FOSSIL ENERGY

BETC—1808-1

INVENTORY OF HEAVY OIL IN WESTERN MISSOURI

Final Report

Prepared for the Department of Energy
Under Contract No. ET-76-S-03-1808

Date Published—September 1979

Missouri Department of Natural Resources
Division of Geology and Survey
Rolla, Missouri

U. S. DEPARTMENT OF ENERGY

NOTICE

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Price: Paper Copy $9.00
Microfiche $3.00

BETC—1808-1
Distribution Category UC-92a

INVENTORY OF HEAVY OIL IN WESTERN MISSOURI

Final Report

by

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FOREWORD

The production potential for oil from U.S. heavy oil deposits is poorly defined; neither industry nor government has made a comprehensive and conclusive examination of the physical extent and economic possibilities of such deposits.

A federal research, development, and demonstration (RD&D) program has been initiated which has as its objectives verification of this resource base and improvement in reservoir data. The resource evaluation includes surface and subsurface mapping, structural studies, geochemical studies, and data acquisition and processing for an appraisal of potential heavy oil reservoirs.

This project is one of three being conducted by geological or mineral resource organizations within the states of Kansas, Missouri, and Oklahoma. Its purpose is for better defining the heavy oil deposits in the area contiguous to these three states.

The results of this study, although indicating the amount of oil available is disappointingly small, do show that a considerable amount of oil exists as small concentrations irregularly distributed in discontinuous sandstone reservoirs.

Larman J. Heath
DOE Technical Project Officer

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ABSTRACT

Tar sand/heavy oil deposits in the Tri-state area of western Missouri, eastern Kansas and northeastern Oklahoma have, over the past 100 years, been the object of speculation and numerous unsuccessful attempts at achieving production utilizing various "conventional" and "unconventional" methods. Because of the national energy situation, a program to improve estimates of the size of this particular energy resource was undertaken by the States of Oklahoma, Kansas, and Missouri.

The objective of the program was to inventory and evaluate these deposits by compilation of existing data and acquisition of new data by a drilling program. This has resulted in the first published estimates for these deposits in the Tri-state area based on specific geologic parameters rather than generalized and often erroneous data.

A resource of 1.4 to 1.9 billion barrels of oil in place is estimated to be present in the study area of Missouri. This estimate is considerably less than the 8.3 billion barrels estimated by Wells in 1974 (unpubl. map) and dramatically lower than the 50 to 75 billion barrels that had been quoted in trade journals. Unfortunately, none of this resource base can be considered in a reserve category under present economic and technological parameters.

Within the study area there are four potential reservoir horizons that occur in the lower Cherokee Group. Two of these units, the lower Bluejacket and the upper Warner, contain 88% of the estimated 1.4-billion-barrel heavy oil resource base in the conservative category. Of all the intervals, the upper Warner is by far the most important, both in areal extent and amount of oil in place. Maps of the four stratigraphic horizons show the areal extent and thickness of sandstone occurring within these horizons as well as areas of oil occurrence. Oil quantity and quality along with desirable reservoir qualities within the individual sand units is extremely variable throughout the study area. Based on mapped sand thickness trends, several areas exist in which further drilling and evaluation could be conducted. Additional oil accumulations may be discovered within some of these areas.

Although there are numerous outcrops of heavy oil-saturated sandstones and two quarrying operations in the area, only an estimated 20% or .4 billion barrels of the total resource base of 1.9 billion barrels occur at depths less than 50 feet. This depth would be the probable limit for stripping or mining methods under current economic conditions.

While a modest potential resource base exists, the irregular distribution of heavy oil within discontinuous sandstone reservoirs will hamper the development of these deposits.

INTRODUCTION

Statement of Problem

The presence of so-called tar sands, asphaltic sandstones or "heavy oil" deposits in western Missouri has been known for over 100 years and described by various workers (Broadhead, 1873-74; Wilson, 1922; Searight, 1957; Wells and Anderson, 1968; Gobel, 1971; Wells 1977). Recently these deposits have become the subject of increasing interest as a potential oil resource.

Gravity of this oil ranges from 25° to 8° API and, in the lower ranges, is very viscous to nearly solid and occurs most commonly in rocks of the Cherokee Group of Middle Pennsylvanian age. The Cherokee is a sequence of alternating shale and sandstone, with thin coal and limestone beds. This sequence varies in thickness, in the area of interest, from virtually zero at the outcrop to 500 or 600 feet in Kansas and Oklahoma. It dips westward at 20 to 30 feet per mile. In Missouri, heavy oil sands are present from exposure at the surface to depths of less than 100 feet in an area of an estimated 700 square miles. These same deposits in westernmost Missouri and easternmost Kansas occur at depths ranging from 100 feet to more than 500 feet.

The only commercial development of these heavy crude oil resources has been small-scale surface mining of two deposits in Vernon and Barton Counties, Missouri, for use as road surfacing material. Numerous in situ recovery experiments were conducted in the eastern Kansas producing trend and in Vernon County, Missouri, in the 1960's. None of these went beyond the stage of pilot testing various recovery processes.

Information on the heavy oil deposits is fragmentary. Numerous surface occurrences of oil-impregnated rock have been reported in the Tri-state area, especially in Missouri, but no attempt has been made to demonstrate the connection of these occurrences with reported heavy oil encountered in shallow borings of subsurface rocks. Lack of subsurface control has prevented correlation of subsurface occurrences with each other or with deeper producing oil fields farther west.

Due to the lack of coordinated study, estimates of the size of this potential oil resource in the Tri-state area range from a few billion barrels to more than 75 billion barrels. Uncertainty about the size of the resource was a factor that has contributed to the delay in the development of these deposits. Over the past few years, improvement in the price of crude oil has provided economic incentive for private industry to consider investment in the development of these resources. Once reliable estimates of the size and location of these oil sand deposits become available, and are matched with new processes for recovering oil, this previously untapped resource may result in a potential oil reserve for the area.

Background and Previous Work

Projects initiated by industry to produce oil from heavy oil sands have been attempted over the past 100 years with results ranging from "disappointing" to "almost" feasible. Others have initiated projects to obtain research data to apply to deposits occurring elsewhere. The most notable attempts have been conducted by Shell Oil, Phillips Petroleum and Carter Oil. Shell Oil's attempt in the early 1960's followed a comprehensive core drilling program. Data derived from their drilling were not made available to the state. Shell's pilot production research project was conducted on an 80-acre tract, with a fireflood in half the area and a steamflood in the remaining half of the tract. Results have not been released.

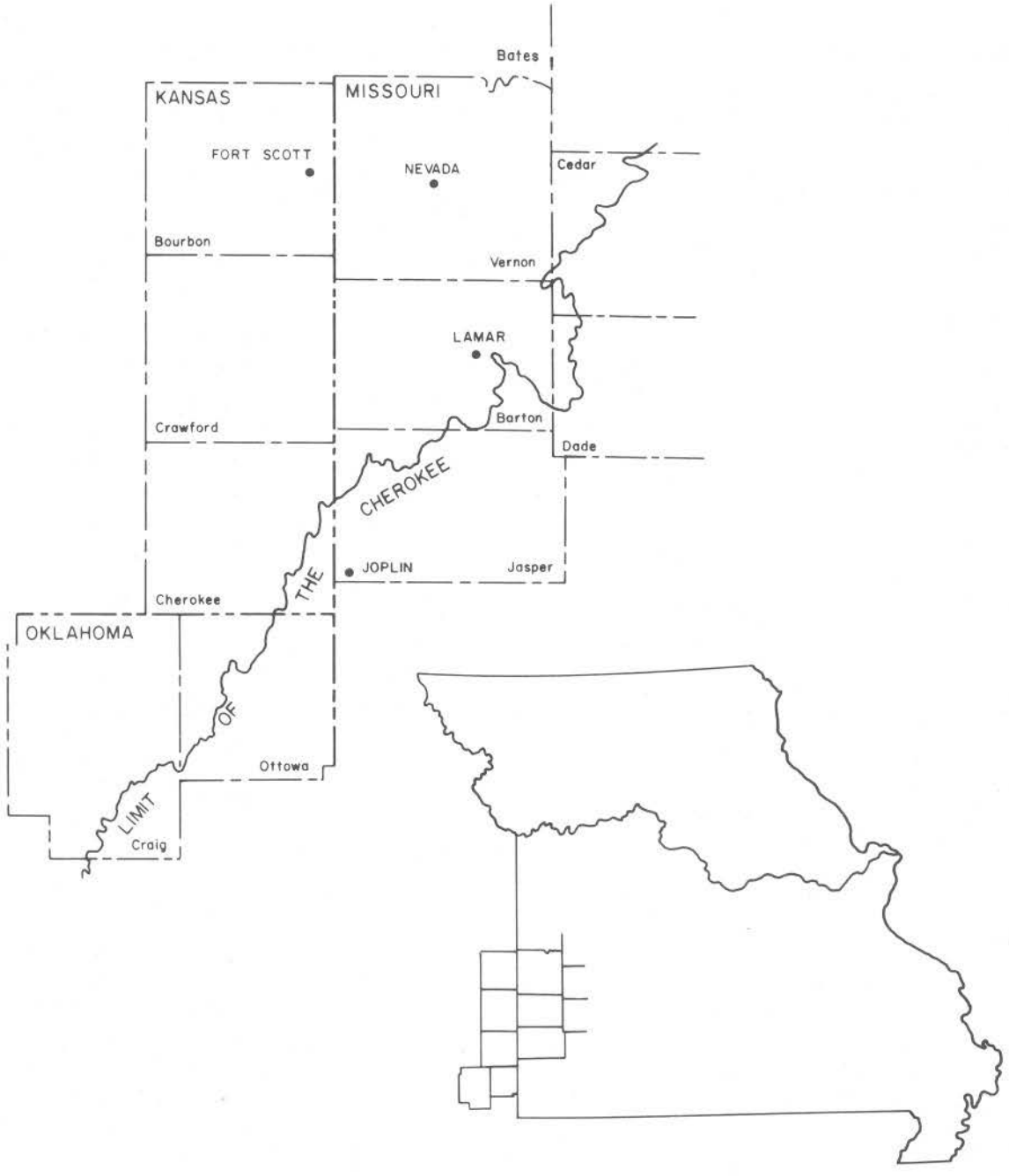


Fig. 1. Index map showing area of study.

Phillips Petroleum conducted a counter-flow combustion project near Bellamy, Missouri, from 1955 to 1958 (Trantham and Marx, 1966). Carter Oil operated a research project near Deerfield from 1955 to 1959 (Valleroy, et al., 1967).

Other work in Missouri has been hindered by the lack of subsurface data detailing the extent of the deposits. Two reports, however, have been published in regard to occurrences and industry-related activity in tar sands. In 1957 the Missouri Geological Survey published Information Circular No. 13, "Asphaltic Rocks in Western Missouri" by Walter V. Searight. Late in 1968 a report on "Heavy Oil in Western Missouri" by J.S. Wells and K.H. Anderson was published in the American Association of Petroleum Geologists Bulletin, Volume 52, No. 9. Other reports have briefly mentioned the occurrence and possible potential of the deposits (Enright, 1964; Goebel, 1966).

Personnel of the Missouri, Kansas, and Oklahoma Geological Surveys recognized that a crude oil resource whose potential size was in the range of several billion barrels was significant, especially at this time when the nation is experiencing an energy shortage. Meetings between the Geological Surveys of Kansas, Missouri, and Oklahoma led to a proposal for a coordinated study of the surface and shallow occurrences of heavy oil in adjacent areas of the three states. Initial funding by the U.S. Geological Survey in 1976 was not sufficient for an effective program within all three states, so the available funds were allocated to Missouri. A report, funded in part by the U.S. Geological Survey, Grant #14-08-001-G0266, summarizing the results of drilling and mapping for an area in the eastern and southeastern portion of Vernon and Barton Counties and the western portion of the adjoining counties of Cedar and Dade, was informally published by the Missouri Division of Geology and Land Survey (Wells, 1977).

Requests for additional funding were submitted by the three State Surveys to ERDA (now DOE), for a coordinated study. Funding for the study by the three states was approved and supported by DOE.

LOCATION

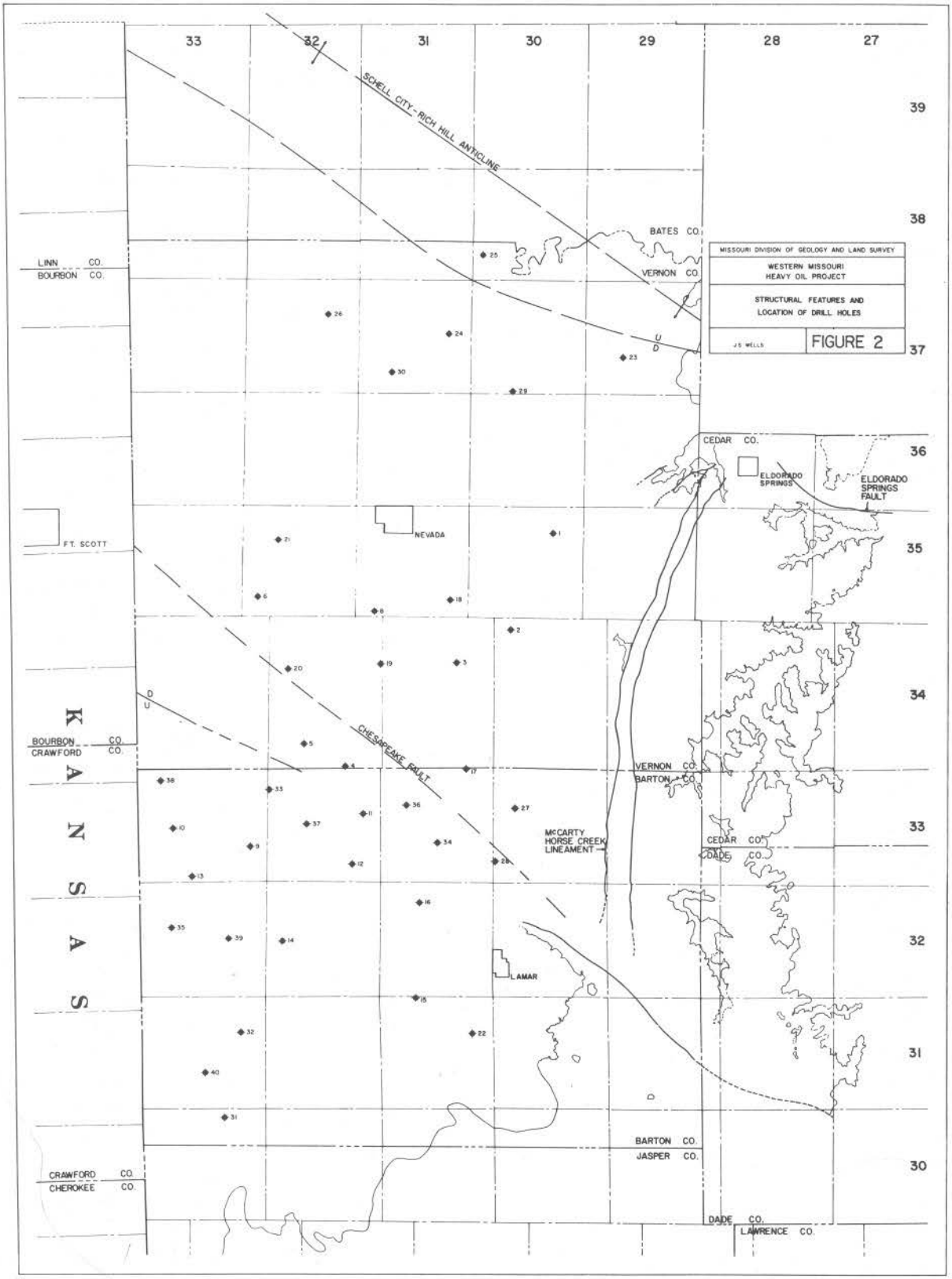
The area of study under this contract covers all of Vernon and Barton Counties in western Missouri and parts of Bates, Cedar, Dade, and Jasper Counties (fig. 1). Allowing for the irregularities of the Pennsylvanian outcrop pattern marking the east and south boundaries, the study area is a north-south rectangular block approximately 64 miles long by 30 miles wide, containing 1,920 square miles, or roughly 1.25 million acres. Although heavy oil deposits extend northward in Missouri (Ball Assoc. Ltd., 1965; Wells and Anderson, 1968), the deposits within the counties included in this study are considered to be more extensively developed and therefore the most promising for any future development either by in situ or mining methods.

General Project Outline

This project was conducted generally in three phases: 1) compilation of existing surface and subsurface data, 2) drilling for new data, and 3) final compilation, review, and publication.

Compilation of existing data was carried out in part during work on the USGS-funded area. However, complete revision of most maps resulted as more data accumulated during the drilling phase. Also, initial correlations of various oil-bearing horizons were revised as a consequence of newly acquired data and from conferences with Survey geologists from Kansas and Oklahoma.

In the drilling phase, 39 test holes (fig. 2) were drilled in two phases. Contracts obtained on the basis of two competitive biddings were awarded to the Layne-Western Drilling Company of Kansas City.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SCHELL CITY - RICH HILL ANTICLINE
BATES CO.
VERNON CO.
LINN CO.
BOURBON CO.
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI HEAVY OIL PROJECT
STRUCTURAL FEATURES AND LOCATION OF DRILL HOLES
J.S. WELLS
FIGURE 2
CEDAR CO.
ELDORADO SPRINGS
ELDORADO SPRINGS FAULT
FT. SCOTT
NEVADA
BOURBON CO.
CRAWFORD CO.
CHESAPEAKE FAULT
VERNON CO.
BARTON CO.
McCARTY HORSE CREEK LINEAMENT
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
CRAWFORD CO.
CHEROKEE CO.
DADE CO.
LAWRENCE CO.
KANSAS

In the initial phase of drilling, 21 test holes were completed. After review and plotting of data, the drilling of the remaining 18 test holes was completed in August of 1977. Permitting, drilling, and plugging required by Missouri Oil and Gas Council regulations. Drill sites were located in or along ditch lines and on back slopes of county roads and state highway right-of-ways. After the tests were completed, the sites were restored to the satisfaction of the appropriate state and county officials.

Gamma-ray, self-potential and resistivity logs were obtained on all of the test holes by the drilling contractor under a subcontract with Roberts Geophysical Service of Council Bluffs, Iowa. These logs as reproduced in Appendix B have been redrafted to conform to a "standard" API format, therefore log analysis based on these reproductions should not be attempted.

Following drilling, correlation of the lithologic and mechanical well logs was coordinated with geologists from the three state surveys ensuring some degree of uniformity in the final report of the three areas of Kansas, Missouri and Oklahoma. The authors recognize that problems exist in the correlation of various stratigraphic horizons within the Tri-state area, although the magnitude of this problem did not become apparent until several complete cores had been taken and correlation attempts made with subsurface sections present in Kansas. Ebanks (December, 1977) concisely stated the problem, "Traditional stratigraphic nomenclature of the three states involved in this project does not recognize the non-continuous nature of many of the sandstones in the area of study; rather, these classifications of formations have fostered the widespread use of the same name for sandstones in about the same stratigraphic position in widely separated areas. While it is clear that some thin 'marker beds,' that is, beds which are recognizable on combination geophysical-sample logs because of some distinctive character and position relative to other markers, do provide a basis for relatively long-distance correlation, the sandstone beds between these markers do not correlate widely."

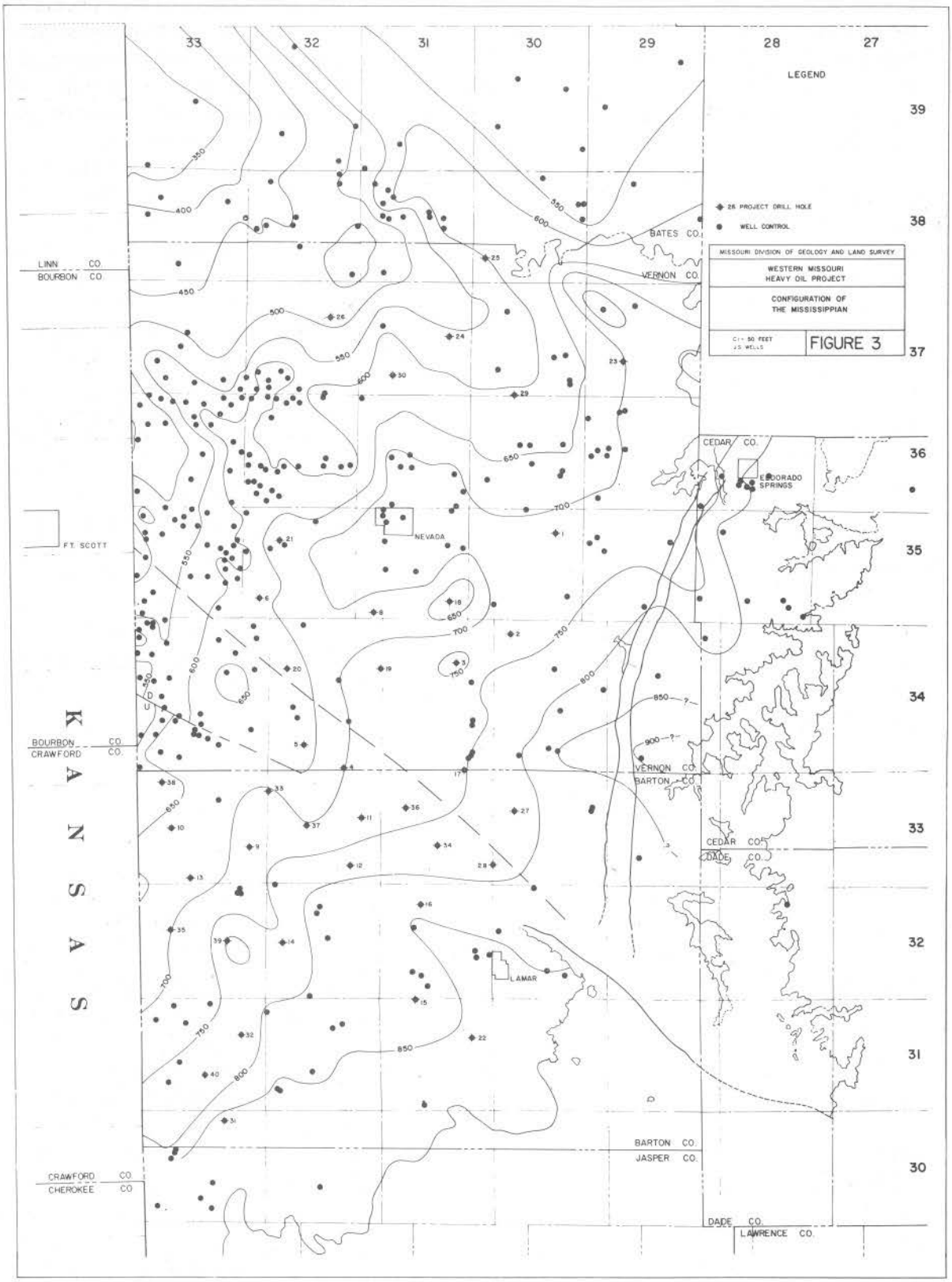
GEOLOGY

Regional Geology

The study area in Missouri is situated on the western flank of the Ozark uplift and extends westward into the northern edge of the Cherokee basin and the southern edge of the Forest City basin. The boundary between these two shallow Pennsylvanian basins is considered to be the Bourbon arch, first named by Moore and Jewett (1942, fig. 8) and later described by Lee (1943, p. 85) as ". . . a broad, low structural divide of Mississippian rocks that separate the Forest City basin and Cherokee basins . . ." Jewett (1951, p. 122) later said, "There is evidence from higher outcropping rocks that later in Pennsylvanian time this area (Bourbon arch) was one of meeting and overlap of sediments from southerly and northerly directions."

Within this area of Missouri, the Pennsylvanian strata dip west to northwest at 10 to 20 feet per mile. Oil-bearing horizons occurring at outcrop to less than 300 feet deep in Missouri are equivalent to horizons which have produced major amounts of oil from greater depths in eastern Kansas.

Pennsylvanian rocks for the most part lie on the erosional surface of Mississippian limestone (fig. 3), which dips west and northwest at a rate slightly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LEGEND
26 PROJECT DRILL HOLE
WELL CONTROL
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI
HEAVY OIL PROJECT
CONFIGURATION OF
THE MISSISSIPPIAN
C.I. = 50 FEET
US WELLS
FIGURE 3
39
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BATES CO.
VERNON CO.
LINN CO.
BOURBON CO.
CEDAR CO.
EL DORADO SPRINGS
FT. SCOTT
NEVADA
BOURBON CO.
CRAWFORD CO.
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
CRAWFORD CO.
CHEROKEE CO.
DADE CO.
LAWRENCE CO.
KANSAS

greater than the Pennsylvanian which, along with other data, would indicate a thickening of Cherokee sediments westward. Ebanks (1977) reports a westward and southward thickening in Kansas at a somewhat greater rate than that in Missouri.

Structure

Major structural features in the study area (fig. 2) include the northwest trending El Dorado Springs fault and the Schell City-Rich Hill anticline which are considered part of the Bolivar-Mansfield fault system of southwestern Missouri (McCracken, 1971, p. 13). A fault recognized by McCracken by plotting wells that penetrated the Arbuckle, parallels the Schell City-Rich Hill anticline a short distance southwest of the axis of the anticline and is also considered to be part of the Bolivar-Mansfield fault system, that extends from Arkansas into Kansas (Gentile, 1966).

Another major structural feature in the southern portion of the study area is the northwest-trending Chesapeake fault that has Mississippian rocks on the southwest side against Pennsylvanian strata on the northeast, or downthrown side. This fault is present to a point near Lamar, Missouri. Northwestward from Lamar, it has not been traced at the surface, but was described by McCracken (1971, p. 20), and extended to the Kansas line based on subsurface data. Cole (1962) has extended this fault into Bourbon County, Kansas.

On the basis of photogeologic mapping by Boyd Haley (USGS) during the USGS-funded drilling program, a north-trending structural lineament was defined and was named the McCarty-Horse Creek lineament (Wells, 1977). This forms a prominent westward-facing topographic scarp along much of its length. Rock strata dip sharply westward over a relatively short distance and then regain the gentle westward regional dip. This feature is described as a monocline, however, it is possible that further studies may reveal faulting along part or all of it.

Ebanks (1978) described a small fault in the Mississippian limestone in T. 27 S., R. 25 E., Bourbon County, Kansas, which has been extended into Missouri in T. 34 N., R. 33 W., on the basis of subsurface mapping on the top of the Mississippian.

There are examples in western Missouri and eastern Kansas where oil is structurally trapped in anticlines, although this does not seem to be the case for the accumulation of heavy oil within the study area. The individual oil sand reservoirs are lenticular and discontinuous in occurrence, and as such, structure would only have served to help localize oil in updip portions of a sand body at places where an oil-bearing sand and a local structure happened to coincide.

More important in trapping oil is the actual extent of porous and permeable sandstone. In this case, the presence of existing structure may have influenced the deposition of some of the lower Pennsylvanian sands. An example of this is the presence of a long, narrow, and thick sandstone body in the upper Warner interval (fig. 7) that occurs along the strike of a Mississippian fault in the southwestern corner of Vernon County. Post depositional faulting or movement along this fault contemporaneous with deposition may well account for this particular sand trend. Although it is doubtful that movement of any great magnitude occurred generally within the area after Mississippian time, Gentile (1968 and 1976) points out that local structural movement contemporaneous with early Pennsylvanian sedimentation influenced the lithology and thickness of certain stratigraphic units in western Missouri.

It may well be that small-scale local movement, as well as irregularities in the original surface of deposition, has influenced the deposition of the various

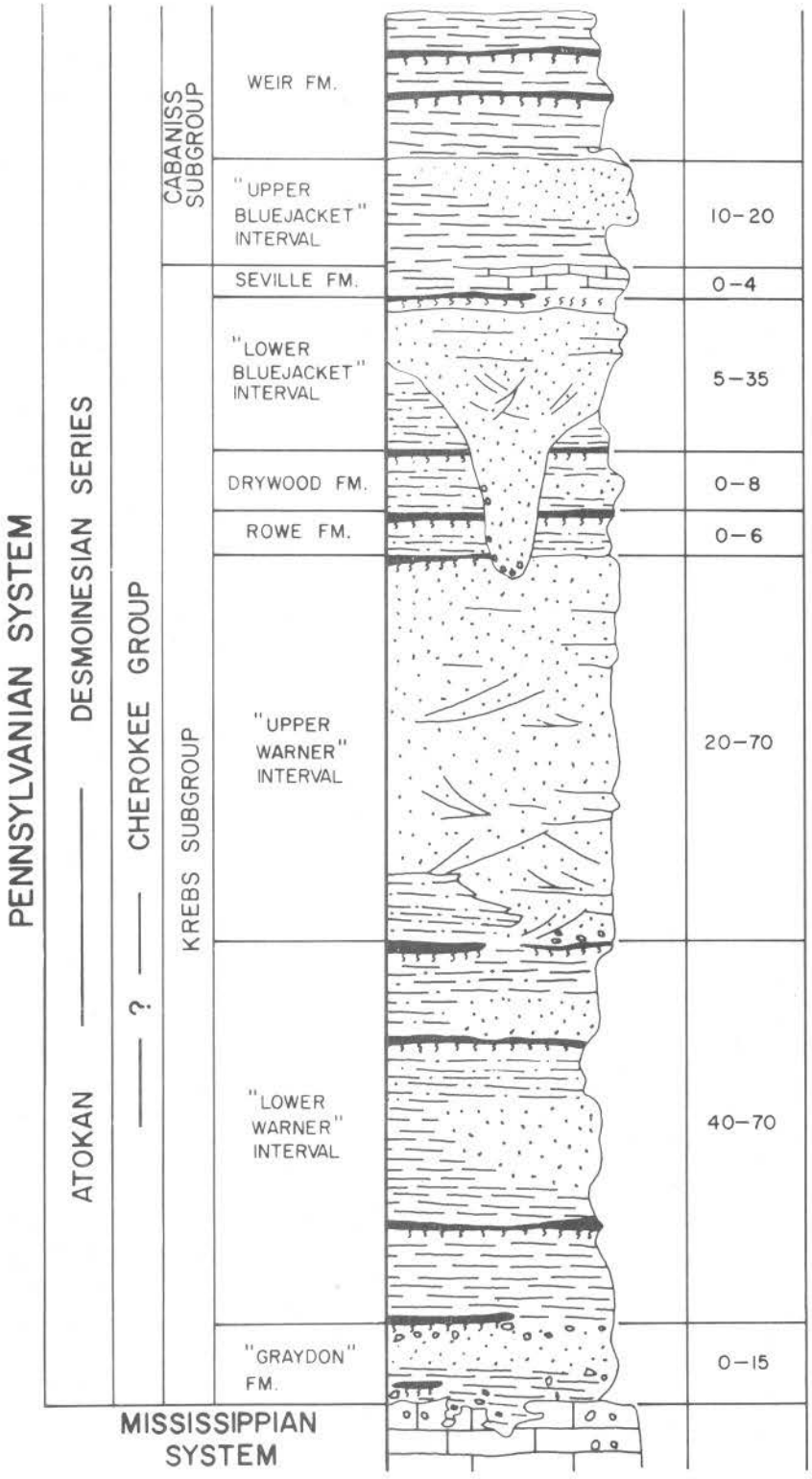


Fig. 4. Generalized Geologic Column showing units mapped.

sand bodies to a greater degree than could actually be determined in the course of this study.

Stratigraphy

Howe (1956) stated that the Cherokee Group was the earliest of the Pennsylvanian cyclic sequence of sediments to be deposited in the Mid-Continent area. However, in the study area, a zone of sediment consisting of several feet of chert breccia in a matrix of clay and sandstone occurs consistently. These strata fit the description of the Graydon Formation as described by Winslow (1894, p. 422-424) and have been so assigned in this report. An interval several feet thick, consisting of dark gray to black shales, thin sandstone stringers, one or more thin coal beds, and an occasional "shelly" limestone, is present in much of the study area overlying the Graydon. These strata are present most commonly in the low areas that occur on the erosional surface of the Mississippian, possibly Atokan in age, were assigned to the Riverton in earlier reports. For this report, however, the black shales and thin sandstones above the Graydon and below the massive sands of the upper Warner have been included in the lower Warner interval.

Depositional environments in this particular area of Missouri probably varied considerably during the deposition of Cherokee strata. Situated on the edges of two basins with the interplay of a varying sediment supply and different ratios of basin subsidence along with minor local tectonic movements, it is understandable that a variety of depositional models have been described. While, no doubt, many of the interpretations are correct for some areas, it appears that the interpretation by Ebanks (1977), in which the predominant mode of deposition of the oil-bearing sediments by repeated pro-grading of fluvial deltaic systems westward into Kansas and thence into Oklahoma, is valid, and this author would essentially agree with his interpretation. Ebanks further described this pro-grading system as ". . . consisting of the extension of sand-rich depositional 'lobes' and belts of sandy deposits into or over environments in which mostly muddy or silty sediment existed or where peat swamps had formed. The sands deposited in this manner are, quite naturally, highly lenticular, curvilinear and discontinuous."

In any case, regardless of which depositional environment anyone might prefer to apply to these oil-bearing sands, the important fact remains that these sands do not occur as continuous, evenly bedded, "blanket" sandstones of uniform thickness, and this fact should be considered in evaluating resource base figures and future potential exploration attempts.

A generalized geologic column, figure 4, shows an idealized section of the major oil-bearing sand horizons occurring in the study area. Only rarely would this section be duplicated in a single well, although well No. 13 in Sec. 33, T. 33 N., R. 33 W., Vernon County, was very nearly complete in this respect.

Stratigraphic nomenclature recognized by the Missouri Geological Survey (Searight and Howe, 1961) could not be applied successfully to this section of strata. The column therefore does not depict the current nomenclature in use by the Survey, nor is it intended to be considered as a proposed version, but was included only for reference to the sandstone units mapped in this report. The names applied to the intervals of sandstones are names used in earlier reports for surface exposures and are used in this report in agreement with Kansas, Oklahoma and Missouri for purposes of continuity in the respective state reports. Although many questions of correlation remain to be answered or otherwise resolved by the state surveys involved, this problem does not affect the heavy oil resource estimates made in this report.

HEAVY OIL RESOURCE

Extent of Oil-Bearing Sandstone

A series of maps has been constructed using existing data from the log files of the Missouri Department of Natural Resources, Division of Geology and Land Survey and data acquired through the drilling of 39 test holes funded under this contract.

These maps are of necessity generalized as a result of the discontinuous nature of the individual sands and the limited amount of subsurface control available. The maps show favorable areas and trends of sand development and hydrocarbon occurrence that can be utilized as a guide for future exploration and development. However, it should be pointed out that the maps undoubtedly do not show all of the favorable areas in which sand development and hydrocarbon may be found by future drilling. Conversely, there may be small areas within the outlines of favorable sand development as mapped, where a particular sand could be poorly developed or non-existent.

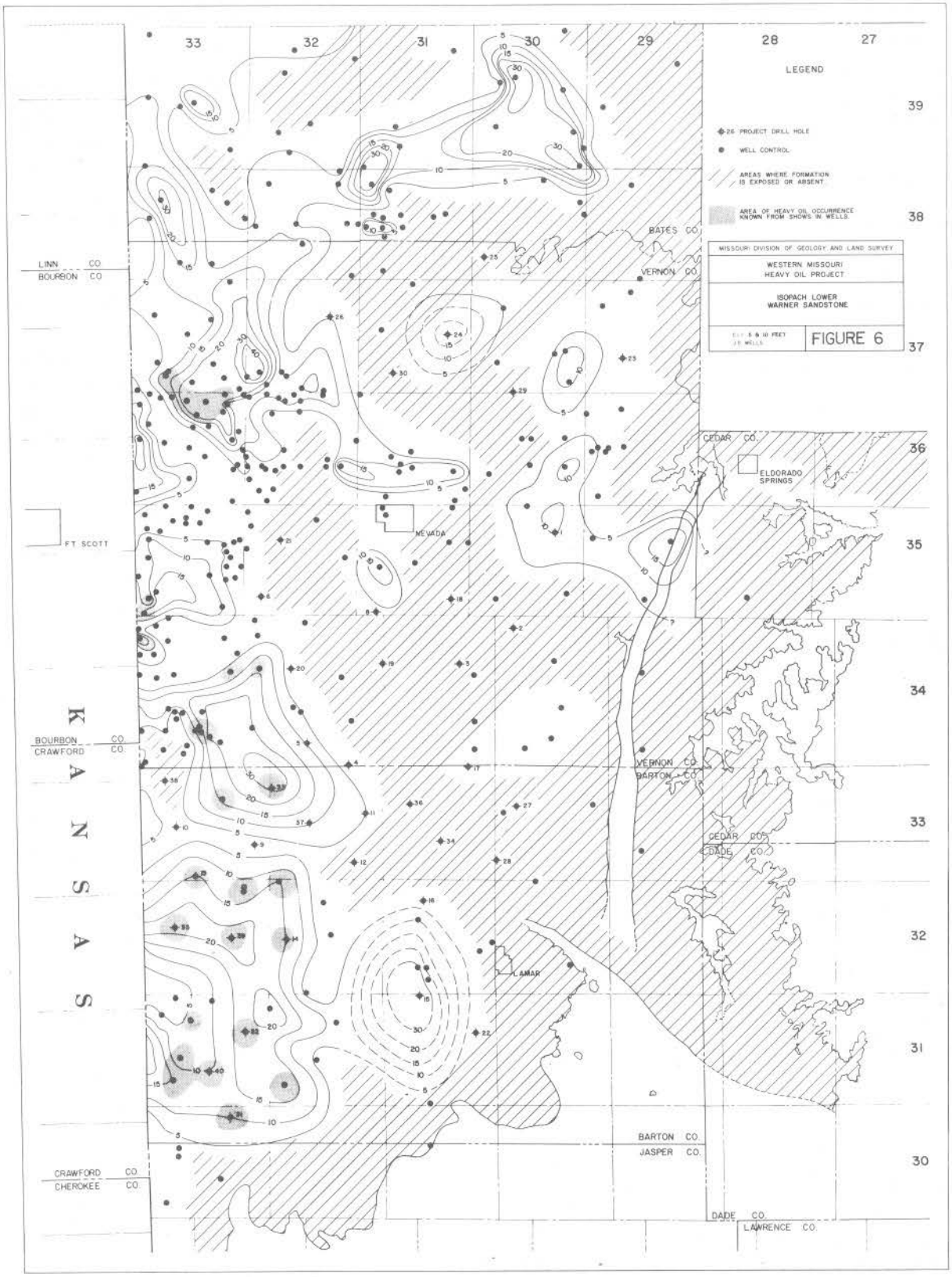
In addition to limited subsurface data, another factor involved in the construction of this series of maps was the problem of correlation of the various sandstone horizons in Missouri with equivalent units in Kansas. Although an attempt was made to correlate the Kansas units with those in Missouri, and an unofficial nomenclature for use in the DOE reports was agreed upon, there may be some areas in Missouri where a sandstone horizon may have been miscorrelated and included in an adjacent interval, resulting in abnormal thicknesses for that interval. This is especially true for an area in eastern Vernon County, involving the lower Bluejacket and upper Warner intervals. While this potential problem may affect resource base estimates for a particular interval, the basic purpose of the study was to arrive at a more reliable resource base figure, and the problems in correlation should not affect the calculation of a total heavy oil resource base estimate.

Within the adjoining three-county study area of Kansas, Ebanks (1977) identifies five stratigraphic intervals of the lower Cherokee in which oil-bearing sandstone occurs. In the Missouri study area four intervals have been mapped and would be equivalent to the lowermost four units mapped in Kansas. A stratigraphic cross-section depicting these intervals is shown in figure 5. The upper sand referred to in the Kansas report is a lower Cabaniss sandstone that is present in only a small portion of the study area in Missouri, occurring in the northern and northwestern portions of Vernon County, and occasionally in Bates County. The limited extent of sand and the even more limited occurrences of hydrocarbons in this interval was not sufficient to justify mapping. The intervals mapped in Missouri therefore are the lower Warner, upper Warner, lower Bluejacket and upper Bluejacket, which correlate with the same units mapped by Ebanks in the Kansas report.

Lower Warner

The lowermost unit mapped (fig. 6) is a sandstone that is developed within a thick (30- to 90-foot) section of dark to black, occasionally silty and sandy shale that was thought to be Atokan and assigned to the Riverton (Wells, 1977). Detailed field work by Ebanks and others of the Kansas Geological Survey has shown that the "occasional" sand that developed in this interval in Missouri, and to a somewhat greater extent in Kansas, is probably equivalent to the Warner Sandstone of Oklahoma.

Drilling in Missouri under this contract has shown this "occasional" sand to be considerably more widespread and better


LEGEND
26 PROJECT DRILL HOLE
WELL CONTROL
AREAS WHERE FORMATION IS EXPOSED OR ABSENT
AREA OF HEAVY OIL OCCURRENCE KNOWN FROM SHOWS IN WELLS
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI HEAVY OIL PROJECT
ISOPACH LOWER WARNER SANDSTONE
CONTOUR INTERVAL 5 & 10 FEET
FIGURE 6
KANSAS
LINN CO.
BOURBON CO.
FT SCOTT
BOURBON CO.
CRAWFORD CO.
CRAWFORD CO.
CHEROKEE CO.
BATES CO.
VERNON CO.
NEVADA
CEDAR CO.
ELDORADO SPRINGS
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
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developed than previously had been suspected. As mapped, it is present over an estimated 400,000 acres with the better, or thicker, sand development being near the Kansas-Missouri border. Several lobes extend across the state line with little to no pattern or trend discernible — which probably reflects the lack of control. Occasional small, discrete pods occur in other areas in an apparently unpredictable pattern. Thickness of sandstone reached a maximum of 40 feet in a few localities, however, 10 to 15 feet is more commonly encountered in those areas in which it was developed most consistently.

Quality of the sand varied considerably, ranging from an interbedded fine silt and dark shale through a dirty, clayey siltstone, to a clean, coarse-grained quartz sandstone. As might be expected from the range of grain sizes, internal structures within the interval also varied. Large-scale cross bedding, as well as small-scale or ripple cross bedding and horizontal thin laminae, were observed. Carbonaceous material and thin coal laminae were common, especially in the lower portion of the unit.

The upper boundary of the lower Warner unit, as based on well logs resulting from drilling under this contract, is slightly different from the "tops" based on the Kansas wells by Ebanks. He chose the ". . . base of an unnamed, but very persistent, coal bed which occurs 30 to 50 feet above the Mississippian unconformable surface . . ." which he called ". . . the lower Warner marker."

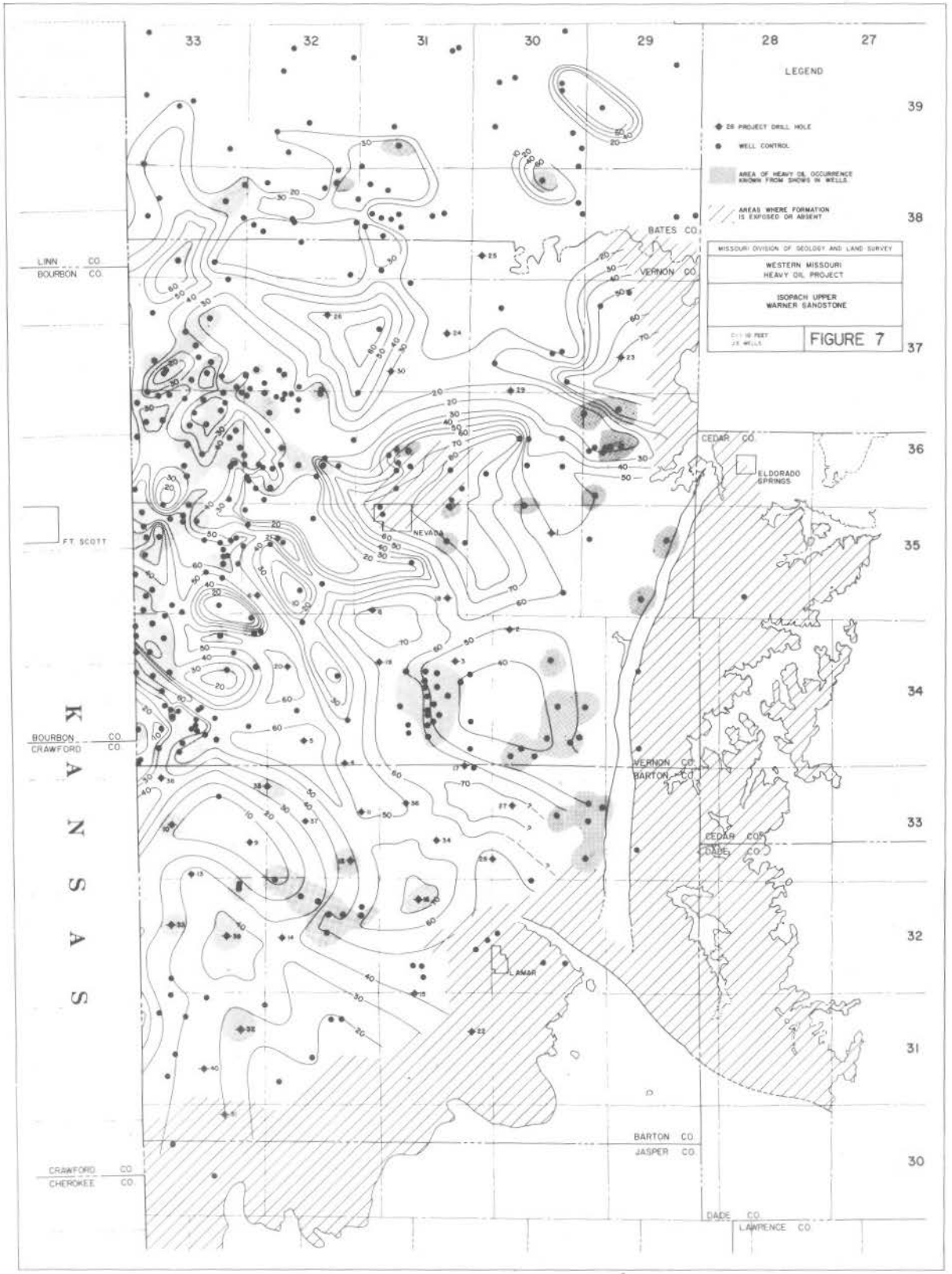
This author has consistently used the top of another fairly consistent coal bed occurring only 10 to 20 feet above Ebanks' "lower Warner marker" as a break between the two units. This "upper" coal bed also occurs fairly consistently and is immediately below the sandstone previously correlated in Missouri as Warner and referred to in this report as the upper Warner. In the absence of this "upper" coal, dark to black fissile shales would be consistently present, and the boundary would then be picked at the base of the sandstone which would also be the top of these black shales. This difference in correlation does not include or exclude any sandstone from the lower Warner unit as compared to Kansas wells, and would therefore not affect resource base estimates within either the upper or lower Warner.

Upper Warner

The upper Warner unit (fig. 7) includes sandstones and shales occurring between the Rowe coal and the lower Warner. The sandstones developed within this unit are the most consistent and widespread of the four units mapped in Missouri, covering an estimated 890,000 acres of the nearly 1.25 million acres in the study area.

The sandstone in the upper Warner interval, which has been referred to as the Warner in Missouri literature, is actually younger than the Warner sandstone of Oklahoma at its type section (Ebanks, et al., 1977). Adding to the difficulties encountered in correlating this particular sand body are the two coal beds underlying the sandstone. It is possible that these two coals, described in the preceeding lower Warner discussion, have been miscorrelated in some areas of both Missouri and Kansas as being the Rowe-Drywood coals. This would then result in the upper Warner sand being correlated as the Bluejacket (lower Bluejacket of this report), and the lower Warner sand interval being correlated as the Warner sandstone.

The upper boundary of the upper Warner is marked at the base of the Rowe Formation. However, in an area eastward from Nevada, Missouri, the upper boundary is difficult to determine because the overlying Rowe and Drywood intervals are often absent as a result of channeling by the lower Bluejacket through these intervals into the upper Warner. In an


LEGEND
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WELL CONTROL
AREA OF HEAVY OIL OCCURRENCE KNOWN FROM SHOWS IN WELLS
AREAS WHERE FORMATION IS EXPOSED OR ABSENT
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI HEAVY OIL PROJECT
ISOPACH UPPER WARNER SANDSTONE
FIGURE 7
KANSAS
LINN CO.
BOURBON CO.
FT. SCOTT
BOURBON CO.
CRAWFORD CO.
CRAWFORD CO.
CHEROKEE CO.
BATES CO.
VERNON CO.
NEVADA
CEDAR CO.
ELDORADO SPRINGS
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
DADE CO.
LAWRENCE CO.
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earlier study (Wells, 1977), a boundary in such cases was picked at a disconformity at the base of the lower Bluejacket marked by a thin conglomerate of rounded and elliptical pebbles, particles of claystone, coal fragments, and shale. Unfortunately, in further drilling during this study, several zones of similar conglomerates were encountered. As a result, a boundary between the lower Bluejacket and upper Warner in the eastern portion of the study area could not be established with any degree of certainty.

Combined thicknesses of sandstones developed within the upper Warner may attain a maximum of 90 feet, where a thickness could be established, with a range of 30 to 40 feet more commonly encountered.

Thicknesses of 80 to 90 feet of upper Warner mapped near Nevada might possibly have resulted from miscorrelating the almost continuous sand section that includes sands from more than one stratigraphic interval (see well No. 19, fig. 5). Although an attempt was made to establish a consistent break within this sand section, it is possible that some lower Bluejacket sands may have been included in the upper Warner interval.

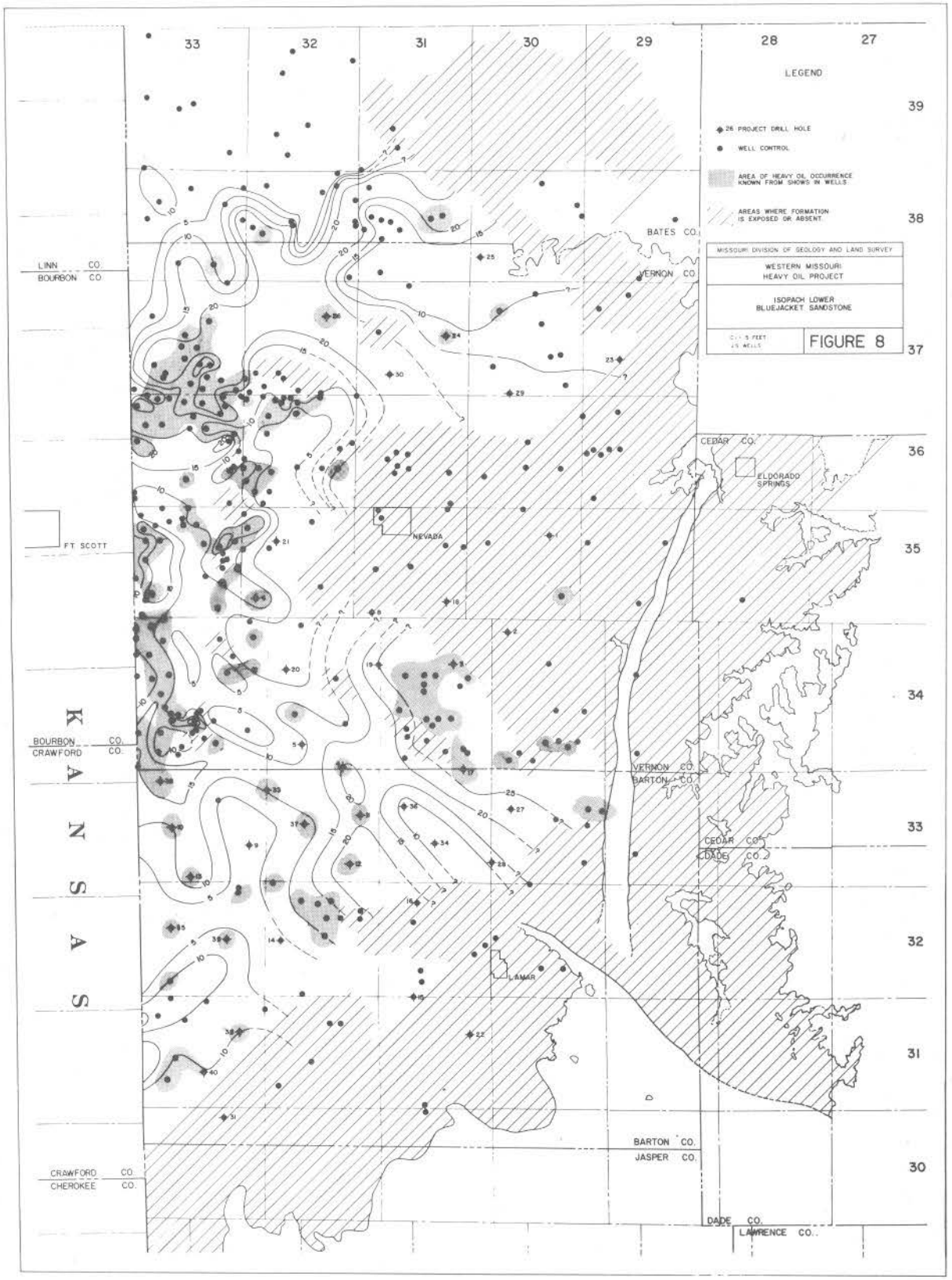
Contrasted to the lower Warner, in which types of patterns or trends of occurrence were not apparent, definite trends can be seen on the map of the upper Warner, especially in the western portion of the area. A correlation between amount of control with sandstone distribution patterns can be seen. Where control is greater, sharp definition and delineation of long linear sand bodies or channels is possible. Where control is sparse, large lobate bodies or pods result. Effects of Mississippian surface configuration upon the distribution patterns or thicknesses of sandstone is not apparent except from one notable exception in southwestern Vernon County, where a long, narrow and quite thick sand occurrence coincides with a small fault in the Mississippian that may be part of the complex Chesapeake fault system.

Lower Bluejacket

The lower Bluejacket sands (fig. 8) are the next best developed after the upper Warner, and also were second after the Warner in amount of hydrocarbon content. As a complete unit (as mapped), where it is not exposed at the surface, the lower Bluejacket extends over approximately 408,000 acres or 33% of the total study area and is confined to the western third of the study area. The Bluejacket, however, extends eastward over much of the area but is exposed at the surface and does not contain significant amounts of hydrocarbons except in southeastern Vernon County (notably in T. 34 N., R. 31 W.), and in the adjoining township east of where it is mined in the Silica Rock Products Company quarry near Bellamy (Sec. 24, T. 34 N., R. 30 W.), for use as road blacktopping material.

The Bluejacket may be the more consistent and widespread sand of the four units mapped. It does, however, not attain the thicknesses that the upper Warner achieves except where it has channeled through the Rowe-Drywood interval into the upper Warner. It appears that deep channeling was more common in the eastern portion of the study area and became rare to non-existent westward.

Combined thickness of sands included in the lower Bluejacket interval attain a maximum of 35 feet, with an average of 15 to 20 feet most commonly encountered. Overall, the characteristics of grain size, porosity, permeability, sorting, abundance of fines, and matrix materials make this unit a rather poor reservoir rock. The unit varies from a thin-bedded, fine-grained sandstone to a medium to massive, cross-bedded and medium-grained sandstone. Often the unit grades from fine-grained sandstone through siltstone to thinly-laminated silty


LEGEND
26 PROJECT DRILL HOLE
WELL CONTROL
AREA OF HEAVY OIL OCCURRENCE KNOWN FROM SHOWS IN WELLS
AREAS WHERE FORMATION IS EXPOSED OR ABSENT
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI HEAVY OIL PROJECT
ISOPACH LOWER BLUEJACKET SANDSTONE
C.I. 5 FEET
25 WELLS
FIGURE 8
KANSAS
LINN CO.
BOURBON CO.
FT SCOTT
BOURBON CO.
CRAWFORD CO.
CRAWFORD CO.
CHEROKEE CO.
BATES CO.
VERNON CO.
NEVADA
CEDAR CO.
ELDORADO SPRINGS
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
DADE CO.
LAWRENCE CO.
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shale within a relatively short distance.

Generally the lower Bluejacket is a thinner-bedded and finer-grained sandstone as compared to the upper Warner. This generality, however, cannot always be relied on to differentiate the two units in the field.

Upper Bluejacket

The upper Bluejacket interval (fig. 9), if correctly identified and correlated with its Kansas equivalent, was not encountered over much of the area, but rather consisted of a few scattered pods of limited size. Areal extent was calculated at 191,000 acres or 15% of the total study area.

When present, the sands of the upper Bluejacket were thin bedded and ranged from silt-sized grains to rarely more than medium-sized grains. Often the units occurred as thin laminae of silt and shale and in general were composed of fractions finer than the lower Bluejacket. However, when thicker sections occurred, the sand would be somewhat cleaner and coarser, and although no cores were obtained from the thicker occurrences, the author would suspect that some crossbedding could be expected. Thickness of sands in the upper Bluejacket averaged less than 10 feet with a maximum of 25 feet encountered in one well in northern Vernon County.

Poor reservoir characteristics along with limited horizontal and vertical extent make this horizon the least attractive as a future producer of heavy oil, at least within the study area. Further north and west, sands in this horizon become better developed and shows of heavy oil have been reported.

EXTENT OF HEAVY OIL

Of the 39 test holes drilled, oil shows of some kind were encountered in 26 of the tests. Of the 26, 13 tests had "good" or better shows in at least 8 feet of sand. Maximum total thickness of oil-saturated sand in any test drilled was 49 feet, encountered in test hole No. 39.

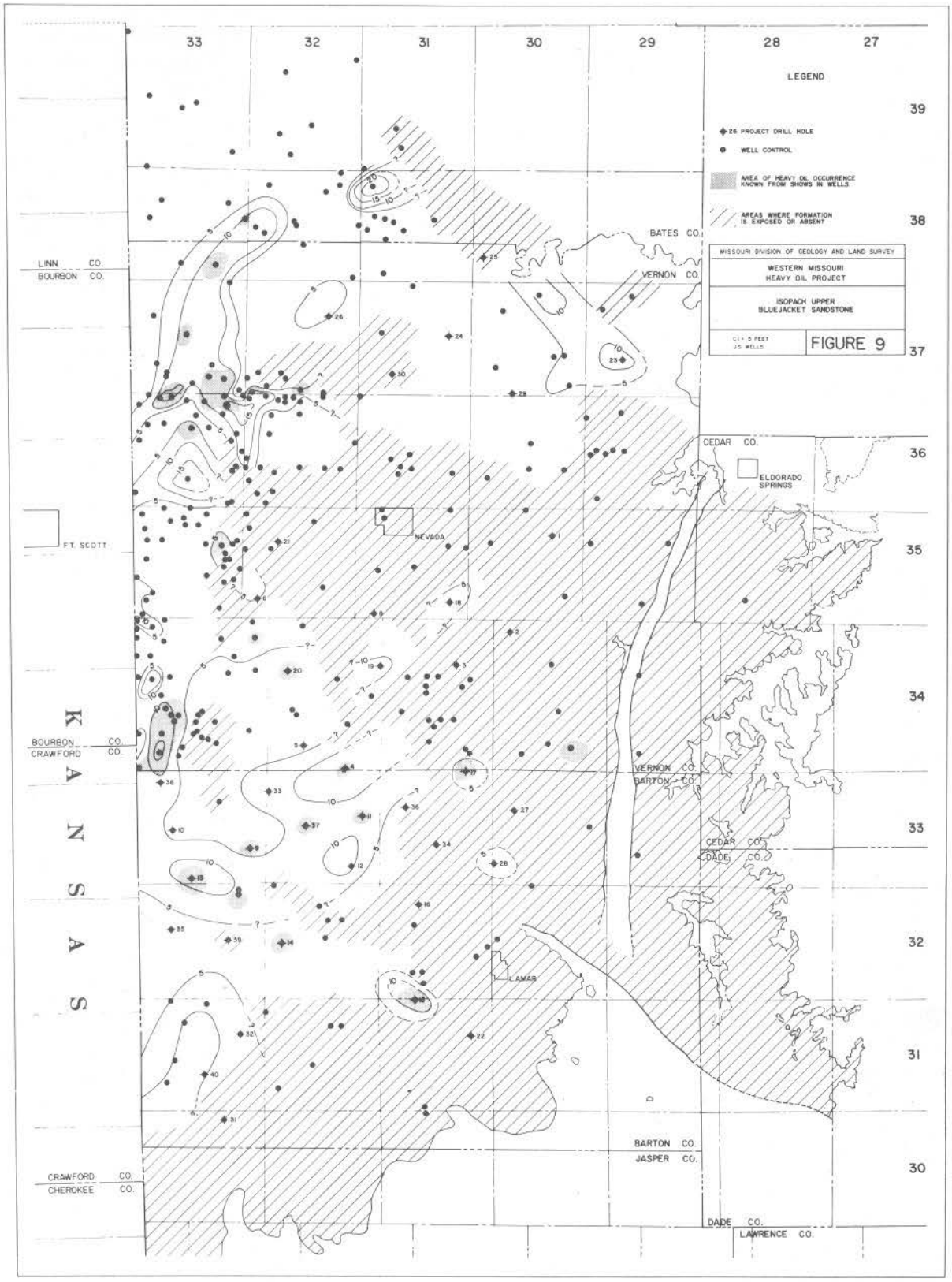
Quality of oil shows varied from trace amounts (estimated as being less then 150 barrels of oil per acre foot); fair (150-400 bbls/acre foot); good (400-800 bbls/acre foot), to very good (estimated at something in excess of 800 bbls/acre foot). In the field, a show in the latter category would appear to be completely saturated and often bubbling or bleeding oil from the core, depending on viscosity of the oil and rock characteristics.

Trace and fair amounts were usually found as light gray to dark gray sandstones in which the hydrocarbon was present as a solid, black, shiny gilsonite or a dark brown to black, soft, tarry residue.

Sandstone made up 2,456 feet of the 7,046 feet of total footage drilled, or approximately 35% sand as compared to other materials. Of the 2,456 feet of sand, approximately 21% or 515 feet contained hydrocarbons to some extent. Out of the 515 feet of oil-stained sandstone, 43% or 223 feet was considered to be a "good" or better show with the remaining 292 feet containing varying amounts of a soft, tarry residue or black, solid gilsonite.

Representative samples from seven core tests were selected for core analysis. Seventy-five samples representing 115 feet of core were analyzed by Oilfield Research Laboratories of Chanute, Kansas. These analyses are reproduced in Appendix A. From the results, an attempt was made to project these values into a more or less quantitative show on the logs reproduced in Appendix B.

From the reports, porosity ranged from an average low of 17.9% to a high of 23%.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LEGEND
26 PROJECT DRILL HOLE
WELL CONTROL
AREA OF HEAVY OIL OCCURRENCE KNOWN FROM SHOWS IN WELLS.
AREAS WHERE FORMATION IS EXPOSED OR ABSENT
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI HEAVY OIL PROJECT
ISOPACH UPPER BLUEJACKET SANDSTONE
C.I. = 5 FEET
35 WELLS
FIGURE 9
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BATES CO.
VERNON CO.
LINN CO.
BOURBON CO.
CEDAR CO.
ELDORADO SPRINGS
FT. SCOTT
NEVADA
KANSAS
BOURBON CO.
CRAWFORD CO.
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
CRAWFORD CO.
CHEROKEE CO.
DADE CO.
LAWRENCE CO.

Oil saturation ranged from an average low of 15.6% to an average high of 48.6%. Permeability ran from an average low of 13.6 millidarcies to an average high of 184 millidarcies. Table 1 shows the extreme limits of low and high values of the core analyses taken on the seven core holes.

Oil content in the cores analyzed ranged from 0 to 1,392 barrels per acre foot. Field observation seemed to indicate that often the highest degree of oil saturation occurred in intervals in which the reservoir rock exhibited lower porosity and permeability. This characteristic, however, did not seem to hold true in several of the cores that were analyzed. In fact the opposite was true, especially in core holes Nos. 17, 20, and 38.

A note of caution is advised regarding saturation of hydrocarbons and water, especially in the core from hole No. 38. Although samples were selected and sealed in the field as soon as possible to eliminate fluid losses, new personnel on this test hole unfamiliar with sampling methods, combined with profuse bleeding of the core, may have resulted in considerable hydrocarbon losses on a number of the samples taken. In most cases, however, any live oil bleeding was not excessive and probably would not have been a major factor in the final fluid calculation results.

Unfortunately, no attempts could be made to produce or recover oil from any of the tests drilled. Enough oil, however, was recovered for an analysis from hole No. 20 while pulling the drilling string. This sample of oil was given to the Kansas Geological Survey, and a hydrocarbon analysis was run by G.W. James and reported by Ebanks (1977) in his report to DOE on the Kansas evaluation.

Characteristics of Cherokee oil in this area have been described and interpreted by Ebanks and James (1974) and Ebanks (1977). Results of group hydrocarbon analysis and hydrocarbon analysis of Cherokee oil sands in southeastern Kansas were reported and discussed thoroughly in Ebanks' DOE report. Briefly, Ebanks concluded that the content of bitumen present in the shallow Cherokee oil sands is moderately high, averaging about 70%, as compared to Athabasca oil sands that average about 50% hydrocarbon. Bitumen saturation, while low (1.6% average), from the three Kansas counties, was considerably higher (8 to 11%) in samples taken from surface quarries in Missouri. This compares to a reported 6 to 12% from major world oil sand deposits (Walters, 1974) and 8 to 18% for the so-called economic sands of the Athabasca Great Canadian Oil Sands operation (Allen and Sanford, 1973).

Estimation of Resource Base

The series of maps (figs. 6 through 9) display by shaded patterns "areas of known oil occurrence," which is based on thicknesses and oil content encountered during drilling. Data obtained from the test holes as to quality of oil shows and reservoir characteristics were projected to other wells within the immediate area on which reservoir data was vague to virtually non-existent. Factors such as type of sandstone, subsurface trends, structural considerations, reservoir characteristics, quality of the oil shows, and a lot of judgment were involved in estimating the sizes of these areas.

An attempt was made to arrive at two estimates. A conservative figure which would have a higher degree of certainty was achieved by calculating areal extent, average saturation, and thickness and then attributing the best estimate of barrels of oil per acre foot to the area and thickness. Obviously, estimations and projections of factors over even small areas may lead to erroneous quantities due to the erratic occurrence of oil within discontinuous sand bodies. A speculative maximum resource base figure that would have a lower reliability was calculated by extending or

TABLE 1

Core Analysis Data

Well	Samples	Footage	Porosity, % low-high	Saturation, % low-high	Oil Content, bbls/ac ft low-high	Permeability, md low-high
16	5	18	15.7-21.4	15-28	194- 341	1.7 - 34
17	10	24	18.6-23	20-44	335- 785	4.5 -346
20	4	6	22.6-25.1	49-55	859-1392	46. -239
26	4	5	18.1-21.6	3-18	50- 253	40. - 92
37	7	8	15.7-22.9	12-74	146-1318	2.3 -110
38	15	15	19.7-23.2	2-62	31-1039	1.6 -377
39	30	40	15.4-23.8	8-59	141- 764	.86-145

projecting the basic areas on the maps into areas of little or no control.

A total of 1,413.8 million barrels of oil is estimated to be in place within the sand intervals mapped. This is the "conservative" figure described above. The area involved is shaded on the maps.

An additional 489.6 million barrels were estimated in the speculative category. Areal extent in this additional category is not shown on the maps. A total of 1.9 billion barrels of oil, therefore, may exist within the study area, which is considerably lower than the 8.4 billion barrels of oil estimated by Wells in 1974, and dramatically lower than the 50 to 75 billion barrels that had been estimated in the early '70's.

Table 2 summarizes the areal extent of sand, areal extent of saturated sand, and the combined categories of barrels of oil in place for each of the four units mapped.

TABLE 2

Areal Extent of Sand, Saturated Sand, and Total Amount of Oil in Place from the Four Mapped Units

Unit	Areal Extent sand, (acres)	Areal Extent saturated sand, (acres)	Oil in Place, barrels
Upper Bluejacket	191,360	18,240	109,214,000
Lower Bluejacket	407,840	76,520	402,765,000
Upper Warner	881,960	101,680	1,165,139,000
Lower Warner	441,280	23,440	226,316,000
Totals	1,922,440	219,880	1,903,434,000

TABLE 3

Conservative Resource Base by Depth for Each Mapped Unit
(In Barrels)

Depth/Formation	0 to 50 feet	50 to 100 feet	100± feet	Total
Upper Bluejacket	28,608,000	23,012,000	17,900,000	69,520,000
Lower Bluejacket	163,306,000	64,980,000	82,872,000	311,158,000
Upper Warner	96,708,000	294,624,000	545,259,000	936,591,000
Lower Warner	---	7,290,000	89,260,000	96,550,000
Totals	288,622,000	389,906,000	735,291,000	1,413,819,000

Table 3 shows the complete breakdown of oil in the conservative category for each unit in the various depth ranges. Table 4 shows the amount of oil in the speculative category for each mapped unit at the same depth.

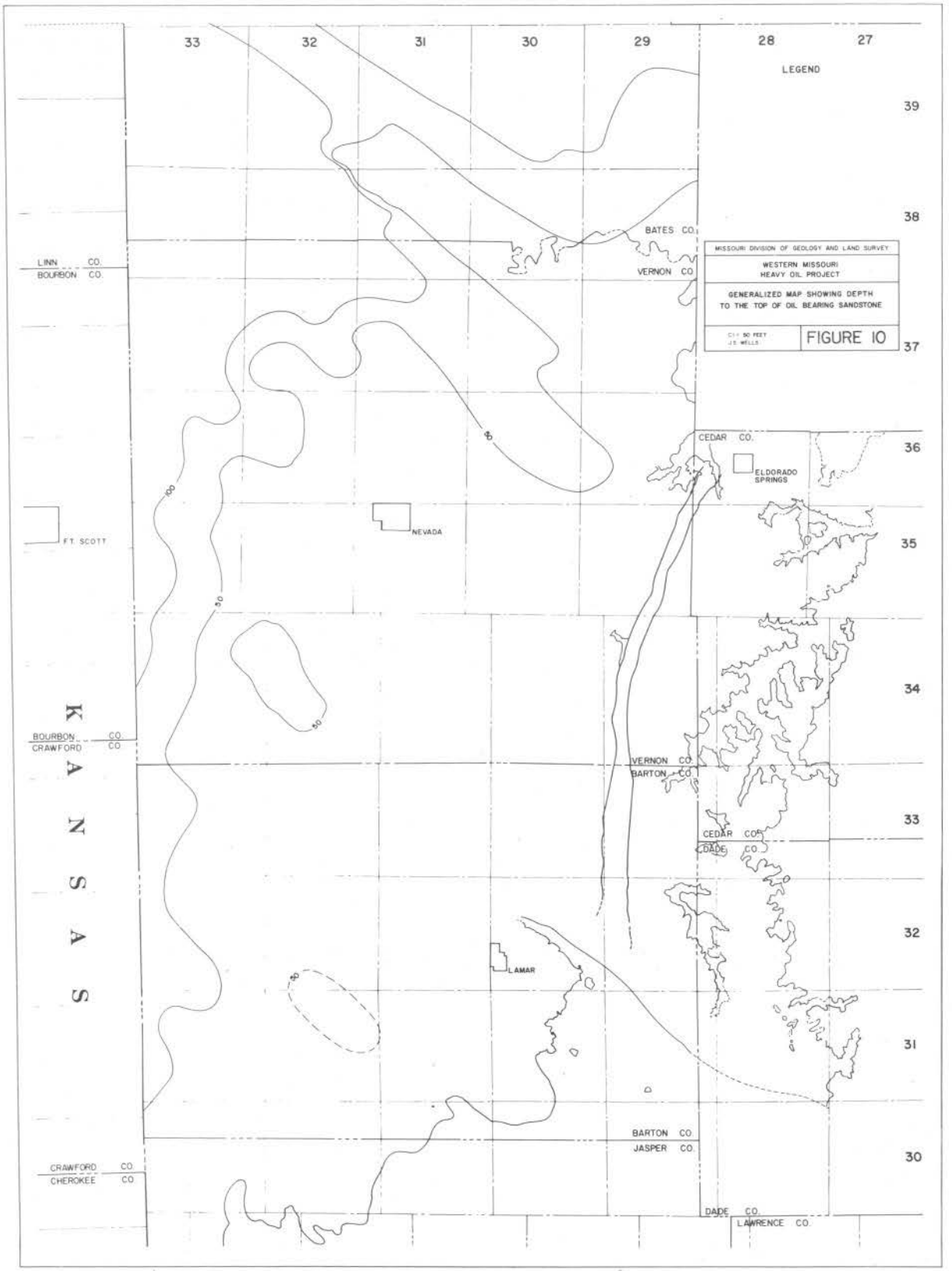
Of the four units mapped and included in the resource base estimates, the upper Warner interval is by far the most important, both in areal extent and amount of oil in place. The second most important unit is the lower Bluejacket.

By comparing various data it appears that the lower Bluejacket has a higher ratio of saturated sand, or sand in which some show occurred, to overall extent of sand. However, the "areal extent" of lower Bluejacket, as calculated, does not include the large area in eastern Vernon County where this unit was not mapped because it is exposed and partially removed by erosion.

TABLE 4

Speculative Resource Base by Depth for Each Mapped Unit
(In Barrels)

Depth/Formation	0 to 50 feet	50 to 100 feet	100± feet	Total
Upper Bluejacket	8,812,000	12,026,000	18,856,000	39,694,000
Lower Bluejacket	58,260,000	16,691,000	16,656,000	91,607,000
Upper Warner	25,036,000	148,300,000	55,212,000	228,548,000
Lower Warner	---	2,688,000	127,078,000	129,766,000
Totals	92,108,000	179,705,000	217,802,000	489,615,000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LEGEND
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BATES CO.
VERNON CO.
LINN CO.
BOURBON CO.
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
WESTERN MISSOURI
HEAVY OIL PROJECT
GENERALIZED MAP SHOWING DEPTH
TO THE TOP OF OIL BEARING SANDSTONE
FIGURE 10
CEDAR CO.
ELDORADO SPRINGS
FT. SCOTT
NEVADA
100
50
50
KANSAS
BOURBON CO.
CRAWFORD CO.
VERNON CO.
BARTON CO.
CEDAR CO.
DADE CO.
LAMAR
BARTON CO.
JASPER CO.
CRAWFORD CO.
CHEROKEE CO.
DADE CO.
LAWRENCE CO.

Strippable Resources

Figure 10 shows generalized areas in which depth to the top of various oil sands is 50 feet or less, 50 to 100 feet deep, and over 100 feet deep.

The amount of oil-in-place combining the "conservative" and "speculative" figures in those areas in which the depth to the top of the oil sands is less than 50 feet, is 20% of the total resource base of 1.9 billion barrels, or 380,730,000 barrels. Nearly 50%, or 949,341,000 of the 1.9-billion-barrel total, would be accounted for if the resource base within the area in which oil is encountered between 50 and 100 feet is added to the 50-foot or less figure.

In Missouri, it would appear that stripping operations to recover the heavy oil should be considered as an alternative method in the study area. In anticipation of and prior to this conclusion, it was suggested by the author that reclamation statutes in Missouri that cover stripping operations by commodity be revised to include these tar sand/heavy oil deposits. Legislation has subsequently been enacted whereby stripping operations for recovery of this commodity are now regulated by the Missouri Land Reclamation Commission.

Reserves

Within the study area, there are several small producing operations which have operated sporadically over the past several years. Sufficient data from which reserve figures could be calculated is practically non-existent; however, a possible reserve of between 5 and 10 million barrels of oil has been estimated by the author. This reserve estimate has not been included in the reported resource base figure.

Realistically, none of the 1.9-billion-barrel resource base can be considered in the reserve category at the present time. Considering the characteristics of the deposits (i.e. shallow depths, unpredictable occurrence, and often poor reservoir characteristics along with the relatively small areal extent of individual saturated sand occurrences) it may be that only a small percentage of this resource estimated to be present will ever become reserves.

Future drilling may delineate areas in which small-scale recovery operations are feasible. Economics and technology, however, remain the major factors in determining how much of this resource becomes a reserve.

SUMMARY AND CONCLUSIONS

The assessment of a heavy oil resource base available for the western Missouri area considered to contain the better heavy oil-sand deposits has been the basic objective of this project. Although a considerable quantity of subsurface data for the area was available in the log files of the Missouri Geological Survey, much of this data was either clustered in small areas or could not be evaluated for use in a study of this nature. The drilling of 39 test holes, of which 21 were complete core holes from grass roots to total depth, aided in the evaluation of existing data and in filling gaps in large areas where no data existed.

Unfortunately, due to the discontinuous nature of the various potential reservoir beds, 39 test holes scattered over an area of nearly 1.25 million acres would not thoroughly evaluate the potential of the area. However, with a good bit of interpolation, a series of maps showing the extent and thickness of four potential reservoir horizons was constructed. Shows of hydrocarbons were evaluated by selecting core samples for core analysis that would represent the various kinds and qualities of hydrocarbons most commonly encountered. Values obtained from core analysis were projected into areas where old well log data existed but could not be confirmed. Many of these old wells could be utilized at least to some extent in calculating a resource base figure.

The areas of hydrocarbon occurrences as portrayed on these maps, represent the author's interpretation of what would "most likely" be encountered in future drilling and was used in calculating the "conservative" resource base figure of 1.4 billion barrels. An extension of these basic areas of hydrocarbon occurrences resulted in an additional but less reliable or "speculative" 0.5 billion barrels of oil.

A total of 1.4 to 1.9 billion barrels of oil is therefore projected for an area previously estimated to contain from 8 billion to as much as 50 billion barrels of heavy oil. Of the 1.9 billion barrels calculated, 20% or 0.4 billion barrels is present in sands, the tops of which are less than 50 feet from the surface. The remaining 80% or 1.5 billion barrels occur at depths greater than 50 feet and would be recoverable by means other than stripping or mining methods.

None of the 1.9-billion-barrel resource base can be considered in a reserve category under economic and technological standards currently available. Estimated reserves of 5 to 10 million barrels in the study area have not been included in the base resource figure.

In general, the indicated amounts of oil resource may be disappointing to many in that this obviously is not a Midwestern Athabasca where large mining or in situ recovery plants could be operated. The study has shown that a considerable amount of oil does exist, but as small, irregularly distributed concentrations within discontinuous sandstone reservoirs. Future recovery operations will need to be designed to take into account the size and nature of occurrence of these deposits. Numerous examples exist illustrating the varying degrees of oil saturation and reservoir characteristics that may occur within a 40-acre plat. Therefore, a closely spaced core drilling program to outline a deposit and establish continuity of the reservoir and oil saturation within the reservoir should be undertaken before initiating any recovery project.

ACKNOWLEDGMENTS

The author acknowledges the generosity and cooperation of the Department of Energy in making funds available under Contract #EY-76-S-02-2996 for this project, and to Mr. Larman J. Heath, Technical Project Officer, Energy Technology Center, Bartlesville, Oklahoma, for his invaluable assistance and guidance.

Thanks are due to colleagues and co-workers for their help and suggestions, which made this report possible. W.J. Ebanks, Jr., John F. Roberts, Boyd R. Haley, and Richard Gentile provided valuable discussion and assistance. Department of Natural Resources staff geologists Charles Robertson, David Smith, and T.L. Thompson provided field assistance during the drilling of the core holes. Staff geologists K.H. Anderson and J.D. Vineyard, along with Kansas Survey geologist W.J. Ebanks, Jr., and University of Missouri—Kansas City, Professor of Geology, Richard J. Gentile, read the manuscript and suggested improvements. W.J. "Jerry" Monk, consulting geologist, was well-site geologist for many of the wells being drilled as was Dr. Gentile who also described all of the cores that were taken during this project.

Gary Clark and Billy Ross drafted the illustrations, Golda Roberts typed the preliminary manuscript, and Barbara Miller typeset the final copy.

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APPENDIX A

CORE ANALYSES

INDEX

DOE – TS #16

Sec. 9, Twp. 32N., Rge. 31W., Barton County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Upper Warner Sandstone							
1	42.7	15.7	28	47	75	341	1.7
2	46.2	16.3	24	51	75	304	2.3
3	57.1	21.4	18	55	73	299	34.
4	59.7	16.7	15	70	85	194	10.
5	61.0	19.4	22	64	86	331	17.

DOE – TS #17

Sec. 2, Twp. 33N., Rge. 31W., Barton County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Lower Bluejacket Sandstone							
1	23.0	19.6	30	63	93	456	10.
2	25.0	18.6	38	56	94	548	4.5
3	27.0	20.5	35	51	86	557	11.
4	29.0	20.4	22	64	86	348	8.7
5	34.5	21.8	23	61	84	389	11.
6	39.5	22.4	41	47	88	713	236.
7	41.0	23.0	44	47	91	785	231.
8	43.0	21.8	31	58	89	524	346.
9	45.0	21.0	22	71	93	359	113.
10	47.0	21.6	20	67	87	335	145.

DOE – TS #20

Sec. 5, Twp. 34N., Rge. 32W., Vernon County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Upper Bluejacket Sandstone							
1	79.5	22.6	49	40	89	859	46.
2	80.7	22.8	55	38	93	973	61.
3	83.0	25.1	55	25	80	1,071	184.
4	84.6	24.5	54	27	81	1,027	178.

DOE – TS #26

Sec. 11, Twp. 37N., Rge. 32W., Vernon County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Lower Bluejacket Sandstone							
1	97.2	21.6	4	53	57	67	92.
2	98.9	21.3	3	78	81	50	40.
3	100.5	21.4	10	76	86	166	70.
4	102.1	18.1	18	69	87	253	50.

DOE – TS #37

Sec. 16, Twp. 33N., Rge. 32W., Barton County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Upper Bluejacket Sandstone							
1	29.7	19.4	67	9	76	1,009	9.4
2	30.7	22.5	68	9	77	1,187	110.
3	32.3	22.9	74	3	77	1,318	20.
Lower Bluejacket Sandstone							
4	49.2	19.9	26	41	67	401	45.
5	52.1	15.7	12	69	81	146	2.3
6	53.4	19.8	15	69	84	230	101.
7	55.15	20.2	20	47	67	313	10.

DOE – TS #38

Sec. 6, Twp. 33N., Rge. 33W., Barton County

Sample No.	Depth, Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Lower Bluejacket Sandstone							
1	111.9	21.6	34	1	35	570	80.
2	112.9	21.2	27	39	66	444	118.
3	113.9	21.6	62	30	92	1,039	191.
4	115.1	20.3	50	28	78	786	132.
5	115.9	22.9	51	40	91	905	324.
6	116.9	21.0	62	25	87	1,010	377.
7	117.9	23.2	43	39	82	774	208.
8	118.5	21.5	53	29	82	883	277.
9	119.9	22.1	58	12	70	993	292.
10	120.9	20.9	42	3	45	680	119.
11	121.9	19.7	2	48	50	31	1.6
12	123.1	21.3	46	28	74	759	71.
13	124.6	19.9	44	21	65	679	37.
14	125.9	20.8	40	28	68	644	49.
15	127.0	21.0	28	42	70	456	26.

DOE – TS #39

Sec. 14, Twp. 32N., Rge. 33W., Barton County

Sample No.	Depth Feet	Effective Porosity Percent	Percent Saturation Oil	Water	Total	Oil Content Bbls./A Ft.	Perm., Mill.
Lower Bluejacket Sandstone							
1	27.7	18.0	43	41	84	601	75.
2	29.1	20.1	48	31	79	748	73.
3	30.5	17.8	53	20	73	731	32.
4	31.7	18.4	52	43	95	741	46.
5	33.0	16.7	59	9	68	764	0.86
Upper Warner Sandstone							
6	65.55	19.7	12	46	58	183	18.
7	65.85	16.8	18	57	75	234	19.
8	67.85	21.4	14	77	91	232	69.
9	69.4	20.6	16	79	95	256	145.
10	70.75	23.0	12	55	67	214	97.
11	71.9	23.4	9	61	70	163	107.
12	73.1	20.2	11	63	74	172	88.
13	74.1	23.8	8	51	59	148	75.
14	75.9	21.6	10	50	60	168	32.
15	77.1	20.2	10	49	59	157	19.
16	78.5	20.9	17	48	65	275	4.3
17	80.3	19.8	13	70	83	200	2.5
18	82.5	20.0	28	51	79	434	9.5
19	83.9	20.2	22	49	71	345	17.
20	85.5	18.3	38	39	77	539	19.
21	86.9	20.0	30	30	60	465	12.
22	88.1	19.7	24	50	74	366	9.4
23	89.8	15.4	16	59	75	191	2.0
24	91.0	18.5	17	46	63	244	11.0
25	92.9	19.1	9	56	65	134	24.
26	94.7	21.0	10	49	59	163	97.
27	96.8	20.2	9	73	82	141	25.
Lower Warner Sandstone							
28	151.55	17.6	24	9	33	328	2.6
29	152.7	19.0	30	10	40	443	3.6
30	154.2	17.9	28	10	38	390	2.7

APPENDIX B

WELL LOGS AND SAMPLE DESCRIPTIONS

INDEX

37	16-33N-32W	168
38	6-33N-33W	173
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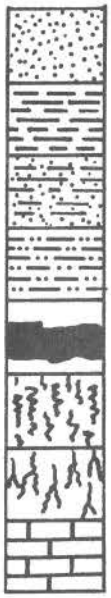
40	28-31N-33W	185

KEY TO SYMBOLS



sandstone

shale

sandy shale

siltstone

coal

underclay

root traces

limestone

pebbles, rounded

pebbles & cobbles, angular

calcareous sandstone

siderite nodules

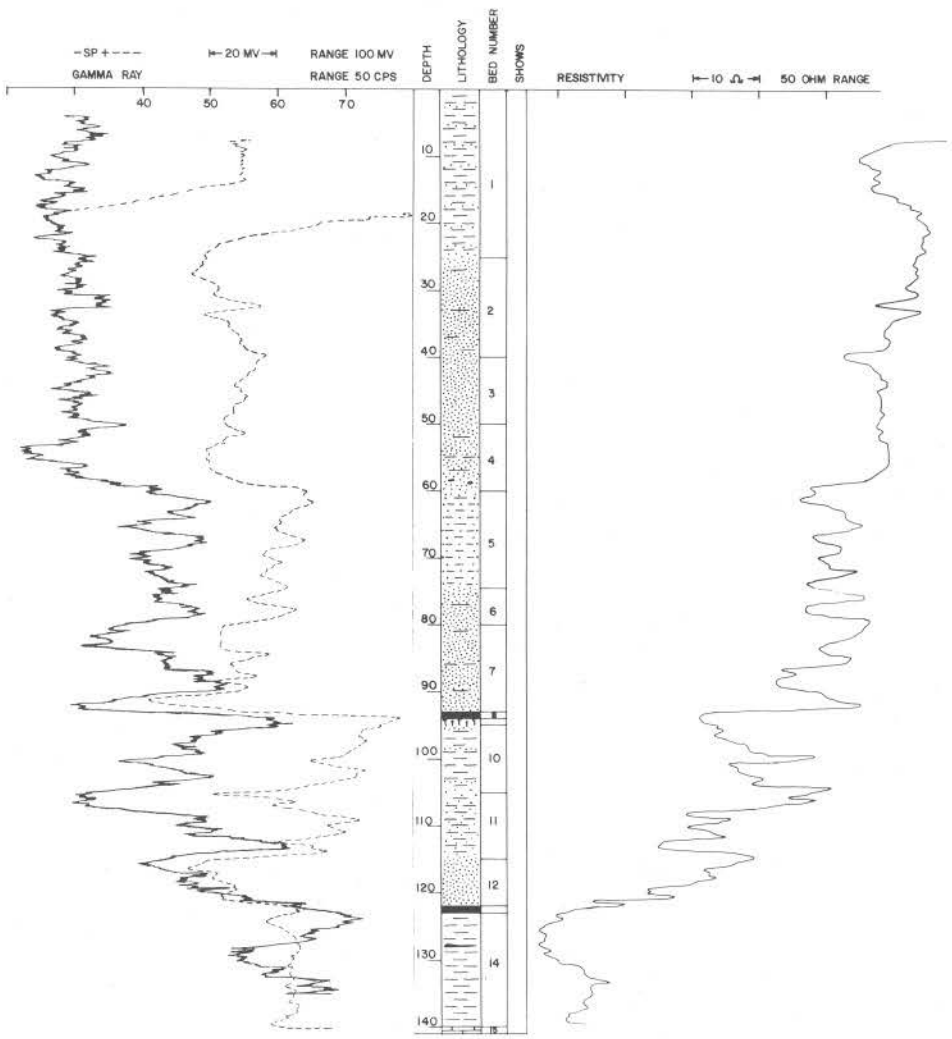
cross bedding

inclined & wavy bedding

no sample interval

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 1

Location: 2620' FSL & 2610' FWL, Sec. 11, T. 35 N., R. 30 W., Vernon County
Elevation: 868' Total Depth: 141'



DOE-TS - No. 1
"Slim hole" cuttings described and logged by Jack Wells
Location: 2620' FSL & 2610' FWL, Sec. 11, T. 35N., R. 30W., Vernon County

Elevation: 868' Total Depth: 141'

DEPTH		UNIT	DESCRIPTION
0.0	25.0	1	Soil - clay and sand, yellowish-brown.
25.0	40.0	2	Sandstone, yellowish-brown, very fine to fine, micaceous, dirty, clayey, loose.
40.0	50.0	3	Sandstone, tan to light gray, very fine to fine, micaceous, trace of siderite.
50.0	60.0	4	Sandstone, light gray, fine to medium-coarse, well consolidated, shaly to silty streaks in lower portion with occasional coal fragments.
60.0	75.0	5	Siltstone, light gray, shaly, with shale streaks, medium gray, silty, micaceous, siltstone grading downward to a very fine grain sandstone.
75.0	80.0	6	Sandstone, light gray, very fine to fine with some siltstone streaks, also still carrying some shale streaks as above.
80.0	93.0	7	Sandstone, light gray, very fine to fine, silty to shaly, micaceous, occasional black carbonaceous material.
93.0	94.0	8	Coal, black, shiny, some pyrite.
94.0	95.0	9	Underclay, light gray, soft, slick.
95.0	105.0	10	Shale, medium to dark gray, firm with occasional streaks of sandstone, white, very fine to fine, especially at 104' to 105'.
105.0	114.0	11	Shale, medium dark gray, very sandy, silty, micaceous.
114.0	122.0	12	Sandstone, light gray to white, very fine to fine, micaceous.
122.0	123.0	13	Coal, black, shiny.
123.0	140.0	14	Shale, dark gray to black, firm, trace of coal at 128'±.
140.0	141.0	15	Limestone, brown to tan, hard dense.

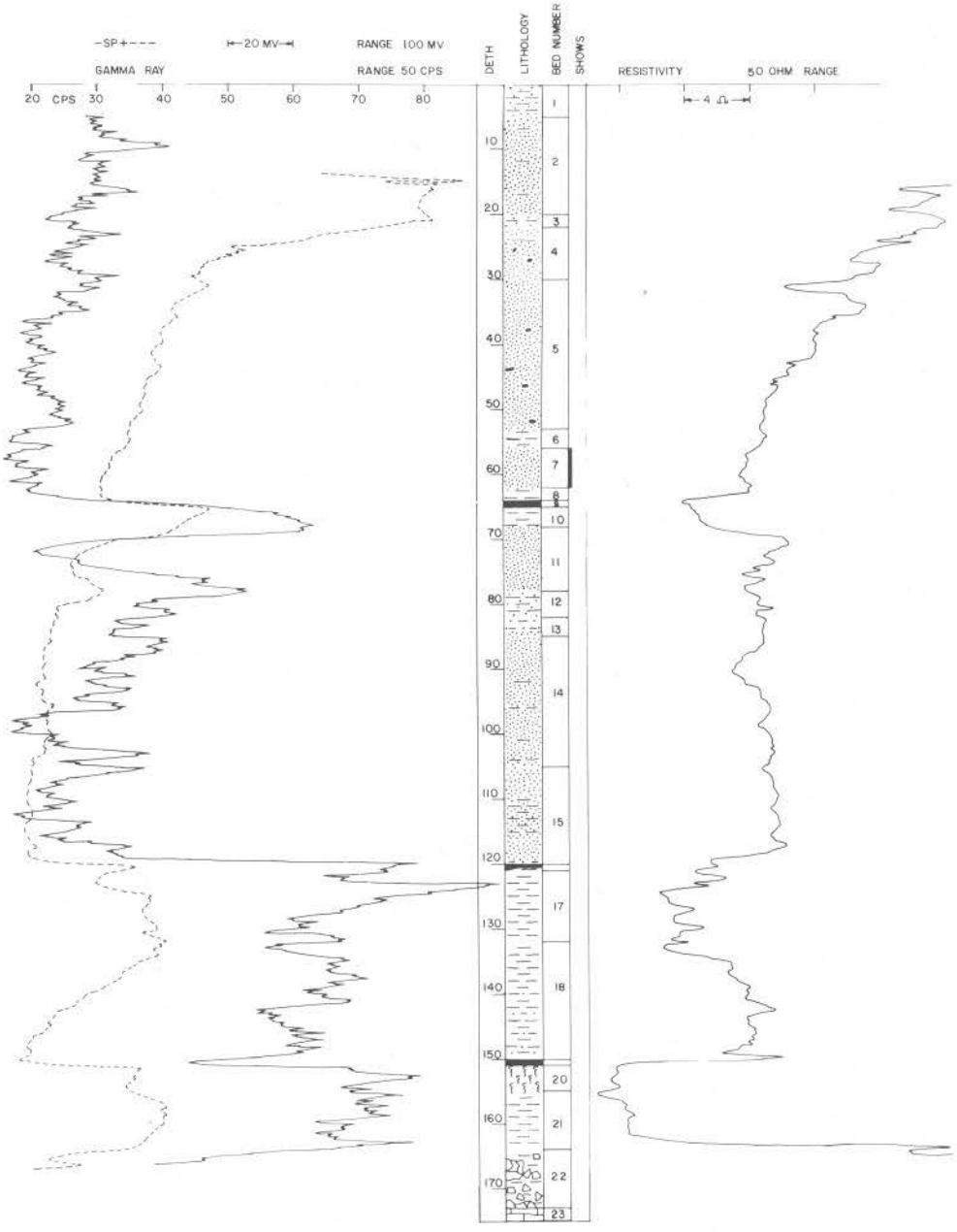
DOE-TS - No. 2
"Slim hole" cuttings described and logged by Jack Wells
Location: 2700' FSL & 60' FEL, Sec. 6, T. 34N., R. 30W., Vernon County

Elevation: 895' Total Depth: 175'

DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil and clay, brown to yellowish-brown, sandy.
5.0	20.0	2	Sand, yellowish-brown, loose, unconsolidated, dirty, clayey.
20.0	22.0	3	Shale, reddish-brown, hematitic, sandy.
22.0	30.0	4	Sandstone, brown, very fine to medium, dirty, shaly, hematitic, stained, black carbonates and coal fragments.
30.0	53.0	5	Sandstone, light gray, medium fine to medium coarse with occasional coal fragments, micaceous.
53.0	56.0	6	Shale, black, trace of coal, considerable siderite.
56.0	62.0	7	Sandstone, tan to brown, medium to coarse, dirty, considerable siderite and pyrite, trace dead oil stain.
62.0	64.0	8	Shale, medium to dark gray.
64.0	65.0	9	Coal, black, shiny, pyritic.
65.0	68.0	10	Shale, medium, greenish-gray, soft, slick.
68.0	78.0	11	Sandstone, white, very fine to fine, angular, tight, slightly micaceous, trace amounts of gilsonite as black shiny specks scattered throughout interval.
78.0	82.0	12	Shale, medium gray, very sandy and silty, micaceous, trace amount of coal.
82.0	85.0	13	Siltstone, light gray, very fine to fine, grades to very fine grain sandstone.
85.0	105.0	14	Sandstone, light gray to white, very fine, micaceous, silty in part with laminae of black carbonaceous material, some tan clayey material in interval 92' to 103', shale streaks at 104' to 105'.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 2

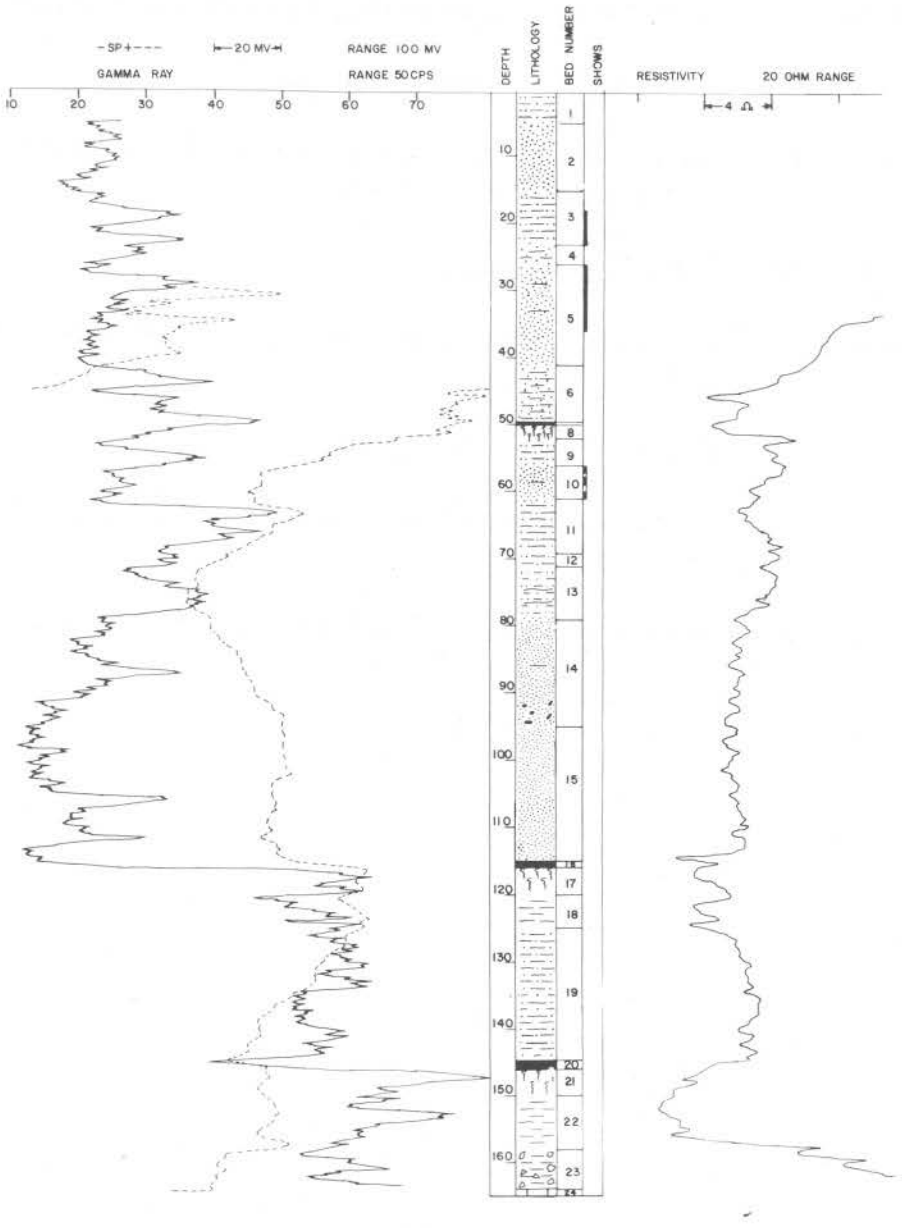
Location: 2700' FSL & FEL, Sec. 6, T. 34 N., R. 30 W., Vernon County
Elevation: 895' Total Depth: 175'



105.0	120.0	15	Sandstone, white, very fine to fine, clean except for hematite streaks at 112'± with tan clay-like shale in interval 110' to 115', unit becoming very fine to siltstone at 120'.
120.0	121.0	16	Coal, black, shiny, grading to black shale, smutty.
121.0	132.0	17	Shale, light grayish-green, slick, firm.
132.0	150.0	18	Shale, medium dark gray, firm becoming laminated with very fine siltstone at 140'.
150.0	151.0	19	Coal, black, shiny.
151.0	155.0	20	Underclay, tan to greenish-gray, grading downward to next unit.
155.0	164.0	21	Shale, black, firm, fissile.
164.0	173.0	22	Chert, mottled, white and brown with green, soft, shale-clay.
173.0	175.0	23	Limestone, tan, medium to coarse crystalline.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 3

Location: 2630' FSL & 220' FWL, Sec. 2, T. 34 N., R 31 W., Vernon County
Elevation: 922' Total Depth: 165'



DOE-TS - No. 3
"Slim hole" cuttings described and logged by Jack Wells
Location: 2630' FSL & 220' FWL, Sec. 2, T. 34N., R. 31W., Vernon County

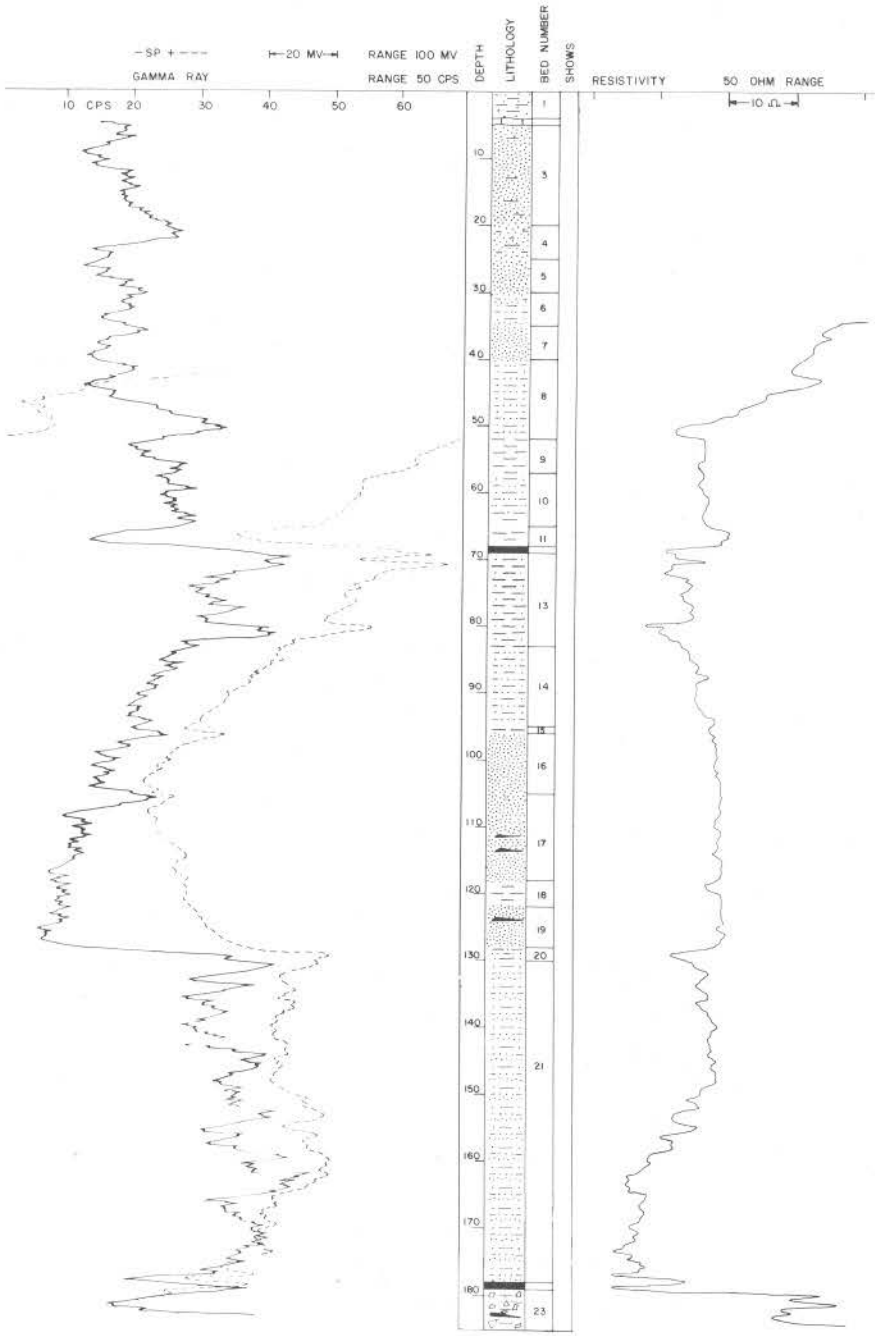
Elevation: 922' Total Depth: 165'

DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil and clay, brown, very silty.
5.0	15.0	2	Sandstone, brown, very fine to fine, loose, becoming harder at 15'.
15.0	23.0	3	Siltstone, brown with few gray streaks, very dirty to shaly, micaceous, slight dead oil stain in lower 5' of interval.
23.0	26.0	4	Shale, gray, sandy, silty with micaceous black carbonaceous laminae.
26.0	41.0	5	Sandstone, brown, very fine, very dirty to shaly, slight dead oil stain to 36' then sand becoming gray, very fine to fine, not as shaly or dirty.
41.0	49.5	6	Shale, light to medium gray, very silty, sandy, black, carbonaceous streaks with considerable siderite shot - especially at 45'±.
49.5	50.0	7	Coal, black, shiny, pyritic.
50.0	52.0	8	Underclay, light gray, soft, slick.
52.0	56.0	9	Siltstone, light gray, dirty to shaly, siderite shot.
56.0	61.0	10	Sandstone, gray, very fine to fine, very dirty and shaly, spotty dead oil stain.
61.0	69.0	11	Shale, light greenish-gray, silty, micaceous.
69.0	71.0	12	Shale, light greenish-gray, very silty, very micaceous.
71.0	79.0	13	Siltstone, light gray, micaceous, clean but with scattered thin carbonaceous laminae.
79.0	95.0	14	Sandstone, light gray to white, very fine to fine, silty in part, micaceous black carbonaceous specks scattered throughout, shale streak and trace of coal at 86', sand be-

			coming fine to medium coarse with abundant carbonaceous streaks and coal fragments in 90' to 95' interval.
95.0	115.0	15	Sandstone, white, medium fine to medium, micaceous, minor amounts of black carbonaceous material.
115.0	116.0	16	Coal, black, shiny.
116.0	120.0	17	Underclay, medium gray, soft, slick.
120.0	125.0	18	Shale, medium greenish-gray, firm, slick, occasional siderite shot.
125.0	144.5	19	Shale, medium to dark gray, firm, silty, with siltstone laminae appearing at approximately 135'.
144.5	146.0	20	Coal, black.
146.0	150.0	21	Underclay, medium brown to greenish-gray, slick.
150.0	158.0	22	Shale, smutty, hard, fissile.
158.0	164.0	23	Chert conglomerate, mottled, white and brown, in a bright green clay matrix.
164.0	165.0	24	Limestone, tan to brown, coarse crystalline.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 4

Location: 20' FSL & 200' FWL, Sec. 35, T. 34 N., R. 32 W., Vernon County
Elevation: 888' Total Depth 185'



DOE-TS No. 4
"Slim hole" cuttings described and logged by Jack Wells
Location: 20' FSL & 200' FWL, Sec. 35, T. 34N., R. 32W., Vernon County

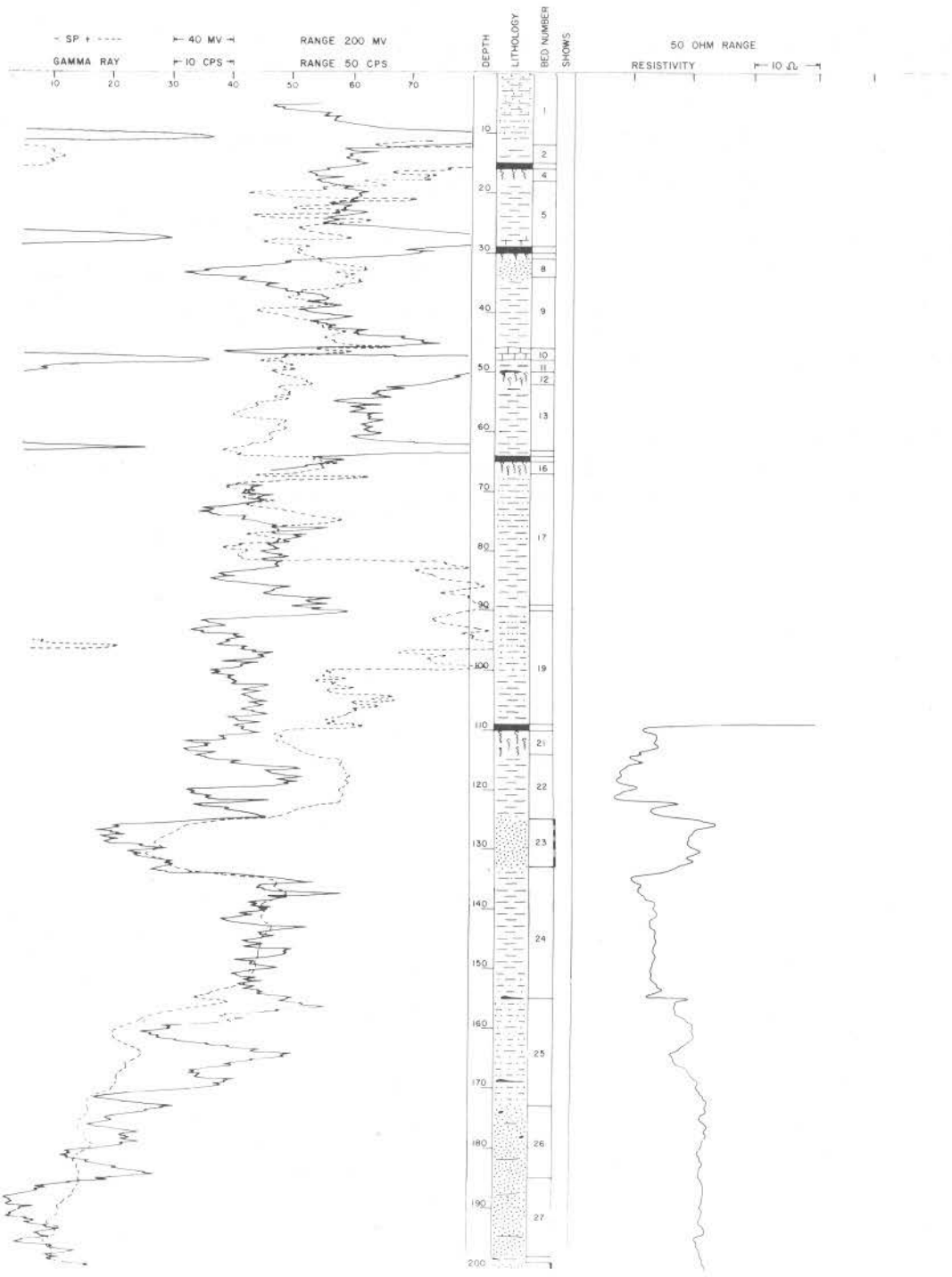
Elevation: 888' Total Depth: 185'

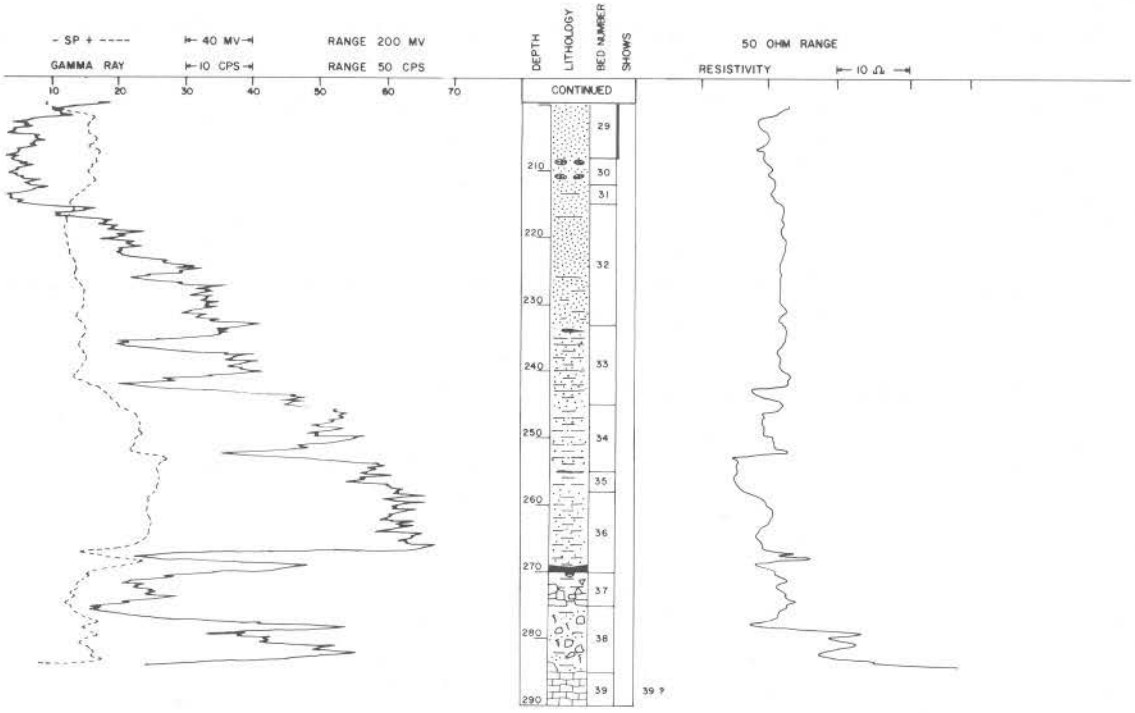
DEPTH		UNIT	DESCRIPTION
0.0	4.0	1	Soil and clay, yellowish-brown, sandy.
4.0	5.0	2	Limestone, brown, fine to medium, crystalline.
5.0	20.0	3	Sandstone, brown to light gray, very fine to fine, tight, dirty to shaly, occasional black carbonaceous streaks in lower portion.
20.0	25.0	4	Sandstone and siltstone, very fine, shaly, micaceous.
25.0	30.0	5	Sandstone, light gray, fine to medium fine, micaceous, occasional black carbonaceous specks.
30.0	35.0	6	Siltstone, light gray, very fine, shaly, occasional medium grained sandstone streaks.
35.0	40.0	7	Sandstone, light gray, very fine to medium fine, dirty, tight.
40.0	52.0	8	Siltstone, light gray, very dirty, shaly, tight.
52.0	57.0	9	Shale, light to medium grayish-green.
57.0	65.0	10	Siltstone, light gray, dirty to very shaly, becoming grayish-green shale at base of unit.
65.0	68.0	11	Shale, medium to dark gray, firm, considerable siderite shot.
68.0	69.0	12	Coal, black.
69.0	83.0	13	Shale, light grayish-green, silty, micaceous, grades downward into underlying unit.
83.0	95.0	14	Siltstone, light gray, very fine, shaly.
95.0	96.0	15	Shale, black, very carbonaceous, very micaceous.
96.0	105.0	16	Sandstone, light gray to tan, very fine to fine, hard, tight.

105.0	118.0	17	Sandstone, light gray, very fine to medium fine, micaceous, occasional black carbonaceous laminae, trace of coal in interval 110' to 115'.
118.0	122.0	18	Shale, light to medium greenish-gray.
122.0	128.0	19	Sandstone, white, very fine to medium, trace of coal in interval 120' to 125'.
128.0	130.0	20	Shale, dark gray, silty and with siltstone as laminae, siderite, trace of coal.
130.0	178.0	21	Shale, dark gray, silty, laminated with sandstone, light gray, fine to medium and with siltstone, light gray, sand and silt content average approximately 50 to 60 percent.
178.0	179.0	22	Coal, black, shiny, pyritic.
179.0	185.0	23	Chert, white and gray mottled with shale, dark gray and some bright green considerable coal in sample interval 180' to 185', coal streak at 183'.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 5

Location: 1450' FSL & 20' FEL, Sec. 29, T. 34 N., R. 32 W., Vernon County
Elevation: 925' Total Depth 290'





DOE-TS No. 5
"Slim hole" cuttings described and logged by Jack Wells
Location: 1450' FSL & 20' FEL, Sec. 29, T. 34N., R. 32W., Vernon County

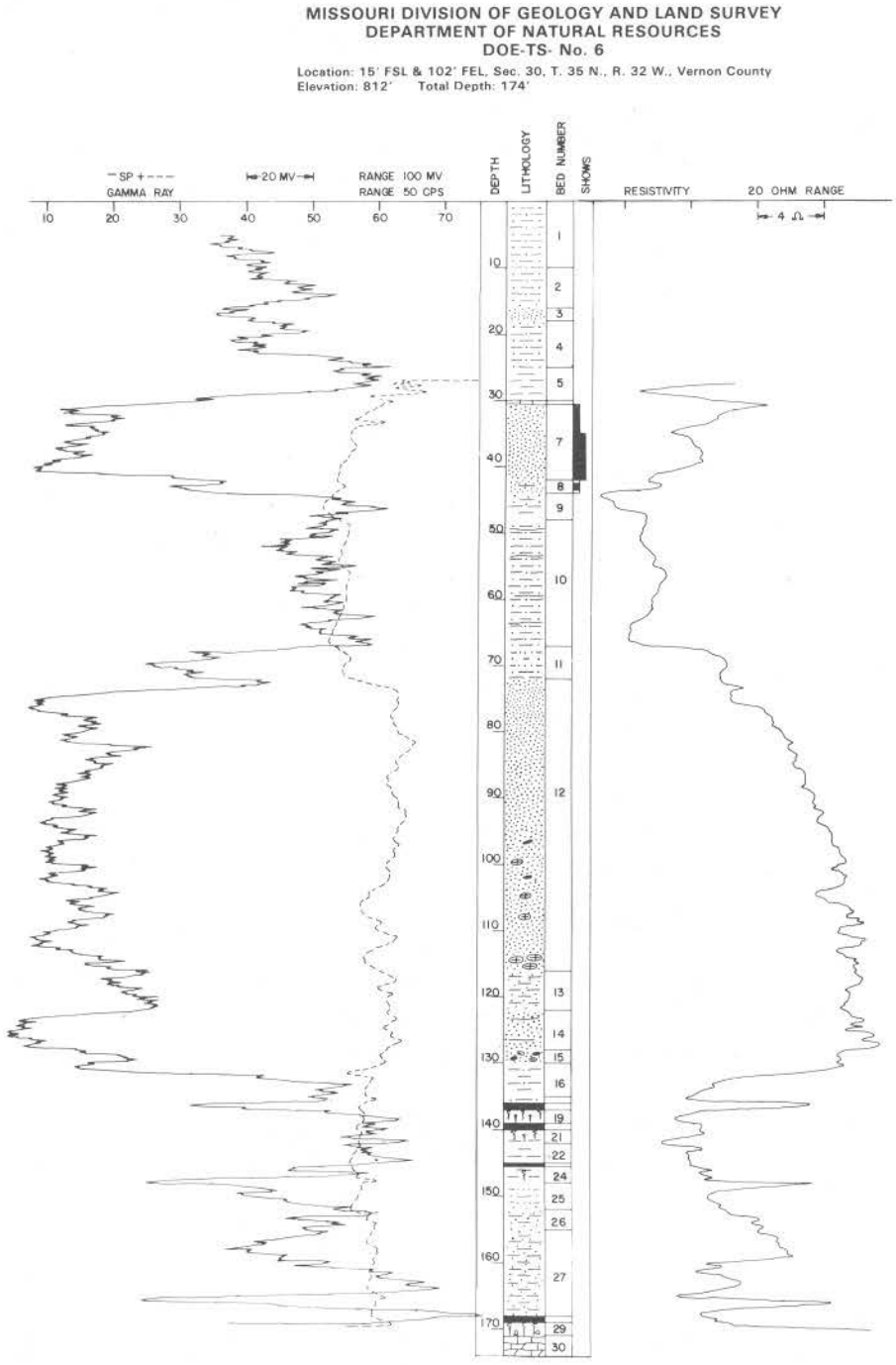
Elevation: 925' Total Depth: 290'

DEPTH		UNIT	DESCRIPTION
0.0	12.0	1	Soil and weathered Pennsylvanian, very sandy grading to very silty gray shale, yellow-brown.
12.0	15.0	2	Shale, black.
15.0	16.0	3	Coal, black, shiny.
16.0	18.0	4	Underclay, light gray, soft.
18.0	29.0	5	Shale, light green grading to light gray downward, trace of shaly fossiliferous limestone at 29'.

29.0	30.0	6	Coal, black, shiny.
30.0	31.0	7	Underclay, light gray, soft.
31.0	34.0	8	Sandstone, white, very fine to fine, micaceous, calcareous.
34.0	46.0	9	Shale, light to medium grayish-green, micaceous with siderite shot.
46.0	48.0	10	Limestone, brown, fine to medium crystalline.
48.0	50.0	11	Shale, medium grayish-green with siderite shot and pyrite, trace of coal at 50'.
50.0	52.0	12	Underclay, light gray, soft.
52.0	63.0	13	Shale, light to medium grayish-green, soft, slick.
63.0	64.0	14	Shale, black, soft, smutty.
64.0	65.0	15	Coal, black, shiny, considerable pyrite.
65.0	67.0	16	Underclay, light gray, soft, slick.
67.0	89.0	17	Shale, light grayish-green, soft, micaceous, slightly silty, some siderite shot, pyritic becoming non-silty in lower half of unit.
89.0	90.0	18	Shale, mottled, medium gray to green, soft, slick.
90.0	109.0	19	Shale, dark gray, with siltstone as fine laminae becoming less silty at 95'.
109.0	110.0	20	Coal.
110.0	114.0	21	Underclay, light gray, soft, slick, grading into next lower unit.
114.0	125.0	22	Shale, light grayish-green in top 2 feet grading into medium to dark greenish-gray shale with thin streak of black shale in lowermost part of interval.
125.0	133.0	23	Sandstone, light gray, very fine to medium, poor sorting, tight, very micaceous, with dead oil stain as gilsonite appearing as black, shiny specks disseminated throughout unit, giving a salt and pepper appearance to unit.

133.0	155.0	24	Shale, dark gray to light green, dark gray shale is silty and sandy, becoming mainly medium gray non-silty at 135'±, sand and siltstone laminae beginning again at 150' with a trace of coal at 155'.
155.0	173.0	25	Siltstone, light gray, clean to dirty (shaly) with scattered siderite shot, micaceous, occasional dark gray non-silty shale streaks, siltstone becoming cleaner at 165', trace coal in 165' to 170' interval.
173.0	185.0	26	Sandstone, light gray, very fine to fine, poorly sorted, shaly and very micaceous in finer grained portions, occasional black carbonaceous laminae and fragments of fusain.
185.0	198.0	27	Sandstone, white, very fine to fine, micaceous, cleaner than preceeding unit, occasional black carbonaceous streaks.
198.0	199.0	28	Shale, black, trace of coal.
199.0	208.0	29	Sandstone, light to medium gray, fine to medium fine, micaceous, trace of brown oil stain, shale and coal caving?.
208.0	212.0	30	Siderite, brown earthy with streaks of sandstone, light gray to black, carbonaceous, pyrite.
212.0	215.0	31	Sandstone, light to medium gray, fine to medium fine, micaceous with black carbonaceous streaks in bedding planes, trace of coal.
215.0	233.0	32	Sandstone, light gray to white, very fine to fine grained, micaceous, black carbonaceous specks and streaks especially along bedding planes, increasing downward to base of unit.
233.0	245.0	33	Shale, dark gray, very carbonaceous to micaceous, sandy with sandstone streaks, light gray to white, fine to medium, micaceous. Trace of coal.
245.0	255.0	34	Shale, dark gray, silty, micaceous with white fine to medium fine-grained sandstone laminae, trace of coal at 255'.
255.0	258.0	35	Shale, greenish-gray, slick with siderite shot.
258.0	270.0	36	Shale, dark to medium gray, sandy, silty, micaceous with coal, black, shiny at 269' to 270'±.
270.0	275.0	37	Chert, white to mottled blue and white with shale, dark gray.

275.0	285.0	38	Chert, as above with clay and shale, green sandy.
285.0	290.0	39	Limestone, brown, medium to medium coarse, crystalline, fossiliferous, Salem Formation?.



DOE-TS No. 6
"Slim hole" cuttings described and logged by Jack Wells
Location: 15' FSL & 102' FEL, Sec. 30, T. 35N., R. 32W., Vernon County

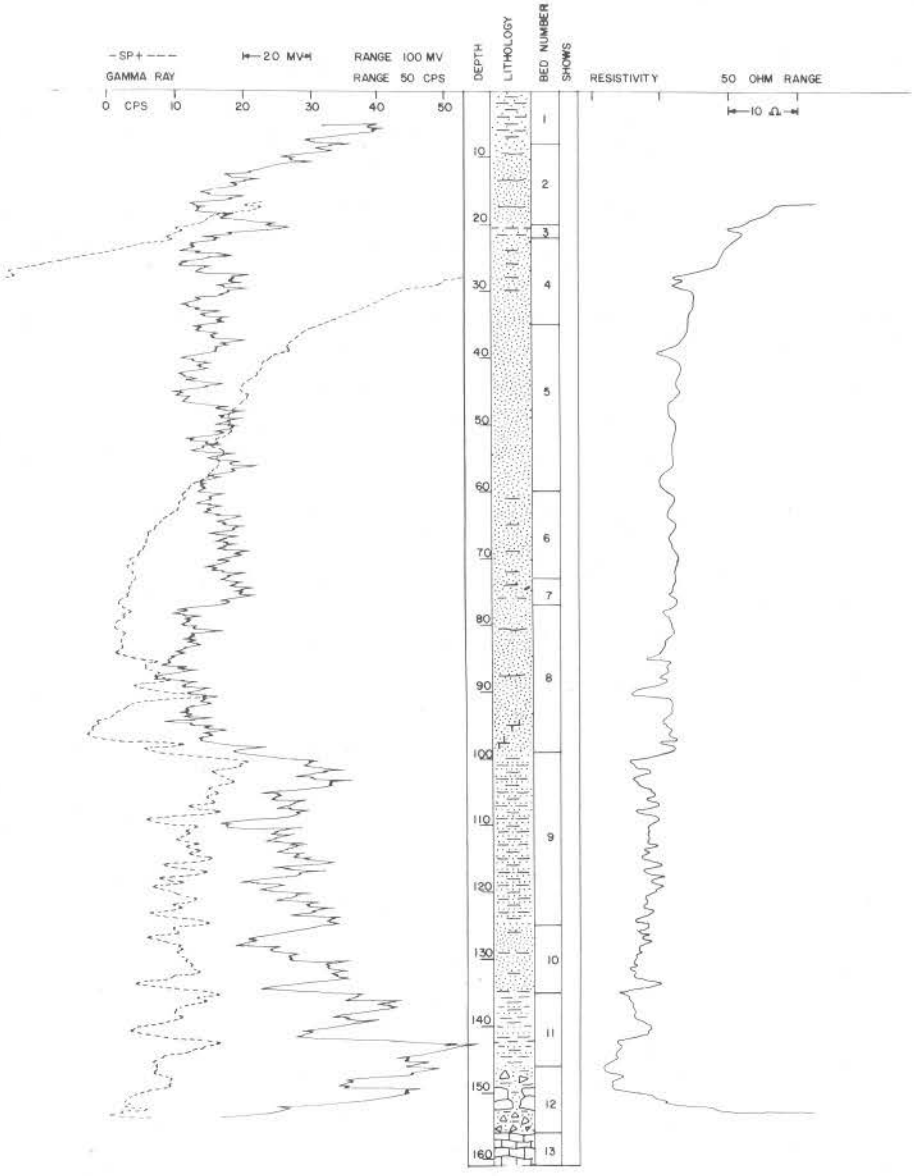
Elevation: 812' Total Depth: 174'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and clay, brown, silty.
10.0	16.0	2	Shale, medium gray, silty, micaceous.
16.0	18.0	3	Sandstone, white, very fine to fine, siderite.
18.0	25.0	4	Shale, greenish-gray, very silty, micaceous, siderite shot scattered throughout.
25.0	30.0	5	Shale, medium to dark gray, soft, slick, slightly micaceous.
30.0	30.5	6	Limestone, brown, fine to medium crystalline, fossiliferous.
30.5	42.0	7	Sandstone, gray to brown, very fine, dirty to medium grained and clean, heavy oil stain in the finer grained sands becoming completely saturated at 35'.
42.0	44.0	8	Sandstone, gray, fine to medium coarse, very shaly to dirty with spotty dead oil.
44.0	48.0	9	Shale, medium grayish-green, sandy in upper portion with considerable siderite shot.
48.0	67.0	10	Shale, medium to dark gray, silty, with considerable black carbonaceous material and silt as laminae.
67.0	72.0	11	Siltstone, light gray, shaly, some siderite shot becoming very shaly at about 71'.
72.0	116.0	12	Sandstone, white, very fine to fine, micaceous, pyritic, becoming fine to medium from approximately 95' with considerable mica and occasional coal fragments, minor amounts of dense brown siderite at 100', 105' and 108', considerable amounts of siderite at 114' to 116' interval.
116.0	122.0	13	Shale, medium gray, very sandy and micaceous, considerable carbonaceous material, unit containing sandstone laminae - 25 to 40 percent.

122.0	128.0	14	Sandstone, white, very fine to fine, micaceous with dark carbonaceous material as thin laminae.
128.0	130.0	15	Sandstone, conglomerate of clay ironstone pebbles and coal fragments, occasional very coarse quartz grains.
130.0	135.0	16	Shale, dark gray to black, slightly silty.
135.0	136.0	17	Shale, dark gray, very silty and micaceous, trace of siderite and coal, black, shiny at approximately 136'.
136.0	137.0	18	Coal, black, shiny.
137.0	139.0	19	Underclay, light greenish-gray, soft, slick.
139.0	140.0	20	Coal, black, shiny.
140.0	142.0	21	Underclay, grading downward into shale.
142.0	145.0	22	Shale, dark gray to black, firm, slick.
145.0	145.5	23	Coal, black, shiny.
145.5	148.0	24	Shale, gray, soft, slick, underclay?.
148.0	152.0	25	Siltstone, light green, very shaly.
152.0	155.0	26	Shale, medium grayish-green, sandy, silty, siderite shot.
155.0	168.0	27	Shale, medium dark gray, very sandy, silty, micaceous.
168.0	169.0	28	Coal, black, shiny, pyritic.
169.0	171.0	29	Underclay, tan to grayish-green, with trace of chert, white 170' to 171'.
171.0	174.0	30	Limestone, tan, fine to medium crystalline, grading to dolomitic limestone, tan, fine grained to sucrosic.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 8

Location: 1400' FSL & 50' FWL, Sec. 32, T. 35 N., R. 32 W., Vernon County
Elevation: 845' Total Depth: 161'



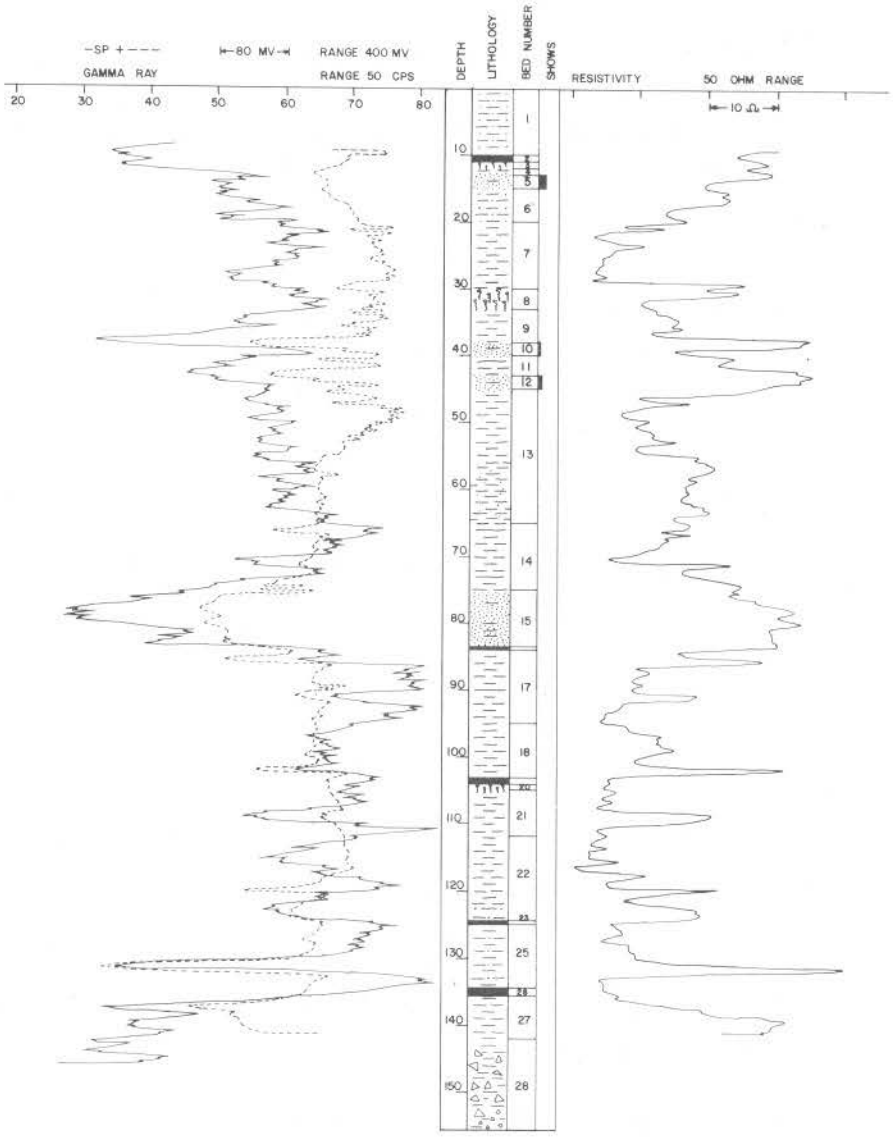
DOE-TS - No. 8
"Slim hole" cuttings described and logged by Jack Wells
Location: 1400' FSL & 50' FWL, Sec. 32, T. 35N., R. 32W., Vernon County

Elevation: 845' Total Depth: 161'

DEPTH		UNIT	DESCRIPTION
0.0	8.0	1	Soil, brown and clay, reddish-brown, silty, sandy.
8.0	20.0	2	Sandstone, brown with gray streaks, very fine to fine, micaceous, considerable black carbonaceous material, tight.
20.0	22.0	3	Shale, medium gray, very silty to sandy, micaceous.
22.0	35.0	4	Sandstone, medium to light gray, very fine to fine, very micaceous, shaly to dirty and tight in upper 8' becoming cleaner at 30' with fair porosity.
35.0	60.0	5	Sandstone, light gray to white, fine to medium, clean, loose, slightly micaceous.
60.0	73.0	6	Sandstone, light gray to white, fine to medium, white clay-like matrix, well consolidated.
73.0	77.0	7	Sandstone as above, shaly with siderite and coal fragments.
77.0	99.0	8	Sandstone, light gray to white, fine to medium, micaceous, occasional black carbonaceous material, coal fragments increasing in amount downward from 85', sand becoming coarser and calcareous at 95' with pyrite and siderite common from 95' to 99'.
99.0	125.0	9	Shale, medium to gray, silty, micaceous with interlaminated sandstone, white, very fine to fine, approximate amounts equal 50 percent shale and 50 percent sandstone.
125.0	135.0	10	Shale and sandstone as above but approximately 75 percent sandstone and 25 percent shale.
135.0	146.0	11	Shale, medium gray, firm, micaceous, with siltstone and sandstone laminae.
146.0	156.0	12	Conglomerate of chert, white and tan mottled in a tan to light gray slick, sandy clay matrix, considerable pyrite, clay becoming predominately bright green at 150'.
156.0	161.0	13	Limestone, brown, medium to coarse crystalline.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 9

Location: 19' FNL & 1050' FWL, Sec. 25, T. 33 N., R. 33 W., Barton County
Elevation: 889' Total Depth: 155.8'



DOE-TS - No. 9
"Slim hole" cuttings described and logged by Jack Wells
Location: 19' FNL & 1050' FWL, Sec. 25, T. 33N., R. 33W., Barton County

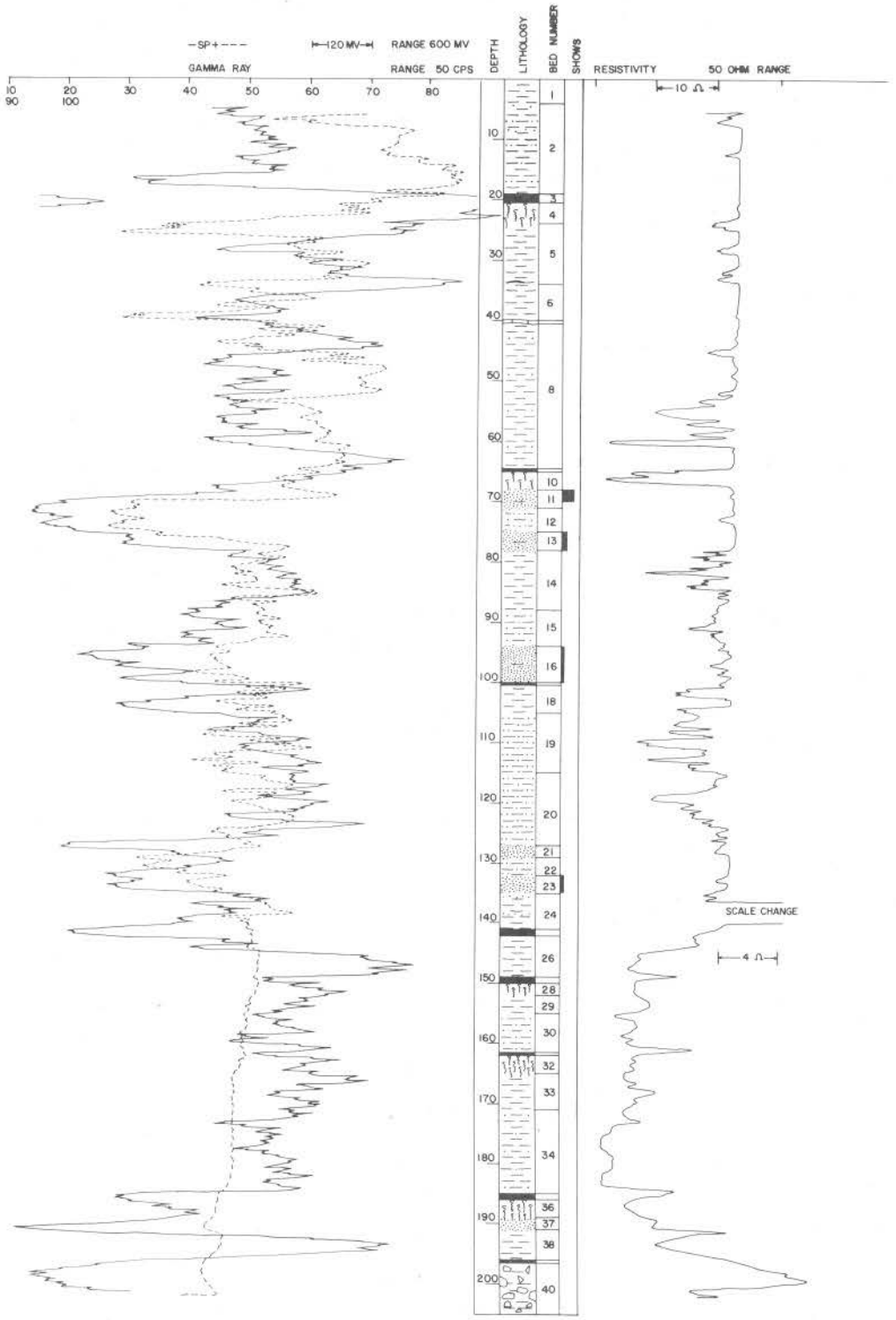
Elevation: 889' topo Total Depth: 155.8'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and clay, yellow-brown, silty with a few streaks of weathered shale.
10.0	11.0	2	Coal, weathered.
11.0	12.0	3	Underclay, weathered, brown.
12.0	13.0	4	Shale, brown, silty, weathered.
13.0	15.0	5	Sandstone, brown, very fine to fine, silty, clayey, micaceous, dead oil stained.
15.0	20.0	6	Shale, light to medium greenish-gray, silty, micaceous.
20.0	30.0	7	Shale, medium to dark gray, slightly micaceous, considerable siderite.
30.0	33.0	8	Underclay, medium gray, soft, slick.
33.0	38.0	9	Shale, medium gray, soft, slick, micaceous.
38.0	40.0	10	Sandstone, dark gray, very fine to fine, dirty to shaly, trace dead oil stain.
40.0	43.0	11	Shale, light grayish-green, slick, slightly micaceous, trace of coal at 41'±.
43.0	45.0	12	Sandstone, dark gray, very fine to fine, dirty to shaly, trace dead oil stain.
45.0	65.0	13	Shale, dark gray to black, firm, fissile, siderite, shale becoming silty and sandy at 55', very carbonaceous and smutty 60' to 65'.
65.0	75.0	14	Shale, medium greenish-gray, soft, slick, trace of coal at 66' and at 73'.

75.0	83.5	15	Sandstone, gray, very fine to fine, dirty to very shaly, especially at 80' to 83', siderite abundant.
83.5	84.0	16	Coal, bright.
84.0	95.0	17	Shale, medium greenish-gray to grayish-green, soft, slick, trace of coal at 90'.
95.0	103.0	18	Shale, medium grayish-green and dark gray laminated, pyritic siderite shot scattered throughout.
103.0	104.0	19	Coal, black.
104.0	105.0	20	Underclay, grayish-green, soft, slick.
105.0	112.0	21	Shale, medium gray to tan, soft, slick.
112.0	122.0	22	Shale, medium dark gray, firm fissile.
122.0	124.5	23	Shale, light greenish-gray, silty.
124.5	125.0	24	Coal.
125.0	134.5	25	Shale, medium to dark gray, slightly silty, micaceous.
134.5	135.5	26	Coal.
135.5	142.0	27	Shale, dark gray to black, firm.
142.0	155.8	28	Chert conglomerate, white and blue mottled, angular chert cobbles in a bright green shale-clay matrix.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 10

Location: 15' FNL & 105' FWL, Sec. 20, T. 33 N., R. 33 W., Barton County
Elevation: 868' Total Depth: 205'



DOE-TS - No. 10
"Slim hole" cuttings described and logged by Jack Wells
Location: 15' FNL & 105' FWL, Sec. 20, T. 33N., R. 33W., Barton County

Elevation: 868' Total Depth: 205'

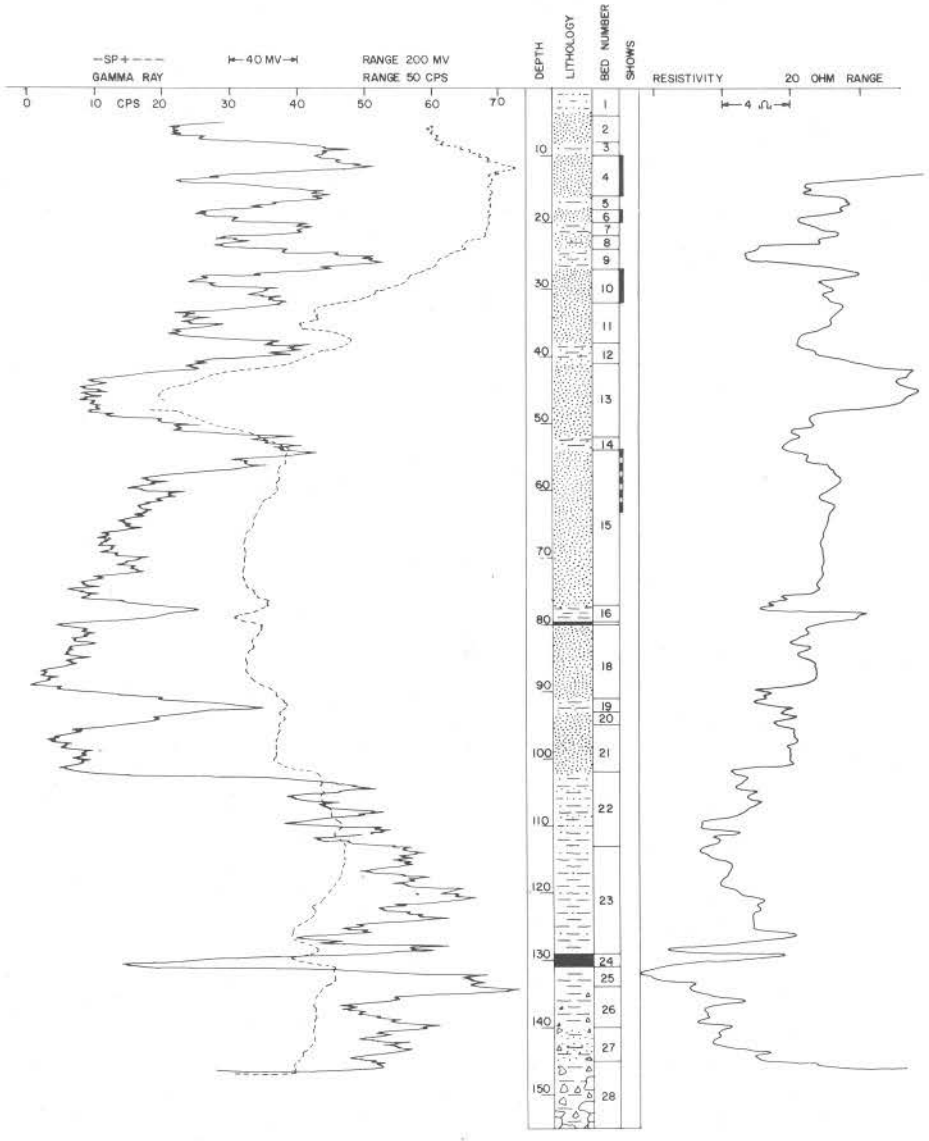
DEPTH		UNIT	DESCRIPTION
0.0	4.0	1	Soil and clay, reddish-brown.
4.0	19.0	2	Shale, light gray with reddish-brown oxidized zones, sandy, silty, micaceous, grading downward to light greenish-gray, occasional siderite and hematite nodules.
19.0	20.5	3	Coal, black.
20.5	24.0	4	Underclay, light gray, soft, slick.
24.0	34.0	5	Shale, medium gray to light grayish-green, firm, slick, with siderite shot scattered throughout, trace of coal at 34'.
34.0	40.0	6	Shale, medium greenish-gray, firm, slick.
40.0	40.5	7	Limestone, dark brown to black, fine to dense, shaly.
40.5	64.5	8	Shale, dark gray, slightly silty, micaceous, considerable siderite, few laminae of siltstone.
64.5	65.0	9	Coal.
65.0	68.0	10	Underclay, light to medium gray, soft, slick.
68.0	71.0	11	Sandstone, brown, very fine to fine, silty to clayey, saturated with dark brown to black heavy oil.
71.0	75.0	12	Siltstone, light gray, hard, with few black shale streaks.
75.0	78.0	13	Sandstone, gray to brown, very fine to medium fine, silty and clayey, micaceous, slight dead oil stain.
78.0	88.0	14	Shale, light gray, soft, gummy, grading downward to medium to dark gray, firm shale.
88.0	94.0	15	Shale, light greenish-gray, soft, sandy, silty, micaceous, grading downward to next unit.

94.0	100.0	16	Sandstone, light gray, very fine to medium fine, micaceous, silty to clayey, slight dead oil stain.
100.0	100.3	17	Coal, trace amounts.
100.3	105.0	18	Shale, light grayish-green, soft, slick.
105.0	115.0	19	Shale, black, hard, very silty, micaceous, trace of shaly black limestone at 108'.
115.0	127.0	20	Shale, light gray, soft, very silty, micaceous becoming medium gray with considerable black carbonaceous material.
127.0	129.0	21	Sandstone, light gray, very fine to medium fine, micaceous.
129.0	132.0	22	Shale, medium gray, firm, slightly silty, micaceous.
132.0	135.0	23	Sandstone, light to medium gray, very fine to medium fine, micaceous, dirty, slight dead oil stain.
135.0	141.0	24	Shale, medium gray, firm, slightly silty, micaceous with occasional sandstone laminae or streaks.
141.0	142.0	25	Coal, black, shiny.
142.0	149.0	26	Shale, medium gray to tan, slick, with occasional black carbonaceous material.
149.0	150.0	27	Coal, black, shiny, pyritic.
150.0	152.0	28	Underclay, light to medium gray, grades downward into underlying unit.
152.0	155.0	29	Shale, medium gray, firm, slick.
155.0	161.5	30	Shale, dark gray to black, silty, micaceous, pyritic.
161.5	162.0	31	Coal, black, shiny, pyritic.
162.0	165.0	32	Underclay, tan to medium green, soft, slick.
165.0	171.0	33	Shale, medium to light gray, firm, slick with siderite shot throughout.
171.0	185.0	34	Shale, dark gray to black, slightly silty, micaceous, pyritic and occasional siderite nodules or streaks.

185.0	186.0	35	Coal, black, shiny, pyritic.
186.0	189.0	36	Underclay, tan, soft, slick.
189.0	191.0	37	Sandstone, light gray, fine to medium fine.
191.0	196.0	38	Shale, black, slick, firm.
196.0	196.5	39	Coal, black, shiny.
196.5	205.0	40	Conglomerate of chert, white with blue and brown mottling in a matrix of clay - tan to light grayish-green.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 11

Location: 2700' FSL & 27' FWL, Sec. 13, T. 33 N., R. 32 W., Barton County
Elevation: 922' Total Depth: 155'



DOE-TS - No. 11
"Slim hole" cuttings described and logged by Jack Wells
Location: 2700' FSL & 27' FWL, Sec. 13, T. 33N., R. 32W., Barton County

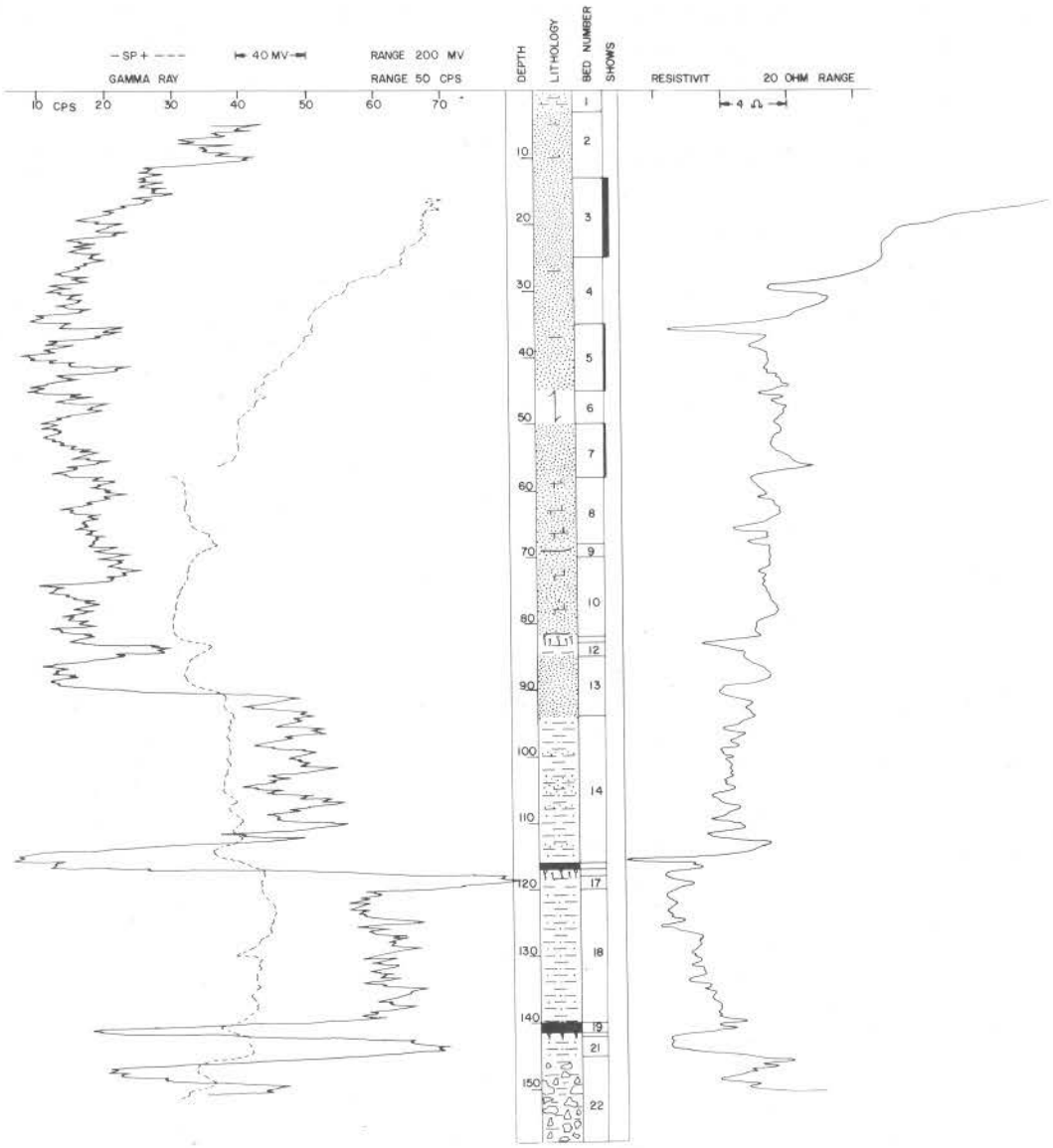
Elevation: 922' Total Depth: 155'

DEPTH		UNIT	DESCRIPTION
0.0	4.0	1	Soil and siltstone, brown, weathered.
4.0	8.0	2	Sandstone, tan to brown, very fine to fine, weathered, micaceous.
8.0	10.0	3	Shale, medium gray, silty, micaceous.
10.0	16.0	4	Sandstone, gray, very fine to fine, considerable amount of black shiny, solid, tar-like (gilsonite) material scattered throughout giving the sandstone a salt and pepper appearance.
16.0	18.0	5	Shale, medium gray, silty, micaceous.
18.0	20.0	6	Sandstone, brown, fine to medium fine, weathered hematitic clay material cementing sandstone, some gilsonite material scattered throughout.
20.0	22.0	7	Shale, medium to light gray, micaceous, silty, sandy to very sandy, appears to grade downward to a dirty sandstone.
22.0	24.0	8	Sandstone, light gray, very fine to medium fine, very shaly, dirty, tight, some black carbonaceous material.
24.0	27.0	9	Shale, medium gray, sandy, silty, micaceous.
27.0	32.0	10	Sandstone, medium to light gray, very fine to fine, contains considerable black, shiny gilsonite throughout and other black carbonaceous material.
32.0	38.0	11	Sandstone, gray, fine to medium fine, micaceous, trace amounts of carbonaceous material.
38.0	41.0	12	Shale, medium gray, very sandy, silty with occasional black carbonaceous laminae.
41.0	52.0	13	Sandstone, medium gray to tan, fine to medium, tan sandstone is calcareous.

52.0	54.0	14	Shale, medium gray, sandy, silty, micaceous.
54.0	77.0	15	Sandstone, medium gray, fine to medium coarse, fair porosity, trace amounts of dead oil stain in upper portion remainder has minor amounts of gilsonite as disseminated black shiny specks, occasional coal fragments in lower portion, grain size increasing downward, friable.
77.0	79.5	16	Shale, light green, with considerable siderite and pyrite.
79.5	80.0	17	Coal.
80.0	91.0	18	Sandstone, light gray to white, fine to medium fine, well consolidated, pyritic, some black carbonaceous material, becoming medium fine to coarse and friable at 85', good to excellent visual porosity.
91.0	93.0	19	Shale, medium gray, sandy and silty.
93.0	95.0	20	Sandstone, light gray to white, fine to medium fine, micaceous, well consolidated, tight to fair porosity, minor amounts of carbonaceous material.
95.0	102.0	21	Sandstone, light gray to white, medium to coarse, considerable black carbonaceous material, micaceous, pyritic, good porosity.
102.0	113.0	22	Shale, medium to dark gray, micaceous, slightly silty with occasional laminae of sandstone and siltstone.
113.0	129.0	23	Shale, dark gray to black, micaceous, slightly silty.
129.0	131.0	24	Coal.
131.0	134.0	25	Shale, dark gray to black, siderite.
134.0	140.0	26	Shale, dark gray to black with chert pebbles.
140.0	145.0	27	Shale, medium gray to tan, very sandy with chert pebbles.
145.0	155.0	28	Conglomerate of chert, mottled white and tan, in a tan and green, slick clay matrix.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 12

Location: 15' FNL & 2700' FEL, Sec. 35, T. 33 N., R. 32 W., Barton County
Elevation: 942' Total Depth: 158'



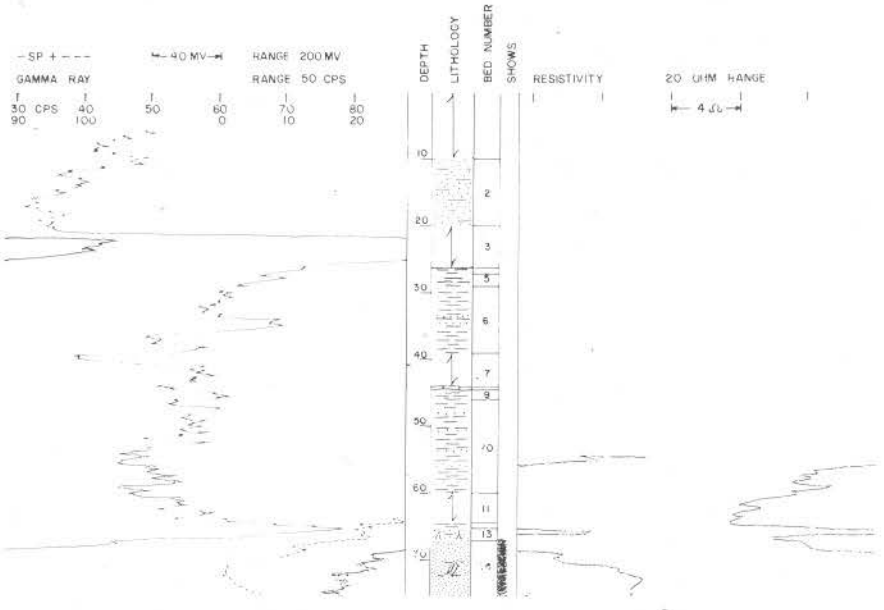
DOE-TS - No. 12
"Slim hole" cuttings described and logged by Jack Wells
Location: 15' FNL & 2700' FEL, Sec. 35, T. 33N., R. 32W., Barton County

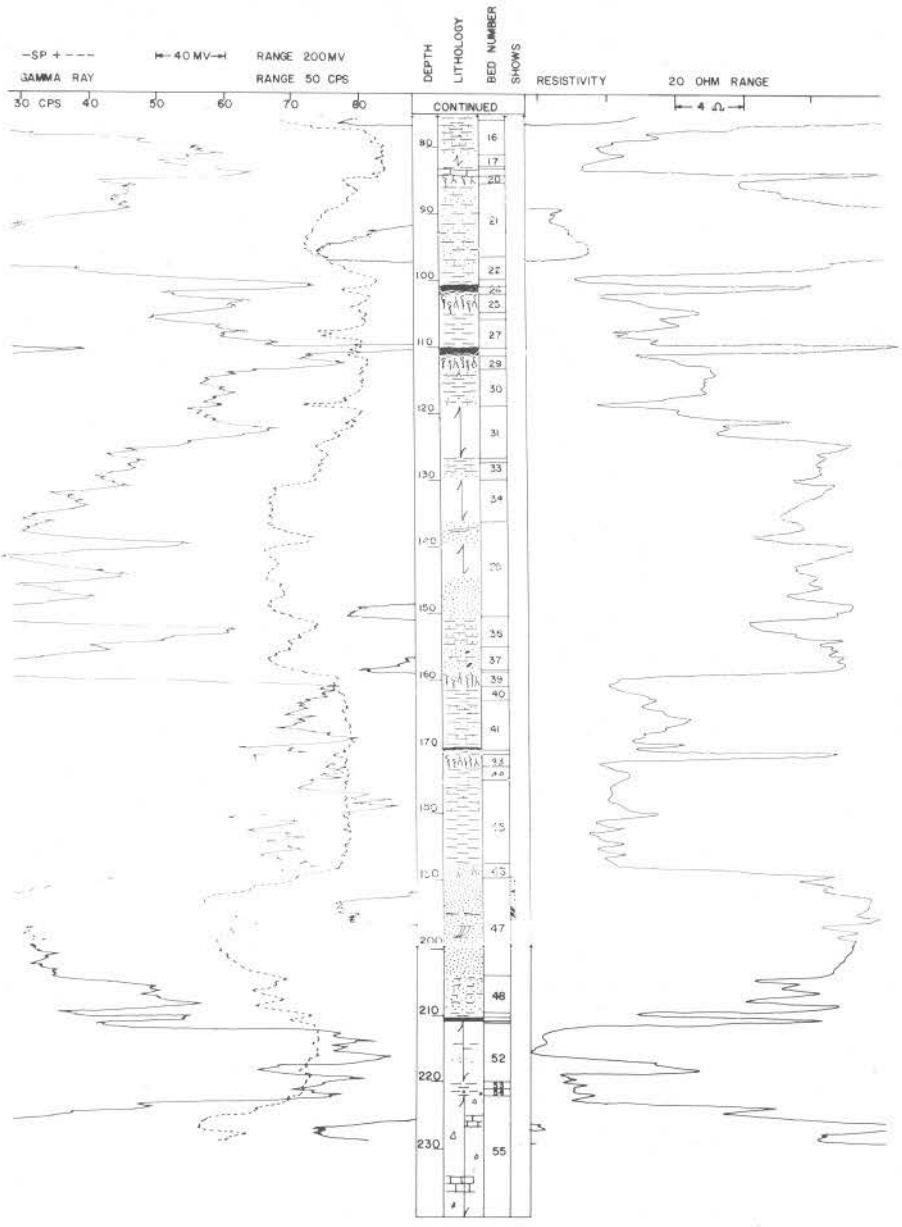
Elevation: 942' Total Depth: 158'

DEPTH		UNIT	DESCRIPTION
0.0	3.0	1	Soil and clay, reddish-brown, sandy, silty.
3.0	13.0	2	Sandstone, light gray with reddish-brown oxidized streaks, very fine to fine, silty to clayey, tight.
13.0	25.0	3	Sandstone, brown, very fine to fine, dirty, tight, dead oil stained.
25.0	35.0	4	Sandstone, tan to light gray, very fine to fine, clayey and tight in upper 5', becomes fine to medium fine and loose.
35.0	45.0	5	Sandstone, medium gray, medium fine to coarse, clayey, considerable amounts of gilsonite as black shiny specks scattered throughout, pyritic.
45.0	50.0	6	No sample.
50.0	58.0	7	Sandstone, gray, fine, friable, considerable amount of disseminated gilsonite.
58.0	68.0	8	Sandstone, tan, very fine to fine, hard, tight, very calcareous to almost sandy limestone.
68.0	70.0	9	Sandstone, as above with considerable hematitic plant debris, partially pyritized, trace of coal in this interval.
70.0	82.0	10	Sandstone, light gray to white, fine to medium, friable and loose to tight and well cemented with $CaCO_3$, some pyrite, zone of siderite, pyrite and coal at base of unit.
82.0	83.0	11	Underclay, light gray, soft, slick.
83.0	85.0	12	Shale, dark gray, firm.
85.0	94.0	13	Sandstone, light gray, medium fine to coarse, friable and loose, zone of siderite and pyrite at base of unit.

94.0	116.0	14	Shale, medium gray, fine, slightly silty, micaceous with occasional thin sandstone laminae or streaks, abundant black carbonaceous material, occasional siderite nodules, very sandy 113' to 116'.
116.0	117.0	15	Coal, black, hard, shiny, considerable pyrite.
117.0	118.0	16	Underclay, light tan, soft, slick.
118.0	120.0	17	Shale, medium to dark gray, firm, fissile.
120.0	140.0	18	Shale, light greenish-gray, slick, siderite shot disseminated throughout, grading to medium to dark gray, firm, silty, micaceous.
140.0	141.5	19	Coal, dark, shiny, pyritic.
141.5	142.0	20	Underclay, gray, soft, slick.
142.0	145.0	21	Shale, dark gray to black, silty, micaceous (gas to surface while making connection).
145.0	158.0	22	Conglomerate of chert, white with brown and blue mottling in a matrix of clay, tan to green, slick, with clay becoming bright green near base of unit.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 13
Location: 1090' FSL & 15' FWL, Sec. 33, T. 33 N., R. 33 W., Barton County
Elevation: 898' Total Depth: 240'

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DOE-TS - No. 13
Core described by Richard J. Gentile
Location: 1090' FSL & 15' FWL, Sec. 33, T. 33N., R. 33W., Barton, County

Elevation: 898' topo. Total Depth: 240'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	20.0	2	Sandstone, brown, fine-grained; cross laminated (ripples) with thin laminae of dark gray clay separating sandstone laminae.
20.0	26.2	3	Lost core.
26.2	27.2	4	Coal, .1 foot, grading into shale, black non-calcareous.
27.2	29.0	5	Clay, light gray, non-calcareous (appearance of underclay but root impressions not observed).
29.0	39.0	6	Shale, medium gray (wet), non-calcareous sand sized concretions of siderite 29.0' to 30.5', 32.2' to 32.6' and 35.6' to 37.0'; cross laminated light gray, sandstone zones 33.7' to 34.2'.
39.0	44.0	7	Lost core.
44.0	44.7	8	Limestone; medium gray; argillaceous, compact; no fossils observed.
44.7	46.0	9	Clay-shale, medium gray, non-calcareous, abundant sand sized siderite concretions.
46.0	60.0	10	Shale, dark gray (dry) to black (wet), non-calcareous, less than 5 percent light gray; parallel, discontinuous sandstone laminae (starved ripples); poorly developed clay ironstone zone 57.7' to 58'.
60.0	64.3	11	Lost core.
64.3	65.2	12	Shale, black; 2' clay ironstone bed near middle; non-calcareous.
65.2	67.0	13	Sandstone, light gray; abundant root impressions; argillaceous.

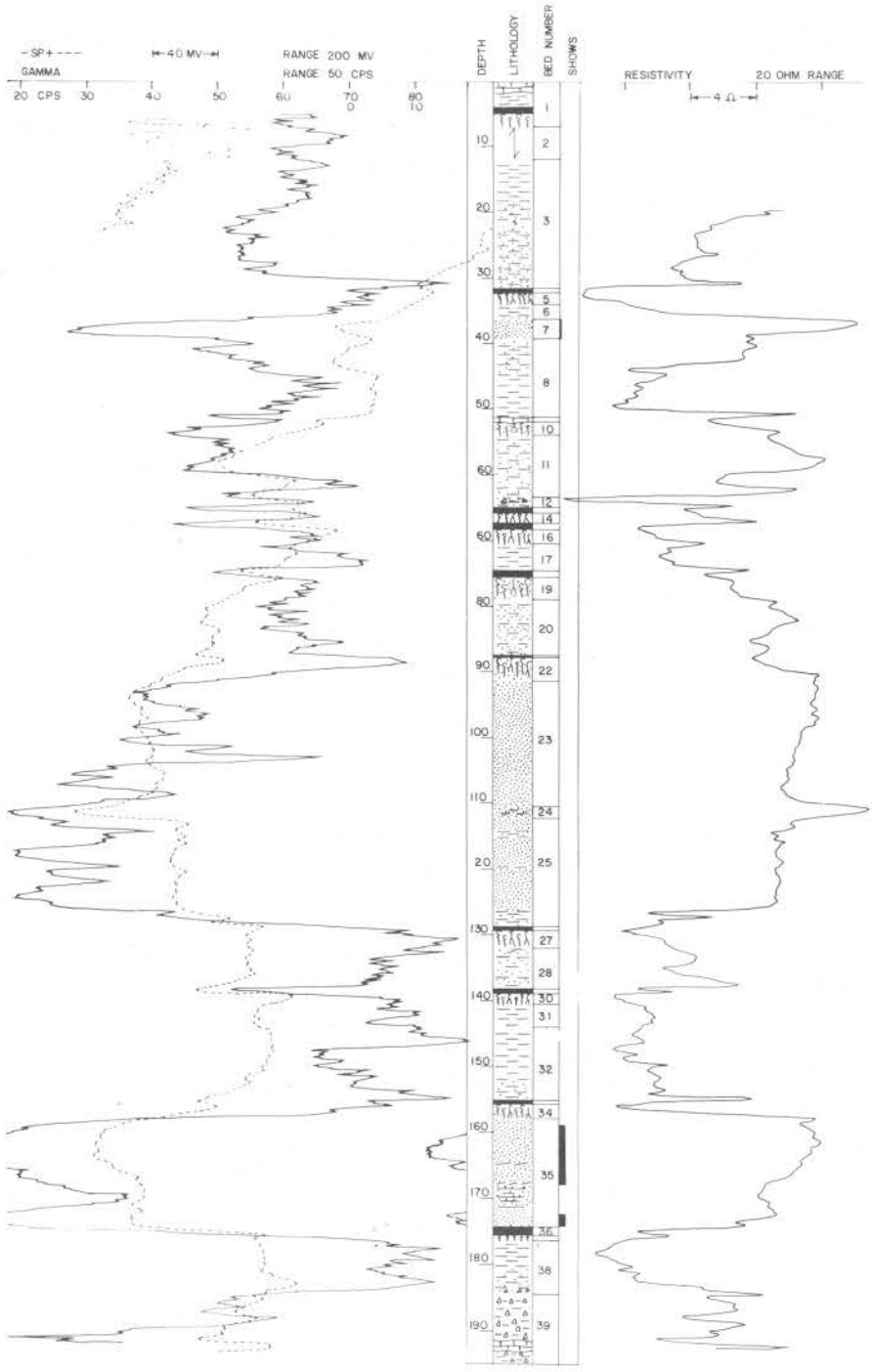
67.0	75.5	14	Sandstone, fine to medium grain size (1/8 to 1/4 mm); cross bedded near middle; asphalt stained.
75.5	76.0	15	Shale, light gray, sandy.
76.0	81.1	16	Shale, black, brittle; sparse light gray lenticular sandstone laminae; sand sized siderite concretions in top 1'; 1' clay ironstone bed at 80.3'.
81.1	83.0	17	Lost core.
83.0	83.2	18	Shale, black, non-calcareous.
83.2	84.4	19	Limestone, dark gray, argillaceous; fauna of brachiopods and gastropods, small spiny concavo-convex brachiopods Antiquatonia?; Ianthinopsis, also high-spired gastropods; crinoid columnals.
84.4	85.4	20	Clay, medium gray, sandy; carbonized root impressions.
85.4	96.5	21	Sandstone, light gray; interlaminated with medium gray shale; sandstone forms cross-bedded ripples but some distorted structure; filled burrows at 92.4'. Sand sized irregular siderite concretions in middle 2'; pyrite; fragments of tan plant material 96.0' to 96.3'.
96.5	100.0	22	Shale, medium gray, very sandy; cross laminated sandstone in top half with mostly shale at bottom with sand sized siderite concretions.
100.0	101.0	23	Shale, light gray at top to black and brittle at bottom, non-calcareous; gradational with underlying coal.
101.0	102.1	24	Coal; pyrite lenses to .025' diameter; a poor grade of coal.
102.1	105.0	25	Underclay, carbonized roots.
105.0	106.0	26	Shale, dark gray, sandy; irregular sand sized patches of siderite concretions mixed with quartz sand; small (match stick sized) areas of white, powdery non-calcareous mineral.
106.0	110.2	27	Shale, black; sparse pores and concretions of clay ironstone to .1' thick.

110.2	111.4	28	Coal, pyritiferous; .1' thick clay band .2' from bottom.
111.4	113.3	29	Underclay, carbonized roots; sand sized siderite concretions in light gray quartz sandstone cross-laminated in bottom 1'.
113.3	119.0	30	Shale, medium gray; approximately 40 percent is laminae of light gray ripple sand in top 2'; possible root impressions; approximately 10 percent laminae of sandstone in bottom, sparse .1' thick zone of clay ironstone and sand sized siderite concretions.
119.0	126.9	31	Lost core.
126.9	127.4	32	Shale, dark gray; 10 percent of unit is randomly spaced light gray, cross-laminated sandstone (ripples).
127.4	130.0	33	Shale, medium gray; grades into cross laminated contorted sandstone at bottom 2'.
130.0	136.3	34	Lost core.
136.3	150.5	35	Sandstone, light gray; parallel laminae "bundles" of carbonaceous material at 137.4' to 138.6', 139.8' to 139.9', lost core 140.0' to 144.3'; cross laminated above 144.3' but becoming homogeneous below this depth.
150.5	155.0	36	Shale, medium to dark gray and light gray, cross-bedded sandstone incalated in beds to .1' thick.
155.0	158.4	37	Sandstone, light gray, fine grained, micaceous; clasts of tan plant material and fusain to .1' diameter; two dark gray shale laminae .1' thick near middle.
158.4	158.8	38	Conglomerate .2' thick underlain and overlain by dark gray shale interlaminated with light gray ripple marked sandstone; predominate angular clasts of tan plant material to .1' long, smaller clasts of fusain; pyritiferous.
158.8	161.0	39	Underclay, slickensided; carbonized root impressions.
161.0	163.0	40	Shale, medium gray; sand-sized siderite concretions.
163.0	170.4	41	Shale, dark gray (dry) to black (wet); approximately 10 percent of unit is light gray ripples "starved" of sandstone, bottom .5' homogeneous shale.

170.4	171.1	42	Coal, pyritiferous.
171.1	173.0	43	Underclay, dark gray; fossil root molds.
173.0	175.0	44	Shale, medium gray; sand sized siderite concretions.
175.0	187.6	45	Shale, dark gray (dry) to black (wet); sandy at top becoming ripple laminated at 179'; .2' thick clay ironstone bed at 179.2' with matchstick sized holes filled with a powdery, white, non-calcareous mineral.
187.6	189.8	46	Sandstone, light gray, with dark gray carbonaceous, irregular roots and possibly sandstone filled vertical burrows.
189.8	204.0	47	Sandstone, fine grained, slight asphaltic stain 190' to 196'; 2 "bundles"of irregular coaly laminae .1' thick at 194.6' to 195.4'; cross-bedded with discontinuous irregular dark shale laminae (paper thin) between foresets.
204.0	209.5	48	Sandstone, light gray; 10 to 20 percent dark gray wavy shale laminae separating ripples; bottom 1' predominantly sandstone.
209.5	210.2	49	Shale, black.
210.2	210.6	50	Coal, fractured; thickness estimated.
210.6	211.0	51	Underclay, dark gray; carbonized roots.
211.0	220.0	52	Lost core; except for a few pieces of black shale and sandstone.
220.0	221.0	53	Shale, black.
221.0	222.0	54	Shale, black; few clasts to .05' diameter of white chert; sparse, coarse, clear quartz grains.
222.0	240.0	55	Lost core except for few pieces of chert and light gray crystalline limestone.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 14

Location: 60' FNL & 60' FEL, Sec. 19, T. 32 N., R. 32 W., Barton County
Elevation: 962' Total Depth: 195'



DOE-TS - No. 14
Core described by Richard J. Gentile
Location: 60' FNL & 60' FEL, Sec. 19, T. 32N., R. 32W., Barton County

Elevation: 962' Total Depth: 195'

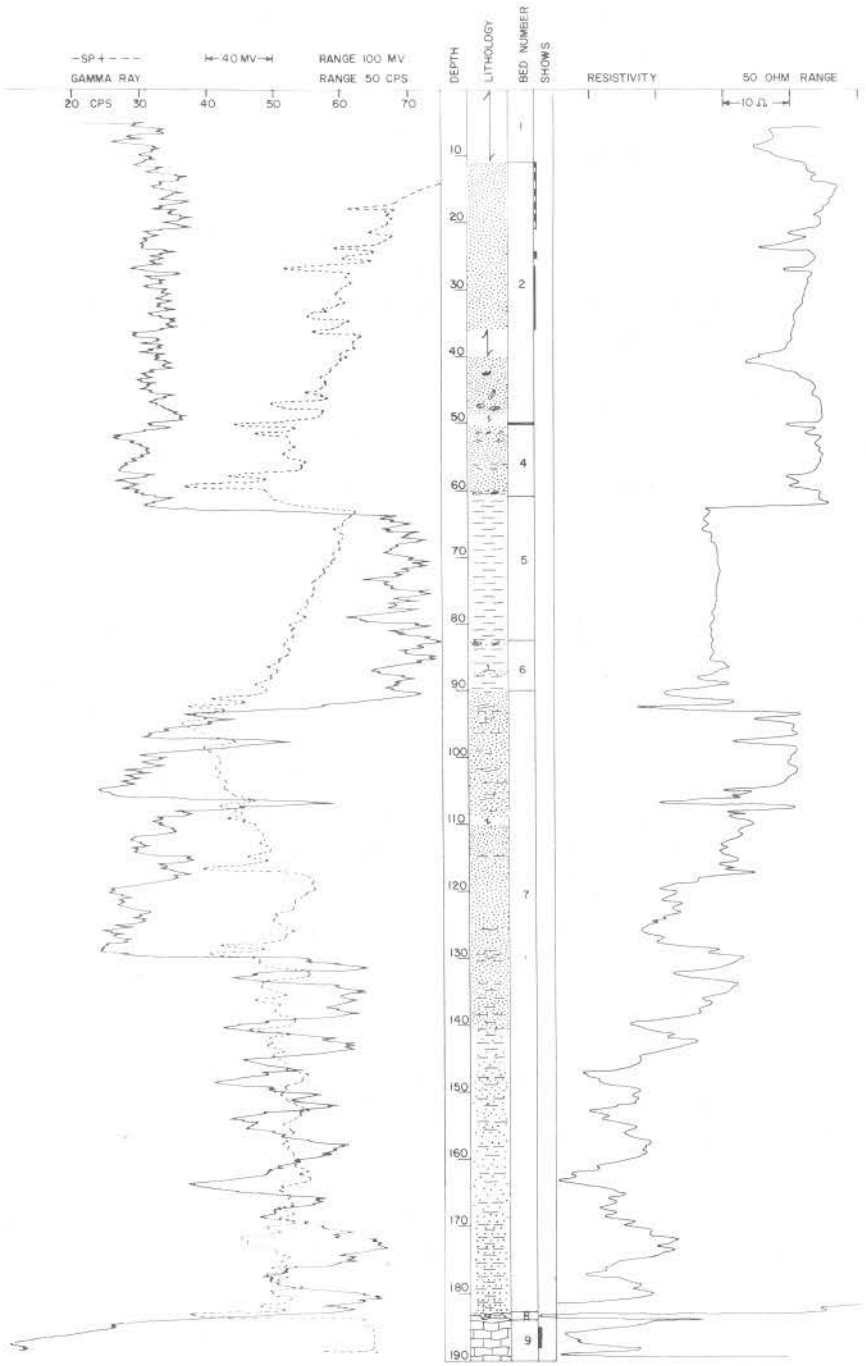
DEPTH		UNIT	DESCRIPTION
0.0	7.0	1	No samples 0' to 12'; but following section exposed in road ditch---8' shale, green with red hematitic streaks. Note: Top of hole elevation 962' = 1' into limestone bed described below: 3' limestone, light gray, finely crystalline, fossiliferous; 2' clay, greenish gray, soft; 0.9' coal; 2.0' underclay.
7.0	12.0	2	No samples.
12.0	31.7	3	Shale, medium gray; brown, non-calcareous; clay ironstone bed .1' thick at 15.6', 21.6', and 23.6'; lost core 21.6' to 22'; becomes sandy at 18' and sand content increases downsection until about 50 percent of unit at bottom is lenticules of cross-laminated sandstone (starved ripples) in shale. Lost core 21.6' to 22'.
31.7	32.1	4	Coal, fragmented.
32.1	34.0	5	Underclay; fossil root molds.
34.0	36.4	6	Clay, light gray, non-calcareous; sandy at bottom.
36.4	39.3	7	Sandstone, dark gray; slight asphalt staining near top.
39.3	51.2	8	Shale, medium dark gray to dark gray at bottom; poorly developed sandstone laminae in top half of unit; ironstone beds, brown, non-calcareous, approximately .1' thick at 49.2', 50', and 50.5'.
51.2	52.0	9	Limestone, dark gray, very argillaceous fragments of Chonetinella and productids; Orbiculoidea missouriensis Lingula carbonia, some crinoid columnals.
52.0	54.0	10	Underclay, light gray, sandy; irregular shaped carbonized roots and pieces plant material.

54.0	63.4	11	Shale, medium gray; sandstone laminations and pods at top decrease downsection until approximately 10 percent of unit at 60'; lenticular laminations ("starved" ripples) from 60' to 62'; sandstone content increases from 62' to 63.4'; sand-sized siderite concretions.
63.4	65.0	12	Shale, dark gray, sandy; conglomeratic, clasts of shale interbedded with lenses of coal.
65.0	65.7	13	Coal, bands vitrain.
65.7	67.3	14	Underclay; poorly developed, dark gray; few carbonized roots; clay ironstone concretions at bottom.
67.3	68.3	15	Coal, shiny; pyritized plant material.
68.3	70.3	16	Underclay, light gray; carbonized roots.
70.3	74.7	17	Shale, medium gray (dry) to dark gray (wet); sand-sized siderite concretions, and clay ironstone concretions to .1' diameter.
74.7	75.6	18	Coal; vitrain banding; pyrite lenses.
75.6	79.0	19	Underclay, sandy; carbonized, randomly oriented fossil roots.
79.0	87.5	20	Sandstone, light gray; lenticular ripple laminations and pods, intercalated with gray shale; sandstone laminations decrease to about 20 percent of unit at bottom; sand-sized siderite concretions randomly dispersed throughout unit.
87.5	87.9	21	Coal; vitrain banding.
87.9	91.5	22	Underclay, sandy; carbonized fossil roots.
91.5	110.6	23	Sandstone, fine-grained to slightly coarser at bottom, light gray (dry) to medium gray (wet); micaceous, homogeneous; cross-laminated 95.5' to 96.5'.
110.6	112.2	24	Sandstone, light gray, fine-grained, hard, calcareous.
112.2	128.8	25	Sandstone, light gray, fine-grained, micaceous; laminated light gray sandstone and medium gray shale 114.4' to 114.8', 19.7' to 120', 126.5' to 127', 127.6' to 127.9'; interlaminated coal and dark gray shale in "bundles" at 115.2' to 115.5'.

128.8	129.3	26	Coal, pyritiferous.
129.3	132.0	27	Underclay, light gray; fossil root molds; slickensided; sand-sized siderite concretions below top 1'.
132.0	138.1	28	Shale, light gray; sandy at top with contorted sandstone laminae; becomes dark gray in bottom 4' with 5 to 10 percent of unit lenticular sandstone laminae ("starved" ripples).
138.1	138.9	29	Coal with pyritized plant remains; sticks to overlying shale.
138.9	140.5	30	Underclay, light greenish-gray, carbonized roots.
140.5	144.0	31	Clay, greenish-gray; irregular-shaped zones of sand-sized siderite concretions with clay matrix.
144.0	155.1	32	Shale, black (wet); sparse light gray sandstone laminae in bottom 3'; beds of clay ironstone .2' thick at 146.8', 148.4', and 149.8'.
155.1	155.7	33	Coal.
155.7	158.0	34	Underclay, light gray, carbonized roots; sandy at bottom.
158.0	174.2	35	Sandstone, cross-stratified with mica along foreset planes; brown asphalt stain 159' to 168.4', 172.5' to 174.2'; sparse gray inclined shale laminae 165' to 165.5', 167' to 167.5', approximately 10 percent of interval from 168.4' to 171.5', 172' to 172.5' is coal laminae.
174.2	175.7	36	Coal; pyritized plant material.
175.7	176.2	37	Underclay, dark gray, slickensided.
176.2	184.4	38	Shale, black (wet); top 1' with abundant sand-sized siderite concretions; approximately 5 percent of bottom of half of unit is light gray lenticular sandstone laminae and pods; angular fragments of white chert (.025' thick in bottom .4').
184.4	195.0	39	Chert, white; brecciated appearance approximately 20 percent of unit is voids filled with green clay; limestone, coarsely crystalline with crinoid stems 191.6' to 192', 192.3' to 192.6', green clay is very pyritiferous; may be a sinkhole deposit.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 15

Location: 60' FNL & 15' FEL, Sec. 5, T. 31 N., R. 31 W., Barton County
Elevation: 990' Total Depth: 190'



DOE-TS - No. 15
Core described by Richard J. Gentile
Location: 60' FNL & 15' FEL, Sec. 5, T. 31N., R. 31W., Barton County

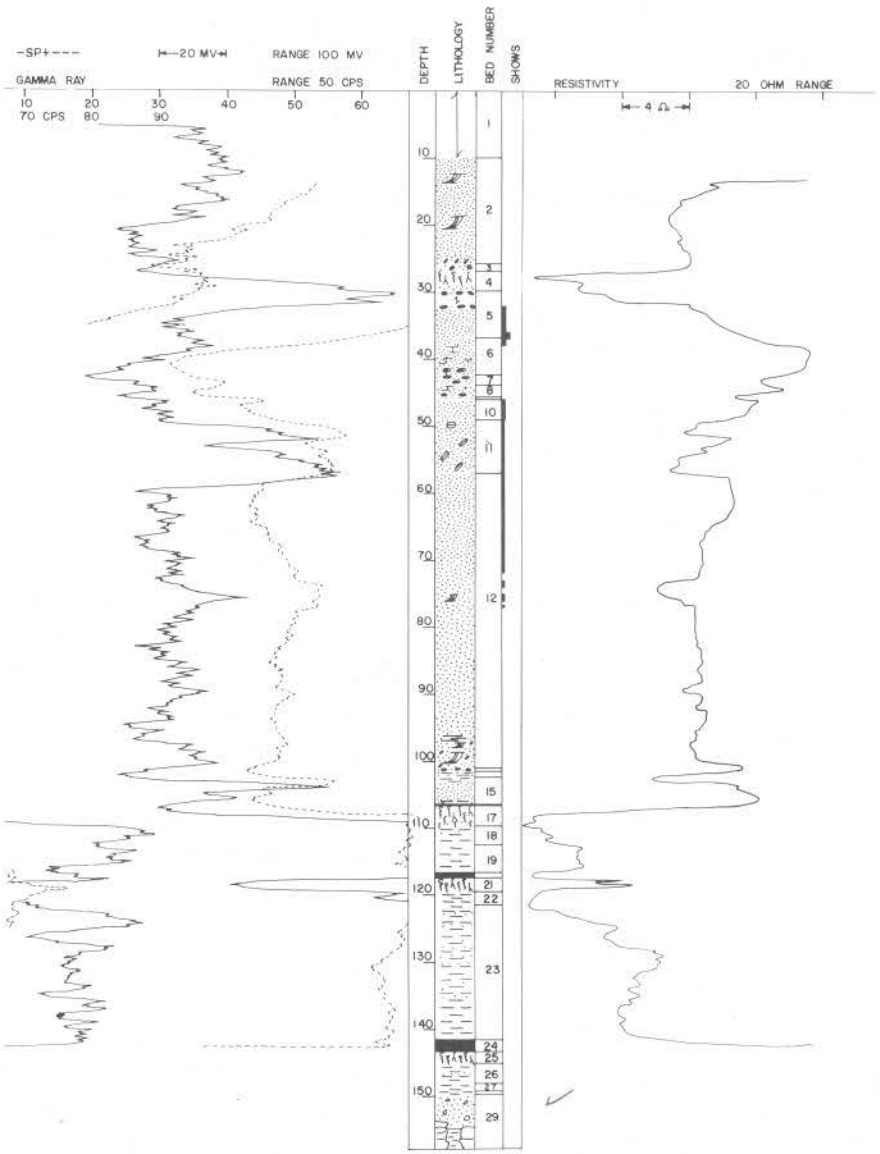
Elevation: 990' Total Depth: 190'

DEPTH		UNIT	DESCRIPTION
0.0	11.0	1	No core.
11.0	50.0	2	Sandstone, brown; iron stained to 12', with iron stained zones to 17'; medium gray (wet); salt and pepper appearance, cross-bedded, micaceous; laminae of carbonaceous plant material and mica 21.5' to 22'; grain size coarsens below 26.5' to $\frac{1}{2}$ mm diameter; some weathered feldspar grains; sporadic clasts of gray shale and fusain below 42' becoming more abundant at bottom. Microscopic examination at 48' - fair sorting (4 Wentworth grade sizes) grains silt sized to $\frac{1}{2}$ mm diameter, sparse blotches of asphalt; grains subangular to subrounded, feldspathic; 3.7' core loss between 35' and 40', lost core 48.6' to 50'. Streaks of dead oil stain 11' to 14'; slight dead oil stain 14' to 17', gilsonite at 17' to 21'. Slight oil staining 24.6' to 25.2' and below 26.5'.
50.0	50.2	3	Conglomerate, clasts of fusain and tan and brown plant material; light gray, sandstone matrix.
50.2	60.9	4	Sandstone, light gray (dry) to medium gray (wet); grain size 1/16 mm to 1/4 mm diameter to 1/4 mm in bottom 4'; cross-bedded, "bundles" of irregular, inclined carbonaceous laminae at 51.3' to 51.7', 52.5' to 52.8', 56.1' to 56.3' (horizontal), 56.4' to 56.7' (carbonaceous laminae occur as bits of charcoal, twigs form continuous laminae, micaceous), conglomeratic in bottom .5' with clasts of coal, gray shale, pyritiferous.
60.9	82.4	5	Shale, medium gray, slickensided; high angle fracture; noncalcarenitic.
82.4	90.0	6	Shale, medium dark gray; top .6' intercalated with wavy light gray sandstone laminae, some clasts of gray shale, coal; pyritiferous, inclined; 2.2' core loss between 80' and 90'; possibly an underclay at 86'; light gray lenticular sandstone laminae, steeply inclined; microfaulted from 87' to 88'.

90.0	182.8	7	Sandstone, light gray, fine-grained; about 10 percent of unit is wavy horizontal "bundles" to .1' thick, evenly spaced of micaceous coal laminae to 129'; mostly sandstone 117.8' to 126.2'; dark gray shale lenses 90.1' to 90.2', 93' to 93.2', 96.3' to 96.9', 105.5' to 106', 114.5' to 114.7', 116.2' to 116.4'; lost core 109.6' to 110'; about 50 percent shale with interlaminated gray sandstone ripples from 129' to 130.5'; predominately sandstone 130.5' to 133', interbedded dark gray shale and light gray sandstone ripples 133' to 138.4'; predominately sandstone 138.4' to 144', 30 percent of unit dark gray shale laminae 144' to 149', predominately sand-sandstone 149' to 150', about 20 percent dark gray wavy shale laminae to .05' thick from 150' to 170'; about equal amounts of interlaminated light gray sandstone ripples, with some pods, and dark gray shale 170' to 182.8'.
182.8	184.0	8	Chert; top .3' dark gray grading downsection into light gray fractured chert; argillaceous, pyritiferous sandstone bed .2' thick about .5' from top.
184.0	190.0	9	Limestone, light gray, coarsely crystalline, stylolitic; coarsely ribbed spirifer? fragments; vugs near middle filled with heavy oil.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 16

Location: 25' FNL & 840' FWL, Sec. 9, T. 32 N., R. 31 W., Barton County
Elevation: 997' Total Depth: 158'



DOE-TS - No. 16
Core described by Richard J. Gentile
Location: 25' FNL & 840' FWL, Sec. 9, T. 32N., R. 31W., Barton County

Elevation: 997' Total Depth: 158'

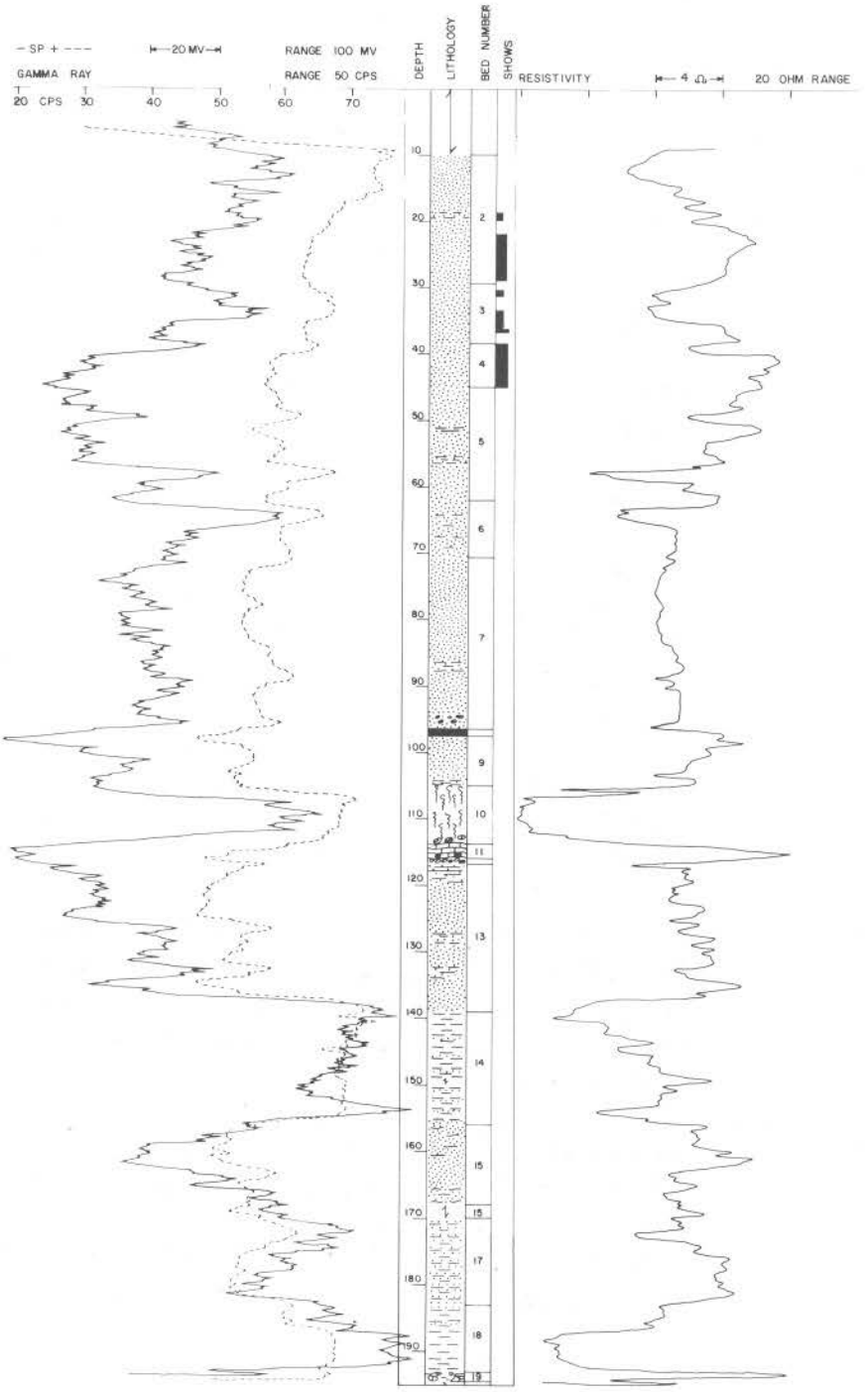
DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	25.8	2	Sandstone, brown; medium gray in bottom 4', fine-grained, cross-bedded, micaceous; pieces charcoal forming imbricate structure in bottom 1'.
25.8	26.8	3	Sandstone, soft, fragmented, clayey, micaceous; conglomeratic appearing with charcoal clasts.
26.8	29.8	4	Underclay, fossil root casts, medium gray grades into sandstone at bottom.
29.8	36.8	5	Sandstone, massive to cross-bedded, micaceous; medium gray with specks of carbonaceous material that gives salt and pepper appearance with quartz sand grains; lost core 30.6' to 31.6'; .2' thick conglomerate overlies and underlies lost core interval, clasts of dark gray shale and tan plant material believed to be pith of Calamites. Dead oil stain 32' to 36' - heavy stain 36' to 37'.
36.8	42.2	6	Sandstone, light gray, calcareous, compact, homogeneous; bottom .4' is a conglomerate with pieces of shale and tan plant material.
42.2	43.8	7	Same as 29.8' to 36.8' interval but contains pieces of tan plant material.
43.8	45.5	8	Sandstone, light gray, calcareous but with few clasts of shale and tan plant material becoming concentrated in bottom .6' to form conglomerate of light gray, dark gray, and green shale and tan plant material clasts to .2' diameter.
45.5	46.0	9	Sandstone, light gray, calcareous.
46.0	49.0	10	Sandstone, salt and pepper appearance, gilsonite and specks of coal, non-calcareous.
49.0	57.0	11	Sandstone, fine-grained with pieces carbonaceous material; conglomeratic throughout interval; clasts of medium gray

			siltstone that appear to be locally derived; beds to .1' thick with clasts aligned in imbricate structure, some clasts of tan plant material; sandstone is cross-laminated, salt and pepper appearance; some light gray steeply inclined sandstone laminae; black laminae of fusain and mica intercalated with laminae of sand-sized quartz and siderite concretions at 57'.
57.0	101.0	12	Sandstone, fine-grained (1/16 to 1/8 mm), medium gray (wet), salt and pepper appearance, bits coal and gilsonite, massive, non-calcareous; light gray (wet) below 72.5'; clay ironstone bed .05' thick at 79.7' and from 81.2' to 81.4'; bits carbonaceous material below 73'; appears cross-bedded at 75' to 76'; .2' thick unit consisting of parallel laminae composed of pieces charcoal at 96', micaceous, bottom 4' cross-bedded containing bits fusain.
101.0	101.3	13	Conglomerate, clasts of plant material and dark gray shale (possibly derived from underlying unit); discontinuous, laminae of coal; light gray, non-calcareous fine grained sandstone matrix.
101.3	102.2	14	Sandstone, light gray, cross laminated, ripples; flame structures intercalated with medium gray shale beds about .05' thick.
102.2	106.5	15	Sandstone, light gray to tan; medium gray shale beds to .05' thick at 102.5' to 102.7' and 106' to 106.1'.
106.5	106.7	16	Coal.
106.7	109.8	17	Underclay, carbonized root impressions; sand sized siderite concretions in bottom 1'.
109.8	112.5	18	Shale, medium gray, sandy, quartzose; sand-sized siderite concretions; grades downward into dark gray to black shale.
112.5	116.7	19	Shale, black, bits of pyritized wood.
116.7	117.5	20	Coal, bands vitrain; lenses pyrite to .05' thick near middle of coal.
117.5	119.5	21	Underclay, dark gray, carbonized roots, slickensided, pyrite.
119.5	121.5	22	Shale, medium gray, sand-sized siderite concretions (.5 mm diameter).

121.5	141.6	23	Shale, dark gray to black at bottom; 1 or 2 percent of unit is light gray lenticular cross-laminated "starved" ripples to 127.5' increasing to 10 percent of unit light gray sandstone ripples to 131'; then decreasing to 1 or 2 percent of unit to 135'.
141.6	143.2	24	Coal, pyritized wood; .1' parting of conglomeratic clay about 2/3 of way from top.
143.2	145.0	25	Underclay, light gray; root impressions.
145.0	148.0	26	Shale, black; 1 percent of unit is light gray "starved" inclined ripples.
148.0	149.2	27	Shale, medium gray to greenish-gray.
149.2	149.6	28	Shale, black, flaky; compressed squeezed appearance; sparse light greenish-gray sandstone laminae.
149.6	158.0	29	Sandstone, medium gray, argillaceous; pyrite lenses which contain a soft white mineral; pieces of white chert increase downsection to comprise about 50 percent of unit at bottom, light gray with crinoid stem molds; cavities filled with medium gray clay and pyrite.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 17

Location: 280' FNL & 2580' FEL, Sec. 2, T. 33 N., R. 31 W., Barton County
Elevation: 943' Total Depth: 195'



DOE-TS - No. 17
Core described by Richard J. Gentile
Location: 280' FNL & 2580' FEL, Sec. 2, T. 33N., R. 31W., Barton County

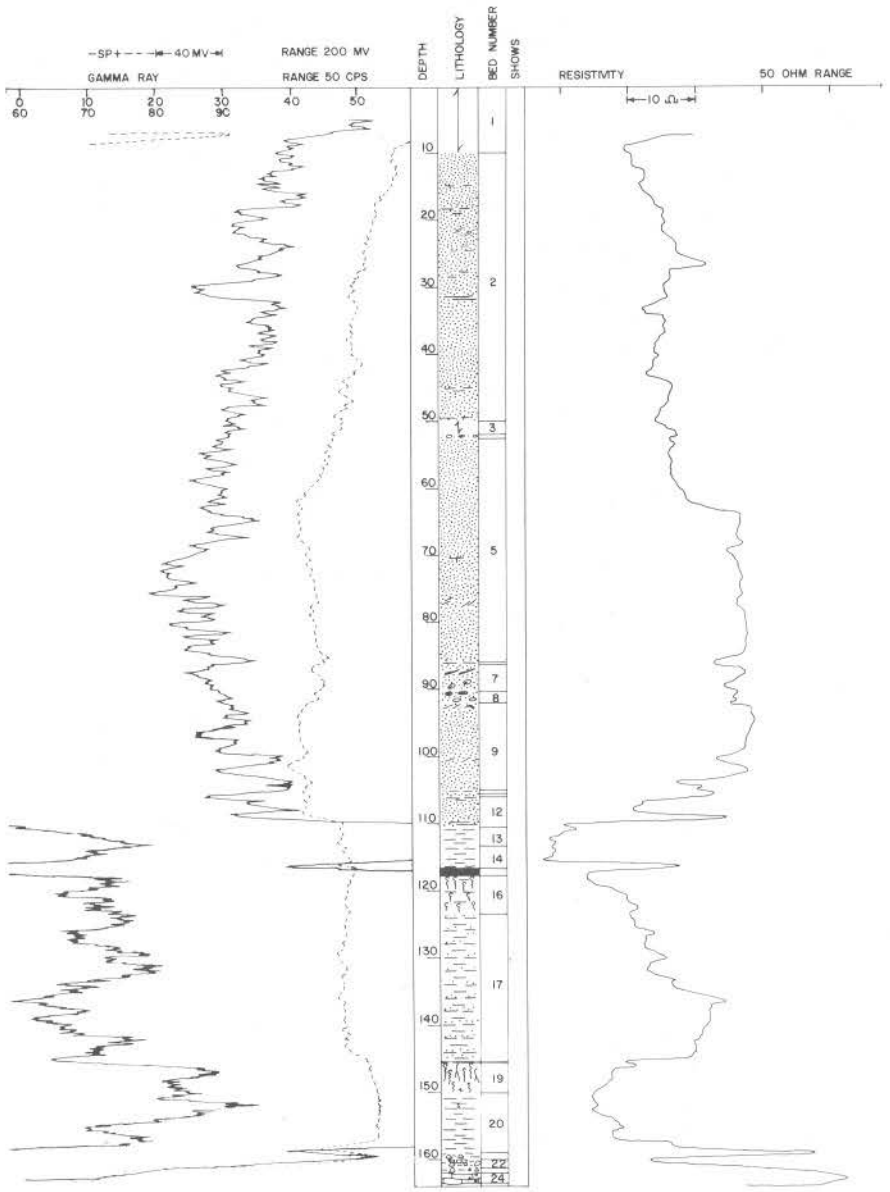
Elevation: 943' Total Depth: 195'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	29.4	2	Sandstone, brown, fine-grained (1/16 to 1/8 mm), compact; dark gray shale lens 18.6' to 19.4'; very slight oil stained zone 1' thick at 19'; fairly heavy brown asphalt stained from 22' to 29'.
29.4	38.4	3	Sandstone, fine-grained, light gray, non-calcareous, argillaceous; brown, asphalt stained 30.6' to 31.1', 33.6' to 36', heavy black asphalt staining 36.2' to 36.6'; possible cross-bedding obscured by drill.
38.4	45.0	4	Sandstone, brown, asphalt stained, micaceous, becoming coarser grained (1/4 mm diameter) at bottom.
45.0	62.0	5	Sandstone, light gray (grain size 1/8 mm diameter); speckled black with carbonaceous plant material, mica along bedding planes, possibly some asphalt but pieces of charcoal with plant structure visible; medium dark gray shale bed 55.8' to 56.4'; discontinuous lenses of coaly material at 51' to 51.5' and 55' to 55.5'.
62.0	70.5	6	Sandstone, light gray, fine-grained, cross-laminated ripples intercalated with dark gray shale which "climb" up ripples; approximately 10 percent of unit dark gray shale laminae from 64' to 68', 30 percent of unit dark gray shale and coaly laminae below 68'.
70.5	96.4	7	Sandstone, light gray, massive appearing, slightly friable; 25 percent of unit is interbedded shale laminae from 86' to 88'; pieces of fossilized wood in bottom 5'; conglomerate from 94.6' to 94'7'; consists of clasts round to flattened, tan shale and clay ironstone, coal; some pyrite nodules.
96.4	97.3	8	Coal, bands of vitrain.
97.3	105.0	9	Sandstone, and coal; thin coal beds 104.2' to 104.45'; 3 coal beds or lenses .05' to .1' thick interbedded with sandstone from 104.45' to 105'.

105.0	113.7	10	Clay, light gray, sandy, slickensided, abundant carbonized root impressions; bottom 4' sandstone, greenish-gray with sand-sized siderite concretions; bottom 1' contains limestone nodules.
113.7	116.0	11	Limestone, light gray, finely crystalline, compact; pyrite and green clay filling vugs; poorly developed stylolites.
116.0	116.9	12	Conglomerate, calcareous; clasts are rounded, flat, ranging in size to .1' diameter but some angular pieces of coal, clasts consist of tan clay ironstone; light to dark gray shale; some tan clasts appear to be clay that filled in pith of Calamites stems; some pyrite.
116.9	139.0	13	Sandstone, light gray, grain size 1/8 mm diameter; few parallel laminae "bundles" of carbonaceous rich material or coal laminae in upper 3'; micaceous, pyritiferous; light gray sandstone and dark gray shale interbedded in .05' thick beds at 127' to 127.5', 128.5' to 129', 132.4' to 134', few inclined coaly laminae throughout unit; sandstone below 134' is slightly coarser than 1/8 mm diameter of grains and contains bits of charcoal.
139.0	156.0	14	Shale, black with light gray lenticular cross-laminated sandstone ripples and pods from 142' and increase to comprise about 10 percent of unit below 150'; lost core 149' to 150'.
156.0	168.0	15	Sandstone, light gray; about 20 percent of unit from 156' to 161' and 165' to 168' is dark gray wavy shale laminae.
168.0	170.0	16	Lost core.
170.0	183.0	17	Shale, black; interlaminated, light gray sandstone (ripples) and dark gray shale.
183.0	193.0	18	Shale, black, very few sandstone ripples in top half.
193.0	194.5	19	Chert, light gray; only a few clasts in black shale at top but increases downsection to massive chert with some clay filled cavities at bottom; fragmented brachiopod molds in the chert.
194.5	195.0	20	Lost core.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 18

Location: 110' FNL & 360' FWL, Sec. 36, T. 35 N., R. 31 W., Vernon County
Elevation: 774' Total Depth: 163.4'



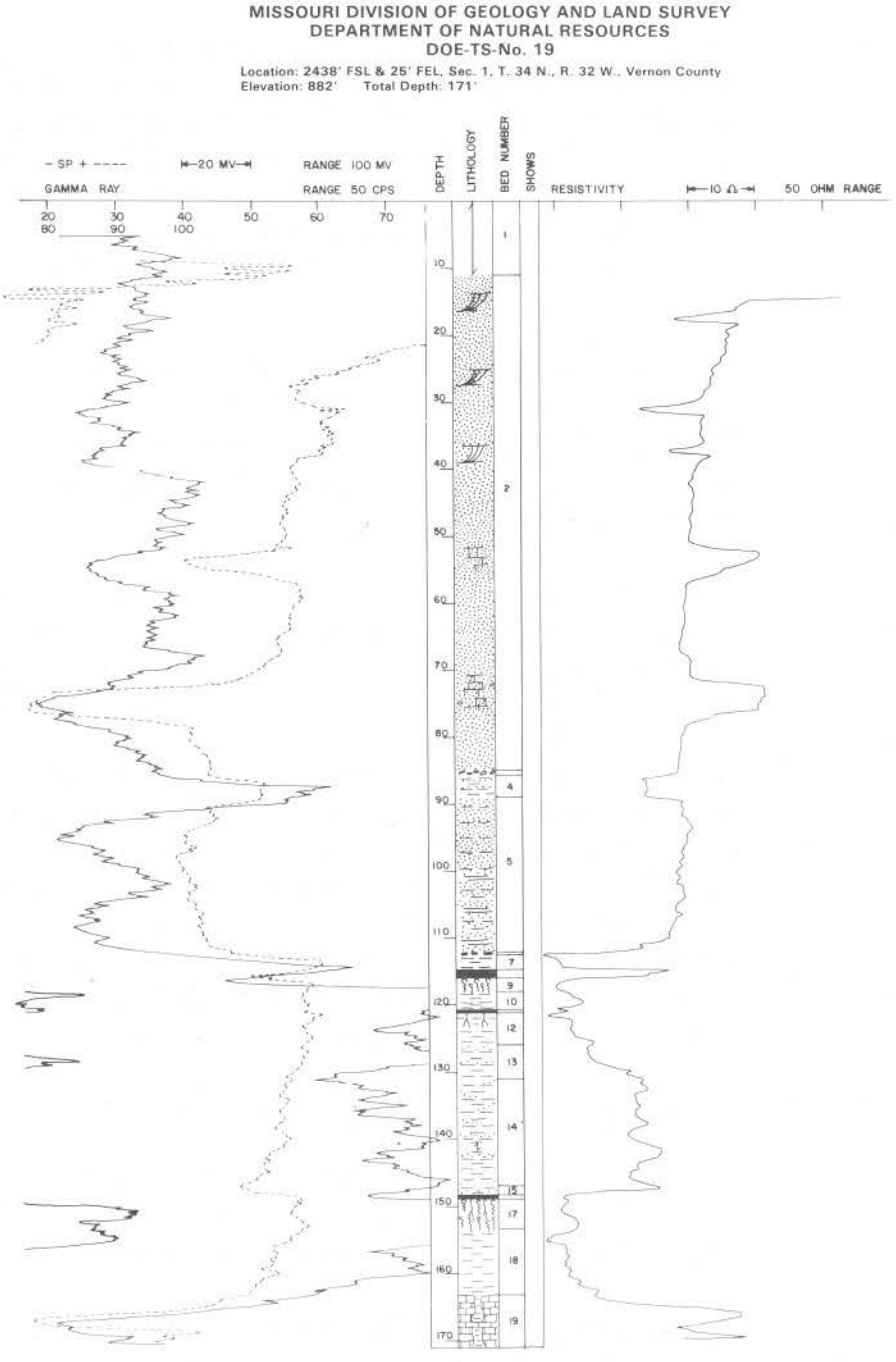
DOE-TS No. 18
Core described by Richard J. Gentile
Location: 110' FNL & 360' FWL, Sec. 36, T. 35N., R. 31W., Vernon County

Elevation: 774' Total Depth: 163.4'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	50.0	2	Sandstone, fine-grained, brown, iron staining to about 20'; "bundles" of black carbonaceous lenses 18' to 19'; .5' red sandy clay hematite zone at 14.5' to 15'; predominantly sandstone below 20' with 5 percent of unit composed of inclined, black carbonaceous shale lenses; 24.2' to 25.4' light gray sandstone cemented with $CaCO_3$ with fragments of brown to black plant material; coal laminae, evenly spaced and parallel forming "bundles" from 31' to 31.7', 45' to 46', and 49.6' to 49.8', pyritiferous; also coal laminae along bedding planes throughout interval; light gray sandstone at 49.8' to 50'.
50.0	52.0	3	Lost core.
52.0	52.6	4	Conglomerate, clasts to .1' diameter of gray, brown and tan shale, rounded to flat, sparse pyrite nodules; light gray quartzose sandstone matrix.
52.6	86.0	5	Sandstone, medium gray, friable, massive to cross-bedded, grain size 1/8 mm diameter, specks of black carbonaceous material; sparse "bundles" of carbonaceous material at top; light gray sandstone cemented with $CaCO_3$ from 70.4' to 71.2'; laminated "bundles" of carbonaceous material 78.0' to 78.3', horizontal, pyritiferous but inclined from 76.0' to 78.0'; micaceous.
86.0	86.2	6	Clay-ironstone, brown, calcareous, contorted.
86.2	90.2	7	Sandstone, light gray, fine-grained (1/8 mm diameter), friable, inclined coal lenses .1' thick at 87', pyrite nodules, sparse clasts of shale; cross-bedded (a high velocity current deposit with plant material washed into an area of sand deposition?).
90.2	92.0	8	Sandstone, light gray, friable with .3' zones of conglomerate at top and bottom consisting of rounded and flattened clasts

			of dark gray and brown shale, clay ironstone, carbonaceous material; pyrite (similar to conglomerate upsection).
92.0	105.0	9	Sandstone, light gray, friable, quartzose; .5' thick zone of sandstone with cross-bedded, contorted appearance inter-laminated with dark gray shale 92' to 92.7', 100.5' to 101'.
105.0	105.5	10	Sandstone, light gray, cross-laminated ripples intercalated with shale.
105.5	106.0	11	Sandstone, light gray and "bundles" of lenticular and irregular shaped, black carbonaceous laminae; pyritized plant material.
106.0	110.5	12	Sandstone, light gray; .5' thick beds of dark gray shale near top; laminated "bundles" of carbonaceous material near bottom.
110.5	113.3	13	Shale, medium gray, abundant sand-sized siderite concretions.
113.3	116.7	14	Shale, black; sparse laminae of pyritized plant material.
116.7	117.8	15	Coal, vitrain streaks; 5 percent of unit is pyrite lenses to .02' thick.
117.8	123.6	16	Clay, medium gray, slickensided at top, abundant zones and irregular patches of sand-sized siderite concretions (an underclay).
123.6	145.3	17	Shale, black; approximately 10 percent of unit at top is light gray lenses and pods of sandstone to .2' thick, increasing to 40 percent at bottom (lenticular cross-laminated sandstone ripples).
145.3	145.5	18	Coal.
145.5	150.0	19	Underclay, light gray to tan, slickensided; irregular shaped carbonized roots; pyrite; lost core 149.6' to 150'.
150.0	159.0	20	Shale, black; 2 or 3 beds to .2' thick of clay ironstone near middle.
159.0	160.0	21	Clay, green to dark gray with chert fragments to .2' thick.
160.0	161.2	22	Chert, light gray to tan, compact, one thick bed with vugs filled with clay.

161.2	162.0	23	Clay, dark gray, slickensided, fragments of light gray chert.
162.0	163.4	24	Limestone, light gray, coarse crystals with tan fine-grained matrix, oolitic appearance.



DOE-TS - No. 19
Core described by Richard J. Gentile
Location: 2438' FSL & 25' FEL, Sec. 1, T. 34N., R. 32W., Vernon County

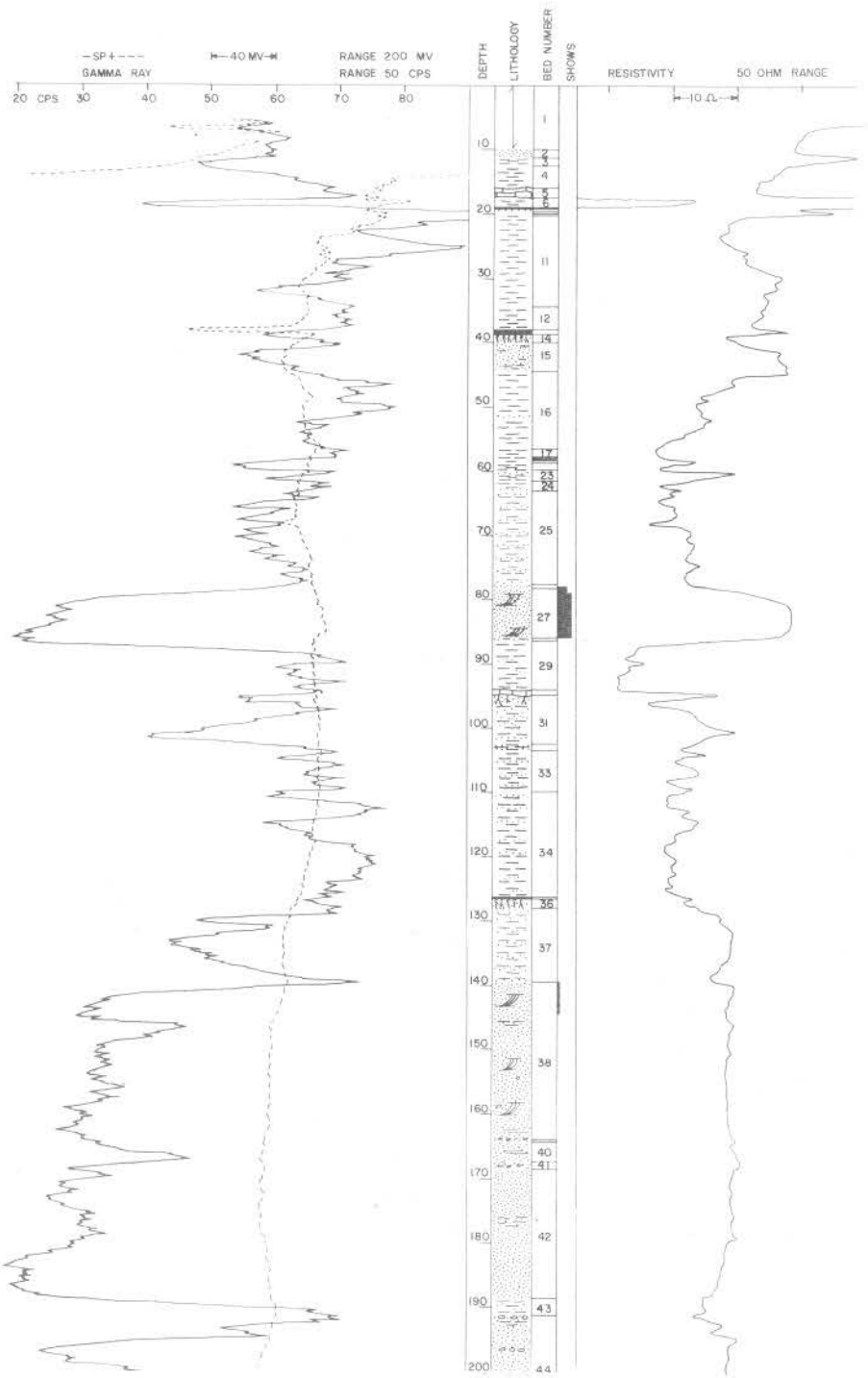
Elevation: 882' Total Depth: 171'

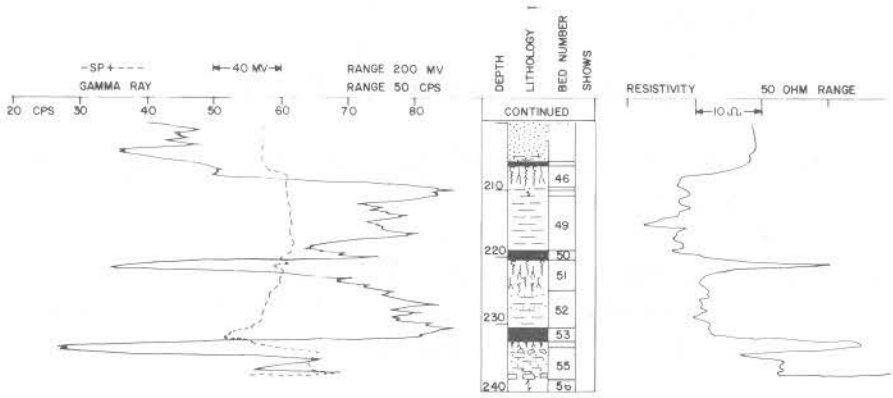
DEPTH		UNIT	DESCRIPTION
0.0	11.0	1	No core.
11.0	85.0	2	Sandstone, bands of brown iron stain to 21'; pieces carbonaceous material; grains 1/16 to 1/4 mm diameter, micaceous, feldspathic; cross-bedding apparent to 40'; light gray, calcareous cemented zones 51' to 54.5' and 70.8' to 76.4' containing bits of leaves and stems to .1' long and quartz sand grains to 1/4 mm diameter, micaceous; bits of wood and mica along bedding planes; unit becomes lighter gray downsection.
85.0	85.7	3	Conglomerate, clasts predominately clay ironstone and pyritized wood, dark gray to black, smooth, non-calcareous, hard to .1' diameter; matrix of quartzose sandstone; grains of feldspar and a green mineral (glauconite?) to 1/8 mm diameter.
85.7	89.0	4	Shale, dark gray (wet), pyritized carbonaceous fragments along bedding planes, approximately 10 percent of unit interbedded light gray sandstone beds to .05' thick; even bedded to flame structure; some sandstone pods to .05' diameter.
89.0	112.2	5	Sandstone, light gray, fine-grained; 10 percent of unit is intercalated dark gray shale to .05' thick but mostly is paper thin laminae; bits of carbonaceous fragments partially pyritized along bedding planes; shale laminae mostly horizontal but some steeply inclined; bits of carbonaceous material with plant structures occur in parallel laminations (1/4 to 1/2 mm thick) intercalated with light gray sandstone to form "bundles" to .5' thick below 100'.
112.2	112.5	6	Conglomerate, composed of soft, weathered, flat clasts of brownish-red shale; imbricate structure, some clasts or nodules of pyrite to pea-size; bits and pieces of carbonaceous material; few contorted laminae, .05' thick, of dark gray shale and light gray sandstone, micaceous.
112.5	114.9	7	Shale, dark gray (wet) smooth, pyritiferous.

114.9	116.0	8	Coal, bands of vitrain; cleats filled with $CaCO_3$; lenses of pyrite .01' thick and .1' long.
116.0	118.0	9	Clay, dark gray to greenish-gray, slickensided.
118.0	120.9	10	Shale, black; zones of sand-sized brown siderite concretions.
120.9	121.1	11	Coal, vitrain streaks.
121.1	126.0	12	Shale, dark gray to greenish-gray at bottom, slickensided, carbonized roots, sand-sized siderite concretions to 1/4 mm diameter.
126.0	131.0	13	Shale, black; about 10 percent of unit is light gray sandstone, lenses equally spaced; clay ironstone bed 129.7' to 129.9'.
131.0	147.0	14	Shale, black, about 20 to 40 percent of unit is light gray, lenticular cross-laminated sandstone; inclined to 20^{o}; some pyrite nodules; lost core 140.5' to 141.6'
147.0	148.3	15	Shale, black; approximately 10 percent inclined sandstone, laminae randomly spaced throughout interval.
148.3	148.9	16	Coal, bands vitrain; abundant pyritized plant fragments .05' wide and .2' long.
148.9	153.2	17	Underclay, light gray, slickensided, sparse carbonized roots.
153.2	163.2	18	Clay-shale, black, slickensided, top half soft becoming hard, fractured and slickensided at bottom; clusters of pyrite to grape-sized.
163.2	171.0	19	Limestone, light gray, coarsely crystalline, brachiopods (Spirifer), stylolites; top .5' thick dark gray clay-filled solution cavities grading into green clay at bottom; pyritiferous.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 20

Location: 1260' FSL & 18' FWL, Sec. 5, T. 34 N., R. 32 W., Vernon County
Elevation: 855' Total Depth: 240'





DOE-TS - No. 20

Core described by Richard J. Gentile

Location: 1260' FSL & 18' FWL, Sec. 5, T. 34N., R. 32W., Vernon County

Elevation: 855' Total Depth: 240'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core
10.0	11.2	2	Sandstone, brown, layers of iron impregnated sandstone.
11.2	12.6	3	Shale, light gray to brown on weathered surface; clay ironstone concretions.
12.6	16.0	4	Shale, dark gray to black, non-calcareous.
16.0	17.6	5	Limestone, finely crystalline, hard, medium gray with some brown iron staining, platy stringers probably algae.
17.6	19.0	6	Shale, black; .2' thick black ironstone or hard shale bed near middle.
19.0	19.2	7	Coal.
19.2	19.6	8	Underclay, fossilized roots.
19.6	20.0	9	Lost core.
20.0	20.1	10	Hematite bed.
20.1	34.4	11	Clay, non-calcareous, medium gray with greenish tinge.

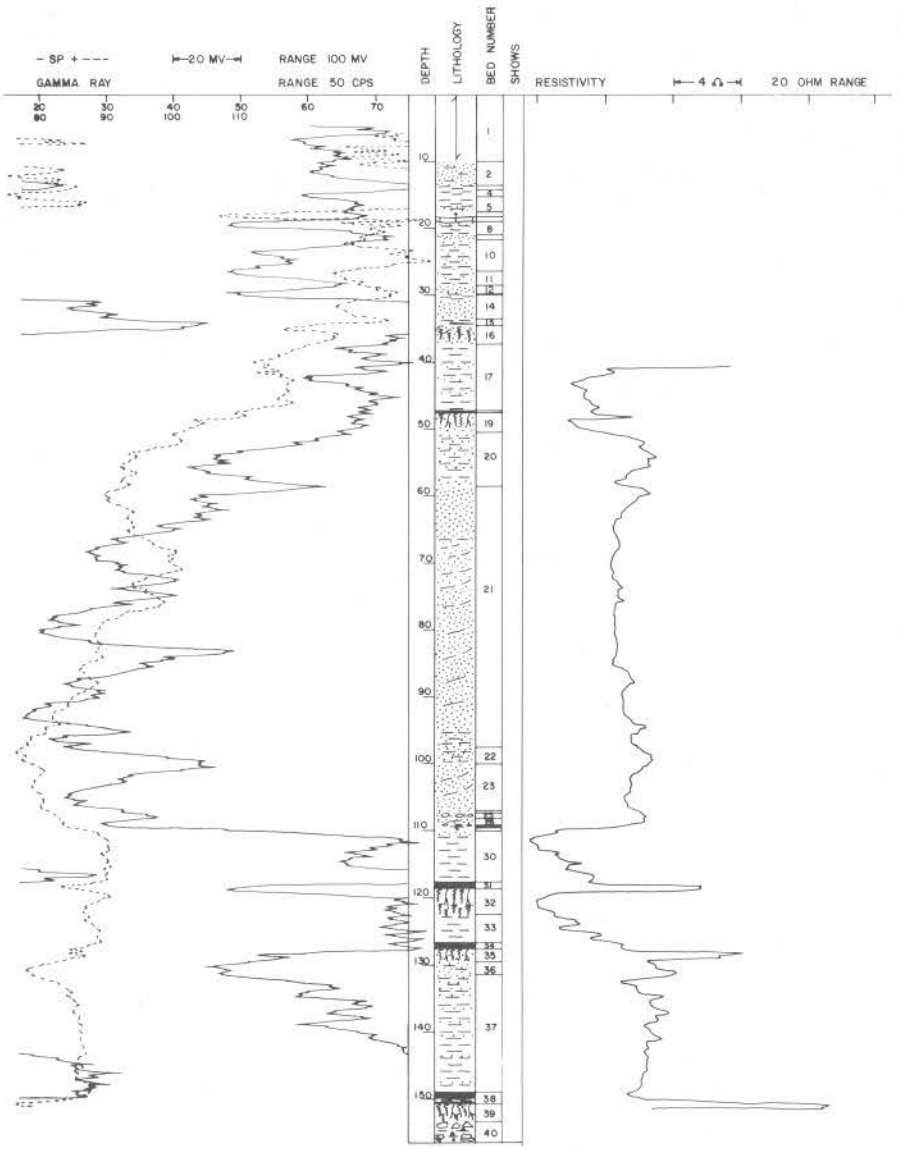
34.4	38.0	12	Shale, non-calcareous, medium gray at top to black at bottom.
38.0	38.8	13	Coal, abundant pyritized plant material.
38.8	40.0	14	Underclay, greenish-gray, non-calcareous; carbonized roots, bottom .2' sandy.
40.0	44.5	15	Sandstone, greenish-gray, argillaceous, fine-grained; black specks of pyrite or siderite; intercalated laminae of sandstone, and shale comprises bottom 1'.
44.5	56.5	16	Shale, greenish-gray, non-calcareous, grades downsection into medium dark gray clay at 50' then into greenish-gray clay shale to 56.5'; sandy (quartz sand and siderite concretions) from 51.5' to 52'.
56.5	57.8	17	Shale, greenish-gray at top to dark gray at bottom, non-calcareous.
57.8	58.0	18	Clay-ironstone, dark gray, non-calcareous; finely crystalline, high specific gravity.
58.0	58.2	19	Shale, dark gray, non-calcareous.
58.2	58.3	20	Shale, dark gray to black, non-calcareous.
58.3	58.5	21	Clay-ironstone, dark gray, finely crystalline, non-calcareous, high specific gravity.
58.5	59.8	22	Shale, black, non-calcareous.
59.8	61.6	23	Clay, light gray to medium gray at bottom; sandy at top, non-calcareous.
61.6	63.0	24	Shale, greenish-gray, bottom half interlaminated with sandstone laminae and pods.
63.0	77.8	25	Shale, dark gray (dry) to black (wet); thin intercalated laminae of sandstone comprise about 40 percent of unit; two .05' thick clay ironstone bands in top 1'; burrows filled with sandstone, in bottom (bioturbite).
77.8	78.2	26	Sandstone, light gray, quartzose, micaceous, greenish-gray clay matrix.

78.2	86.0	27	Sandstone, "bleeds" with brownish black oil, cross-bedded; coarser at bottom (1/8 mm diameter top to 1/4 mm diameter bottom) grains subangular to subrounded.
86.0	86.5	28	Sandstone, light gray, interbedded with greenish-gray shale.
86.5	94.0	29	Shale, dark gray (wet), few light gray sandstone pods, non-calcareous; 2' thick clay ironstone bed at 89.3', non-calcareous, then dark gray clay ironstone beds at 92.6' and 93'.
94.0	94.8	30	Limestone, dark gray, ferrugenous, argillaceous, Bellerphon, Neospirifer; Mesolobus striatus, Derbyia crassa.
94.8	102.5	31	Claystone, greenish-gray, very sandy; top 2' with carbonized roots; irregular cross-laminated sandstone and pods to 100.5' then becomes interlaminated with light gray horizontal cross-laminated sandstone ripples (top part an underclay).
102.5	103.5	32	Shale, dark gray, 10 percent of unit is intercalated light gray sandstone laminae.
103.5	110.0	33	Claystone, light greenish-gray, intercalated with light gray cross-laminated lenses and pods of sandstone.
110.0	126.2	34	Shale, medium gray, interlaminated with light gray lenticular sandstone; 30 percent of unit at top is sandstone laminae decreasing to approximately 10 percent at 120', non-calcareous; burrows .02' diameter filled with sandstone.
126.2	126.4	35	Coal; bands vitrain.
126.4	128.0	36	Underclay, greenish-gray; pyritized roots, sandy at bottom; bioturbite appearing.
128.0	139.5	37	Clay, greenish-gray, sandy, intercalated with sandstone laminae at bottom, micaceous; irregular, non-calcareous, hard, pyritiferous blotches to .1' diameter in top 2'; possible fossil root structures about equal amounts of light gray sandstone in lenticular laminae (ripples) and medium greenish-gray shale below 130'; micaceous, sand-sized siderite concretions.

139.5	164.0	38	Sandstone, fine-grained, light gray, quartzose, micaceous; spotted with specks of carbonaceous material; micaceous, cross-bedded; .4' thick bed of intercalated sandstone and shale at 145.9' to 146.2'; some flame (scour or turbidity structures) at 146.8'; porosity below 150' may result from washing out of clay clasts; irregular thin "bundles" of carbonaceous material at 162.4' (parallel black shale laminae in light gray sandstone).
164.0	164.2	39	Conglomerate, imbricate structure; tan clay ironstone clasts most of them elongated; microscopic to .1' long; quartz sandstone matrix; pyritiferous.
164.2	167.5	40	Sandstone, light gray; cross-bedded, contorted; "bundles" of black carbonaceous, micaceous material and dark gray shale in inclined laminae comprise approximately 10 percent of unit.
167.5	168.5	41	Conglomerate, clay ironstone clasts to .2' diameter, most of them rounded, also clasts of coal and dark gray shale in a quartzose sandstone matrix; inclined stringers of carbonaceous material (charcoal?) comprise 50 percent of unit especially near middle (a high turbulent water deposit).
168.5	188.7	42	Sandstone, fine-grained (1/16 to 1/8 mm diameter); approximately 10 percent of 2'zone near middle consists of black carbonaceous wavy inclined laminae; 3 or 4 clay ironstone beds .1' thick throughout interval.
188.7	191.1	43	Shale, dark gray (wet); 10 percent light gray, lenticular cross-laminations of sandstone (ripples), flame structure.
191.0	205.8	44	Sandstone, light gray (1/8 mm diameter grains) about 15 percent dark gray shale beds to .1' thick; becoming carbonaceous, wavy and inclined in places; approximately 50 percent of top and bottom 1' of unit is shale; .2' thick bed of ironstone conglomerate at 196.5' and .1' thick bed conglomerate at top.
205.8	206.3	45	Coal, pyrite.
206.3	209.5	46	Underclay, light to dark gray; pyritized fossil roots.
209.5	210.0	47	Clay, dark gray, hackly fracture; few sandstone pods at bottom.
210.0	210.6	48	Lost core.

210.6	219.0	49	Shale, black; sparse clay ironstone nodules to .2' diameter.
219.0	220.5	50	Coal, abundant fusain; sparse pyritized plant material near middle.
220.5	225.0	51	Underclay, fossil roots, slickensided, greenish-gray; sand-sized siderite concretions in bottom 1'.
225.0	230.8	52	Shale, dark gray to black (wet); top half with 20 percent light gray contorted sandstone lenses; bottom .5' has hackly fracture.
230.8	232.8	53	Coal, abundant pyritized fusain.
232.8	233.5	54	Underclay, dark gray, slickensided, root impressions.
233.5	238.2	55	Clay, sandy with white chert fragments to .2' long at bottom of unit; clay is dark gray becoming greenish-gray at bottom; chert comprises about 10 percent of unit and occurs mostly at top and bottom; non-calcareous.
238.2	240.0	56	Lost core.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 21
Location: 75' FSL & 18' FEL, Sec. 8, T. 35 N., R. 32 W., Vernon County
Elevation: 830' Total Depth: 156.5'



DOE-TS - No. 21
Core described by Richard J. Gentile
Location: 75' FSL & 18' FEL, Sec. 8, T. 35N., R. 32W., Vernon County

Elevation: 830' topo Total Depth: 156.5'

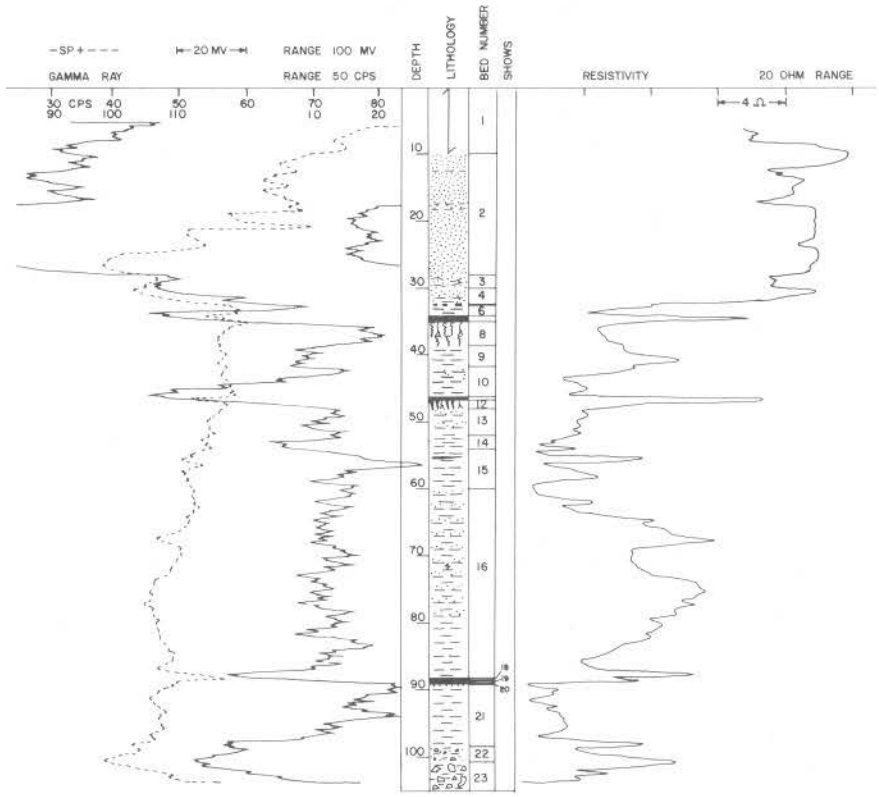
DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	13.7	2	Sandstone, thin-bedded, clayey, weathered brown.
13.7	14.2	3	Shale, dark gray, non-calcareous.
14.2	15.2	4	Shale, brown, with a .2' thick red hematitic, calcareous ironstone bed at top.
15.2	17.7	5	Shale, medium dark gray; .2' thick dark gray, calcareous, clay ironstone bed .2' from bottom and a .1' thick calcareous red, oolitic hematite bed .1' from bottom.
17.7	18.2	6	Lost core.
18.2	19.0	7	Limestone, medium gray, argillaceous, top half weathering red; brachiopod fragments (outline of biconvex shell composita); .2' thick, fossiliferous shale bed .3' from top.
19.0	21.0	8	Shale, medium gray; 5 percent of unit sandstone lenses and pods, possibly burrows filled with light gray sandstone, micaceous, non-calcareous.
21.0	21.8	9	Sandstone, fine-grained, medium gray, non-calcareous.
21.8	26.4	10	Shale, greenish-gray, non-calcareous, sandy, micaceous.
26.4	28.5	11	Shale, dark gray (dry) to black (wet), non-calcareous, pyritiferous; sparse sandstone laminae and pods.
28.5	29.8	12	Sandstone, dark gray, bits of carbonaceous fragments, mica, argillaceous; burrowed appearance.
29.8	30.0	13	Shale, dark gray, sandy, non-calcareous, fragments of coal (possibly coal not in place).
30.0	33.6	14	Sandstone, light gray, fine grained 1/16 to 1/8 mm diameter; top .3' a dark gray shale with burrows? filled with sandstone.

33.6	34.4	15	Shale, black, soft; .1' thick fractured coal bed at bottom.
34.4	37.1	16	Sandstone, light gray, argillaceous; abundant .3' long vertical root impressions in top becoming sparse at bottom.
37.1	47.1	17	Shale, greenish-gray at top to dark gray at bottom; approximately 10 percent of unit is light gray sandstone ripple laminae and pods; 2 or 3 sandstone beds .1' thick near middle composed of grains of siderite and quartz.
47.1	47.35	18	Coal, vitrain, some fusain, pyritized plant material.
47.35	50.5	19	Underclay, sandy, greenish-gray, carbonized roots.
50.5	58.4	20	Sandstone and shale, light greenish-gray sandstone (wet), top .2' argillaceous, grades downsection into equal amounts of greenish-gray shale interlaminated with sandstone decreasing to approximately 10 percent light gray sandstone laminae from 57' to 58' and medium gray shale; predominately sandstone below 58'.
58.4	97.4	21	Sandstone, fine-grained (1/16 to 1/8 mm) micaceous, even-bedded; sparse shale laminae intercalated with light gray sandstone ripples from 66' to 67'; approximately 5 percent of unit is dark gray carbonaceous shale laminae which separate and "climb up" sandstone ripples; .05' thick tan clay ironstone beds at approximately 73', 74.4', 76.4', 80.6', 87.5', and 95.5'; dark gray shale laminae to .1' thick at 95.6' and 96.3'.
97.4	100.0	22	Sandstone, light gray, composed of cross-laminated ripple sandstone separated by black, paper-thin carbonaceous laminae; 30 percent of unit medium gray shale laminae to .02' thick, sparse lenses coal; similar to 58.4' to 97.4' interval but shale units separating sandstone beds are thicker.
100.0	107.0	23	Sandstone, fine-grained, cross-laminated ripples separated by paper-thin dark gray shale laminae.
107.0	107.3	24	Sandstone, same as above but shale units more abundant.
107.3	108.2	25	Conglomerate, clasts of shale and tan clay; tan clay clasts are surrounded by black rinds and appear to be the interior pulp or pith of the Calamites tree; horizontal to vertical discontinuous lenses of coal; matrix of micaceous quartzose sandstone.

108.2	109.1	26	Sandstone, light gray, quartzose; inclined coal laminae form about 10 percent of unit.
109.1	109.2	27	Conglomerate, same as 107.3' to 108.2'.
109.2	109.3	28	Clay, medium gray, non-calcareous.
109.3	110.0	29	Lost core.
110.0	117.6	30	Shale, black; upper 1' of unit interbedded with light gray sandstone lenses and pods; clay ironstone bed 115.3' to 115.6'.
117.6	118.6	31	Coal, with pyritized fusain.
118.6	122.3	32	Underclay, greenish-gray, slickensided, root molds.
122.3	126.7	33	Shale, black; .1' thick dark gray non-calcareous, clay ironstone bed at 120.8' and 123.3'.
126.7	127.6	34	Coal, pyritized plant leaves.
127.6	129.4	35	Underclay, dark gray, becoming light gray and sandy downsection; root molds.
129.4	131.4	36	Sandstone, argillaceous, light gray, sand-sized siderite concretions.
131.4	149.0	37	Shale, medium dark gray, 50 percent of unit near top is intercalated light gray sandstone laminae decreasing to 5 percent in bottom of unit.
149.0	150.9	38	Coal, fractured .5' from top; .2' thick dark gray shale lens .5' from bottom; pyrite lens near bottom.
150.9	153.2	39	Underclay, medium gray, carbonized roots, slickensided.
153.2	156.5	40	Chert rubble, fragments to .3' long, chert rubble interbedded with bright green clay; cubic pyrite crystals, noncalcareous.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 22

Location: 15' FNL & 65' FEL, Sec. 14, T. 31 N., R. 31 W., Barton County
Elevation: 967' Total Depth:105'



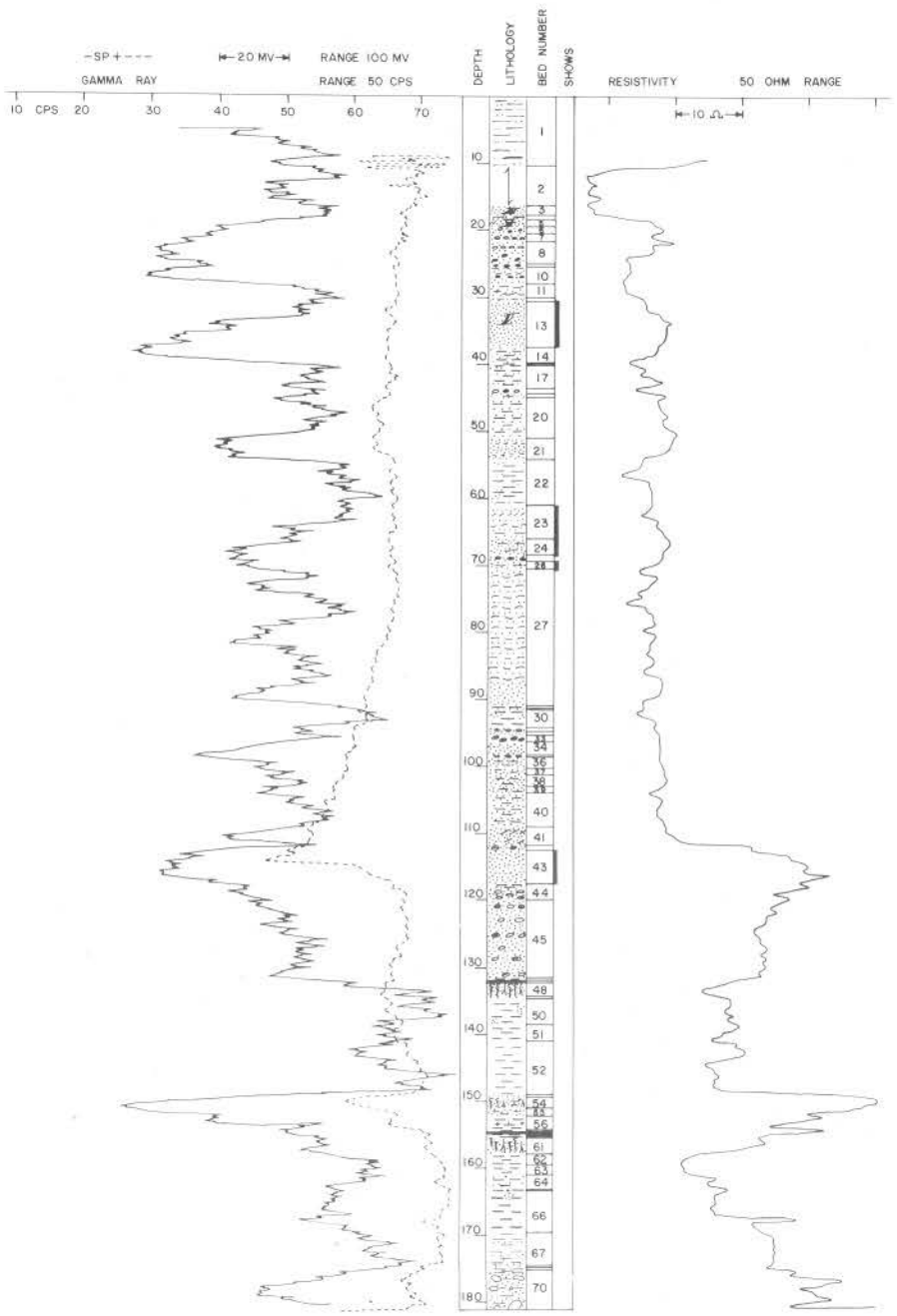
DOE-TS - No. 22
Core described by Richard J. Gentile
Location: 15' FNL & 65' FEL, Sec. 14, T. 31N., R. 31W., Barton County

Elevation: 967' Total Depth: 105'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core.
10.0	28.0	2	Sandstone, fine-grained light gray, non-calcareous, quartzose, brown iron stain in top 2', tight; .1' thick light gray shale lenses with thin carbonaceous stringers at 12.4', 17.5', and 18.2'.
28.0	30.0	3	Sandstone, light gray, interlaminated with dark gray, micaceous, horizontal, crinkly laminae of shale.
30.0	32.3	4	Sandstone, light gray; bottom half contains dark gray, carbonaceous shale with broken pieces of fusain; pods of light gray sandstone to .1' diameter near middle.
32.3	32.4	5	Conglomerate, flat clasts of shale, light to dark brown woody material; pyrite nodules.
32.4	34.1	6	Shale, medium gray non-calcareous; top half interbedded with lenticular laminae (starved ripples) of light gray sandstone.
34.1	35.0	7	Coal, bands of vitrain; flattened nodules of pyrite to grape-size comprise 2 or 3 percent of unit.
35.0	38.6	8	Underclay, light gray with dark gray carbonized root impressions.
38.6	41.8	9	Shale, dark gray with cross laminae and pods of sand-sized siderite concretions that weather red; some quartz sand grains with the siderite.
41.8	46.1	10	Shale, dark gray (dry) black (wet); parallel cross laminae of sandstone; sandstone also fills in vertical burrows in top 1'.
46.1	46.6	11	Coal, bands vitrain; pyrite nodules .02' thick and .1' wide.

46.6	48.0	12	Underclay, medium gray (dark gray wet), slickensided, carbonized and pyritized roots.
48.0	52.0	13	Shale, black, light gray; sandstone cross-laminae with grains of siderite; siderite evenly distributed throughout bottom 1'.
52.0	54.0	14	Shale, black; ironstone concretions .1' diameter near middle.
54.0	60.0	15	Shale, slickensided; medium dark gray zones of sand-sized siderite in shale matrix to 1' thick at top and near middle; coal lenses at 55.5' appear discontinuous.
60.0	88.1	16	Shale, black; 10 percent of unit is "starved" light gray sandstone ripples to 80'; lost core 71' to 72'; sparse .1' thick bands of brown clay ironstone in bottom 4'.
88.1	88.5	17	Coal, pyrite nodules.
88.5	88.7	18	Shale, clay ironstone at top.
88.7	88.9	19	Coal.
88.9	90.0	20	Underclay, slickensided; dark gray clusters of pyrite nodules in bottom .2'.
90.0	98.3	21	Shale, black; clusters of pyrite nodules at 90' to 90.4' and at 92.2'; .1' thick clay ironstone band at 97'.
98.3	100.9	22	Clay, dark gray to green at bottom; light gray contorted sandstone; fragments of light gray angular chert.
100.9	105.0	23	Chert, mottled light gray, pink and dark gray; angular, brecciated appearance. 40 percent of unit is greenish-gray clay and pyrite filling cavities in the chert.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 23
Location: 460' FNL & 15' FEL, Sec. 29, T. 37 N., R. 29 W., Vernon County
Elevation: 858' Total Depth: 181'



DOE-TS - No. 23
Core described by Richard J. Gentile
Location: 460' FNL & 15' FEL, Sec. 29, T. 37N., R. 29W., Vernon County

Elevation: 858' Total Depth: 181'

DEPTH		UNIT	DESCRIPTION
0.0	10.4	1	Soil, sandy clay (flush samples).
10.4	16.2	2	Lost core.
16.2	17.7	3	Sandstone, argillaceous, cross bedded, brown; grains to 1/4 mm diameter.
17.7	18.4	4	Shale, dark gray, sandy.
18.4	19.4	5	Sandstone, brown, cross-bedded, micaceous.
19.4	20.4	6	Sandstone, conglomeratic; clasts of shale, coal, plant fragments predominately Calamites.
20.4	21.7	7	Sandstone, fine-grained, brown; .1' conglomerate bed at 21.4'; clasts of shale and ironstone.
21.7	25.0	8	Sandstone, conglomeratic with flattened, elongated clasts of coal that form lenses in places, few granule sized shale clasts, contorted, inclined bedding; clay ironstone concretion .2' diameter at 22.4' (represent plant material washed into an area of sand deposition).
25.0	25.3	9	Conglomerate, clasts of greenish-gray sandy shale to .05' diameter in a fine-grained quartz sandstone matrix, micaceous.
25.3	28.0	10	Sandstone, brown, fine to medium grained; inclined bedding; disturbed gray shale bed at 25.7' with pieces to .1' thick; gray shale bed 26.4' to 26.5'; conglomerate 26.9' to 27.3' with clasts of shale to .2' diameter and tan plant (pith) material.
28.0	30.0	11	Shale and interbedded medium to light gray lenticular cross-laminated (starved ripples) becoming trough stratified in bottom .4'.
30.0	30.4	12	Sandstone, light gray, interlaminated with dark gray shale; burrowed appearance (bioturbite).

30.4	37.3	13	Sandstone, fine-grained cross-bedded, micaceous; laminae from 33.0' to 33.3' of black sand-sized particles of plant material and gilsonite? mica; bottom .1' has contorted burrowed appearance.
37.3	39.8	14	Sandstone and shale; interlaminated dark gray shale and light gray cross-laminated sandstone (ripples) with sparse planar-tabular cross-bedded units to .4' thick.
39.8	40.0	15	Shale, dark gray.
40.0	40.2	16	Shale, dark gray.
40.2	43.6	17	Shale, dark gray with light gray sandstone laminae (ripples) and pods.
43.6	44.2	18	Conglomerate, clasts granule-size (4mm) of tan plant (pith) material, green and gray shale, pieces coal.
44.2	44.9	19	Sandstone, medium gray, fine-grained, cross-laminated, contorted; soft gray clay layer 44.7' to 44.8'.
44.9	51.0	20	Shale, dark gray and light gray sandstone lenses and pods intercalated in evenly spaced laminae .01' thick or less and inclined 10^{o}; contorted sandstone laminae (bioturbite or deformation structures from 48.9' to 49.5').
51.0	54.1	21	Sandstone, light gray cross-laminated; separated by paper-thin laminae of black carbonaceous material and mica; sandstone grain size ranges from 1/32 mm (silt) to 1/4 mm (fine sand); average grain size 1/16 mm; bioturbite structure 51' to 51.4'.
54.1	61.0	22	Shale, medium gray (wet); evenly spaced light gray lenticular lenses and pods of sandstone to .01' thick comprise about 20 percent of unit; equal amounts of sandstone and shale from 58' to 58.3'; contorted slumpage structure of light gray sandstone .1' thick at 59'.
61.0	66.0	23	Sandstone, light gray in lenses and pods, horizontal, to inclined, and deformed attitude; interlaminated with dark gray shale; sandstone beds to .1' thick at bottom; specks coal and/or gilsonite.
66.0	68.6	24	Sandstone, medium gray, approximately 10 percent of unit is contorted dark gray shale laminae intercalated with sandstone beds to .2' thick; specks coal and/or gilsonite.

68.6	69.4	25	Conglomerate in beds of elongated clasts to .1' long of dark gray shale and sparse clay ironstone; imbricate structure; light gray sandstone matrix (several beds in sequence with imbrication in same direction indicate directional currents); conglomerate beds to .1' thick interbedded with medium to light gray sandstone (an intraformational conglomerate).
69.4	70.5	26	Sandstone, light gray, cross-laminated; sandstone medium gray, cross-laminated (salt and pepper appearance from bits of plant material and gilsonite), dark gray to black shale. These 3 lithologies form an alternating sequence of laminae; clay ironstone concretion to .1' thick at 69.8'.
70.5	91.0	27	Sandstone, light gray, lenticular, cross-laminated, intercalated with dark gray wavy shale laminae; black shale beds with clay ironstone concretions at 76.3' to 76.6', 76.8' to 76.9', 77.2' to 77.5', 77.8' to 77.9', 80.2' to 80.4'; predominately black shale from 86.3' to 87.4'; approximately 80 percent of unit is sandstone below 87.4', contorted structure at 86.7'; flame structure at 87.5'.
91.0	91.3	28	Shale, dark gray (wet).
91.3	91.5	29	Sandstone, light gray and shale dark gray, interlaminated.
91.5	94.2	30	Shale, dark gray, few contorted lenses of light gray sandstone 92.2' to 93.0'.
94.2	94.8	31	Conglomerate, bladelike clasts of dark gray shale with light gray sandstone matrix, imbricate structure.
94.8	95.3	32	Sandstone, light gray.
95.3	96.3	33	Conglomerate, bladelike, rounded edges, clasts of dark gray shale, imbricate structure, clasts to .2' long.
96.3	98.2	34	Sandstone, light gray, fine-grained, contorted in top 1'; few clasts of dark gray shale, tan plant (pith) material.
98.2	98.4	35	Conglomerate same as 95.3' to 96.3' (Bed 33).
98.4	100.2	36	Sandstone, light gray, fine grained; interlaminated with dark gray carbonaceous (plant material), micaceous shale.
100.2	101.3	37	Sandstone, light gray, cross laminated; approximately 20 percent of unit is interlaminated dark gray wavy shale lenses.

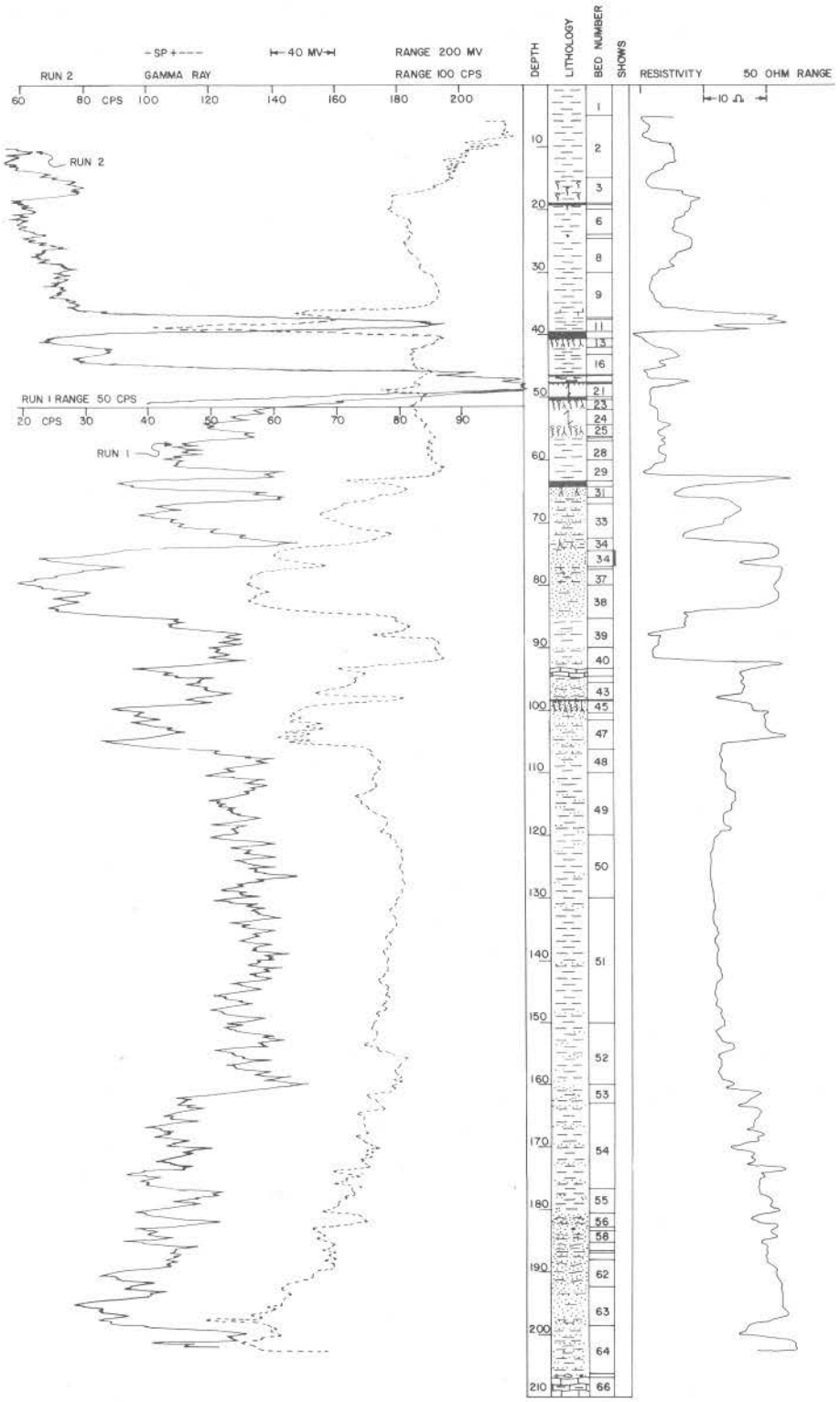
101.3	103.0	38	Sandstone, light gray interlaminated with dark gray shale.
103.0	104.0	39	Sandstone, light gray; few dark gray laminae of shale.
104.0	109.0	40	Sandstone, light gray lenticular, cross laminated, and dark gray shale interlaminated; flame structure at bottom.
109.0	111.9	41	Sandstone, light gray, cross laminated; dark gray inclined shale laminae evenly spaced comprise approximately 5 percent of unit.
111.9	112.4	42	Conglomerate; clasts of dark gray shale, sparse ironstone and tan plant (pith) material; imbricate structure; light gray fine-grained sandstone (to 1/4 mm diameter grains) matrix; many clasts "floating" in sandstone.
112.4	117.5	43	Sandstone, light gray, fine-grained; specks carbonaceous material and gilsonite; even bedding.
117.5	120.0	44	Conglomerate, same as 111.2' to 112.4' (Bed 42); two dark gray shale layers .1' thick at top; predominately sandstone from 118.7' to 119.2'.
120.0	131.7	45	Conglomerate, same as above; dark gray to black clasts form 50 percent of unit; clasts to .2' diameter.
131.7	131.9	46	Shale, black (wet); approximately 10 percent of unit is light gray, lenticular, cross-laminated sandstone.
131.9	132.2	47	Coal, vitrain banding; pyritized plant pieces.
132.2	134.3	48	Underclay, sandy, dark gray at top to sandy at bottom; carbonized and pyritized roots.
134.3	134.6	49	Clay, light gray, soft.
134.6	138.7	50	Shale, light greenish-gray; irregular patches of sand-sized siderite concretions.
138.7	141.0	51	Shale, dark gray at top to black at bottom.
141.0	149.0	52	Shale, black (wet); clay ironstone layers 143.05' to 143.1', 145' to 145.1', 146.8' to 146.9'; soft black shale bed 148.8' to 149.9'; sparse lenses and clusters of pyrite crystals.
149.0	149.3	53	Sandstone, argillaceous, light gray, disturbed structures (bioturbites?); pyritiferous.

149.3	151.0	54	Sandstone, light to medium gray, quartzose; sparse green grains (glauconite?) carbonized roots; calcareous below 149.7'; pieces brachiopod shell at 151'.
151.0	152.1	55	Sandstone, light gray, irregular dark gray shale lenses, calcareous, recrystallized shell fragments; fossil debris.
152.1	154.1	56	Shale, dark gray, calcareous; abundant fossiliferous lenses small spiny productids, chonetids, Mesolobus?; Composita, Derbyia, crinoid columnals; fossils fragmented, recrystallized, some pyritized.
154.1	154.4	57	Shale, black, non-calcareous.
154.4	154.9	58	Coal, vitrain banding; pyrite nodules to .1' long.
154.9	155.0	59	Clay parting, hard, plant cuticles; carbonaceous (does not burn in brunsen flame).
155.0	155.1	60	Shale, black, hard, streaks of coal.
155.1	157.9	61	Underclay, medium gray, sandy, pyritized roots; sand-sized siderite concretions in bottom 1'.
157.9	159.5	62	Shale, black, thin lenticular lenses greenish-gray shale, non-calcareous.
159.5	161.0	63	Shale, dark gray, soft, non-calcareous.
161.0	163.1	64	Shale, black, 5 percent of unit is evenly spaced lenticular light gray calcareous sandstone laminae, slightly inclined.
163.1	163.2	65	Shale, dark gray, slightly calcareous.
163.2	169.7	66	Shale, dark gray to black; top .5' with light gray filled sandstone burrows; pyrite nodules to .05' diameter at 164.3', 164.9'; clay ironstone nodules 167.7' to 168'.
169.7	174.5	67	Shale, black (wet), approximately 10 percent of unit evenly spaced light gray, non-calcareous, lenticular, inclined, sandstone laminae, some pods sandstone; high angle fracture, slickensided.
174.5	174.8	68	Sandstone, light gray, lenticular and shale dark greenish-gray, interlaminated; sparse clasts of white angular chert to .02' diameter.

174.8	175.1	69	Shale, dark greenish-gray, non-calcareous, slickensided.
175.1	181.0	70	Conglomerate, clasts of white (few dark gray with white rinds), subangular to subround, poorly sorted granules to .5' diameter, clasts dispersed in a greenish-gray, sandy, non-calcareous clay matrix, some carbonized roots; approximately 50 percent of unit sandstone matrix, sparse sand-sized siderite concretions throughout matrix.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 24

Location: SW¼, SE¼, SE¼, Sec. 14, T. 37 N., R. 31 W., Vernon County
Elevation: 768' Total Depth: 210'



DOE-TS - No. 24
Core described by Richard J. Gentile
Location: SW$\frac{1}{4}$, SE$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 14, T. 37N., R. 31W., Vernon County

Elevation: 768' Total Depth: 210'

DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil, black.
5.0	15.0	2	Clay, brown, pea-sized ironstone concretions.
15.0	19.0	3	Clay, medium gray to brown.
19.0	19.2	4	Coal, soft.
19.2	20.0	5	Clay, gray, soft; hematite concretion or a thin bed.
20.0	24.0	6	Shale, dark gray (ditch samples to 24').
24.0	24.6	7	Lost core.
24.6	30.0	8	Shale, dark gray, non-calcareous, clay ironstone bed 26.5' to 26.6'.
30.0	37.2	9	Shale, dark gray, non-calcareous, clay ironstone bed 30.8' to 30.85' and slightly calcareous clay ironstone bed 37.2' to 37.3'.
37.2	37.4	10	Shale, dark gray, calcareous, thin-shelled convex shells (productids ?) mostly fragments.
37.4	39.4	11	Shale, black, hard, joints filled with $CaCO_3$.
39.4	40.5	12	Coal, pyrite lenses to .05' thick; bottom part fragmented.
40.5	42.0	13	Underclay, poorly developed, few pyritized roots but roots may be masked by dark color of clay.
42.0	43.1	14	Clay, dark gray, non-calcareous.
43.1	43.4	15	Clay, medium gray with sand-sized siderite concretions and pyrite crystals dispersed throughout unit.
43.4	46.5	16	Shale, medium gray at top to dark gray at bottom.

46.5	46.7	17	Coal, bright, vitrain streaks.
46.7	47.7	18	Shale, black, non-calcareous.
47.7	47.8	19	Coal, bright.
47.8	48.0	20	Underclay, slickensided, carbonized roots.
48.0	50.0	21	Lost core; most likely here but loss could be anywhere between 40' to 50' interval.
50.0	50.4	22	Coal; .1' dark gray shale parting .1' from bottom.
50.4	52.0	23	Underclay, medium gray, carbonized roots.
52.0	54.5	24	Lost core, may be coal.
54.5	56.2	25	Underclay, medium gray, carbonized roots.
56.2	56.5	26	Ironstone, sand-sized siderite concretions, medium gray; high S. G.
56.5	57.0	27	Shale, dark gray (dry) to black (wet); non calcareous; lenticular sandstone laminae.
57.0	60.0	28	Shale, black, non-calcareous; small pyrite nodules and lenses; poorly developed clay ironstone bands 57.2' to 57.4', 58.3' to 58.4'.
60.0	63.4	29	Shale, black, non-calcareous; pyritiferous; .1' clay ironstone bed near center.
63.4	64.2	30	Coal, pyritiferous; cleats filled with $CaCO_3$.
64.2	66.0	31	Sandstone, light gray, argillaceous; carbonized roots; sandstone content decreases toward bottom.
66.0	67.0	32	Shale, black, approximately 5 percent of unit is light gray sandstone pods; sparse pyritized plant material.
67.0	72.5	33	Shale, dark gray and sandstone light gray interlaminated in equal amounts; sandstone is contorted to horizontal, lenticular; some pods sandstone; scour and fill structures; burrowed (bioturbite) appearance in places; shale lenses range in color from medium gray to dark gray.

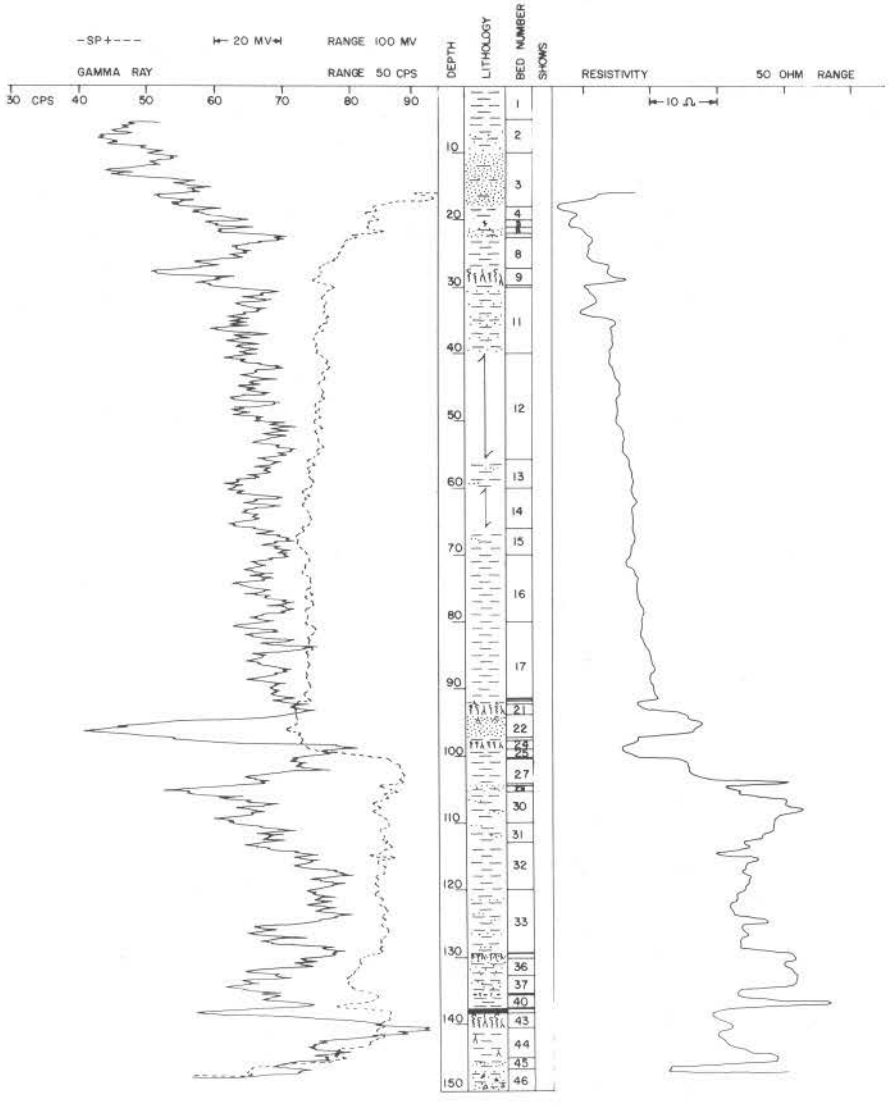
72.5	74.5	34	Clay, light gray, very sandy; carbonized roots; sand-sized siderite concretions; mostly sandstone at bottom.
74.5	77.0	35	Sandstone, light gray, fine-grained, slight asphalt stain, non-calcareous.
77.0	77.5	36	Shale, medium gray; light gray sandstone laminae evenly spaced comprise 40 percent of unit.
77.5	80.0	37	Sandstone, medium gray, argillaceous; sand-sized siderite concretions form bed .1' thick at top and are disseminated throughout unit.
80.0	85.3	38	Sandstone, light gray, argillaceous, sparse lenses of clay.
85.3	90.0	39	Shale, dark gray to black; sparse pyrite laminae and nodules; 3 thin (to .1') thick beds clay ironstone; micaceous; few paper-thin laminae of light gray sandstone.
90.0	93.3	40	Shale, dark gray (dry) to black (wet); less than 5 percent of unit is lenticular paper-thin, light gray sandstone laminae.
93.3	94.6	41	Limestone, dark gray, argillaceous; thin bedded; brachiopods (productids .1' diameter).
94.6	95.6	42	Shale, dark gray, sandy at bottom; few shell fragments.
95.6	98.2	43	Sandstone, light gray, fine-grained ripple cross-laminations; approximately 20 percent of unit is dark gray, wavy shale laminae composed of bits of carbonaceous material; shale and sandstone laminae evenly spaced.
98.2	98.3	44	Coal, bright.
98.3	100.3	45	Underclay, light gray, sandy; carbonized roots; sand-sized siderite concretions in patches in bottom 1'.
100.3	101.6	46	Sandstone, light gray, greenish-gray sand shale lenses; bottom .3' with disseminated specks gilsonite and coal.
101.6	106.2	47	Sandstone, light gray, cross-laminated, lenticular; intercalated with dark gray shale consisting of carbonaceous specks; burrowed structures mostly in top half of unit.
106.2	110.0	48	Shale, black, non-calcareous; approximately 10 percent of top half is light gray lenticular sandstone laminae evenly spaced but decreasing in number downsection.

110.0	120.0	49	Shale, black; light gray cross-laminated lenticular ripples, evenly spaced form 5 percent of unit 112' to 114.4', 30 percent of unit 114.4' to 116.7', 10 percent of unit 116.7' to 120'; bits of carbonaceous material and mica along bedding planes.
120.0	130.0	50	Shale, dark gray (dry) to black (wet); approximately 5 percent of unit is evenly spaced light gray lenticular sandstone laminae paper-thin to .01' thick; pyritized Aviculopecten at 126.7'; plants Calamites, ferns at 127' to 129' but bits of plant material or bedding planes throughout unit.
130.0	150.0	51	Shale, medium gray (dry) to dark gray (wet); 5 percent of unit is light gray lenticular sandstone laminae (paper-thin to .01' thick), evenly spaced throughout, pieces plant material on bedding planes.
150.0	160.0	52	Shale, medium gray (dry) to dark gray (wet); approximately 20 percent of unit is light gray lenticular cross-laminated ripples (paper-thin to .02' thick); approximately 10 percent sandstone laminae from 154' to 156'.
160.0	163.0	53	Shale, black, 10 percent of unit is light gray horizontal cross-laminated sandstone increasing to 20 percent at bottom, disturbed (bioturbite) structure 162.8' to 163.1'.
163.0	176.8	54	Shale, dark gray (dry) to black (wet) and sandstone light gray, cross-bedded intercalated in equal amounts in unit to .2' thick, wavy, lenticular, fine to medium grain. The .2' thick shale and sandstone beds contain thin laminae of sandstone or shale.
176.8	180.3	55	Shale, black and light gray sandstone pods (marble size) oriented in horizontal zones or beds within the shale in approximately equal amounts.
180.3	182.9	56	Sandstone, light gray, fine-grained, units to .05' thick, cross-bedded, 20 percent of unit is wavy dark gray to black shale laminae.
182.9	183.2	57	Sandstone, light gray, calcareous; sparse elongated angular clasts of dark gray shale, pyritiferous.
183.2	185.1	58	Same as 180.3' to 182.9' interval.
185.1	186.6	59	Sandstone, light brownish-gray, fine grained; 10 percent of

			unit is wavy dark gray to black shale laminae, evenly spaced; micaceous along bedding planes.
186.6	186.9	60	Shale, black and sandstone light gray, in distorted laminae and pods (bioturbite).
186.9	188.0	61	Same as 185.1' to 186.6' interval (Unit 59).
188.0	192.2	62	Sandstone, light gray, ripple cross-laminated in units to .1' thick; 30 percent wavy black shale laminae; bioturbite appearance (light gray sandstone pods, bedded, 188.2' to 188.4', 190.5' to 191.1').
192.2	198.6	63	Sandstone, light brownish-gray, fine-grained in units to .3' thick and black shale laminae to .02' thick intercalated, evenly spaced form 5 percent of unit; light gray calcareous blotches in bottom 1-1/2'.
198.6	206.1	64	Shale, dark gray (dry) to black (wet), intercalated with equal amounts of light gray sandstone laminae; bioturbite structure at 198.6' to 200', 201.6' to 202.4', 204.2' to 204.5', 204.6' to 204.8', 204.9' to 205.2', slickensided in bottom 5'.
206.1	206.9	65	Conglomerate, chert clasts rounded to angular, light gray to red, to .2' diameter; matrix of dark gray to green sandy clay, sparse clasts of black shale, pyritiferous.
206.9	210.0	66	Limestone, light brownish-gray, medium crystalline; sparse greenish-gray shale laminae and filled vugs in middle 1'.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 25

Location: 2500' FWL & 1260' FSL, Sec. 30, T. 38 N., R. 30 W., Vernon County
Elevation: 761' Total Depth: 150'



DOE-TS - No. 25
Core described by Richard J. Gentile
Location: 2500' FWL & 1260' FSL, Sec. 30, T. 38N., R. 30W., Vernon County

Elevation: 761' Total Depth: 150'

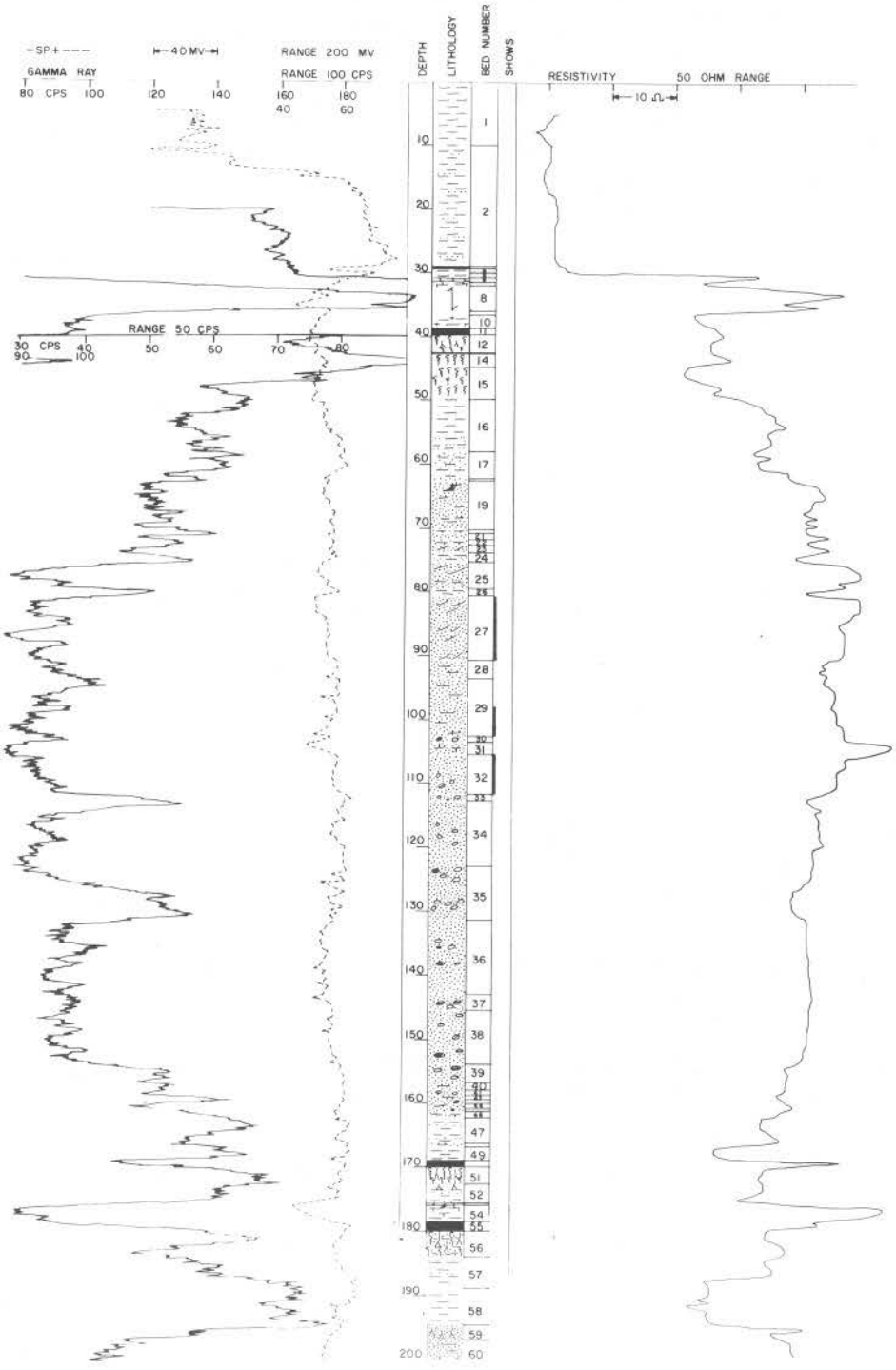
DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil and clay, brown.
5.0	10.0	2	Clay, yellow, becoming sandy at bottom.
10.0	18.0	3	Sandstone, yellow brown; very fine to medium grained, weathered, soft, clayey.
18.0	20.0	4	Shale, gray, soft, sticky (ditch samples to 20' - core from 20' to total depth).
20.0	21.0	5	Lost core.
21.0	22.0	6	Shale, dark gray (wet), equal amounts of light gray lenticular sandstone laminae (ripples).
22.0	22.5	7	Sandstone, light gray, disturbed and clayey (bioturbite).
22.5	27.1	8	Shale, dark gray, fauna of ferns etc., increasing in content toward bottom.
27.1	29.8	9	Underclay, light gray, arenaceous, carbonized roots.
29.8	30.0	10	Shale, dark gray.
30.0	40.0	11	Shale, dark gray, 10 percent light gray lenticular sandstone laminae (paper-thin to .01' thick) increasing to 30 percent in middle 2' of interval; some pods light gray sandstone (grape-size) broken pieces plant material concentrated near middle 3', core loss in interval 30' to 40'.
40.0	55.8	12	Lost core.
55.8	60.0	13	Shale, black, hard, non-calcareous; 5 percent paper-thin, lenticular laminae of light gray sandstone, evenly spaced, broken plant fragments along bedding planes.
60.0	66.0	14	Lost core.

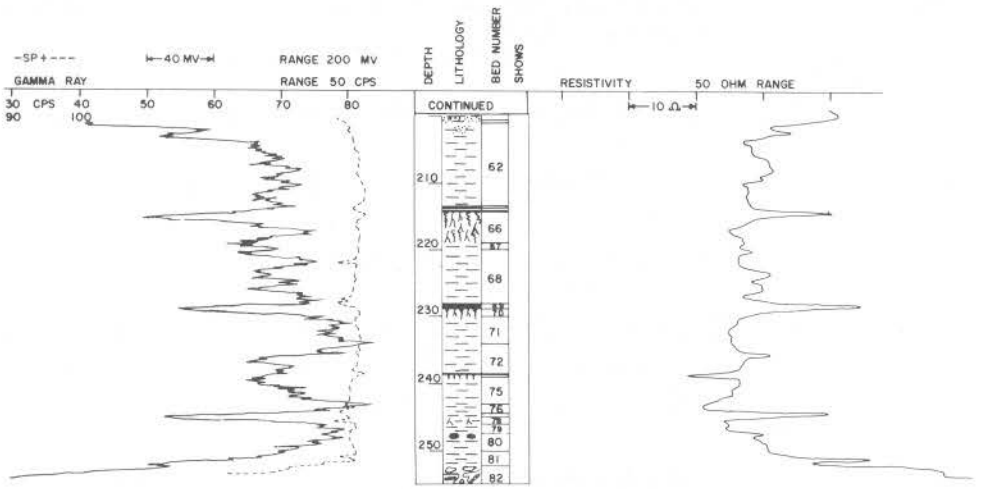
66.0	70.0	15	Shale, black, non-calcareous, 1 or 2 percent light gray sandstone lenses and pods dispersed throughout interval; plant fragments and mica along bedding planes.
70.0	80.0	16	Shale, dark gray (wet), non-calcareous; plant fragments mostly Calamites, and mica along bedding planes.
80.0	91.3	17	Shale, black, non-calcareous; dark gray clay ironstone bed 80.4' to 80.6'; plant fragments Annularia, Calamites, Cordaites, ferns, tan cuticle material and mica along bedding planes; pyritiferous.
91.3	91.35	18	Clay ironstone, dark gray.
91.35	91.45	19	Sandstone, light brownish-gray, non-calcareous; fine-grained cross-bedded.
91.45	92.1	20	Clay, dark gray, plant leaves and carbonized roots.
92.1	93.9	21	Underclay, light gray, non-calcareous carbonized roots.
93.9	97.2	22	Sandstone, light gray, medium grained, quartzose; sand-sized siderite concretions, carbonized roots in top 1'.
97.2	97.6	23	Shale, dark gray, non-calcareous.
97.6	99.0	24	Underclay, light gray, carbonized roots.
99.0	100.1	25	Shale, medium gray, non-calcareous; bed or concretion of sand-sized siderite concretions at 99.5' to 99.6'.
100.1	100.2	26	Ironstone bed of sand-sized siderite concretions; high S.G.
100.2	104.1	27	Shale, medium gray at top to black at bottom.
104.1	104.4	28	Clay ironstone, sandy; pyritiferous, light gray sandy clay fills vugs in bottom .1'.
104.4	105.2	29	Shale, light gray at top to medium gray at bottom; sandy.
105.2	110.0	30	Shale, black at top to medium gray at bottom; 20 percent of unit is evenly spaced light gray lenticular sandstone laminae.
110.0	113.0	31	Shale, dark gray; 20 percent of unit is evenly spaced light gray cross-laminated sandstone ripples (paper-thin to .01' diameter).

113.0	120.0	32	Shale, black.
120.0	129.3	33	Shale, black, non-calcareous, pyritized plant material along bedding plane; approximately 50 percent paper-thin light gray laminae of sandstone or siltstone; clay ironstone bed 125.2' to 125.3'.
129.3	129.5	34	Shale, black, irregular contact with underlying unit.
129.5	130.2	35	Underclay, light gray, sandy, carbonized roots.
130.2	132.9	36	Claystone, light greenish-gray, very sandy (quartz), abundant sand-sized siderite concretions.
132.9	135.3	37	Shale, light greenish-gray at top to dark gray at bottom; approximately 40 percent of unit is light gray lenticular sandstone laminae evenly distributed.
135.3	135.4	38	Conglomerate clasts of coal, dark gray shale, elongated into lenses; sandy clay matrix, sand-sized siderite concretions, pyritiferous.
135.4	135.6	39	Underclay, light gray, carbonized roots.
135.6	137.4	40	Shale, light greenish-gray; abundant sand-sized siderite concretions.
137.4	137.6	41	Shale, black.
137.6	138.3	42	Coal, fragmented, shiny, pyritiferous.
138.3	140.4	43	Underclay, dark gray to light gray at bottom, hackly fracture; Stigmarian roots.
140.4	145.0	44	Claystone, medium gray, few carbonized roots.
145.0	146.8	45	Shale, sparse inclined light gray lenticular sandstone laminae; sand-sized siderite concretions.
146.8	150.0	46	Claystone, medium gray, very sandy; clasts of angular white chert to .1' diameter comprise 5 percent of unit.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 26

Location: 1935' FEL & 30' FSL, Sec. 11, T. 37 N., R. 32 W., Vernon County
Elevation: 752' Total Depth: 255'





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Core described by Richard J. Gentile
Location: 1935' FEL & 30' FSL, Sec. 11, T. 37N., R. 32W., Vernon County

Elevation: 752' Total Depth: 255'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and gray clay to reddish-gray clay at bottom.
10.0	29.0	2	Clay, reddish-brown, silty.
29.0	29.2	3	Coal, shiny.
29.2	30.0	4	Shale or clay, dark gray (churn samples to 30').
30.0	30.7	5	Shale, dark gray, non-calcareous.
30.7	31.3	6	Limestone, dark gray, argillaceous, cross section of brachiopods, small productids and biconvex types resembling Composita, crinoid columnals.
31.3	32.0	7	Shale, dark gray to black at bottom; calcareous.
32.0	36.0	8	Lost core.
36.0	36.7	9	Brown creek chert gravel (out of place).
36.7	38.8	10	Shale, black, non-calcareous with zones of dark gray, argillaceous, pyritiferous limestone containing fragments of shells at 36.8' to 36.9' and 38.6' to 38.8'.

38.8	39.9	11	Coal, shiny, calcite along cleats; sticks to overlying cap limestone.
39.9	42.7	12	Clay, medium gray, slickensided; few root impressions.
42.7	42.8	13	Coal, .01' thick clay band .02' from top.
42.8	44.7	14	Clay, medium gray, non-calcareous.
44.7	49.9	15	Clay, greenish-gray, reddish-brown, sand-sized siderite concretions scattered throughout, form irregular shaped nodules to .2' diameter at 47.5' to 47.9'.
49.9	58.0	16	Shale, greenish-gray, non-calcareous; becoming silty, micaceous in lower half; zones of sand-sized reddish-brown siderite concretions at 52.4' to 52.7', 54.4' to 54.6'.
58.0	62.1	17	Shale, greenish-gray, very sandy.
62.1	62.4	18	Sandstone, fine-grained nodules of pyrite, appears conglomeratic.
62.4	70.2	19	Sandstone, light gray to greenish-gray; small scale cross bedding in top 2'; predominately greenish-gray shale 68.5' to 69' with small number of greenish-gray shale laminae throughout unit.
70.2	70.9	20	Shale, greenish-gray, interlaminated with light gray sandstone.
70.9	71.8	21	Sandstone, light gray, fine-grained, quartz predominates; black carbonaceous laminae at bottom (consist of bits of fusain).
71.8	72.7	22	Shale, greenish-gray, interlaminated with light gray sandstone.
72.7	73.9	23	Sandstone, light gray, fine-grained, inclined micaceous black carbonaceous coal laminae form 5% of unit.
73.9	75.2	24	Shale, dark greenish-gray, intercalated with light gray sandstone laminae and pods.
75.2	79.6	25	Sandstone, fine-grained, light gray, cross-bedded quartzose, shale lens 78.4' to 78.6'; few inclined paper-thin black coal laminae in top half.

79.6	80.4	26	Shale, greenish-gray, few light gray sandstone laminae.
80.4	90.8	27	Sandstone, light gray, quartz predominates, cross-bedded; paper-thin black coal laminae (most places discontinuous, inclined, at 81.8' to 82.1', 82.5' to 82.7', 85.3' to 85.6', 87.3' to 87.5', 90.5' to 90.7'), small amounts of live brown oil bleeding from coal or black carbonaceous laminae.
90.8	93.5	28	Sandstone, light gray, paper-thin laminae consisting of black coaly material and tan woody pieces, horizontally inclined, comprise about 20% of unit, dispersed throughout; piece of tan woody material .1' long and .05' thick at 92'.
93.5	102.6	29	Sandstone, light gray, fine-grained; quartz predominates, micaceous; top half argillaceous; small percentage of paper-thin, tan wood laminae at 98.9' to 99', 100.4' to 100.5', 102.' to 102.2'; sand-sized specks of black material, coal and/or gilsonite in bottom half; core loss 97.1' to 97.3'.
102.6	103.4	30	Conglomerate clasts to .2' long, angular to rounded tan sandy clay, some small dark gray shale clasts; matrix of light gray, calcareous sandstone.
103.4	105.3	31	Sandstone, whitish light gray; calcareous cement.
105.3	111.7	32	Sandstone, light gray, non-calcareous, fine-grained; sand-sized pieces coal and/or gilsonite; clasts of pyritized clay to .05' diameter 108' to 111.7'.
111.7	113.6	33	Conglomerate, clasts of dark gray shale and tan woody material or clay; medium gray sandy clay matrix.
113.6	123.0	34	Sandstone, light gray, massive, quartz predominates but specks of black coal and/or gilsonite; few scattered rounded clasts tan clay 117' to 119.8' (appear to be clay impregnated pith material of plants); brown clay ironstone bed or nodule at 119.8' to 120'.
123.0	131.3	35	Conglomerate, clasts of tan clay and dark gray shale, tan clay clasts to .02' diameter concentrated in top 3', dark gray shale clasts (some consist of shale and light gray sandstone) to .2' diameter form 50% of unit 128' to 130'; light gray sandstone matrix clasts are randomly oriented and many highly inclined (appear to be an intraformational type conglomerate formed by streams scouring into shale) clasts grade into underlying unit; few clasts touching, mostly floating.

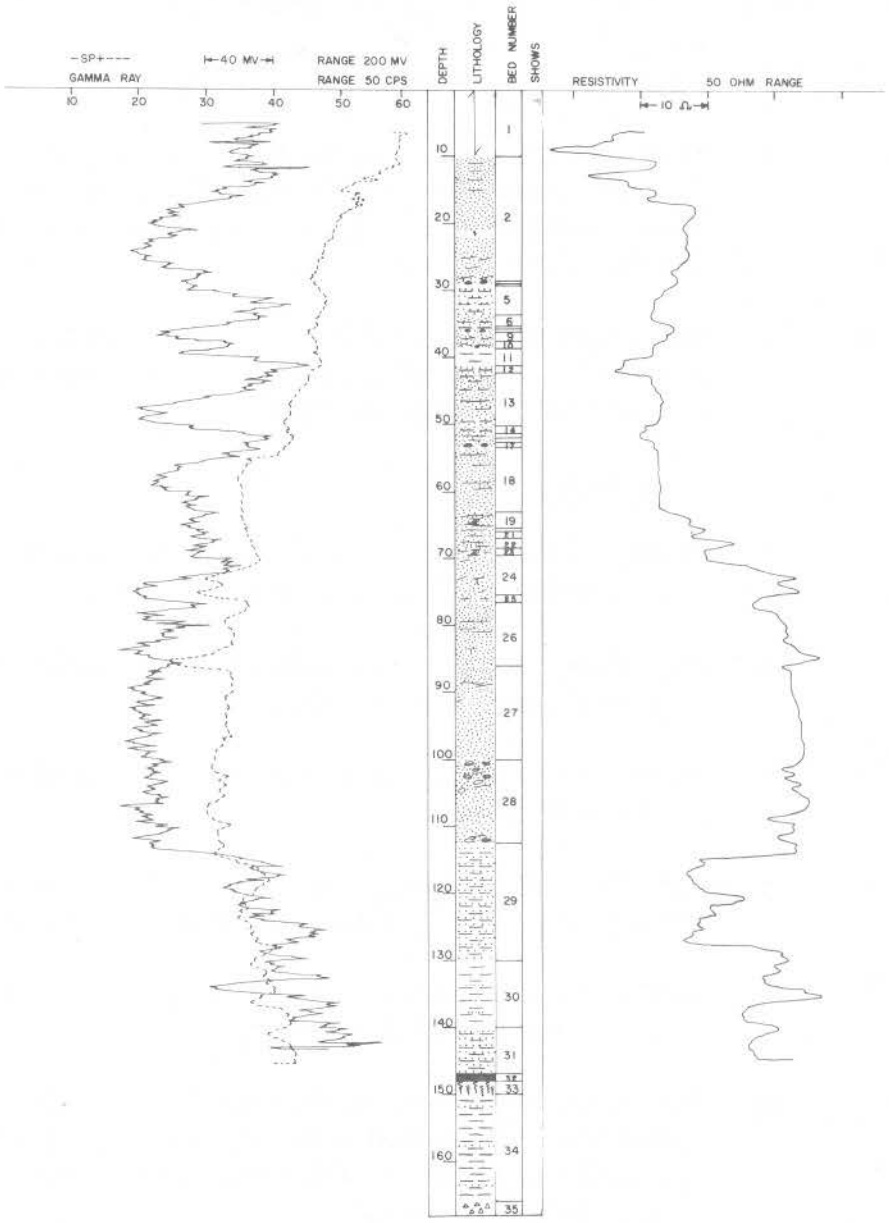
131.3	143.0	36	Sandstone, light gray, non-calcareous, fine grained (1/10 to 1/4 mm grain diameter), predominately quartz; few scattered small tan clay clasts at 134.5' to 135'; dark gray shale clasts to .2' diameter at 137.9' to 138.2'.
143.0	145.3	37	Conglomerate, approximately 20% of unit is rounded clasts of tan clay to .3' diameter "floating" in a light gray sandstone matrix.
145.3	154.0	38	Sandstone, light gray, non-calcareous, conglomeratic; scattered "floating" .01' to .03' diameter round to flat tan clay clasts, very few dark gray shale clasts.
154.0	156.7	39	Conglomerate, dark gray shale, clasts to .4' thick in a light gray sandstone matrix; imbricate structure; some larger shale clasts interlaminated with light gray sandstone (represent underlying shale beds disrupted by currents?).
156.7	158.0	40	Sandstone, medium gray, argillaceous, sand-sized grains of tan mica and coal common.
158.0	158.9	41	Conglomerate, similar to 154' to 156.7' interval.
158.9	159.5	42	Sandstone, similar to 156.7' to 158'.
159.5	160.1	43	Sandstone, cross-bedded, inclined paper-thin coaly laminae, conglomeratic with dark gray shale clasts at bottom.
160.1	160.9	44	Sandstone, light gray and shale medium gray, interlaminated, inclined.
160.9	161.3	45	Sandstone, light gray, few tan clay clasts, lenticular paper-thin, inclined laminae of dark gray shale and coal comprise 5% of unit; evenly spaced.
161.3	162.2	46	Shale, medium gray and light gray sandstone interlaminated; predominate sandstone bottom .2'
162.2	166.2	47	Shale, medium gray; 5% of unit is light gray sandstone laminae and "swirled" pea-sized pods (bioturbite).
166.2	166.7	48	Sandstone, light gray and medium gray shale, interlaminated; flame structures.
166.7	169.0	49	Shale, medium gray, non-calcareous.

169.0	170.0	50	Coal, shiny, pyritiferous (in nodules and lenses) calcite filling cleats.
170.0	172.6	51	Underclay, light gray, sandy; abundant carbonized Stigmarian roots; clusters small pyrite nodules in bottom 5'.
172.6	175.7	52	Shale, medium gray, interlaminated with light gray distorted sandstone; few carbonized roots in top .5'.
175.7	175.9	53	Limestone, dark gray, argillaceous; crinoid columnals.
175.9	178.6	54	Shale, dark gray, calcareous; crinoid columnals and shell fragments of brachiopods (spirifers?) mostly in top half.
178.6	180.0	55	Coal, shiny; laminae of pyritized plant material forms 1 to 3% of unit; cleats filled with calcite.
180.0	184.0	56	Underclay, medium gray; carbonized Stigmarian roots; interlaminated with light gray sandstone in top half; wavy discontinuous laminae with bioturbite appearance in bottom half.
184.0	189.0	57	Shale, medium gray at top to dark gray at bottom; top few inches interlaminated with light gray sandstone decreasing downsection to predominate shale at bottom; non-calcareous.
189.0	194.7	58	Shale, black, non-calcareous; tan clay ironstone beds at 190' to 190.1', 191.2' to 191.3', 192.7' to 192.9', 193.4' to 193.5'.
194.7	197.0	59	Sandstone, carbonized Stigmarian roots; argillaceous.
197.0	200.7	60	Sandstone, light gray, fine-grained, 5% of unit is evenly spaced paper-thin, micaceous coaly laminae; clusters of sand-sized siderite concretions; calcareous cement below 199.9'.
200.7	201.0	61	Sandstone, light gray, sand-sized siderite concretions; approximately 20% of unit is dark gray wavy shale laminae.
201.0	213.3	62	Shale, medium gray at top to black at bottom; sandy bioturbite appearance at 201.8' to 202.2'; brown clay ironstone beds approximately .02' thick at 203.9', 204.5', 205.9' and 206.9'.
213.3	213.4	63	Coal, shiny.

213.4	214.0	64	Shale, black.
214.0	214.3	65	Coal, shiny.
214.3	219.0	66	Underclay, carbonized, pyritized roots especially in top 2'.
219.0	220.0	67	Shale, dark gray, sand-sized siderite concretions form bed .1' thick at 219.5'.
220.0	228.0	68	Shale, black, non-calcareous, brown clay ironstone beds at 220' to 220.2', 223' to 223.1', bottom 1' contains plant material, Cordaites.
228.0	228.9	69	Coal, shiny.
228.9	230.0	70	Underclay, carbonized roots.
230.0	234.0	71	Shale, dark gray grading to black at bottom.
234.0	238.4	72	Shale, black, non-calcareous; brown clay ironstone bed at 235.4' to 235.5'.
238.4	238.5	73	Coal, soft, sooty, pyrite, charcoal (fusain) with woody texture.
238.5	239.0	74	Underclay, light gray, carbonized roots.
239.0	243.0	75	Clay, medium gray, non-calcareous.
243.0	244.3	76	Shale, black.
244.3	245.0	77	Clay, dark gray, abundant siderite concretions.
245.0	246.0	78	Shale, greenish-gray, carbonized roots.
246.0	247.3	79	Shale, black, slickensided.
247.3	250.0	80	Clay, greenish-gray with irregular patches of black which may be carbonized roots; slickensided; clasts of angular white chert to .1' diameter in top .5'.
250.0	252.1	81	Clay, top 1' dark gray grading downsection into greenish-gray; abundant clusters of coarse sand-sized siderite concretions; siderite bed 251.2' to 251.5'.
252.1	255.0	82	Chert, white to pink, homogeneous, compact; vugs lined with small quartz crystals; recrystallized fabric.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 27

Location: 17' FNL & 75' FWL, Sec. 17, T. 33 N., R. 30 W., Barton County
Elevation: 939' Total Depth: 168'



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Elevation: 939' Total Depth: 168'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	No core, soil and clay.
10.0	28.7	2	Sandstone, fine-grained, medium gray, top 5' very argillaceous; weathered zone 11.7' to 11.9'; lost core 21' to 21.4'; inclined dark gray shale lenses comprise approximately 10% of unit below 24'.
28.7	29.0	3	Sandstone, light gray (1/8 to 1/4 mm diameter grains), clasts of shale to .01' diameter; discontinuous wavy, paper-thin laminae of coaly material.
29.0	29.2	4	Lost core.
29.2	33.8	5	Shale, medium gray, approximately 40% of unit is light gray sandstone laminae, lenticular, cross-laminated.
33.8	35.3	6	Sandstone, medium gray, fine-grained, laminated with dark gray shale in bottom half.
35.3	35.7	7	Shale, medium gray and cross-laminated light gray sandstone; intercalated.
35.7	36.2	8	Sandstone, light gray, conglomeratic with pieces of coal and fusain especially along bedding planes; micaceous.
36.2	37.7	9	Sandstone, light gray, cross-bedded, inclined bedding and medium gray shale intercalated.
37.7	38.7	10	Sandstone, light gray, conglomeratic with clasts of coal in discontinuous contorted lenses; Calamites impressions (probably represent twigs and branches carried into an area of sand deposition).
38.7	41.2	11	Shale, light gray, carbonized impressions of Calamites, Cordaites.
41.2	42.3	12	Sandstone, light gray, cross-laminated, intercalated with medium gray shale laminae.

42.3	50.1	13	Sandstone, light gray; medium gray shale beds at 42.4' to 42.6', 42.8' to 43.2', 43.5' to 43.8', 44.8' to 44.9', 49' to 49.3'; discontinuous paper-thin laminae of coal, mica and sand-sized tan woody grains 45.8' to 48'.
50.1	51.3	14	Sandstone, light gray and dark gray shale interbedded.
51.3	52.0	15	Sandstone, light gray, wavy paper-thin laminae of coal forms 5% of unit.
52.0	52.7	16	Sandstone; light gray and shale medium gray interlaminated; predominately sandstone from 52.5' to 52.7'.
52.7	53.3	17	Conglomerate, dark gray shale clasts elongated to tabular, granule-sized to .2' thick beds that show faulted "pull apart" structures (probably result of penecontemporaneous slumpage) light gray sandstone matrix.
53.3	63.0	18	Sandstone, light gray; discontinuous paper-thin coal laminae form 5% of unit and increase to 20% from 58' to 60', evenly distributed, interlaminated light gray sandstone and shale from 53.6' to 53.8'.
63.0	65.4	19	Sandstone, light gray, fine-grained, cross-laminated, 5% of unit is wavy discontinuous paper-thin coal laminae.
65.4	66.0	20	Same as above unit but coal laminae comprise 20% of unit.
66.0	67.0	21	Same as above unit but less than 5% coal laminae.
67.0	68.4	22	Same as above unit but 20% of unit is coal laminae increasing downsection to 40%.
68.4	69.6	23	Sandstone, light gray, fine-grained, cross-laminated; interlaminated with dark gray shale.
69.6	75.5	24	Sandstone, light gray, approximately 5% of unit is dark gray micaceous shale and coal laminae, inclined, concentrated near top, middle and bottom; calcareous, cementented from 73.4' to 74.8'.
75.5	76.7	25	Sandstone, light gray, fine-grained sandstone interlaminated with black shale laminae, horizontal attitude.
76.7	86.0	26	Sandstone, light gray, cross-bedded, non-calcareous, approximately 5% of unit is inclined coal laminae 79.4' to

			79.8', 80.1' to 81', 81.7' to 82'; only about 1% of unit is inclined coal laminae below 82'; calcareous cemented 83.7' to 85.7'.
86.0	100.0	27	Sandstone, light gray, non-calcareous, fine-grained, few wavy, horizontal, coal laminae; concentrated from 88.6' to 88.9' into inclined bundles; pyritiferous.
100.0	112.4	28	Sandstone, light gray, fine-grained, non-calcareous; conglomerate intervals from 100.6' to 101.2', 101.7' to 101.75', 102' to 103.2', 104.1' to 104.4', 104.9' to 105.1', 108.4' to 108.9', 109.8' to 109.9', 111.2' to 112', 112.2' to 112.4' consisting of clasts of coal in beds to .1' thick, horizontal to distorted and inclined discontinuous laminae, also clasts of tan plant material to .1' thick with thin coaly rinds; pyrite nodules to .1' diameter at 112.4'.
112.4	130.0	29	Sandstone, light gray, cross-laminated (ripples), intercalated with dark gray (dry) to black (wet) shale in approximately equal amounts in beds .2' to .01' thick wavy, mostly horizontal. Test hole churn drilled below 130' to 168' (diamond bit lost in hole).
130.0	140.0	30	Shale, black, laminae of siltstone and very fine sandstone.
140.0	147.0	31	Shale, black and sandstone light gray, interlaminated.
147.0	148.0	32	Coal (1' to 2' thick, possibly over 2' thick).
148.0	150.0	33	Underclay, soft, sticky.
150.0	166.0	34	Shale, black, some light gray sandstone laminae.
166.0	168.0	35	Chert, bluish-white and white.

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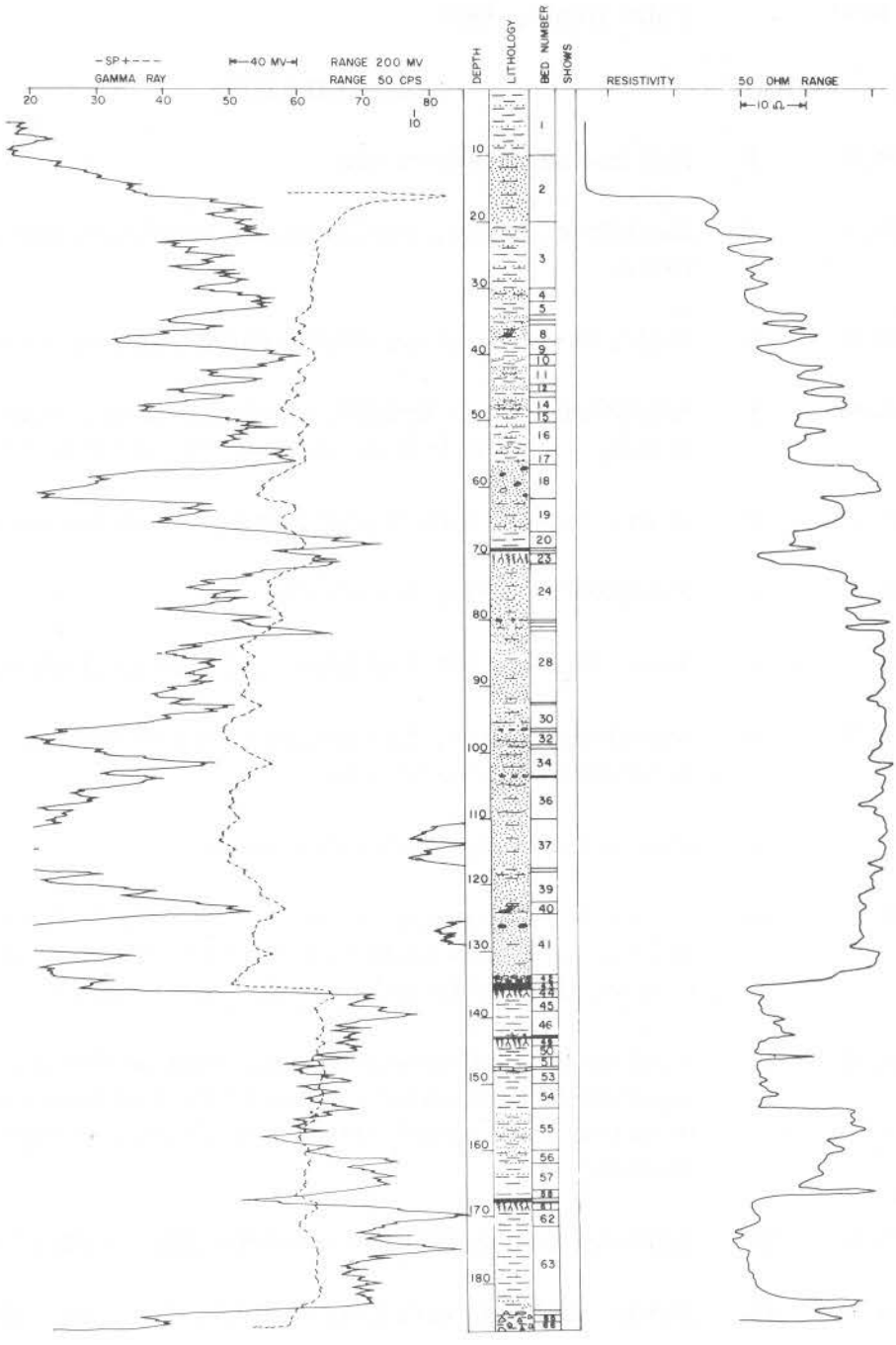

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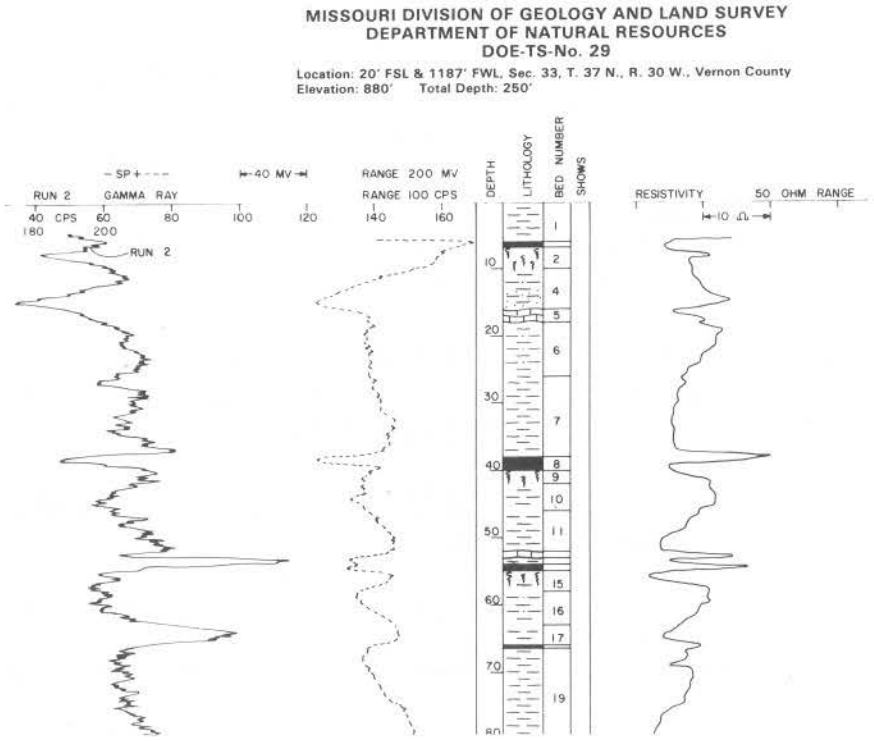
DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and sandy brown clay.
10.0	20.0	2	Sandstone, brown, argillaceous, small hematite concretions.
20.0	30.0	3	Shale, brown to gray, sandy (churn samples to 30').
30.0	32.0	4	Sandstone, cross-bedded, intercalated with shale lenses, brown, weathered; flora zone (ferns) at 31' to 31.8'.
32.0	34.0	5	Shale, brown, zone of gray, sandy, inclined laminae.
34.0	34.8	6	Sandstone, brown, fine-grained.
34.8	35.5	7	Shale, brown, zones of gray, inclined sandstone lenses.
35.5	38.0	8	Sandstone, brown, fine-grained, cross-bedded, micaceous, sand-sized specks fusain.
38.0	40.0	9	Shale, dark gray, non-calcareous.
40.0	41.8	10	Shale, medium gray, sandy, micaceous, horizontal to inclined, light gray sandstone laminae comprise about 20% of unit, flora of ferns, Cordaites near middle.
41.8	44.3	11	Sandstone, argillaceous grading downsection into predominate shale; sandstone lenses, cross-laminated at top to distorted "pull apart" structures (from slumpage?) at bottom.
44.3	45.6	12	Sandstone, gray weathered brown along joints, micaceous.
45.6	46.3	13	Shale, medium gray; flora of ferns (large tip leaves).
46.3	48.8	14	Sandstone, medium gray, fine-grained, few dark gray shale laminae and paper-thin wavy laminae of coal (bits of fusain).

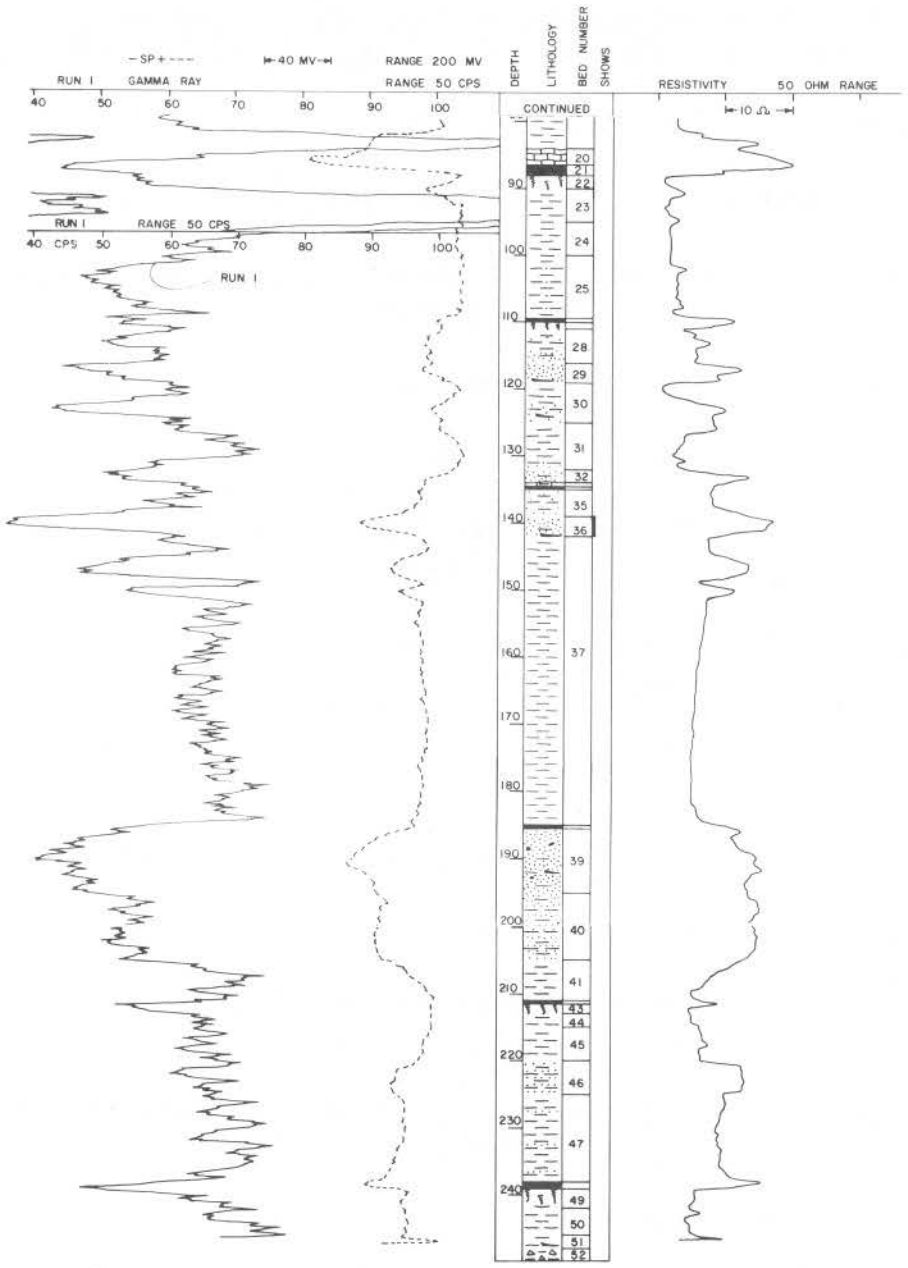
48.8	50.2	15	Shale, dark gray, approximately 30% of unit is light gray laminae and lenses of cross-laminated sandstone (ripples).
50.2	54.3	16	Shale, medium gray, very sandy with light gray sandstone laminae in form of contortions possibly caused by slumpage, some scour and fill; fern fronds, micaceous.
54.3	56.6	17	Shale, medium gray, sandy, 5% of bottom 1' is light gray sandstone laminae.
56.6	61.7	18	Conglomerate, approximately 10% of unit is clasts of dark gray shale, coal, clay ironstone and tan clay with coalified rinds; clasts in lenses to randomly oriented contortions, clasts .1' diameter, but most of granule-size; light gray sandstone matrix.
61.7	66.6	19	Sandstone, light gray, wavy lenses and pods separated by paper-thin dark gray shale laminae; filled burrow (bioturbite) structure.
66.6	69.1	20	Shale, black (wet) mica along bedding planes, non-calcareous, gradational with overlying unit.
69.1	69.4	21	Coal, shiny, pyrite lense near bottom.
69.4	70.0	22	Lost core.
70.0	71.5	23	Underclay, medium gray carbonized roots.
71.5	80.0	24	Sandstone, light gray, abundant sand-sized siderite concretions disseminated throughout unit, clay matrix gives light greenish-gray appearance when wet; cross-laminated in places.
80.0	80.3	25	Sandstone, light gray, conglomerate appearance with wavy lens-like clasts of shale and coal.
80.3	81.0	26	Sandstone, whitish light gray, compact, non-calcareous, fine-grained.
81.0	81.7	27	Sandstone, light gray and medium gray clay, interlaminated; nodular appearance; plant rootlets? near top.
81.7	92.4	28	Sandstone, light greenish-gray, argillaceous, slumpage structure 84' to 85'; paper-thin coal laminae at 88.3' to 88.5'; non-calcareous; vertical joints 82' to 84'.

92.4	92.7	29	Sandstone, light gray and shale dark gray (plant fragments) interlaminated.
92.7	96.3	30	Sandstone, light gray, fine-grained .02' thick coal lens at 95.7'; argillaceous; slump structures especially in top 2'.
96.3	96.8	31	Sandstone, 1/8 to 1/4 mm grain size, conglomeratic, clasts of coal in form of lenses, rounded pods with sandstone filling interiors; bottom .2' especially conglomeratic; scour surface at bottom.
96.8	98.9	32	Sandstone, light gray, few paper-thin wavy coal laminae near bottom.
98.8	99.3	33	Sandstone, light gray and coal laminae (bits of fusain) intercalated.
99.3	103.4	34	Sandstone, light gray, approximately 10% of unit is paper-thin coal laminae; some flame structures.
103.4	103.7	35	Conglomerate, clasts of dark gray shale, rounded, grape-size; light gray sandstone matrix.
103.7	110.0	36	Sandstone, light gray, approximately 5% of unit is paper-thin coal laminae mostly horizontal wavy, micaceous, and dark gray shale beds to .1' thick randomly spaced.
110.0	117.5	37	Sandstone, light gray bits of coal disseminated in top part; shale laminae to .05' thick comprise about 5% of unit and distributed randomly throughout interval.
117.5	118.0	38	Shale, medium gray sandy, pieces fusain.
118.0	122.7	39	Sandstone, light gray, 2 or 3 shale laminae in top 1'.
122.7	124.5	40	Sandstone, light gray cross-laminated and dark gray carbonaceous shale and coaly material; interlaminated; flame structures.
124.5	133.4	41	Sandstone, light gray, few thin laminae of dark gray shale and coal scattered throughout interval, especially in top 1'; conglomeratic with pieces fusain at 126' to 126.2'.
133.4	134.9	42	Conglomerate, 80% clasts with small amount of light gray sandstone matrix; clasts tabular to spheroidal, rounded, consist of tan clay or woody material, sandstone, dark

			gray shale, clay ironstone, pieces coal poorly sorted range from .2' long and .1' thick to granules, some imbrication; gradational with overlying unit.
134.9	135.8	43	Coal, shiny, pyrite lenses and cleat fillings.
135.8	137.0	44	Underclay, dark gray, Stigmarian roots; slickensided.
137.0	139.0	45	Shale, medium gray, non-calcareous.
139.0	142.7	46	Shale, black; zone of sand-sized siderite concretions 140.6' to 140.9'.
142.7	143.0	47	Shale, black, fragments of light gray recrystallized fossils.
143.0	143.1	48	Coal, shiny.
143.1	144.2	49	Underclay, medium gray, carbonized roots.
144.2	146.0	50	Shale, greenish-gray, abundant shot-sized siderite concretions.
146.0	147.3	51	Shale, black, mottled green at bottom.
147.3	147.8	52	Limestone, nodular, light gray to brown, greenish clay matrix, fragments of small productids.
147.0	150.0	53	Shale, greenish-gray, non-calcareous.
150.0	153.9	54	Shale, black, pyritiferous.
153.9	160.0	55	Sandstone, light gray, cross-laminated, paper-thin to .1' thick lenses and pea-sized pods (.01') in layers intercalated with black shale in equal amounts.
160.3	162.0	56	Shale, black (wet) intercalated with light gray sandstone lenses paper-thin to .1' thick comprises 40% of unit at top decreasing to 10% at bottom.
162.0	166.0	57	Shale, black (wet), less than 5% light gray sandstone, lenticular laminae.
166.0	167.3	58	Shale, black, brown clay ironstone band .2' thick at 166.7'.
167.3	167.8	59	Coal, shiny.

167.8	168.0	60	Shale, black, hard, slickensided.
168.0	169.0	61	Underclay, medium gray, carbonized roots.
169.0	171.5	62	Clay, greenish-gray, slickensided, bottom .5' mottled black.
171.5	184.0	63	Shale, black, non-calcareous; 5% of unit is light green sandstone lenses and pods from 182.6' to 183.6'.
184.0	184.7	64	Conglomerate; white to pink chert clasts (.1' diameter to sand-sized) larger clasts subangular to subrounded while sand-size is angular; black shale matrix.
184.7	185.8	65	Breccia, white chert clasts; voids around large clasts (.2' largest dimension) filled in by smaller chert fragments with a greenish-gray to black clay matrix; 90% of unit is clasts.
185.8	187.0	66	Breccia, approximately 20% of unit is white chert clasts with greenish-gray clay matrix.

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RUN I
DEPTH
LITHOLOGY
BED NUMBER
SHOWS
CONTINUED
RESISTIVITY
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DOE-TS - No. 29
"Slim hole" cuttings described and logged by Jack Wells
Location: 20' FSL & 1187' FWL, Sec. 33, T. 37N., R. 30W., Vernon County

Elevation: 880' Total Depth: 250'

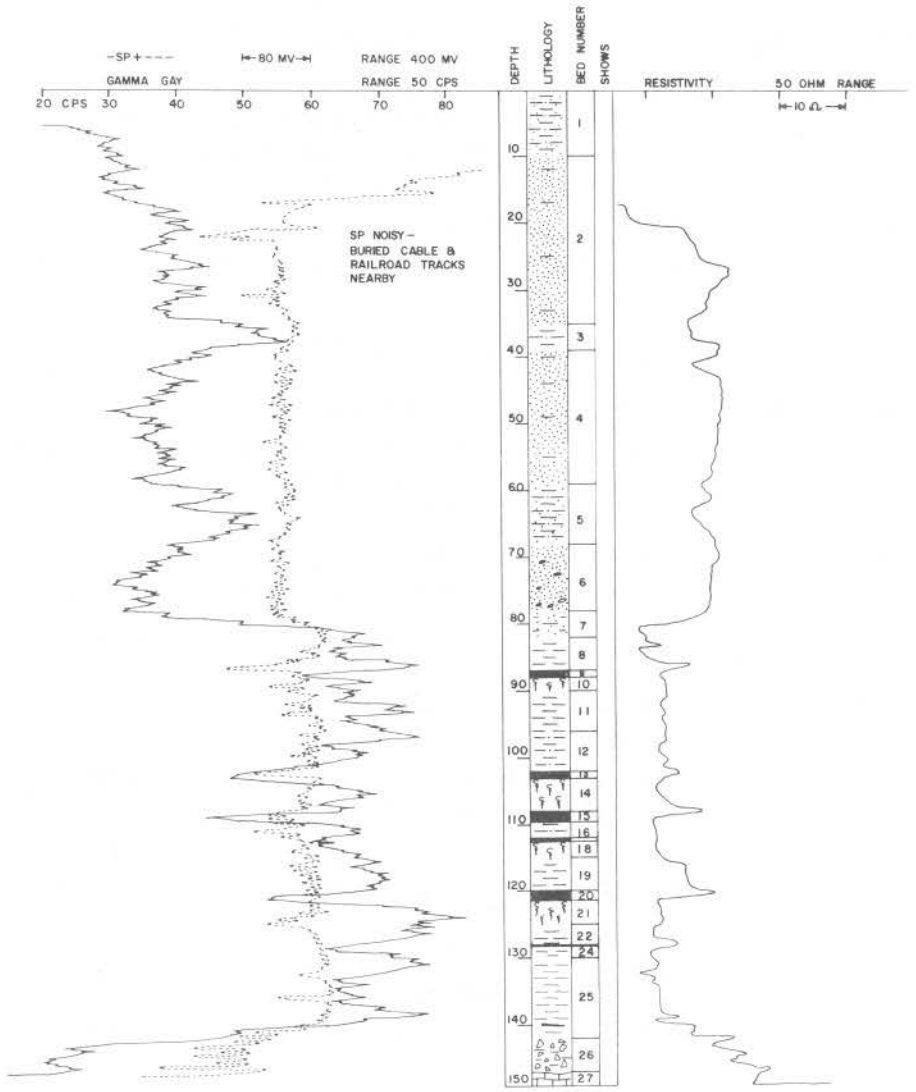
DEPTH		UNIT	DESCRIPTION
0.0	6.0	1	Soil and reddish-brown weathered, oxidized shale becoming mottled gray (unoxidized).
6.0	6.8	2	Coal; black, weathered.
6.8	10.0	3	Underclay; light gray, soft, slick.
10.0	16.0	4	Shale; light greenish-gray, soft, slick, silty becoming very silty and sandy at 14'.
16.0	18.0	5	Limestone; tan to gray, dense to very fine crystalline, some shell debris.
18.0	26.0	6	Shale; medium gray, silty, micaceous, firm, abundant fine siderite shot throughout.
26.0	38.0	7	Shale; medium to dark gray, fissile, siderite.
38.0	40.0	8	Coal; bright, some pyrite.
40.0	42.0	9	Underclay; light greenish-gray, soft, slick, grades into next lower unit.
42.0	46.0	10	Shale; light greenish-gray, slick, micaceous, firm, fair amounts of siderite.
46.0	52.0	11	Shale; medium gray, firm fissile.
52.0	53.0	12	Limestone; brown, fine to dense, dirty, fossiliferous.
53.0	54.0	13	Shale; black, smutty with considerable siderite.
54.0	55.0	14	Coal; black, bright with some calcite and pyrite.
55.0	58.0	15	Underclay; light greenish-gray, soft, slick, grades into shale.
58.0	63.0	16	Shale; light greenish-gray, firm, slightly silty, micaceous.

63.0	66.0	17	Shale; medium to dark green, firm, fissile, micaceous.
66.0	66.3	18	Coal, black, bright, thin (4"±) streak.
66.3	84.0	19	Shale, medium to dark gray, hard, fissile, becoming black and smutty at 80'.
84.0	86.5	20	Limestone, dark gray to black, fine to earthy with considerable shell debris.
86.5	88.0	21	Coal, black, bright, with calcite and pyrite.
88.0	90.0	22	Underclay, medium gray, soft, slick.
90.0	95.0	23	Shale; medium gray, fissile, grading to black at 95'.
95.0	100.0	24	Shale; light to medium gray, slick.
100.0	109.5	25	Shale; medium to dark gray, slightly silty, micaceous, siderite.
109.5	110.0	26	Coal; bright, pyritic.
110.0	111.0	27	Underclay; light gray, soft, slick.
111.0	116.0	28	Shale; dark gray, silty, micaceous, with thin laminae of siltstone and sandstone, becoming very sandy grading to a shaly sandstone at base.
116.0	119.0	29	Sandstone; very fine to fine, dirty, tight, trace amounts of coal at ±119'.
119.0	125.0	30	Shale; light greenish-gray to tan, soft, slick, becoming sandy, occasional black carbonaceous streaks or laminae.
125.0	132.0	31	Shale; medium greenish-gray with dark gray streaks, fissile, becoming silty and sandy at 132'.
132.0	134.0	32	Sandstone; light gray, very fine to fine, dirty, shaly.
134.0	134.5	33	Limestone; dark gray to black, fossiliferous, shaly, dirty.
134.5	135.0	34	Coal.
135.0	139.0	35	Shale; tan to medium gray, slick, soft, slightly sandy, grading into next lower unit.

139.0	142.0	36	Sandstone; light to medium gray, very fine to fine, dirty, shaly, micaceous, with black carbonaceous shale streaks at base of unit. Trace of ZnS and pyrite, trace brown dead oil stain.
142.0	185.0	37	Shale; medium to dark gray, hard, fissile.
185.0	185.5	38	Coal, thin laminae in black smutty clay-shale.
185.5	195.0	39	Sandstone; light gray to white, very fine to siltstone, dirty, tight, micaceous, pyritic with occasional black carbonaceous specks throughout, dark gray thin shale streaks from 190', sideritic.
195.0	205.0	40	Sandstone; light gray, very fine to fine, tight, intercalated with slightly less than equal amounts of medium gray shale; becoming increasingly shaly toward base of unit.
205.0	211.0	41	Shale; dark gray to black with considerable siderite, few streaks of green shale.
211.0	211.5	42	Coal; black, bright.
211.5	213.0	43	Underclay; light greenish-gray.
213.0	215.0	44	Shale; medium to dark gray, firm, fissile, with light green mottled shale, disturbed, burrowed?.
215.0	220.0	45	Shale; dark gray, black, fissile.
220.0	225.0	46	Shale; dark gray with light gray intercalated, very fine to fine sandstone, micaceous.
225.0	238.0	47	Shale; medium to dark gray, with very occasional laminae of very fine sandstone, siderite.
238.0	239.0	48	Coal; black, bright.
239.0	242.0	49	Underclay; tan to medium greenish-gray, soft, slick, grading into shale at 242'.
242.0	246.0	50	Shale; medium greenish-gray to tan, slick.
246.0	248.0	51	Shale; black, hard, fissile, smutty with thin coal laminae.
248.0	250.0	52	Conglomerate of white and tan chert in a bright green clay matrix.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 30

Location: 17' FSL & 850' FEL, Sec. 29, T. 37 N., R. 31 W., Vernon County
Elevation: 771' Total Depth: 149'



DOE-TS - No. 30
"Slim hole" cuttings described and logged by Jack Wells
Location: 17' FSL & 850' FEL, Sec. 29, T. 37N., R. 31W., Vernon County

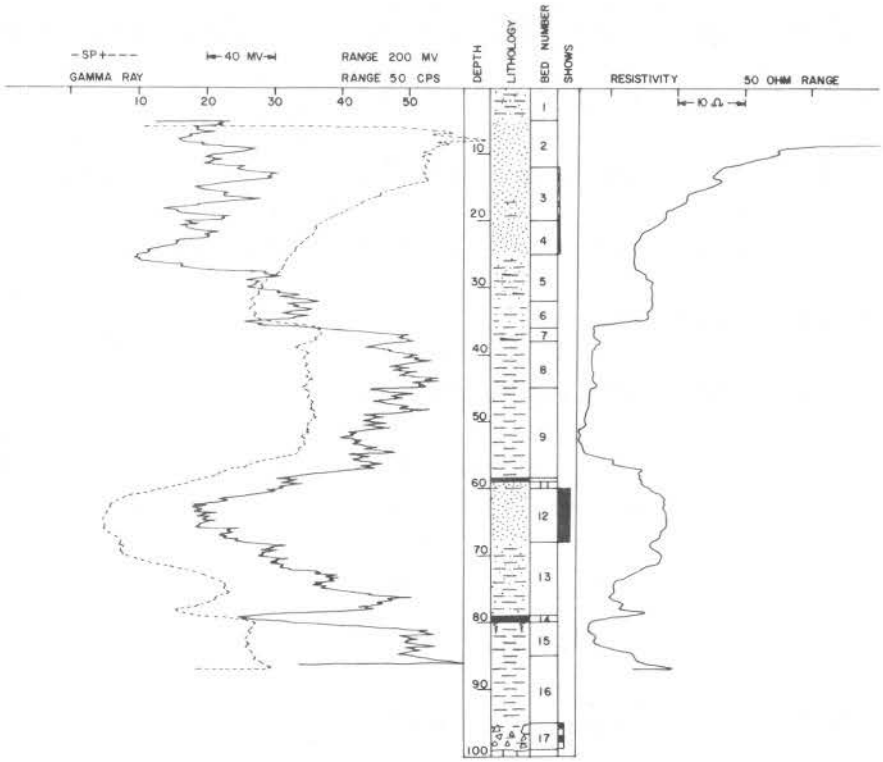
Elevation: 771' Total Depth: 149'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and clay; tan to yellowish-brown, with reddish-brown streaks, silty, becoming very sandy at base.
10.0	35.0	2	Sandstone; yellowish-brown, very fine to fine, very dirty to clayey, weathered, loose, occasional siderite pebbles.
35.0	39.0	3	Shale; light gray, silty, micaceous.
39.0	59.0	4	Sandstone; tan, very fine to medium, poor sorting, dirty, clayey streaks, micaceous becoming fine to medium, cleaner with fair sorting at 50'.
59.0	68.0	5	Shale; tan to light gray, very sandy, very silty, medium coarse sandstone streak at 62', scattered black carbonaceous streaks, occasional clay ironstone streaks.
68.0	78.0	6	Sandstone; tan, medium to coarse, well cemented, considerable amounts of siderite, occasional gray silty shale streaks, carbonaceous streaks and occasional coal fragments becoming almost conglomeratic toward base.
78.0	82.0	7	Shale; medium gray, sandy, numerous sand and siltstone laminae.
82.0	87.0	8	Shale; light to medium greenish-gray, slick, slightly micaceous, firm with occasional black carbonaceous shale streaks.
87.0	88.0	9	Coal; black, shiny, with pyrite.
88.0	90.0	10	Underclay; light gray, soft, sticky.
90.0	96.0	11	Shale; light greenish-gray with medium gray shale streaks, considerable siderite shot throughout.
96.0	102.0	12	Shale; dark gray to black, silty, numerous siderite nodules.
102.0	103.0	13	Coal; black, shiny, pyritic.

103.0	108.0	14	Underclay; light gray to tan, soft, slick.
108.0	109.5	15	Coal; black, pyritic.
109.5	112.0	16	Shale; dark gray to black, silty, firm, siderite nodules.
112.0	112.5	17	Coal.
112.5	115.0	18	Underclay; tan to olive, grades downward to next unit.
115.0	120.0	19	Shale; light greenish-gray with siderite shot throughout.
120.0	121.5	20	Coal.
121.5	125.0	21	Underclay; tan to olive, soft, slick.
125.0	128.0	22	Shale; tan to light greenish-gray, firm, slick, with occasional dark gray shale laminae or streaks.
128.0	128.2	23	Coal.
128.2	130.0	24	Shale; as Unit 22, underclay?.
130.0	142.0	25	Shale; dark gray to black, firm, slightly micaceous, siderite shot, pyrite, trace of coal at 140'.
142.0	147.0	26	Conglomerate of chert; white in a green clay matrix.
147.0	149.0	27	Limestone; brown to cream, coarse crystalline with scattered glauconite.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 31

Location: 2596' FSL & 12' FEL, Sec. 3, T. 30 N., R. 33 W., Barton County
Elevation: 960' Total Depth: 100'



DOE-TS - No. 31
"Slim hole" cuttings described and logged by Jack Wells
Location: 2596' FSL & 12' FEL, Sec. 3, T. 30N., R. 33W., Barton County

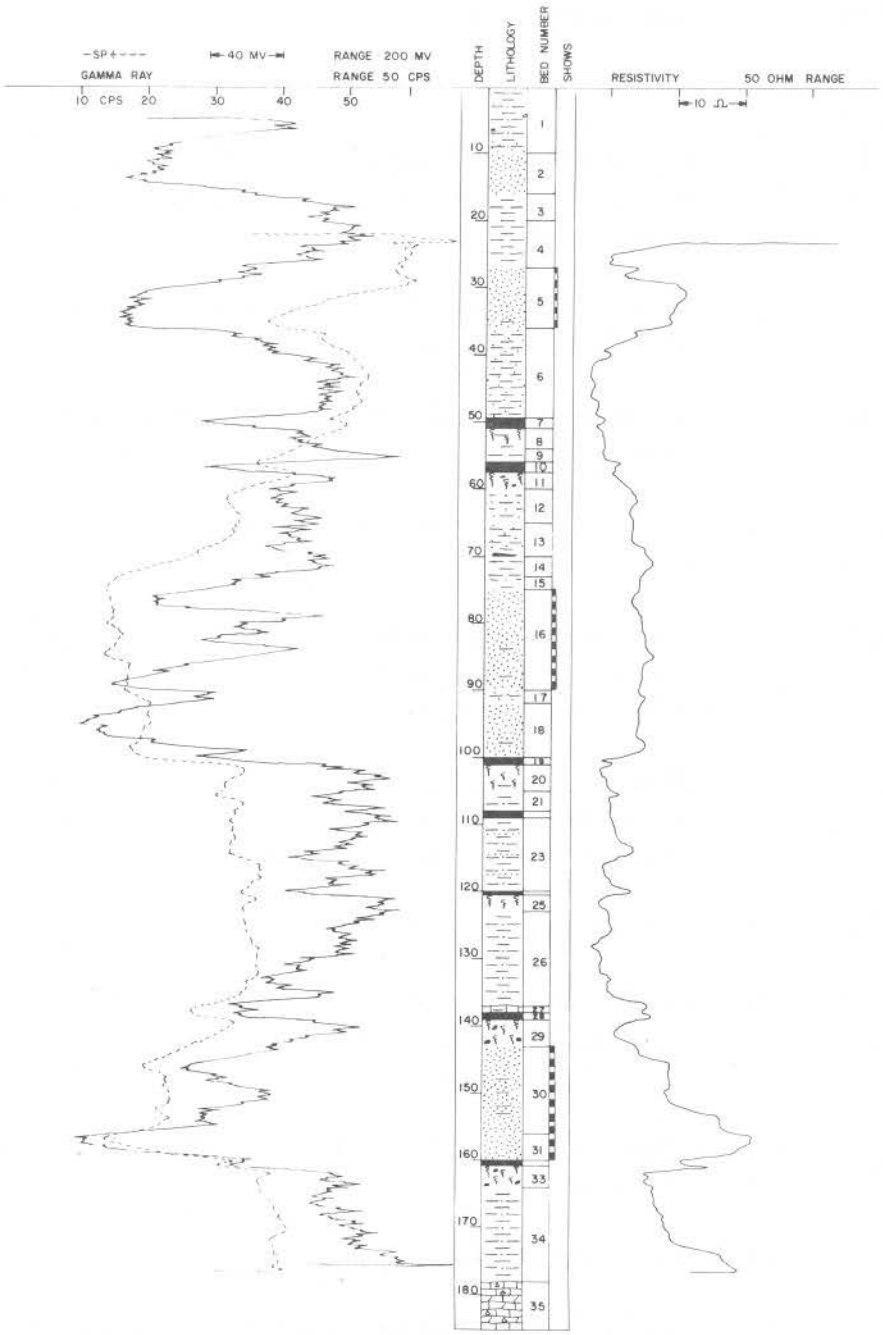
Elevation: 960' Total Depth: 100'

DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil and clay; yellow to brown, very silty, very sandy.
5.0	12.0	2	Sandstone; brown, very fine to medium, weathered, loose.
12.0	20.0	3	Sandstone; tan to gray, very fine to medium, loose to fairly consolidated, slight brown dead oil stain, spotty. Sandstone becoming very fine to silty and shaly from 17' to 20'.
20.0	25.0	4	Sandstone; tan, fine to medium, well consolidated, slight dead oil stain.
25.0	32.0	5	Shale; medium gray, very silty, very sandy, micaceous with black carbonaceous streaks.
32.0	36.0	6	Siltstone; medium gray, very shaly, considerable amounts of black carbonaceous streaks, micaceous.
36.0	38.0	7	Shale; dark green to black, hard, fissile, trace of coal at ±38'.
38.0	45.0	8	Shale; medium gray, soft, slick, underclay?, grading to firm greenish-gray, slick shale at ±40'.
45.0	58.5	9	Shale; dark gray to black, firm, micaceous, few siderite nodules.
58.5	59.0	10	Coal; black, shiny.
59.0	60.0	11	Sandstone; light tan, very fine to fine, silty, shaly, dirty, tight with shale streak at 60'.
60.0	68.0	12	Sandstone; dark brown, very fine to fine, saturated with dark brown heavy oil.
68.0	79.0	13	Shale; medium gray, very silty to sandy, very micaceous in upper portion grading to medium gray, silty, micaceous shale with black carbonaceous streaks.

79.0	80.0	14	Coal; black, shiny.
80.0	85.0	15	Shale; medium gray, soft, slick, underclay?.
85.0	95.0	16	Shale; medium to dark gray, firm, micaceous, pyritic.
95.0	99.0	17	Conglomerate of chert, siderite, pyrite in dark gray shale matrix. Spotty dark brown dead oil stain.
99.0	100.0	18	Limestone; brown to tan, coarse crystalline.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 32

Location: 15' FSL & 1124' FEL, Sec. 11, T. 31 N., R. 33 W., Barton County
Elevation: 753' Total Depth 185'



DOE-TS - No. 32
"Slim hole" cuttings described and logged by Jack Wells
Location: 15' FSL & 1124' FEL, Sec. 11, T. 31N., R. 33W., Barton County

Elevation: 753' Total Depth: 185'

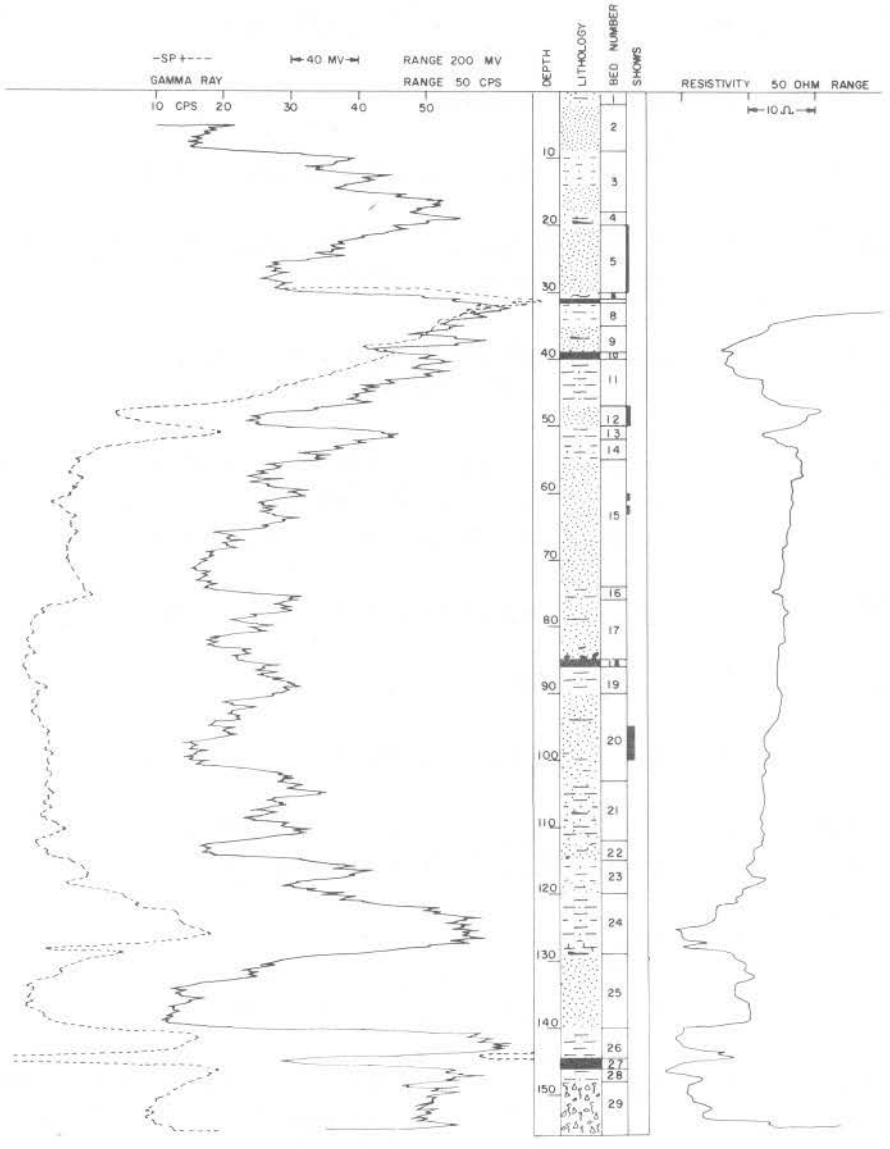
DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and clay; reddish-brown to dark yellowish-brown, sandy, silty, few clay ironstone pebbles, becoming very sandy in lower 2'.
10.0	16.0	2	Sandstone; yellowish-brown, very fine to fine, fair sorting, slightly micaceous.
16.0	20.0	3	Shale; medium gray, soft, with occasional yellowish-brown weathered streaks, one streak of dark red hematitic clay.
20.0	27.0	4	Shale; medium gray, firm, slightly micaceous, occasional nodules or streaks of siderite, pyritic.
27.0	36.0	5	Sandstone; tan to brown, very fine to silty, micaceous, dirty, slight dark brown dead oil, spotty, appears to grade into next lower unit.
36.0	49.5	6	Shale; medium gray, very sandy with streaks of light green, soft, slick, non-sandy shale, considerable amounts of siderite in lower portion of unit.
49.5	51.0	7	Coal; black, shiny with some black smutty clayey material.
51.0	54.0	8	Underclay; light greenish-gray, soft, slick, with scattered black carbonaceous material becoming firm, grading into shale at ±54'.
54.0	56.0	9	Shale; light greenish-gray with occasional dark gray shale laminae.
56.0	57.5	10	Coal; black, pyritic.
57.5	60.0	11	Underclay; light greenish-gray, soft, slick, with scattered black carbonaceous material.
60.0	65.0	12	Siltstone: light gray, shaly, micaceous with occasional medium gray shale laminae.

65.0	70.0	13	Shale; dark gray, hard, sandy, trace of coal in interval probably at 70'.
70.0	73.0	14	Shale; greenish-gray, soft, waxy, grading downward to underlying unit.
73.0	75.0	15	Siltstone, light gray, very shaly, micaceous.
75.0	90.0	16	Sandstone; light gray to white, very fine to medium fine, poor sorting, micaceous, spotty dark brown dead oil stain with minor amounts of black shiny gilsonite, disseminated throughout, sand becoming shaly with some siderite cemented streaks.
90.0	92.0	17	Shale; medium gray, very sandy, very micaceous.
92.0	100.0	18	Sandstone; white, fine to medium coarse, clean in upper portion becoming very fine to silty and shaly in lower 3' of unit with numerous black carbonaceous streaks and pyrite.
100.0	101.0	19	Coal; black, dull, pyritic.
101.0	105.0	20	Underclay; medium greenish-gray, soft, slick, grading downward into shale.
105.0	108.0	21	Shale; medium gray to dark gray, silty, micaceous.
108.0	109.0	22	Coal; black, shiny, pyritic.
109.0	120.0	23	Shale; dark gray to black, silty with thin laminae of fine-grained sandstone, siderite.
120.0	120.5	24	Coal.
120.5	123.0	25	Underclay; light to medium gray, slick.
123.0	137.0	26	Shale; dark gray to black, silty, micaceous, abundant siderite.
137.0	138.0	27	Limestone; black, fine to coarse crystalline, fossiliferous, very shaly, dirty.
138.0	139.0	28	Coal; black, shiny.
139.0	143.0	29	Underclay; medium gray, slick with fragments of coal and black carbonaceous material.

143.0	156.0	30	Sandstone; light gray, very fine to silt, shaly as darker gray, thin laminae, very micaceous, slight brown dead oil stain (spotty) becoming very shaly as black carbonaceous laminae and thin dark gray silty, micaceous shale streaks from 148' to 155'.
156.0	160.0	31	Sandstone; brown, medium to coarse, well cemented, tight, spotty brown dead oil stain and black shiny gilsonite-like material scattered throughout.
160.0	160.8	32	Coal; black, shiny.
160.8	164.0	33	Shale-underclay?; medium gray to dark gray, mottled, disturbed, burrowed?, with fine coaly fragments.
164.0	178.0	34	Shale; dark gray to black, silty, micaceous.
178.0	185.0	35	Limestone; brown to tan, fine to coarse crystalline, slightly dolomitic, minor amounts of chert, slightly glauconitic.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 33

Location: 5' FNL & 96' FWL, Sec. 7, T. 33 N., R. 32 W., Barton County
Elevation: 873' Total Depth: 156'



DOE-TS - No. 33

"Slim hole" cuttings described and logged by Jack Wells

Location" 5' FNL & 96' FWL, Sec. 7, T. 33N., R. 32W., Barton County

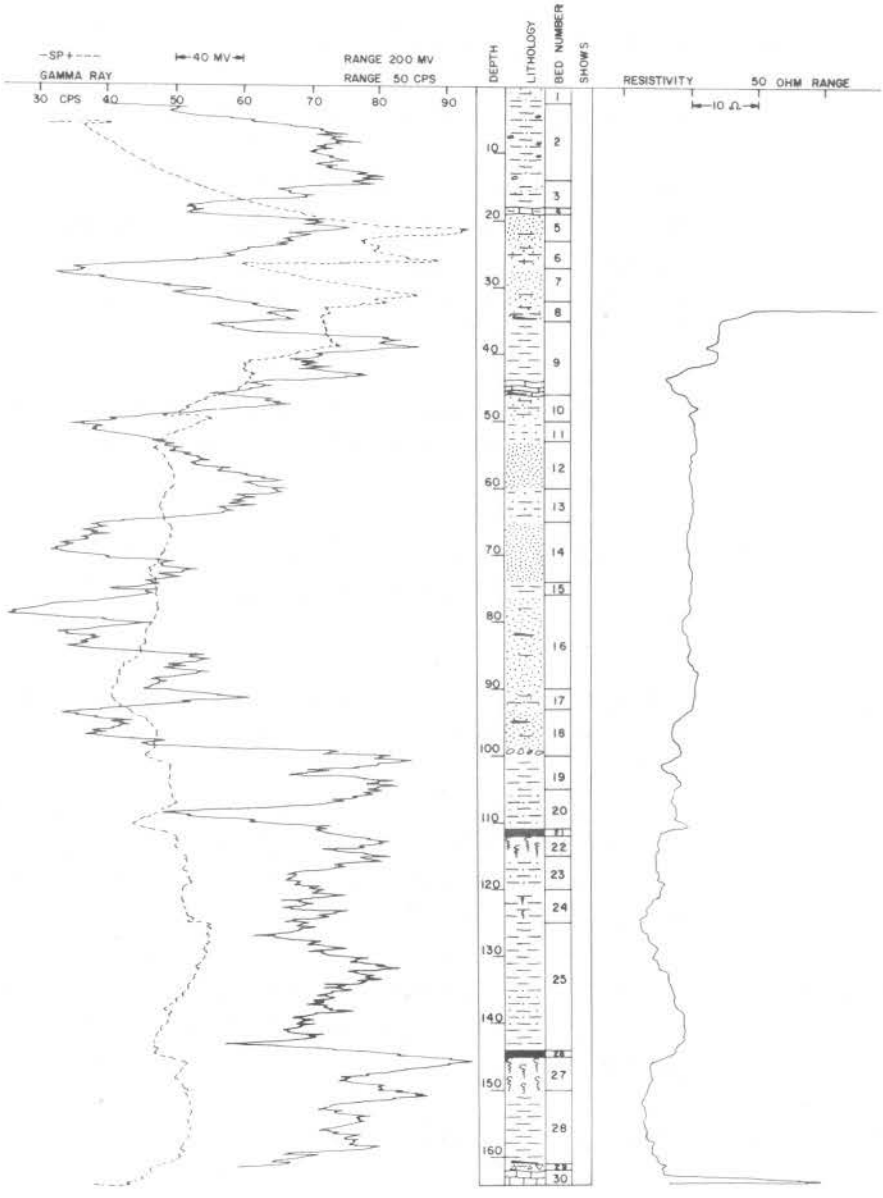
Elevation: 873' Total Depth: 156'

DEPTH		UNIT	DESCRIPTION
0.0	2.0	1	Soil, light brown, silty.
2.0	9.0	2	Sand, yellow to brown, loose, weathered.
9.0	18.0	3	Siltstone, gray, dirty to shaly, with few streaks of brown dead oil stains, sandstone.
18.0	20.0	4	Shale, medium to dark gray, sandy, silty, considerable siderite and hematite. Trace of coal.
20.0	30.0	5	Sandstone, light gray to white, very fine to medium fine, micaceous, siderite shot, trace amounts of brown dead oil stain, gilsonite as black shiny spects.
30.0	31.0	6	Shale, light green, waxy, slick, soft.
31.0	31.5	7	Coal, black, shiny.
31.5	35.0	8	Siltstone, gray, very fine to very shaly, micaceous.
35.0	39.0	9	Sandstone, gray, very fine to fine, micaceous, considerable black carbonaceous laminae.
39.0	40.0	10	Coal.
40.0	47.0	11	Shale, medium gray, very silty, micaceous.
47.0	50.0	12	Sandstone, brown, very fine to fine, dirty, tight, brown dead oil stain and considerable shiny, black disseminated gilsonite.
50.0	52.0	13	Shale, medium to dark gray, micaceous, slightly silty.
52.0	55.0	14	Siltstone, white, very fine, shaly, micaceous.
55.0	74.0	15	Sandstone, white, silty to very fine, tight, micaceous, becoming fine to medium fine, clean with disseminated black shiny gilsonite at 60', siderite at base of unit.

74.0	76.0	16	Shale, medium gray, silty, sandy.
76.0	85.0	17	Sandstone, light gray, very fine to fine, micaceous, carbonaceous laminae, siderite, pyrite and coal fragments near base.
85.0	86.0	18	Coal, black, shiny, pyritic.
86.0	90.0	19	Shale, medium to dark gray, silty, micaceous.
90.0	103.0	20	Sandstone, light gray, fine to medium fine, micaceous, black carbonaceous material throughout, siderite nodules as streaks, sandstone becoming very fine, dirty, very micaceous, shaly at 100'. Good oil show while drilling from 95' to 100'.
103.0	112.0	21	Shale, medium gray, sandy, silty, with black carbonaceous laminae and siltstone, gray as thin streaks, considerable siderite at base of unit.
112.0	115.0	22	Sandstone, gray, very fine to fine, dirty, micaceous, tight, considerable black carbonaceous material and some coal fragments.
115.0	120.0	23	Siltstone, light gray, dirty, with interbedded gray shale, micaceous, becoming very sandy at 118' to 120'.
120.0	129.0	24	Shale, medium to dark gray, silty, micaceous with occasional thin siltstone laminae, becoming black, smutty with some limy shell debris near base. Trace of coal at 129'.
129.0	140.0	25	Sandstone, light gray to white, medium fine to medium coarse, micaceous, pyrite, very good visual porosity and permeability.
140.0	144.5	26	Shale, black, hard, pyritic.
144.5	146.0	27	Coal.
146.0	148.0	28	Shale, black, hard, silty.
148.0	156.0	29	Clay, tan to light olive green, with chert fragments and pebbles, pyritic.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 34

Location: 24' FSL & 128' FWL, Sec. 22, T. 33 N., R. 31 W., Barton County
Elevation: 926' Total Depth: 164'



DOE-TS - No. 34
"Slim hole" cuttings described and logged by Jack Wells
Location: 24' FSL & 128' FWL, Sec. 22, T. 33N., R. 31W., Barton County

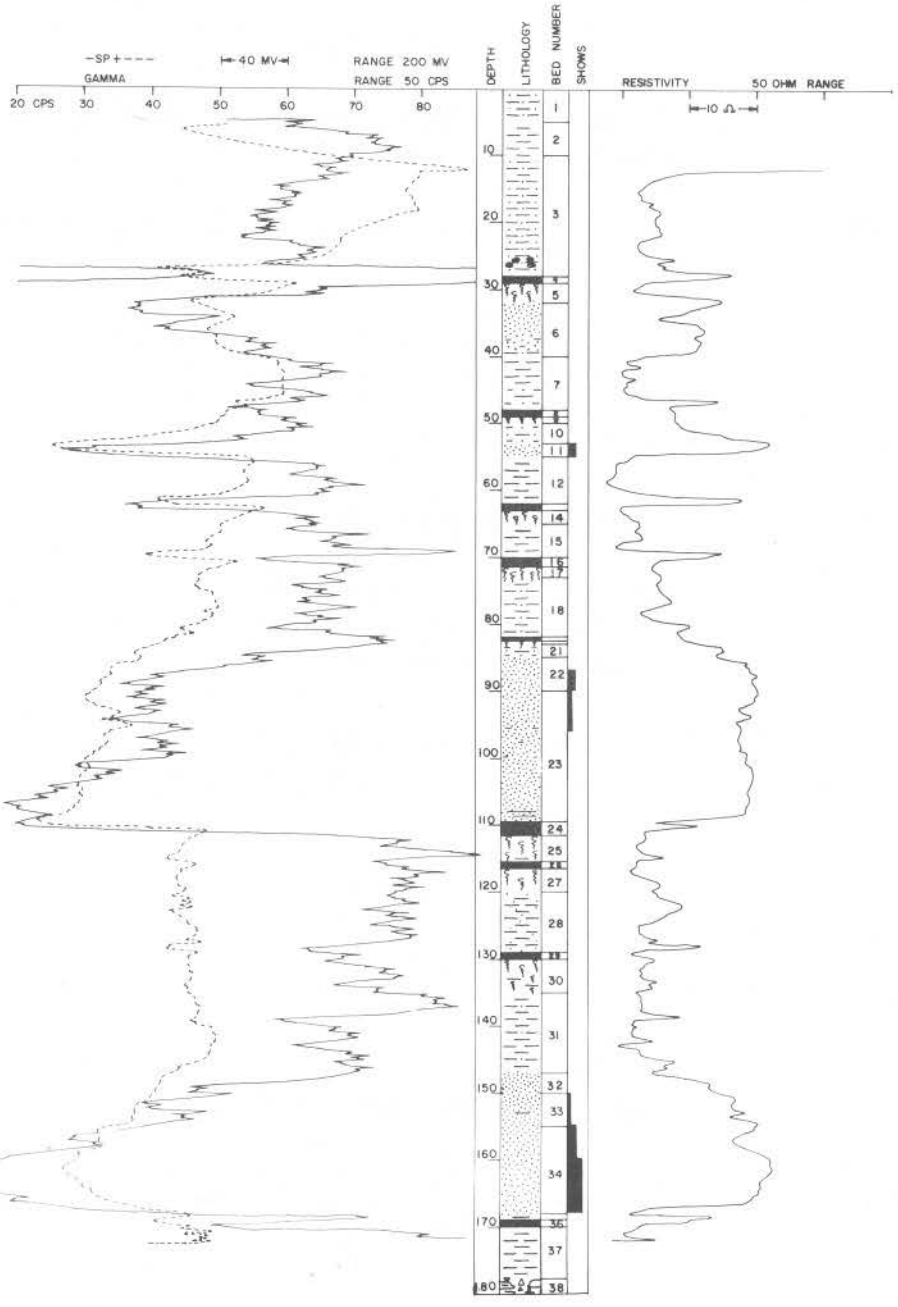
Elevation: 926' Total Depth: 164'

DEPTH		UNIT	DESCRIPTION
0.0	2.5	1	Soil, dark brown, silty.
2.5	14.0	2	Shale, light gray with light yellow oxidized streaks in upper portion, silty, micaceous, siderite shot and hematite nodules.
14.0	18.0	3	Shale, medium gray, firm, few sandstone streaks.
18.0	19.0	4	Limestone, gray to brown, dense to fine crystalline, few fossils, shaly.
19.0	23.0	5	Sandstone, white, very fine, tight, hard, slightly micaceous--becoming shaly in lower 2'.
23.0	27.0	6	Shale, gray, very sandy.
27.0	32.0	7	Sandstone, white, very fine to fine, micaceous--becoming shaly in lower 1', grading to underlying unit.
32.0	35.0	8	Shale, medium gray, sandy, silty, micaceous with black carbonaceous streaks.
35.0	46.0	9	Shale, black, micaceous, shaly becoming very fossiliferous, limestone at base of unit, with trace of coal at 46'.
46.0	50.0	10	Shale, medium gray, very sandy, very silty, micaceous.
50.0	53.0	11	Siltstone, tan to light gray, hard, tight.
53.0	60.0	12	Sandstone, white, fine to medium fine, micaceous.
60.0	65.0	13	Siltstone, light gray, hard, tight with occasional light green shale streaks.
65.0	74.0	14	Sandstone, white, very fine to fine, micaceous, tight.
74.0	76.0	15	Shale, dark gray, micaceous.

76.0	90.0	16	Sandstone, white, very fine to fine, micaceous, tight, occasional black carbonaceous laminae and shaly streaks.
90.0	93.0	17	Shale, medium gray, very sandy, silty, micaceous.
93.0	100.0	18	Sandstone, light gray, very fine to medium fine, micaceous with black carbonaceous laminae and occasional shale streaks, becoming conglomeritic with siderite and coal fragments at base.
100.0	105.0	19	Shale, light to medium gray, soft, slick with some siderite shot.
105.0	111.0	20	Shale, medium gray, silty, micaceous, firm.
111.0	112.0	21	Coal, black.
112.0	115.0	22	Underclay, light gray, soft, slick, grades into underlying shale unit.
115.0	120.0	23	Shale, medium to dark gray, silty, micaceous, few siderite nodules.
120.0	125.0	24	Shale, light greenish-gray to tan, soft, slick, resembles an underclay.
125.0	144.0	25	Shale, dark to medium gray, firm, micaceous becoming very silty at 135' to 144'.
144.0	145.0	26	Coal, black, shiny.
145.0	150.0	27	Underclay, light gray to tan, soft, slick.
150.0	161.0	28	Shale, black, hard, fissile, pyritic with trace of coal at 161'.
161.0	162.0	29	Chert conglomerate in black shale matrix.
162.0	164.0	30	Limestone, brown, dense to fine crystalline, slightly dolomitic calcite crystals.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 35

Location: 1950' FNL & 20' FWL, Sec. 17, T. 32 N., R. 33 W., Barton County
Elevation: 884' Total Depth: 180'



DOE-TS - No. 35
"Slim hole" cuttings described and logged by Jack Wells
Location: 1950' FNL & 20' FWL, Sec. 17, T. 32N., R. 33W., Barton County

Elevation: 884' Total Depth: 180'

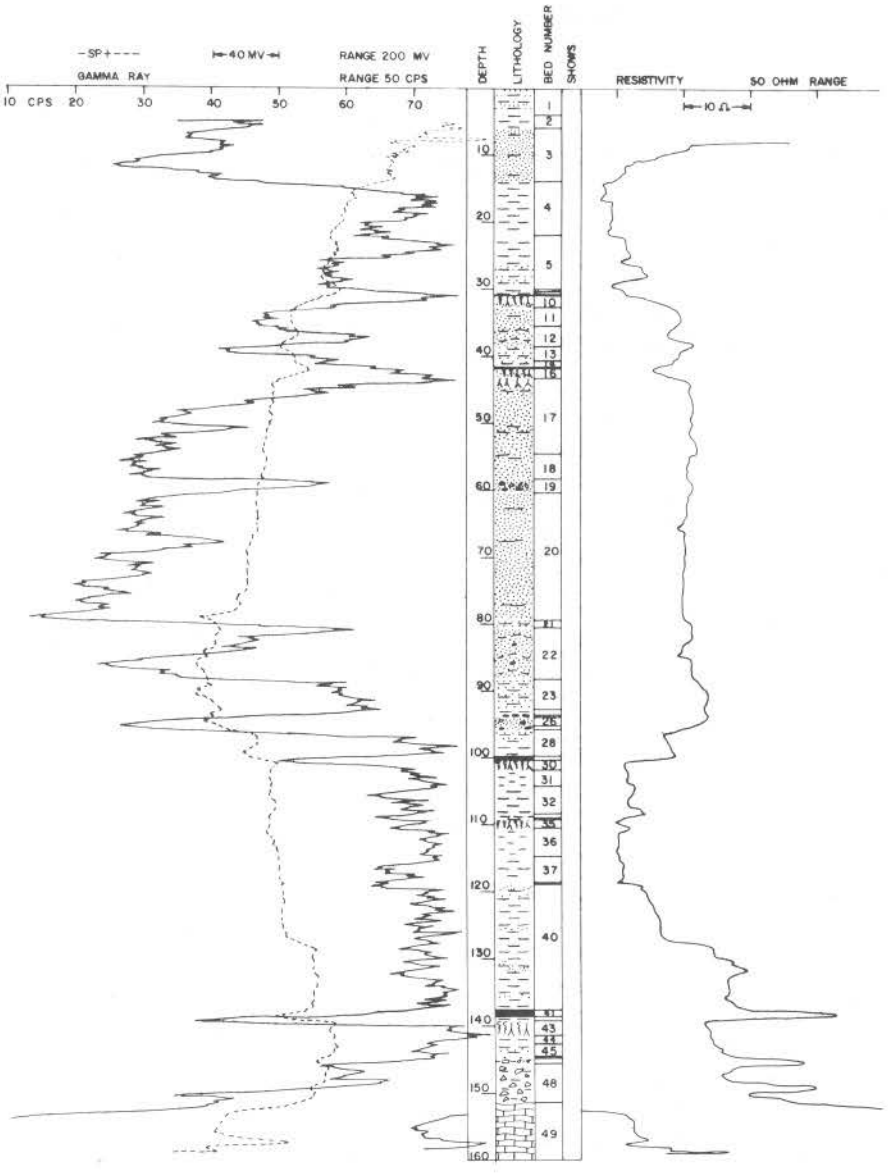
DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Soil and clay, yellow to brown, slightly silty, with minor amounts of soft, slick, gray shale.
5.0	10.0	2	Shale, light gray, soft, slick, with streaks of brick-red shale.
10.0	28.0	3	Shale, medium to dark gray, silty, siderite shot near top of unit, zone of massive siderite at 28'.
28.0	29.0	4	Coal.
29.0	32.0	5	Underclay, light gray, soft, slick.
32.0	40.0	6	Sandstone, white, very fine to fine, grades to siltstone, tight, becoming increasingly shaly toward base of unit, considerable siderite shot in lower half of unit.
40.0	48.0	7	Shale, medium to dark gray, slick, with siderite nodules, few siltstone streaks, especially in 45' to 48' interval.
48.0	49.0	8	Coal, black, shiny, blocky.
49.0	50.0	9	Underclay, gray, soft, slick.
50.0	53.0	10	Siltstone, medium gray, very shaly.
53.0	55.0	11	Sandstone, medium brown, very fine to fine, with black gilsonite and brown dead oil stain.
55.0	62.0	12	Shale, light gray to greenish-gray, soft, slick, with siderite shot, shale becoming medium gray and firm toward base of unit.
62.0	63.0	13	Coal, pyritic.
63.0	65.0	14	Underclay, light gray, soft, slick, grading into next lower unit.

65.0	70.0	15	Shale, medium to dark gray, firm.
70.0	71.5	16	Coal, black, shiny.
71.5	73.0	17	Underclay, light gray, soft, slick, grades into underlying unit.
73.0	82.0	18	Shale, light to medium gray, firm, slick, becoming medium gray, silty, very micaceous.
82.0	82.5	19	Coal, black.
82.5	83.0	20	Underclay, soft, slick, grading into siltstone.
83.0	85.0	21	Siltstone, light gray to greenish-gray, very micaceous and shaly.
85.0	90.0	22	Sandstone, light gray, very fine to fine in upper 3', to brown, very fine to fine with black specks of gilsonite and brown dead oil stain starting about 87'.
90.0	109.5	23	Sandstone, gray, very fine to medium fine, very micaceous, very slight dead oil stain 90' to 96', some light gray siltstone streaks 96' to 100', becoming fine to medium at 100' and containing brown and black carbonaceous streaks, considerable siderite at 109'.
109.5	111.5	24	Coal, black, shiny, blocky, pyritic.
111.5	115.5	25	Underclay, light to medium greenish-gray, soft, slick, grading into shale.
115.5	116.5	26	Coal.
116.5	120.0	27	Underclay, light to medium gray, soft, slick.
120.0	129.0	28	Shale, medium gray, silty, sandy, micaceous, becoming black, smutty at 128'.
129.0	130.0	29	Coal.
130.0	135.0	30	Underclay, medium olive-gray, soft, slick, grades into brownish-gray, hard slickensided shale.
135.0	147.0	31	Shale, dark gray to black, slightly silty, micaceous, hard with occasional siderite.

147.0	150.0	32	Sandstone, light gray, very fine to medium fine and silty with siderite shot in upper portion.
150.0	155.0	33	Sandstone, medium dark gray, very fine to fine, very dirty to shaly, trace amounts of dead oil stain.
155.0	168.0	34	Sandstone, brown, fine to medium fine, micaceous, dirty to clean with brown dead oil stain 155' to 160' becoming dark brown to black, heavy oil stained at 160', bleeding from samples, considerable dark brown to black oil coming to surface of mud pit.
168.0	169.0	35	Shale, dark gray, firm.
169.0	170.0	36	Coal, black, shiny.
170.0	177.5	37	Shale, dark gray to black, hard, micaceous, pyritic, grades to hard black, slick shale at 174'±.
177.5	180.0	38	Conglomerate of chert, mottled blue, white and brown in a matrix of black shale in upper portion grading into soft, slick, green shale-clay at total depth.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 36

Location: 17' FSL & 2710' FEL, Sec. 8, T. 33 N., R. 31 W., Barton County
Elevation: 893' Total Depth: 160'



DOE-TS - No. 36
Core described by Richard J. Gentile
Location: 17' FSL & 2710' FEL, Sec. 8, T. 33 N., R. 31W., Barton County

Elevation: 893' Total Depth: 160'

DEPTH		UNIT	DESCRIPTION
0.0	4.0	1	Soil and clay, brown and yellow, sandy, silty.
4.0	6.0	2	Clay, light gray, soft, slick.
6.0	14.0	3	Sandstone, yellow-brown, fine-grained, numerous reddish-brown clay seams.
14.0	22.0	4	Shale, medium gray, soft, slick.
22.0	30.0	5	Shale, medium gray, firm, slick, carbonized plant remains; few siltstone laminae below 26'; rock chip samples to 30'.
30.0	30.2	6	Shale, medium greenish-gray, abundant sand-sized siderite concretions weathered reddish-brown, non-calcareous.
30.2	30.8	7	Shale, medium greenish-gray, non-calcareous; few laminae of light gray sandstone.
30.8	30.9	8	Sandstone, light gray, distorted; thin laminae of coal.
30.9	30.95	9	Coal, thin bedded; dull with bright bands vitrain.
30.95	32.7	10	Underclay, greenish-gray, carbonized roots; bottom .8' sandy.
32.7	35.3	11	Sandstone, light gray, fine-grained, argillaceous; abundant sand-sized siderite concretions; bioturbite-like structures.
35.3	38.5	12	Sandstone, light gray, wavy, cross-laminated ripples; intercalated with medium gray shale; predominately sandstone in bottom half; pyritiferous and micaceous.
38.5	40.7	13	Sandstone, light gray, discontinuous laminae and pods intercalated with medium gray shale; plant leaves.
40.7	41.6	14	Shale, medium gray, sandy, distorted light gray sandstone laminae in top .1'; bottom .4' intercalated with light gray sandstone lenses in about equal amounts, non-calcareous.

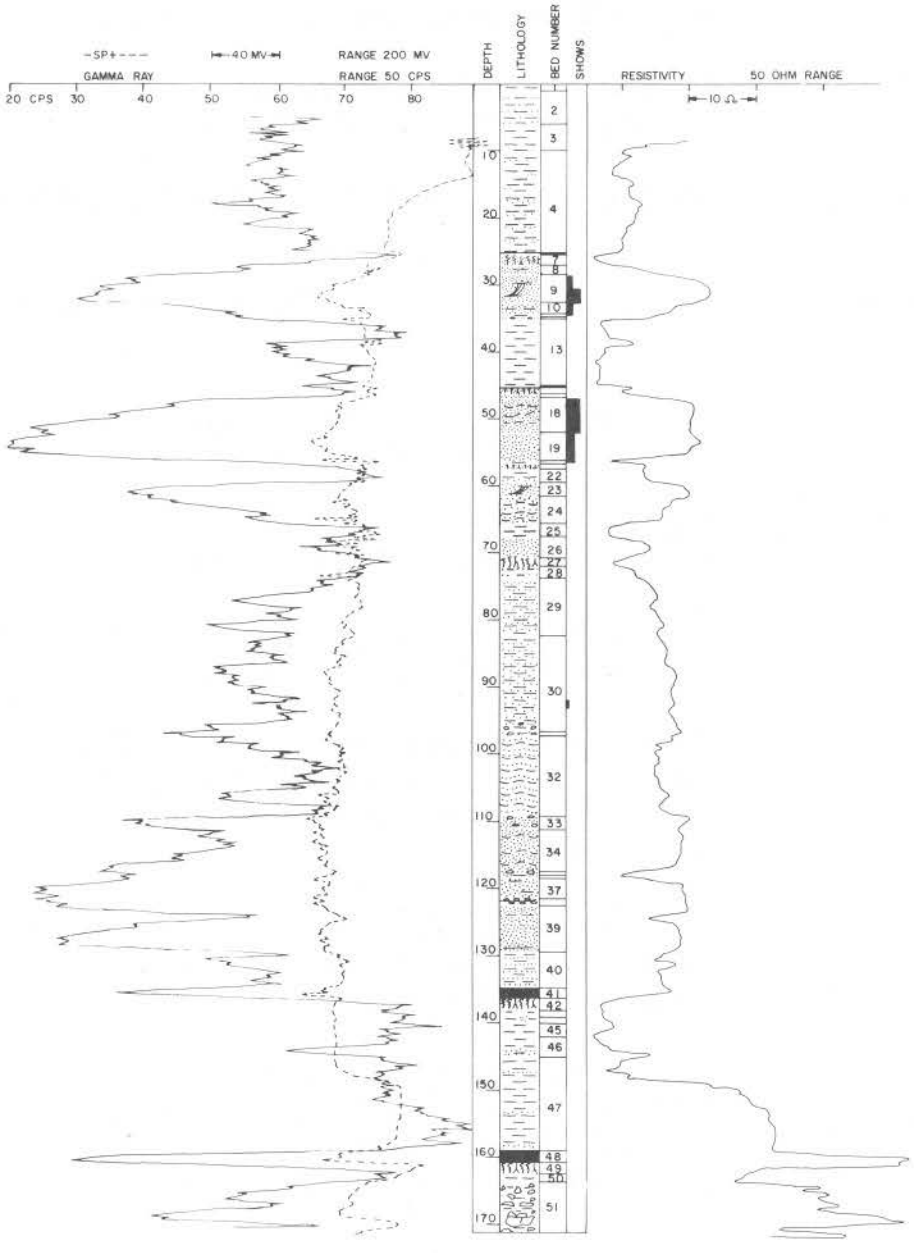
41.6	41.7	15	Coal, thin-bedded, pyritiferous, bright.
41.7	43.3	16	Underclay, greenish-gray, micaceous, sandy, carbonized roots.
43.3	54.5	17	Sandstone, light gray, fine-grained, carbonized root impressions in top 1'; 20% of unit from 44.6' to 45.1' is medium gray wavy shale laminae; slight asphaltic stain 48.4' to 48.6'; 20% of unit is wavy greenish-gray shale laminae from 50.6' to 51.2'.
54.5	58.2	18	Sandstone, light gray; bits of coal, brown woody material and shale 54.5' to 55.6', sharp scour surface at top; thin black laminae composed of bits fusain at 56.5' to 56.6' and 57.2' to 57.5'.
58.2	60.2	19	Sandstone, light gray; conglomeratic with flat shale clasts of medium gray shale to .02' thick, oriented randomly; flame structures (medium to dark gray clay in light gray sandstone), medium gray slickensided shale bed 58.7' to 58.8'.
60.2	79.3	20	Sandstone, light gray to medium gray; silt-sized bits of black shiny coaly material; concentrated in places to form dark gray horizontal laminae; few discontinuous laminae of pyritiferous coal; cross-bedded 70.5' to 70.6'; slightly coarser grained in bottom half.
79.3	80.6	21	Sandstone, light gray, cross-laminated ripples and pods interlaminated with medium to dark gray shale in approximately equal amounts.
80.6	88.1	22	Sandstone, light gray, thin black wavy laminae consisting of bits coaly material and mica comprise approximately 20% of unit; few pieces of pyritized fusain to .05' across.
88.1	92.8	23	Sandstone, light gray, cross-laminated ripples intercalated with medium gray shale in equal amounts; shale contains abundant bits of coaly material and mica.
92.8	93.4	24	Shale, medium gray; less than 5% light gray discontinuous sandstone laminae.
93.4	93.8	25	Conglomerate, predominately flat clasts of tan woody material .01' thick and .1' long, imbricate structure (some tan woody clasts with black coaly rinds); less than 10% light gray sandstone matrix.

93.8	95.2	26	Sandstone, light gray, conglomeratic; approximately 10% clasts of tan woody material and inclined laminae of coaly material.
95.2	95.8	27	Conglomerate; clasts of tan woody material, randomly oriented, pieces coal or fusain, pyritized, also thin discontinuous stringers coal (coalified twigs of Calamites and ferns); approximately 50% of unit is light gray sandstone matrix.
95.8	99.9	28	Shale, black, non-calcareous; top 1' interlaminated with light gray, cross-laminated ripple sandstone; grades downsection into shale at about middle of unit.
99.9	100.3	29	Coal, bright, pyrite in discontinuous laminae and disseminating form.
100.3	101.9	30	Underclay, medium to dark greenish-gray, slickensided; few root impressions at top.
101.9	104.2	31	Claystone, medium greenish-gray, profuse sand-sized siderite concretions dispersed throughout; pyritiferous.
104.2	108.3	32	Shale, black, non-calcareous.
108.3	109.0	33	Shale, black, calcareous, fossiliferous; Neospirifer?, productids, crinoid columnals, worm trails (fossils are light gray, recrystallized and dispersed throughout unit).
109.0	109.2	34	Shale, black, non-calcareous, pyritiferous; fills in vertical burrow or root holes in underlying unit to .2'.
109.2	110.5	35	Underclay, medium greenish-gray, carbonized roots, slickensided.
110.5	114.8	36	Claystone, medium greenish-gray; few sand-sized siderite concretions and pyrite crystals; lost core 112.7' to 113.6'.
114.8	118.9	37	Shale, black, non-calcareous, brown clay ironstone band at 118.3' to 118.4'.
118.9	118.95	38	Conglomerate, granule-sized clasts of coal, tan woody material, stringers coal, dark gray clay; bright green sand-sized clay mineral in matrix of light gray quartzose sandstone.
118.95	119.0	39	Clay ironstone, tan; sharp wavy scour contact with overlying unit.

119.0	137.7	40	Shale, dark gray, non-calcareous, approximately 5% light gray, discontinuous sandstone laminae (starved ripples) dispersed throughout unit except from 119.05' to 119.2' and 130' to 132' where approximately 20% of unit is light gray, cross-laminated sandstone and pods.
137.7	138.7	41	Coal, bright, pyritized stems; cleats filled with a white non-calcareous mineral (gypsum?).
138.7	139.1	42	Shale, dark gray, hard, non-calcareous, pieces pyritized wood.
139.1	141.4	43	Underclay, medium greenish-gray, few carbonized roots, ferns.
141.4	142.4	44	Shale, medium greenish-gray at top to dark gray at bottom; sand-sized siderite concretions.
142.4	144.5	45	Shale, black, non-calcareous; 1 or 2% lenticular laminae and pods light gray sandstone at bottom.
144.5	144.8	46	Breccia, light gray, angular clasts of chert in .05' diameter comprise about 10% of unit "floating" in a black shale matrix.
144.8	145.7	47	Breccia, chert clasts granular size to .5' comprise approximately 90% of unit; weathered with white rinds and tan interiors; molds of planispirally coiled gastropods; green clay matrix.
145.7	151.4	48	Breccia, chert clasts comprise approximately 10% of unit, white to muddy-brown; matrix of green clay, slickensided, hard, top 1' brown; lost core 148.8' to 149.6'
151.4	160.0	49	Limestone, light gray, oolitic (oolites in a sand-sized fossil hash, fenestellate bryozoans, brachiopods), stylolitic, thin dark gray clay residue laminae along stylolites which contain abundant pyrite crystals.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 37

Location: 132' FSL & 7' FWL, Sec. 16, T. 33 N., R. 32 W., Barton County
Elevation: 880' Total Depth: 171'



DOE-TS - No. 37
Core described by Richard J. Gentile
Location: 132' FSL & 7' FWL, Sec. 16, T. 33N., R. 32W., Barton County

Elevation: 880' topo Total Depth: 171'

DEPTH		UNIT	DESCRIPTION
0.0	1.0	1	Soil, brown.
1.0	5.0	2	Clay, yellow-brown, silty.
5.0	10.0	3	Shale, dark gray, weathered. Rock chip samples to 10'.
10.0	25.1	4	Shale, medium gray with paper-thin lenses of light gray sandstone; increased sandstone content at middle; non-calcareous tan sandy ironstone zones at 14.5' to 14.7' and 16' to 16.3'.
25.1	25.12	5	Coal, bright, fractured into pieces.
25.12	25.3	6	Shale, dark gray, fractured into pieces.
25.3	27.0	7	Sandstone, light gray, argillaceous, carbonized roots.
27.0	28.4	8	Sandstone, light gray, argillaceous, sand-sized siderite concretions, micaceous, bioturbite structures.
28.4	32.7	9	Sandstone, fine-grained, cross-bedded, dark brown to black, oil stained, saturated from 30.6' to 32.7'.
32.7	34.2	10	Sandstone, stained brown with asphalt, cross-laminated ripples interlaminated with equal amounts of greenish-gray sandy non-asphaltic clay; sharp contact with overlying unit.
34.2	34.6	11	Shale, greenish-gray, sandy.
34.6	35.0	12	Sandstone, small scale cross bedding, sand-sized siderite concretions; conglomeratic from 34.85' to 34.95' with granule-size clasts of coal and dark gray shale; sharp wavy contact with underlying unit.
35.0	45.0	13	Shale, dark gray, non-calcareous; bits pyritized wood, non-calcareous, tan clay-ironstone zones at 38.7' to 38.8'.
45.0	45.2	14	Limestone, dark gray, hard, fossiliferous with small chonetid brachiopods and spines of productids.

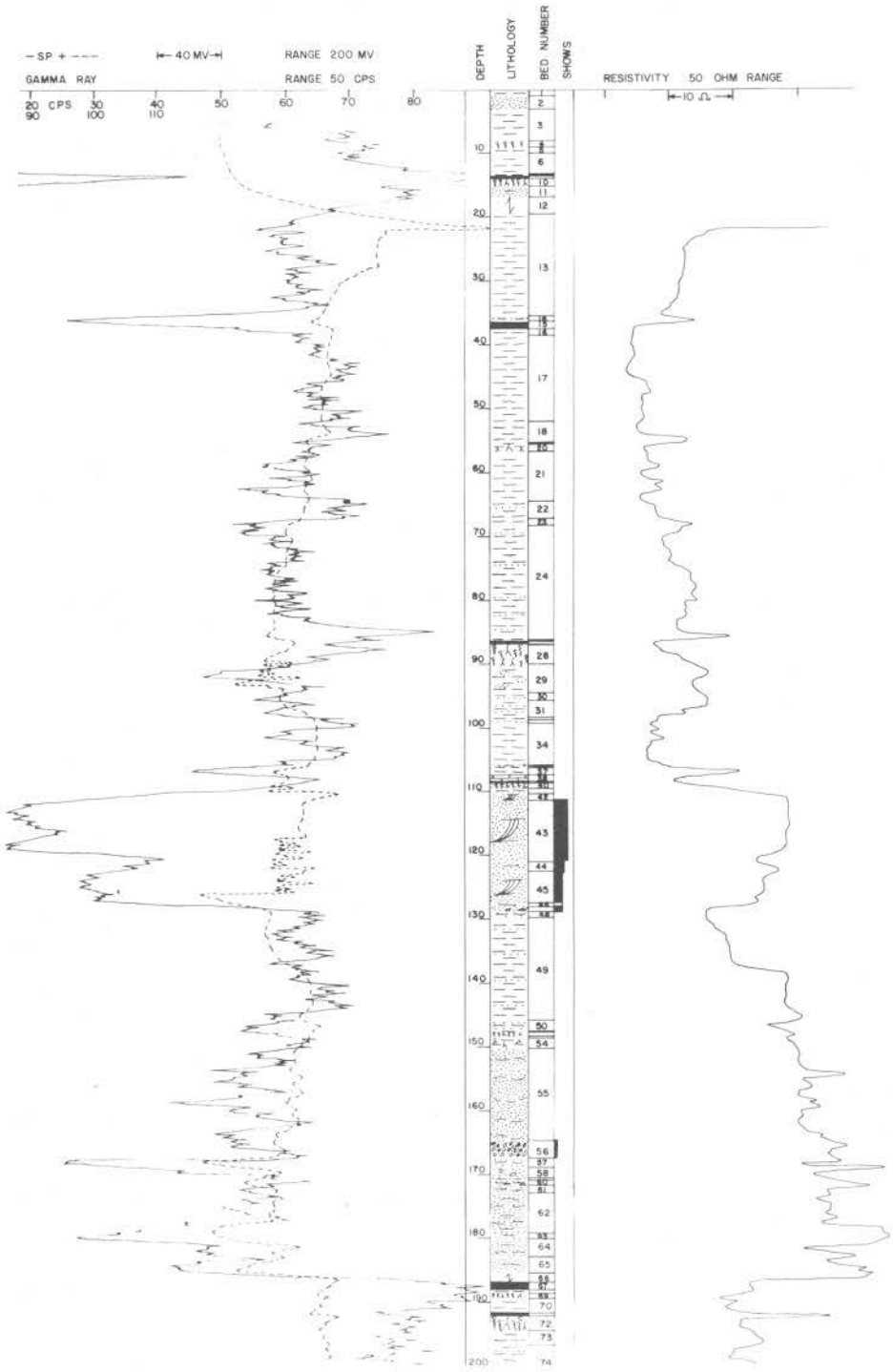
45.2	45.21	15	Coal, bright.
45.21	46.2	16	Underclay, very sandy; carbonized roots; sand-sized siderite concretions.
46.2	46.8	17	Sandstone, medium gray, argillaceous, bioturbite appearance.
46.8	52.0	18	Sandstone, ripple cross-laminations to cross-bedded, stained with dark brown to black asphalt, intercalated with light gray argillaceous, non-asphaltic clay lenses which comprise approximately 40% of unit (clayey lenses impermeable to asphaltic penetration).
52.0	56.1	19	Sandstone, homogeneous, dark gray, salt and pepper appearance with sand-sized specks of gilsonite with spotty to heavy dead oil stain.
56.1	56.6	20	Shale, dark gray; flora of Cordaites leaves, fern stems, stringers of bright coal; fractured into pieces.
56.6	57.4	21	Underclay, light greenish-gray, carbonized roots, sandy.
57.4	59.4	22	Shale, greenish-gray; abundant sand-sized siderite concretions in top 1'; becoming sandy at bottom with quartzose sandstone.
59.4	61.6	23	Sandstone, cross-bedded, medium gray, bits of gilsonite and/or coal, very micaceous.
61.6	65.5	24	Sandstone, light gray wavy laminae (ripples), intercalated with dark gray shale laminae, units paper-thin to .01' thick.
65.5	67.6	25	Shale, black, pyritized worm trails and twigs.
67.6	70.9	26	Sandstone, dark gray with light gray swirls and pods of sandstone (bioturbite structure).
70.9	72.0	27	Underclay, light greenish-gray, carbonized roots; sharp irregular contact with overlying unit.
72.0	73.8	28	Claystone, greenish-gray, silty; abundant sand-sized siderite concretions.
73.8	82.4	29	Sandstone, light gray (ripple, cross-laminated) intercalated with medium gray shale; units lenticular to .02' thick.

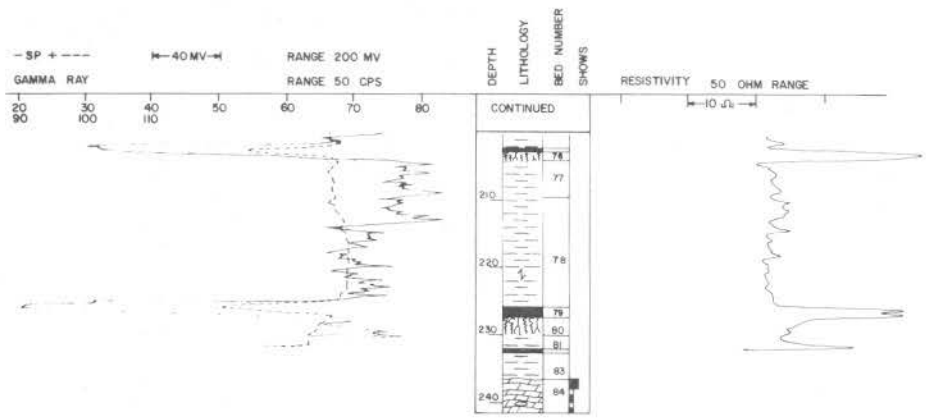
82.4	96.4	30	Sandstone, light gray, lenticular ripple laminated, intercalated with medium gray shale containing bits coaly material and caramel colored spore sacks, micaceous (color from GSA rock color chart N8 light gray and N5 medium gray); predominately sandstone 92.5' to 92.9' speckled black with bits gilsonite or coaly material (dead oil stain), conglomeratic near bottom with few elongated clasts of tan clay or plant material.
96.4	97.2	31	Sandstone, light gray, fine to medium grained (1/8 to 1/4 mm diameter), angular to rounded grains, quartzose; to .03' thick gray and brown shale beds in places broken and disoriented to form conglomeratic sandstone; flat elongated clasts.
97.2	109.2	32	Sandstone, light gray and dark gray wavy shale (N3 dry) intercalated, units paper-thin to .05' thick; sandstone bed 97.7' to 98.4'.
109.2	111.1	33	Sandstone, light gray, fine-grained conglomeratic especially in top and bottom .3', granule-size to .05' diameter clasts of dark gray shale, tan woody material, coal, blade-like to spherical clasts; few paper-thin laminae consisting of bits of fusain, mica.
111.1	117.5	34	Sandstone, light gray, contorted structures 111.4' to 111.8' otherwise evenly bedded with approximately 30% of unit medium gray shale laminae and paper-thin wavy coal, laminae, micaceous, pyritiferous, non-calcareous.
117.5	118.0	35	Conglomerate, spherical to blade-like clasts to .03' diameter of tan woody material, clay ironstone, coal; light gray fine to medium grained sandstone matrix.
118.0	118.5	36	Sandstone, light gray and coal interlaminated in equal amounts, few pieces brown woody material, micaceous.
118.5	121.6	37	Sandstone, light gray, fine-grained, non-calcareous, few paper-thin laminae consisting of randomly oriented bits coal or charcoal.
121.6	122.5	38	Conglomerate, predominately oblong-shaped to lenticular clasts of tan (dark yellowish-brown 10YR 4/2 GSA Rock Color Chart) imbricate to randomly oriented to .05' diameter; light gray fine-grained sandstone matrix; predominately sandstone, light gray interlaminated with coal from 121.9' to 122.3', micaceous.

122.5	129.5	39	Sandstone, light gray, fine grained, micaceous, medium gray shale interlaminated with light gray sandstone 123.7' 124.4'; .1' thick bed coal at 129.2' (coalified twig).
129.5	134.9	40	Sandstone, light gray, ripples and medium gray shale interlaminated in equal amounts.
134.9	136.2	41	Coal, shiny, pieces of fusain common; cleats filled with calcite; 1 or 2% of unit is nodules and lenses pyrite.
136.2	138.0	42	Underclay, dark gray at top to medium gray at bottom, root impressions.
138.0	139.0	43	Claystone, medium gray, sand-sized concretions of siderite and nodules pyrite.
139.0	140.0	44	Shale, medium gray, lenses and pods of light gray sandstone bioturbite structures.
140.0	142.0	45	Shale, medium gray, grades downsection into greenish-gray shale.
142.0	145.0	46	Shale, greenish-gray, clay ironstone bed 143.9' to 144.2'; sandy at bottom.
145.0	159.0	47	Shale, dark gray (dry, black wet) 1 or 2% of unit is light gray sandstone, lenses (paper-thin) dispersed throughout; non-calcareous.
159.0	160.9	48	Coal, bright bands (vitrain) to dull bands (fusain); lenses of pyrite to .01' thick.
160.9	162.4	49	Underclay, dark gray, slickensided, carbonized roots.
162.4	163.4	50	Shale, black, non-calcareous.
163.4	171.0	51	Breccia, light gray to white dense chert clasts, granule size to .3' thick; approximately 40% of unit is clay matrix (black 163.4' to 163.6', tan 163.4' to 165.4' and predominately green to bottom of hole); lost core 167.5' to 168.5'.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 38

Location: 2560' FSL & 2620' FEL, Sec. 6, T. 33 N., R. 33 W., Barton Couonty
Elevatin: 861' Total Depth: 241.6'





DOE-TS - No. 38
Core described by Richard J. Gentile
Location: 2560' FSL & 2620' FEL, Sec. 6, T. 33N., R. 33W., Barton County

Elevation: 861' topo Total Depth: 241.6'

DEPTH		UNIT	DESCRIPTION
0.0	1.0	1	Soil.
1.0	3.0	2	Sandstone, hard, weathered brown.
3.0	8.0	3	Shale, light greenish-gray, soft, slick, brown iron oxide streaks.
8.0	9.0	4	Clay, bright red, soft.
9.0	10.0	5	Shale, medium gray, firm. Rock chip samples to 10'.
10.0	13.1	6	Shale, dark gray at top (N3, dry to black at bottom N1, dry, GSA Rock Color Chart), non-calcareous.
13.1	13.3	7	Limestone, dark gray, weathering red, fragments of brachiopod shells.
13.3	13.6	8	Shale, black, soft, fragments of brachiopod shells, Mesolobus, in top half; calcareous phosphatic nodules?; gypsum crystals, bottom non-calcareous.

13.6	14.0	9	Coal, bright, broken, iridescent.
14.0	15.2	10	Underclay, medium gray, poorly developed root impressions.
15.2	16.9	11	Sandstone, light gray, argillaceous, micaceous, clusters of sand-sized siderite concretions and pyrite nodules.
16.9	19.6	12	Lost core.
19.6	35.4	13	Shale, light gray (N7, dry); .05' thick siderite concretion bed at 25.8'; non-calcareous.
35.4	36.2	14	Shale, light gray, silty, interlaminated with coal; paper-thin to .03' thick, non-calcareous.
36.2	37.4	15	Coal, bright; pyritized plant material; .05' thick pyritized clay band .05' from top.
37.4	38.6	16	Claystone-shale, medium gray; no root impressions observed.
38.6	52.0	17	Claystone-shale, light gray, non-calcareous; irregular blotches of dark gray claystone at 42.6' to 43.7'; sand-sized siderite concretions 44' to 50'.
52.0	55.2	18	Shale, medium gray grading to dark gray downsection, non-calcareous.
55.2	55.4	19	Shale, black, non-calcareous, sooty, bits of coal.
55.4	56.8	20	Shale, light gray, sandy at bottom, few poorly developed root impressions.
56.8	64.4	21	Shale, light gray, top few inches medium gray, clusters of sand-sized siderite concretions 58' to 58.8'; siderite concretion beds 61.6' to 61.8', 63.3' to 63.6'; shale, medium gray, sand-sized siderite concretions dispersed throughout to bottom of unit.
64.4	67.1	22	Shale, dark gray (N2, dry), non-calcareous; approximately 5% of unit is light gray, lenticular laminae of sandstone (starved ripples).
67.1	68.1	23	Shale, grayish-black (N2, dry) darker at top; non-calcareous.

68.1	86.1	24	Shale, medium gray (N4, dry) to dark gray (N3, dry) below 84.6'; approximately 10% of unit is light gray lenticular paper-thin laminae of sandstone; siderite zone at 68.6' to 68.9', additional zones about .1' thick at 70.7', 71.4', 74.7', 79.2' and 81'.
86.1	86.4	25	Shale, black, pyritiferous, bits of light gray fossil fragments.
86.4	86.9	26	Coal, shiny, pieces of pyritized plant material.
86.9	87.0	27	Shale, black, pyritiferous.
87.0	90.0	28	Underclay, medium gray at top to light gray at bottom; root impressions.
90.0	94.4	29	Shale, light greenish-gray, very sandy with sandstone lenses; clusters of tan sand-sized siderite concretions dispersed throughout unit.
94.4	95.5	30	Shale, greenish-gray (5GY 6/1, wet); approximately 5% of unit is lenticular, paper-thin light gray sandstone units.
95.5	98.2	31	Shale, light greenish-gray and light gray sandstone (ripples), interlaminated, lenticular.
98.2	98.7	32	Shale, medium dark gray, sharp contact with overlying unit.
98.7	99.1	33	Siderite, sand-sized siderite concretion bed; dark gray to brown.
99.1	105.9	34	Shale, light to medium gray, sideritic.
105.9	105.96	35	Shale, sandy, calcareous.
105.96	106.3	36	Shale, medium gray, non-calcareous.
106.3	107.4	37	Shale, black, non-calcareous; .1' thick brown siderite zone .3' from top.
107.4	108.5	38	Limestone, dark gray, argillaceous; very fossiliferous mostly with fragments of thin shelled convex brachiopods (small productids), few gastropods, crinoid columnals.
108.5	108.55	39	Coal, shiny, pyritized compressed stems (.005' thick).
108.55	109.6	40	Underclay, silty, carbonized roots; clusters of sand-sized siderite concretions.

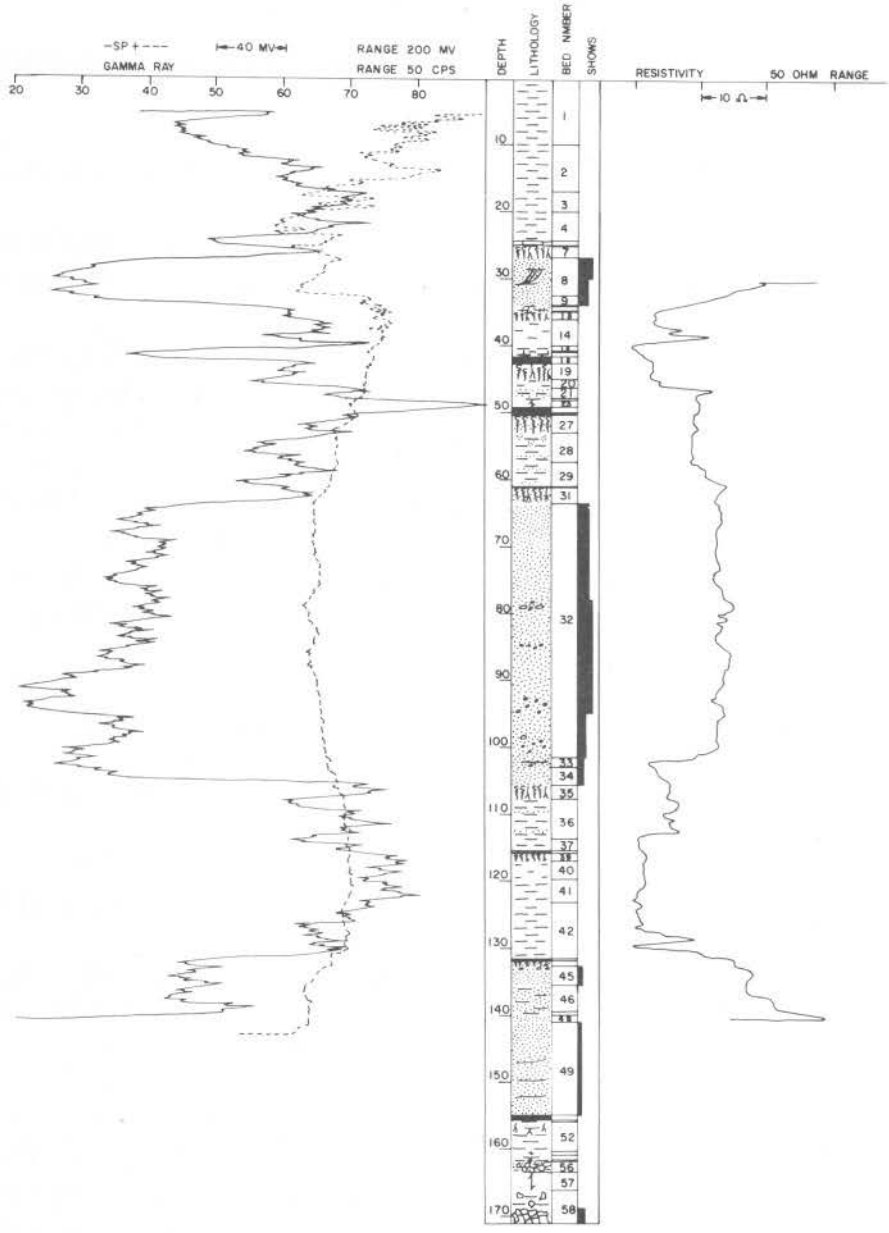
109.6	110.2	41	Shale, greenish-gray, sandy.
110.2	111.3	42	Sandstone, light gray, fine-grained, cross-bedding accentuated by greenish-gray clay along cross sets, micaceous.
111.3	121.0	43	Sandstone, fine-grained (1/8 mm), cross-bedded, saturated with brownish-black asphalt; 2 or 3 greenish-gray micaceous clay partings between foresets (unit sampled at intervals).
121.0	122.5	44	Sandstone, light gray, cross-bedded to cross-laminated; abundant thin greenish-gray shale laminae; moderate asphalt staining of sandstone (unit sampled at intervals).
122.5	127.4	45	Sandstone, fine-grained, micaceous; stained with dark brown asphalt; cross-bedded to cross-laminated.
127.4	128.0	46	Sandstone, light gray and dark gray shale, interlaminated.
128.0	128.7	47	Sandstone, light gray, fine-grained, localized staining with asphalt; conglomeratic with tan clay clasts near bottom.
128.7	129.7	48	Shale, medium dark gray (N4, dry); light gray sandstone, ripple laminated, comprises 40% of unit.
129.7	145.9	49	Same as above but light gray sandstone laminae comprise approximately 10% of unit, plant fragments along bedding planes; soft clay bed 139.7' to 139.9'.
145.9	147.5	50	Same as above but sandstone laminae comprise approximately 50% of unit.
147.5	147.6	51	Shale, dark gray.
147.6	148.2	52	Underclay, medium gray, carbonized root impressions.
148.2	148.5	53	Clay, soft; brownish-gray (not representative of section).
148.5	150.2	54	Shale, greenish-gray, very sandy; clusters of brown sand-sized siderite concretions, carbonized roots.
150.2	164.7	55	Sandstone, light gray, greenish-gray clay in distorted "wispy" laminae to disseminated throughout unit; sand-sized siderite concretions.
164.7	167.3	56	Conglomerate, clasts mostly granule-size of coal, light gray shale, dark gray shale, spherical to lens-like shape, aligned; light gray to brown sandstone matrix; trace oil stain.

167.3	168.9	57	Sandstone, light gray, cross-laminated ripples and medium dark gray shale intercalated in units to approximately .1' thick in equal amounts.
168.9	170.4	58	Sandstone, light gray, few tan claystone clasts.
170.4	170.9	59	Sandstone, light gray, cross-laminated ripples and medium dark gray shale intercalated in equal amounts, units to .1' thick, wavy.
170.9	171.5	60	Conglomerate, clasts to .05' diameter consist of tan woody material, dark gray shale and clay ironstone, interlaminated light gray sandstone and dark gray shale from 171' to 171.3'.
171.5	172.9	61	Sandstone, light gray, fine-grained; 10% of unit is dark gray wavy shale laminae.
172.9	179.1	62	Sandstone, light gray, cross-laminated ripples and dark gray shale interlaminated in approximately equal amounts; wavy; similar to 170.4' to 170.9'.
179.1	180.0	63	Sandstone, light gray, fine-grained, dark gray shale laminae comprise approximately 10% of unit; few clasts of tan woody material.
180.0	182.9	64	Sandstone, light gray (N7 to N8, dry) fine-grained, ripple cross-laminated; approximately 40% of unit is medium gray (N5, dry) shale, laminae .01' to .02' thick, wavy, micaceous along bedding planes.
182.9	185.3	65	Sandstone, light gray, fine-grained, micaceous, few paper-thin, wavy, medium gray shale laminae.
185.3	186.9	66	No core, roller bit drilled interval.
186.9	187.0	67	Coal, shiny, pyritiferous.
187.0	187.3	68	Shale, dark gray, slick, gradational with overlying unit.
187.3	189.2	69	Underclay, medium gray, carbonized roots.
189.2	191.7	70	Shale, black, pyrite nodules .01' diameter throughout interval.
191.7	192.0	71	Coal, bright, pyrite.
192.0	194.2	72	Underclay, medium gray, carbonized and pyritized roots and other plant material; sand-sized siderite concretions.

194.2	196.4	73	Shale, medium gray; sand-sized siderite concretions and pyrite nodules.
196.4	202.1	74	Shale, dark grayish-black (N2, dry); approximately 10% of unit to 200' depth is light gray, lenticular sandstone cross-laminae (starved ripples).
202.1	202.8	75	Coal, bright, fractured; pyrite laminae .01' thick; calcite filled cleats.
202.8	204.0	76	Underclay, medium gray, soft; carbonized roots.
204.0	209.6	77	Shale, medium gray; tan sand-sized siderite concretions dispersed throughout form clusters near bottom of unit.
209.6	225.9	78	Shale, black, non-calcareous; approximately 1% light gray paper-thin sandstone laminae (starved ripples) equally spaced throughout unit; tan clay ironstone zones at 210.3' to 210.4', 211.05' to 211.1', 204' to 204.2', 205.9' to 205.95', 207.5' to 207.6'. Lost core 220.2' to 221.6'.
225.9	227.2	79	Coal, bright with pieces of fusain forming dull bands; approximately 1% of unit is pyrite mostly forming cleat fill, also calcite cleat fill.
227.2	230.0	80	Underclay, medium gray, carbonized roots.
230.0	232.0	81	Shale, dark gray to grayish-black (dry); pieces carbonized and pyritized stems.
232.0	232.6	82	Coal, bright to dull, pyritized plants and pyrite fill cleats.
232.6	236.3	83	Shale, slickensided, dark grayish-black (N2, dry) to black (N1, wet) pyrite nodules .01' diameter, sharp contact with underlying unit.
236.3	241.6	84	Dolomite, sugary texture, light olive gray (5Y 6/1); vuggy, porous, saturated with brownish-black asphalt from 236.3' to 238.2' becoming randomly dispersed in pores throughout remainder of unit, also pyrite in pores; bluish-gray chert nodule .1' diameter at 241.2'.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 39

Location: 10' FSL & 55' FWL, Sec. 14, T. 32 N., R. 33 W., Barton County
Elevation: 948' Total Depth: 171



DOE-TS - No. 39
Core described by Richard J. Gentile
Location: 10' FSL & 55' FWL, Sec. 14, T. 32N., R. 33W., Barton County

Elevation: 948' topo Total Depth: 171'

DEPTH		UNIT	DESCRIPTION
0.0	10.0	1	Soil and shale, weathered brown to light gray, soft.
10.0	17.0	2	Shale, medium light gray, soft, slick.
17.0	20.0	3	Shale, dark gray, soft, firm; lenses of red shale at 18.5'. Note: Rock bit samples to 20'--core starts at 20'.
20.0	24.2	4	Shale, dark gray (GSA Rock Color Chart, N3, dry), non-calcareous, soft; .1' thick clay ironstone beds at 21' and 23.4'.
24.2	25.0	5	Limestone, medium gray (N5, dry) to dark gray (N3, dry) at bottom, fossiliferous, small productids, biconvex brachiopods (.01' in cross sectional shape), high spired gastropods, crinoid columnals.
25.0	25.05	6	Shale, dark gray, non-calcareous; almost a coal.
25.05	26.9	7	Underclay, light gray (N7, dry), carbonized root impressions; small irregular patches of siderite in bottom 1'.
26.9	32.4	8	Sandstone, fine-grained, micaceous, cross-bedded, stained brownish-black with asphalt; samples removed at selected intervals.
32.4	34.0	9	Sandstone, medium gray, specks gilsonite, micaceous.
34.0	34.05	10	Clay ironstone, medium brownish-gray.
34.05	35.95	11	Shale, medium dark gray, approximately 25% of unit is light gray laminae and pods of sandstone; evenly spaced throughout, horizontal.
35.95	36.0	12	Shale, black, non-calcareous.
36.0	37.0	13	Claystone, medium dark gray, poorly developed roots.
37.0	40.0	14	Claystone, soft, medium greenish-gray; sand-sized siderite concretions dispersed throughout unit.

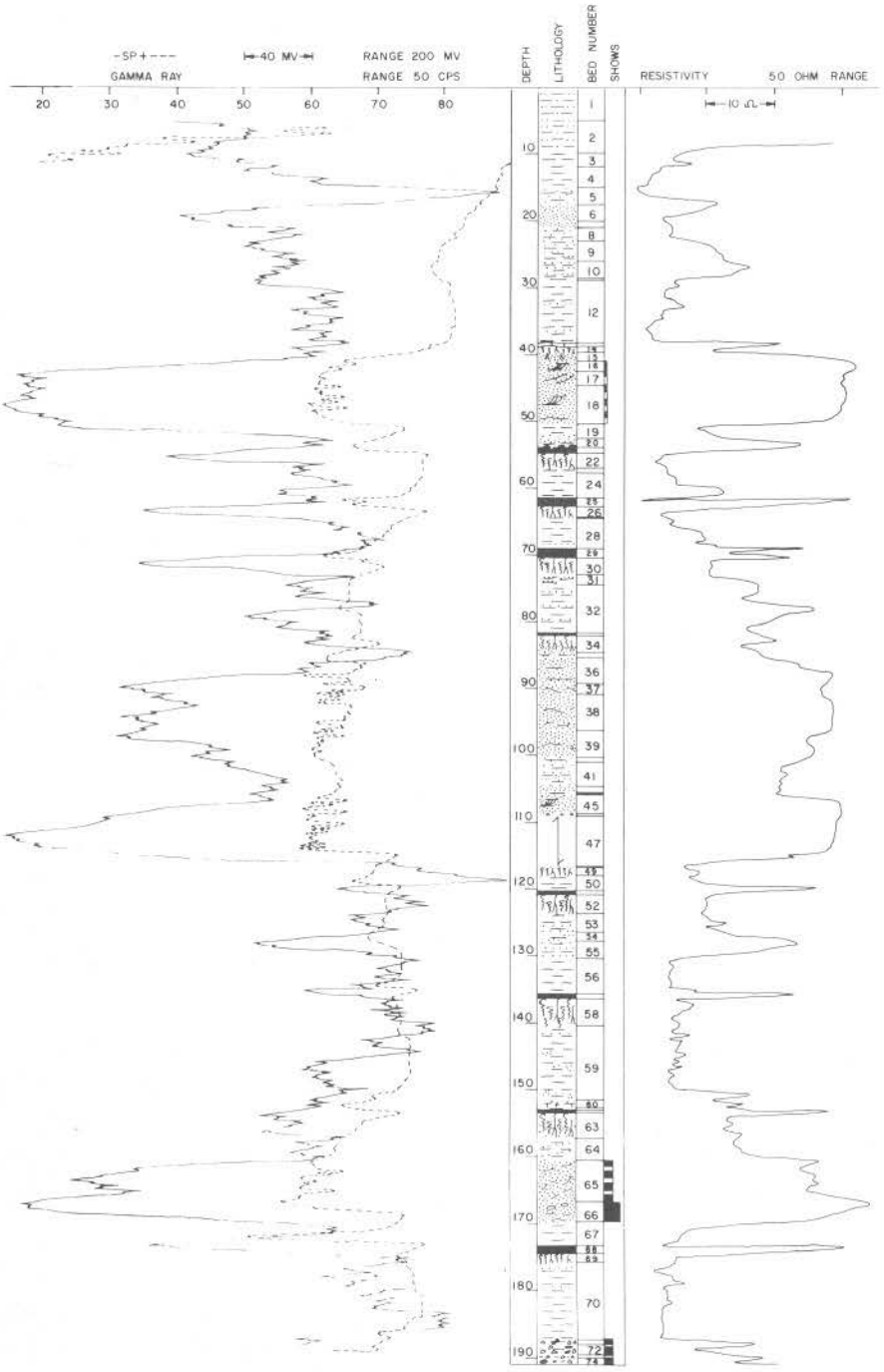
40.0	40.7	15	Shale, dark gray, non-calcareous.
40.7	41.0	16	Clay ironstone, medium brownish-gray, dense, hard.
41.0	41.6	17	Shale, grayish-black (N2, dry), laminae of white recrystallized shale fragments, brachiopods?.
41.6	42.7	18	Coal, bright, 1 or 2% pyrite in the form of compressed stems, leaves.
42.7	45.0	19	Underclay, medium gray, carbonized roots
45.0	46.2	20	Claystone, greenish-gray.
46.2	47.9	21	Shale, dark gray, 5% of unit is light gray lenticular laminae of sandstone (starved ripples) evenly spaced throughout unit.
47.9	48.1	22	Clay ironstone, medium gray, hard, dense.
48.1	49.2	23	Lost core.
49.2	50.0	24	Coal, bright to dull, pyritized plant material.
50.0	50.1	25	Claystone, hard, non-calcareous.
50.1	50.2	26	Coal, bright to dull.
50.2	53.0	27	Underclay, medium gray, silty, clusters of sand-sized siderite concretions in bottom half.
53.0	57.3	28	Shale, medium greenish-gray, silty to fine sand-disturbed in top half (bioturbite structure) to interlaminated with light gray sandstone in bottom half; sand-sized siderite concretions in clusters and disseminated throughout.
57.3	61.0	29	Shale, medium dark gray, approximately 10% of unit is light gray sandstone lenses (paper-thin) equally spaced throughout unit.
61.0	61.05	30	Coal, bright.
61.05	63.4	31	Underclay, light greenish-gray, carbonized roots, sandy, disturbed bioturbite appearance; brown clusters of sand-sized siderite concretions in bottom half.

63.4	101.6	32	Sandstone, fine-grained, micaceous, dark gray to grayish-black from abundant dispersed specks of shiny brittle asphalt (gilsonite) throughout unit; conglomerate from 78.9' to 79.2' of tan clasts to .1' diameter (clayey plant pith material) rounded to flattened comprised 10% of unit with grayish-black sandstone matrix; paper-thin crinkly laminae of coaly material also randomly oriented pieces of coal, sand-sized from 84.5' to 85', 92.8' to 95.4', 98.4' to 101' comprise small percentage of unit most abundant below 98.4'; sections removed for asphalt sampling at selected intervals.
101.6	103.0	33	Sandstone, fine-grained, gilsonite but not as abundant as in overlying unit; distorted shiny laminae of coal to .01' thick and randomly oriented granule-sized flattened clasts for about 5% of unit, dispersed throughout.
103.0	105.6	34	Sandstone, fine-grained, dark gray with gilsonite.
105.6	107.8	35	Claystone, light greenish-gray, poorly developed root impressions, sand-sized siderite concretions near middle.
107.8	113.7	36	Shale, dark gray with about 10% of unit light gray paper-thin lenticular sandstone laminae, distorted laminations in top 1', horizontal below.
113.7	115.5	37	Shale, dark gray, non-calcareous, pyritiferous; dark gray clay ironstone bed, dense, hard from 114.2' to 114.4'.
115.5	115.8	38	Coal, bright.
115.8	117.0	39	Underclay, medium gray, carbonized roots.
117.0	119.8	40	Claystone, medium greenish-gray, irregular patches of dark gray clay which may be carbonized roots especially near top, few sand-sized siderite concretions.
119.8	123.1	41	Shale, medium greenish-gray; .3' thick siderite zone at top.
123.1	131.7	42	Shale, dark gray grading downsection into grayish-black at bottom, non-calcareous; .1' thick brownish-gray clay ironstone zone at 130.2'.
131.7	132.0	43	Coal, bright, fractured.
132.0	133.7	44	Underclay, light gray, sandy; abundant carbonized-pyritized roots.

133.7	135.4	45	Sandstone, fine-grained, dark gray clay ironstone clasts to .05' diameter in top .5'; .5' diameter, nodules pyrite, light gray to tan with slight asphalt stain.
135.4	139.5	46	Sandstone, tan with slight asphalt stain; paper-thin dark gray, micaceous shale laminae comprise approximately 20% of unit, evenly spaced throughout.
139.5	140.0	47	Shale, medium gray, micaceous.
140.0	141.0	48	Sandstone, light gray, fine grained.
141.0	155.0	49	Sandstone, grayish-black to 144', cross-bedded and medium dark gray to bottom of unit, asphaltic staining and gilsonite particles, thin crinkly coal laminae (paper-thin) inclined to horizontal, form about 10 to 20% of unit from 145.3' to 145.6', 149.5' to 149.7', 152.2' to 152.3', 152.7' to 153.7'; few flattened granule-sized clasts of tan woody material dispersed throughout unit below 150'; samples removed at selected intervals below 151'.
155.0	155.7	50	Coal, bright, pyritized plant material.
155.7	156.0	51	Shale, dark gray, hard.
156.0	160.5	52	Shale, dark gray to grayish-black, soft, less than 2% of unit is light gray sandstone, laminae and pods, root impressions in top half.
160.5	161.0	53	Lost core.
161.0	161.7	54	Shale, grayish-black, fractured slickensided.
161.7	161.9	55	Shale, grayish-black, white angular chert clasts to .03' across.
161.9	163.7	56	Breccia, white to bluish-gray, white angular chert clasts to .1' across; greenish-gray clay matrix (5G 6/1 dry) slickensided comprises about 50% of unit; sandy (some clear round quartz grains); localized asphalt staining, pyrite.
163.7	166.2	57	Lost core.
166.2	171.0	58	Same as from 161.9' to 163.7' but predominately fractured chert in bottom 2', pyrite nodules to .05' diameter at 168.3', asphalt stain at bottom.

MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY
DEPARTMENT OF NATURAL RESOURCES
DOE-TS-No. 40

Location: 18' FNL & 711' FEL, Sec. 28, T. 31 N., R. 33 W., Barton County
Elevation: 938' Total Depth: 190.8'



DOE-TS - No. 40
Core described by Richard J. Gentile
Location: 18' FNL & 711' FEL, Sec. 28, T. 31N., R. 33W., Barton County

Elevation: 938' Total Depth: 190.8'

DEPTH		UNIT	DESCRIPTION
0.0	5.0	1	Clay, brown, silty.
5.0	10.0	2	Clay, brown, and silty gray clay.
10.0	12.0	3	Shale, brown, soft.
12.0	15.0	4	Shale, brown, zones of gray, firm.
15.0	17.5	5	Shale, brown and gray, sandy; .01' "dead" oil zone at 15.5'.
17.5	20.0	6	Sandstone, gray, zones of brown, fine-grained, soft.
20.0	21.0	7	Sandstone, light gray, zones of brown, soft. Rock chip samples with finger bit to 21'.
21.0	23.0	8	Shale, light gray, non-calcareous, silty to sandy, weathered dark yellowish-orange (10YR 6/6) along bedding planes.
23.0	26.0	9	Shale and sandstone interlaminated, weathered grayish-orange (10YR 7/4), micaceous.
26.0	28.6	10	Sandstone, light gray, fine-grained, ripple laminated; interlaminated with medium gray shale in equal amounts; fine sand-sized siderite concretions near middle.
28.6	28.65	11	Clay ironstone zone, reddish-brown.
28.65	38.2	12	Shale, medium gray at top to dark gray at bottom (dry); approximately 1% light gray lenticular sandstone laminae dispersed throughout unit; .05' thick tan clay-ironstone beds and concretions at 35.6', 36.5', 37.2', 37.5'.
38.2	38.6	13	Limestone, dark gray (wet), thin bedded, hard, fossils of small productids, biconvex brachiopods Composita?, high spired gastropods; predominately thin shells of calcite, many shells pyritized.
38.6	39.7	14	Underclay, medium light gray, carbonized, stems, fern fronds and roots?.

39.7	41.0	15	Sandstone, light gray, fine-grained, quartzose, upper .5' with carbonized roots.
41.0	42.8	16	Sandstone, light gray with brownish tinge, cross-bedded; small black specks of gilsonite and/or coal.
42.8	44.8	17	Sandstone, light gray with tan tinge approximately 10% of unit is high angle (45^{o}) black smutty coaly laminae, micaceous, pyritiferous.
44.8	50.4	18	Sandstone, light brownish-gray, cross-bedded, specks of gilsonite and/or coal; few distorted paper-thin coaly laminae below 49'.
50.4	52.7	19	Shale, medium gray; sharp contact with overlying unit; grades into sandstone at bottom.
52.7	53.95	20	Sandstone, light gray, micaceous, interlaminated with medium gray shale from 53.5' to 53.7' with bioturbite appearance; elongated to lense shaped coal clasts near bottom; irregular scour surface contact with underlying coal.
53.95	54.7	21	Coal, banded bright and dull, pyritized plant material and nodules form approximately 2% of unit.
54.7	57.0	22	Underclay, medium dark gray, soft, carbonized roots; clusters of sand-sized siderite concretions near bottom.
57.0	57.8	23	Shale, medium dark gray to dark gray at bottom.
57.8	61.4	24	Shale, dark gray (dry), tan clay ironstone zones about .05' thick at 58.1', 58.4', 58.8', 59', 59.4'; pyritized bits of plants.
61.4	62.7	25	Coal, bright, dull bands of fusain; pyritized plant fragments; cleats filled with calcite.
62.7	64.2	26	Underclay, medium gray, carbonized roots.
64.2	64.4	27	Shale with clusters of sand-sized siderite concretions, some pyritized.
64.4	69.0	28	Shale, medium gray at top grading downsection into dark grayish-black (dry) at bottom; non-calcareous, approximately 5% of unit is evenly spaced light gray lenticular

			sandstone laminae from 68' to 68.5'; .01' thick tan clay ironstone beds at 67.5' and 68'.
69.0	70.5	29	Coal, .05' thick hard dark gray clay parting at 70.2'; bright; paper-thin lenses of pyritized plant material throughout unit; cleats filled with calcite.
70.5	73.0	30	Underclay, medium gray, carbonized roots; clusters of sand-sized siderite concretions form vertical patches .05' wide and .2' long in bottom half of unit.
73.0	74.3	31	Shale, medium gray, light gray paper-thin distorted silty sandstone laminae form approximately 30% of unit; bioturbite appearance; microfaulted slump? structure.
74.3	81.9	32	Shale, dark gray (wet) approximately 30% of unit is light gray fine-grained lenticular sandstone laminae (starved ripples); horizontal, evenly spaced; many ripples have "salt and pepper" appearance resulting from bits of coaly material; top 1' with clusters of sand-sized siderite concretions; non-calcareous.
81.9	82.05	33	Coal, bright, cleats filled with white calcite.
82.05	84.8	34	Underclay, medium gray carbonized and pyritized roots; very sandy at bottom.
84.8	86.3	35	Sandstone, light gray, approximately 20% of unit is medium gray shale laminae; sandstone structures range from horizontal laminae to lenticular cross-laminae and pods, slump and scour fill.
86.3	89.3	36	Sandstone, light gray, fine-grained, mica, bits of coaly material in sandstone form sporadic thin zones.
89.3	90.9	37	Sandstone, light gray, distorted flame (slumpage?) structures apparent in dark gray shale intervals which comprise approximately 20% of unit.
90.9	96.2	38	Sandstone, light gray, fine-grained, mica and coaly material along bedding planes; distorted flame structure sporadically located in shaly intervals, form less than 5% of unit.
96.2	100.1	39	Sandstone, light gray; fine-grained, silty, structures accentuated in shale intervals which form about 5% of unit and include cross-laminated ripples, flame structures, slumpage and compressional structures.

100.1	101.0	40	Shale, approximately 5% of unit is pods of light gray sandstone.
101.0	104.6	41	Shale, medium gray and sandstone, light gray, fine-grained intercalated; lenticular cross-ripples, load cast-like pods of sandstone in shale; flame structures; conglomeratic with tan clasts of woody material and fragmented shale bed from 103.8' to 103.85'; sand matrix grain size 1/16 to 1/8 mm diameter.
104.6	105.3	42	Sandstone, light gray, fine-grained micaceous.
105.3	105.4	43	Conglomerate, clasts of tan woody material, coal, pyritized wood, tan shale to .1' long and .05' thick; matrix of fine-grained quartzose sandstone.
105.4	105.8	44	Sandstone, light gray and shale medium gray, interlaminated, mica, bits coaly material, horizontal to cross-laminated.
105.8	108.9	45	Sandstone, light gray fine-grained, cross-bedded to massive.
108.9	109.0	46	Conglomerate, blades and crinkly lenses of coal, fusain; light gray fine-grained (1/16 to 1/8 mm diameter grains) quartzose sandstone matrix; micaceous.
109.0	116.6	47	Lost core.
116.6	116.7	48	Sandstone, light gray, fine-grained, few bits coal (possibly out of place).
116.7	118.0	49	Underclay, medium gray, slickensided, carbonized roots.
118.0	120.25	50	Shale, medium gray at top with sand-sized siderite concretions becoming mottled dark gray to uniformly dark gray at bottom.
120.25	120.95	51	Coal, bright, pyritized plant material; cleats filled with calcite.
120.95	123.8	52	Underclay, medium gray, carbonized roots, slickensided; bottom half with clusters of sand-sized siderite concretions.
123.8	126.5	53	Shale, medium gray at top to grayish-black (dry) at bottom, approximately 5% of unit below 125' is evenly spaced light

			gray lenticular, horizontal sandstone laminae; clusters of tan sand-sized siderite concretions in bottom 1'.
126.5	127.9	54	Shale, black, approximately 5% of unit is evenly spaced light gray lenticular sandstone laminae.
127.9	130.4	55	Sandstone, light gray fine-grained, small scale cross-bedding to cross-laminated ripples; intercalated with grayish-black shale; wavy; sandstone decreases down-section.
130.4	135.8	56	Shale, dark gray to grayish-black, clay ironstone bed 135.4' to 135.5'.
135.8	136.3	57	Coal, bright with bands of dull fusain, pyrite; cleats filled with calcite.
136.3	140.5	58	Underclay, medium gray, bottom few inches dark gray, carbonized roots throughout unit; sand-sized siderite concretions below 137.5' forming clusters or concretions in bottom 2'.
140.5	151.6	59	Shale, dark gray (N3, dry) to black (N1, wet); approximately 2% of unit is light gray paper-thin lenticular sandstone laminae and pods from 141' to 146.5' and below 151.2'; tan clay ironstone zones 142.6' to 142.7', 144.1' to 144.2', 147.2' to 147.25', 148.7' to 148.9'; small nodules pyrite 141.5' to 145.8'.
151.6	153.8	60	Shale, dark gray (dry) to black (wet) very fossiliferous with recrystallized fragments predominately arched thin shells (productids); abundantly fossiliferous areas occur as pods or tubular structures possibly filled in burrows, mostly shale from 152.7' to 153'.
153.8	154.0	61	Shale, black, hard, non-calcareous.
154.0	154.6	62	Coal, bright, cleats filled with calcite.
154.6	157.2	63	Underclay, dark gray, very sandy, carbonized roots; sand-sized siderite concretions in bottom few inches.
157.2	161.7	64	Shale, medium gray, approximately 10% of unit light gray ripple sandstone laminae evenly spaced, inclined.
161.7	166.8	65	Sandstone, light gray approximately 20% of unit is dark gray inclined shale laminae, selected thick sandstone beds

			stained brown with asphalt comprises 40% of unit; contorted wavy structure, some possibly caused by compaction of clay.
166.8	169.9	66	Sandstone, saturated with brownish-black asphalt; few dark gray, micaceous shale laminae and wavy paper-thin laminae of coal material in bottom half; conglomeratic with flattened tan woody clasts and dark gray shale from 167' to 167.4'; sandstone grain-size 1/16 to 1/8 mm.
169.9	173.2	67	Shale, medium gray at top to black (wet) at bottom; sharp contact with overlying unit; pyritized clay ironstone nodules .05' diameter at base overlying coal.
173.2	174.6	68	Coal, bright, pyritized compressed leaves, twigs, etc., form paper-thin lenses; cleats filled with calcite.
174.6	175.8	69	Underclay, medium gray, few carbonized roots; soft.
175.8	187.1	70	Shale, black slickensided, tan clay ironstone bed 178.6' to 178.8'; 1 or 2% of unit is paper-thin light gray sandstone lenses from 176.5' to 179.8'
187.1	188.0	71	Breccia, chert clasts angular to subangular to .2' in largest dimension; black shale matrix; color of chert ranges from light gray, green to pink, porous in places and saturated with brownish-black asphalt.
188.0	189.6	72	Breccia, predominately light gray to greenish-gray clay with approximately 20% chert clasts to .2' diameter concentrated near bottom; few elongated black shale clasts in upper .5'.
189.6	190.1	73	Chert, light gray to bluish-gray, approximately 50% of unit is vuggy, porous and saturated with brownish-black asphalt.
190.1	190.8	74	Clay, greenish-gray (5GY 6/1) slickensided; clast of tan fine-grained limestone at top .1' in largest dimension, pyrite.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1979—671-115/62

UNITED STATES DEPARTMENT OF ENERGY
BARTLESVILLE ENERGY TECHNOLOGY CENTER
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