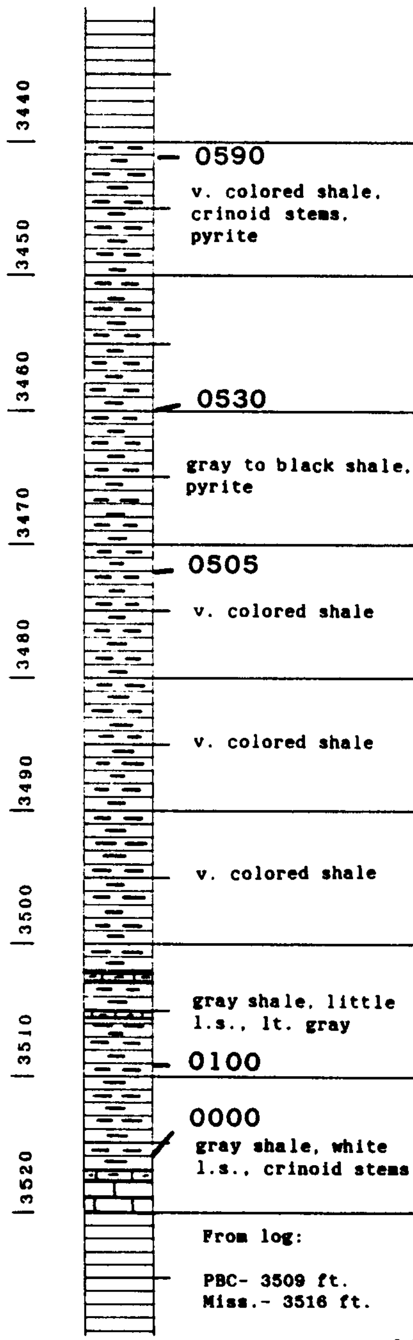

sec. 26
T 22S R 2E
National Oil COMPANY
Klassen NO 1
COMMENCED 1/28/78
COMPLETED 2/3/78
REMARKS NE-SW-NE
ELEVATION 1441 G.L
PRODUCTION D&A
416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.
2680
2690
2700
2710
2720
2730
2740
2750
2760
1000
l.s., white to gray, shly. l.s., and gray shale, pyrite.
l.s., gray to off-white.
0780
l.s., shly. l.s., gray to off-white, shale gray, few crinoids
0720
0640
v. colored shale, some pyrite
0100
fine gr. s.s., some shale, pyrite


sec. 26
T 22S R 2E
National Oil COMPANY
Klassen NO 1
COMMENCED 1/28/78
COMPLETED 2/3/78
REMARKS NE-SW-NE
ELEVATION 1441 G L
PRODUCTION D&A
416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.
2760
2770
2780
2790
2800
2810
2820
fine gr. s.s., chert
silty l.s., gray to lt. gray, chert
cherty siltstone
purple cherty siltstone
0000
chert and shale
chert
From log:
PBC- 2742 ft.
Miss.- 2803 ft.

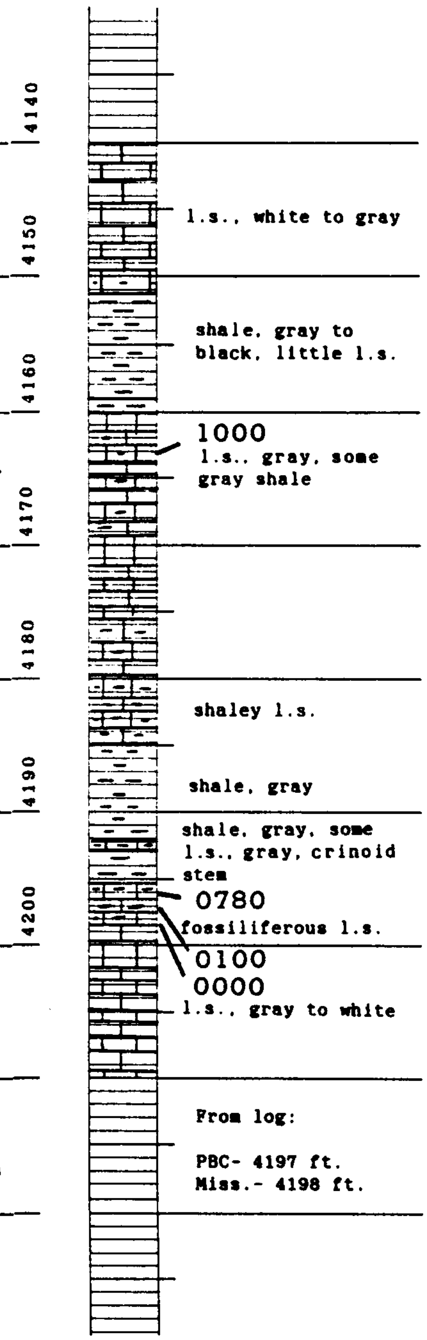

sec. 11
T 26S
R 2E
Vincent Oil Corp. COMPANY
Mitchell NO 2
COMMENCED 11/2/81
COMPLETED 1/30/82
ELEVATION 1373 G.L
REMARKS SE-SE-SW
PRODUCTION Oil
416-H
BOX 600 TULSA OK 74101
PRINTED IN U.S.A.
2780
2790
2800
2810
2820
2830
2840
2850
2860
1000
v. colored shale
gray shale
v. colored shale, some l.s., white
gray shale, some l.s., white
0780
v. colored shale, little l.s., gray
l.s., gray, shale, gray
v. colored shale
0720
v. colored shale, little l.s., little chert


sec. 11
T 26S
R 2E
Vincent Oil Corp. COMPANY
Mitchell NO 2
COMMENCED 11/2/81
COMPLETED 1/30/82
ELEVATION 1373 G.L
REMARKS SE-SE-SW
PRODUCTION Oil
416-H
BOX 600 TULSA OK 74101
PRINTED IN U.S.A.
2860
2870
2880
2890
2900
2910
0100
l.s., white, chert, some shale
shale, gray, cherty l.s.
silty shale, little l.s., white, chert
0000
chert
From log:
PBC- 2864 ft.
Miss.- 2896 ft.

sec. 11
T 28S R 2W
Gear Petroleum COMPANY
Stringer NO 1
COMMENCED 12/2/81
COMPLETED 12/12/81
ELEVATION 1384 G.L.
REMARKS W2-NE-NW
PRODUCTION D&A
416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 2
T 29S R 9W
Little George Oil COMPANY
Julia Govert NO 1
COMMENCED 7/15/74
COMPLETED 7/27/74
ELEVATION 1715 G.L.
REMARKS SW-SW-SW
PRODUCTION D&A
416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 6

T	R
30S	8W

McCoy Petroleum COMPANY

Whitmer "C" NO 1

COMMENCED 8/17/77

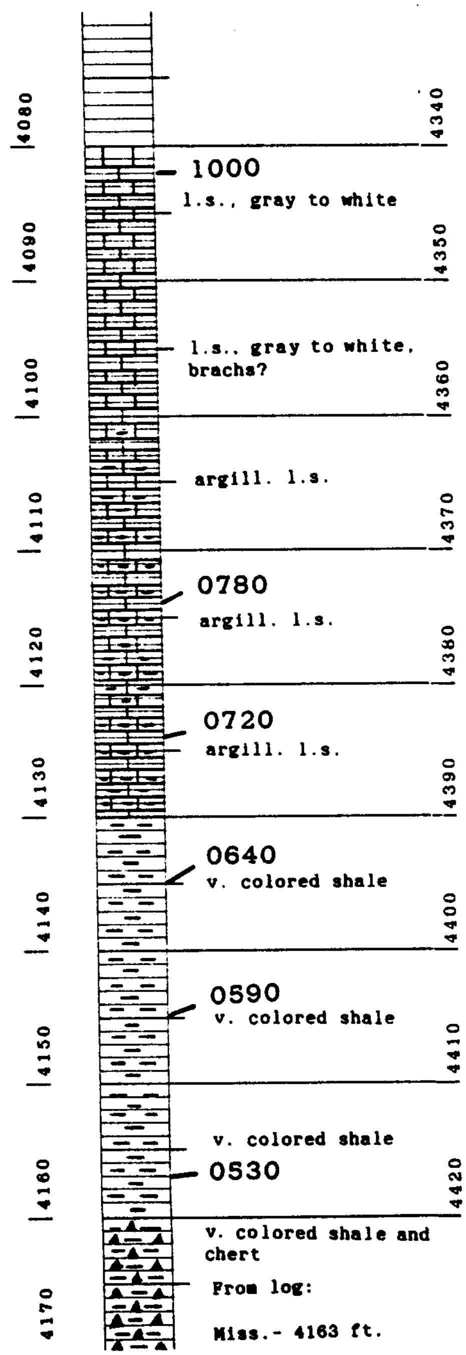
COMPLETED 12/9/77

REMARKS C-NE-SW

ELEVATION 1538 G.L.

PRODUCTION Oil/Gas

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 15

T	R
31S	9W

Magnolia Petroleum COMPANY

F. Kennedy NO 1

COMMENCED 3/6/57

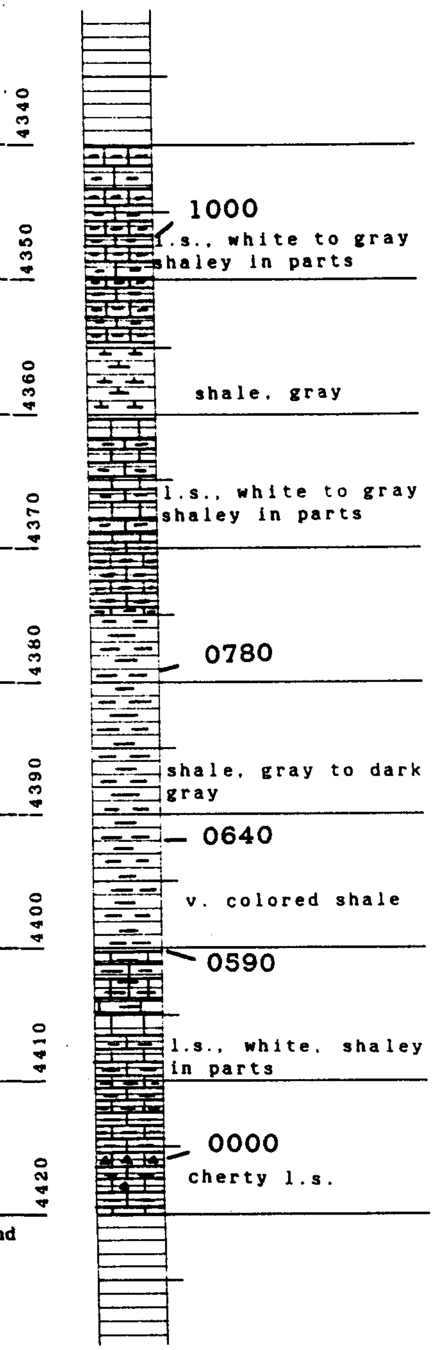
COMPLETED 4/3/57

REMARKS NE-NW-SE

ELEVATION 1657 GL

PRODUCTION Oil/Gas

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 15

T	R
31S	9W

Magnolia Petroleum COMPANY

F. Kennedy NO 1

COMMENCED 3/6/57

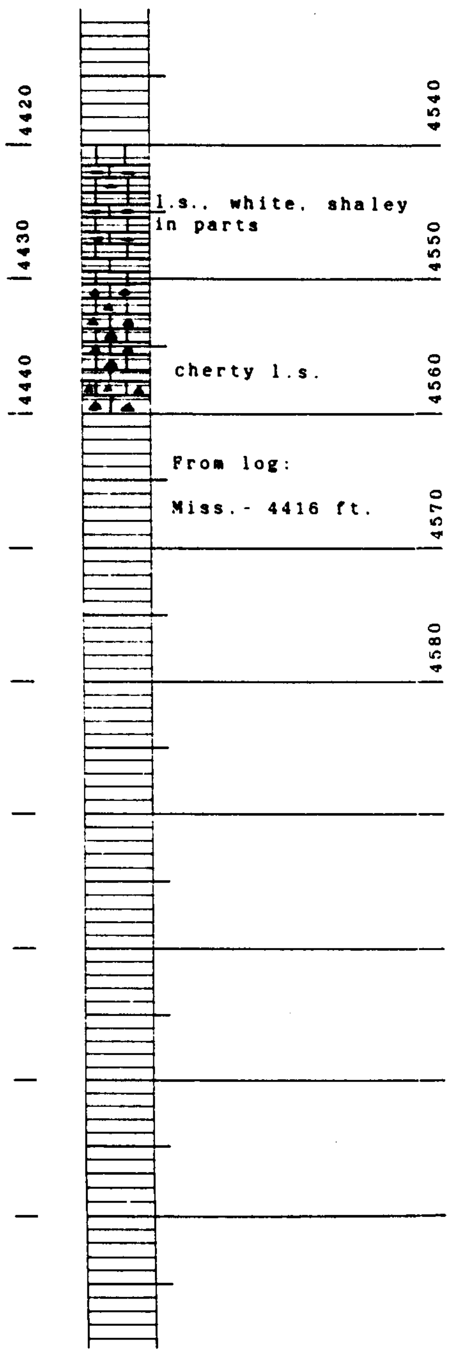
COMPLETED 4/3/57

ELEVATION 1657 GL

REMARKS NE-NW-SE

PRODUCTION Oil/Gas

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 17

T	R
33S	10W

Range Oil COMPANY

Stewart "A" NO 2

COMMENCED 9/26/81

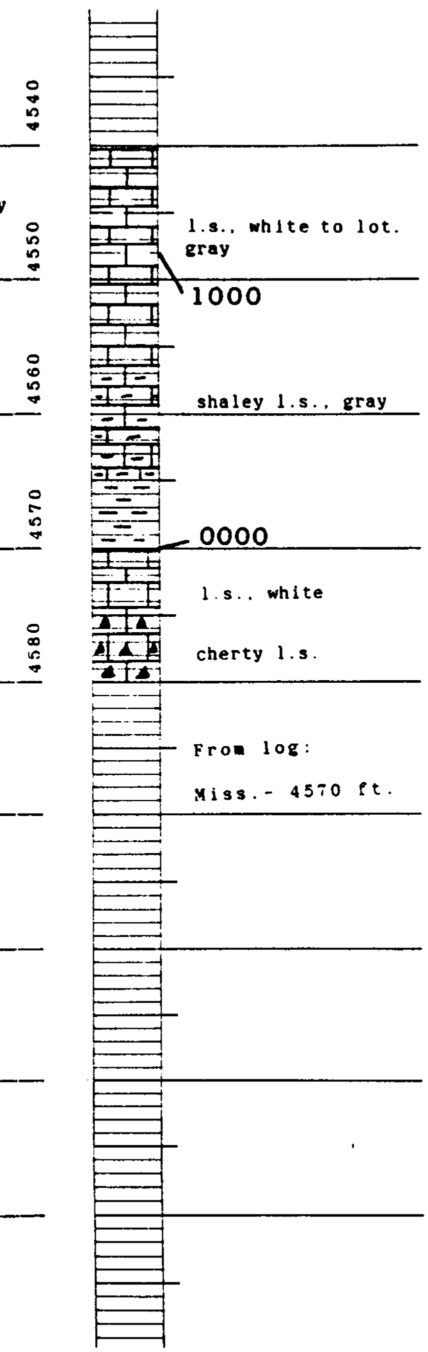
COMPLETED 1/21/82

ELEVATION 1537 GL

REMARKS C-NE-SW

PRODUCTION Oil

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 36

T 33S R 6W

National Oil COMPANY

Burgmeier NO 2

COMMENCED 1/19/78

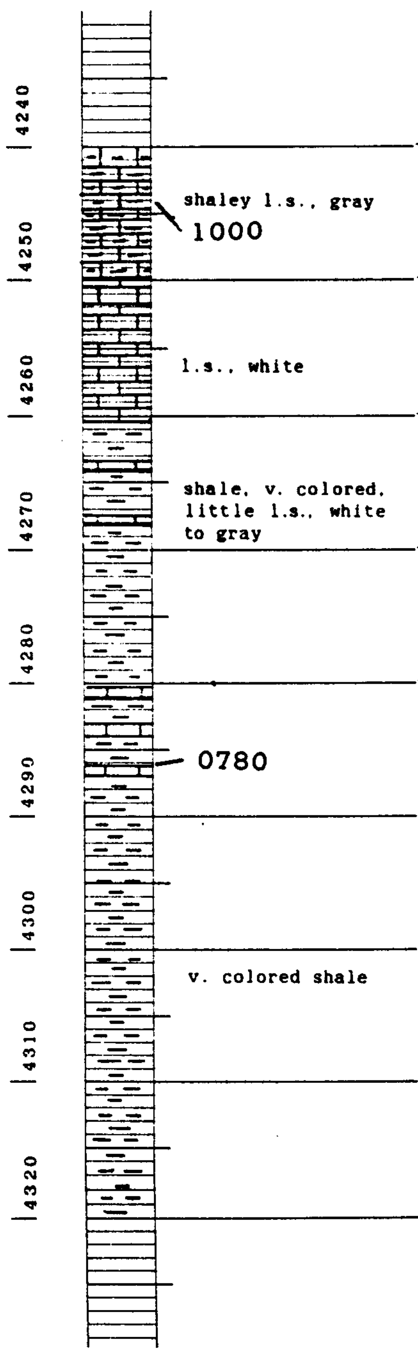
COMPLETED 4/25/78

REMARKS SW-SE-SE

ELEVATION 1258 GL

PRODUCTION Oil

416-H BOX 800 TULSA OK 74101 PRINTED IN U S A



sec. 36

T 33S R 6W

National Oil COMPANY

Burgmeier NO 2

COMMENCED 1/19/78

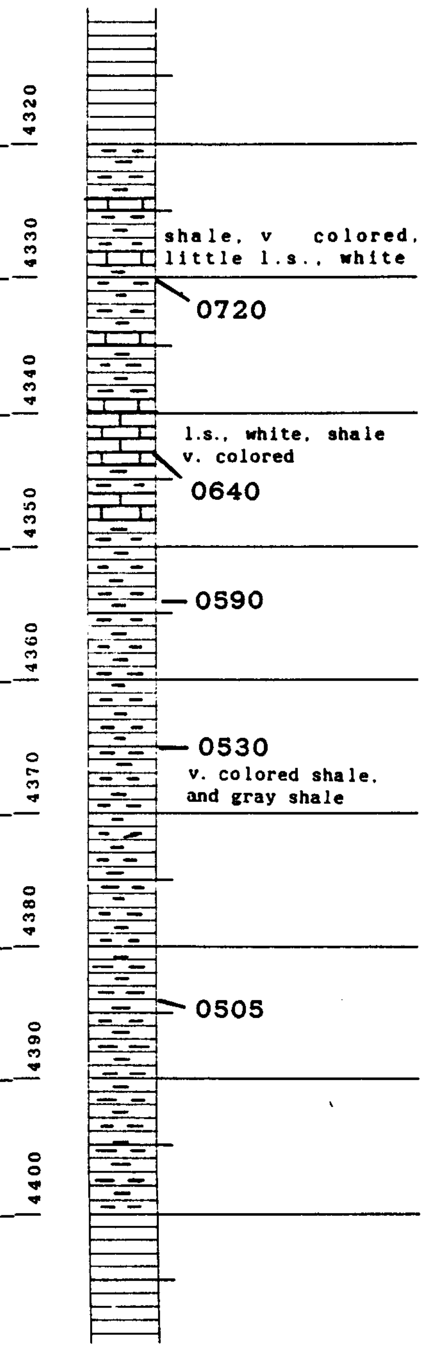
COMPLETED 4/25/78

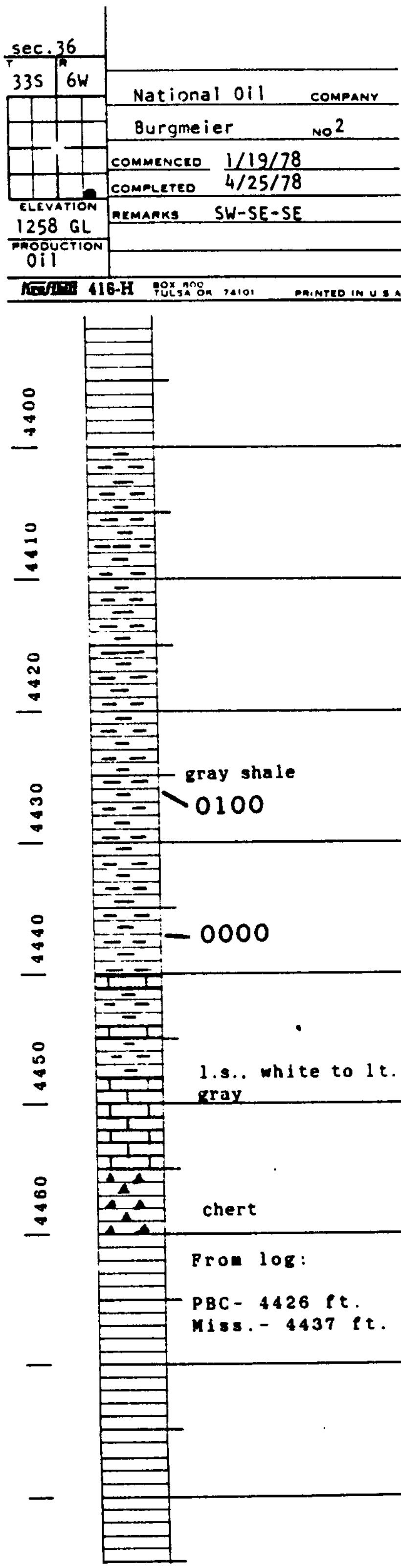
REMARKS SW-SE-SE

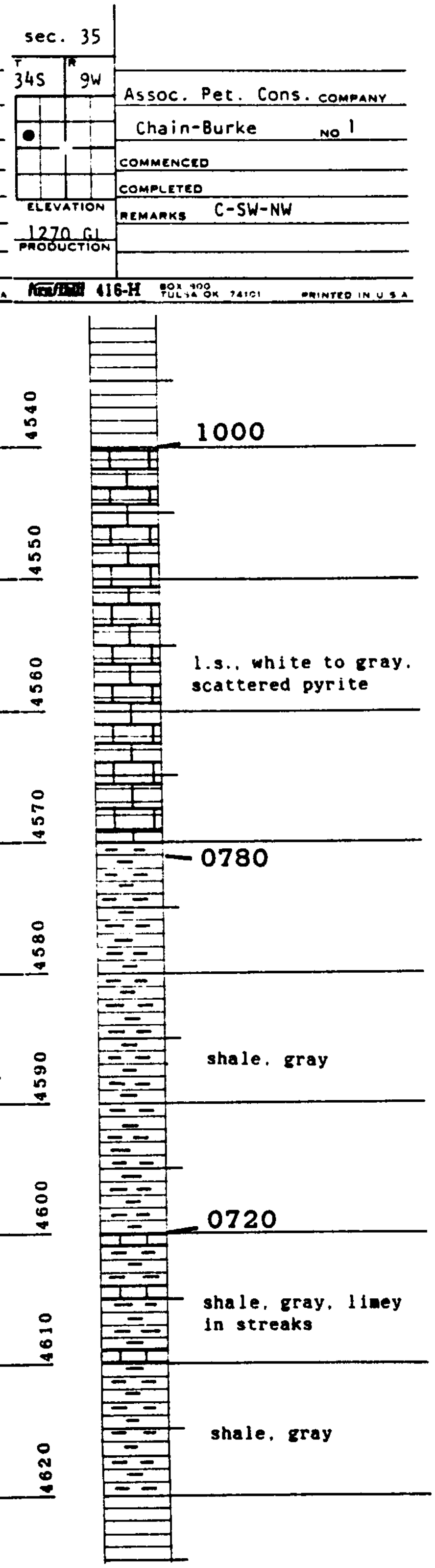
ELEVATION 1258 GL

PRODUCTION Oil

416-H BOX 800 TULSA OK 74101 PRINTED IN U S A




sec. 36
T 33S
R 6W
National Oil COMPANY
Burgmeier NO 2
COMMENCED 1/19/78
COMPLETED 4/25/78
ELEVATION
1258 GL
REMARKS SW-SE-SE
PRODUCTION
Oil
416-H
PRINTED IN U.S.A.
4400
4410
4420
4430
4440
4450
4460
gray shale
0100
0000
l.s.. white to lt. gray
chert
From log:
PBC- 4426 ft.
Miss.- 4437 ft.


sec. 35
T 34S
R 9W
Assoc. Pet. Cons. COMPANY
Chain-Burke NO 1
COMMENCED
COMPLETED
ELEVATION
1270 GL
REMARKS C-SW-NW
PRODUCTION
416-H
PRINTED IN U.S.A.
4540
4550
4560
4570
4580
4590
4600
4610
4620
1000
l.s., white to gray, scattered pyrite
0780
shale, gray
0720
shale, gray, limey in streaks
shale, gray

sec. 35

T 34S R 9W

Assoc. Pet. Cons. COMPANY

Chain-Burke NO 1

COMMENCED

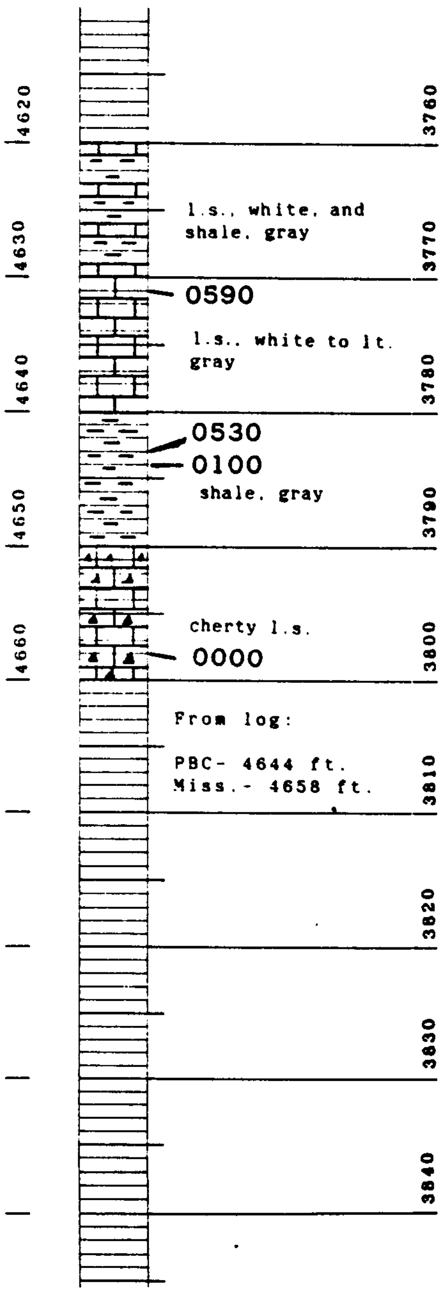
COMPLETED

ELEVATION 1270 GL

REMARKS C-SW-NW

PRODUCTION

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 4

T 35S R 1W

Cities Service COMPANY

Hagar "A" NO 1

COMMENCED 8/25/83

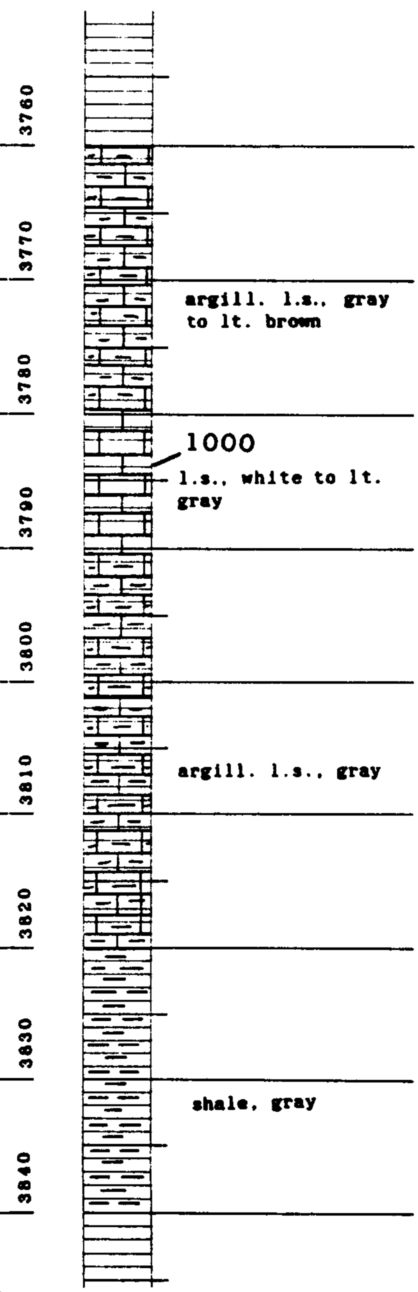
COMPLETED 9/5/83

ELEVATION 1142 GL

REMARKS E2-W2-E2

PRODUCTION D&A

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 4

T 35S | R 1W

Cities Service COMPANY

Hagar "A" NO 1

COMMENCED 8/25/83

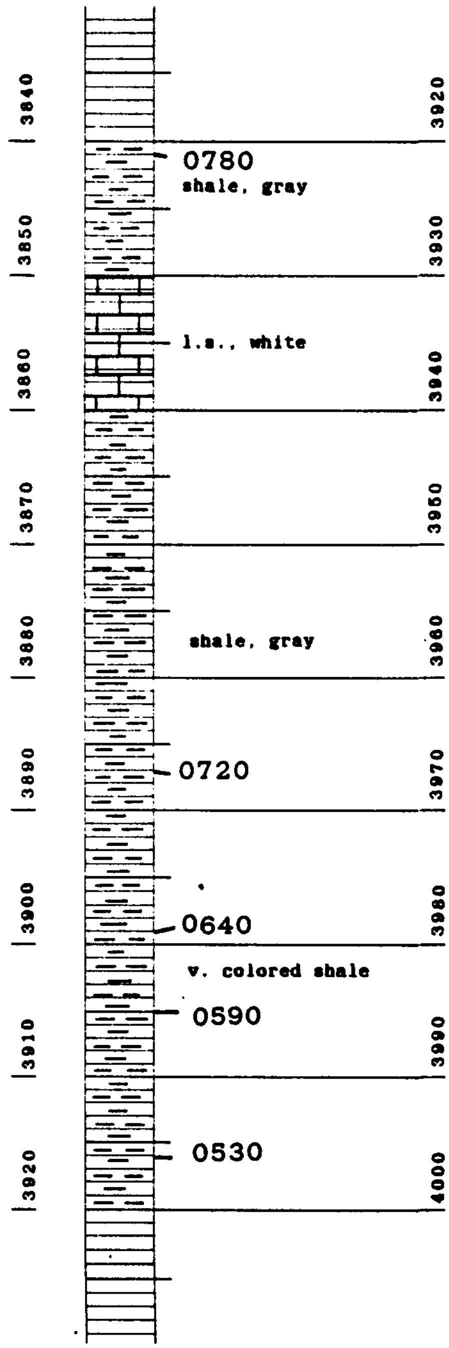
COMPLETED 9/5/83

ELEVATION 1142 GL

REMARKS E2-W2-E2

PRODUCTION D&A

416-H BOX 800 TULSA OK 74101 PRINTED IN U S A



sec. 4

T 35S | R 1W

Cities Service COMPANY

Hagar "A" NO 1

COMMENCED 8/25/83

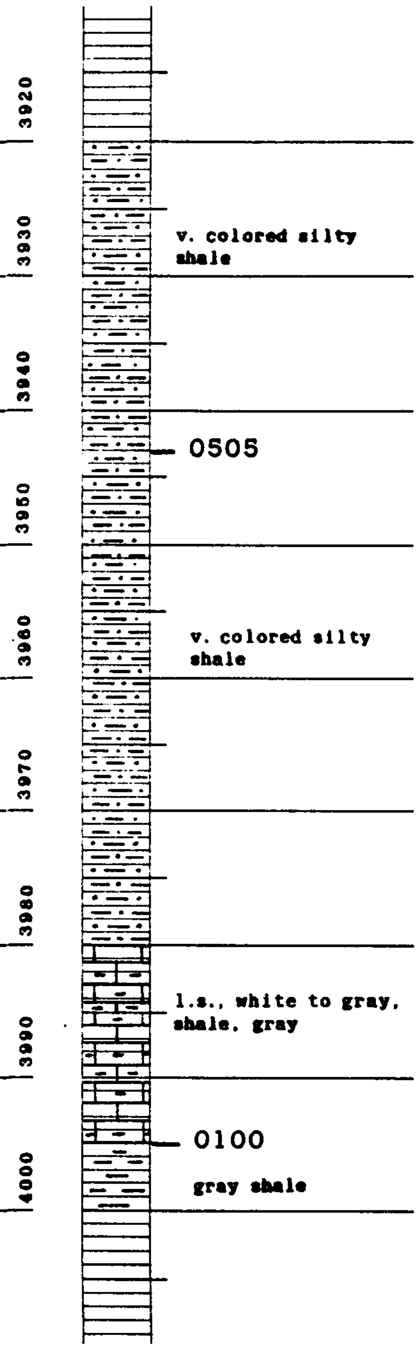
COMPLETED 9/5/83

ELEVATION 1142 GL

REMARKS E2-W2-E2

PRODUCTION D&A

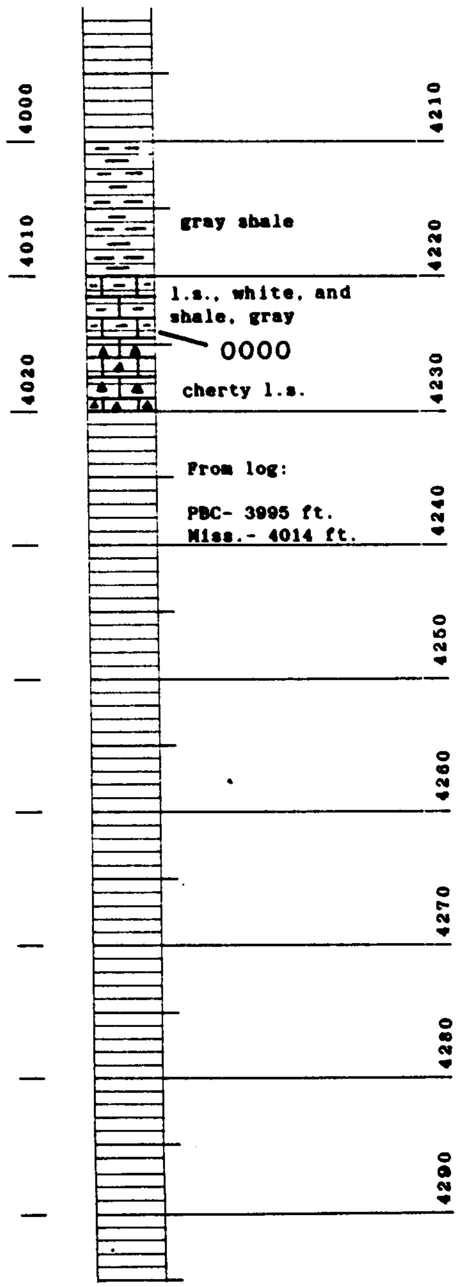
416-H BOX 800 TULSA OK 74101 PRINTED IN U S A



sec. 4
T 35S R 1W

Cities Service COMPANY
Hagar "A" NO 1
COMMENCED 8/25/83
COMPLETED 9/5/83
REMARKS E2-W2-E2
ELEVATION 1142 GL
PRODUCTION D&A

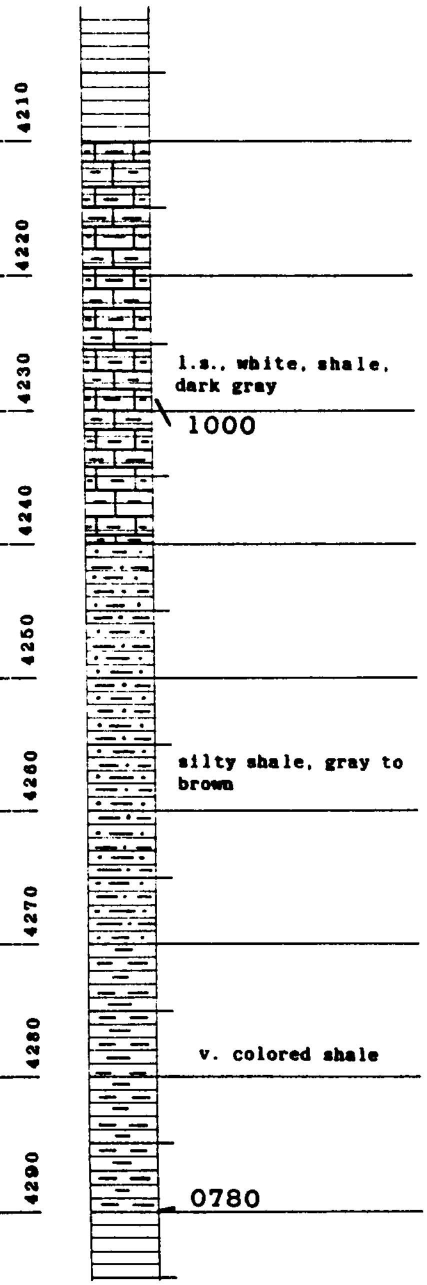
416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 12
T 35S R 4W

National & Amarex COMPANY
Moss NO 1
COMMENCED 9/23/74
COMPLETED 10/11/74
REMARKS SE-SW-SE
ELEVATION 1162 GL
PRODUCTION D&A

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



sec. 12

T 35S R 4W

National & Amarex COMPANY

Moss NO 1

COMMENCED 9/23/74

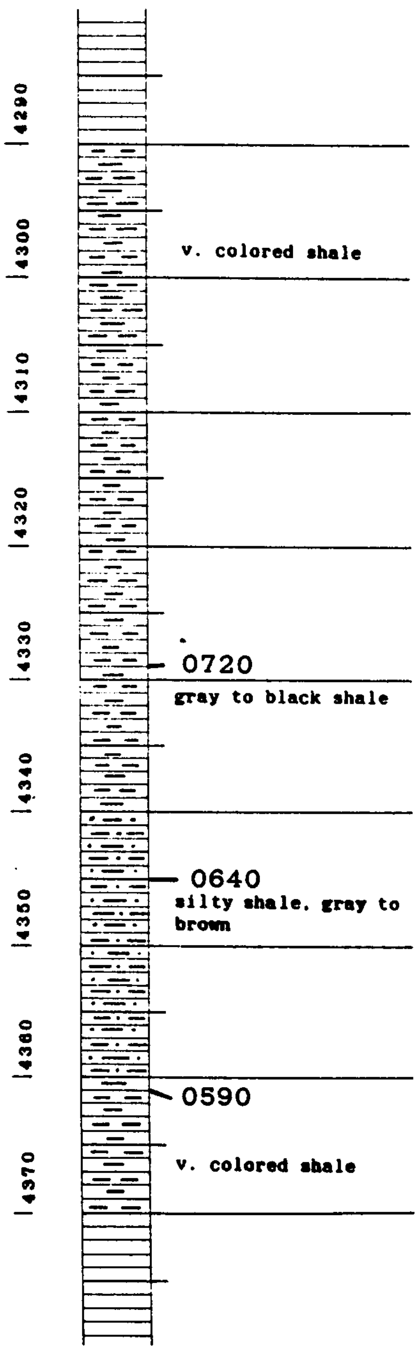
COMPLETED 10/11/74

ELEVATION 1162 GL

REMARKS SE-SW-SE

PRODUCTION D&A

416-H BOX 400 TULSA OK 74101 PRINTED IN U.S.A.



sec. 12

T 35S R 4W

National & Amarex COMPANY

Moss NO 1

COMMENCED 9/23/74

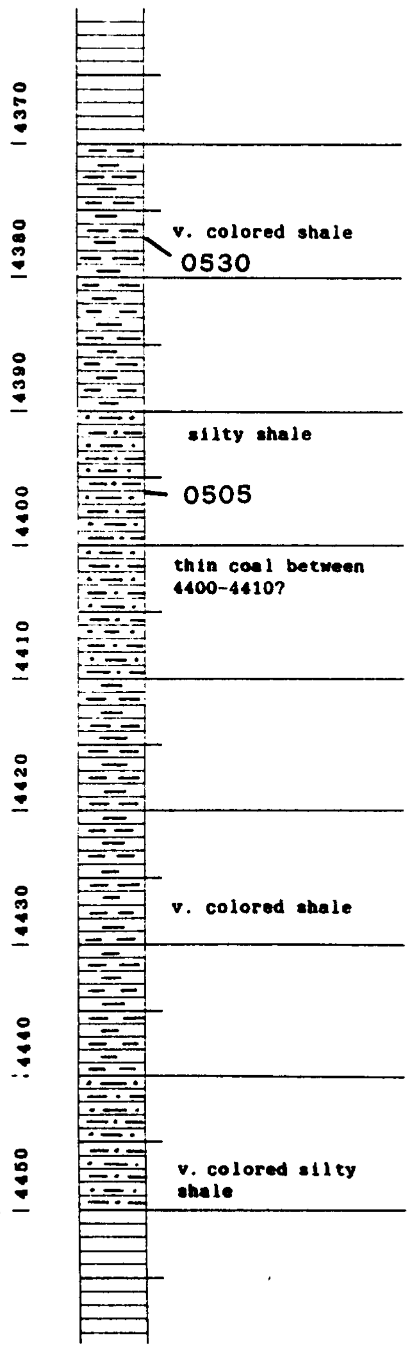
COMPLETED 10/11/74

ELEVATION 1162 GL

REMARKS SE-SW-SE

PRODUCTION D&A

416-H BOX 400 TULSA OK 74101 PRINTED IN U.S.A.



sec. 12

T 35S R 4W

National & Amarex COMPANY

Moss NO 1

COMMENCED 9/23/74

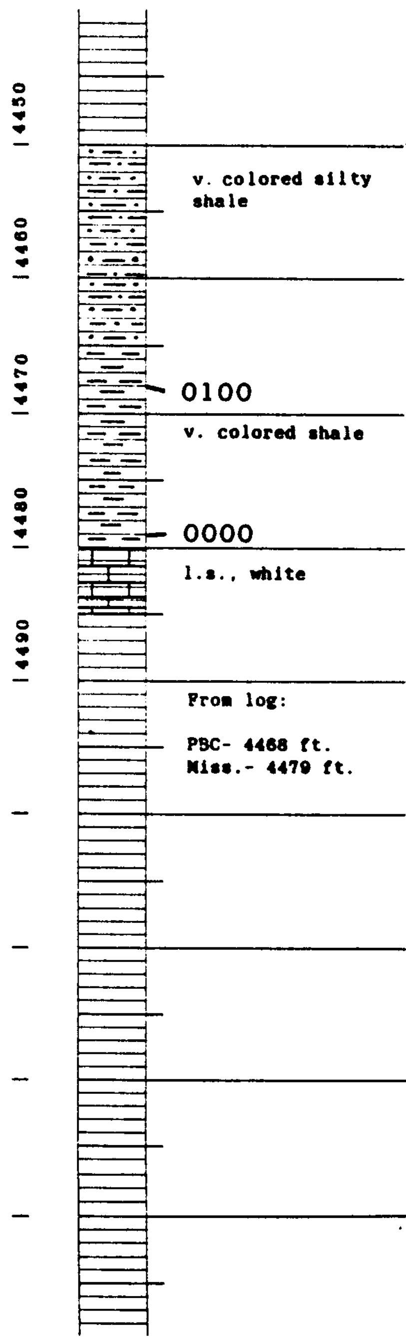
COMPLETED 10/11/74

ELEVATION 1162 GL

REMARKS SE-SW-SE

PRODUCTION D&A

416-H BOX 400 TULSA OK 74101 PRINTED IN U S A



sec. 11

T 35S R 6W

Sanders Oil COMPANY

Smith NO 1

COMMENCED 10/14/79

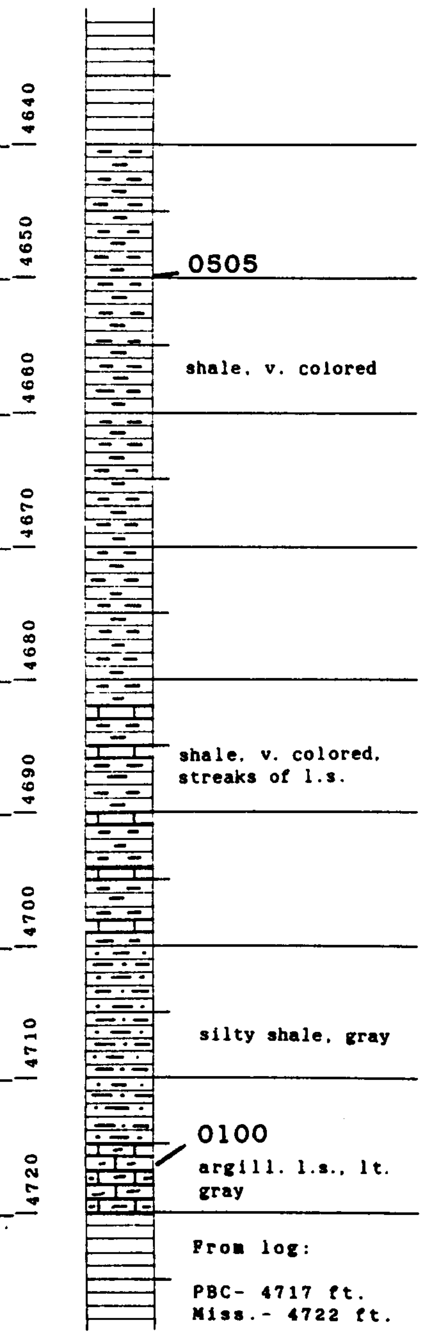
COMPLETED 10/26/79

ELEVATION 1255 GL

REMARKS C-SW-NW

PRODUCTION D&A

416-H BOX 400 TULSA OK 74101 PRINTED IN U S A



sec. 14

T 35S | R 14W

Reach Petroleum COMPANY

Snyder NO 1

COMMENCED 11/13/81

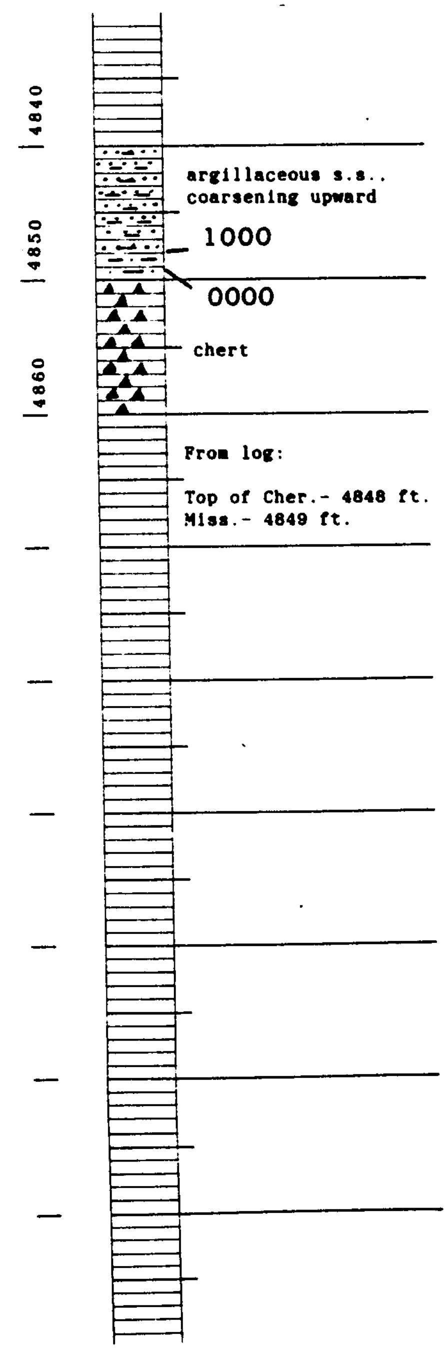
COMPLETED 11/23/81

REMARKS N2-SW-NW

ELEVATION 1491 G.L.

PRODUCTION D&A

416-H BOX 800 TULSA OK 74101 PRINTED IN U.S.A.



APPENDIX E

Cherokee Group Logs in the Sedgwick Basin*

Location	Spot	Well Name	Operator	County
2-20S-4E	SE-SE-NE	Mehl #1	Time	Marion
31-20S-3E	NE-NW-NW	Suderman A-1	Anadarko	Marion
28-20S-2E	C-SE-NE	Suderman #1	Veedeer	Marion
18-20S-1E	SE-NE-SE	#1-18 Goering	Walker	Marion
2-20S-1W	C-E2-NW	Seltzer #1	Bass	McPherson
19-20S-2W	C-NW-NE	Zerger #1	Hummon	McPherson
23-20S-3W	NW-SW-NE	J. Goering #1	Ingling	McPherson
15-20S-4W	SE-NE-SE	No. 1 Wall	American	McPherson
31-20S-5W	NE-E2-E2	Ensz #3	Edwards	McPherson
34-20S-6W	W2-W2-NE	Holderman #1	Sher-Lon	Rice
21-20S-7W	SW-SE-SE	No. 1-A Baker	Aspen	Rice
5-21S-4E	NE-SW-SW	Keirns #1	Raymond	Marion
18-21S-3E	SW-SW-SW	Good-B #9	Cities	Marion
11-21S-2E	NE-NE-NW	Litton #1	National	Marion

*Logs are in files of the Kansas Geological Survey, Lawrence, Kansas.

Location	Spot	Well Name	Operator	County
21-21S-1E	NW-SE-NE	Schmidt-X #1	Slawson	Marion
4-21S-1W	SW-SW-SE	Downey #1	Rice	McPherson
23-21S-2W	SE-SW-NE	Unruh No. 2	Ritchie	McPherson
35-21S-3W	W2-NW-SW	Goering #1	Midco	McPherson
11-21S-4W	NE-NW-SW	Weins-C #1	Pickrell	McPherson
5-21S-5W	N2-NE-SW	Peterson #1	Ash	McPherson
9-21S-6W	SE-NW-NW	Walsten-A #3	Holl	Rice
1-21S-7W	NE-NE-NE	Brothers #5	Holl	Rice
22-21S-8W	C-NE-NE	#1 Gore	Hummon	Rice

11-22S-4E	NE-SW-SE	Schmidt #1	Range	Marion
16-22S-3E	SE-SE-NW	#1 Litton	Leben	Marion
26-22S-2E	NE-SW-NE	Klassen #1	National	Harvey
11-22S-1E	SW-SE-SW	Wyckoff #1	Time	Harvey
18-22S-1W	SE-NE-SE	#1-18 Nelson	Walker	Harvey
3-22S-2W	NE-NE-SE	Krehbiel #1	Barnett	Harvey
21-22S-3W	NW-NE-SE	Schrag #1	Sanders	Harvey
7-22S-4W	N2-SE-SW	J. Lewis #1	Pendleton	Reno
12-22S-5W	C-SW-NE	Bontrager #1	Jantz	Reno
34-22S-6W	NE-SE-NE	Nelson #1	Pet. Mngmt.	Reno
34-22S-7W	SE-SE-SE	Griffen #1	Trans Am.	Reno
19-22S-8W	C-NW-SW	Rupp #1	Eagle	Reno

Location	Spot	Well Name	Operator	County
1-23S-3E	NE-NW-SE	Young No. 3	Ritchie	Butler
14-23S-2E	SW-SW-SW	Reiger No. 1	McJilton	Harvey
3-23S-1E	SE-SW-SW	Sauder #1	Bay	Harvey
20-23S-1W	C-W2-SE	#1 Ortman	Bass	Harvey
10-23S-2W	SW-NW-NE	Will No. 1	Anderson	Harvey
4-23S-3W	N2-NW-NE	#1-C Sizemore	F & B	Harvey
12-23S-4W	NE-SW-NE	Teten #10	S & K	Reno
26-23S-5W	NE-SW-SE	Brawner #1	National	Reno
22-23S-6W	SW-SW-SW	Hamilton #1	Cities	Reno
19-23S-7W	C-NE-SW	McArthur #1	Sanders	Reno
14-23S-8W	C-NW-NW	Evarts #1	Wofford	Reno
14-23S-9W	C-NW-SE	Norquist #1	Century	Reno
12-23S-10W	C-SE-NE	Heylmum-E #1	Cities	Reno

14-24S-4E	SW-NE-NE	Voth #2	K & L	Butler
35-24S-3E	NW-SE-SW	# 1 Toews-A	Ainsworth	Butler
11-24S-2E	W2-W2-NW	Ulmer-B #2	Slawson	Harvey
27-24S-1E	SW-SE-NW	#1 Kurr	Lit. George	Harvey
26-24S-1W	C-SE-SE	Chavez #1	Adair	Harvey
5-24S-2W	C-SW-NE	#1 Krehbiel	Darrah	Harvey
1-24S-3W	SW-SE-SW	Wendling #1	National	Harvey
3-24S-4W	W2-NE-SW	Matlack #7	S & K	Reno

Location	Spot	Well Name	Operator	County
27-24S-5W	SW-NE-NE	Schrock #1	Oil Prop.	Reno
6-24S-6W	NW-NW-SE	Benton #1	Osage	Reno
17-24S-7W	NW-NW-NW	Eisiminger #1	Ram	Reno
5-24S-8W	C-NW-NW	Gagnebin #1	Denver	Reno
33-24S-9W	C-NW-SE	Redd #1	Everly	Reno
31-24S-10W	NE-NW-SW	Brownlee #2	Demeir	Reno
6-25S-4E	SE-SE-NW	Jacobs #5	Dbl. Eagle	Butler
24-25S-3E	S2-SE-SW	#3 Wilson-B	Range	Butler
3-25S-2E	NE-SW-NE	Sanders No. 5	Brown	Sedgwick
16-25S-1E	SW-SW-NE	Black-A No. 2	Cities	Sedgwick
36-25S-1W	S2-S2-SE	#1 Royal	Catron	Sedgwick
24-25S-2W	W2-E2-NE	Flowers #1	Vincent	Sedgwick
10-25S-3W	NW-NE-NE	Jorgenson #1	Rupp-Sincl.	Sedgwick
34-25S-4W	W2-SW-NW	Newby #1	Africo	Reno
18-25S-5W	C-SE-SE	Krehbiel #1	Aurora	Reno
10-25S-6W	C-SE-SE	Smythe #1	F & M	Reno
18-25S-7W	SE-SE-NE	Trembley #1	Thunderbird	Reno
23-25S-8W	C-SE-NE	#1 Krehbiel	Okmar	Reno
26-25S-9W	SE-SE-SE	McAtee No. 1	El Dorado	Reno
12-25S-10W	N2-NE-NW	Morris No. 1	Schmrhn.	Reno

Location	Spot	Well Name	Operator	County
2-26S-4E	NE-NW-SW	Paulson #1	Newman	Butler
18-26S-3E	SW-SW-SW	Lygrisse #1	Giles	Butler
11-26S-2E	SE-SE-SW	Mitchell #2	Vincent	Sedgwick
6-26S-1E	C-NE	T. Kamp #2	Eagle	Sedgwick
1-26S-1W	N2-NW-NW	Schnitzler #3	Lachenmayr	Sedgwick
13-26S-2W	SW-SW-SE	M. Weninger #1	Euwer	Sedgwick
3-26S-3W	C-SW-SE	No. 1 Winters	Taylor	Sedgwick
10-26S-4W	S2-NE-NW	Hefling #2	Raymond	Reno
31-26S-5W	C-NW-NE	White #1	Brad's Pet.	Reno
2-26S-6W	C-SE-SE	Graber #1	Ritchie	Reno
31-26S-7W	C-SE-NW	Bruch-E #1	Pickrell	Reno
9-26S-8W	C-SW-SE	#1 Cole-B	Bankoff	Reno
13-26S-9W	C-SE	Snell #1	Inger	Reno
21-26S-10W	NW-NW-SW	Hayes No. 1	Bennett	Reno
1-26S-11W	SW-SW-NE	Slater No.1	Deep Rock	Pratt

3-27S-2E	C-NE-NE	Woods #1	Providence	Sedgwick
3-27S-1E	NE-NW-NE	Jade Unit-B #2	Kewanee	Sedgwick
5-27S-1W	NW-NW-NE	Donell #1	Allison	Sedgwick
13-27S-2W	S2-NE-SE	Miller No. 1	Abercrombie	Sedgwick
14-27S-3W	NE-NE-NE	Klausmeyer #1	Aurora	Sedgwick
25-27S-4W	SW-SW-SW	Asendorf #1	Lion	Sedgwick

Location	Spot	Well Name	Operator	County
25-27S-5W	NE-SE-NE	Busch #1	Starland	Kingman
23-27S-6W	S2-SW-NE	Zercha No. 1	Berexco	Kingman
21-27S-7W	SW-NW-NE	Wooldridge #1	Kathol	Kingman
35-27S-8W	N2-NW-SW	#2 M. Arnold	Pub. Pet.	Kingman
20-27S-9W	C-NE-SW	Boswell #1	Bander	Kingman
16-27S-10W	C-SE-NE	Shepherd No. 1	Patton	Kingman
12-27S-11W	C-NW-SE	#1 Conley	Hummon	Pratt
12-28S-2E	SE-SW-SE	R.G. Gribble	Ash	Sedgwick
20-28S-1E	SW-NW-NE	M.A. Brown #4	Pan-Am	Sedgwick
19-28S-1W	S2-S2-NE	Neises #1	Shaffer	Sedgwick
11-28S-2W	W2-NE-NW	Stringer #1	Gear	Sedgwick
6-28S-3W	NE-NE-SW	Peutz #1	Sutton	Sedgwick
15-28S-4W	C-SE-SE	Spurrier #1	Mull	Sedgwick
14-28S-5W	SW-SW-NE	No. 1 Hilltop	Graves	Kingman
12-28S-6W	C-NE-SE	Clouse #1	Gear	Kingman
25-28S-7W	C-NE-SE	#1 Reida	Mall.-Mah.	Kingman
25-28S-8W	C-NE	Bock #1	Walcher	Kingman
17-28S-9W	C-SW-SE	Allbritton #1	National	Kingman
19-28S-10W	SW-SW-SW	Zrubek #1-19	Kimbark	Kingman

Location	Spot	Well Name	Operator	County
17-29S-2E	NW-SW-NE	Donaldson #1	Unnamed	Sedgwick
33-29S-1E	E2-SW-NW	Butts #1	Sho-Bar	Sedgwick
9-29S-1W	C-SE-SE	Upl Strunk #1	Ultramar	Sedgwick
32-29S-2W	C-SW-SE	Eagan #1	Pan Western	Sedgwick
26-29S-3W	SW-SW-NW	#1 Pauly	Canaday	Sedgwick
15-29S-4W	C-SE-NE	Gregroy #1-15	Mohawk	Sedgwick
5-29S-5W	SW-NE-SW	Kinkaid #1	Keener	Kingman
3-29S-6W	SW-NE-SW	Calkin #3	Cambell	Kingman
1-29S-7W	C-SE-NW	Shrag-L #1	Pickrell	Kingman
15-29S-8W	C-NE-SW	Voran #1	Beech Air	Kingman
2-29S-9W	SW-SW-SW	J. Govert #1	Lit. George	Kingman
21-29S-10W	SE-NW-SE	#1 Simon	National	Kingman
15-29S-11W	SW-SW-SE	Blkwldr. #1-15	Holl	Pratt

17-30S-2E	NE-NE-SW	Young #1-17	Gunzelman	Sumner
4-30S-1E	NE-NW-SW	Lockert-A #2	Slawson	Sumner
11-30S-1W	SE-NW-NW	Weston-A #1	Slawson	Sumner
30-30S-2W	C-SW-NW	#1 Hartman	National	Sumner
16-30S-3W	C-NW-NE	Wolfe #16-2	Oxford	Sumner
26-30S-4W	SW-SW-NE	#1 Hemberger	Kan-Go	Sumner
5-30S-5W	SE-SW-SE	Kimberlen #1	Rns.-Wlmsn.	Kingman
3-30S-6W	NW-NW-NW	Risley #1	Lochiel	Kingman

Location	Spot	Well Name	Operator	County
4-30S-7W	C-NE-SE	No. 2 Early	McCoy	Kingman
6-30S-8W	C-NE-SW	Whitmer-C #1	McCoy	Kingman
2-30S-9W	NE-NW-NE	Whitmer #1	Ram	Kingman
10-30S-10W	C-NE-SW	Sheperd #1	Mack	Kingman
25-30S-11W	NW-SE-NE	Westerman #1	Edmiston	Barber
1-30S-12W	C-SW-NW	Knop #1	Beacon	Barber

26-31S-2E	E2-SE-NW	Evers No. 1	Brnt.-Clk.	Sumner
22-31S-1E	C-SW-NW	Nugen No. 1	Cities	Sumner
25-31S-1W	SW-SW-NE	Stewart #1	Edmiston	Sumner
5-31S-2W	C-SW-SE	No.1 Harry	Mack	Sumner
24-31S-3W	NE-NW-SE	Duff #1	Raymond	Sumner
24-31S-4W	SE-NW-NW	Cole #3	Imperial	Sumner
1-31S-5W	C-NW-SW	Simmons #1	Mull	Harper
17-31S-6W	NW-SE-SW	Gish #3	Hummon	Harper
6-31S-7W	S2-N2-NE	Hunter #1	Reach	Harper
10-31S-8W	S2-SW-SE	Muir-A #1	McCoy	Harper
15-31S-9W	NE-NW-SE	F. Kennedy #1	Magnolia	Harper
32-31S-10W	C-E2	Hanchett #1	Jones	Barber
28-31S-11W	NE-NW-SE	Stephenson #1	F & M	Barber

Location	Spot	Well Name	Operator	County
34-32S-2E	SW-NE-NE	Nofsinger #3	Crest	Sumner
20-32S-1E	NE-NW-NE	Weber #20-21	Oxford	Sumner
8-32S-1W	S2-N2-NE	Huff #2	Hummon	Sumner
5-32S-2W	SE-SW-NW	Hill #3	Indian	Sumner
30-32S-3W	SE-NE-NW	Hartman #2	Hummon	Sumner
12-32S-4W	C-SW-SE	Bruce #1	Hummon	Sumner
18-32S-5W	SE-SE-NW	Hallman #2	Robinson	Harper
9-32S-6W	SE-SE-NW	Phye #1	Moore	Harper
17-32S-7W	NE-NE-SW	#1 Boyt's-A	F & M	Harper
8-32S-8W	C-SE-NW	Hadsall #1	Patton	Harper
6-32S-9W	C-NE-SE	#1 Hogard-B	Pickrell	Harper
29-32S-10W	W2-SW-NE	Goemann #4	Molz	Barber
4-32S-11W	C-NE-SE	Davenport #1	F & M	Barber
12-32S-12W	N2-NW-SE	De Weese #1	Graves	Barber
19-33S-2E	N2-NE-NE	#1 SW College	Kansas Oil	Sumner
5-33S-1E	SW-NW-NE	Barnes #2	Aladdin	Sumner
6-33S-1W	W2-SE-SE	Allen #1	Beren	Sumner
32-33S-2W	C-NW-SW	Builta A-1	Anadarko	Sumner
18-33S-3W	C-W2-NE	Small #3	Hummon	Sumner
5-33S-4W	C-SW-NE	Tracy #1	Beren	Sumner
27-33S-5W	SW-NE-NE	#1 R. Rump	Midco	Harper

Location	Spot	Well Name	Operator	County
36-33S-6W	SW-SE-SE	Burgmeier #2	National	Harper
12-33S-7W	C-NE-NW	Hayter A-1	Anadarko	Harper
25-33S-8W	C-NE-NW	Norman #1-A	McCoy	Harper
36-33S-9W	E2-SE-NE	Stejskal #1	Wht.-Ellis	Harper
17-33S-10W	C-NE-SW	Stewart-A #2	Range	Barber
16-33S-11W	NW-NW-SW	Newkirk #7	Sinclair	Barber
11-33S-12W	SE-NE-NE	#1 Bower	Okmar	Barber
34-33S-13W	C-N2-NW	Holmes-C#1	TXO	Barber

4-34S-2E	E2-W2-SE	2E No. 1	Opulent	Sumner
15-34S-1E	C-SW-NW	No. 1 Wolf	Tom Kat	Sumner
6-34S-1W	SW-SE-NE	W. Johnson #1	MacKeller	Sumner
6-34S-2W	NW-SE-SE	Ogden #1	Herndon	Sumner
34-34S-3W	E2-W2-NE	Schmidt #1	Pendleton	Sumner
6-34S-4W	N2-SW-NE	Netahla	Mack RG	Sumner
5-34S-5W	C-SW-NE	Equity #1	Int. Hydcb.	Harper
16-34S-6W	E2-E2-NE	Robb #1	Pet. Cnslt.	Harper
23-34S-7W	C-SW-NE	Orr No. 1	McCoy	Harper
2-34S-8W	C-NE-SW	#1 D-Gates	McCoy	Harper
35-34S-9W	C-SW-NW	Chain-Burke #1	Pet. Cnslt.	Harper
13-34S-10W	C-SW-NE	Betty #1	Juniper	Barber
19-34S-11W	C-SE-SW	Ftzgrld. #B-1	Cities	Barber

Location	Spot	Well Name	Operator	County
27-34S-12W	NE-NE-SE	Sterling #2	McGinness	Barber
36-34S-13W	SW-NE-NE	Sterling-D #1	Atlantic	Barber
12-34S-14W	SW-SE-SE	Birdie #12-15	DLB Energy	Barber

18-35S-1E	NW-NE-SE	#1 Houdek	Wheatland	Sumner
4-35S-1W	E2-W2-E2	Hagar-A #1	Cities	Sumner
3-35S-2W	SE-NE-SE	Unruh #1	MacKeller	Sumner
8-35S-3W	NE-SE-SE	Seltzer #1	Mid-Contnt.	Sumner
12-35S-4W	SE-SW-SE	#1 Moss	National	Sumner
17-35S-5W	N2-NW-SW	Bush #1	Texaco	Harper
11-35S-6W	C-SW-NW	Smith #1	Sanders	Harper
12-35S-7W	C-SW-SW	K. Meyer #1	National	Harper
10-35S-8W	SW-SW-SW	Zellers No. 1	Aurora	Harper
4-35S-9W	C-NE-NW	Burke-A #1	Anadarko	Harper
10-35S-10W	NW-NW-NE	Gudeman #1	Aurora	Barber
7-35S-11W	C-NW-NW	Platt-A #1	Molz	Barber
14-35S-12W	N2-SW-NE	Petermann #4	K & O	Barber
11-35S-13W	N2-N2-NE	Achenbach #5-A	Okmar	Barber
14-35S-14W	C-E2-NW	Snyder #1	Reach	Barber

APPENDIX F

Well Logs used to construct Cross Sections

Cross Section A-A'

Location	Spot	Well Name	Operator	County
34-29S-24E	NW-NE-NW	N	KGS	Crawford
8-30S-24E	NW-NW-NW	V	KGS	Crawford
32-30S-23E	SW-SW-SW	GG	KGS	Crawford
3-31S-21E	C-SW-SW	McGown #8	Hickory	Labette
22-31S-20E	C-C-SW	Ks. Ord #1	USGS & KGS	Labette
29-31S-18E	C-SW-NE	Myers #1	Ringard	Labette
28-31S-17E	C-C-NE	Driskel #5	R.C. Oil	Montgomery
23-31S-16E	NE-SE-SE	Suzy #1	Heritage	Montgomery
20-31S-15E	C-C-SE	Sherwin #1-B	Benson	Montgomery
27-32S-14E	C-SW-SE	Vaughn #1-17	Benson	Montgomery
3-32S-12E	NE-NW-NW	Donahoe #5	Union Gas	Chautauqua
19-32S-11E	NE-NE-SE	Knox-A #2	Black Star	Chautauqua
24-31S-10E	SW-SW-SE	Morgan #3	Durbin	Elk
14-31S-9E	NE-NE-NE	Loyd #1	Griggs	Elk
16-31S-8E	NW-NE-SE	Bannon #1	Stelbar	Cowley

Cross Section B-B'

Location	Spot	Well Name	Operator	County
17-31S-7E	C-NW-NE	Alyward #2	Alyward	Cowley
5-31S-6E	C-C-C	Sphar-A #1	Martin Oil	Cowley
17-31S-5E	C-C-SW	Jarvis-E #1	Range Oil	Cowley
15-31S-4E	SE-NE-SW	Watt #1	Teichgrbr.	Cowley
29-31S-3E	C-NE-NE	Abel #1	Sanders	Cowley
26-31S-2E	E2-SE-NW	Evers No. 1	Brnt.-Clk.	Sumner
22-31S-1E	C-SW-NW	Nugen No. 1	Cities	Sumner
25-31S-1W	SW-SW-NE	Stewart #1	Edmiston	Sumner
5-31S-2W	C-SW-SE	No.1 Harry	Mack	Sumner
24-31S-3W	NE-NW-SE	Duff #1	Raymond	Sumner
24-31S-4W	SE-NW-NW	Cole #3	Imperial	Sumner

Cross Section C-C'

1-31S-5W	C-NW-SW	Simmons #1	Mull	Harper
17-31S-6W	NW-SE-SW	Gish #3	Hummon	Harper
6-31S-7W	S2-N2-NE	Hunter #1	Reach	Harper
10-31S-8W	S2-SW-SE	Muir-A #1	McCoy	Harper
15-31S-9W	NE-NW-SE	F. Kennedy #1	Magnolia	Harper
32-31S-10W	C-C-E2	Hanchett #1	Jones	Barber
28-31S-11W	NE-NW-SE	Stephenson #1	F & M	Barber

Cross Section D-D'

Location	Spot	Well Name	Operator	County
10-25S-3W	NW-NE-NE	Jorgenson #1	Rupp-Sinc.	Sedgwick
3-26S-3W	C-SW-SE	#1 Winters	Taylor	Sedgwick
14-27S-3W	NE-NE-NE	Klausmeyer #1	Aurora	Sedgwick
6-28S-3W	NE-NE-SW	Peutz #1	Sutton	Sedgwick
26-29S-3W	SW-SW-NW	#1 Pauly	Canaday	Sedgwick
16-30S-3W	C-NW-NE	Wolfe #16-2	Oxford	Sumner
24-31S-3W	NE-NW-SE	Duff #1	Raymond	Sumner
30-32S-3W	SE-NE-NW	Hartman #2	Hummon	Sumner
18-33S-3W	C-W2-NE	Small #3	Hummon	Sumner
34-34S-3W	E2-W2-NE	Schmidt #1	Pendleton	Sumner
8-35S-3W	NE-SE-SE	Seltzer	Mid-Cont.	Sumner

Cross Section E-E'

23-20S-3W	NW-SW-NE	Goering #1	Ingling	McPherson
35-21S-3W	W2-NW-SW	Goering #1	Midco	McPherson
21-22S-3W	NW-NE-SE	Schrag #1	Sanders	Harvey
4-23S-3W	N2-NW-NE	#1-C Sizemore	F & B	Harvey
1-24S-3W	SW-SE-SW	Wendling #1	National	Harvey

Cross Section F-F'

6-25S-4E	SE-SE-NW	Jacobs #5	Dbl. Eagle	Butler
24-25S-3E	S2-SE-SW	#3 Wilson-B	Range	Butler

Location	Spot	Well Name	Operator	County
3-25S-2E	NE-SW-NE	Sanders No. 5	Brown	Sedgwick
16-25S-1E	SW-SW-NE	Black-A No. 2	Cities	Sedgwick
36-25S-1W	S2-S2-SE	#1 Royal	Catron	Sedgwick
24-25S-2W	W2-E2-NE	Flowers #1	Vincent	Sedgwick
10-25S-3W	NW-NE-NE	Jorgenson #1	Rupp-Sincl.	Sedgwick
34-25S-4W	W2-SW-NW	Newby #1	Africo	Reno
18-25S-5W	C-SE-SE	Krehbiel #1	Aurora	Reno
10-25S-6W	C-SE-SE	Smythe #1	F & M	Reno
18-25S-7W	SE-SE-NE	Trembley #1	Thunderbird	Reno
23-25S-8W	C-SE-NE	#1 Krehbiel	Okmar	Reno
26-25S-9W	SE-SE-SE	McAtee No. 1	El Dorado	Reno
12-25S-10W	N2-NE-NW	Morris No. 1	Schmrhn.	Reno

Cross Section G-G'

2-20S-4E	SE-SE-NE	Mehl #1	Time	Marion
31-20S-3E	NE-NW-NW	Suderman A-1	Anadarko	Marion
28-20S-2E	C-SE-NE	Suderman #1	Veedeer	Marion
18-20S-1E	SE-NE-SE	#1-18 Goering	Walker	Marion
2-20S-1W	C-E2-NW	Seltzer #1	Bass	McPherson
19-20S-2W	C-NW-NE	Zerger #1	Hummon	McPherson
23-20S-3W	NW-SW-NE	J. Goering #1	Ingling	McPherson
15-20S-4W	SE-NE-SE	No. 1 Wall	American	McPherson

Location	Spot	Well Name	Operator	County
31-20S-5W	NE-E2-E2	Ensz #3	Edwards	McPherson
34-20S-6W	W2-W2-NE	Holderman #1	Sher-Lon	Rice
21-20S-7W	SW-SE-SE	No. 1-A Baker	Aspen	Rice

Cross Section H-H'

4-34S-2E	E2-W2-SE	2E No. 1	Opulent	Sumner
15-34S-1E	C-SW-NW	No. 1 Wolf	Tom Kat	Sumner
6-34S-1W	SW-SE-NE	W. Johnson #1	MacKeller	Sumner
6-34S-2W	NW-SE-SE	Ogden #1	Herndon	Sumner
34-34S-3W	E2-W2-NE	Schmidt #1	Pendleton	Sumner
6-34S-4W	N2-SW-NE	Netahla	Mack RG	Sumner
5-34S-5W	C-SW-NE	Equity #1	Int. Hydcb.	Harper
16-34S-6W	E2-E2-NE	Robb #1	Pet. Cnslt.	Harper
23-34S-7W	C-SW-NE	Orr No. 1	McCoy	Harper
2-34S-8W	C-NE-SW	#1 D-Gates	McCoy	Harper
35-34S-9W	C-SW-NW	Chain-Burke #1	Pet. Cnslt.	Harper
13-34S-10W	C-SW-NE	Betty #1	Juniper	Barber
19-34S-11W	C-SE-SW	Ftzgrld. #B-1	Cities	Barber
27-34S-12W	NE-NE-SE	Sterling #2	McGinness	Barber
36-34S-13W	SW-NE-NE	Sterling-D #1	Atlantic	Barber

Cross Section I-I'

Location	Spot	Well Name	Operator	County
31-20S-3E	NE-NW-NW	Suderman A-1	Anadarko	Marion
18-21S-3E	SW-SW-SW	Good-B #9	Cities	Marion
16-22S-3E	SE-SE-NW	#1 Litton	Leben	Marion
14-23S-2E	SW-SW-SW	Reiger #1	McJilton	Harvey
11-24S-2E	W2-W2-NW	Ulmer-B #2	Slawson	Harvey
3-25S-2E	NE-SW-NE	Sanders #5	M. Brown	Sedgwick
11-26S-2E	SE-SE-SW	Mitchell #2	Vincent	Sedgwick
3-27S-1E	NE-NW-NE	Jade-B #2	Kewannee	Sedgwick
20-28S-1E	SW-NW-NE	Brown #4	Pan-Am.	Sedgwick
33-29S-1E	E2-SW-NW	Butts #1	Sho-Bar	Sedgwick
4-30S-1E	NE-NW-SW	Lockert-A #2	Slawson	Sumner
25-31S-1W	SW-SW-NE	Stewart #1	Edmiston	Sumner
8-32S-1W	S2-N2-NE	Huff #2	Hummon	Sumner
6-33S-1W	W2-SE-SE	Allen #1	Beren	Sumner
6-34S-1W	SW-SE-NE	Johnson #1	MacKellar	Sumner

Cross Section J-J'

34-20s-6W	W2-W2-NE	Holderman #1	Sher-Lon	Rice
9-21S-6W	SE-NW-NW	Walsten-A #3	Holl	Rice
34-22S-6W	NE-SE-NE	Nelson #1	Pet. Mngmt.	Reno
22-23S-6W	SW-SW-SW	Hamilton #1	Cities	Reno

Location	Spot	Well Name	Operator	County
17-24S-7W	NW-NW-NW	Eisiminger #1	Ram	Reno
18-25S-7W	SE-SE-NE	Trembley #1	Thunderbird	Reno
31-26S-7W	C-SE-NW	Bruch-E #1	Pickrell	Reno
35-27S-8W	N2-NW-SW	#2 Arnold	Publishers	Kingman
25-28S-8W	C-C-NE	Bock #1	Walcher	Kingman
15-29S-8W	C-NE-SW	Voran #1	Beech	Kingman
2-30S-9W	NE-NW-NE	Whitmer #1	Ram	Kingman
15-31S-9W	NE-NW-SE	Kennedy #1	Magnolia	Harper
6-32S-9W	C-NE-SE	#1 Hogard-B	Pickrell	Harper
36-33S-9W	E2-SE-NE	Stejskal #1	Ellis	Harper
35-34S-9W	C-SW-NW	Chain-Burke #1	Pet. Cons.	Harper