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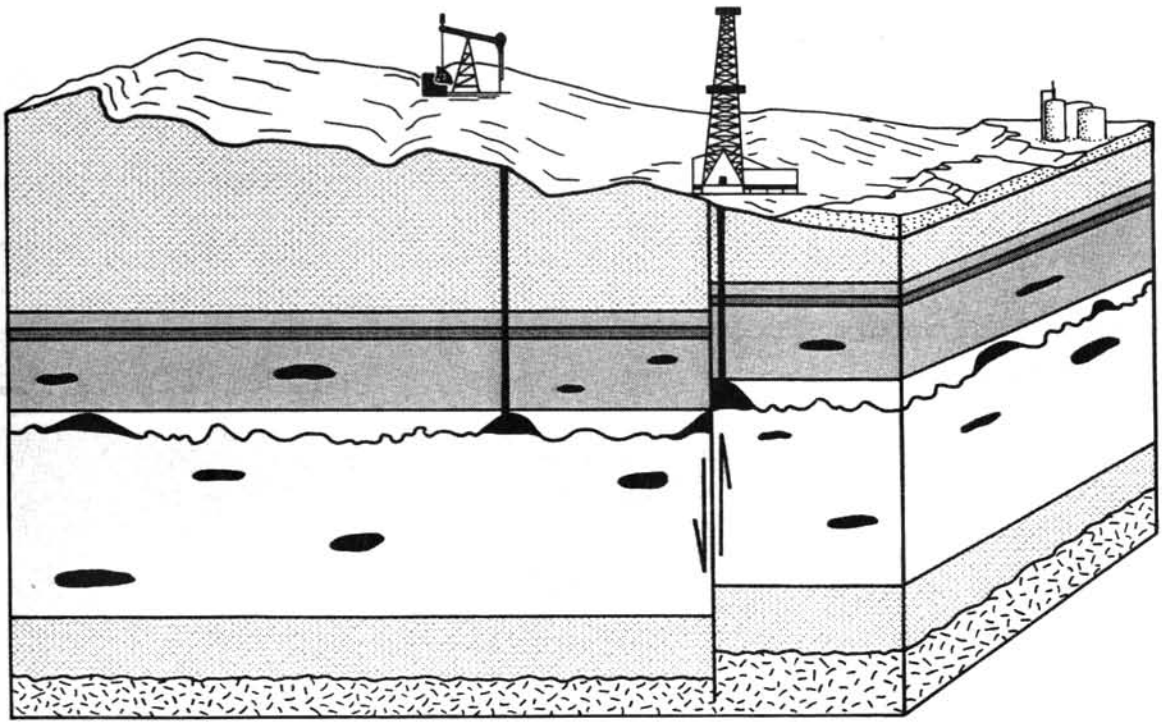
KENTUCKY GEOLOGICAL SURVEY
Donald C. Haney, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

UNCONFORMITY AT THE TOP OF THE KNOX GROUP (CAMBRIAN AND ORDOVICIAN) IN THE SUBSURFACE OF SOUTH–CENTRAL KENTUCKY

Patrick J. Gooding



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FOREWORD

This thesis was accepted by the Department of Geology and the Graduate School at Eastern Kentucky University in partial fulfillment of requirements for the degree of Master of Science, which was awarded in 1983. The Kentucky Geological Survey is grateful to the author for permission to publish this report. This report is identical to the thesis turned in to Eastern Kentucky University, except that production figures have been updated to 1989, the latest year for which figures are available.

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UNCONFORMITY AT THE TOP OF THE KNOX GROUP (CAMBRIAN AND ORDOVICIAN) IN THE SUBSURFACE OF SOUTH-CENTRAL KENTUCKY

Patrick J. Gooding

ABSTRACT

An unconformity of regional extent is present at the top of the Knox Group of Cambrian and Ordovician age. In south-central Kentucky, extensive paleokarst topography, caused by subaerial weathering and erosion during Early Ordovician time, is developed on the upper Mascot Dolomite of the Knox Group.

Data generated from the examination of cores, well samples, geophysical logs, and drillers' logs were used to compile a paleotopographic map showing the general configuration of the eroded surface at the top of the Knox Group. This surface is characterized by closed depressions, residual hills, and interrupted, elongate, steep-sided valleys; no well-developed drainage pattern is apparent. Paleotopographic relief in the area studied is about 400 feet. The variable thickness (10 to 95 feet) of the overlying Wells Creek Dolomite (Middle Ordovician) further supports the interpretation of karst development on top of the Knox Group.

In addition to the highly irregular karst surface, the following other criteria were used in identifying the unconformity in the subsurface: a break in the stratigraphic record, with an abrupt change in lithology between the overlying Wells Creek Dolomite and the Knox Group; the occurrence of a brecciated zone containing reworked Knox material at the base of the Wells Creek; and the presence of oil residues, weathered chert, and porous zones.

Shallow drilling depths, generally less than 2,000 feet, combined with possibilities for high production, have made the Knox in this area a prime exploration target. Hydrocarbon entrapment at the Knox unconformity is related to enhancement of porosity and permeability at the weathered paleokarst surface and structural highs caused by residual hills on the eroded surface. Occurrences of oil and gas production are also associated with the presence of faults.

INTRODUCTION

In recent years, south-central Kentucky has been undergoing a very active period of oil and gas exploration. The primary exploration target in this area is the Knox Group of Cambrian-Ordovician age. The purpose of this study is twofold: first, to provide stratigraphic and structural information on the Paleozoic rocks ranging in age from Early Cambrian to Late Devonian and, second, to provide a map of the erosional surface at the top of the Knox Group. The results of this investigation should aid in the exploration for and development of hydrocarbon production in the area.

The study area (Fig. 1), which includes all or parts of 10 counties in south-central Kentucky, is bounded by longitude 84°55' and 85°37'30" west, and latitude 37°15' north and the Kentucky-Tennessee border (approximately 36°36'30" north latitude).

Datum points for the top of the Knox Group, the Wells Creek Dolomite, and the Pencil Cave bentonite were compiled from information derived from the examination of surface and subsurface data. Surface data were evaluated from 36 geologic quadrangle maps and the examination of 20 selected outcrops. Subsurface data were gathered from cores, well samples, geophysical logs, and drillers' logs on file at the Kentucky Geological Survey. In addition, well records and cores were made available by several oil and gas and mining companies.

Fifty-two cores were examined megascopically with the aid of a hand lens. Over 400 sets of well samples were examined with a binocular microscope, and descriptions of an interval extending from 250 feet above to

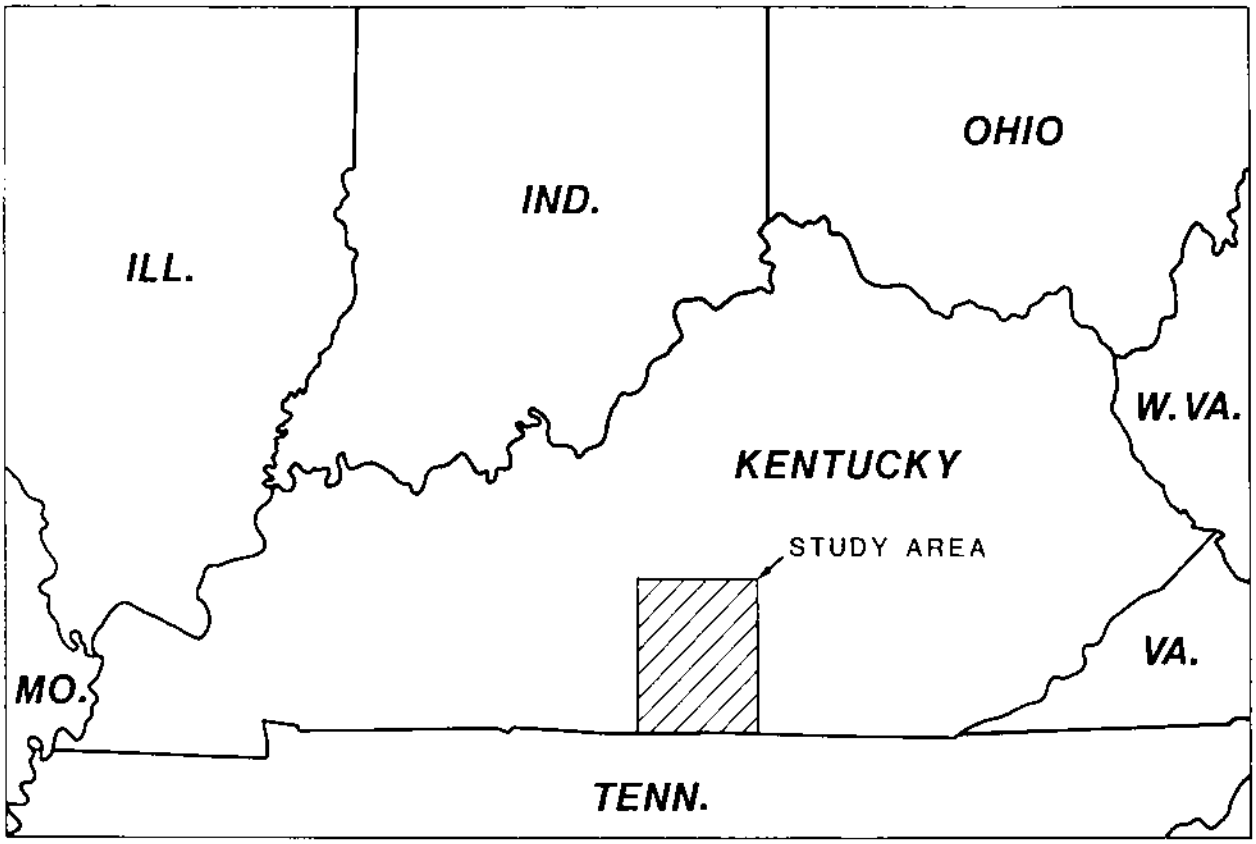

Figure 1. Location of study area in south-central Kentucky.

150 feet below the Knox unconformity were prepared for nine wells in the study area (Appendix A). Both cores and samples were tested with dilute hydrochloric acid. Rock characteristics were noted, and the color was determined using the Geological Society of America Rock Color Chart (1965). Over 1,000 geophysical logs (gamma ray, neutron, and bulk density) were examined. In areas where no other information was available, drillers' logs were used, but with reservation about their accuracy.

Stratigraphic units that occur in the area, both at the surface and in the subsurface, are shown on Plate 1, a generalized columnar section for south-central Kentucky. The paleotopography of the unconformable surface at the top of the Knox Group is shown on Plate 2. Plate 3 is an isopach map showing the thickness of the Middle Ordovician Wells Creek Dolomite that overlies the Knox Group. Structure on top of the Middle Ordovician Pencil Cave bentonite, an important marker bed, is shown on Plate 4. The Surface II computer software package developed by the Kansas Geological Survey (Sampson, 1975) was used to generate the preliminary structure and isopach maps. Surface II was also used to generate a transect plot of the eroded Knox surface in the study area. Four structural cross sections showing the interval between the Pencil Cave bentonite and the top of the Knox Group were also made. In addition, a map showing the locations of oil and gas pools in south-central Kentucky was prepared. More than 1,725 control points were incorporated in this study.

STRUCTURE

Regional Setting

The study area lies within the Mississippian Plateau physiographic province (Fig. 2). The axis of the Cincinnati Arch, a major structural feature that separates the Appalachian Basin to the east from the Illinois Basin to the west, passes in a north-south direction through the study area (Fig. 3). Structural features associated with the Cincinnati Arch are the Jessamine Dome in central Kentucky, the Nashville Dome of central Tennessee, and the Cumberland Saddle, a structurally low feature that lies within the study area and separates the two domes.

The Cincinnati Arch extends from southern Ohio to south-central Tennessee. In southern Ohio the Cincin-

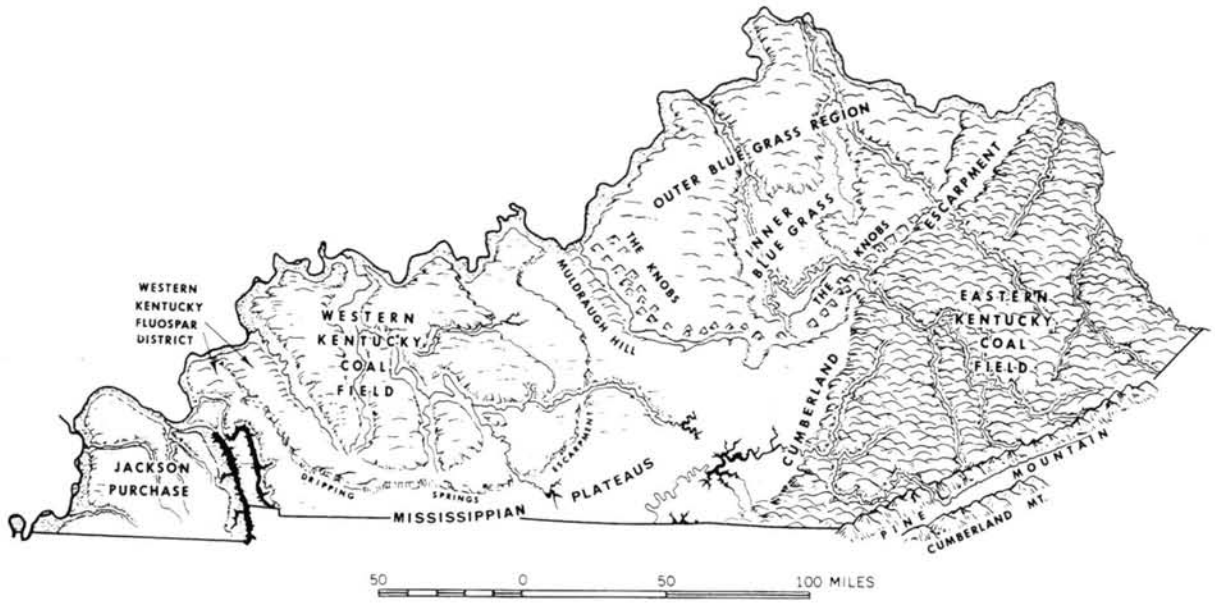

Figure 2. Physiographic diagram of Kentucky.

nati Arch splits into two limbs, the Findlay Arch and the Kankakee Arch (Fig. 3). Regionally, the axis of the Cincinnati Arch generally trends in a northerly or northeasterly direction. In south-central Kentucky, the arch passes through four counties: Cumberland, Clinton, Casey, and Russell. Strata dip approximately 20 to 30 feet per mile eastward into the Appalachian Basin and westward into the Illinois Basin from the crest of the arch (McFarlan, 1943).

The Jessamine Dome (Fig. 3), centered in Jessamine County, Kentucky, is an irregular domal structure developed on the axis of the Cincinnati Arch. Strata associated with the Jessamine Dome dip gently away from the crest of the dome in all directions, although the dip is seemingly more pronounced toward the west and northwest (Cressman, 1973). The Nashville Dome (Fig. 3), located in central Tennessee, marks the southern extent of the Cincinnati Arch. Rocks associated with this broad domal structure dip more steeply toward the northeast. The Cumberland Saddle, a structurally low portion of the Cincinnati Arch in Cumberland County, lies between the Jessamine Dome and the Nashville Dome (Fig. 3).

The Appalachian Basin (Fig. 3), which extends southward from New York to Alabama, is bounded on the west in Kentucky by the Cincinnati Arch. The Illinois Basin (Fig. 3), which extends from Illinois and Indiana into Kentucky, lies west of the Cincinnati Arch and east of the Mississippi River.

The Mississippian Plateau (Fig. 2) consists of hilly and rolling topography, and is underlain primarily by Mississippian-age rocks. The total topographic relief in the study area is about 1,260 feet. The highest elevation is in Casey County (1,760 feet), and the lowest elevation is in Green County (500 feet), both above mean sea level.

Faults

Within the study area, six surface faults are exposed in the Paleozoic rocks (Plate 2). The Goose Creek Fault System is the most complex of the faulted areas. This fault system trends in a north-south direction through Casey and northern Russell Counties and has a displacement of 125 feet. Oil is being produced from several pay zones in the Thomas Ridge, Thomas Ridge West, Webb, and Phil West oil pools. Production from all of these pools is associated with the Goose Creek Fault System. The Lester Creek and Irish Bottom oil pools are both associated with the northward-trending Lester Creek Fault. This fault is located in the southwestern corner of Russell County and the northeastern corner of Cumberland County. The downthrown side is to the east. A third north-south-trending fault, the Sulphur Creek Fault, which is downthrown to the east, is mapped at the surface in the southwestern portion of the study area in central Monroe County and north of the Tennessee border. Another fault, the Big Renox Creek Fault, is found in northwestern Cumberland County and trends in an east-west direction. The downthrown side is to the south. The Edwards Mountain Fault is located in south-central Wayne County. This fault trends northeast-southwest, and the downthrown side is to the north. The Jamestown Fault, located in Russell County, trends

Figure 3. Major regional tectonic features in Kentucky and adjacent areas.

in a northeast-southwest direction and is downthrown to the west. As a result of this study, a major subsurface fault, the Pickett Fault, which trends in a northwest-southeast direction, was documented in southeastern Green County and central Adair County. The downthrown side is to the north, and displacement is about 200 feet. This subsurface fault is associated with four oil pools: Pickett, Maple Grove, Gradyville North, and Bliss.

STRATIGRAPHY

Seven rock systems above the Precambrian basement are represented in south-central Kentucky: Cambrian through Pennsylvanian in the Paleozoic Era and the Quaternary System of the Cenozoic Era. Plate 1 lists all the sedimentary rock units present at the surface and in the subsurface. Rocks exposed at the surface within the study area range in age from Ordovician to Quaternary. Cambrian and Ordovician strata constitute an estimated total thickness of about 7,600 feet, or approximately 70 percent of the total thickness of the sedimentary section. The following is a description, in ascending stratigraphic order, of Precambrian through Devonian sedimentary rocks in south-central Kentucky.

Precambrian Rocks

Within the study area, no wells have penetrated the basement. Two wells, one east of the study area in Casey County, and the other west of the study area in Metcalfe County, have been drilled to the Precambrian. Granitic rocks encountered in both of these wells at

depths of approximately 7,000 feet were black to red, and contained quartz, feldspar, biotite, hematite, and ilmenite.

Cambrian System

The total thickness of the Cambrian System within the study area is approximately 4,155 feet. It includes the Lower to Middle Cambrian Basal sand, the Rome Formation, and the Conasauga Formation, plus the Upper Cambrian Copper Ridge Dolomite. The Copper Ridge Dolomite is the oldest formation of the Knox Group.

Basal Sand

The Basal sand is about 700 feet thick; it unconformably overlies the eroded Precambrian basement and fills in low areas on the unconformable surface. McGuire and Howell (1963) observed that the Basal sand contains a zone of arkosic or "granite wash-type" sand at the base, indicating an unconformable relationship with the underlying Precambrian. The Basal sand is composed principally of sandstone and shale in varying amounts; it also contains scattered argillaceous and dolomitic zones. The sandstone is white to gray, fine to coarse grained, angular to rounded, calcareous to noncalcareous, and in some places, silty. The shale is gray to greenish gray and red. Zones of sandy shale are present throughout the unit.

Rome Formation

The Rome Formation is a clastic sequence, about 1,025 feet thick, of varying amounts of interbedded shale, siltstone, sandstone, limestone, and dolostone. The upper part of the formation is commonly argillaceous, and the lower part is a sandstone. The shale is gray to greenish gray, green, and red. Red shale is generally abundant, especially in the upper part, and is easily recognized. The shale is interbedded with limestone and is commonly silty and calcareous. The siltstone is gray to brownish gray, glauconitic, and micaceous. The sandstone of the Rome Formation is gray to brown to green, fine to coarse grained, angular to rounded, and commonly micaceous. The limestone is white to gray to brown, very fine to medium grained, and partly dolomitic; it contains scattered zones of oolites and fossils.

Conasauga Formation

The Conasauga Formation is primarily shale interbedded with limestone, but contains thin dolostone and siltstone beds. The shale is tan to greenish gray, soft, and may be clayey, silty, and glauconitic. It may also contain traces of pyrite. The limestone is tan to gray to brown, very fine grained, oolitic, and highly fossiliferous. The thin zones of dolostone are tan to gray, finely crystalline, and oolitic. The less common siltstone is glauconitic and calcareous. The Conasauga Formation overlies the Rome Formation and is about 180 feet thick.

Cambrian-Ordovician Rocks (Knox Group)

The Knox Group consists of five formations. They are, in ascending order, the Copper Ridge Dolomite of Late Cambrian age and the Early Ordovician Chepultepec Dolomite, Longview Dolomite, Kingsport Dolomite, and Mascot Dolomite, which are equivalent to the Beekmantown Dolomite. Within the study area, the Cambrian-Ordovician carbonate sequence has a total thickness of about 3,500 feet. The top of the Cambrian System is placed at the top of the Copper Ridge Dolomite that is conformably overlain by the Lower Ordovician section, which averages 1,250 feet in thickness.

The predominantly carbonate Knox sediments were deposited on a broad continental shelf in relatively shallow hypersaline water (Harris, 1973). Throughout most of North America, the Ordovician System contains a major unconformity between the Knox Group and overlying rock units (Plate 1). This regional unconformity developed when the seas retreated at the end of Early Ordovician time, resulting in subaerial exposure and erosion. In south-central Kentucky, the top of the Knox is generally encountered at depths ranging from 550 to 950 feet below mean sea level (Plate 2). However, in a small portion of the northwestern part of the study area in Green and Adair Counties, the top of the Knox is encountered at depths from 950 to 1,200 feet below mean sea level on the downthrown side of the Pickett Fault. Various lithologies are present in the Knox Group; however, it is composed predominantly of dolostone and limestone, with minor amounts of chert, shale, siltstone, and sandstone.

Copper Ridge Dolomite

The Copper Ridge Dolomite of Late Cambrian age is the oldest formation in the Knox Group. It overlies the Conasauga Formation and, within the study area, attains a thickness of about 2,250 feet. The most distinctive rock type in the Copper Ridge is a tan to gray to brown, fine- to coarse-crystalline dolostone. In the upper portion of the formation, a light- to medium-gray, fine-crystalline dolostone predominates, with rare thin zones of light-gray, medium-crystalline dolostone. A variety of chert occurs in the formation, ranging from white to gray to black. Oolitic chert is most abundant. The unit contains scattered shaly and silty zones. Interbedded quartz sandstone is generally present in varying

amounts and is fine to medium grained. In general, the lower part of the formation increases in shale content. This argillaceous dolostone contrasts sharply with the underlying interbedded limestone and shale of the Conasauga Formation.

Chepultepec Dolomite

The Lower Ordovician Chepultepec Dolomite lies conformably on the Copper Ridge Dolomite. The Chepultepec is composed of dolostone, sandstone, limestone, and chert. The most distinctive rock type is light-gray, fine- to medium-grained limestone. Abundant white to dark-gray, oolitic chert occurs throughout this unit. The quartz sandstone sequence at the base of the Chepultepec marks the contact with the Copper Ridge Dolomite.

Longview Dolomite

The Longview Dolomite overlies the Chepultepec Dolomite. The Longview consists of tan to gray, fine- to medium-crystalline dolostone and medium-gray, sandy dolostone in almost equal amounts. Limestone is present in minor amounts and generally occurs in the upper portion of the formation. The lower boundary between this formation and the underlying Chepultepec is drawn at the base of a zone where there is a marked decrease in chert content and a change in lithology from medium- to dark-gray, medium-grained limestone to light-gray, very fine- to fine-crystalline dolostone.

Kingsport Dolomite

The Kingsport Dolomite overlies the Longview Dolomite and is chiefly composed of limestone and interbedded dolostone, with minor shaly and silty zones. Tan to medium-gray, fine-grained limestone comprises most of the formation. The dolostone is light gray and medium to coarse crystalline. Chert occurs throughout the formation.

Mascot Dolomite

An unconformity marks the top of the Mascot Dolomite, the uppermost formation of the Knox Group. This formation is composed principally of dolostone, with some interbedded limestone. Chert and a few sandy zones are also present. The dolostone is tan to gray to brown and very fine to medium crystalline. Interbedded with the dolostone is a tan to gray, very fine- to medium-grained limestone. A few very thin beds of gray to greenish-gray shale and silty shale are present.

Ordovician System

The Ordovician System includes, from oldest to youngest, the Early Ordovician Knox Group (described previously); the Middle Ordovician Wells Creek Dolomite, High Bridge Group, and Lexington Limestone; the Middle and Late Ordovician Clays Ferry Formation; and the Late Ordovician Garrard Siltstone, Leipers Formation, and Cumberland Formation. The total thickness of Ordovician-age rocks is about 3,450 feet.

Wells Creek Dolomite

In south-central Kentucky the Middle Ordovician Wells Creek Dolomite unconformably overlies the Mascot Dolomite, the uppermost formation in the Knox Group, and ranges from 10 to 95 feet in thickness (Plate 3). It is composed principally of alternating strata of limestone and dolostone. Thin shale and siltstone zones are common throughout the formation. The limestone is generally medium to dark gray and very fine to medium grained; it contains scattered shaly and silty zones. The dolostone is light to medium dark gray, fine to medium crystalline, and, in places, argillaceous and silty, with thin zones of dolomitic limestone. The shale is gray to greenish gray and silty in some places; it occurs as interbeds in both dolostone and limestone. The siltstone is tan to olive gray.

The lower contact between the Wells Creek Dolomite and the Mascot Dolomite of the Knox Group is placed at the base of a rubble breccia zone, usually less than 2 feet thick (Fig. 4). This zone generally consists of fine-crystalline dolostone and limestone containing reworked Knox fragments. In some areas, this zone consists of shale. Directly below the contact, the Mascot generally consists of very fine- to medium-crystalline dolostone. Figure 5 shows a characteristic pick of the top of the Knox on a representative geophysical log.

High Bridge Group

The High Bridge Group consists predominantly of carbonates, and averages about 1,025 feet in thickness. Within the study area the High Bridge consists of two formations, the Camp Nelson Limestone and the overlying Tyrone Limestone. Both formations are composed principally of limestone and contain beds of dolostone of variable thickness. Shale is present in small amounts.

The limestone is light olive to brown to dark gray and very fine to coarse grained. It contains scattered fossils and is commonly interbedded with calcareous shale or argillaceous limestone. There are also zones of light-olive to gray, very fine- to fine-crystalline dolostone and dolomitic limestone.

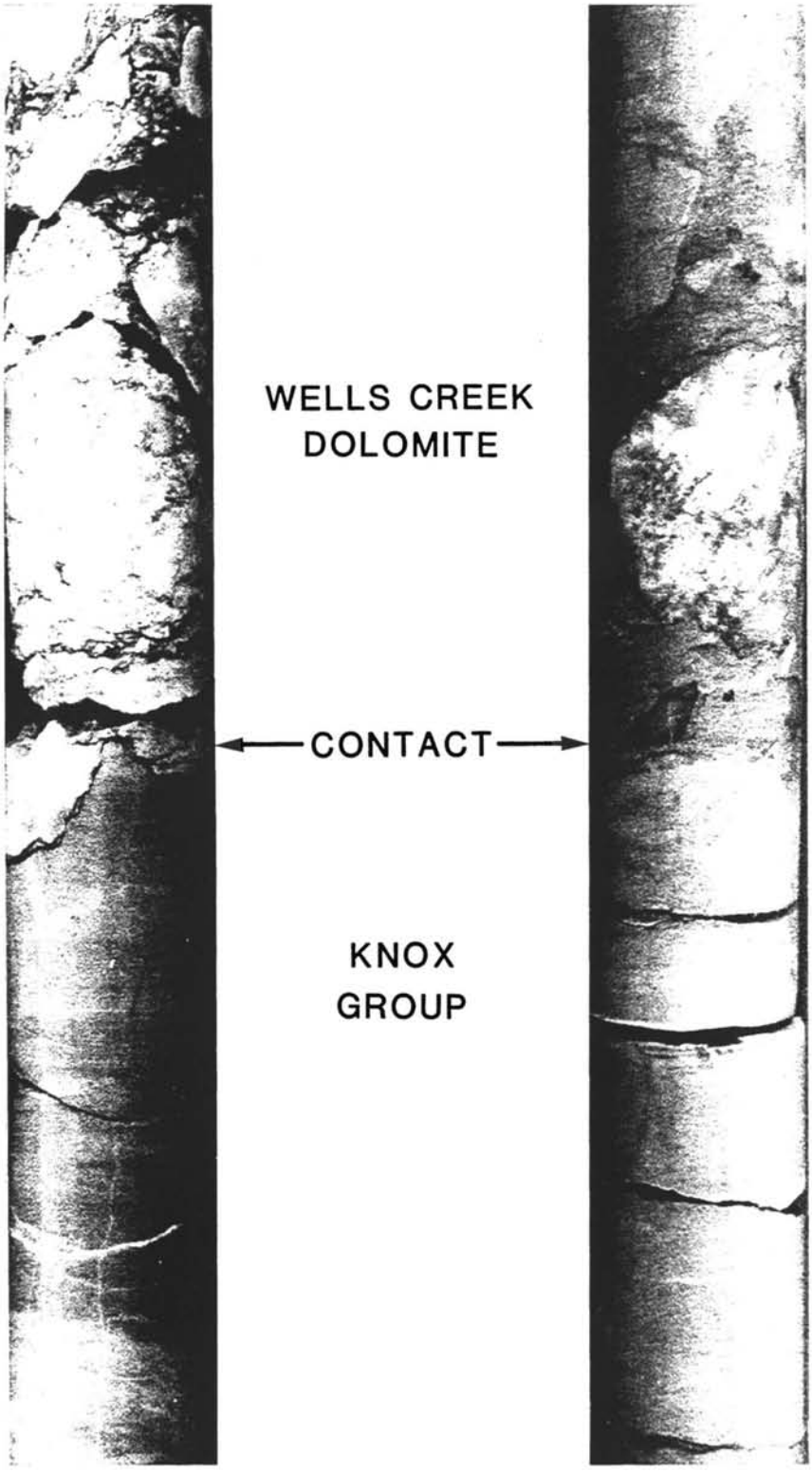

Figure 4. Typical contact between the top of the Knox Group and base of the overlying Wells Creek Dolomite in drill core.

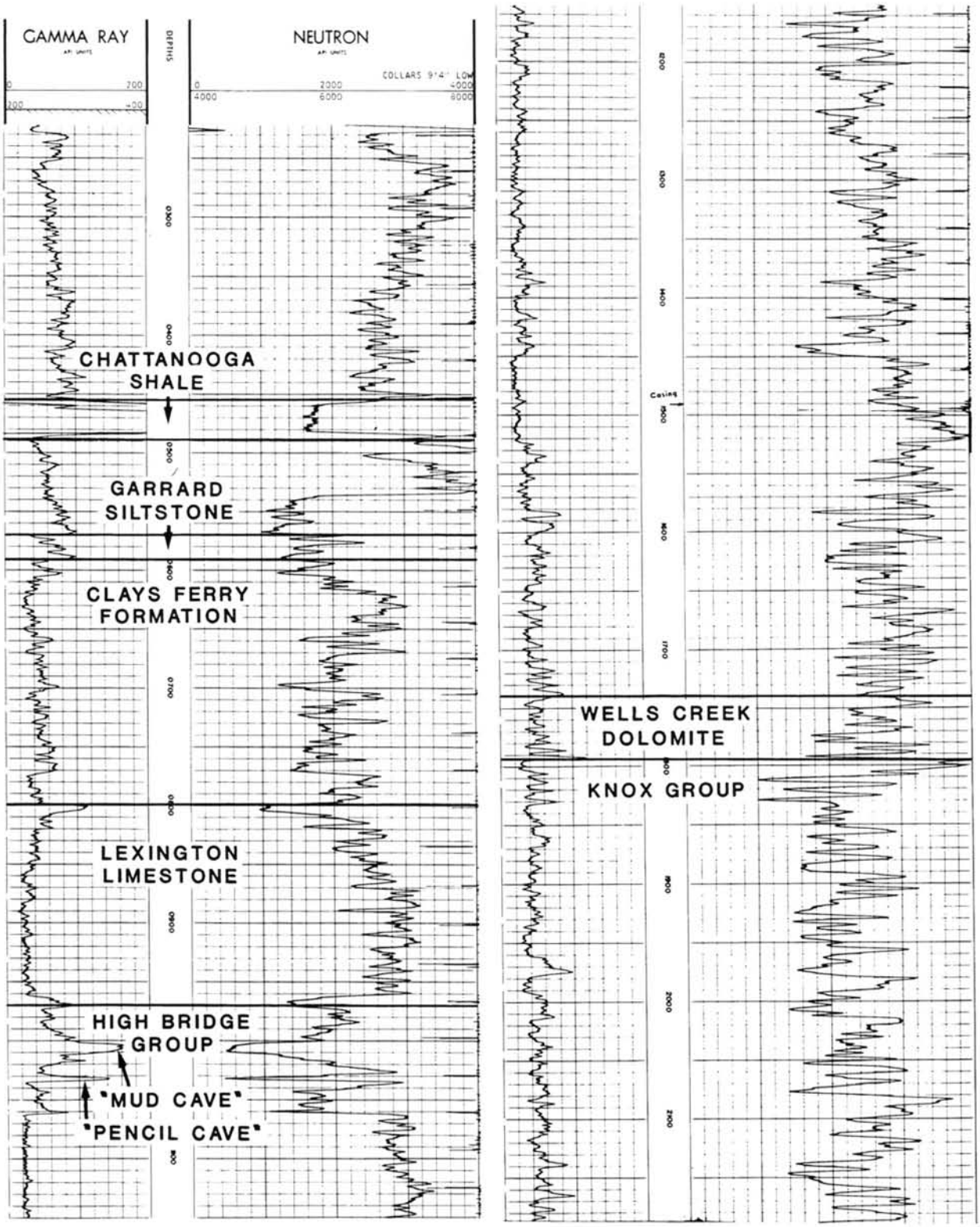

Figure 5. Representative gamma ray-neutron log of a continuous section from above the Chattanooga Shale to below the top of the Knox Group.

The High Bridge Group is conformable with the underlying Wells Creek Dolomite. The contact is picked where the lithology changes from a zone of medium- to dark-gray, interbedded shale and limestone at the base of the High Bridge Group to a tan to medium-gray, fine- to medium-grained dolomitic limestone with minor, very thin shale beds in the Wells Creek Dolomite (Fig. 6). The upper contact with the overlying Lexington Limestone occurs slightly above the uppermost bentonite bed (Mud Cave) (Fig. 5).

Pencil Cave Bentonite

Periodic volcanic ash falls during Middle Ordovician time resulted in the formation of thin bentonite beds in the upper portion of the Tyrone Limestone. In the study area, below the contact with the Lexington Limestone, the two most prominent bentonite beds are the Pencil Cave (about 15 to 25 feet below the contact) and the Mud Cave (about 10 to 15 feet below the contact).

The Pencil Cave bentonite (Fig. 7), which attains a maximum thickness of about 3 feet, was selected as a stratigraphic marker because it is persistent throughout the study area. It is easily recognizable, both by its swelling properties and by a characteristic "kick" on geophysical logs (Fig. 5). A structure map (Plate 4) contoured on the upper surface of the Pencil Cave indicates that it occurs at subsurface elevations ranging from 15 feet above sea level to 50 feet below sea level, and is relatively flat lying.

Lexington Limestone

The Lexington Limestone immediately overlies the High Bridge Group and ranges from 190 to 225 feet in thickness. It is composed principally of limestone with minor amounts of shale and dolostone. It is light to dark gray, very fine to coarse grained, generally fossiliferous, and may contain slightly silty and dolomitic zones. Gray to greenish-gray shale, which is calcareous and silty in places, is commonly interbedded with the limestone. The Lexington Limestone is conformably overlain by the Middle and Upper Ordovician Clays Ferry Formation (Fig. 5).

Clays Ferry Formation

The Clays Ferry Formation consists mainly of interbedded limestone and shale in approximately equal amounts, with silty zones at both the top and bottom of the formation. The limestone is light gray to medium olive gray, very fine to medium grained, contains shaly and silty zones, and is highly fossiliferous. The shale is gray to greenish gray to dark gray, commonly calcareous, and sparsely fossiliferous. The siltstone is tan to greenish gray and calcareous. The Clays Ferry Formation ranges in thickness from 60 to 390 feet. The contact with the underlying Lexington Limestone is placed below the last zone of interbedded thin limestone and shale beds (Fig. 5).

Garrard Siltstone

The Upper Ordovician Garrard Siltstone, which ranges from 10 to 125 feet in thickness, is conformable with the underlying Clays Ferry Formation. The Garrard is composed principally of siltstone with minor thin interbedded shale and limestone in varying amounts (Fig. 5). The siltstone is light gray to greenish gray and calcareous. The limestone is medium gray, fine to medium grained, and in part, silty and argillaceous.

Leipers Formation

The Leipers Formation ranges from 20 to 180 feet in thickness and consists predominantly of limestone, with shaly zones, minor siltstone, and abundant fossils. The limestone is gray to blue gray to brownish gray, fine to coarse grained, and commonly contains argillaceous and silty zones. The shale is gray to greenish gray, dolomitic, and, in places, calcareous. Greenish-gray calcareous siltstone is interbedded with the limestone and shale, and generally occurs in the upper part of the formation.

Cumberland Formation

The Upper Ordovician Cumberland Formation, which is equivalent to the Ashlock and Drakes Formations to the north, attains a maximum thickness of about 130 feet in the study area. The lithologies of this sequence are varied and consist of interbedded dolostone, limestone, shale, and minor amounts of siltstone. The dolostone is light gray to olive brown, very fine to medium crystalline, and shaly and silty in part. The limestone is medium gray to brownish gray to greenish gray, fine grained, argillaceous, sparsely fossiliferous, and partly dolomitic. The shale is dark gray to greenish gray, calcareous, and dolomitic. The siltstone is generally olive gray to brownish gray and dolomitic. The formation is commonly argillaceous at the top, while the lower part is chiefly calcareous and dolomitic shale. The Cumberland Formation rests conformably on the Leipers Formation.

Silurian System

The Upper Silurian section is completely missing in south-central Kentucky. From oldest to youngest, the Lower and Middle Silurian section includes the Brassfield Dolomite, the Osgood Shale, the Laurel Dolomite,

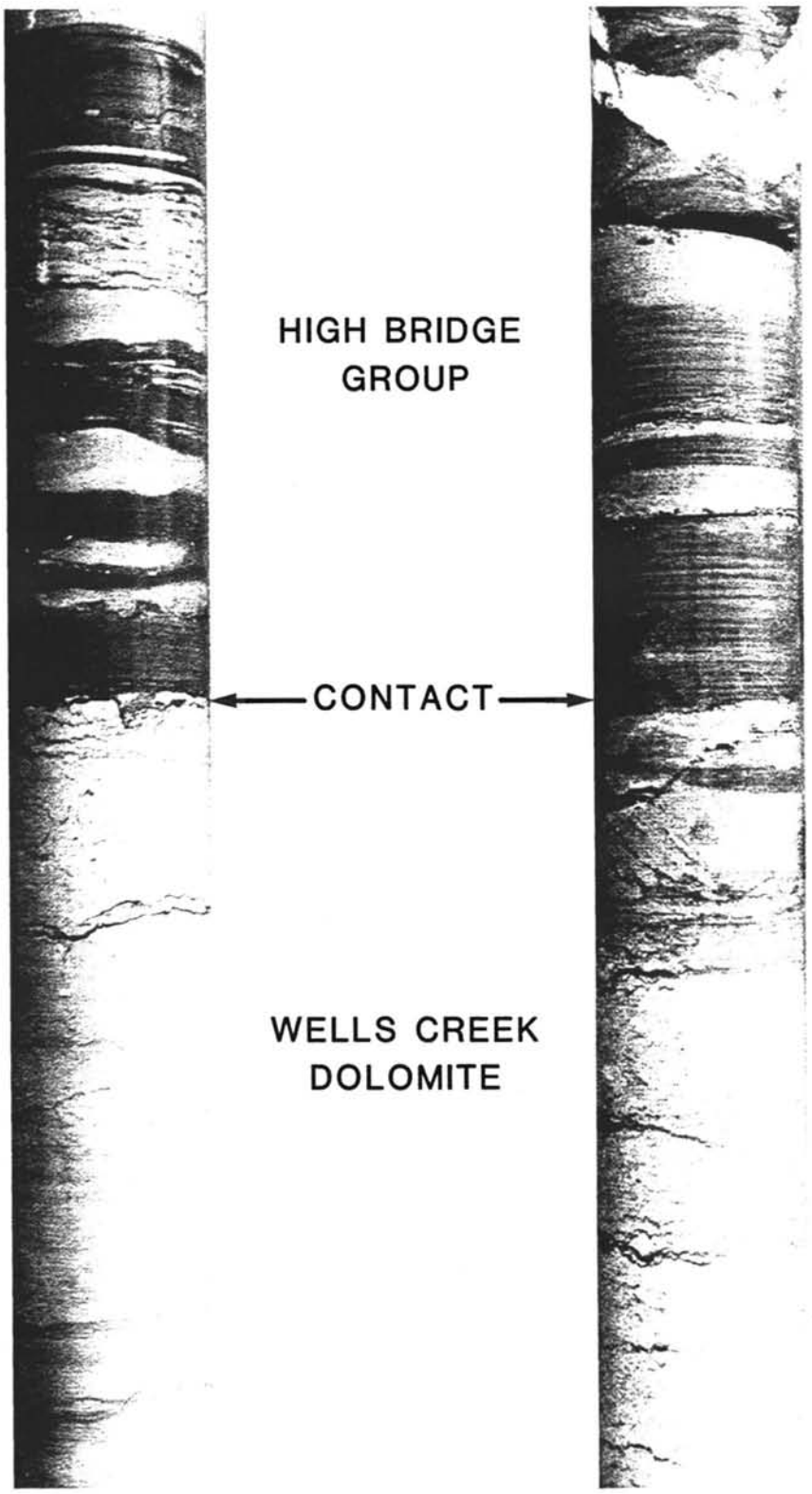

Figure 6. Typical contact between the top of the Wells Creek Dolomite and the base of the overlying High Bridge Group in drill core.

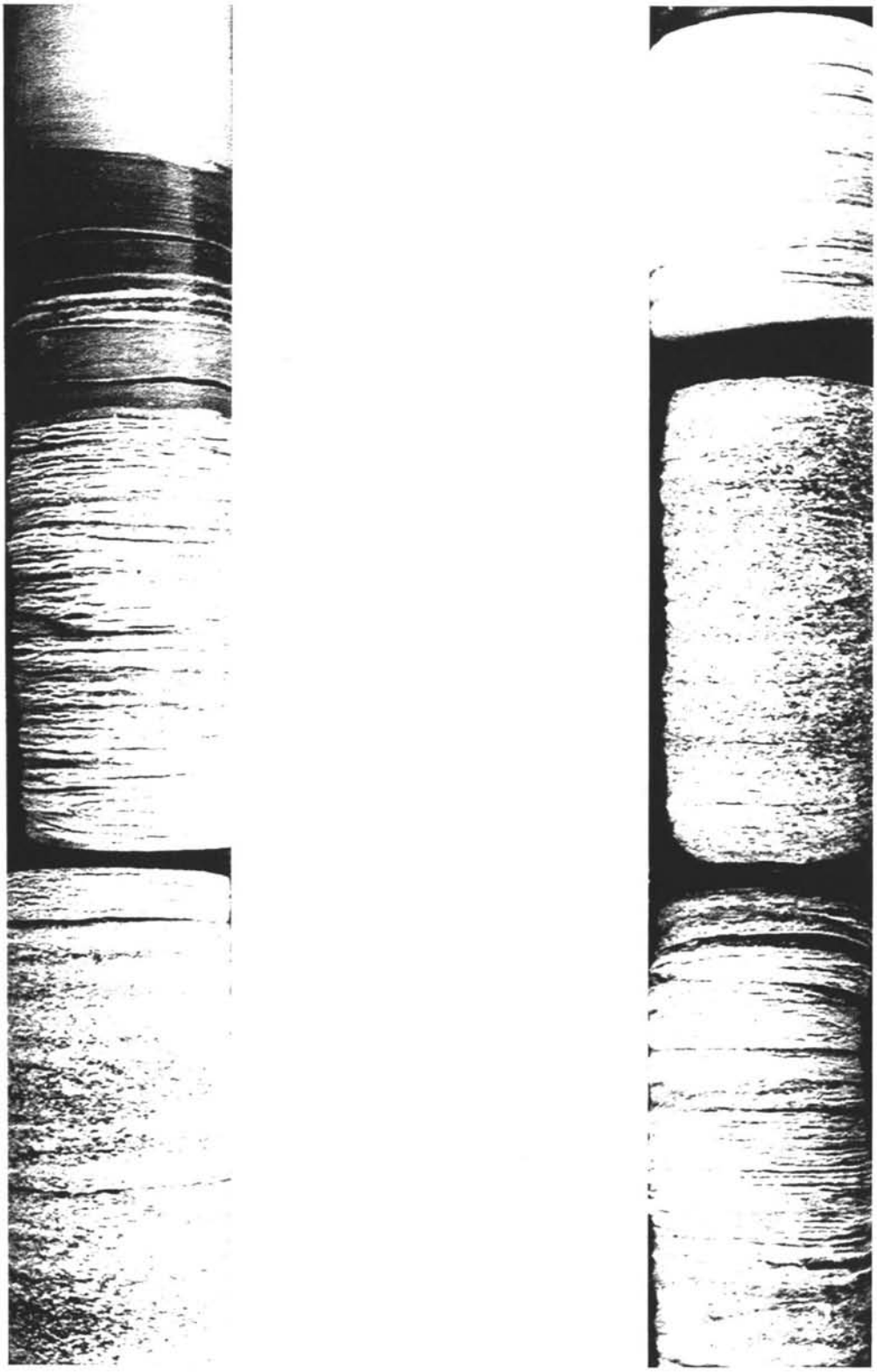

Figure 7. Drill cores showing typical Pencil Cave bentonite.

the Waldron Shale, and the Louisville Limestone. The Silurian section is about 280 feet thick.

Brassfield Dolomite

The Lower Silurian Brassfield Dolomite is no more than 30 feet thick. It is composed predominantly of dolostone and is commonly interbedded with thin shaly and silty zones. The dolostone is pink to brownish gray and fine to coarse crystalline; it contains a few scattered fossils, and generally contains chert, especially toward the base of the formation.

Osgood Shale

The Osgood Shale, with a total thickness of about 55 feet, includes the beds between the Brassfield Dolomite and the Laurel Dolomite. It consists mainly of shale with small amounts of dolostone. The shale is gray to grayish green to red, and is commonly calcareous and dolomitic. The dolostone is gray to olive gray, fine to medium crystalline, and shaly; it contains scattered fossils.

Laurel Dolomite

The Laurel Dolomite consists of sparsely fossiliferous, light-gray to bluish-gray, fine- to medium-crystalline dolostone and dolomitic limestone. The lower and upper contacts are both marked by the occurrence of shale beds. The Laurel Dolomite attains a total thickness of about 70 feet.

Waldron Shale

The Waldron Shale is about 10 feet thick. The shale is olive gray to greenish gray, fossiliferous, and contains thin clayey and silty beds, with minor dolomitic limestone.

Louisville Limestone (Lego)

The uppermost Middle Silurian unit, the Louisville Limestone, has a total thickness of 115 feet. The Louisville Limestone consists mainly of limestone, dolomitic limestone, and dolostone. The limestone is gray to olive gray to greenish gray, fine to coarse grained, partly dolomitic, argillaceous, and fossiliferous. The lower contact between the Louisville Limestone and the Waldron Shale is marked by a fairly sharp change from limestone to shale.

Devonian System

Devonian-age rocks have a total thickness of about 75 feet, and consist of the Middle Devonian Boyle Limestone and the Upper Devonian Chattanooga Shale. A major unconformity is recognized at the base of the Chattanooga Shale. In the study area the Chattanooga Shale rests on underlying formations as old as the Late Ordovician Cumberland Formation and as young as the Middle Devonian Boyle Limestone. All of the Upper Silurian and Lower Devonian units are missing.

Boyle Limestone

The Boyle Limestone is about 15 feet thick and is composed of limestone and sandstone. The limestone is gray to brown to tan-brown, fine to medium grained, and partly dolomitic, with varying amounts of chert. The sandstone is very fine to coarse grained, buff to gray, and calcareous; it occurs in the basal part of the formation.

Chattanooga Shale

The Chattanooga Shale within the study area ranges in thickness from 5 to 60 feet. The shale is black to brownish black to grayish black, and fissile. Pyrite and phosphate nodules are common. Toward the base, thin layers of siltstone are present. The most distinctive features of this formation which make it easily recognized are the black color and its distinctive "kick" on geophysical logs (Fig. 5).

UNCONFORMITY AT THE TOP OF THE KNOX GROUP

Five unconformities are recognized within the geologic column for south-central Kentucky (Plate 1). The oldest occurs on the Precambrian basement surface. This is followed by the Lower Ordovician-Middle Ordovician unconformity at the top of the Knox Group. A major unconformity is present at the base of the Upper Devonian Chattanooga Shale; in places, this erosional surface cuts down into Upper Ordovician strata. Another unconformity is recognized at the boundary between the Mississippian and Pennsylvanian Systems. The present-day land surface marks the youngest unconformity in the area.

A major unconformity occurs between the Mascot Dolomite of the Knox Group and the overlying Wells Creek Dolomite. The development of karst topography on the upper surface of the Knox indicates an extensive period of subaerial erosion. This surface is of economic importance because of its relationship to hydrocarbon entrapment and localization of mineral deposits.

At the end of Early Ordovician time, the widespread shallow seas that had prevailed over most of North America withdrew (Harris, 1978). As a result, the upper Mascot Dolomite of the Knox Group was exposed to subaerial weathering and erosion. The total thickness of

Mascot Dolomite that was eroded is not known, but within the study area, erosion did not extend below the Mascot.

In south-central Kentucky more than 3,000 wells have been drilled to the top of the Knox Group, and examination of more than 450 cores and well cuttings has provided valuable information concerning this buried erosional surface. The following criteria were used in identifying the unconformity in the subsurface: a break in the stratigraphic record, with an abrupt change in lithology between the Wells Creek Dolomite above (mainly limestone, dolostone, and shale) and the Knox Group below (mainly dolostone with some limestone) (Appendix A); the occurrence of a brecciated zone at the base of the Wells Creek (Fig. 4), which is generally less than 2 feet thick and contains weathered, etched, and angular fragments of reworked Knox material; the recognition of a highly irregular karst surface at the top of the Knox (Fig. 8 and Plate 2); and the presence of oil residues, weathered chert, and porous zones, features that are commonly associated with unconformities, and which occur at or near the eroded surface.

During the period when carbonate rocks of the Knox Group were subaerially exposed, many geomorphic processes contributed to the extensive development of karst topography. The principal agents of erosion were physical and chemical weathering, running water, and ground water. The most important process in the development of karst topography is solution. Carbon dioxide (CO_2) present in the atmosphere becomes dissolved in water (H_2O) to form carbonic acid (H_2CO_3). This weak acid reacts with the calcium carbonate ($CaCO_3$) in limestones and dolomites, causing it to be dissolved. The following simplified reaction represents this process:

$$CaCO_3 + H_2O + CO_2\ (gas) \leftrightarrow Ca^{+2} + 2HCO_3.$$

Most of the dolostones and limestones in the upper Knox Group are very susceptible to karstification. The following factors are favorable for the development of karst: (1) the occurrence of soluble strata as thick homogenous beds (allowing the development of large karst features); (2) the presence of dense fine-grained rock types, which are more susceptible to the development of joints and fractures; and (3) abundant thin beds and joints. Ground water will move through these more permeable zones with ease and dissolve the carbonate rock, thus widening the openings. As a result, secondary porosity is enhanced and the system is able to hold more water, leading to increased circulation of ground water. This increase in the circulating ground water causes voids in carbonate rocks beneath the surface to be widened and enlarged. In time, when the roofs of the enlarged voids can no longer support the weight above, collapse may occur, causing a sinkhole. Since underground water movement is usually complex, sinkholes and underground caverns may or may not be interconnected.

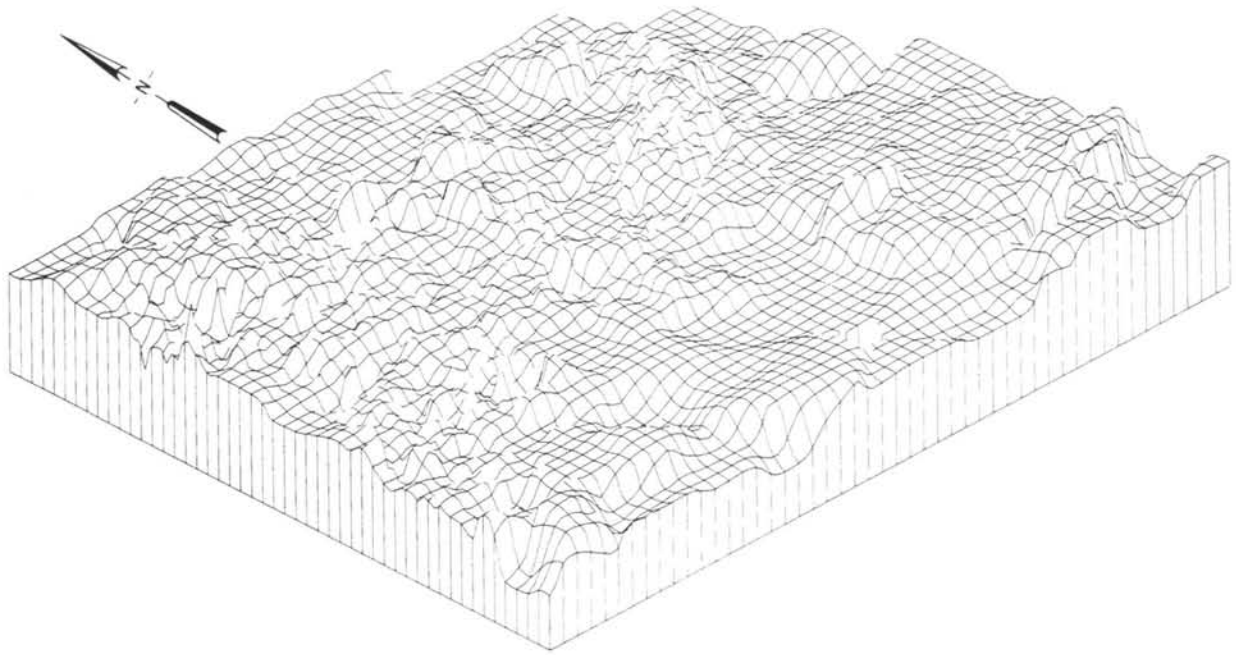

Figure 8. Transect plot of the eroded surface at the top of the Knox Group in south-central Kentucky. Generated through the use of the Surface II computer program, this plot shows a generalized configuration of the unconformable Knox surface.

The following evidence for karst development was interpreted from the paleotopographic map and the transect plot prepared for the Knox surface (Plate 2 and Fig. 8). The irregular topography, which gives an appearance of disorder, is made up of many closed depressions (sinkholes) throughout the study area. These sinkholes range in size from a few hundred feet to several thousand feet in diameter and are circular or elliptical.

Sinkholes, which are typical karst features, generally form as a result of solution or collapse. The Knox paleosurface is also characterized by numerous residual hills scattered throughout the study area. They are generally conical and occur between the sinkholes; many of these hills are steep sided. Some valleys are interrupted, elongate, steep sided, and of limited extent, suggesting that they were formed as a result of vertical and underground drainage, followed by collapse of the roof. In addition, the surface at the Knox unconformity in the study area generally lacks a well-developed drainage pattern because surface water has been diverted into underground systems, thus disrupting the normal flow. Fracture zones within the Knox probably controlled the direction of subterranean channels.

Relief on the Knox paleosurface varies as much as 400 feet. The paleotopographic features may be in part structurally controlled and may have developed partially in response to differential erosion caused by different lithologies, mainly dolostones and limestones.

In early Middle Ordovician time, the sea slowly advanced over the unconformable surface and deposition resumed, resulting in formation of the Wells Creek Dolomite. Deposition initially filled lower areas on the truncated surface and continued until the Knox hills were covered. The Wells Creek Dolomite is present throughout the study area and ranges in thickness from about 10 to 95 feet (Plate 3).

Four structural cross sections were prepared using data from 57 wells (Fig. 9). Three of the cross sections were drawn in an east-west direction roughly perpendicular to the Cincinnati Arch, and one was drawn in a northwest-southeast direction. A sea-level datum was used for all of the cross sections. Stratigraphic identification of the Pencil Cave, the Wells Creek, and the Knox was made from the examination of cores, well cuttings, and geophysical logs. All four cross sections (Figs. 10-13) show the great variability of the Wells Creek thickness, which supports the interpretation of karst development on top of the Knox Group. Generally, where the Wells Creek is thin, a topographic high exists on the Knox surface, and where the Wells Creek thickens, a depression is present on the Knox. The interval between the Pencil Cave and the top of the Wells Creek remains generally constant. The contact between the unconformable surface of the Knox Group and the Wells Creek is well defined and is usually represented as a thin, brecciated zone of reworked Knox material (Fig. 4).

OIL AND GAS

Oil and gas have been produced within the study area in south-central Kentucky since 1820. The first well was drilled in Clinton County for salt, but instead of finding salt, the well encountered both oil and gas in the upper Lexington Limestone (Jillson, 1948). Another successful well was drilled in Cumberland County in 1829. By 1866, commercial oil wells had been drilled in Cumberland, Clinton, Russell, and Wayne Counties, and all were very productive (Jillson, 1948).

Today, commercial quantities of oil and gas are being produced in 9 of the 10 counties included in this report. A total of 120 oil pools are scattered throughout the area (Plate 5). They are producing from 11 relatively shallow stratigraphic zones, which range in age from Ordovician to Mississippian. Producing formations include the Lower Ordovician Knox Group, the Middle Ordovician Wells Creek Dolomite, the High Bridge Group (Stones River)[1], and the Lexington Limestone (Lower Sunnybrook, Anderson, Upper Sunnybrook). Middle to Upper Ordovician production is from the Clays Ferry Formation (Granville, Modoc). The Lower Silurian Brassfield Dolomite (Yellow Cap) and the Middle Silurian Laurel Dolomite (Blue Sand) are producing formations. Mississippian production is limited to the Lower Mississippian Fort Payne Formation. Of the 120 oil and gas pools, 11 are producing exclusively from the Knox, 44 have combined production from the Knox and other formations, and 65 produce from formations other than the Knox (Plate 5).

The area has seen many periods of boom activity. Presently, most of the activity in the study area is concentrated in Adair, Clinton, and Cumberland Counties (Fig. 14). Clinton County was the leader in total production from 1940 to 1981, with over 5.5 million barrels (Fig. 15).

In Adair County there was relatively little activity prior to 1961, until the discovery of the Breeding oil pool. Production rose from 104 barrels in 1960 to 18,707 barrels in 1961. High production from 1970 to 1975 was due to discoveries in the Gradyville East, Bliss, Gradyville North, Maple Grove School, and Pickett oil pools. Production peaked in 1971 with 367,706 barrels.

[1]Drillers' terms listed on Plate 2 are shown in parentheses.

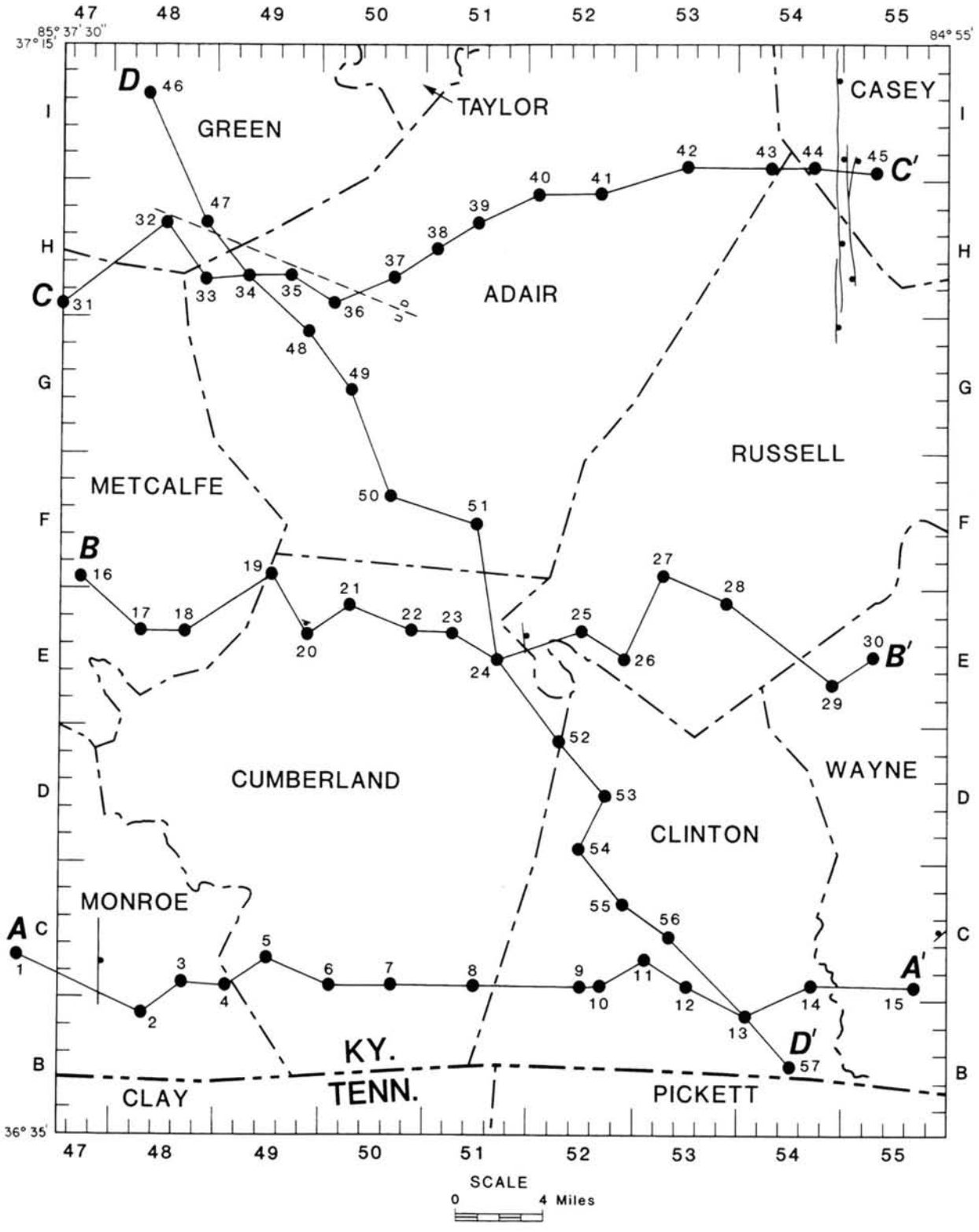

Figure 9. Locations of structural cross sections A-A' (Fig. 10), B-B' (Fig. 11), C-C' (Fig. 12), and D-D' (Fig. 13). Letters and numbers along the margins pertain to the Carter coordinate grid system.

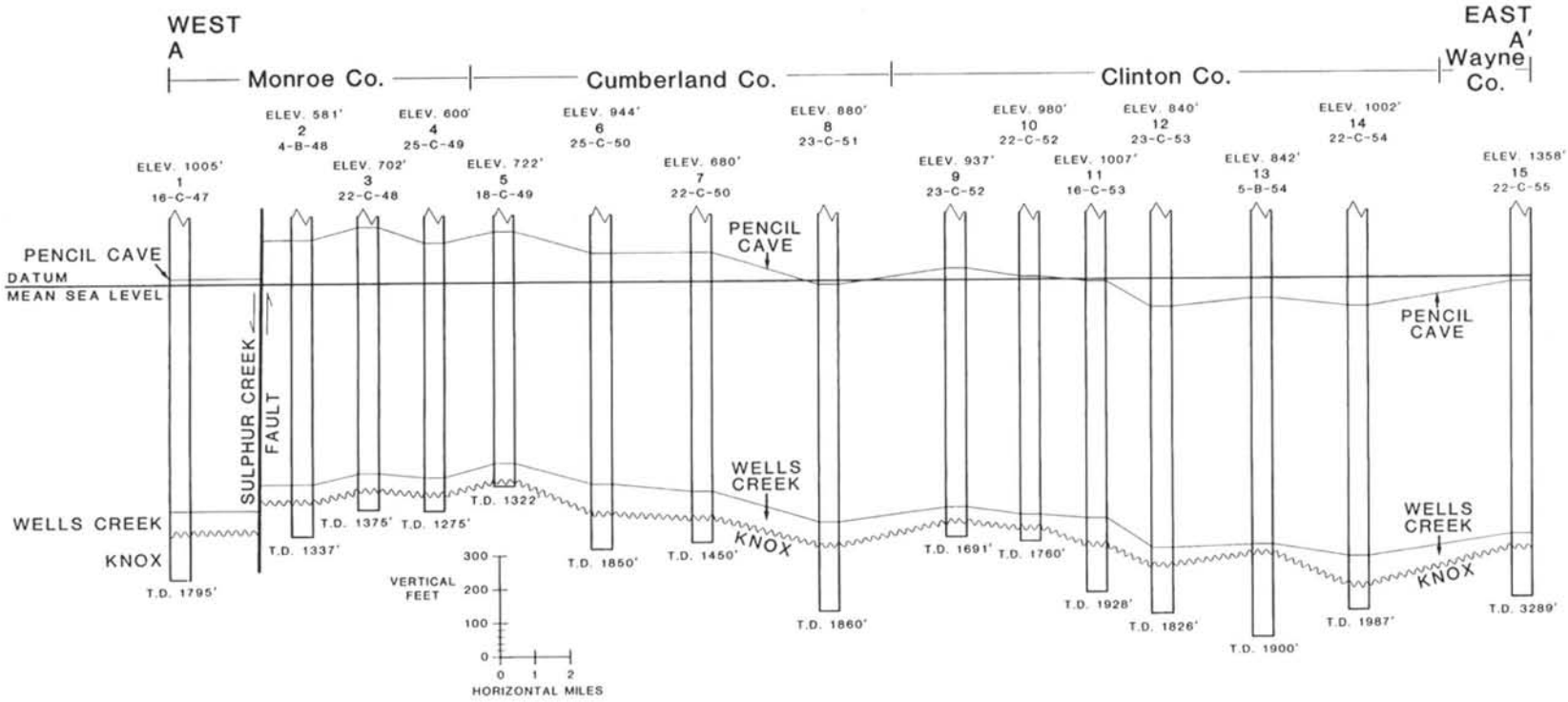

Figure 10. Structural cross section showing interval between the Pencil Cave bentonite and the top of the Knox Group in south–central Kentucky along line A–A' on Figure 9.

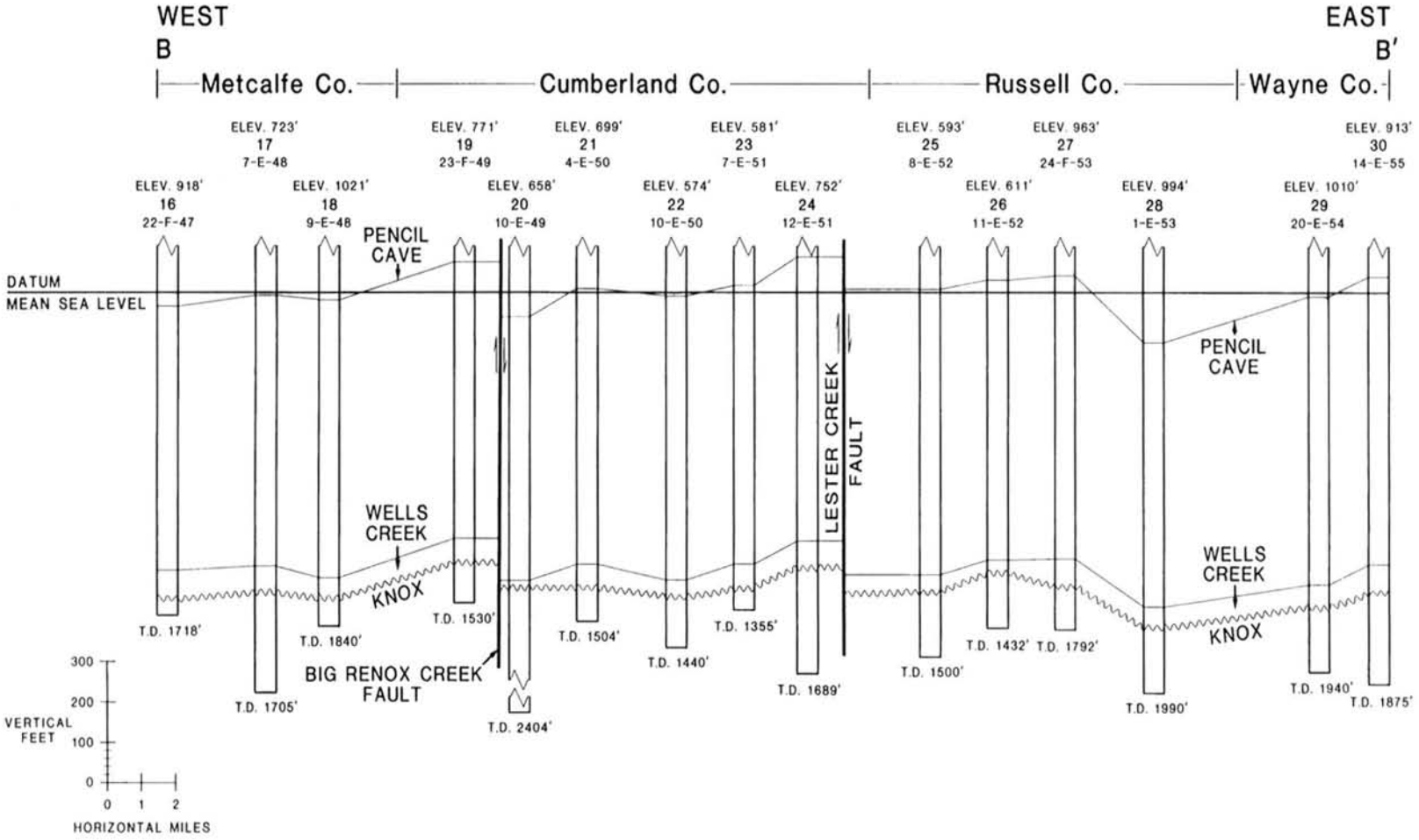

Figure 11. Structural cross section showing interval between the Pencil Cave bentonite and the top of the Knox Group in south–central Kentucky along line B–B' on Figure 9.

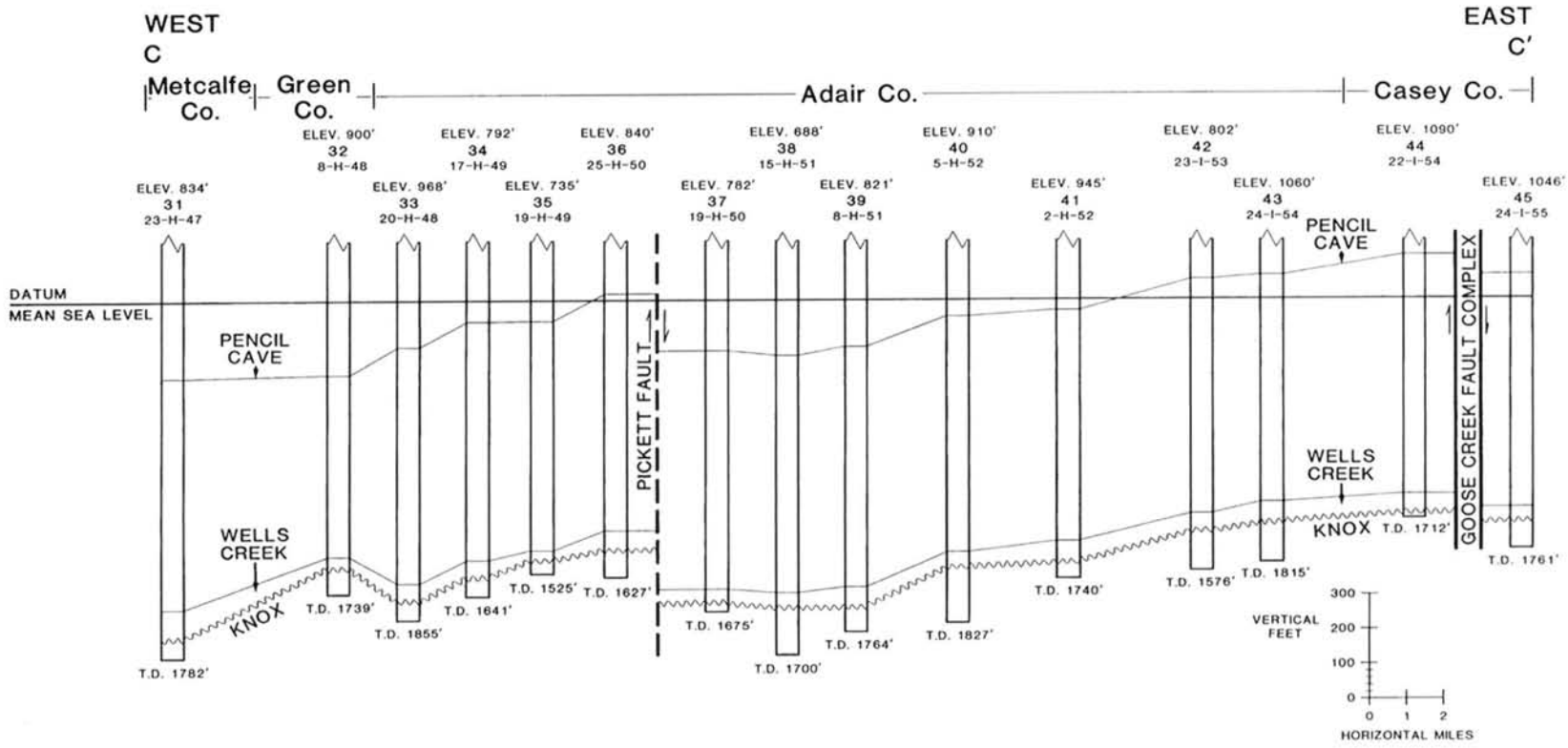

Figure 12. Structural cross section showing interval between the Pencil Cave bentonite and the top of the Knox Group in south–central Kentucky along line C–C' on Figure 9.

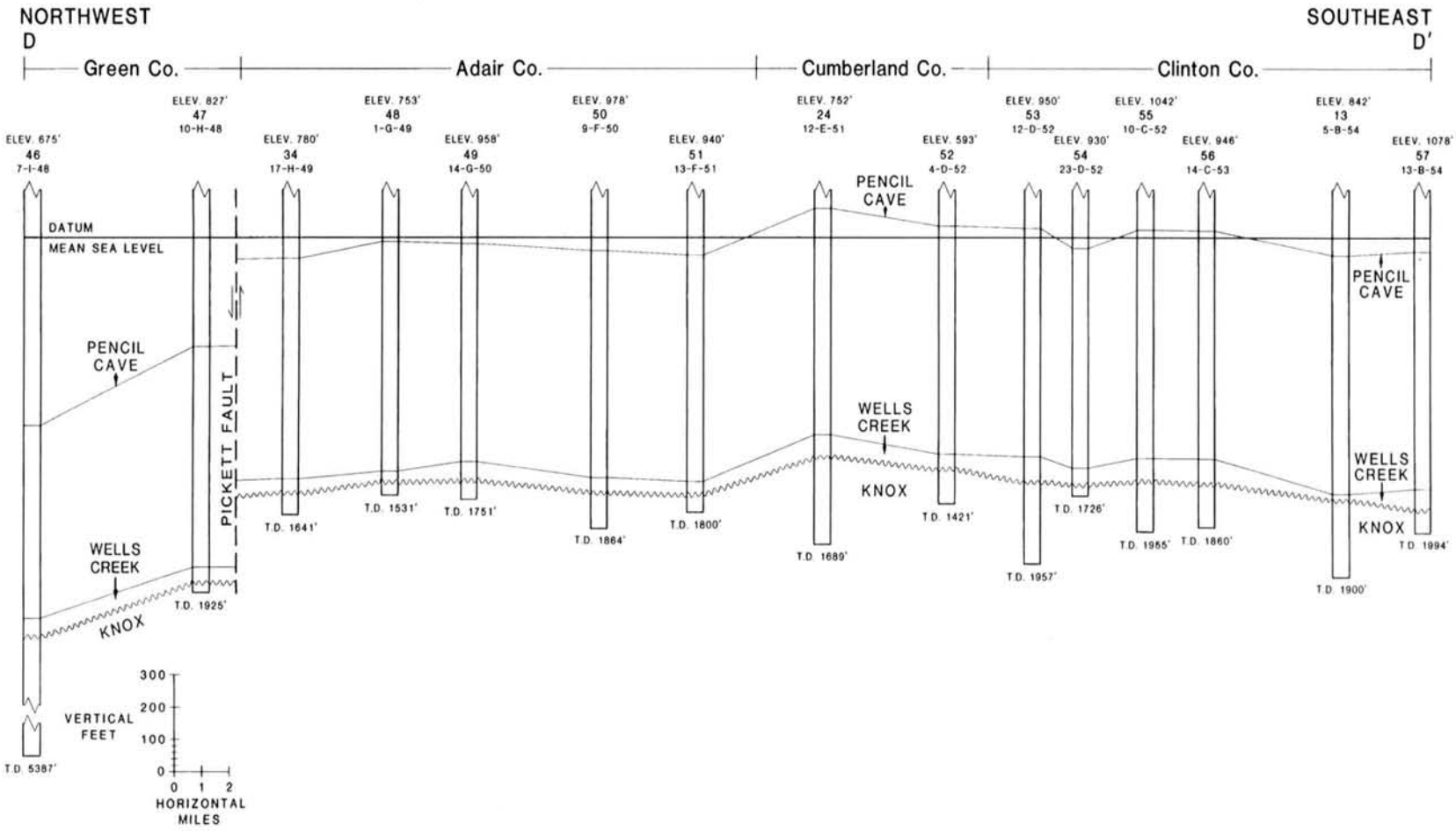

Figure 13. Structural cross section showing interval between the Pencil Cave bentonite and the top of the Knox Group in south–central Kentucky along line D–D' on Figure 9.

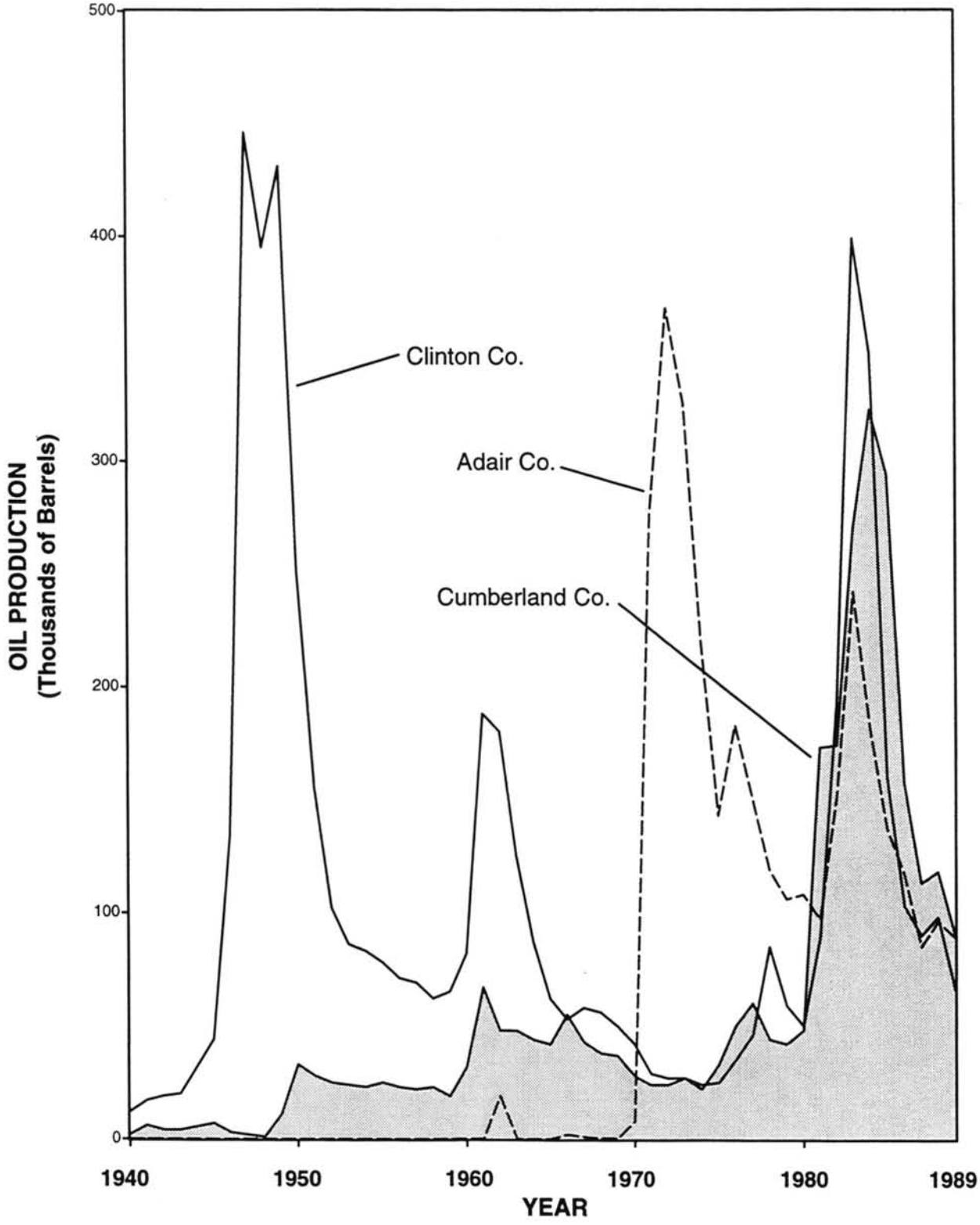

Figure 14. Oil production in Adair, Clinton, and Cumberland Counties, 1940–1989.

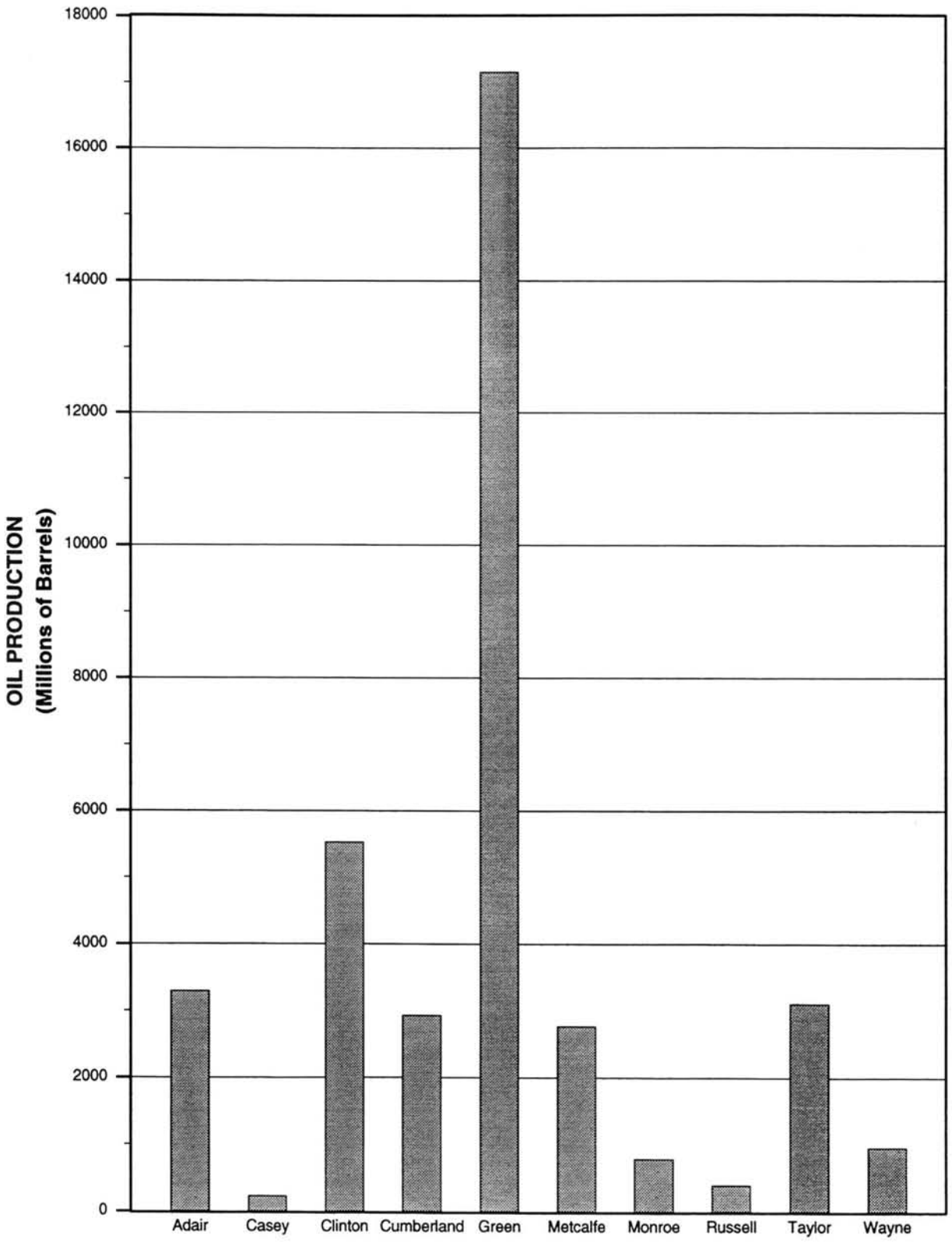

Figure 15. Cumulative oil production by county for south–central Kentucky, 1940–1989.

Clinton County has not fallen below the 11,000-barrel-per-year mark since 1940. In 1944 overall production took an upward turn, and peaked in 1946 at 446,158 barrels. For the next 2 years, 395,488 and 431,286 barrels were recorded. This record-breaking production was attributed to the discovery of oil in the Desda, Decide, and Willis Creek oil pools. With the discovery in 1960 of the Seventy Six and Ida oil pools, production again rose sharply from 82,272 barrels in 1959 to 188,177 barrels in 1960. In 1963 production decreased again to 86,631 barrels and continued downward, hitting a low of 24,104 barrels in 1973. Production increased to 84,981 barrels in 1977, only to decline again during the next 2 years. However, production increased substantially from 88,596 barrels in 1980 to 399,000 barrels in 1982. Since 1982, production has continued to decline, reaching 55,042 barrels in 1989.

Cumberland County was relatively inactive until 1949, when production rose to 32,566 barrels, with activity focusing in the Bakerton oil pool. Production declined and remained level until 1960, when it more than doubled from 32,056 to 67,252 barrels as a result of discoveries in the Goose Creek and Bear Creek oil pools. Cumberland County production reached an all-time high of 322,560 barrels in 1983, and has continued to decline since then, amounting to about 77,000 barrels in 1989.

All 10 counties within the study area had marked increases in production, followed by decreases, during the period 1940 to 1989. This cyclic pattern is directly related to new discoveries and the price of crude oil on the world market. The average wellhead price per barrel of crude in the United States rose from about $3.00 in 1969 to $6.90 in 1974. From 1980 to 1983, the average price per barrel of oil ranged from $21.60 to $31.80, and thus generated increased drilling. In 1986, the price of crude fell drastically from $24.00 to $12.50 per barrel. Oil production in south-central Kentucky took a similar drop, going from a high of 1 million barrels in 1982 to about 262,000 barrels in 1989.

Over 39.6 million barrels of oil have been recovered from all producing zones in south-central Kentucky (Fig. 16), according to records at the Kentucky Geological Survey. No production figures are available for the individual formations. Gas wells are usually capped or are used domestically, and production figures are therefore not available. Green County has the largest cumulative production in the study area, about 17 million barrels (Fig. 15). In 1959 production rose to 11 million barrels. This staggering increase was because of new discoveries in the Greensburg oil pool, where production rose from 1,435 barrels in 1953 to 9,417,460 barrels in 1959.

Most of the world's oil that is recoverable by conventional methods in carbonate reservoirs is related to unconformities (Weeks, 1958). The paleotopographic surface developed on top of the Knox Dolomite is of considerable economic importance because of potential hydrocarbon entrapment at or near this unconformity. Areas where permeable and porous zones developed on the exposed Knox surface due to erosion and weathering may provide reservoir conditions; also, the unconformable surface of the Knox was sealed by the overlapping Wells Creek Dolomite, an impermeable formation capable of entrapping hydrocarbons. Because of pressures exerted, hydrocarbons driven by fluids or gas may migrate along the eroded Knox surface laterally and upward onto topographic highs. These conditions increase the probability of finding commercial oil and gas deposits in the study area.

Within the study area, more than 3,000 wells have reportedly penetrated the upper Knox (Mascot Dolomite), and a substantial amount of oil has been recovered from 55 pools that produce from the Knox (Plate 5). Most of these wells are shallow, usually at depths of less than 2,000 feet. Generally, these wells are drilled no more than 50 feet into the Knox. Stratigraphic determinations made as part of this study indicate that many of the so-called Knox wells did not actually penetrate the Knox, but stopped short in the Wells Creek Dolomite.

Some Knox wells have a high initial production; however, within a short period of time the production levels off and then falls sharply. McGuire and Howell (1963) reported this erratic production and suggested fracture porosity as a cause. Examination of cores of the upper part of the Knox during this study confirmed the presence of abundant fractures in this interval.

The potential for new oil and gas discoveries in the Knox is promising. Many areas in south-central Kentucky are sparsely drilled. In addition, most of the wells drilled to the Knox only penetrate a short distance below the unconformity, and deeper Knox possibilities remain untested.

SUMMARY

Data generated from the examination of cores, well samples, drillers' logs, and geophysical logs were used to compile a paleotopographic map of the erosional surface of the upper Knox Group and a structure map of the top of the Pencil Cave bentonite. An isopach map of the Wells Creek Dolomite, which immediately overlies the Knox, was also prepared. A previously unknown subsurface fault was recognized in the northwestern part of the study area on the basis of information from geophysical logs.

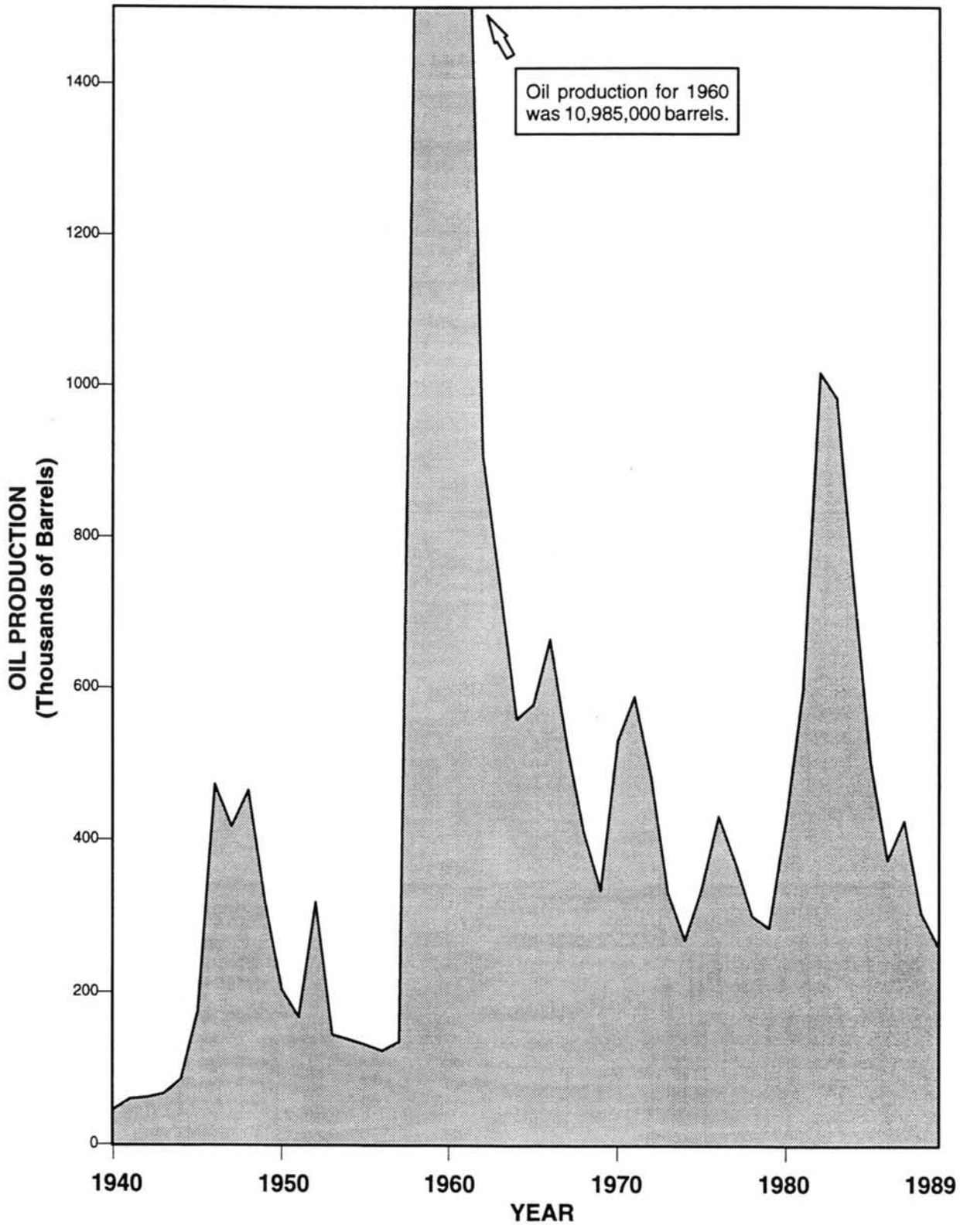

Figure 16. Total cumulative oil production for south–central Kentucky, 1940–1989.

The irregular configuration of the Knox surface, with a total relief of about 400 feet, and the variability of the thickness of the overlying Wells Creek Dolomite (10 to 95 feet) suggest that an extensive karst topography developed on the unconformable surface of the Knox.

The Wells Creek Dolomite, present everywhere in the study area, is composed mainly of limestone and dolostone, with varying amounts of interbedded shale. During the course of this study, it was found that many of the wells in south-central Kentucky reported as having been completed in the Knox were in fact drilled only into the Wells Creek Dolomite.

Because of the relatively shallow depth to the Knox Group (usually less than 2,000 feet), the porosity and permeability associated with the unconformable surface, and structures related to the paleotopographic highs, the Knox will continue to generate interest for petroleum exploration. Many areas are sparsely drilled, and deeper Knox strata remain untested.

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APPENDIX A
Sample Descriptions for Typical Wells in the Study Area in South-Central Kentucky

Descriptions of cuttings from a selected well in each of the nine counties in the study area are included. In order to have a better understanding of the lithologies that are associated with the unconformity, an interval from 150 feet above to 250 feet below the top of the Knox Group was studied. Well locations are listed below, and detailed sample descriptions follow.

COUNTY	CARTER COORDINATE	OPERATOR	WELL NO.	FARM	ELEV. (FT.)	KGS CALL NO.
Adair	24-I-54	Ashland Oil & Ref. Co.	1	Tarter, R. F.	850	8475
Casey	24-I-55	Pitts, W. H.	1	Luttrell, F. B.	1046	5453
Clinton	15-D-53	Deacon, Lionel	1	Tallent, Charlie	974	6398
Cumberland	20-C-49	Hawk Oil Co.	1	Blythe, Raymond	863	6259
Green	20-J-48	Hughes, Joe	3	Murrey	680	6615
Metcalfe	16-F-46	Benz Oil Corp.	1	Nunnally, Charles	757	9193
Monroe	13-C-47	Howard, Obra	1	Martin, O. L.	1017	5505
Russell	14-G-55	Collings, C. G.	1	Tarter, Della	1046	12585
Wayne	10-C-55	Alexander, Leroy	1	Coyle, James	1358	9591

ADAIR COUNTY

OPERATOR: Ashland Oil and Ref. Co. **WELL NO.:** 1 **FARM:** Tarter, R. F. **CARTER COORDINATE:** 24-I-54 600 FNL x 2050 FEL **ELEV.:** 850 ft. **KGS CALL NO.:** 8475.

Depth in Feet	Description
1100-1110	Limestone, medium-gray (N5), fine- to medium-grained, some dolomitic; calcite crystals; bryozoans and ostracodes.
1110-1120	Limestone, medium-gray (N5), fine-grained; streaks of dolomite; calcite crystals; contains bryozoans.
1120-1130	Limestone, medium-gray (N5), fine- to medium-grained; dark-gray (N3) shale streaks, dense, slightly fossiliferous; calcite crystals.
1130-1140	Limestone, medium-dark-gray (N4), medium-grained; fragmented ostracodes.
1140-1150	Limestone, medium-gray (N5), fine- to medium-grained; scattered calcite crystals.
1150-1160	Limestone, medium-gray (N5), fine- to medium-grained; dark-gray (N3) shale streaks; rare trace of pyrite.
1160-1170	Limestone, medium-gray (N5), fine- to medium-grained, argillaceous, slightly dolomitic; fossil fragments.
1170-1180	Limestone, medium-light-gray (N6), fine-grained; trace of dark-gray (N3) shale, calcareous; calcite crystals.
1180-1190	Limestone, medium-light-gray (N6), fine-grained; some dark-gray (N3) shale; trace of pyrite; fragmented brachiopods.
1190-1200	Limestone, medium-dark-gray (N4), fine- to medium-grained, argillaceous, partly dolomitic; sparse ostracodes.
1200-1210	Limestone, light-olive-gray (5Y6/1), fine-grained; dark-gray (N4) shale streaks; trace of pyrite; minor calcite crystals.
1210-1220	Limestone, light-gray (N7), very fine- to fine-grained; olive-black (5Y2/1) shale streaks; trace of pyrite; calcite crystals.
1220-1230	Limestone, light-olive-gray (5Y6/1), fine-grained; ostracode fragments.
1230-1240	Limestone, medium-dark-gray (N4), medium-grained; dolomite stringers, fine-crystalline, argillaceous and calcareous.

1240-1250	Limestone, medium-gray (N5), fine-grained; black (N1) shale streaks; trace of pyrite; minor calcite crystals.
1250-1260	Limestone, medium-dark-gray (N4), with olive-gray (5Y4/1), fine-grained; with some argillaceous dolomite; bryozoan debris.
1260-1270	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine-grained; some dark-gray (N3) shale; trace of pyrite; bryozoans and ostracodes.
1270-1280	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine- to medium-grained; occasional streaks of greenish-black (5GY2/1) shale; few calcite crystals.
1280-1290	Limestone, medium-dark-gray (N4), fine- to medium-grained.
1290-1300	Limestone, medium-dark-gray (N4), medium-grained, argillaceous; dolomite, medium-gray (N5), fine-crystalline; trace of dark shale, silty.
1300-1310	Limestone, olive-gray (5Y4/1), fine-grained, argillaceous; trace of pyrite; sparse fossil fragments.
1310-1320	Limestone, dark-gray (N3), fine-grained; with black (N1) shale streaks; minor dolomitic limestone; trace of pyrite.
1320-1330	Limestone, medium-dark-gray (N4), fine- to medium-grained, argillaceous and calcareous; olive-black (5Y2/1) shale streaks; few calcite crystals.
1330-1340	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine- to medium-grained; some calcite crystals.
1340-1350	Limestone, olive-gray (5Y4/1), fine-grained, slightly dolomitic; few calcite crystals; contains small crinoid stems.
1350-1360	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), fine- to medium-grained; with traces of dark shale, calcareous; trace of pyrite; ostracodes.
1360-1370	Limestone, olive-gray (5Y4/1), and medium-gray (N5), very fine-grained; traces of slightly argillaceous limestone; streaks of dark shale; minor crystalline dolomite.
1370-1380	Limestone, olive-gray (5Y4/1), very fine-grained; with streaks of dark shale; trace of calcite crystals; slightly fossiliferous.
1380-1390	Limestone, medium-dark-gray (N4), fine- to medium-grained; trace of pyrite; scattered fragmented brachiopods.
1390-1400	Limestone, medium-dark-gray (N4), fine- to coarse-grained, some very slightly argillaceous, some dolomitic; traces of dark shale, calcareous, silty.
1400-1410	Limestone, olive-gray (5Y4/1), fine- to medium-grained, fairly argillaceous; some calcite crystals; trace of pyrite; bryozoans.
	TOP OF WELLS CREEK: 1412 feet
1410-1420	Limestone, light-gray (N7), fine- to medium-grained, some argillaceous; streaks of dolomite, microcrystalline; some shale, greenish-gray (5GY6/1), slightly silty.
1420-1430	Limestone, medium-light-gray (N6), very fine- to medium-grained, slightly argillaceous, some silty; streaks of crystalline dolomite; trace of pyrite; ostracode debris.
1430-1440	Limestone, light-gray (N7), and medium-dark-gray (N4), medium-grained, some dolomitic; siltstone, white (N9), very fine-grained, dolomitic to calcareous; some streaks of crystalline dolomite.
1440-1450	Limestone, medium-gray (N5), fine- to coarse-grained, some argillaceous and silty; streaked with fine-crystalline dolomite; trace of greenish-gray shale (5G6/1); minor pyrite.
	TOP OF KNOX: 1457 feet
1450-1460	Dolomite, olive-gray (5Y4/1), and medium-gray (N5), very fine-crystalline, slightly argillaceous, scattered sandy; streaks of dark shale; some calcite crystals.
1460-1470	Dolomite, light-olive-gray (5Y6/1), and dark-gray (N3), very fine- to medium-crystalline, slightly silty; rare dark shale; chert, white (N9), dense; calcite crystals.
1470-1480	Dolomite, light-olive-gray (5Y6/1), and medium-light-gray (N6), fine-crystalline; rare traces of dark shale; some calcite in fractures; chert, white (N9), translucent.
1480-1490	Dolomite, light-olive-gray (5Y6/1), fine- to medium-crystalline, partly silty; with streaks of greenish-gray shale (5G6/1); chert, white (N9), clear to translucent; few calcite crystals.
1490-1500	Dolomite, light-olive-gray (5Y6/1), and medium-dark-gray (N4), fine- to medium-crystalline, partly silty; trace of pyrite.
1500-1510	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), fine-crystalline; chert, dense, translucent; rare streaks of dark shale.
1510-1520	Dolomite, light-olive-gray (5Y6/1), and medium-dark-gray (N4), fine- to medium-crystalline, slightly silty; chert, white (N9), translucent.
1520-1530	Dolomite, very light-gray (N8), and medium-dark-gray (N4), medium-crystalline;

	chert, white (N9), dense; few calcite crystals; traces of pyrite.
1530-1540	Dolomite, light-olive-gray (5Y6/1), medium-crystalline; chert, light-bluish-gray (5B7/1), oolitic; minor greenish-gray shale (5GY6/1).
1540-1550	Dolomite, medium-light-gray (N6), fine- to medium-crystalline; chert, light-gray (N7) to light-bluish-gray (5B7/1), oolitic.
1550-1560	Dolomite, light-olive-gray (5Y6/1), and olive-gray (5Y4/1), fine-crystalline; rare dark shale streaks; chert, yellowish-gray (5Y8/1); trace of calcite fracture fillings.
1560-1570	Dolomite, olive-gray (5Y4/1), fine-crystalline, very slightly argillaceous; trace of pyrite.
1570-1580	Dolomite, medium-gray (N5), with olive-gray (5Y4/1), fine- to medium-crystalline; some silty.
1580-1590	Dolomite, light-gray (N7), and dark-reddish-brown (10R4/6), fine- to medium-crystalline, slightly silty; chert, white (N9), dense, translucent.
1590-1600	Dolomite, medium-gray (N5), fine- to coarse-crystalline, slightly sandy and argillaceous; chert, white (N9), dense; some calcite in fractures.
	BASE OF DESCRIBED INTERVAL

CASEY COUNTY

OPERATOR: Pitts, W. H. **WELL NO.:** 1 **FARM:** Luttrell-Russell **CARTER COORDINATE:** 24-I-55 1650 FNL x 900 FWL **ELEV.:** 1046 ft. **KGS CALL NO.:** 5453.

Depth in feet	Description
1400-1410	Limestone, very light-gray (N8), and medium-light-gray (N6), fine- to medium-grained, slightly argillaceous; streaks of dolomite; trace of pyrite; ostracodes.
1410-1418	Limestone, very light-gray (N8), and olive-gray (5Y4/1), fine-grained, slightly dolomitic; sparse ostracodes.
1418-1424	Limestone, light-gray (N7), fine-grained; streaks of dolomite.
1424-1430	Limestone, olive-gray (5Y4/1), and medium-gray (N5), fine- to coarse-grained; trace of dolomite; scattered calcite crystals; bryozoans.
1430-1444	Limestone, light-gray (N7), and light-olive-gray (5Y6/1), medium-grained; trace of dolomite.
1444-1454	Limestone, olive-gray (5Y4/1), and light-gray (N7), fine-grained, slightly argillaceous.
1454-1464	Limestone, light-olive-gray (5Y6/1), and medium-gray (N5), very fine- to fine-grained, slightly dolomitic; flecked with calcite crystals; scattered brachiopods.
1464-1472	Limestone, medium-gray (N5), fine-grained; contains brownish-black shale (5YR2/1); minor pyrite.
1472-1480	Limestone, medium-gray (N5), and olive-gray (5Y4/1), fine-grained; dark-gray shale streaks (N3).
1480-1490	Limestone, medium-gray (N5), and olive-gray (5Y4/1), fine- to medium-grained; dark-gray shale streaks (N3); minor calcite crystals; bryozoan fragments.
1490-1500	Limestone, medium-gray (N5), and olive-gray (5Y4/1), fine-grained; scattered calcite crystals; trace of pyrite; bryozoan fragments.
1500-1515	Limestone, medium-gray (N5), and olive-gray (5Y4/1), very fine- to fine-grained; dolomite, olive-black (5Y2/1), medium-crystalline.
1515-1525	Limestone, medium-gray (N5), and olive-gray (5Y4/1), fine- to medium-grained; streaks of dark shale; trace of calcite crystals; minor pyrite; sparse ostracodes.
1525-1535	Limestone, light-olive-gray (5Y6/1), and medium-dark-gray (N4), fine- to medium-grained; streaked with dolomite; contains sparse pyrite.
1535-1545	Limestone, light-olive-gray (5Y6/1), and medium-light-gray (N6), very fine-grained; trace of calcite crystals.
1545-1555	Limestone, medium-dark-gray (N4), fine-grained, fine- to medium-grained, argillaceous; scattered fragmented brachiopods.
1555-1566	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine-grained, argillaceous; contains minor amounts of dolomite; sparse fossil fragments.
1566-1580	Limestone, light-gray (N7), and medium-dark-gray (N4), fine- to medium-grained, some dolomitic; flecked with calcite crystals; bryozoans and ostracodes.
1580-1593	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine- to medium-grained, slightly dolomitic; contains trace of olive-black shale (5Y2/1).
1593-1606	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine-grained, slightly argillaceous; contains dolomitic limestone; crinoid fragments.

1606-1611	Limestone, medium-dark-gray (N4), fine-grained; dark-gray (N3) shale streaks; crinoid fragments.
1611-1621	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), very fine- to fine-grained; minor silty shale, brownish-black (5Y2/1); sparse ostracodes and brachiopods.
1621-1636	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine-grained; shale, brownish-black (5YR2/1), fine-grained, slightly silty; contains sparse pyrite and calcite crystals.
	TOP OF WELLS CREEK: 1644 feet
1636-1645	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine-grained; slight traces of shale; minor calcite crystals.
1645-1648	Limestone, medium-gray (N5), fine- to medium-grained; dolomite, olive-black (5Y2/1), fine-crystalline; minor calcite crystals.
1648-1651	Limestone, light-olive-gray (5Y6/1), and light-gray (N7), very fine-grained; dolomite, olive-black (5Y2/1), fine- to medium-crystalline; ostracodes.
1651-1655	Limestone, light-olive-gray (5Y6/1), very fine-grained, slightly dolomitic; minor shale streaks; ostracodes.
1655-1659	Limestone, light-olive-gray (5Y6/1), very fine- to fine-grained; dolomite, light-olive-gray (5Y6/1), medium-crystalline; trace of dark-gray (N3) shale.
1659-1666	Dolomite, medium-gray (N5), and light-olive-gray (5Y6/1), fine- to medium-crystalline; shale, dark-gray (N3), slightly silty.
1666-1667	Dolomite, medium-gray (N5), and light-olive-gray (5Y6/1), fine-crystalline, slightly argillaceous; minor silty shale.
1667-1671	Limestone, yellowish-gray (5Y8/1), medium-to coarse-grained; dolomite, medium-dark-gray (N4), fine- to medium-crystalline; olive-black (5Y2/1) shale streaks.
1671-1680	Limestone, yellowish-gray (5Y8/1), and olive-gray (5Y4/1), fine- to coarse-grained, silty; minor trace of pyrite.
1680-1683	Limestone, yellowish-gray (5Y8/1), medium-grained, silty; shale, dark-gray (N3); scattered pyrite; calcite crystals.
	TOP OF KNOX: 1686 feet
1683-1689	Dolomite, light-gray (N7), and light-bluish-gray (5B7/1), fine- to medium-crystalline, slightly silty; contains some pyrite and calcite-filled vugs.
1689-1696	Dolomite, medium-light-gray (N6), fine-crystalline; minor amounts of chert, light-bluish-gray (5B7/1); trace of pyrite.
1696-1700	Dolomite, light-olive-gray (5Y6/1), fine-crystalline.
1700-1702	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), fine- to coarse-crystalline, slightly silty; minor shale.
1702-1705	Dolomite, light-olive-gray (5Y6/1), fine- to medium-crystalline; slight traces of chert; oolitic.
1705-1707	Dolomite, light-gray (N7), very fine-crystalline; chert, white (N9), dense; minor shale streaks.
1707-1709	Dolomite, light-gray (N7), very fine- to fine-crystalline; minor amounts of chert.
1709-1710	Dolomite, light-gray (N7), and medium-gray (N5), fine- to medium-crystalline.
1710-1711	Dolomite, light-gray (N7), and medium-light-gray (N6), very fine- to fine-crystalline; trace of dark-gray (N3) shale, silty.
1711-1712	Dolomite, medium-light-gray (N6), and medium-gray (N5), very fine- to fine-crystalline, argillaceous.
1712-1713	Dolomite, light-gray (N7), very fine-crystalline; chert, white (N9), dense; minor shale.
1713-1715	Dolomite, medium-light-gray (N6), and light-gray (N7), very fine- to medium-crystalline.
1715-1715	Dolomite, medium-gray (N5), very fine-crystalline.
1715-1717	Dolomite, medium-gray (N5), very fine- to fine-crystalline; minor pyrite and chert.
	BASE OF DESCRIBED INTERVAL

CLINTON COUNTY

OPERATOR: Deacon, Lionel **WELL NO.:** 1 **FARM:** Tallent, Charlie **CARTER COORDINATE:** 15-D-53 1580 FNL x 2400 FWL **ELEV.:** 974 ft. **KGS CALL NO.:** 6398.

Depth in Feet	Description
1518-1530	Limestone, medium-light-gray (N6), and medium-dark-gray (N4), very fine- to fine-grained, argillaceous; streaks of dolomite; abundant bryozoan fragments.
1530-1538	Limestone, medium-light-gray (N6), and medium-dark-gray (N4), very fine- to fine-grained, argillaceous; minor pyrite; bryozoan fragments.
1538-1542	Limestone, medium-gray (N5), and medium-dark-gray (N4), very fine-grained; shale, dark-gray (N3), calcareous; ostracodes and bryozoans.
1542-1548	Limestone, light-olive-gray (5Y6/1), and medium-dark-gray (N4), fine- to medium-grained; dark-gray (N3) shale streaks; trace of pyrite; fragmented brachiopods.
1548-1555	Limestone, light-olive-gray (5Y6/1), and olive-gray (5Y4/1), fine- to medium-grained; scattered whole and fragmented brachiopods.
1555-1564	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine- coarse-grained, argillaceous, slightly dolomitic; dark-gray (N3) shale streaks; trace of pyrite; calcite crystals.
1564-1571	Limestone, medium-gray (N5), medium-grained, slightly dolomitic.
1571-1580	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), very fine-grained, partly dolomitic; scattered calcite crystals; sparse bryozoans and ostracodes.
1580-1588	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine-grained, argillaceous; streaks of dark shale; calcite crystals; ostracodes.
1588-1600	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine- to medium-grained, slightly dolomitic; calcite crystals; contains ostracodes.
1600-1609	Limestone, medium-dark-gray (N4), fine- to coarse-grained; shale, greenish-black (5GY2/1); few calcite crystals.
1609-1621	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to very coarse-grained, argillaceous; slight traces of pyrite.
1621-1629	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to coarse-grained; trace of dark shale, calcareous; fossil fragments.
1629-1637	Limestone, medium-dark-gray (N4), and medium-gray (N5), very fine- to medium-grained, slightly dolomitic; minor pyrite; calcite crystals.
1637-1648	Limestone, medium-gray (N5), and medium-light-gray (N6), very fine- to medium-grained; shale, greenish-gray (5G6/1); brachiopods and bryozoans.
1648-1662	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), fine- to coarse-grained, slightly dolomitic; few calcite crystals; trace of pyrite.
1662-1669	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to coarse-grained; shale, greenish-gray (5G6/1); some calcite crystals; bryozoans.
1669-1678	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), medium-grained, partly silty; scattered calcite crystals.
1678-1687	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to coarse-grained, slightly silty; streaks of dark shale; minor pyrite.
	TOP OF WELLS CREEK: 1690 feet
1687-1695	Dolomite, brownish-gray (5YR4/1), and dark-gray (N3), very fine- to medium-crystalline, partly argillaceous; scattered calcite crystals.
1695-1706	Dolomite, medium-dark-gray (N4), and medium-light-gray (N6), very fine- to medium-crystalline, slightly silty; slight traces of dark shale.
1706-1717	Limestone, light-gray (N7), and light-brownsh-gray (5YR4/1), fine- to coarse-grained, some very slightly silty, some dolomitic; fossil fragments.
1717-1729	Limestone, light-gray (N7), and light-brownsh-gray (5YR4/1), fine- to coarse-grained; with traces of dark shale; scattered bryozoan debris.
1729-1738	Limestone, light-gray (N7), and medium-light-gray (N6), fine- to medium-grained; streaked with crystalline dolomite; minor pyrite.
1738-1745	Dolomite, medium-light-gray (N6), and brownish-gray (5YR4/1), very fine- to coarse-crystalline; some calcite crystals.
1745-1755	Dolomite, medium-light-gray (N6), and brownish-gray (5YR4/1), very fine- to coarse-crystalline, slightly silty; limestone, light-gray (N7), fine-grained.

1755-1766	Dolomite, light-brownish-gray (5YR4/1), and light-gray (N7), fine- to medium-crystalline; limestone, medium-gray (N5), medium-grained; scattered pyrite; trace of calcite crystals.
	TOP OF KNOX: 1768 feet
1766-1776	Dolomite, light-gray (N7), and medium-bluish-gray (5B5/1), very fine-crystalline; some argillaceous limestone; chert, white (N9); scattered pyrite; flecked with calcite crystals.
1776-1783	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), very fine-crystalline; chert, white (N9), clear to translucent; minor streaks of shale; scattered pyrite.
1783-1795	Dolomite, light-gray (N7), and brownish-gray (5YR4/1), very fine- to coarse-crystalline; chert, light-gray (N7); trace of pyrite; some calcite crystals.
1795-1805	Dolomite, light-gray (N7), and brownish-gray (5YR4/1), fine- to coarse-crystalline; chert, light-bluish-gray (5B7/1); trace of pyrite.
1805-1811	Dolomite, light-gray (N7), and medium-light-gray (N6), medium-crystalline, slightly silty; with slight traces of chert; scattered pyrite; calcite crystals.
1811-1819	Dolomite, very light-gray (N8), and light-brownish-gray (5YR6/1), medium- to coarse-crystalline, partly silty; chert, light-bluish-gray (5B7/1); trace of pyrite; few calcite crystals.
1819-1837	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), fine- to coarse-crystalline, slightly silty and argillaceous.
1837-1847	Dolomite, light-gray (N7), and light-brownish-gray (5YR6/1), very fine- to fine-crystalline; chert, dense, translucent.
1847-1855	Dolomite, light-gray (N7), and medium-light-gray (N6), very fine-crystalline, partly silty; chert, white (N9); trace of calcite crystals.
1855-1863	Dolomite, light-gray (N7), and medium-light-gray (N6), very fine-crystalline.
1863-1871	Dolomite, light-gray (N7), and brownish-gray (5YR4/1), very fine- to medium-crystalline; contains abundant white (N9) chert; scattered pyrite.
1871-1882	Dolomite, pinkish-gray (5YR8/1), and brownish-gray (5YR4/1), fine- to coarse-crystalline, slightly argillaceous; minor shale streaks.
1882-1892	Dolomite, light-gray (N7), medium- to coarse-crystalline, partly argillaceous.
1892-1900	Dolomite, pinkish-gray (5YR8/1), medium-crystalline; minor trace of pyrite.
1900-1911	Dolomite, light-gray (N7), and light-brownish-gray (5YR6/1), very fine- to coarse-crystalline, partly silty; chert, light-bluish-gray (5B7/1).
1911-1918	Dolomite, light-gray (N7), medium-crystalline, partly silty; chert, white (N9), clear to translucent, oolitic.
1918-1927	Dolomite, light-gray (N7), and medium-gray (N5), fine-crystalline; chert, white (N9), clear to opaque, oolitic; flecked with calcite crystals.
	BASE OF DESCRIBED INTERVAL

CUMBERLAND COUNTY

OPERATOR: Hawk Oil Co. **WELL NO.:** 1 **FARM:** Blythe, Raymond **CARTER COORDINATE:** 20-C-49 400 FSL x 1410 FEL **ELEV.:** 863 ft. **KGS CALL NO.:** 6259.

Depth in Feet	Description
1303-1309	Limestone, medium-dark-gray (N4), and light-gray (N7), medium-grained, fairly argillaceous; shale, dark-gray (N3), partly silty; fossil fragments.
1309-1320	Limestone, medium-dark-gray (N4), medium- to coarse-grained, fairly argillaceous; contains some calcite crystals; contains bryozoans.
1320-1326	Limestone, medium-dark-gray (N4), and dark-gray (N3), fine- to medium-grained; crinoidal fragments.
1326-1330	Limestone, medium-dark-gray (N4), and dark-gray (N3), fine- to medium-grained; small crinoid stems.
1330-1337	Limestone, medium-dark-gray (N4), very fine-grained; minor calcite crystals.
1337-1346	Limestone, medium-dark-gray (N4), and white (N9), very fine- to coarse-grained.
1346-1353	No sample.
1353-1360	Limestone, medium-dark-gray (N4), and very light-gray (N8), fairly argillaceous.
1360-1367	Limestone, medium-dark-gray (N4), and very light-gray (N8), fine-grained, partly dolomitic; trace of shale; calcite crystals; ostracodes.
1367-1371	Limestone, medium-dark-gray (N4), and very light-gray (N8), fine- to medium-grained, in part slightly argillaceous; minor amounts of shale, olive-black (5Y2/1).

1371-1381	Limestone, medium-dark-gray (N4), medium-grained; shale, olive-black (5Y2/1), calcareous; scattered calcite crystals; fragmented bryozoans.
1381-1390	Limestone, medium-dark-gray (N4), fine- to coarse-grained; scattered bryozoan debris.
1390-1396	Limestone, dark-gray (N3), and medium-gray (N5), very fine- to coarse-grained, partly dolomitic and argillaceous; dark-gray (N3) shale streaks; minor calcite crystals.
1396-1406	Limestone, medium-dark-gray (N4), and medium-light-gray (N6), medium- to coarse-grained, partly dolomitic; slight traces of dark shale; ostracodes.
1406-1417	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine- to medium-grained; minor calcite crystals.
1417-1427	Limestone, medium-gray (N5), very fine- to coarse-grained; with small amount of dolomite, fine- to medium-crystalline.
1427-1441	Limestone, olive-gray (5Y4/1), fine- to coarse-grained, partly dolomitic, slightly argillaceous; trace of dark shale; minor calcite crystals.
1441-1445	Limestone, medium-gray (N5), and medium-light-gray (N6), medium-grained; shale, olive-black (5Y2/1); minor pyrite; contains brachiopods.
1445-1455	Limestone, medium-gray (N5), very fine- to fine-grained; shale, dark-gray (N3), partly silty; scattered calcite crystals.
1455-1460	Limestone, medium-gray (N5), very fine-grained, slightly argillaceous; dolomite, light-olive-gray (5Y6/1), medium-crystalline; calcite crystals; ostracodes.
1460-1469	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine- to medium-grained; small amount of shale.
1469-1479	Limestone, medium-gray (N5), and white (N9), fine- to coarse-grained; bryozoan fragments.
1479-1489	Limestone, medium-gray (N5), very fine- to fine-grained; dolomite, medium-gray (N5), fine-crystalline; trace of dark shale.
1489-1500	Limestone, medium-dark-gray (N4), fine- to medium-grained, slightly dolomitic; shale, dark-gray (N3).
1500-1510	Limestone, medium-dark-gray (N4), fine- to medium-grained; streaked with dolomite; fossil fragments.
1510-1521	Limestone, olive-gray (5Y4/1), very fine- to medium-grained.
1521-1533	Limestone, medium-dark-gray (N4), very fine- to coarse-grained, fairly dolomitic.
1533-1541	Limestone, medium-dark-gray (N4), very fine- to coarse-grained, partly argillaceous; streaks of dark shale; trace of calcite crystals; sparse ostracodes.
1541-1554	Limestone, medium-dark-gray (N4), coarse-grained, slightly dolomitic; shale, greenish-black (5GY2/1).
	TOP OF WELLS CREEK: 1562 feet
1554-1562	Limestone, medium-dark-gray (N4), and dark-gray (N3), very fine- to coarse-grained; minor silty shale; trace of pyrite; bryozoan fragments.
1562-1572	Dolomite, light-gray (N7), fine- to medium-crystalline; small amount of medium- to coarse-grained limestone.
1572-1581	Dolomite, light-gray (N7), and medium-dark-gray (N4), fine- to medium-crystalline; contains minor silty shale.
1581-1594	Limestone, medium-dark-gray (N4), and light-gray (N7), medium-grained, slightly silty; sparse ostracodes.
1594-1602	Dolomite, medium-gray (N5), and light-gray (N7), fine-crystalline; flecked with calcite crystals; abundant pyrite.
	TOP OF KNOX: 1603 feet
1602-1611	Dolomite, light-gray (N7), very fine- to coarse-crystalline; scattered pyrite; trace of calcite crystals.
1613-1622	Dolomite, light-gray (N7), and dark-gray (N3), very fine-crystalline, partly silty; scattered pyrite; minor calcite crystals.
1622-1634	Dolomite, light-olive-gray (5Y6/1), fine-crystalline.
1634-1638	Dolomite, light-olive-gray (5Y6/1), and very light-gray (N8), very fine- to coarse-crystalline; chert, light-gray (N7) to white (N9), oolitic; minor pyrite.
1638-1649	Dolomite, medium-gray (N5), and light-olive-gray (5Y6/1), fine-crystalline; chert, white (N9), clear to opaque; calcite crystals.
1649-1658	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), fine-crystalline; minor amounts of chert.
1658-1668	Dolomite, light-gray (N7), and light-olive-gray (5Y6/1), fine- to medium-crystalline, in part slightly silty; trace of pyrite.
1668-1680	Dolomite, light-gray (N7), and medium-gray (N5), very fine- to fine-crystalline, slightly silty; minor amounts of chert; trace of pyrite.
1680-1690	Dolomite, light-gray (N7), fine- to coarse-crystalline.

1690-1701	Dolomite, light-gray (N7), and medium-light-gray (N6), medium-crystalline, slightly silty and argillaceous; some calcite crystals.
1701-1708	Dolomite, light-olive-gray (5Y6/1), and light-gray (N7), very fine-crystalline, slightly sandy; chert, yellowish-gray (5Y8/1); minor calcite crystals.
1708-1720	Dolomite, very light-gray (N8), and light-gray (N7), very fine- to coarse-crystalline; minor oolitic chert.
1720-1730	Dolomite, medium-gray (N5), and very light-gray (N8), very fine- to medium-crystalline; scattered pyrite.
1730-1741	Dolomite, medium-gray (N5), very fine- to medium-crystalline, partly argillaceous; abundant white (N9) chert; trace of calcite.
1741-1756	Dolomite, very light-gray (N8), medium-crystalline; minor pyrite.
1756-1765	Dolomite, light-gray (N7), and light-olive-gray (5Y6/1), fine-crystalline; chert, light-gray (N7), oolitic.
1765-1780	Dolomite, light-gray (N7), and medium-gray (N5), fine-crystalline; chert, light-gray (N7) to white (N9), dense; sparse pyrite.
1780-1787	Dolomite, medium-gray (N5), and light-gray (N7), medium-crystalline; flecked with calcite crystals; minor pyrite.
1787-1794	Dolomite, medium-gray (N5), very fine- to coarse-crystalline; streaked with greenish-gray (5GY6/1) shale, slightly silty.
1794-1805	Dolomite, light-gray (N7), and medium-gray (N5), fine- to medium-crystalline.
	BASE OF DESCRIBED INTERVAL

GREEN COUNTY

OPERATOR: Hughes, Joe **WELL NO.:** 3 **FARM:** Murrey **CARTER COORDINATE:** 20-J-48 2890 FSL x 100 FEL **ELEV.:** 680 ft. **KGS CALL NO.:** 6615.

Depth in Feet	Description
1705-1722	Limestone, medium-light-gray (N6), very fine- to medium-grained; shale, medium-dark-gray (N4), slightly silty; some calcite crystals; ostracodes.
1722-1735	Limestone, medium-gray (N5), very fine- to fine-grained, fairly argillaceous; shale, medium-dark-gray (N4); slight traces of calcite crystals.
1735-1743	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine- to medium-grained.
1743-1750	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), very fine- to medium-grained; chert, white (N9), translucent; ostracodes.
1750-1755	Limestone, brownish-gray (5YR4/1), and medium-dark-gray (N4), very fine- to coarse-grained; streaked with calcareous shale; minor pyrite; fragmented bryozoans.
1755-1764	Limestone, brownish-gray (5YR4/1), fine- to medium-grained, argillaceous; chert, light-bluish-gray (5B7/1); minor pyrite; trace of calcite crystals.
1764-1775	Limestone, brownish-gray (5YR4/1), and medium-dark-gray (N4), fine- to coarse-grained; slight trace of shale; contains bryozoans debris.
1775-1781	No sample.
1781-1795	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), very fine- to medium-grained; contains some shale; ostracodes.
1795-1805	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), medium- to coarse-grained; chert, white (N9); minor silty shale; ostracode fragments.
1805-1813	Limestone, medium-light-gray (N6), medium-grained, slightly argillaceous.
1813-1824	Limestone, brownish-gray (5YR4/1), fine- to medium-grained.
1824-1833	Limestone, brownish-gray (5YR4/1), and medium-dark-gray (N4), fine- to coarse-grained.
1833-1842	Limestone, brownish-gray (5YR4/1), fine- to coarse-grained, partly dolomitic and argillaceous; contains white (N9) chert; trace of pyrite; bryozoans.
1842-1851	Limestone, brownish-gray (5YR4/1), and dark-gray (N3), very fine- to medium-grained; dolomite, medium-gray (N5), fine-crystalline; chert, light-gray (N7); minor pyrite.
1851-1861	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine- to medium-grained, slightly dolomitic; contains bryozoan debris.
1861-1871	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), fine- to medium-grained; trace of shale; fragmented bryozoans and ostracodes.
1871-1881	Limestone, brownish-gray (5YR4/1), and medium-dark-gray (N4), very fine- to coarse-grained; trace of shale; scattered pyrite; ostracodes and bryozoans.
1881-1890	Limestone, brownish-gray (5YR4/1), and light-brownish-gray (5YR6/1), medium-grained; shale, fairly silty; calcite crystals.

1890-1902	Limestone, brownish-gray (5YR4/1), medium- to coarse-grained, partly argillaceous; trace of dark shale; fragmented brachiopods.
	TOP OF WELLS CREEK: 1908 feet
1902-1911	Limestone, brownish-gray (5YR4/1), and medium-light-gray (N6), fine- to coarse-grained; dolomite, light-gray (N7); trace of greenish-gray (5G6/1) shale.
1911-1925	Dolomite, light-gray (N7), and very light-gray (N8), fine- to medium-crystalline; shale, greenish-gray (5G6/1); trace of pyrite.
1925-1934	Limestone, light-gray (N7), and light-bluish-gray (5B7/1), medium-grained; trace of pyrite; scattered calcite crystals; ostracodes.
1934-1946	Dolomite, light-gray (N7), and light-brownish-gray (5YR4/1), medium- to coarse-grained, argillaceous; limestone, medium-gray (N5), fine-grained; trace of pyrite.
1946-1960	Dolomite, light-gray (N7), and dark-greenish-gray (5GY6/1), fine-crystalline.
1960-1972	Limestone, pinkish-gray (5YR8/1), and light-brownish-gray (5YR4/1), fine- to medium-grained; slight traces of dark shale, silty; contains some pyrite; brachiopods.
1972-1979	Dolomite, brownish-gray (5YR4/1), and pinkish-gray (5YR8/1), fine- to medium-crystalline; limestone, fine- to medium-grained; trace of pyrite.
	TOP OF KNOX: 1990 feet
1979-1991	Dolomite, pinkish-gray (5YR8/1), and light-brownish-gray (5YR4/1), very fine- to medium-crystalline; chert, white (N9), oolitic; trace of pyrite.
1991-2000	Dolomite, light-brownish-gray (5YR6/1), and light-bluish-gray (5B7/1), very fine- to medium-crystalline; chert, light-gray (N7), oolitic; trace of pyrite; calcite crystals.
2000-2010	Dolomite, light-brownish-gray (5YR6/1), and greenish-gray (5G6/1), very fine-crystalline; scattered calcite crystals.
2010-2020	Dolomite, light-brownish-gray (5YR6/1), and light-bluish-gray (5B7/1), fine- to coarse-crystalline; chert, light-bluish-gray (5B7/1); scattered pyrite.
2020-2030	Dolomite, pinkish-gray (5YR8/1), and light-brownish-gray (5YR4/1), fine-crystalline; trace of greenish-gray (5G6/1) shale.
2030-2042	Dolomite, pinkish-gray (5YR8/1), and brownish-gray (5YR4/1), medium-crystalline, partly silty; chert, light-bluish-gray (5B7/1); trace of pyrite; minor calcite crystals.
2042-2056	Dolomite, light-gray (N7), and very dusky-red (10R2/2), very fine- to fine-crystalline; chert, light-gray (N7) to white (N9), dense, oolitic; trace of greenish-black (5GY2/1) shale.
2056-2070	Dolomite, light-gray (N7), and grayish-red (10R4/2), very fine-crystalline; chert, white (N9), oolitic; trace of pyrite.
2070-2078	Dolomite, light-gray (N7), and grayish-red (10R4/2), very fine-crystalline, slightly silty.
2078-2089	Dolomite, light-brownish-gray (5YR6/1), and very light-gray (N8), fine-crystalline; chert, white (N9), oolitic; minor trace of calcite crystals.
2089-2098	Dolomite, light-gray (N7), and moderate-brown (5YR4/4), fine- to medium-crystalline, partly silty.
2098-2105	Dolomite, light-gray (N7), and moderate-brown (5YR4/4), very fine-crystalline.
2105-2112	Dolomite, moderate-brown (5YR4/4), and medium-light-gray (N6), very fine- to coarse-crystalline.
2112-2116	Dolomite, light-brownish-gray (5YR6/1), very fine- to medium-crystalline, slightly cherty; trace of pyrite.
2116-2128	Dolomite, grayish-orange-pink (10R3/2), and light-brown (5YR5/6), medium-crystalline.
2128-2138	Dolomite, light-brownish-gray (5YR6/1), and moderate-reddish-brown (10R4/6), medium- to coarse-crystalline; chert, light-gray (N7), translucent, oolitic.
2138-2148	Dolomite, light-brownish-gray (5YR6/1), fine-crystalline; slight trace of chert; minor silty shale.
	BASE OF DESCRIBED INTERVAL

METCALFE COUNTY

OPERATOR: Benz Oil Corp. **WELL NO.:** 1 **FARM:** Nunnally, Charles **CARTER COORDINATE:** 16-F-46 2600 FSL x 1250 FEL **ELEV.:** 757 ft. **KGS CALL NO.:** 9193.

Depth in Feet	Description
1200-1210	Limestone, medium-gray (N5), and light-olive-gray (5Y6/1), very fine- to medium-grained; dolomite, olive-gray (5Y4/1), fine- to medium-crystalline; minor chert.
1210-1220	Limestone, medium-dark-gray (N4), fine-grained, partly argillaceous; shale, dark-greenish-gray (5GY4/1); scattered calcite crystals.

1220-1230	Limestone, medium-gray (N5), very fine- to medium-grained, trace slightly argillaceous, partly dolomitic; scattered calcite crystals.
1230-1240	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), fine- to coarse-grained; trace of dark shale; fragmented bryozoans.
1240-1250	Limestone, medium-gray (N5), and olive-gray (5Y4/1), very fine- to coarse-grained; chert, white (N9); fragmented bryozoans and ostracodes.
1250-1260	Limestone, medium-gray (N5), and light-olive-gray (5Y6/1), medium- to coarse-grained, slightly dolomitic; trace of silty shale.
1260-1270	Limestone, medium-gray (N5), medium-grained; contains abundant chert, white (N9); ostracodes.
1270-1280	Limestone, medium-gray (N5), fine- to medium-grained, partly dolomitic; sparse fossil fragments.
1280-1290	Limestone, medium-light-gray (N6), and light-olive-gray (5Y6/1), medium-grained; trace of dark shale.
1290-1300	Limestone, light-olive-gray (5Y6/1), and olive-gray (5Y4/1), very fine- to medium-grained, partly dolomitic; brownish-black (5YR2/1) shale streaks; calcite crystals.
1300-1310	Limestone, light-olive-gray (5Y6/1), and medium-gray (N5), very fine- to coarse-grained, partly cherty.
1310-1320	Limestone, light-olive-gray (5Y6/1), and olive-gray (5Y4/1), fine- to medium-grained; dolomite, medium-dark-gray (N4), fine-crystalline; fragmented brachiopods.
1320-1330	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine-grained, argillaceous; trace of shale; scattered calcite crystals.
1330-1340	Limestone, olive-gray (5Y4/1), and dark-gray (N3), medium-grained; chert, light-bluish-gray (5B7/1); slight trace of shale; scattered brachiopods.
1340-1350	Limestone, light-olive-gray (5Y6/1), very fine- to fine-grained; minor crinoid fragments.
1350-1360	Limestone, olive-gray (5Y4/1), fine-grained, partly shaly.
1360-1370	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), medium-grained, slightly dolomitic; trace of dark shale, calcareous; bryozoans.
1370-1380	Limestone, olive-gray (5Y4/1), fine- to medium-grained; shale, greenish-black (5GY2/1); few calcite crystals.
1380-1390	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), medium- to coarse-grained, partly dolomitic; also contains bryozoan debris.
1390-1400	Limestone, medium-dark-gray (N4), and olive-gray (5Y4/1), very fine- to fine-grained; trace of dark shale; scattered calcite crystals.
1400-1410	Limestone, medium-dark-gray (N4), and light-olive-gray (5Y6/1), medium-grained; dolomite, medium-gray (N5), medium-crystalline; trace of pyrite.
1410-1420	Limestone, medium-dark-gray (N4), and dark-gray (N3), very fine- to medium-grained, partly dolomitic; minor silty shale.
1420-1430	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), fine-grained; conodonts.
1430-1440	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), fine- to coarse-grained, slightly dolomitic; trace of dark shale.
1440-1450	Limestone, olive-gray (5Y4/1), and dark-gray (N3), very fine- to fine-grained, silty.
1450-1460	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), medium-grained; argillaceous; scattered calcite crystals; fossil fragments.
1460-1470	Limestone, olive-gray (5Y4/1), medium- to coarse-grained; dolomite, olive-black (5Y2/1), fine- to medium-crystalline; chert, white (N9).
1470-1480	Limestone, olive-gray (5Y4/1), and medium-gray (N5), fine-grained; trace of shale.
1480-1490	Limestone, olive-gray (5Y4/1), medium- to coarse-grained, partly silty; shale, greenish-gray (5GY6/1); minor pyrite.
1490-1500	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), medium-grained, argillaceous; shale, greenish-gray (5GY6/1); contains bryozoan debris.
1500-1510	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), medium-grained, partly dolomitic; minor silty shale; trace of pyrite; scattered calcite crystals.
1510-1520	Limestone, medium-dark-gray (N4), and medium-gray (N5), fine- to medium-grained; shale, dark-greenish-gray (5GY4/1), slightly silty.

TOP OF WELLS CREEK: 1526 feet

1520-1530	Limestone, light-gray (N7), and medium-light-gray (N6), very fine- to medium-grained, fairly dolomitic; trace of dark shale; minor pyrite; calcite crystals.
1530-1540	Limestone, light-olive-gray (5Y6/1), and light-gray (N7), fine- to medium-grained, slightly dolomitic; olive-black (5Y2/1) shale streaks; minor calcite crystals.
1540-1550	Dolomite, yellowish-gray (5Y8/1), and light-gray (N7), medium- to coarse-crystalline; slight trace of pyrite.
1550-1560	Limestone, yellowish-gray (5Y8/1), medium-grained; shale, dark-greenish-gray (5GY4/1), slightly silty; bryozoans.
1560-1570	Limestone, light-gray (N7), fine- to medium-grained; dolomite, coarse-crystalline; shale, dark-greenish-gray (5GY4/1); minor pyrite.
	TOP OF KNOX: 1572 feet
1570-1580	Dolomite, very light-gray (N8), very fine- to medium-crystalline; chert, white (N9); some pyrite- and calcite-filled vugs.
1580-1590	Dolomite, light-gray (N7), fine-crystalline, slightly argillaceous; chert, light-olive-gray (5Y6/1); minor pyrite.
1590-1600	Dolomite, light-gray (N7), and light-olive-gray (5Y6/1), very fine- to coarse-crystalline; minor silty shale; trace of pyrite.
1600-1610	Dolomite, light-gray (N7), and yellowish-gray (5Y8/1), fine-crystalline.
1610-1620	Dolomite, yellowish-gray (5Y8/1), and light-olive-gray (5Y6/1), fine- to medium-crystalline, slightly silty; chert, white (N9), dense; calcite crystals.
1620-1630	Dolomite, medium-light-gray (N6), and medium-dark-gray (N4), very fine- to fine-crystalline; streaks of greenish-black (5GY2/1) shale.
1630-1640	Dolomite, light-gray (N7), fine- to medium-crystalline.
1640-1650	Dolomite, light-olive-gray (5Y6/1), fine-crystalline; streaks of greenish-black (5GY2/1) shale.
1650-1660	Dolomite, very light-gray (N8), and light-olive-gray (5Y6/1), fine-crystalline; chert, light-gray (N7) to white (N9).
1660-1670	Dolomite, light-gray (N7), and light-olive-gray (5Y6/1), fine- to coarse-crystalline; minor pyrite.
1670-1680	Dolomite, yellowish-gray (5Y8/1), and light-olive-gray (5Y6/1), very fine- to coarse-crystalline, silty; contains abundant chert, oolitic.
1680-1690	Dolomite, very light-gray (N8), and light-olive-gray (5Y6/1), fine- to medium-crystalline.
1690-1700	Dolomite, light-gray (N7), very fine- to medium-crystalline.
1700-1710	Dolomite, medium-light-gray (N6), fine-crystalline; chert, light-bluish-gray (5B7/1), oolitic; scattered calcite crystals.
	BASE OF DESCRIBED INTERVAL

MONROE COUNTY

OPERATOR: Howard, Orba **WELL NO.:** 1 **FARM:** Martin, O. L. **CARTER COORDINATE:** 13-C-47 530 FNL x 2200 FWL **ELEV.:** 1017 feet **KGS CALL NO.:** 5505.

Depth in Feet	Description
1400-1410	Limestone, medium-gray (N5), and olive-gray (5Y4/1), very fine- to medium-grained, in part slightly calcareous; trace of shale; calcite crystals.
1410-1420	Limestone, medium-gray (N5), fine- to medium-grained, slightly dolomitic; scattered calcite crystals; minor pyrite.
1420-1430	Limestone, medium-gray (N5), and light-olive-gray (5Y6/1), medium-grained, slightly dolomitic; calcite crystals; abundant ostracodes.
1430-1440	Limestone, medium-gray (N5), and olive-gray (5Y4/1), fine- to medium-grained; dolomite, olive-black (5Y2/1); chert, white (N9), oolitic; minor pyrite.
1440-1450	Limestone, medium-dark-gray (N4), fine- to coarse-grained, partly dolomitic, slightly argillaceous; dark-gray (N3) shale streaks; trace of pyrite; calcite crystals.
1450-1460	Limestone, medium-dark-gray (N4), and light-olive-gray (5Y6/1), very fine- to medium-grained; abundant calcite crystals.
1460-1470	Limestone, medium-gray (N5), medium-grained; shale, greenish-black (5GY2/1), calcareous; trace of pyrite; fossil fragments.
1470-1480	Limestone, medium-gray (N5), fine- to coarse-grained, with traces of dolomitic limestone; ostracodes.
1480-1490	Limestone, medium-gray (N5), and olive-black (5Y2/1), very fine- to medium-grained; olive-black (5Y2/1) shale streaks.
1490-1500	Limestone, medium-gray (N5), and olive-gray (5Y4/1), very fine- to medium-grained, fairly dolomitic; scattered calcite crystals.

1500-1510	Limestone, medium-gray (N5), and medium-dark-gray (N4), fine- to coarse-grained, partly dolomitic; streaks of dark shale.
1510-1520	Limestone, olive-black (5Y2/1), and medium-gray (N5), very fine- to fine-grained; contains brachiopods.
1520-1530	Limestone, medium-dark-gray (N4), and light-olive-gray (5Y6/1), medium-grained; minor shale; few brachiopods and ostracodes.
1530-1540	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), fine- to medium-grained, partly dolomitic; streaks of dark shale; scattered calcite crystals.
1540-1550	Limestone, olive-gray (5Y4/1), and light-gray (N7), very fine- to fine-grained; dolomite, brownish-gray (5YR4/1), medium-crystalline; trace of shale.
1550-1560	Limestone, olive-gray (5Y4/1), fine- to medium-grained; dolomite, brownish-gray (5YR4/1), fine- to medium-crystalline; trace of calcite crystals.
1560-1570	Limestone, olive-gray (5Y4/1), fine- to medium-grained, partly dolomitic; trace of dark shale; chert, white (N9); calcite crystals; sparse ostracodes.
1570-1580	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine-grained, slightly dolomitic; with streaks of greenish-gray (5G6/1) shale; bryozoans.
1580-1590	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine- to medium-grained; dolomite, light-olive-gray (5Y6/1), medium-crystalline; calcite crystals.
1590-1600	Limestone, olive-gray (5Y4/1), and dark-gray (N3), fine-grained; bryozoan fragments.
1600-1610	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), very fine- to medium-grained, slightly silty.
1610-1620	Limestone, olive-gray (5Y4/1), and medium-dark-gray (N4), fine- to medium-grained; scattered whole and fragmented bryozoans.
1620-1630	Limestone, olive-gray (5Y4/1), and dark-gray (N3), medium-grained, fairly dolomitic; abundant streaks of dark shale; ostracodes.
1630-1640	Limestone, olive-black (5Y2/1), and greenish-black (5GY2/1), medium- to coarse-grained; rare pyrite.
1640-1650	Limestone, light-olive-gray (5Y6/1), and olive-black (5Y2/1), medium-grained, partly dolomitic; shale, dark-gray (N3), silty in part.
1650-1660	Limestone, light-olive-gray (5Y6/1), fine- to coarse-grained, partly dolomitic; ostracodes and bryozoan fragments.
1660-1670	Limestone, light-olive-gray (5Y6/1), and light-gray (N7), fine- to coarse-grained; trace of pyrite.
1670-1680	Limestone, yellowish-gray (5Y8/1), and light-olive-gray (5Y6/1), medium-grained, slightly silty and dolomitic; minor pyrite; fossil fragments.
1680-1690	Limestone, yellowish-gray (5Y8/1), and light-gray (N7), fine- to medium-grained, calcareous; shale, dark-greenish-gray (5GY4/1); minor pyrite.
	TOP OF WELLS CREEK: 1695 feet
1690-1700	Limestone, light-olive-gray (5Y6/1), and medium-dark-gray (N4), medium-grained, partly dolomitic; minor silty shale; ostracodes.
1700-1710	Dolomite, light-olive-gray (5Y6/1), fine- to coarse-crystalline, slightly argillaceous and limy; slight traces of calcite crystals; minor pyrite.
1710-1720	Dolomite, light-olive-gray (5Y6/1), and some yellowish-gray (5Y8/1), medium-crystalline; shale, greenish-gray (5GY6/1), partly silty; trace of pyrite.
	TOP OF KNOX: 1727 feet
1720-1730	Dolomite, light-olive-gray (5Y6/1), and white (N9), fine- to coarse-crystalline, slightly silty; chert, white (N9), oolitic; scattered pyrite.
1730-1740	Dolomite, light-olive-gray (5Y6/1), and very light-gray (N8), very fine- to medium-crystalline; minor greenish-gray (5GY6/1) shale.
1740-1750	Dolomite, olive-gray (5Y4/1), and yellowish-gray (5Y8/1), very fine- to medium-crystalline, slightly silty; chert, light-bluish-gray (5B7/1); trace of pyrite; minor calcite crystals.
1750-1760	Dolomite, light-olive-gray (5Y6/1), and yellowish-gray (5Y8/1), fine- to medium-crystalline; chert, light-gray (N7); calcite crystals.
1760-1770	Dolomite, olive-gray (5Y4/1), and yellowish-gray (5Y8/1), medium-crystalline.
1770-1780	Dolomite, yellowish-gray (5Y8/1), and light-gray (N7), very fine- to fine-crystalline; chert, light-bluish-gray (5B7/1), oolitic.
	BASE OF DESCRIBED INTERVAL

RUSSELL COUNTY

OPERATOR: Collins, C. G. **WELL NO.:** 1 **FARM:** Tarter, Della **CARTER COORDINATE:** 14-G-55 1680 FSL x 350 FEL **ELEV.:** 1046 ft. **KGS CALL NO.:** 12585.

Depth in Feet	Description
1505-1515	Limestone, medium-light-gray (N6), medium-grained, partly argillaceous and dolomitic; trace calcite crystals; few fossil fragments.
1515-1522	Limestone, medium-gray (N5), medium- to coarse-grained, partly argillaceous; scattered calcite crystals; trace of pyrite.
1522-1534	Limestone, medium-gray (N5), fine- to coarse-grained, slightly argillaceous; trace of calcite crystals; minor pyrite; bryozoans.
1534-1547	Limestone, medium-gray (N5), fine- to medium-grained, trace slightly silty; shale, dark-gray (N3); minor pyrite; fragmented bryozoans.
1547-1557	Limestone, medium-light-gray (N6), fine-grained; trace of dolomite, fine-crystalline; scattered fossil fragments.
1557-1571	Limestone, medium-gray (N5), very fine- to medium-grained, fairly argillaceous; calcite crystals; sparse bryozoans.
1571-1581	Limestone, medium-gray (N5), very fine- to medium-grained, partly dolomitic; fragmented bryozoans and ostracodes.
1581-1591	Limestone, medium-gray (N5), fine-grained, streaked with dolomite; minor pyrite; fragmented bryozoans and ostracodes.
1591-1612	Limestone, medium-gray (N5), fine- to coarse-grained; dolomite, olive-black (5Y2/1), fine- to medium-crystalline; ostracodes.
1612-1623	Limestone, light-gray (N7), and medium-gray (N5), medium-grained, slightly dolomitic; ostracodes.
1623-1638	Limestone, pinkish-gray (5YR8/1), and brownish-gray (5YR4/1), very fine- to medium-grained, slightly argillaceous; minor dolomitic limestone.
1638-1648	Limestone, light-brownish-gray (5YR6/1), and brownish-gray (5YR4/1), fine- to coarse-grained; slight trace of dark shale; minor calcite crystals.
1648-1658	Limestone, brownish-gray (5YR4/1), and light-gray (N7), fine-grained; shale, greenish-black (5GY2/1), silty; sparse ostracodes.
1658-1668	Limestone, brownish-gray (5YR4/1), and light-gray (N7), fine- to medium-grained; scattered calcite crystals.
1668-1678	Limestone, brownish-gray (5YR4/1), and light-gray (N7), fine- to medium-grained, partly dolomitic; slight trace of shale; bryozoan debris.
1678-1688	Limestone, brownish-gray (5YR4/1), and yellowish-gray (5Y8/1), very fine- to medium-grained, slightly dolomitic; minor pyrite.
1688-1694	No sample.
1694-1702	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), medium-grained; dolomite, light-gray (N7), coarse-crystalline; fragmented bryozoans.
1702-1717	Limestone, light-brownish-gray (5YR6/1), and yellowish-gray (5Y8/1), medium- to coarse-grained; dolomite, light-gray (N7), medium- to coarse-crystalline; minor shale streaks.
1717-1730	Limestone, light-brownish-gray (5YR6/1), and medium-light-gray (N6), medium-grained, slightly argillaceous and dolomitic; slight trace of dark shale, calcareous.
1730-1743	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), fine- to medium-grained; minor pyrite; calcite crystals; few fossil fragments.
1743-1753	Limestone, brownish-gray (5YR4/1), very fine- to fine-grained; shale, medium-dark-gray (N4), slightly silty; scattered calcite crystals.
	TOP OF WELLS CREEK: 1765 feet
1753-1768	Dolomite, brownish-gray (5YR4/1), and light-brownish-gray (5YR4/1), fine- to medium-crystalline, fairly argillaceous; streaks of dark shale; minor pyrite.
1768-1778	Limestone, light-brownish-gray (5YR6/1), and medium-dark-gray (N4), fine- to coarse-grained; streaked with crystalline dolomite; minor pyrite.
1778-1789	Limestone, dark-gray (N3), and brownish-gray (5YR4/1), medium-grained, fairly dolomitic; shale, greenish-gray (5G6/1); some calcite crystals; bryozoans.
1789-1805	Limestone, brownish-gray (5YR4/1), and yellowish-gray (5Y8/1), medium to coarse-grained; dolomite, medium-dark-gray (N4), very fine- to medium-crystalline; bryozoans.
1805-1811	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), very fine- to coarse-grained, dolomitic, slightly argillaceous; slight traces of shale; scattered fossils.
1811-1822	Limestone, brownish-gray (5YR4/1), and yellowish-gray (5Y8/1), fine- to medium-grained, slightly silty; shale, olive-gray

	(5Y4/1), calcareous; scattered pyrite; minor calcite crystals.
	TOP OF KNOX: 1830 feet
1822-1834	Dolomite, brownish-gray (5YR4/1), and dark-gray (N3), very fine- to coarse-crystalline; chert, white (N9), oolitic; minor dark shale, silty; scattered pyrite.
1834-1845	Dolomite, yellowish-gray (5Y8/1), and dark-gray (N3), fine- to medium-crystalline, partly silty; chert, light-bluish-gray (5B7/1); minor silty shale; trace of pyrite.
1845-1852	Dolomite, light-brownish-gray (5YR6/1), and light-bluish-gray (5B7/1), fine-crystalline; small amount of limestone, olive-gray (5Y4/1), medium- to coarse-grained; minor chert.
1852-1861	Dolomite, light-gray (N7), very fine- to coarse-crystalline, partly silty; trace argillaceous limestone; scattered calcite crystals; trace of chert.
1861-1869	Dolomite, very light-gray (N8), and light-brownish-gray (5YR4/1), very fine- to medium-crystalline; chert, light-gray (N7) to white (N9), oolitic; minor shale, dark-greenish-gray (5GY4/1).
1869-1880	Dolomite, light-brownish-gray (5YR6/1), and pinkish-gray (5YR8/1), fine- to medium-crystalline; streaked with dark-greenish-gray (5GY4/1) shale, slightly silty; calcite crystals.
1880-1888	Dolomite, light-gray (N7), and very light-gray (N7), fine- to coarse-crystalline; chert, light-gray (N7), oolitic, translucent to opaque; trace shale.
1888-1896	Dolomite, light-brownish-gray (5YR6/1), fine- to medium-crystalline, slightly argillaceous; shale, dark-greenish-gray (5GY4/1); minor pyrite.
1896-1908	Dolomite, light-brownish-gray (5YR6/1), and white (N9), medium-crystalline, silty; contains abundant chert, oolitic; minor silty dark shale; sparse pyrite.
1908-1917	Dolomite, light-brownish-gray (5YR6/1) and pinkish-gray (5YR8/1), medium- to coarse-crystalline, slightly silty; chert, light-gray (N7) to white (N9).
1917-1926	Dolomite, light-brownish-gray (5YR6/1), and very light-gray (N8), medium-crystalline; minor white (N9) chert; trace of olive-gray (5Y4/1) shale, silty.
1926-1937	Dolomite, light-brownish-gray (5YR6/1), and light-gray (N7), fine- to medium-crystalline; chert, light-gray (N7); calcite crystals; trace of pyrite.
1937-1942	No sample.
1942-1947	Dolomite, light-brownish-gray (5YR6/1), and white (N9), fine- to medium-crystalline, slightly argillaceous; traces of calcite crystals; sparse pyrite.
1947-1952	Dolomite, light-brownish-gray (5YR6/1), and white (N9), medium-crystalline; minor greenish-gray (5GY6/1) shale.
1952-1960	Dolomite, yellowish-gray (5Y8/1), very fine- to medium-crystalline, slightly silty; chert, light-bluish-gray (5B7/1), oolitic.
1960-1970	No sample.
1970-1980	Dolomite, very light-gray (N8), and medium-light-gray (N6), fine- to medium-crystalline; minor pyrite and chert.
1980-1985	Dolomite, light-gray (N7), and brownish-gray (5YR4/1), fine-crystalline; chert, white (N9), dense; minor shale streaks; scattered calcite crystals.
1985-1992	Dolomite, light-gray (N7), and brownish-gray (5YR4/1), fine-crystalline, slightly silty; chert, light-bluish-gray (5B7/1); trace of pyrite.
1992-1998	Dolomite, brownish-gray (5YR4/1), and white (N9), very fine- to fine-crystalline; slight traces of chert, oolitic; scattered calcite crystals.
1998-2005	Dolomite, light-brownish-gray (5YR6/1), and light-bluish-gray (5B7/1), medium-crystalline, slightly argillaceous and silty; contains some calcite-filled vugs.
	BASE OF DESCRIBED INTERVAL

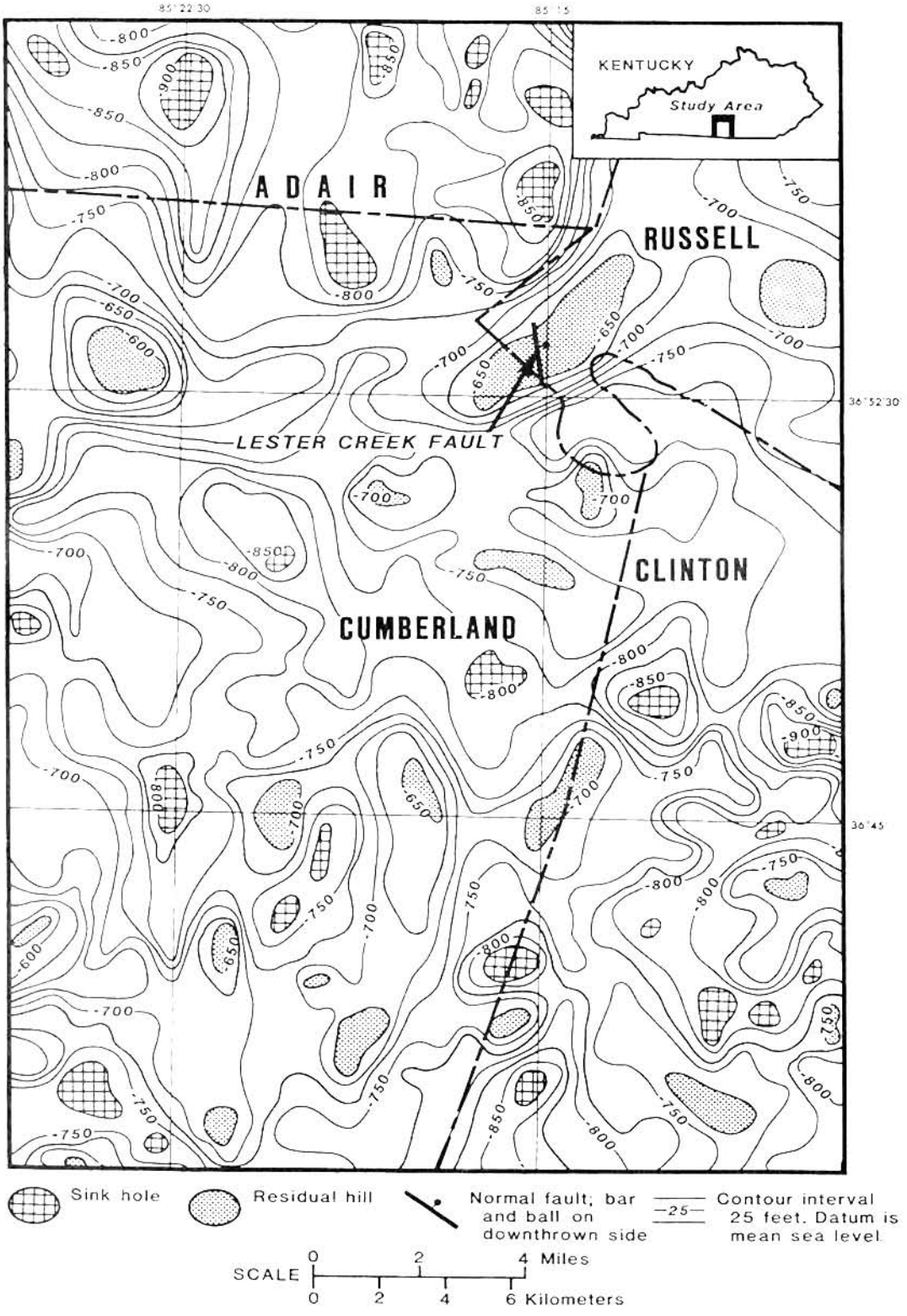
WAYNE COUNTY

OPERATOR: Alexander, Leroy **WELL NO.:** 1 **FARM:** Coyle, James **CARTER COORDINATE:** 10-C-55 2600 FSL x 2700 FEL **ELEV.:** 1358 ft. **KGS CALL NO.:** 9591.

Depth in Feet	Description
1900-1910	Limestone, medium-dark-gray (N4), medium-grained, slightly argillaceous; shale, brownish-black (5YR2/1).
1910-1920	Limestone, medium-dark-gray (N4), fine- to medium-grained; shale, brownish-black (5YR2/1), partly calcareous; contains small amount of calcite crystals.
1920-1930	Limestone, medium-dark-gray (N4), medium-grained, argillaceous, slightly dolomitic; slight traces of dark shale; minor pyrite.

1930-1940	Limestone, medium-dark-gray (N4), very fine- to fine-grained; dolomite stringers, light-brownish-gray (5YR4/1) to brownish-gray (5YR4/1), argillaceous.
1940-1950	Limestone, medium-dark-gray (N4), very fine- to medium-grained, partly dolomitic; scattered calcite crystals; sparse bryozoans and ostracodes.
1950-1960	Limestone, medium-dark-gray (N4), fine- to coarse-grained, argillaceous; streaks of dark shale; calcite crystals; ostracodes.
1960-1970	Limestone, medium-dark-gray (N4), fine- to medium-grained, slightly argillaceous and dolomitic; few calcite crystals; trace of pyrite; fossil fragments.
1970-1980	Limestone, medium-dark-gray (N4), medium-grained; minor amounts of shale, olive-black (5Y2/1).
1980-1990	Limestone, medium-dark-gray (N4), medium-grained; slight traces of dark shale; minor pyrite; ostracodes.
1990-2000	Limestone, medium-dark-gray (N4), fine-grained; fairly dolomitic; shale, dark-gray (N3), silty and calcareous; sparse pyrite.
2000-2010	Limestone, medium-dark-gray (N4), fine- to medium-grained; shale, dark-gray (N3), silty; few crinoid fragments.
2010-2020	Limestone, brownish-gray (5YR4/1), and medium-dark-gray (N4), fine-grained; minor silty shale; scattered calcite crystals.
2020-2030	Limestone, brownish-gray (5YR4/1), and dark-greenish-gray (5GY4/1), fine-grained; shale, brownish-black (5YR2/1), slightly silty; bryozoans.
2030-2040	Limestone, brownish-gray (5YR4/1), and dark-greenish-gray (5GY4/1), fine- to coarse-grained, fairly argillaceous; dolomite, olive-black (5Y2/1), fine-crystalline.
2040-2050	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), very fine- to medium-grained; dolomite, olive-black (5Y2/1), fine-crystalline; some pyrite.
2050-2060	Limestone, brownish-gray (5YR4/1), and medium-gray (N5), fine- to medium-grained, partly slightly dolomitic; brachiopods and bryozoans.
2060-2070	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to coarse-grained; bryozoan fragments.
2070-2080	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), coarse-grained.
2080-2090	Limestone, medium-dark-gray (N4), fine- to coarse-grained; bryozoans.
2090-2100	Limestone, medium-gray (N5), and medium-dark-gray (N4), medium-grained, partly dolomitic; streaks of dark shale; scattered calcite crystals.
2100-2110	Limestone, olive-gray (5Y4/1), and dark-gray (N3), medium- to coarse-grained; dolomite, brownish-gray (5YR4/1), medium-crystalline; trace of shale.
2110-2120	Limestone, medium-gray (N5), and brownish-gray (5YR4/1), medium-grained, slightly dolomitic; shale, dark-gray (N3), partly silty; ostracode fragments.
2120-2130	Limestone, light-olive-gray (5Y6/1), and medium-gray (N5), very fine- to medium-grained.
2130-2140	Limestone, medium-dark-gray (N4), and white (N9), very fine- to fine-grained, partly dolomitic; minor dark shale; calcite crystals; fossil fragments.
2140-2150	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine-grained, argillaceous; shale, greenish-black (5GY2/1); few calcite crystals.
2150-2160	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine- to medium-grained, argillaceous; shale, greenish-black (5GY2/1).
	TOP OF WELLS CREEK: 2166 feet
2160-2170	Limestone, medium-dark-gray (N4), and brownish-gray (5YR4/1), fine-grained, slightly dolomitic; minor shale, greenish-black (5GY2/1), scattered calcite crystals.
2170-2180	Limestone, medium-gray (N5), and light-brownish-gray (5YR4/1), fine- to coarse-grained, trace slightly dolomitic; minor shale; trace of pyrite; conodonts.
2180-2190	Limestone, light-brownish-gray (5YR6/1), and medium-dark-gray (N4), medium-grained, partly dolomitic, silty; shale, greenish-gray (5G6/1); bryozoans.
2190-2200	Limestone, light-brownish-gray (5YR6/1), and medium-dark-gray (N4), medium- to coarse-grained, partly silty; minor dark shale; scattered calcite crystals.
2200-2210	Limestone, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), fine- to medium-grained; shale, brownish-gray (5YR4/1), slightly silty.
2210-2220	Limestone, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), medium-grained; streaks of dark shale; minor pyrite; sparse calcite crystals.
2220-2230	Limestone, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), me-

	dium-grained, partly silty; shale, greenish-gray (5GY6/1); trace of pyrite; bryozoans.
2230-2240	Limestone, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), fine- to medium-grained, slightly dolomitic; slight traces of shale; calcite crystals; minor pyrite.
	TOP OF KNOX: 2240 feet
2240-2250	Dolomite, light-brownish-gray (5YR6/1), and light-greenish-gray (5G8/1), very fine- to coarse-crystalline; minor silty shale, greenish-gray (5GY6/1); trace of pyrite.
2250-2260	Dolomite, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), very fine- to medium-crystalline; chert, light-gray (N7), dense; trace of pyrite.
2260-2270	Dolomite, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), fine-crystalline, slightly sandy; chert, light-gray (N7) to white (N9); calcite crystals.
2270-2280	Dolomite, light-brownish-gray (5YR6/1), and dark-greenish-gray (5GY4/1), fine-crystalline; shale, olive-gray (5Y4/1), slightly silty; flecked with calcite crystals.
2280-2290	Dolomite, light-brownish-gray (5YR6/1), and light-green (N7), very fine- to coarse-crystalline, trace slightly argillaceous; minor shale; scattered pyrite.
2290-2300	Dolomite, light-brownish-gray (5YR6/1), and greenish-gray (5G6/1), medium- to coarse-crystalline; chert, light-bluish-gray (5B7/1), oolitic, translucent to opaque.
2300-2310	Dolomite, light-brownish-gray (5YR6/1), and yellowish-gray (5Y8/1), medium-crystalline; minor greenish-gray (5GY6/1) shale; trace of pyrite.
2310-2320	Dolomite, yellowish-gray (5Y8/1), and light-brownish-gray (5YR4/1), fine- to coarse-crystalline, partly silty.
2320-2330	Dolomite, greenish-gray (5G6/1), and light-brownish-gray (5YR4/1), fine- to medium-crystalline; chert, light-gray (N7) to white (N9), dense.
2330-2340	Dolomite, greenish-gray (5G6/1), and medium-light-gray (N6), medium-crystalline, slightly silty; chert, white (N9), oolitic, dense; calcite crystals.
2340-2350	Dolomite, light-gray (N7), and light-brownish-gray (5YR4/1), fine- to medium-crystalline; trace of greenish-gray (5G6/1) shale.
2350-2360	Dolomite, medium-light-gray (N6), fine- to coarse-crystalline, scattered sandy; chert, white (N9), translucent; few calcite crystals.
2360-2370	Dolomite, light-gray (N7) to light-olive-gray (5Y6/1), very fine- to fine-crystalline; chert, white (N9), oolitic; some calcite in fractures.
2370-2380	Dolomite, medium-gray (N5), very fine-crystalline, partly silty; rare dark shale streaks; trace of pyrite.
2380-2390	Dolomite, medium-light-gray (N6), and light-gray (N7), very fine- to medium-crystalline, slightly silty; chert, yellowish-gray (5Y8/1), oolitic; calcite crystals.
	BASE OF DESCRIBED INTERVAL



Paleotopographic map showing residual hills and sinkholes developed on the eroded Knox Dolomite in south–central Kentucky (portion of Plate 2). Structure contours on top of the Knox Group.

GENERALIZED GEOLOGIC COLUMN FOR SOUTH-CENTRAL KENTUCKY

PATRICK J. GOODING

THESIS SERIES 4
PLATE 1

EXPLANATION OF LITHOLOGIC SYMBOLS

- Gravel or Conglomerate
- Sand and Sandstone
- Crossbedded Sandstone
- Ripplebedded Sandstone
- Interbedded Limestone and Calcareous Shale
- Silt or Siltstone
- Calcareous Siltstone
- Dolomitic Siltstone
- Clay Shale
- Carbonaceous Shale
- Calcareous Shale
- Dolomitic Shale
- Sandy Shale
- Interbedded Sandstone and Shale
- Interbedded Shale and Silty Limestone
- Interbedded Limestone and Shale
- Interbedded Limestone and Calcareous Shale
- Limestone
- Crossbedded Limestone
- Argillaceous Limestone
- Silty Limestone
- Dolomitic Limestone
- Cherty Limestone
- Oolitic Limestone
- Clastic Limestone
- Dolomite
- Sandy Dolomite
- Silty Dolomite
- Oolitic Dolomite
- Cherty Dolomite
- Coal
- Bentonite
- Granite
- Unconformity

SYSTEM	SERIES	FORMATION, GROUP, OR MEMBER	LITHOLOGY	THICKNESS IN FEET	Drillers Terminology
QUATERNARY	PLEISTOCENE AND HOLOCENE	ALLUVIUM		0–60	
	PLEISTOCENE	TERRACE DEPOSITS		0–60	
PENNSYLVANIAN	LOWER AND MIDDLE	BREATHITT AND LEE FORMATIONS		630 +	
MISSISSIPPIAN	UPPER	PENNINGTON FORMATION		30–220	
		BANGOR LIMESTONE		35–180	
		HARTSELLE FORMATION		10–50	
		MONTEAGLE LIMESTONE: KIDDER LIMESTONE MEMBER		55–300	
		MONTEAGLE LIMESTONE: STE. GENEVIEVE MEMBER			
		ST. LOUIS LIMESTONE		25–180 +	
		SALEM AND WARSAW FORMATIONS		35–140	
	LOWER	FORT PAYNE FORMATION / BORDEN FORMATION		50–365	✳ Beaver
DEVONIAN	UPPER	CHATTANOOGA SHALE		5–60	
	MIDDLE	BOYLE LIMESTONE		0–15	
SILURIAN	MIDDLE	LOUISVILLE LIMESTONE (LEGO)		0–115	
		WALDRON SHALE		0–10	• ✳ Blue Sand
		LAUREL DOLOMITE		0–70	
		OSGOOD SHALE		0–55	
	LOWER	BRASSFIELD DOLOMITE		0–30	• Yellow Cap
ORDOVICIAN	UPPER	CUMBERLAND FORMATION: DRAKES FORMATION		0–130	
		CUMBERLAND FORMATION: ASHLOCK FORMATION			
		LEIPERS FORMATION		20–180	
		GARRARD SILTSTONE		10–125	
	MIDDLE AND UPPER	CLAYS FERRY FORMATION		60–390	• Modoc • ✳ Granville
		LEXINGTON LIMESTONE		190–255	• ✳ Upper Sunnybrook • Anderson • ✳ Lower Sunnybrook
	MIDDLE	HIGH BRIDGE GROUP: TYRONE AND CAMP NELSON LIMESTONES		1025 ±	Mud Cave Pencil Cave • Stones River • Murfreesboro

Continued

SYSTEM	SERIES	FORMATION, GROUP, OR MEMBER	LITHOLOGY	THICKNESS IN FEET
ORDOVICIAN	LOWER	WELLS CREEK DOLOMITE		10–95
		GROUP: BEEKMANTOWN DOLOMITE: MASCOT DOLOMITE		1250 ±
		GROUP: BEEKMANTOWN DOLOMITE: KINGSPORT DOLOMITE		
		GROUP: BEEKMANTOWN DOLOMITE: LONGVIEW DOLOMITE		
		GROUP: BEEKMANTOWN DOLOMITE: CHEPULTEPEC DOLOMITE		
	UPPER	KNOX: COPPER RIDGE DOLOMITE		2250 ±
CAMBRIAN	LOWER–MIDDLE	CONASAUGA FORMATION		180 ±
		ROME FORMATION		1025 ±
		BASAL SAND		700 ±
PRECAMBRIAN		BASEMENT		

THESIS SERIES 4
PLATE 2

EXPLANATION

-875 — Structure drawn on top of the Knox Group. Contour interval 25 feet. Datum is mean sea level

-850

-825

Location of control point used in drawing structure contours

-750
-725
Lowest contour of closed structural low indicated by hachures. Probably represents paleosinkhole

-575
-600
Structural high indicated by stipple pattern. May represent residual hill on eroded Knox surface

Normal fault; bar and ball on downthrown side

Strike-slip movement; arrows indicate direction of relative displacement

D U
Subsurface fault. U, upthrown side; D, downthrown side

Scale 1:125,000

5 0 5 MILES

5 0 5 KILOMETERS

Letters and numbers along the map margins pertain to the Carter coordinate grid system that is used for locating wells in the KGS files.

MAP SHOWING STRUCTURE ON TOP OF THE KNOX GROUP

Patrick J. Gooding

THESIS SERIES 4
PLATE 3

ISOPACH MAP OF THE WELLS CREEK DOLOMITE

Patrick J. Gooding

EXPLANATION

- 50 — Isopach line showing thickness of the Wells Creek Dolomite. Contour interval 10 feet
- Location of control point used in drawing isopach lines
- Normal fault; bar and ball on downthrown side
- Strike-slip movement; arrows indicate direction of relative displacement
- D/U — Subsurface fault. U, upthrown side; D, downthrown side

Scale 1:125,000

5 0 5 MILES

5 0 5 KILOMETERS

Letters and numbers along the map margins pertain to the Carter coordinate grid system that is used for locating wells in the KGS files.

THESIS SERIES 4
PLATE 4

MAP SHOWING STRUCTURE ON TOP OF THE PENCIL CAVE BENTONITE

Patrick J. Gooding

EXPLANATION

-125 — Structure contour drawn on top of the Pencil Cave bentonite. Contour interval 25 feet. Datum is mean sea level

Location of control point used in drawing structure contours

Normal fault; bar and ball on downthrown side

Strike-slip movement; arrows indicate direction of relative displacement

Subsurface fault. U, upthrown side; D, downthrown side

Scale 1:125,000

5 0 5 MILES

5 0 5 KILOMETERS

Letters and numbers along the map margins pertain to the Carter coordinate grid system that is used for locating wells in the KGS files.

LOCATIONS OF OIL AND GAS POOLS IN SOUTH-CENTRAL KENTUCKY

Patrick J. Gooding

EXPLANATION

OIL
- Producing oil pool
- Abandoned oil pool

GAS
- Producing gas pool
- Abandoned gas pool
- Pool-consolidation outline

PRODUCING FORMATIONS
- A — Knox production
- B — Production from both Knox and other formations
- C — Production from formation other than Knox

FAULTS
- Normal fault; bar and ball on downthrown side
- Strike-slip movement; arrows indicate direction of relative displacement
- Subsurface fault. U, upthrown side; D, downthrown side

Scale 1:125,000

5 0 5 MILES

5 0 5 KILOMETERS

Letters and numbers along the map margins pertain to the Carter coordinate grid system that is used for locating wells in the KGS files.