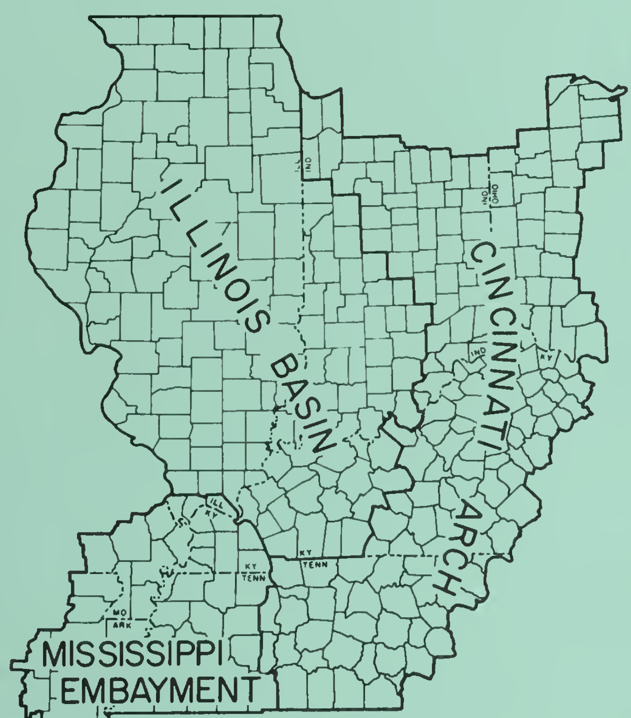
STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

BACKGROUND MATERIALS
FOR
SYMPOSIUM ON FUTURE PETROLEUM POTENTIAL OF NPC REGION 9 (ILLINOIS BASIN, CINCINNATI ARCH, AND NORTHERN PART OF MISSISSIPPI EMBAYMENT)

CHAMPAIGN, ILLINOIS, MARCH 11-12, 1971



ILLINOIS PETROLEUM 96

ILLINOIS STATE GEOLOGICAL SURVEY
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CONTENTS

Errata

Page 48, well 88:	There should be a question mark under "Top of Trenton"
Page 52, well 156:	*For* 1,590 *read* 1,598
	For -1,688 *read* -1,680
	For -2,674 *read* -2,666
Page 52, well 160:	*For* Cambrian Pre-Knox *read* Cambrian basal sandstone
	For -5,551 *read* -5,501
Page 54, well 210:	*For* 13-I-57 *read* 13-L-57
Page 55, well 238:	*For* Knox *read* Conasauga
Page 56, map:	*For* 100 *read* 99
	For 99 *read* 100

INTRODUCTION

A symposium on the future petroleum potential of NPC Region 9 (Illinois Basin, Cincinnati Arch, and northern part of Mississippi Embayment) was held in Champaign, Illinois, March 11 and 12, 1971. The symposium was an outgrowth of a study on the same topic that was made for the National Petroleum Council and subsequently published by the American Association of Petroleum Geologists in their Memoir 15 (Future Petroleum Provinces of the United States—Their Geology and Potential, 1971, Ira H. Cram, editor). The purpose of the symposium was to present new information and concepts and to further develop ideas based on the material in the NPC study.

Before this symposium was held, a preprint was prepared and given to all who registered for the meeting. The preprint contained the program of the symposium, abstracts of the papers to be presented, and the texts of three papers giving background information on the stratigraphy and structure of the Eastern Interior Region (NPC Region 9).

The proceedings of the symposium have been published in Illinois Petroleum 95. This includes the texts of the papers presented, together with some materials presented at round-table discussions, and the summary and concluding remarks by L. L. Sloss.

The present volume, Illinois Petroleum 96, contains the three background papers which originally appeared in the preprints, a list of selected deep tests, a map showing the location of these tests, and a list of those who registered for the symposium.

Of the three background papers, the one by T. C. Buschbach on the stratigraphic setting and the one by H. M. Bristol and T. C. Buschbach on the structural features have been modified or expanded from the material in the NPC study. The third paper, by Elwood Atherton on the tectonic development of the region, assumes a knowledge of the first two papers and is a new report, much more detailed than the discussion of the structure of Region 9 in the earlier study. A number of the maps in this volume were prepared for the NPC report and have been published in Memoir 15. They appear here by permission of the American Association of Petroleum Geologists. Small differences exist in the approved nomenclature of the geological surveys of the states included in this region. The usage followed in these three papers is somewhat generalized and does not exactly conform to official usage in any one of these states. The authors of these three papers acknowledge with thanks the considerable contributions and assistance of the members of the task force who worked on the NPC study of Region 9. The task force included John C. Frye, Co-ordinator, D. C. Bond, Elwood Atherton, H. M. Bristol, T. C. Buschbach, and D. L. Stevenson, Illinois Geological Survey; L. E. Becker and T. A. Dawson, Indiana Geological Survey; E. C. Fernalld, Howard Schwalb and E. N. Wilson, Kentucky Geological Survey; A. T. Statler, Tennessee Division of Geology; R. G. Stearns, Vanderbilt University; and J. H. Buehner, Marathon Oil Company.

D. C. Bond
Chairman of Symposium Committee

STRATIGRAPHIC SETTING OF THE EASTERN INTERIOR REGION OF THE UNITED STATES

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ABSTRACT

Coordinated studies of the Illinois Basin, Cincinnati Arch, and upper Mississippi Embayment Provinces show that Paleozoic rocks, here divided into 10 major rock-stratigraphic units, are more than 14,000 feet thick in the deep part of the Illinois Basin. They thin depositionally and by erosion to 2000 to 3000 feet on the arches and domes surrounding the basin. Tertiary and Cretaceous sediments are present in the upper Mississippi Embayment. They thicken southward and are about 3300 feet thick near Memphis, Tennessee.

The Pennsylvanian System - chiefly shale and sandstone - and the Chesterian Series - shale, sandstone, and limestone - are restricted almost entirely to the Illinois Basin. They are up to 3300 and 1400 feet thick, respectively, in the southern part of the basin. The Mammoth Cave-Knobs Megagroups - carbonates above, siltstones and shales below - and the Hunton Megagroup - chiefly carbonates - have a wider distribution in the region, but they are thin or eroded outside the basin area. Each unit reaches about 2000 feet in thickness, and like the Pennsylvanian and Chesterian strata they appear to thicken southward in the Illinois Basin up to their truncated edges.

The Maquoketa Group - a shaly unit of Cincinnatian (Upper Ordovician) age - is 200 feet thick in much of Illinois but thickens eastward to 1000 feet in northwestern Ohio. It is eroded along much of the Cincinnati Arch. The Ottawa Megagroup is a widespread carbonate unit that thickens southward in the region from 300 feet in northern Illinois to 1400 feet in the northern part of the Mississippi Embayment. The Glenwood Shale and the St. Peter Sandstone are relatively thin units that were mapped separately because of their caprock and reservoir possibilities.

The Knox Megagroup - Lower Ordovician and Upper Cambrian dolomites - underlies a marked unconformity, and as a result, its thickness is unpredictable in the northern part of the region. The Knox thickens regularly southward to about 7000 feet before it reaches the Pascola Arch in the upper Mississippi Embayment Province. The Potsdam Megagroup includes all sediments - chiefly sandstone, siltstone, and shale - below the Knox. It is less than 500 feet thick at the eastern edge of the region, over the Waverly Arch, and thickens to about 3000 feet in the Rome Trough of central Kentucky and in an area of thick Mt. Simon deposition in northern Illinois.

Figure 1 - Area of study showing counties and major geologic provinces. From AAPG Memoir 15. Published with permission of the American Association of Petroleum Geologists.

INTRODUCTION

To discuss the stratigraphy of the Eastern Interior Region (fig. 1) without becoming immersed in details of correlations, facies relationships, and local names, required combining units of similar rock types into major rock-stratigraphic units. Many of the units are larger than groups and have been designated as megagroups (Swann and Willman, 1961). The units are defined on the basis of their gross lithology, and their boundaries do not generally follow time planes. The units mapped and discussed in the text are shown with their principal rock types, generalized geologic age, and some common local names (fig. 2).

The author gratefully acknowledges the basic contributions made by members of the National Petroleum Council task force, Region 9, and particularly Elwood Atherton, who wrote the post-Ordovician stratigraphy portion of the N.P.C. report. Figure 1 and figures 3 through 12 are taken from a report on Region 9 (Bond et al., 1971) for AAPG Memoir 15, Future Petroleum Provinces of the United States—Their Geology and Potential, edited by Ira H. Cram, and are used with permission of the American Association of Petroleum Geologists.

STRATIGRAPHY

Post-Paleozoic Rocks

The post-Paleozoic rocks have not been mapped for this report. Most of the northern half of the region, north of the Ohio River, has been covered by from a few to a few hundred feet of Pleistocene glacial drift. Tertiary and Cretaceous sediments are present chiefly in the upper Mississippi Embayment portion of the region. They thicken southward from southernmost Illinois and are about 3300 feet thick near Memphis, Tennessee. The sediments are mostly sand and clay and contain some lignite and impure limestone.

Pennsylvanian System

The Pennsylvanian System underlies most of the southern four-fifths of Illinois, much of southwestern Indiana, and a portion of northwestern Kentucky (fig. 3). The strata have a maximum thickness of almost 3300 feet in the Moorman Syncline of western Kentucky.

The several hundred lithologic units show cyclical repetition and have been grouped into about 50 cyclothems. Pennsylvanian rocks consist mostly of shale and sandstone with thin, but extensive, beds of limestone, coal, and underclay. The Pennsylvanian is divided into seven formations in Illinois, ten in Indiana, and five in Kentucky.

Chesterian Series

The Chesterian Series is present in southern Illinois, southwestern Indiana, and western Kentucky (fig. 4) and has thicknesses of over 1400 feet in southern Illinois. To permit the use of pre-existing maps, the Aux Vases is included with the Chesterian in Illinois, whereas the Paoli is excluded from the Mammoth Cave in Indiana.

The Chesterian Series is a sequence of about 20 formations, alternately limestone-with-shale and sandstone-with-shale units. Almost all of these units thicken southward to their truncated edges. The Chesterian is composed of about two parts of shale to one each of sandstone and limestone. Much of the limestone and shale is abundantly fossiliferous. In the southern part of the Chesterian area, the lower portion of the series is almost all limestone; in the southeastern part of the area, the upper portion is almost all shale.

Mammoth Cave and Knobs Megagroups

The Mammoth Cave Megagroup is the main body of Mississippian carbonate rocks, often called "Mississippi lime" by drillers. Its base is at the top of the Borden Siltstone (fig. 2). In western

System	Mapped intervals	Principal rock types	Geologic age	Common local names: Illinois Basin	Common local names: Cincinnati Arch (North)	Common local names: Cincinnati Arch (South)	Common local names: Mississippi Embayment	Sequence
PENN.	Pennsylvanian System	Shale, sandstone	Pennsylvanian					ABSA.
MISSISSIPPIAN	Chesterian Series	Shale, sandstone, limestone	Upper Mississippian					KASKASKIA
MISSISSIPPIAN	Mammoth Cove	Carbonates	Middle Mississippian	Ste. Genevieve St. Louis Salem (West) Warsaw, Keokuk, Burlington (East) Borden		Ste. Genevieve St. Louis Warsaw	Ste. Genevieve St. Louis Warsaw Fort Payne	KASKASKIA
MISSISSIPPIAN / SIL. - DEV.	Knobs Megagroups	Siltstone, shale	Middle & Lower Mississippian Upper Devonian	New Albany		Fort Payne Chattanooga	New Providence New Albany	KASKASKIA
SIL. - DEV.	Hunton Megagroup	Carbonates	Middle Devonian Lower Devonian Silurian					TIPPECANOE
ORDOVICIAN	Maquoketa Group	Shale	Upper Ordovician (Cincinnatian)	Maquoketa	Richmond Maysville Eden	Richmond Maysville Eden	Maquoketa	TIPPECANOE
ORDOVICIAN	Ottawa Megagroup	Carbonates	Middle Ordovician (Champlainian)	Galena Platteville Joachim	Trenton Black River	Lexington (Ky.) Nashville (Tenn.) Tyrone "Pencil Cave" High Bridge (Ky.) Stones River (Tenn.)	Kimmswick Plattin Pecatonica Joachim Dutchtown	TIPPECANOE
ORDOVICIAN	Glenwood Shale	Shale	Middle Ordovician					TIPPECANOE
ORDOVICIAN	St. Peter Sandstone	Sandstone	Middle Ordovician					TIPPECANOE
ORDOVICIAN	Knox Megagroup	Dolomite	Lower Ordovician (Canadian)	Prairie du Chien Group: Shakopee New Richmond Oneota Gunter Ss.	Prairie du Chien	Upper Knox Rose Run Sd.	Everton Smithville Powell Cotter Jefferson City Roubidoux Gasconade Gunter Ss. M.	SAUK
CAMBRIAN	Knox Megagroup	Dolomite	Upper Cambrian (Croixan)	Eminence Potosi Franconia (Upper & South)	Trempealeau	Copper Ridge	Eminence Potosi Elvins (Upper)	SAUK
CAMBRIAN	Potsdam Megagroup	Sandstone, siltstone, shale, carbonates	Cambrian	Franconia (Lower & North) Ironton (North) Galesville (North) Eau Claire Mt. Simon	Franconia Ironton - Galesville (NW) Eau Claire Mt. Simon	Conasauga Rome Tomstown Antietam	Elvins (Lower) Bonneterre Lamotte Pre-Lamotte sedimentary rocks?	SAUK

Figure 2 - Mapped intervals showing Paleozoic rock types, geologic ages, and common local names.

Illinois, where the Borden is absent, the base of the Mammoth Cave is at the top of the New Albany Shale. The upper part of the Mammoth Cave contains important oil-bearing oolite beds.

The Knobs Megagroup, a body of Mississippian siltstone and shale and Upper Devonian shale, underlies the Mammoth Cave. In this report, the two megagroups are combined, and together they reach a maximum thickness of more than 2200 feet in southern Illinois. The thickness of the Mammoth Cave-Knobs is mapped only where it is overlain by continuous Chesterian deposits, chiefly in the Illinois Basin (fig. 5). The Knobs Megagroup includes a major deltaic deposit of siltstone to the northeast, rimmed by very cherty strata. In Kentucky and northern Tennessee the Knobs includes bioherms that are oil-productive.

Near the base of the Knobs Megagroup there is a thin limestone (Chouteau in Illinois, Rockford in Indiana) which is underlain by up to 400 feet of dominantly black or brownish black shale (New Albany in Illinois and Indiana, Chattanooga in Kentucky and Tennessee). The shale has been removed by erosion over the major arches in the region.

Hunton Megagroup

The carbonate rocks of the Middle and Lower Devonian Series are combined with those of the Silurian System to make the Hunton Megagroup. The Hunton has a maximum thickness of over 1800 feet in southern Illinois and is eroded or absent over most of the domes and arches that bound the Illinois Basin (fig. 6).

The Middle Devonian Series is limestone with some dolomite. It is more than 400 feet thick in southeastern Illinois and adjacent Kentucky. It thins more rapidly to the south and west than to the east and north of that area and is absent on the Sangamon Arch of western Illinois. In this series, the Tioga Bentonite Bed is a useful marker, best recognized on sonic logs. It extends, with erosional interruptions, from central Illinois into the Appalachian Basin. The Dutch Creek Sandstone Member is a discontinuous but widely distributed basal unit of the Middle Devonian. The Lower Devonian Series is present chiefly in the southern part of the Illinois Basin and the northern part of the Mississippi Embayment and as a thin wedge on the west side of the Cincinnati Arch in Tennessee and southern Kentucky. It is limestone and dolomite, cherty to very cherty, with a maximum thickness of about 1200 feet at the southern tip of Illinois. One or two relatively pure limestone units occur in the middle part of the series.

The Silurian System is dolomite and limestone and contains minor shale units. The upper part (Cayugan and most of the Niagaran Series) shows contrasting facies of silty interreef rock and relatively pure reef rock. In a few places where reefs are present, the Silurian is 900 to more than 1000 feet thick. In an area about 50 miles east and southeast of St. Louis, a number of Silurian reefs stood high enough to project through the Lower Devonian. Important reefs occur in Indiana along the Wabash River Valley. In northern Indiana the biohermal and biostromal Fort Wayne Bank restricts the salt-bearing Salina Formation to the Michigan Basin. The Alexandrian Series, at the base of the Silurian, is a relatively thin but persistent limestone that underlies much of the region.

Maquoketa Group

The Maquoketa Group includes the relatively shaly strata of Cincinnatian (Late Ordovician) age. Shale and carbonate facies relations cause the base of the Cincinnatian to be indistinct in the Tennessee and Kentucky part of the Cincinnati Arch Province. In that area, the shaly strata just below the Cincinnatian are included in the Maquoketa map, and the base of the mapped interval is placed at the "Pencil Cave," a distinctive metabentonite bed just below the top of the Middle Ordovician Tyrone Limestone (fig. 2).

The Maquoketa is about 200 feet thick throughout most of Illinois (fig. 7). In Indiana and Kentucky it thickens regularly eastward from 300 to 900 feet and reaches a thickness of 1000 feet in western Ohio. The Cincinnati Arch seems to have had no influence as a positive area during Cincinnatian time. The Maquoketa is absent by erosion in northern Illinois; along the western edge of Illinois; and over the Pascola Arch, the Nashville Dome, and the Lexington Dome.

The Maquoketa consists chiefly of silty and dolomitic or calcitic shales with a prominent limestone or dolomite unit in the middle. The proportion of carbonate rocks increases southeastward. In central Tennessee the Cincinnatian strata are composed primarily of limestone.

Ottawa Megagroup

The Middle Ordovician carbonate rocks between the Maquoketa and the St. Peter Sandstone are assigned to the Ottawa Megagroup. The Ottawa thickens southward from about 300 feet in northern Illinois to 1400 feet at the north edge of the Mississippi Embayment, in northwest Kentucky (fig. 8). The Ottawa crops out in northern Illinois and on the Lexington and Nashville Domes. It is absent by erosion in central northern Illinois and over the Pascola Arch.

The Ottawa contains many persistent, widely traceable carbonate units. Several meta-bentonite beds also are useful in making regional correlations. The top of the unit coincides with the top of the Trenton throughout much of the area, and it is widely used as a horizon for mapping structure because of the marked lithologic and geophysical contrasts between the relatively pure Middle Ordovician carbonates and the shaly strata of the overlying Cincinnatian beds.

The Ottawa consists chiefly of limestone that grades locally to dolomite, especially in northern Indiana and northern Illinois. The upper part of the Ottawa is generally light colored, medium grained, and fossiliferous. The middle part is darker and finer. Over much of its extent, the basal part of the Ottawa contains some silt, sand, and anhydrite.

Glenwood Shale and St. Peter Sandstone

Underlying the Ottawa in parts of the region are the Glenwood Shale (fig. 9) and the St. Peter Sandstone (fig. 10). These two units have been mapped separately because the updip pinching out of the St. Peter Sandstone is a potential trap for petroleum in western Indiana and the Glenwood Shale is important as a seal and potential source rock where it directly overlies an unconformity at the top of the Knox.

East of a north-south line through west-central Indiana, the Glenwood consists of shale with some partly sandy carbonate. Its thickness varies within short distances. Locally it exceeds 50 feet, but nowhere in the area is it known to be as much as 100 feet thick. In northern Illinois the Glenwood contains considerable amounts of sandstone, and therefore it is mapped with the underlying St. Peter Sandstone. As the Glenwood is traced southward into the Illinois Basin, it grades into dolomite (Joachim) which is included in the Ottawa Megagroup.

The unit mapped as St. Peter is restricted to relatively pure sandstone underlying Ottawa carbonates or Glenwood Shale and overlying carbonates of the Knox Megagroup. The St. Peter is composed predominantly of quartz sand with well rounded and frosted grains. The limited heavy mineral suite is dominated by highly resistant grains of tourmaline and zircon. The sand is fine to medium grained and well sorted, and throughout much of the area it lacks any trace of clay or shale. A unit of shale and chert rubble (Kress Member) is locally present at the base of the St. Peter.

Despite the blanket distribution of the St. Peter in Illinois, western Indiana, and northwestern Kentucky, its thickness is extremely difficult to predict at a given locality. The sandstone fills irregularities on a complex erosional surface, which includes karst and stream topography. In general the St. Peter is absent or patchy in the eastern and southern parts of the region (fig. 10). It is 100 to 200 feet thick throughout much of central and southern Illinois and 200 to 400 feet thick in parts of northern Illinois. In some places, thicknesses of 600 to 800 feet of St. Peter have been penetrated by drilling. Where the St. Peter is abnormally thick, the Knox is reciprocally thinned below.

Knox Megagroup

The Knox Megagroup includes the Lower Ordovician and Upper Cambrian dolomites that unconformably underlie the St. Peter Sandstone, Glenwood Shale, or Ottawa Megagroup and overlie the Potsdam Megagroup, which consists of sandstone, shale, and carbonates. The Knox correlates with the Arbuckle of the Great Plains and, in general, with the Ellenburger of Texas.

The Knox is chiefly dolomite, although some limestone is present in the southernmost part of the region. There are small percentages of sandstone, chert, and shale. Algal deposits are common, but other fossils are rare and poorly preserved. The chert is commonly oolitic and the shale is present as thin partings. Fine- to medium-grained, rounded sand occurs as beds of sandstone and as floating grains in the dolomite.

The sandstone units in the Knox are thin compared to the dolomite units. Several sandstones are widely traceable and thick enough to be designated as formations or members (fig 2): the New Richmond, the Gunter, the Roubidoux, and the Rose Run. Locally, in southeastern Indiana, there is a bed of sandstone several hundred feet thick in the upper part of the Knox.

The maximum thickness of the Knox occurs at the northern edge of the Mississippi Embayment Province where it is estimated to be 7000 feet (fig. 11). The Knox thins northward (1) by truncation at the top, (2) by thinning of individual units, and (3) by upward shifting of its basal boundary owing to a facies change from dolomite to clastic rocks.

The Knox as a whole is characterized by a moderate to high electrical resistivity and self-potential, low gamma radioactivity, moderate to high neutron response, and high sonic velocity. It has a higher resistivity and sonic velocity than the overlying St. Peter Sandstone. The thin sandstones in the Knox are distinguished most readily from the thicker carbonate units by their decreased sonic velocity.

Potsdam Megagroup

All Cambrian sediments below the relatively pure dolomites of the Knox are included in the Potsdam Megagroup in this report. The upper part of the Potsdam includes many transitional or intermediate units, but in general it contains much more shale and sandstone than the overlying Knox.

In the northern part of the Illinois Basin, the upper part of the Potsdam is chiefly sandstone and siltstone. Traced southward, the clastics become finer grained and grade to dolomite. Some of these dolomite beds are oolitic. The lower part of the Potsdam includes relatively coarse-grained, partly arkosic sandstones commonly called the "basal sands," Mt. Simon Sandstone, Lamotte Sandstone, or "earlier Cambrian sediments," all of which unconformably overlie Precambrian igneous or metamorphic rocks.

The Potsdam, as mapped, includes a wide range of ages and types of rocks. The isopach map (fig. 12), therefore, represents a composite of several areas where maximum deposition occurred at different times. One prominent area of thick Potsdam occurs in northeastern Illinois, where a very thick section of Mt. Simon Sandstone accounts for most of the 3000 feet of Potsdam. Another interesting thick section of Potsdam occurs in the Rome Trough in the eastern half of Kentucky. This trough has over 3000 feet of Potsdam sediments just east of the area of this study and is believed to extend westward into the upper Mississippi Embayment. The Rome Trough contains thick deposits dated (eastward) or suspected (westward) as being of Middle or Early Cambrian age. The upper part of the Potsdam (Eau Claire, Conasauga) does not appreciably thicken in the trough. Closely spaced wells in east-central Kentucky show abrupt thickening of the Potsdam at the north flank of the Rome Trough. This thickening is apparently a result of active faulting during Potsdam deposition. The south flank of the Rome Trough is not well defined.

Precambrian Rocks

Precambrian rocks throughout most of the region consist chiefly of granite or rhyolite with isotopic ages of from 1.2 to 1.4 billion years. In the eastern part of the Cincinnati Arch Province, the Precambrian rocks are younger and of more varied types.

Figure 3 - Thickness of the Pennsylvanian System. (After preliminary map by H. R. Wanless, February, 1969). From AAPG Memoir 15. Published with permission of the American Association of Petroleum Geologists.

Figure 4 - Thickness of the Chesterian Series (Upper Mississippian). (Modified from a map prepared by Humble Oil Company, 1968, for "Geology and Petroleum Production of the Illinois Basin," published by Illinois and Indiana-Kentucky Geological Societies).

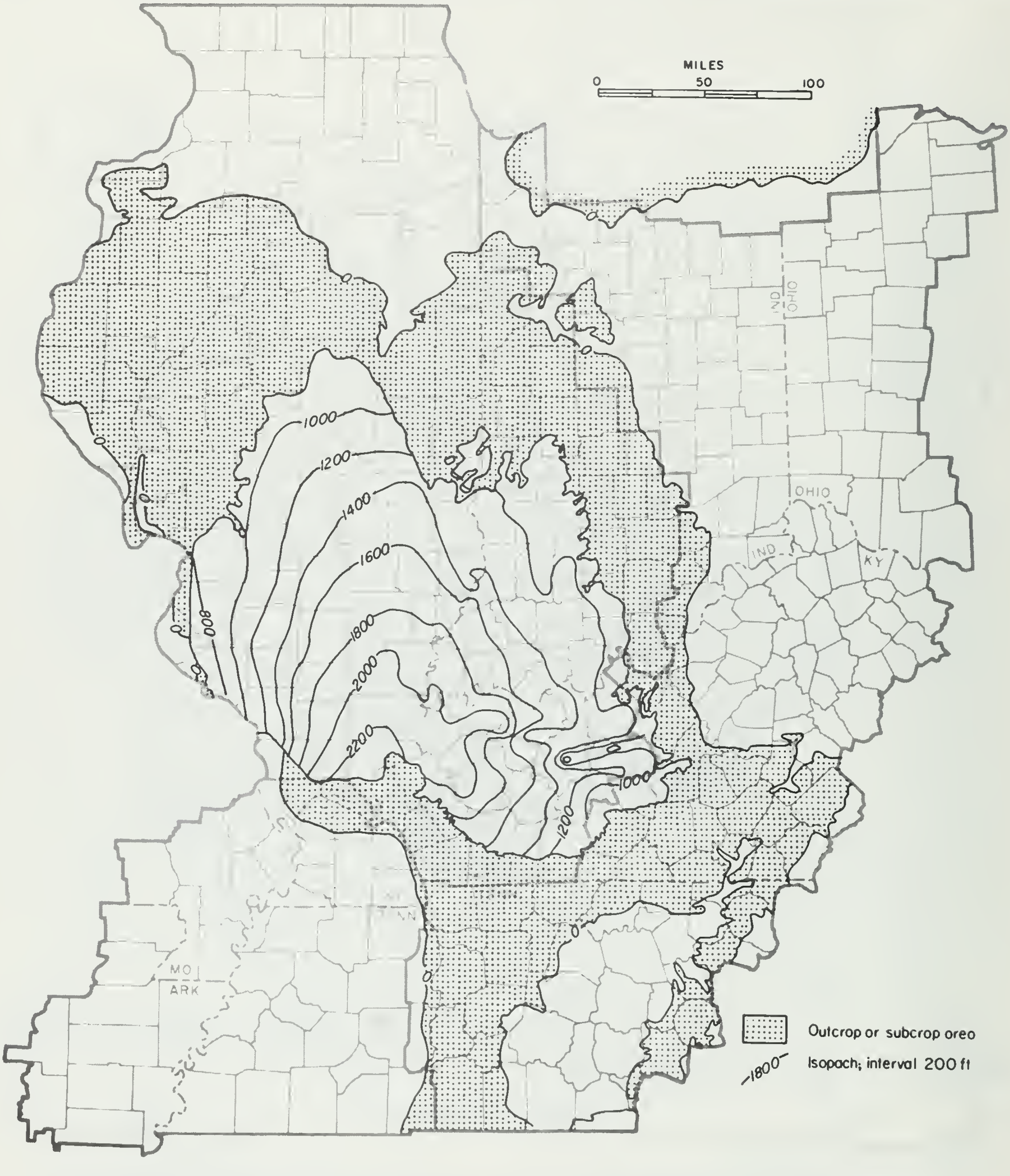

Figure 5 - Thickness of the Mammoth Cave and Knobs Megagroups (Middle and Lower Mississippian, Upper Devonian). Prepared by E. Atherton in cooperation with H. M. Bristol, L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

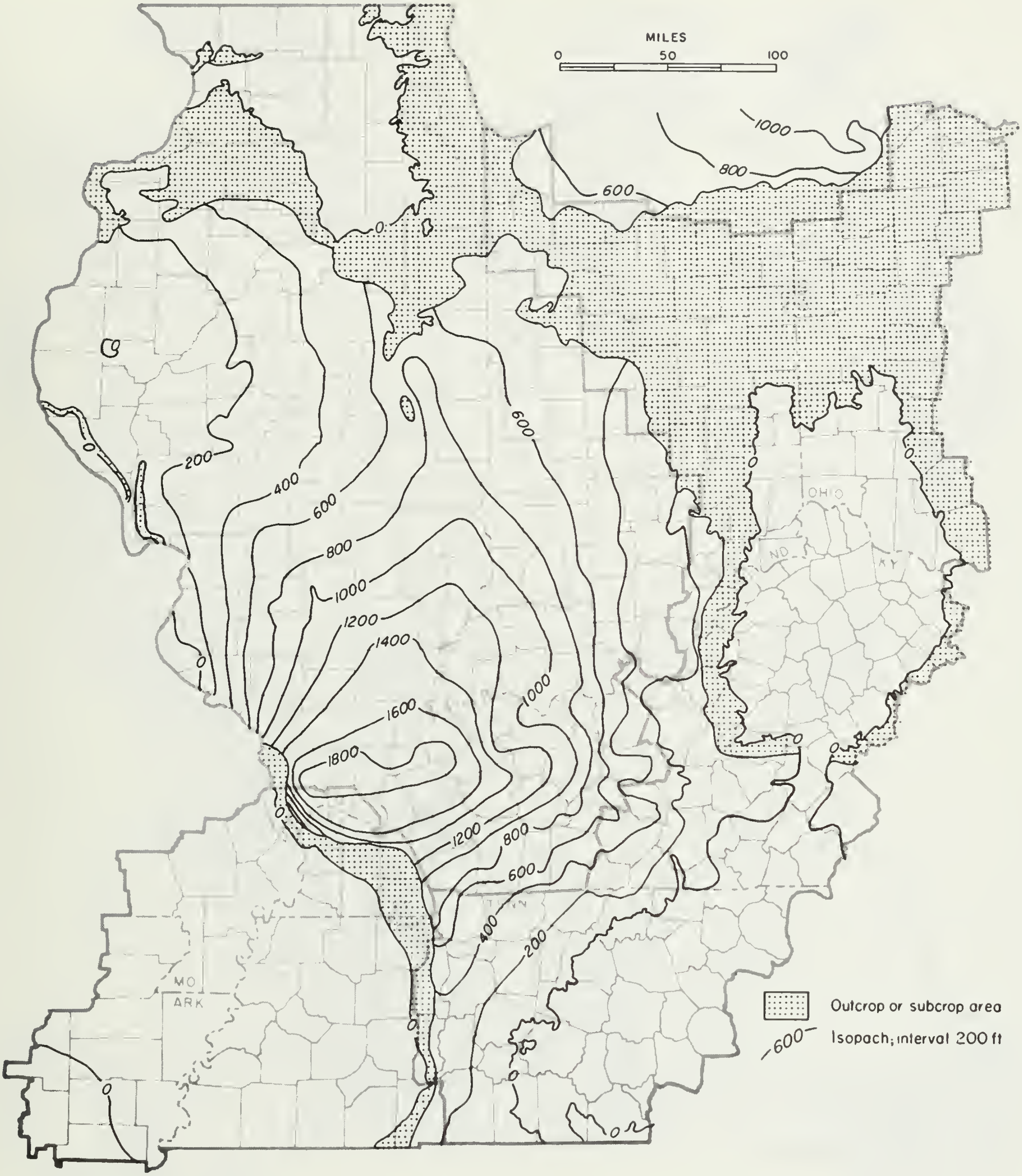

Figure 6 - Thickness of the Hunton Megagroup (Middle and Lower Devonian, Silurian). Prepared by H. M. Bristol in cooperation with E. Atherton, T. C. Buschbach, L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

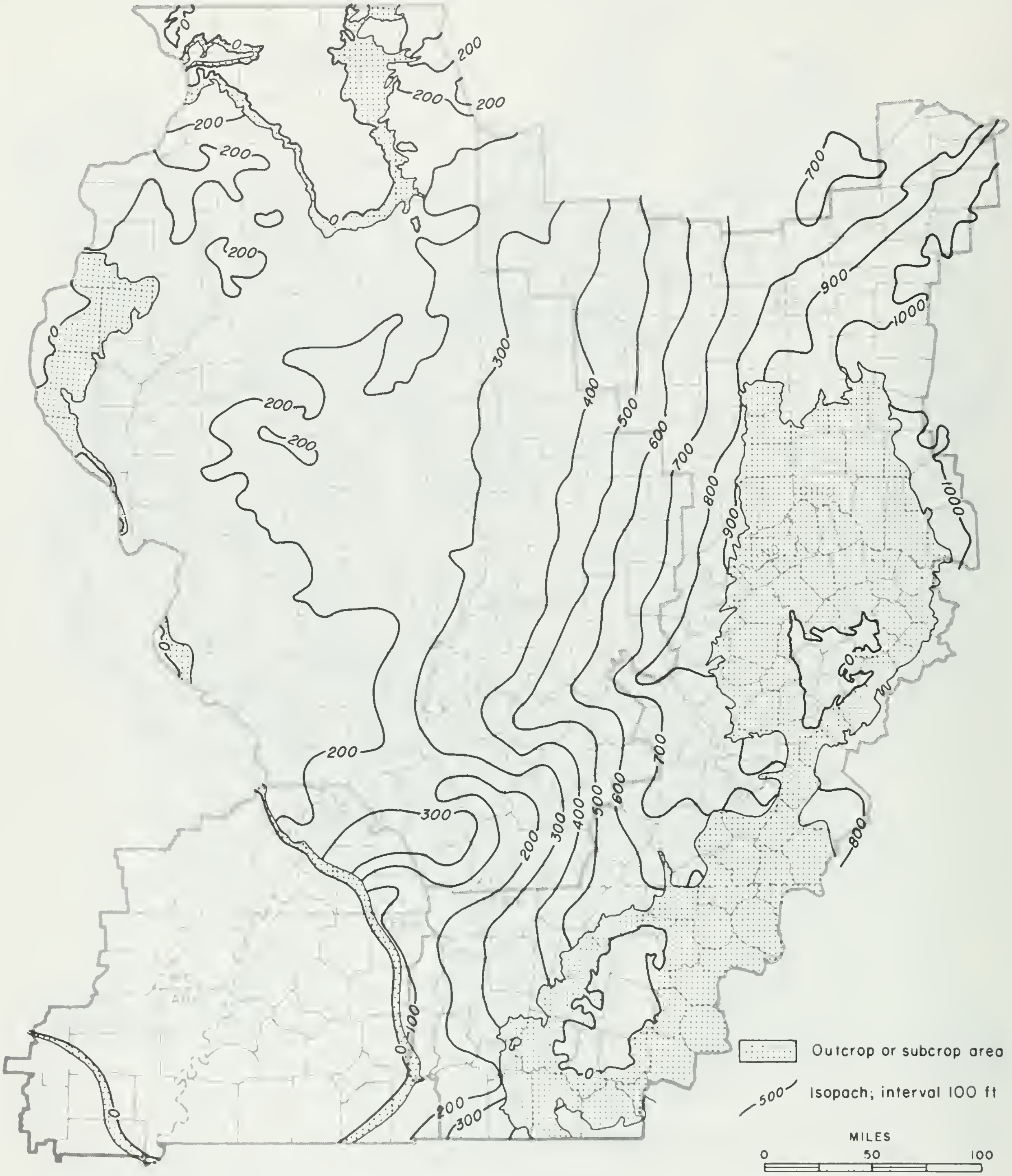

Figure 7 - Thickness of the Maquoketa Group (Upper Ordovician), including Champlainian strata above "Pencil Cave" in Kentucky and Tennessee portions of the Cincinnati Arch Province. Prepared in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

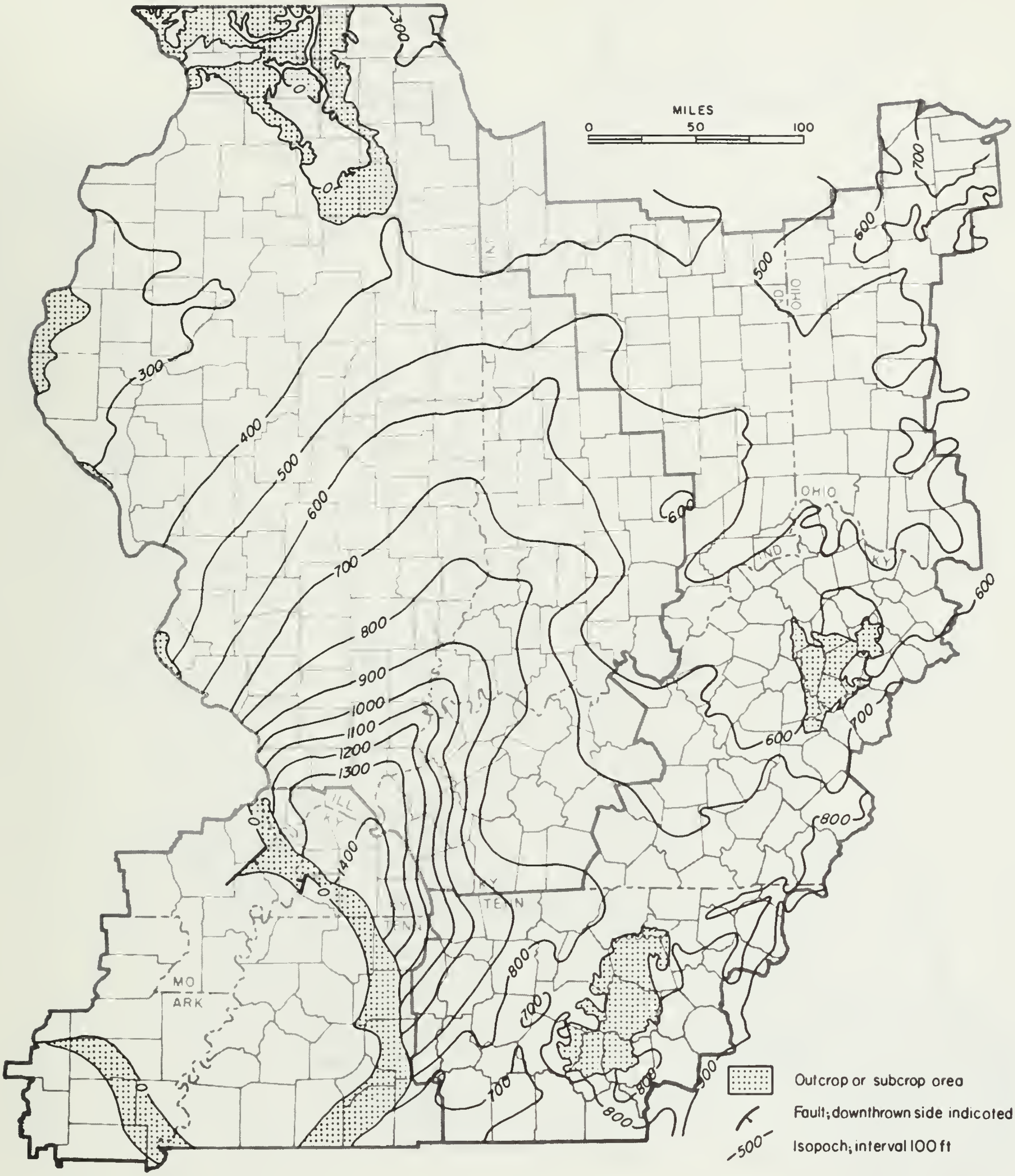

Figure 8 - Thickness of the Ottawa Megagroup (Middle Ordovician), excluding Champlainian above "Pencil Cave" in Kentucky and Tennessee portions of the Cincinnati Arch Province. Prepared in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

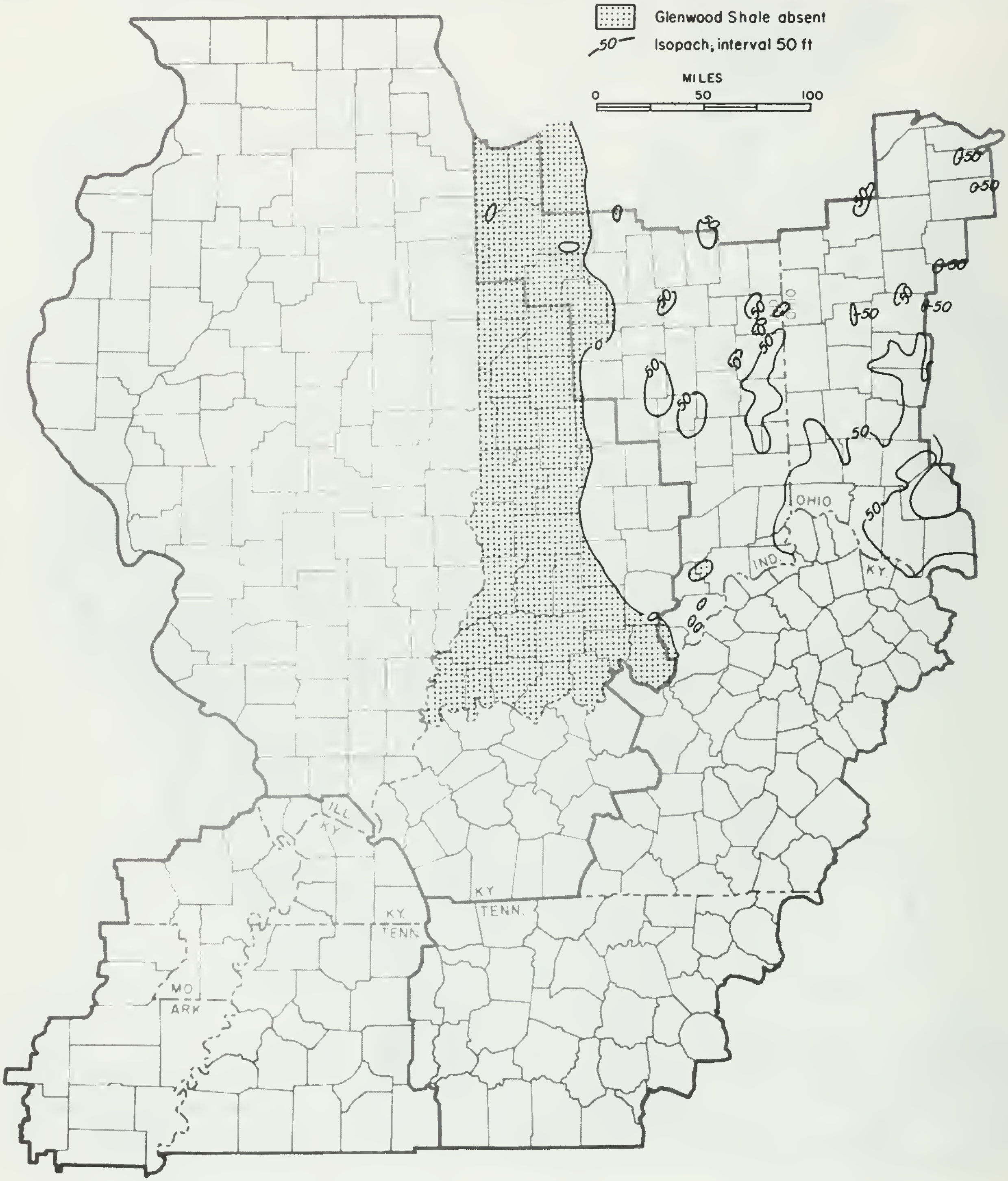

Figure 9 - Thickness of the Glenwood Shale (Middle Ordovician), mapped only in Indiana and western Ohio. Prepared by L. E. Becker, T. A. Dawson, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

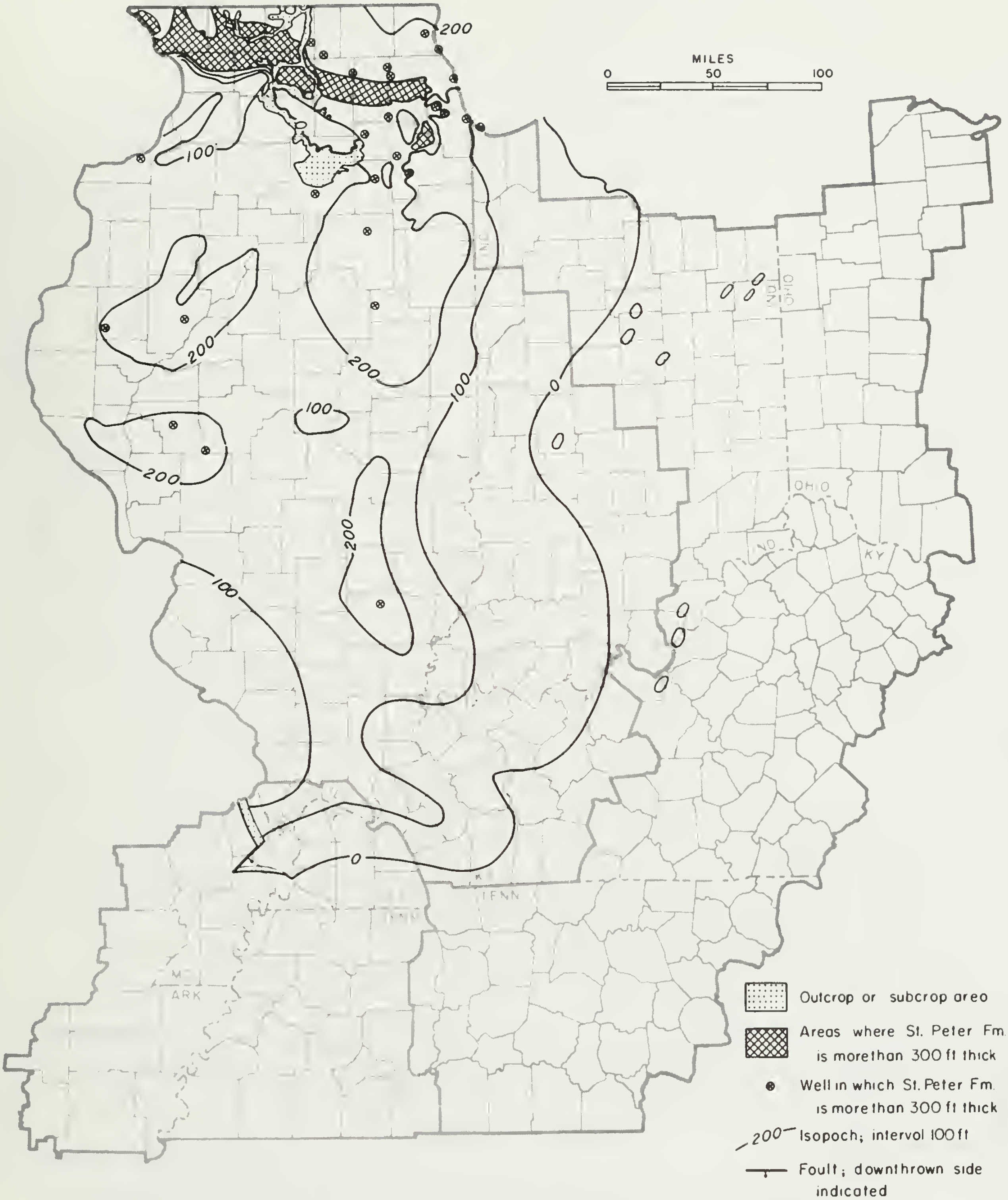

Figure 10 - Thickness of the St. Peter Sandstone (Middle Ordovician), including some sandy carbonates in Kentucky. Prepared in cooperation with L. E. Becker, T. A. Dawson, and H. Schwalb for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

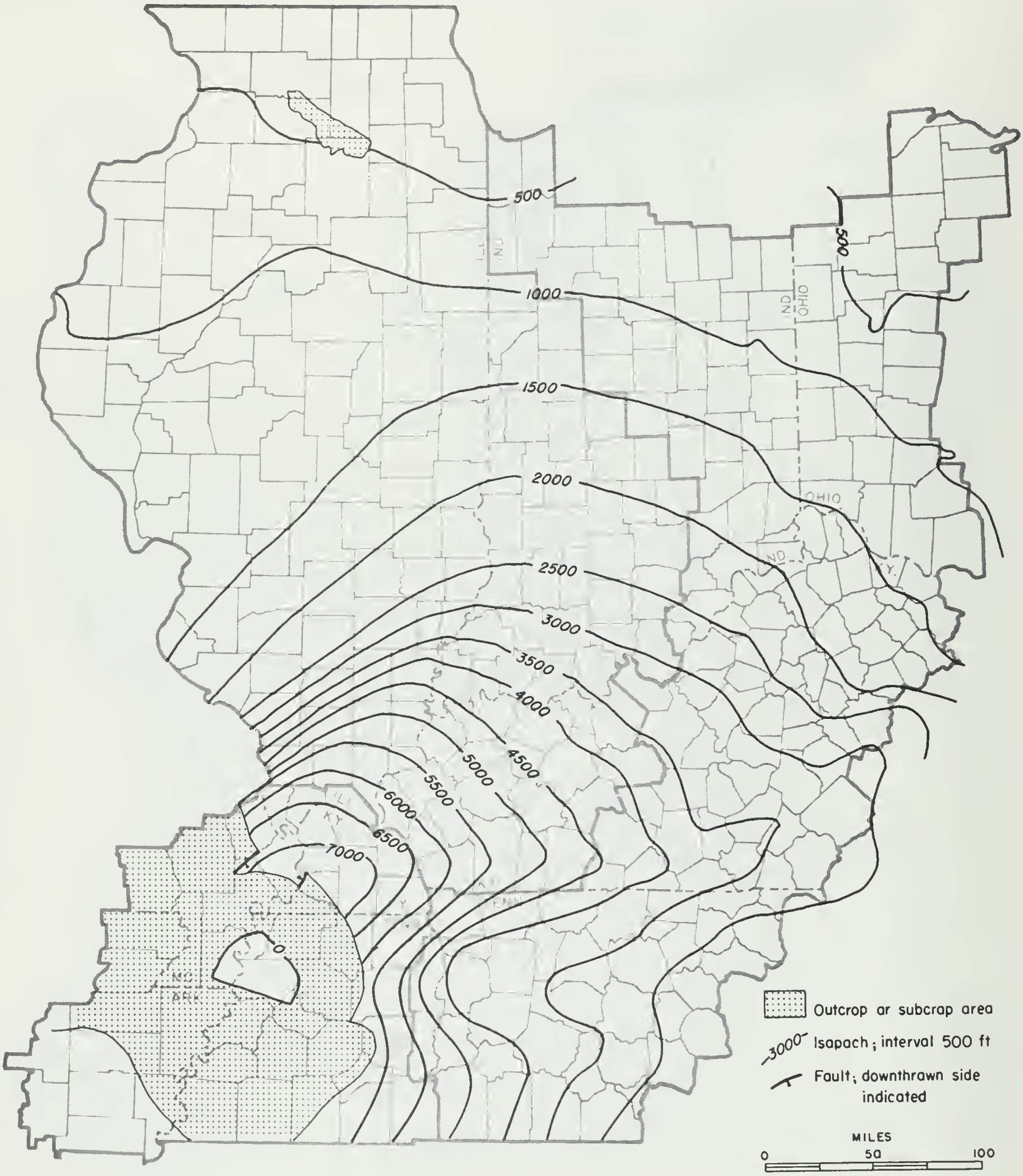

Figure 11 - Thickness of the Knox Megagroup (Lower Ordovician, Upper Cambrian). Prepared in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

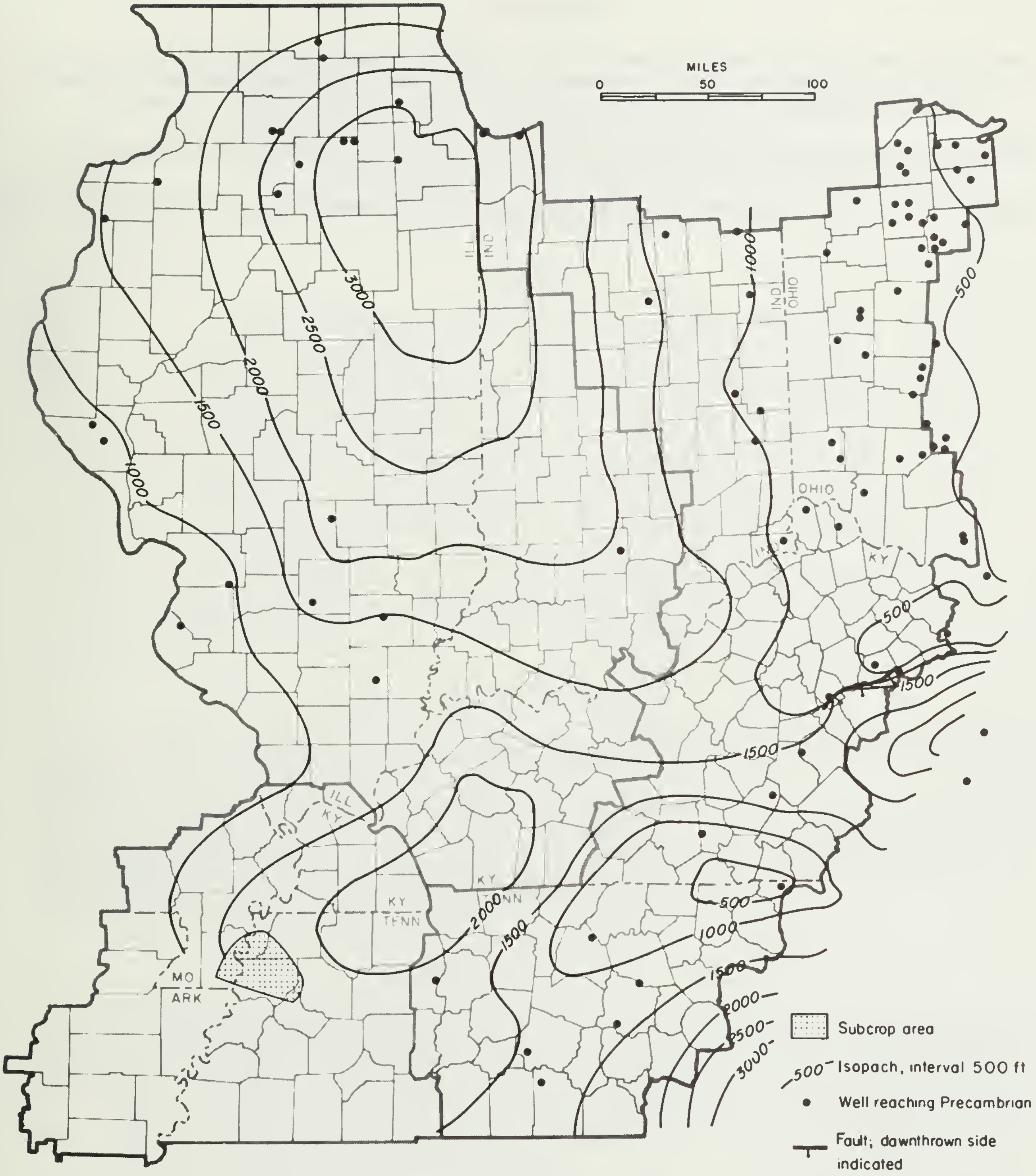

Figure 12 - Thickness of the Potsdam Megagroup (expanded to include all pre-Knox sediments). Prepared in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

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STRUCTURAL FEATURES OF THE EASTERN INTERIOR REGION OF THE UNITED STATES

H. M. Bristol and T. C. Buschbach
Illinois State Geological Survey

ABSTRACT

The dominant structural features of the Eastern Interior Region are the Illinois Basin, the Cincinnati Arch, and the upper Mississippi Embayment. The Illinois Basin is a spoon-shaped structure that trends north-south and is filled with more than 14,000 feet of Paleozoic sediments at its deepest part. The Cincinnati Arch is a broad uplift that separates the Illinois Basin from the Appalachian Basin. It includes the Nashville and Lexington Domes to the south; to the north, bifurcating arms of the Arch, the Kankakee and Findlay Arches, embrace the southern limits of the Michigan Basin. The Mississippi Embayment is a southward-plunging trough filled with Late Cretaceous and Tertiary sediments.

An extensive zone of faulting, the Rough Creek-Kentucky River Fault Zone, extends across the region in an east-west direction from southern Illinois to central Kentucky.

INTRODUCTION

The dominant structural provinces of the Eastern Interior Region are the Illinois Basin, the Cincinnati Arch, and the upper Mississippi Embayment (fig. 1). This report discusses the locations of the significant structural features of each province.

The authors gratefully acknowledge the contributions made by members of the National Petroleum Council Task Force, Region 9, who compiled the basic data. Figures 1 through 4 and figure 6 are taken from a report on Region 9 (Bond et al., 1971) for AAPG Memoir 15, Future Petroleum Provinces of the United States—Their Geology and Potential, edited by Ira H. Cram, and are used with permission of the American Association of Petroleum Geologists.

REGIONAL STRUCTURE

A widespread and easily recognized datum surface for mapping structure in the region is the top of the Middle Ordovician Ottawa Megagroup (fig. 2). This surface coincides with the top of the Trenton, Galena, or Kimmswick throughout most of the area, although the "Pencil Cave" metabentonite bed was used for mapping in the Kentucky and Tennessee portion of the Cincinnati Arch Province.

The top of the Ottawa is more than 6000 feet below sea level in the deeper part of the Illinois Basin. It rises to above sea level on the arches surrounding the basin, and it is eroded in northern Illinois and over the Lexington and Nashville Domes.

A structure map on top of the Precambrian (fig. 3) shows that the basement is depressed to more than 13,000 feet below sea level in the Illinois Basin. The closest the Precambrian comes to the surface in this region is in extreme northwestern Illinois where it is slightly less than 1500 feet below sea level. The top of the Precambrian marks a significant erosional unconformity. Relief of

Figure 1 - Structural features of the Eastern Interior Region. Prepared in cooperation with E. Atherton, L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

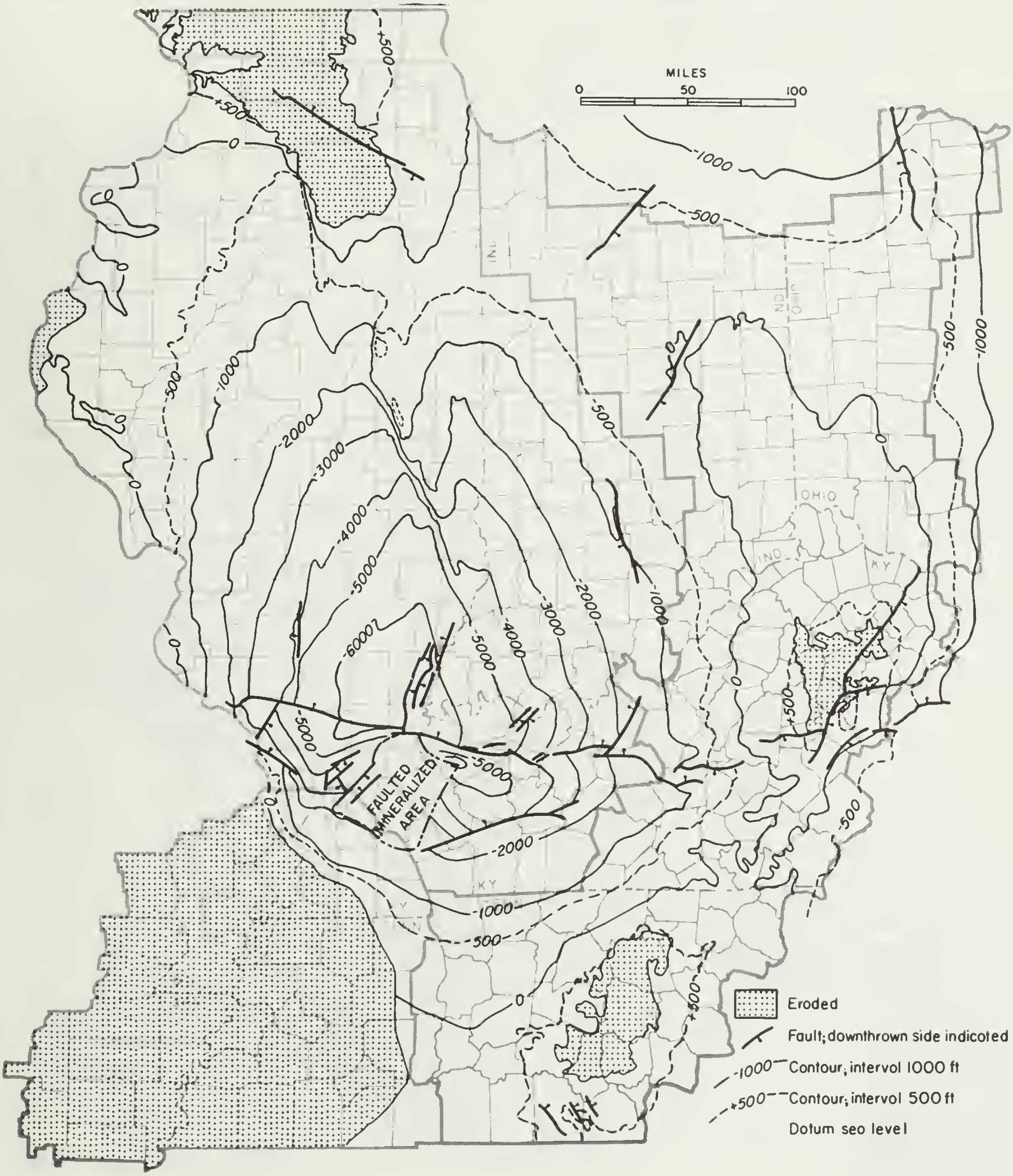

Figure 2 - Structure on top of Ottawa Megagroup (top of Trenton). Prepared in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

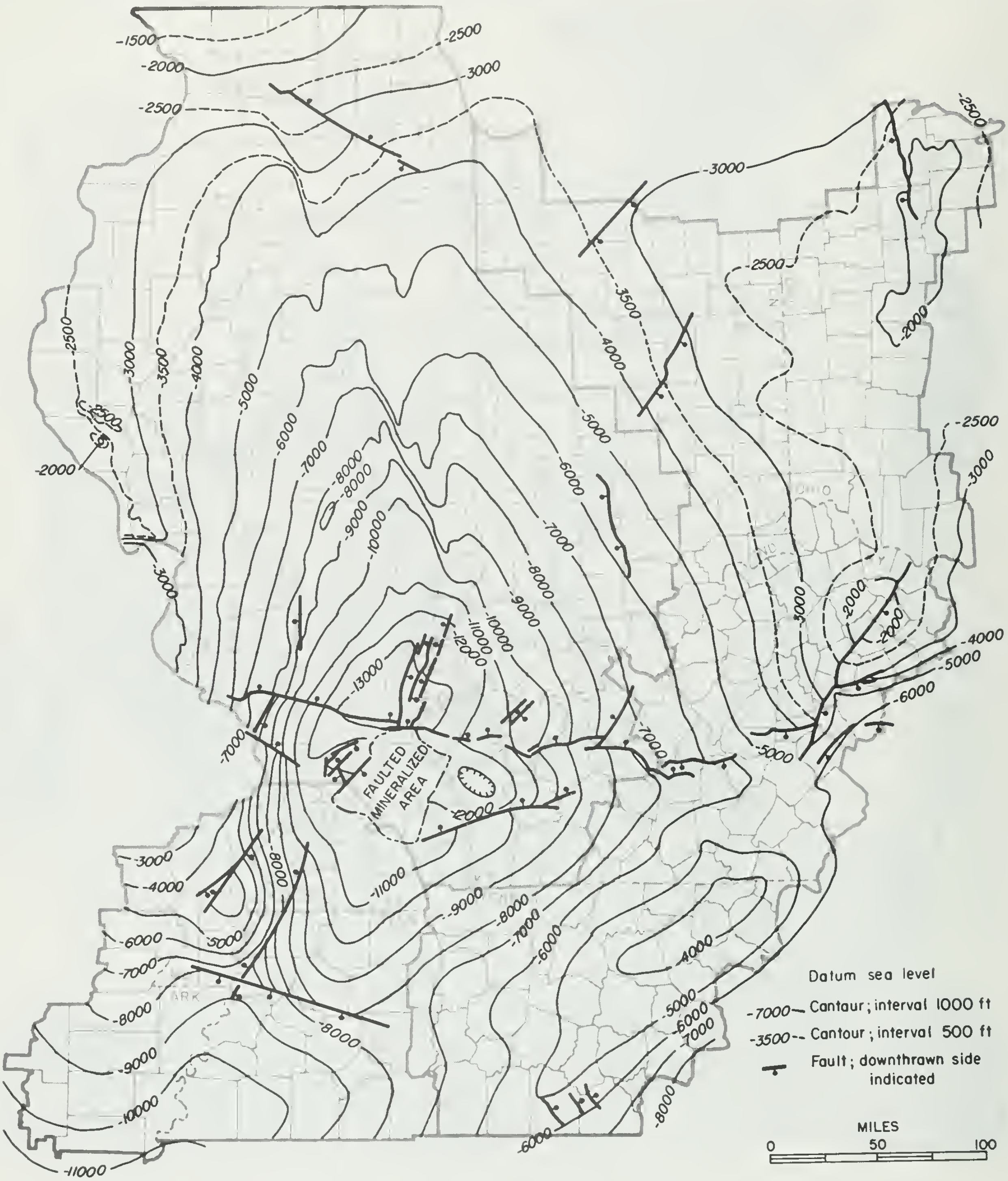

Figure 3 - Structure on top of Precambrian basement. Prepared by E. Atherton in cooperation with H. M. Bristol, T. C. Buschbach, L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

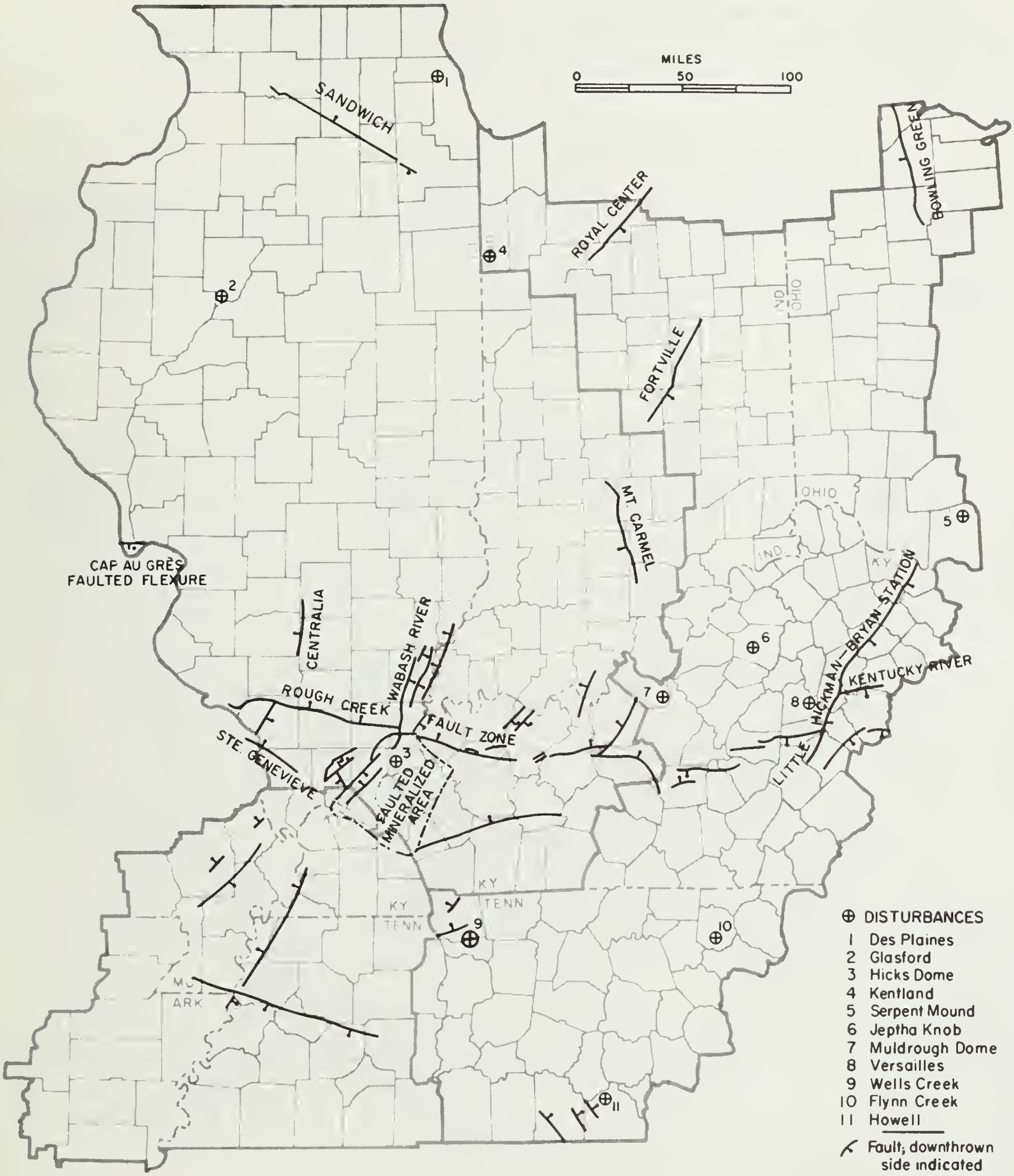

Figure 4 - Major faults and disturbances in the Eastern Interior Region. Prepared in cooperation with E. Atherton, L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

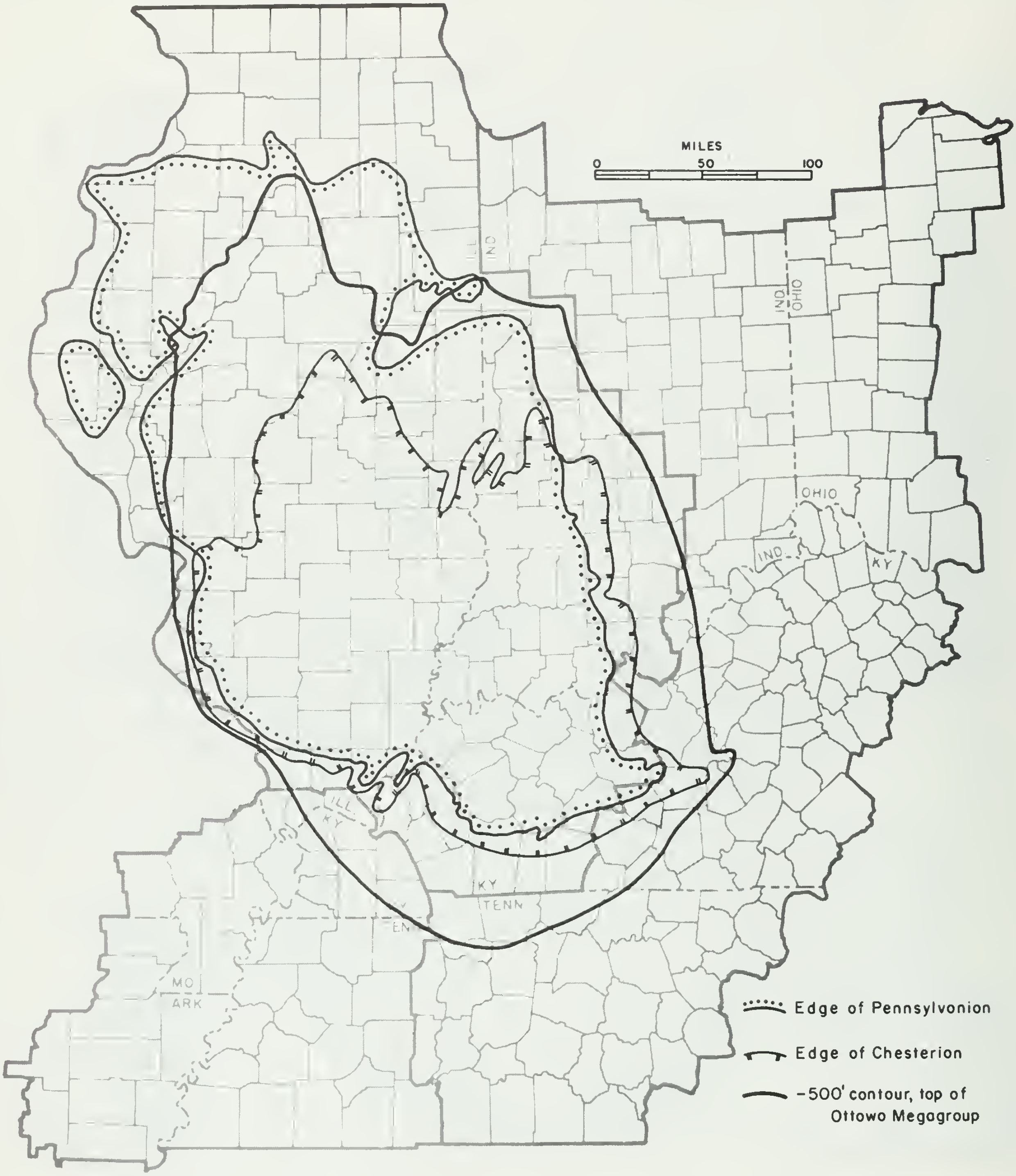

Figure 5 - Some boundaries used to delimit the Illinois Basin.

several hundreds of feet on that surface can be seen in the Ozarks of Missouri, just outside the region, and also in a few closely spaced wells in western Illinois and western Ohio. It therefore seems reasonable to expect that amount of relief on the Precambrian surface throughout much of the region.

FAULTS AND DISTURBANCES

Significant faulting is sparse in the Eastern Interior Region, except along the Rough Creek-Kentucky River Fault Zone and in the faulted and mineralized area of southeastern Illinois and adjacent Kentucky (fig. 4). Most faulting in the region is high-angle faulting.

Eleven localities have been mapped where the rocks are highly disrupted within a compact, usually circular area. The origin of these disturbances is controversial, but some recent workers have favored a theory that at least some of them were formed by the impact of meteorites.

ILLINOIS BASIN

Although northern Illinois was included in the Illinois Basin Province (fig. 1) for convenience in the National Petroleum Council study, the basin is commonly defined as the oval area within a structural contour line such as the minus 500-foot contour on top of the Ottawa Megagroup (top of Trenton), or as the area covered by a certain unit of rocks, such as the Pennsylvanian System or the Chesterian Series (fig. 5).

The Illinois Basin is separated from the Forest City Basin to the west by the Mississippi River Arch and from the Appalachian Basin to the east by the Cincinnati Arch. To the northeast the Illinois Basin is separated from the Michigan Basin by the Kankakee Arch, and to the south it is separated from the Black Warrior Basin by the Pascola Arch, which is now covered by Cretaceous and Tertiary sediments.

Three major lines of uplift in the basin are the La Salle Anticlinal Belt, the Du Quoin Monocline, and the Rough Creek Fault Zone. These structures bound the Fairfield Basin, the central, deep part of the Illinois Basin, where the Precambrian basement is more than 14,000 feet deep.

The La Salle Anticlinal Belt is a complex of minor structures, roughly aligned en echelon and having an over-all trend to the north-northwest. It is asymmetrical, with steep dips to the west and gentle dips to the east onto the Eastern Shelf. The Du Quoin Monocline trends slightly east of north and dips down to the east into the Fairfield Basin. To the west and northwest is the relatively shallow Western Shelf.

The Rough Creek Fault Zone on the south side of the Fairfield Basin extends eastward into Kentucky. It is a high-angle reverse fault with uplift on the south side. South of the fault zone is the east-west trending Moorman Syncline, and south of the syncline is the shallower Southern Shelf. Scant data hint that the southern part of the Illinois Basin, south of the fault zone, may be significantly different from the northern part. The Rome Trough, which contains thick Cambrian deposits in central and eastern Kentucky, appears to extend westward through the area of the Moorman Syncline into the ancestral Reelfoot Basin.

An upwarp that occurred during Silurian and Devonian time in central and western Illinois has been named the Sangamon Arch. Later movements have masked the arch so that it does not show on the structure map of the top of the Ottawa Megagroup (fig. 2). The arch, however, had significant influence on the distribution of Devonian and Silurian strata in the area.

CINCINNATI ARCH

The Cincinnati Arch is a structurally positive area between the Appalachian Basin on the east and the Illinois Basin on the west. Major structural features on the southern part of the arch are the Nashville and Lexington (Jessamine) Domes with the Cumberland Saddle between them. To the north the Cincinnati Arch broadens onto the Indiana-Ohio Platform and bifurcates into an eastern arm, the Findlay Arch, and a western arm, the Kankakee Arch; these arms form the southern limits of the Michigan Basin.

Just east of the region of study there is an ancestral upwarp, the Waverly Arch. The axis of this arch runs north-south through central Ohio and generally parallels the axis of the Cincinnati Arch.

UPPER MISSISSIPPI EMBAYMENT

The upper Mississippi Embayment is a structural trough that developed in Late Cretaceous and Tertiary time. The axis of the trough coincides roughly with the present course of the Mississippi River and plunges to the south. The plunging trough is well illustrated by a structure map on top of the Paleozoic (fig. 6). The trough is not evident on the Precambrian structure map (fig. 3) because the Precambrian surface has been strongly influenced by (1) the presence of the Reelfoot Basin, which was an area of maximum deposition during Cambrian and Ordovician times, and (2) the now buried Pascola Arch, over which more than 8000 feet of Paleozoic sediments were removed before Late Cretaceous deposition began in the area.

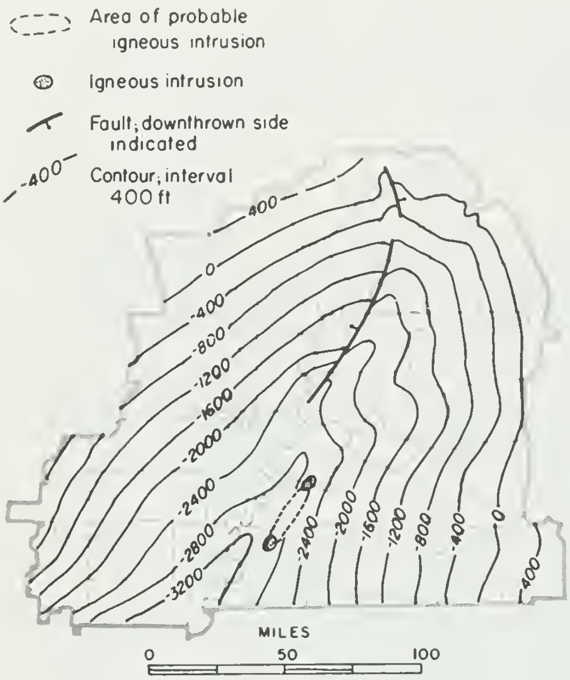

Figure 6 - Structure of the Paleozoic unconformity surface in the upper Mississippi Embayment Province. Prepared by H. Schwalb for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

REFERENCE

Bond, D. C., et al., 1971, Possible future petroleum potential of Region 9—Illinois Basin, Cincinnati Arch, and northern Mississippi Embayment, in Ira H. Cram, ed., Future petroleum provinces of the United States—their geology and potential: AAPG Memoir 15, v. 2, p. 1165-1218.

TECTONIC DEVELOPMENT OF THE EASTERN INTERIOR REGION OF THE UNITED STATES

Elwood Atherton
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ABSTRACT

In the Eastern Interior Region (the Illinois Basin, the Cincinnati Arch and the northern part of the Mississippi Embayment), the Precambrian basement everywhere is buried by younger rocks. Its tectonic features are largely concealed, but they must have had great influence on the structures of younger strata. Where the surface of the Precambrian can be adequately studied, it has a relief of several hundred feet. Draping and differential compaction of overlying Paleozoic beds have resulted in structures that reflect the influence of buried Precambrian hills.

The Eastern Interior Region is part of a cratonic area in which most of the deformation since Precambrian time has been produced by regional warping and differential sinking. The structural relief has developed chiefly by subsidence of negative elements. During the Paleozoic, the paleoslope was to the south or southwest, and the basin opened to the south. Not until Croixan (Upper Cambrian) time was much of the Region inundated by the sea. Canadian (Lower Ordovician) sediments succeeded Cambrian with little break. At the close of the Canadian, diastrophism tilted the Region down to the south. The Kankakee Arch appeared in northern Indiana and separated the Illinois Basin from the Michigan Basin. Erosion then beveled the area and as a result, younger strata rest on a widespread angular unconformity that marks the top of the Sauk Sequence.

The Region was relatively stable during Champlainian (Middle Ordovician) time. A wedge of shaly rocks, thickening eastward, that was deposited during Cincinnatian (Upper Ordovician) time is an indication of the Taconic Orogeny along the eastern border of North America. The Silurian was deposited on an erosional unconformity of low relief. The Niagaran (Middle Silurian) is notable for the growth of large reefs, many of which stood high enough to influence the structure of younger rocks. At the close of the Silurian Period most of the Region emerged. Only in the deepest part of the Illinois Basin was deposition continuous from the Silurian into the Devonian. Lower Devonian sediments were deposited in a rather restricted basin centered in southern Illinois while erosion of the surrounding area continued. Subsequently, most of the area of Lower Devonian deposits was included in the region being eroded, and some warping of the arches occurred. This very extensive erosion marks the top of the Tippecanoe Sequence.

The Middle Devonian started with a major transgression of the sea. The deposits rest with angular unconformity on pre-Middle

Devonian strata and in places overlap Silurian to rest on Ordovician rocks. The Middle Devonian was a time of oscillating seas and ended with uplift and erosion. Sediment from rising land to the east (Acadian Orogeny) became in Late Devonian time an extensive deposit, dominantly shale, that overlaps eroded older rocks to rest in places on Ordovician strata. The transition from Devonian to Mississippian was gradual as the Illinois Basin continued to sink slowly. During Chesterian (Upper Mississippian) time fluctuations of the shoreline are recorded as rhythmical alternations of limestone-dominated and clastic-dominated units. Chesterian deposition was followed by retreat of the sea. The Illinois Basin was tilted down to the south and beveled by erosion. The resulting extensive unconformity marks the top of the Kaskaskia Sequence. Several positive structures, notably the La Salle Anticlinal Belt, were active during this interval of erosion.

Pennsylvanian sediments, laid down on the beveled edges of Mississippian and older formations, are cyclic in character. During the Pennsylvanian, the Fairfield Basin developed by differential downwarping between the La Salle and Du Quoin structures. Pennsylvanian sedimentation was followed by additional differential warping and a very long interval of erosion which removed a great thickness of strata, probably at least a mile in southern Illinois. Important tectonic events occurred during this interval, many of them presumably related to the Appalachian Revolution that occurred near the close of the Paleozoic in the East. Notable among these events were the differential rise of the Cincinnati Arch, faulting along the Rough Creek-Kentucky River Fault Zone, faulting in the Fluorspar District of southern Illinois and western Kentucky, and activity along the La Salle Anticlinal Belt and the Du Quoin Monocline.

The Pascola Arch rose during Mesozoic time and was deeply truncated, structurally separating the Illinois Basin from the Black Warrior Basin to the south. Development of this arch and post-Pennsylvanian sinking that was centered on the Fairfield Basin transformed the Illinois Basin into its present spoon-shaped structure. The Mississippi Embayment sank during much of the Tertiary, but for most of the Eastern Interior Region the Tertiary was a time of erosion. The weight of thick Pleistocene glaciers caused some warping in the northern part of the Region, part of which deformation has been recovered by rebound.

INTRODUCTION

This report, which deals with the tectonic development of the Eastern Interior Region, is a compilation intended to supply background information for the symposium on the future petroleum potential of NPC Region 9 (the Illinois Basin, the Cincinnati Arch and the northern part of the Mississippi Embayment).

PRECAMBRIAN

In this Region, the Precambrian basement is buried by younger rocks. Thus the tectonic features of the basement affect the present-day structure of the Region. The thickness of the cover of younger rocks ranges from about 1500 to 14,000 feet; as a consequence, the basement rocks have been only sparsely sampled, especially where the cover is thick. Because they are deeply buried, the Precambrian features are obscure and can be studied only by geophysical methods and by the use of well logs, cuttings and cores. The nearest Precambrian outcrops are in the Ozarks of Missouri and in the Baraboo Range of southern Wisconsin. Precambrian time was long enough to account for a complex history, but only scant hints about this history remain and these are largely concealed.

The basement complex in a region which extends from the Mississippi River into Ohio consists mainly of granite and rhyolite and is characterized by rocks from 1.2 to 1.5 billion years old. The over-all homogeneity of its magnetic anomaly pattern suggests that the area forms a distinct crustal unit (Zietz et al., 1966). East of this broad area are metamorphic rocks, ranging in age from 0.8 to 1.1 billion years, which represent the subsurface extension of the Precambrian Grenville Province of the Canadian Shield (Lidiak et al., 1966). The western boundary of the Grenville Province in Canada is a metamorphic front, in places marked by faults. In Ohio, this boundary, which runs in a southerly direction from near Sandusky, probably marks a major structural boundary since it coincides with a break in slope in the Precambrian surface. Gravity contours, age data and surface evidence also support such an interpretation (Summerson, 1962). The Grenville rocks presumably once lay fairly deep in a metamorphosed belt, and the granites to the west must have been emplaced below a thick layer of rocks, possibly a mountainous terrain, which subsequently was eroded. Only a few clues to the story have been preserved.

The present-day structural pattern ought to parallel the Precambrian trends, inasmuch as we find no evidence for any considerable horizontal deformation that might have caused a radical change in the pattern. Faulting in Precambrian time is suspected in some locations. For example, a likely location of early faulting that has persisted into the Paleozoic is the Rough Creek-Kentucky River Fault Zone. This is a major line of weakness, and there is evidence of faulting during Cambrian time along part of this zone. A basement scarp underlies parts of the fault zone, particularly along the eastern part of the north flank of the Rome Trough. This scarp may mark a major strike-slip or wrench fault, with eastward shift of the platform block on the north (Summerson, 1962). The arrangement of anticlines in the central part of the Illinois Basin along lines of folding that are persistent except for slight en echelon offsets may indicate that the anticlines follow old lines of faulting in the basement rocks (Clark and Royds, 1948). Paleozoic rocks in south-central Tennessee have a northwest-southeast grain. This orientation suggests that there is no direct genetic relationship with compressive stresses from the Appalachian region which were active during the close of the Paleozoic. The closely spaced and sharply asymmetrical character of these minor parallel folds suggests that they resulted from vertical movement along a set of pre-existing northwest-southeast fractures in the basement. The folded area is located where the axis of the Nashville Dome swings from north-northeast strike to an east-west position (Wilson and Born, 1943).

The buried surface of the Precambrian has been described as a peneplain, but where it can be adequately studied, it is hilly. The St. Francois Mountains in the Ozarks are Precambrian hills from which the Cambrian cover has been eroded. The Cambrian beds show marked initial dip, and the attitude of the beds indicates that they were draped over the hills of igneous rock. In the central Ozarks, the Precambrian surface has a local topographic relief of nearly 1500 feet and has a cover of Upper Cambrian and Lower Ordovician sediments (Dake and Bridge, 1932). In southern Wisconsin, the Precambrian rises in three ranges: the well-known Baraboo Range and the buried Fond du Lac and Waterloo Ranges. The relief on the concealed Precambrian surface of Wisconsin is much greater than was formerly supposed. Much of the surface, particularly where rocks of diverse character occur, was quite rugged before burial under Cambrian sediments (Thwaites, 1931). In western Ohio, the Precambrian rises to form a broad Indiana-Ohio Platform. Local relief on the surface of the platform is about 400 feet (Summerson, 1962). In Pike County in western Illinois, two granite tests eight miles apart reveal a relief of about 800 feet on the Precambrian surface. Not enough Precambrian wells have been drilled in the deep part of the Illinois Basin to demonstrate the amount of local relief. Several tests have found the basal Cambrian Mt. Simon Sandstone unexpectedly thin or absent over the Precambrian. Presumably, these wells encountered Precambrian hills too high to be covered by the regional blanket of Mt. Simon Sandstone, expected to be about 400 feet thick. Wells that pass through the Mt. Simon normally enter fresh-looking igneous rock from which any deeply weathered material has been eroded and transported elsewhere. The feldspar grains in the basal arkose and in the underlying granitic rock have a fresh appearance. Of course, if all the tests have been drilled only on "highs," weathered sediment may yet be found to have accumulated in the untested "lows."

The monadnocks and other "highs" on the Precambrian surface affect the structure of the overlying Paleozoic strata. The sedimentary layers are draped over the hills with more or less initial dip. This dip is accentuated by differential compaction. This compaction was cumulative and generally slow enough that the influence of the buried "highs" may persist well up into the overlying section. A stratigraphic cross section in Wisconsin and northern Michigan (fig. 1) where the subsurface control is good illustrates the influence of buried Precambrian topography on the strata above. Thwaites (1931) says of Wisconsin, "Irregularities of the Precambrian basement are commonly reflected in the structure of the overlying rocks. This relationship is ascribed to (a) initial dip along the old shore lines, and (b) differential compaction in the course of settling around a mass of hard rock....The factors outlined above point to the conclusion that most if not all, of the local irregularities of structure that occur in great numbers throughout the state are related to the topography of the underlying Precambrian." This statement obviously applies also to the Eastern Interior Region.

PALEOZOIC

Tectonic development during the Paleozoic showed several persistent features. The Eastern Interior Region is part of a cratonic area known as the Central Stable Region. Most of the deformation here since Precambrian time has been produced by regional warping and differential sinking. The major structural features are large arches, domes, basins and localized lines of faulting (Moss, 1936). The structural relief of the Region has been developed chiefly by subsidence of negative elements. While the Illinois Basin gradually sank, the Cincinnati Arch remained stable, or sank much more slowly, resulting in a flat-topped, platform-like feature rather than a sharply bowed up or crested anticline. The center of most rapid sinking in the basin shifted from time to time, and the axes of the arches bounding the basin also shifted somewhat. The paleoslope was to the south or southwest. Many formations now thicken southward to their truncated edges and thus indicate that the basin opened to the south into the Black Warrior and Arkoma Basins. A maximum of nearly three miles of Paleozoic sediment now fills the Illinois Basin, and coalification studies indicate that about one mile more has been removed by erosion (Heinz Damberger, personal communcation, 1970). Until Mississippian time most of the clastics originated from Precambrian areas to the north of the Eastern Interior Region. Some of the sediment passed through several cycles with the result that Middle Ordovician and Devonian sands are mature and supermature (Potter and Pryor, 1961). Generally sedimentation kept up with the sinking, with the result that most of the filling was by shallow water marine deposits. At times, as in the later part of Silurian and again early in Valmeyeran (Middle Mississippian) times, sedimentation lagged behind sinking, with the result that water depth exceeded 500 feet in large areas.

The Cambrian Period lasted a long time, long enough for a lot to have happened in nearby Oklahoma, for which a fairly complex Cambrian history has been worked out. The story seems simpler for most of the Eastern Interior Region, where only Croixan (Upper Cambrian) rocks are known. In the Mississippi Embayment the Cambrian is less well known; Middle and Lower Cambrian rocks may be present and the history may be more complex. The Reelfoot Basin in Tennessee was the area of greatest sinking and of thickest sedimentation in the Region during Cambrian time. A second center of thickening, located in northeastern Illinois, is shown by the Mt. Simon Sandstone. The areas of least thickening, relatively positive areas during Cambrian time, do not closely follow the axes of the present arches. The relation of the Illinois and Michigan Basins at this time is obscure, but no structural divide separating the two is apparent (fig. 2). The axis of the arch between the Illinois and Appalachian Basins in Cambrian (and Lower Ordovician) time ran north-south through central Ohio. In this position the arch is known as the Waverly Arch (Woodward, 1961). The Lexington and Nashville Domes also were not in the position they show in younger beds. The Cincinnati Arch rises from the Appalachian Basin and Rome Trough along a steep slope that probably is in part a fault scarp. As the Appalachian Basin sank and filled with thick layers of sediment during Early and Middle Cam-

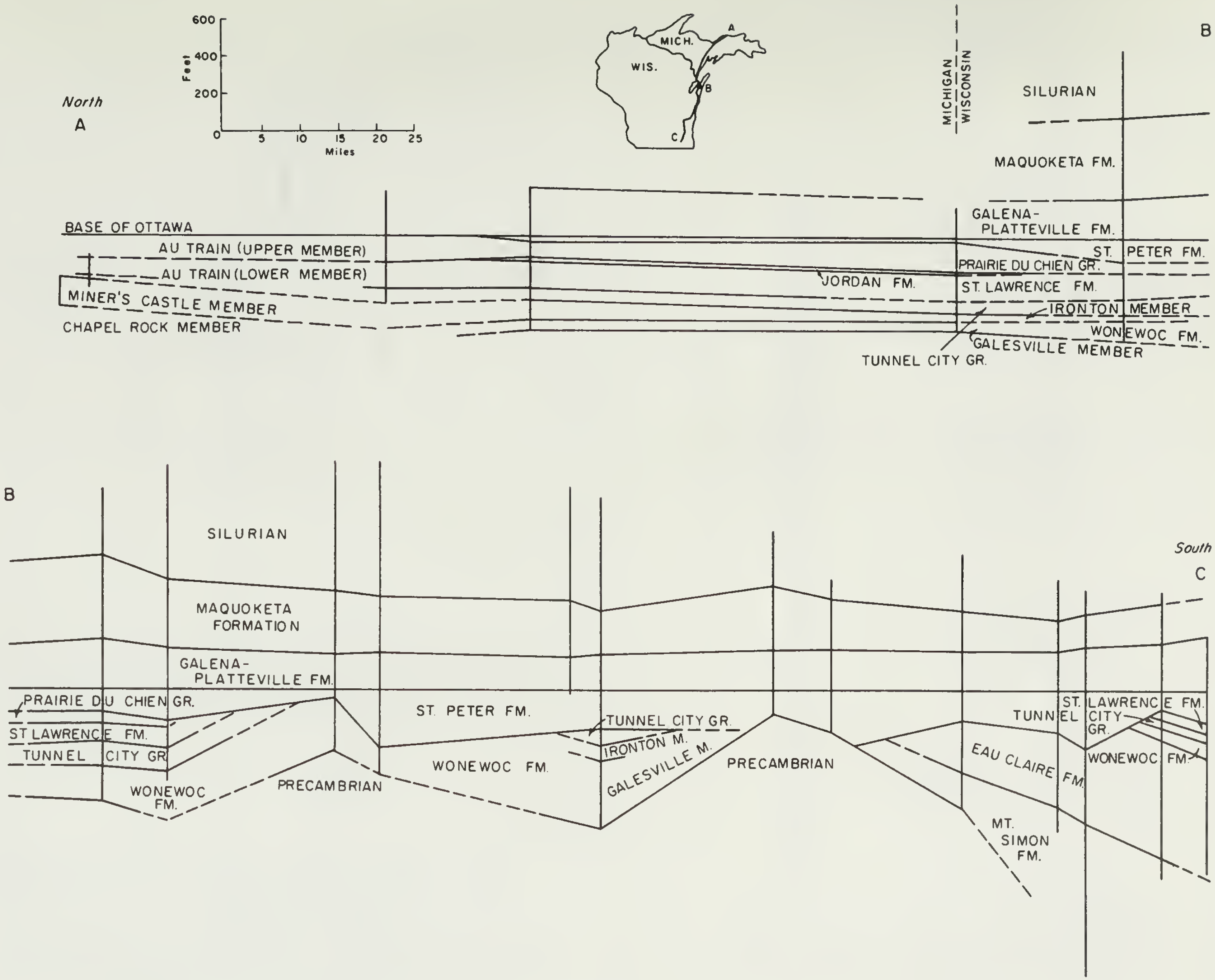
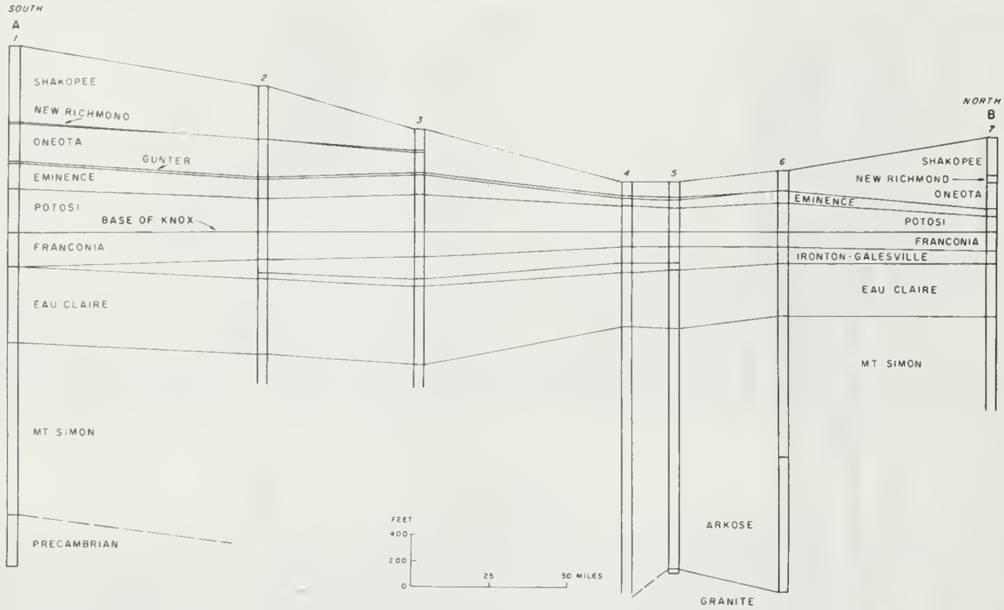


Figure 1 - Stratigraphic cross section running from Walworth County, Wis., to Alger County, Mich., showing influence of Precambrian surface topography on a structure of overlying strata. (Adapted from a cross section by M. E. Ostrom, 1967).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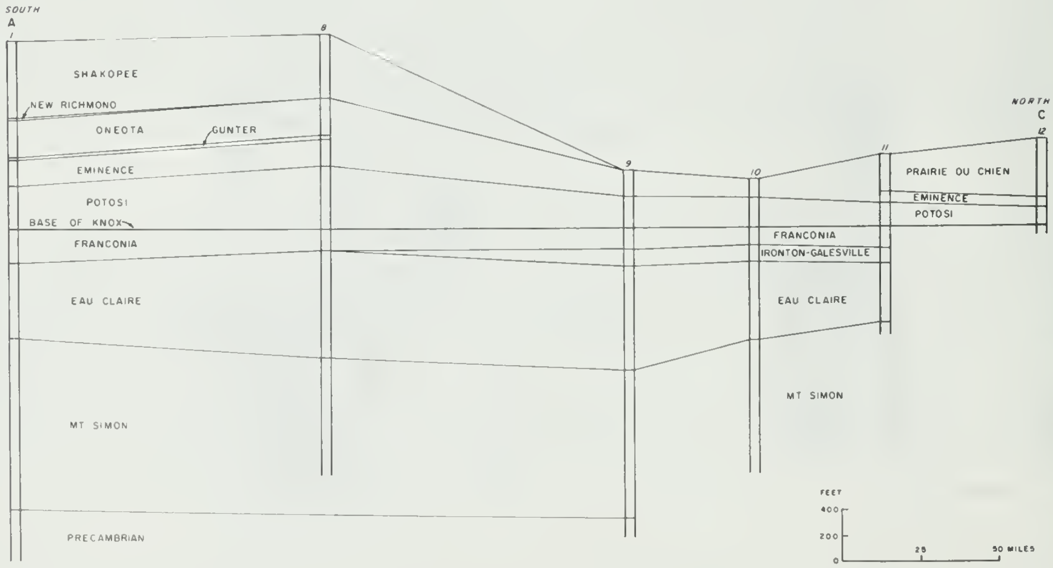
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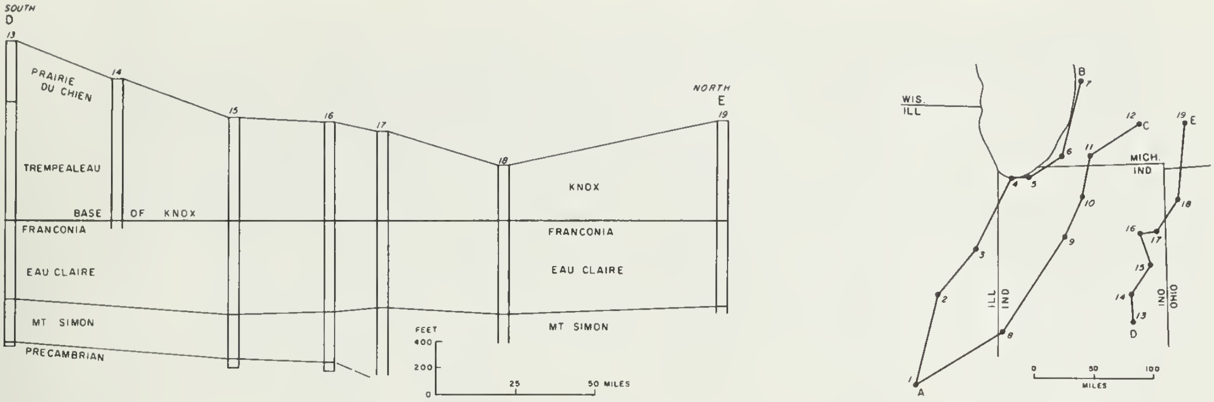
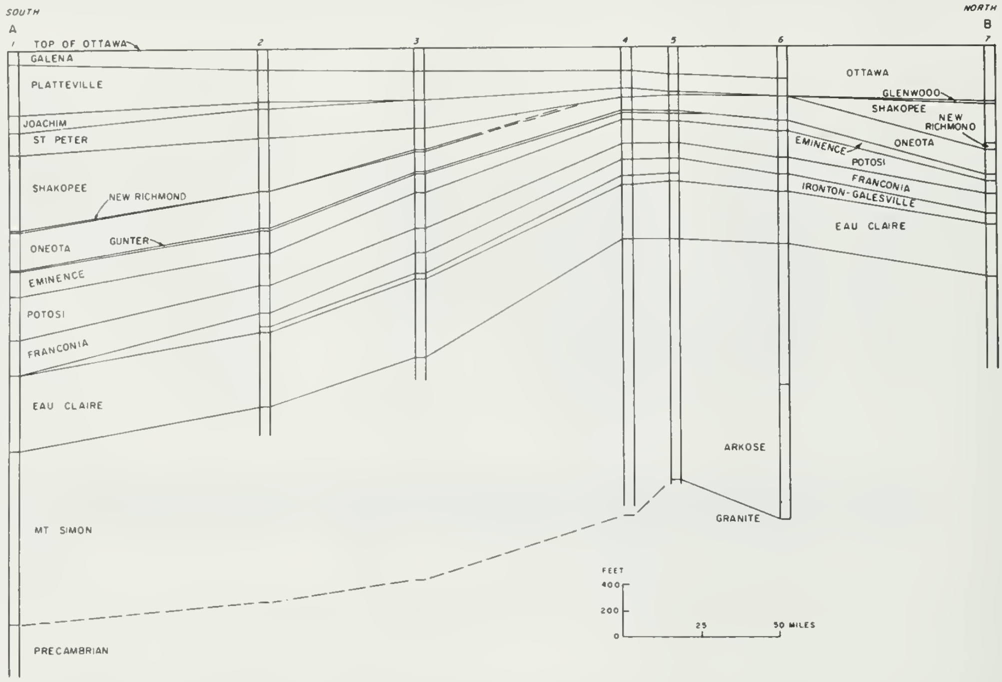


Figure 2 - Stratigraphic cross sections of older Paleozoic rocks from Illinois Basin to Michigan Basin. Datum: Top of Potsdam Megagroup. Data from Michigan wells from Garland D. Ells (1967). See table 1 for well identifications.

TABLE 1 - WELLS USED IN CROSS SECTIONS (FIGURES 2 AND 3)

Well	Sec.-T.-R.	County
1. Humble, No. 1 Weaber - Horn	28-8N-3E	Fayette Co., Ill.
2. Union Hill, No. 1 Webster	17-21N-7E	Champaign Co., Ill.
3. Northern Illinois Gas, No. 1 Condit	24-27-14W	Iroquois Co., Ill.
4. U. S. Steel, Gary Plant	29-37N-8W	Lake Co., Ind.
5. Bethlehem Steel, No. 1 Disposal	28-37N-6W	Porter Co., Ind.
6. Security, No. 1 Thalman	10-6S-17W	Berrien Co., Mich.
7. Holland Suco Color, No. 1 Disposal	30-5N-15W	Ottawa Co., Mich.
8. Food Machinery, No. 1 Newport	9-16N-9W	Vermillion Co., Ind.
9. Composite log, No. 2 Webb and No. 5 Pfeil	32-29N-1E	Fulton Co., Ind.
10. Northern Indiana Public Service, H. Ames	21-34N-3E	Marshall Co., Ind.
11. Perry and Son, No. 1 Wooden	8-7S-14W	Cass Co., Mich.
12. Trenton and McClure, No. 1 Bernloehr	13-3S-8W	Calhoun Co., Mich.
13. Ohio, No. 1 May	12-16N-11E	Henry Co., Ind.
14. Baggett, No. 1 Ladron	18-20N-11E	Delaware Co., Ind.
15. Farm Bureau, No. 1 Binegar	29-24N-13E	Jay Co., Ind.
16. Tecumseh, No. 1 Gibson	33-29N-12E	Allen Co., Ind.
17. Northern Indiana, No. 1 Levenburger	14-29N-14E	Allen Co., Ind.
18. Brown, No. 1 Haver	Mark Twp.	Defiance Co., Ohio
19. Collin-Black, No. 1 Daneer	29-3S-1W	Jackson Co., Mich.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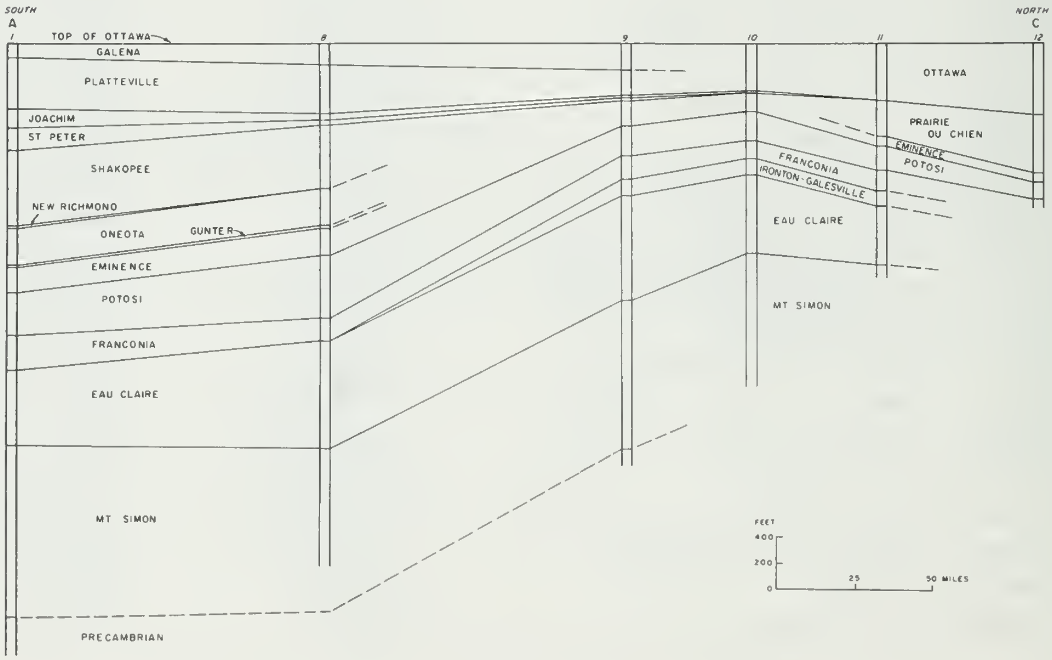
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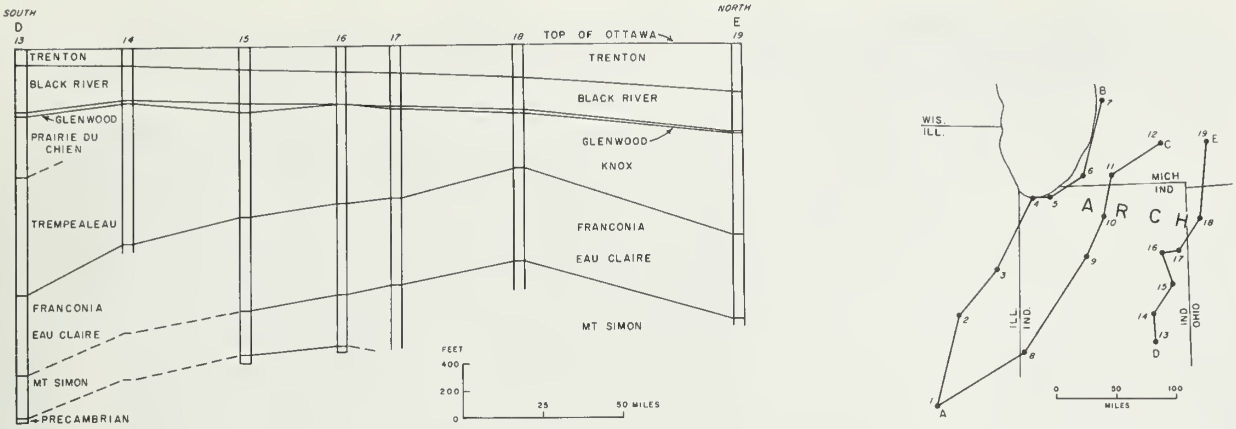

Figure 3 - Stratigraphic cross sections of older Paleozoic rocks from Illinois Basin to Michigan Basin. Datum: Top of Ottawa Megagroup. Data for Michigan wells from Garland D. Ells (1967). See table 1 for well identifications.

brian time, its adjustment to the adjacent cratonic arch province was in part by contemporaneous faulting (Webb, 1969). The absence of any conglomerates or coarse detritus adjacent to the faults in the zone of adjustment indicates that at no time did the exposed fault scarps stand high. Lower and Middle Cambrian sediments on the east wedge out against this scarp. Not until Croixan (Upper Cambrian) time had most of the Eastern Interior Region sunk low enough to be inundated by the sea. Two marine transgressions are indicated by two sedimentary cycles in the Croixan of this Region (Ostrom, 1964). At the close of Cambrian time the sea retreated, but no tectonic disturbance is known to have occurred in this Region.

Canadian (Lower Ordovician) sediments were deposited onto Cambrian strata with little break. Two marine transgressions are indicated by two sedimentary cycles (Ostrom, 1964). At the close of the Canadian, diastrophism tilted the Region down to the south. The Kankakee Arch separating the Illinois from the Michigan Basin made its first appearance in northern Indiana at that time. Cross sections show that Prairie du Chien strata are truncated over this axis (fig. 3). The location of the Kankakee Arch at that time was a short distance northeast of its location later in Paleozoic time. Erosion was deep in northern Illinois, and karst topography is believed to have developed in that area (Buschbach, 1961). Farther east, a landscape of buttes and mesas developed with a relief of more than 100 feet, suggesting that arid conditions were present by the time the overlying St. Peter Sandstone was deposited (Patton and Dawson, 1969). In the Cincinnati Arch Province, where sandstone zones and other porous layers within the Knox were truncated by pre-St. Peter erosion and sealed by overlying impervious Glenwood-Joachim cover, situations favorable for entrapment of oil occur where structural conditions are also favorable. Erosion that beveled the Eastern Interior Region resulted in a widespread angular unconformity that marks the top of the Sauk Sequence.

By the time the Ottawa Dolomite Megagroup was deposited, the Region was very stable, as indicated by the fact that thin, relatively uniform units can be traced over large areas. The megagroup is slightly thinner in western Ohio and northern Indiana (fig. 4), suggesting only slight positive influence in the area of the Indiana-Ohio Platform. The Cincinnati Arch was active in central Tennessee during Champlainian and Cincinnatian (Middle and Upper Ordovician) times. Recurrent uplifts here resulted in a north-south belt of shallow water, the Central Tennessee Bank, which for short periods of time was above sea level (Wilson, 1962). Doming just before Richmond time is indicated by buried stream channels nearly 100 feet deep (Wilson and Stearns, 1962). Near the end of Champlainian time, a large area west of a hinge line running from the Findlay Arch to the eastern edge of the Ozark Dome was raised as a broad plateau and exposed to subaerial erosion which truncated the Galena (Rooney, 1966). The Trenton production in the Lima-Indiana district is due to dolomitization porosity enlarged by weathering before the Cincinnatian submergence (Landes, 1970).

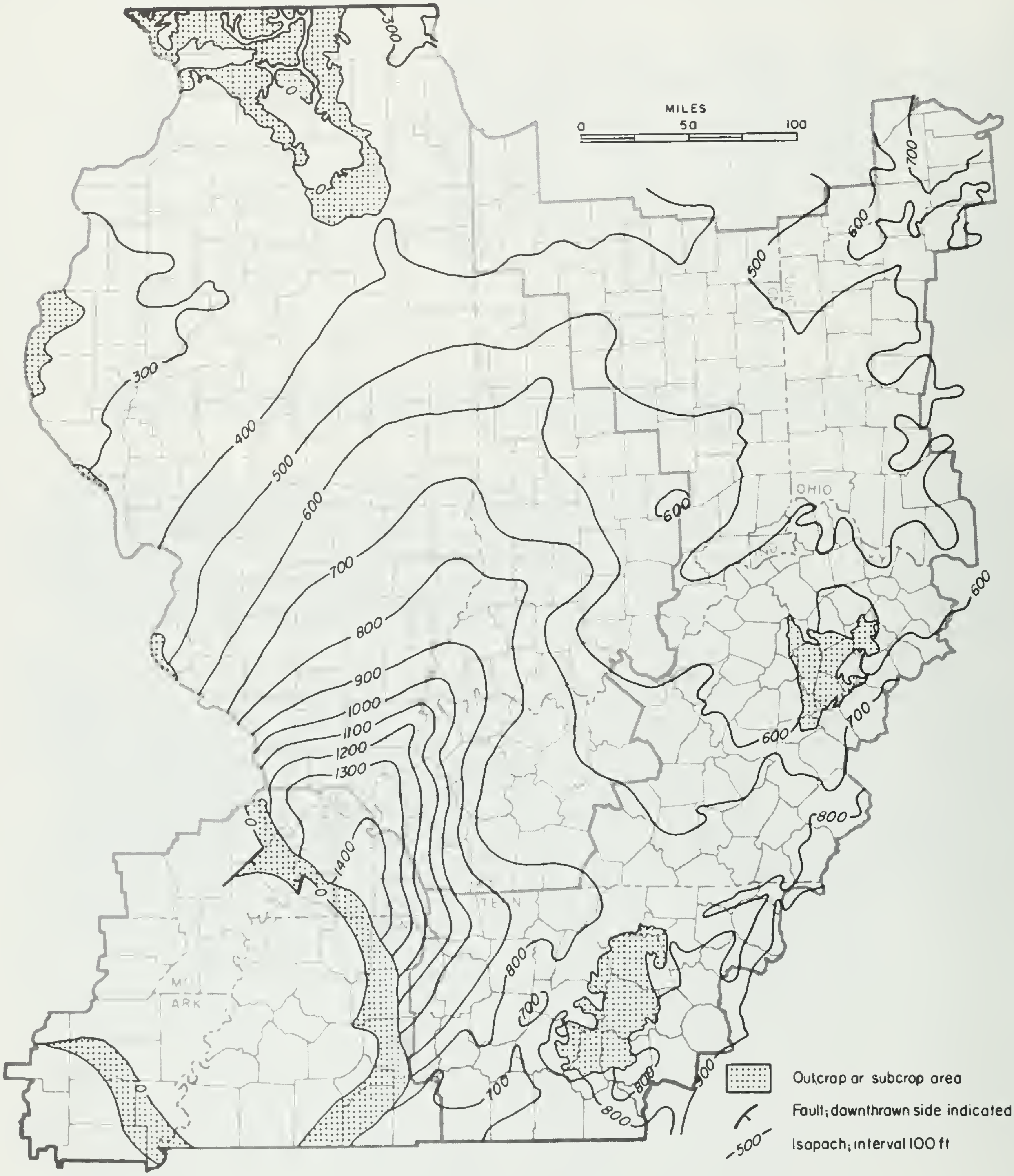

Figure 4 - Thickness of Ottawa Megagroup in Eastern Interior Region. Prepared by T. C. Buschbach in cooperation with L. E. Becker, T. A. Dawson, H. Schwalb, E. N. Wilson, A. T. Statler, and J. H. Buehner for publication in AAPG Memoir 15. Used with permission of the American Association of Petroleum Geologists.

East of the hinge line, deposition was continuous into Cincinnatian time, when muddy seas transgressed the region to the west. The hinge line marks the boundary between the Trenton limestone to the west and the Cynthiana Formation to the east. At present a belt of seismic activity follows this hinge line, and other data indicate that it has been a major zone of structural weakness since Precambrian time (Woolard, 1958). The Cincinnati Arch was not in evidence in Kentucky or Ohio when the Cincinnatian (Maquoketa Shale) strata were deposited. The Maquoketa clastic wedge thickens fairly regularly from west to east across the Eastern Interior Region and probably represents the first indications of the Taconic Orogeny along the eastern border of North America.

The Silurian was deposited on an erosional unconformity of low relief. The Silurian of the Illinois Basin is very similar to that of Oklahoma, suggesting a close connection now broken by a younger uplift (Pascola Arch) and erosion. The Niagaran (Middle Silurian) is notable for the growth of large reefs, the tops of which were well above the level of the inter-reef deposits. A number of the reefs stand high enough to project through Lower Devonian sediments that were deposited in the vicinity. Draping and differential compaction of overlying beds resulted in numerous structures in the younger strata. The Cincinnati Arch began to rise during the Silurian in Kentucky and Tennessee. In Kentucky, dissimilar faunas of the Silurian Clinton and Niagaran to the east and west of the Cincinnati Arch have been explained as probably due to a barrier along the rising arch. Erosion occurred during Late Silurian and Early Devonian time, cutting down to Upper Ordovician rocks on structurally high areas.

Sand grains rarely occur in Niagaran (Middle Silurian) and younger rocks until about the base of Middle Devonian, implying that potential sources of sand in the Ozarks and in Wisconsin were sealed by a cover that was not breached by erosion until about the end of Early Devonian time (Summerson and Swann, 1970). In central Illinois, initial upwarping of the Sangamon Arch is indicated by the absence of the basal Silurian Edgewood Formation over much of the central area of the arch (Whiting and Stevenson, 1965). Isopach maps of the Silurian of Illinois do not indicate any major uplift, but they do suggest tilting toward the east and southeast that began after or possibly during Niagaran deposition. The Michigan Basin to the north of the Eastern Interior Region deepened markedly during the Silurian. Near the center of this basin the Salina (Upper Silurian) is about 4500 feet thick and contains about 1800 feet of rock salt. At the close of the Silurian Period the Region emerged, with the exception of the deepest part of the Illinois Basin, where deposition was continuous from the Silurian into the Devonian.

Lower Devonian sediments were deposited in a rather restricted basin that developed in southern Illinois, southwesternmost Indiana, and western Kentucky. Although the basin was relatively small, sinking was pronounced and more than 1200 feet of Lower Devonian strata accumulated near the southern tip of Illinois. The area originally covered by Lower Devonian sediments probably has not been cut back much by later erosion. It is bordered in part by a rim of thick, reef-containing Silurian. During deposition of the Lower Devonian, erosion continued on the positive areas, including the Sangamon Arch. Subsequently, most of the Lower Devonian was included in the area being eroded; in only a small area is deposition believed to have been continous into the Middle Devonian. This very extensive erosion marks the top of the Tippecanoe Sequence. Sand, released from sources uncovered by the erosion, was blown out onto the erosion surface as far east as central Ohio (Summerson and Swann, 1970).

The Middle Devonian started with a major transgression of the sea. The Sangamon, Kankakee and Cincinnati Arches remained as barriers, however, separating highly saline water to the north in interconnected basins in Michigan and Iowa from normal marine water to the south (bordered by hypersaline intertidal flats on the south flank of the arches). In Kentucky, Middle Devonian limestone overlaps the Silurian to rest on Richmond and Maysville rocks. This angular unconformity indicates pre-Middle Devonian arching and truncation by erosion (McFarlan, 1943). These minor amounts of Middle Devonian limestone and some patches of Hardin Sandstone were later partly eroded before deposition of the overlying Chattanooga Shale (Perkins, 1968). Highlands east of the Appalachian Trough started to rise during Middle Devonian time (the Acadian Orogeny), followed by ever increasing orogenic activity during the Late Devonian. Sediment eroded from the rising land produced a clastic wedge, known as the Catskill Delta, in the Appalachian Trough, while mud from the uplift moved westward across the Cincinnati Arch, becoming in Late Devonian time an extensive deposit

(Chattanooga, New Albany) that overlapped eroded areas of older Devonian and Silurian to lie in places directly on Ordovician rocks. In Illinois, the New Albany Shale covered the Sangamon Arch. In central Kentucky, the Chattanooga Shale overlaps beveled Silurian and Middle Devonian rocks and serves as a seal for reservoirs in them (Landes, 1970). On the Ozark Dome, Lower Ordovician rocks at the crest are overlain in places by residual cherts of Middle Mississippian age, indicating considerable uplift and truncation. Late Devonian normal faulting is recognized in Ste. Genevieve County, Missouri. The youngest Devonian clastic units thicken northward, indicating a source of sediments in that direction.

The transition from Devonian to Mississippian was gradual, and the boundary is difficult to recognize in the Eastern Interior Region. During Mississippian time a major shift occurred in the source of clastic sediment entering the Region. The Northern Appalachian region became the chief dispersal center of Mississippian and Pennsylvanian clastics (Potter and Pryor, 1961), a shift implying considerable change in the borderlands northeast of the craton. During the Mississippian Period, the Illinois Basin continued to sink. At times sedimentation kept up with the sinking, at other times it fell behind. During Valmeyeran (Middle Mississippian) time a carbonate bank built up in western Illinois, while in eastern Illinois and Indiana a delta extended down from the northeast into water several hundred feet deep. A similar delta extended southward in Ohio east of the Cincinnati Arch. After the delta had built up, mud (Warsaw Shale) flooded across the carbonate bank, followed by an advance of the sea and deposition of extensive carbonate formations (Salem, St. Louis, and Ste. Genevieve). Minor sandstone layers interbedded with the limestone of the Ste. Genevieve (upper part of Valmeyeran) give a first indication of cyclic deposition during Chesterian time.

During Chesterian time the slowly sinking Illinois Basin, flanked by the stable Ozark Dome and Cincinnati Arch, received sediment from the northeast. Fluctuations of the shoreline are recorded as cyclical alternations of limestone-dominated and clastic-dominated units. The sedimentary rhythms have been explained as resulting from an alternation of wet and dry climates in the source area rather than as resulting from periodic uplifts of the source area (Swann, 1964). Chesterian deposition was followed by retreat of the sea. The Illinois Basin was tilted down to the south and beveled by erosion. The resulting extensive unconformity marks the top of the Kaskaskia Sequence. Notable during this interval of erosion was the beginning of the development of the La Salle Anticlinal Belt. As it rose, the locus of maximum deformation moved progressively southward from the La Salle area. Although erosion stripped its crest of younger strata, it stood high enough to act as a topographic barrier. Development of the Mississippi River Arch began in Mississippian time and continued into Pennsylvanian. Its presence is indicated by the thinning of sedimentary units as they rise onto the arch from either side. The principal folding along the Cap au Grès Flexure was post-St. Louis and pre-Pottsville, but there were other movements at both earlier and later periods (Rubey, 1952). About 300 feet of uplift of the Nashville Dome occurred at the beginning of the Pennsylvanian (Wilson and Stearns, 1962). During the erosion interval that followed Chesterian deposition, streams cut valleys 200 to 300 feet below the surrounding plains. Some of the folding that is mappable in Pennsylvanian beds can be shown to be wholly or in part due to the presence of topographic features on the pre-Pennsylvanian surface (Clark and Royds, 1948). In northern Illinois, caves and sinkholes were formed in carbonate rocks of the Ordovician, Silurian, Devonian, and Mississippian. These cavities were later filled with Pennsylvanian sediments.

Pennsylvanian sediments, laid down on the beveled edges of Mississippian and older formations, clearly have a rhythmic nature. At least 50 cyclic units are recognized. Several explanations, some tectonic, others primarily climatic, have been tentatively suggested to account for the great number of strand-line oscillations these 50 cycles imply. Sea level fluctuations were probably world-wide rather than a result of local tectonism, for they are independent of local tectonic events. The earlier marine transgressions entered the Region from the east; later others came from the west around the north side of the Ozark Dome. The area originally covered by Pennsylvanian deposits has been reduced by erosion. Pennsylvanian outliers rest on older rocks down to Lower Ordovician in the Ozarks. In places there and in northern Illinois Pennsylvanian deposits fill sinkholes on the older erosion surface (King, 1951). It is generally believed that the eastern and western coal fields of Kentucky were formerly continuous across the Cincinnati Arch (McFarlan, 1943). Spore studies show that the Pennsylvanian Abbott and Spoon Formations occur in a fault block in the Des Plaines Complex northwest of Chicago (Russel Peppers, personal communication, 1970). This outlier is the northern-most occurrence of Pennsylvanian rocks in the Illinois Basin. It is not known how much farther north Pennsylvanian sediments once extended. Differential downwarping of the Fairfield Basin is shown by abrupt thickening of some sedimentary units near the La Salle and Du Quoin structures. These structures acted as hinge lines bordering the basin and separating it from the eastern and western shelves of the Illinois Basin. Several of the Pennsylvanian sandstone units are markedly lenticular in cross section. Differential compaction of shaly units on either side of these lenticular sandstones resulted in formation of local structures in overlying beds.

LATE PALEOZOIC AND MESOZOIC

Pennsylvanian sedimentation was followed by some further downwarping and a very long interval of erosion. Actually, sedimentation probably continued from Pennsylvanian into Permian time, but all Permian strata have been removed by erosion. There is reason to believe that this "lost" portion of the upper part of the Paleozoic column was about a mile thick (Damberger, personal communication, 1970). Only the Embayment portion of the Eastern Interior Region has been invaded by the sea since then. No Permian, Triassic, or Jurassic sediments have been found in the Region. During post-Pennsylvanian time important tectonic events occurred that cannot be dated closely because we lack near-contemporaneous sedimentary strata to bracket their dates closely. Much of the activity was presumably related to the Appalachian Revolution that occurred near the close of the Paleozoic in the East, but some deformation may be Cretaceous (Heyl and Brock, 1961). Notable during this interval was the differential rise of the Cincinnati Arch as well as faulting along the Rough Creek-Kentucky River Fault Zone and in the highly faulted mineralized area of the Fluorspar District of southern Illinois and western Kentucky. Faults in the Fluorspar District generally are post-Pennsylvanian and terminate beneath the Cretaceous cover of the Mississippi Embayment, but there is some evidence that faulting on a small scale continued into the Tertiary. The nature of the younger sediments precludes the common preservation of evidence of such structures in surface outcrop (McFarlan, 1943). The La Salle Anticlinal Belt and the Du Quoin Monocline stayed active after deposition of the youngest Pennsylvanian beds involved, and many of the smaller structures of the Region had their beginning or their greatest development during this time.

Inasmuch as Pennsylvanian strata generally parallel older strata in structures developed in post-Pennsylvanian time, any structures discovered in Pennsylvanian rocks may be an indication of potentially productive structures in deeper layers. The structures of the zinc-lead district of northwestern Illinois probably had their origin during the general disturbance caused by the Appalachian and Ouachita orogenesis which took place in late or post-Pennsylvanian time (Heyl et al., 1959).

The east side of the Ozarks was uplifted, probably during or after the Permian (Moss, 1936), and high-angle faults and a steep dip mark the border between the Ozark Uplift and the Illinois Basin.

The Pascola Arch rose and was truncated, separating the Illinois Basin from the Black Warrior Basin to the south. Development of this arch and post-Pennsylvanian sinking that was centered on the Fairfield Basin transformed the Illinois Basin into its present spoon-shaped structure. More than 8000 feet of strata had been eroded from the crest of the Pascola Arch by the beginning of Tuscaloosa (Late Cretaceous) deposition, with the result that beds as old as Cambrian were exposed (Marcher, 1961). The arch is believed to have stood nearly 1000 feet above sea level during Tuscaloosa deposition. At about this time the arch began to subside and the Mississippi Embayment started to sink. Superposition of the synclinal bend across the now-buried "high" resulted in faults that cut Paleozoic rocks and, in some areas, extended upward into the overlying younger strata (Marcher, 1961). The Nashville Dome had at least 200 feet of uplift after deposition of Tuscaloosa Gravel (Wilson and Stearns, 1962). Dikes and plugs of dark igneous rock in the vicinity of the southern end of Illinois are believed to be late Paleozoic or Cretaceous. The age of one monazite intrusion has been determined to be Cretaceous.

TERTIARY AND QUATERNARY

The Mississippi Embayment continued to sink during much of the Tertiary, but for most of the Eastern Interior Region the Tertiary was a time of erosion. The thick Pleistocene glaciers spread over the northern part of the Region, extending at times as far south as the Ohio River, and depressed the surface in the vicinity of the Great Lakes. Subsequent rebound is indicated by tilted lake shorelines that formed during the glacial retreat. The full story of subglacial depression and of bulging upward of the region just south of the glacier is poorly known.

In conclusion, it is important to emphasize the influence of Precambrian structures and the buried topography of the Precambrian surface on the structures that developed in overlying strata. A second point, especially significant in the search for oil, is that a largely unknown structural development is concealed beneath the sub-St. Peter unconformity. Potentially productive structures that are not revealed by the younger strata may be present in pre-St. Peter Paleozoic beds.

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SELECTED DEEP TESTS IN NPC REGION 9

The tables on the following pages contain information about 239 selected deep tests in NPC Region 9. In general, these were selected because they were considered to be the most significant from the standpoint of exploration for oil and gas. A few tests outside NPC Region 9 are included. Locations of the wells are plotted on figure 1.

This information was supplied by: H. M. Bristol (Illinois), T. A. Dawson (Indiana), J. H. Buehner (Ohio), H. R. Schwalb (Mississippi Embayment), A. T. Statler (Tennessee, minus Mississippi Embayment), and E. N. Wilson (Kentucky, minus Mississippi Embayment).

This is not a complete listing. Information on other deep tests is available at the Illinois, Indiana, Kentucky, and Tennessee Geological Surveys. More information about the holes listed here, such as formation tops, is also available.

TABLE 1 - SELECTED DEEP TESTS IN ILLINOIS

Well no. on map	Well	County	Sec.-T.-R.	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)		
							Top of Trenton	Top of Knox	Top of Basement
1	Northern Ill. Oil & Gas No. 1 Taylor	Boone	28-43N-3E	815	2,998	Precambrian	+785*	+150	-2,104
2	Peoples Gas Light & Coke No. 1 Flessner	Champaign	17-21N-7E	760	4,530	Mt. Simon	-388	-1,052	
3	Illinois Development Co. No. 3 Alderson	Christian	32-15N-2W	588	3,218	Knox	-1,824	-2,619	
4	Carter No. 1 Seaman	Coles	35-12N-7E	760	4,908	Knox	-3,295	-4,026	
5	Magnolia No. 1 Rodda	Coles	4-11N-9E	609	5,389	Knox	-3,985	-4,761	
6	Getty Oil No. 21 Shoulders	Crawford	20-5N-11W	492	5,317	Knox	-3,816	-4,623	
7	Schulte No. 1 Wyman	De Kalb	35-41N-5E	910	4,484	Precambrian	+660	-105	-2,953
8	Peoples Gas Light & Coke No. 1 Lamb	De Witt	1-20N-4E	736	4,933	Mt. Simon	-1,101	-1,764	
9	Ohio No. 1 Shaw	Douglas	36-16N-8E	666	4,151	Mt. Simon	-281	-1,029	
10	Cabot No. 1 Cabot	Douglas	31-16N-8E	696	5,317	Knox	-2,664	-3,411	
11	Union Hill Gas Storage No. 1 Powers	Edgar	27-15N-14W	670	2,520	Knox	-1,094	-1,800	
12	Kingwood No. 1 McWhorter	Effingham	15-6N-6E	536	6,543	Knox	-4,746	-5,659	
13	Humble No. 1 Weaber-Horn	Fayette	28-8N-3E	536	8,616	Precambrian	-3,284	-4,098	-7,676
14	Texaco No. 1 Walters	Gallatin	29-9S-9E	372	7,686	Knox	-5,962	-7,188	
15	Texaco No. 1 E. Cuppy	Hamilton	6-6S-7E	393	13,051	Precambrian	-6,268	-7,365	-12,574
16	Miller No. 1 Anderson	Henderson	36-9N-5W	752	2,616	Eau Claire	+207?	-394	
17	Davis No. 1 South	Henry	30-16N-1E	793	3,863	Precambrian	-77	-510	-3,062
18	Northern Ill. Gas No. 1 J. Taden	Iroquois	11-26N-13W	653	3,475	Mt. Simon	-156	-728	
19	Natural Gas Storage No. 7 Schwark	Kankakee	32-30N-10E	674	5,003	Mt. Simon	+441	-164	
20	Lawinger No. 1 Miller	La Salle	1-36N-4E	681	3,659	Precambrian	Absent	+435	-2,788
21	Otto No. 1 Swenson	La Salle	1-36N-5E	659	3,725	Precambrian	Absent	+514	-3,041
22	Vickery No. 1 P. Mathesius	La Salle	32-35N-1E	677	3,556	Precambrian	Absent	+607	-2,838
23	Amboy Oil & Gas No. 1 McElroy	Lee	30-20N-10E	714	3,772	Precambrian	?	-151	-3,040
24	Carr No. 1 Vedovell	Lee	35-20N-10E	812	3,653	Precambrian	+662*	+288	-2,633
25	Sun Oil No. 1 Damery	Macon	5-15N-1E	612	3,780	Knox	-1,861	-2,503	

TABLE 1 – Continued

Well no. on map	Well	County	Sec.-T.-R.	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)		
							Top of Trenton	Top of Knox	Top of basement
26	Maryland Service No. S-1 Kircheis	Madison	27-3N-6W	504	5,018	Precambrian	-1,796	-2,446	-4,506
27	Texaco No. 1 R. A. Johnson	Marion	6-1N-2E	541	9,210	Precambrian	-3,955	-4,869	-8,629
28	Kelley No. 1 Fullerton	Mercer	19-13N-4W	584	3,716	Precambrian	+42	-356	-2,793
29	Miss. River Fuel No. A-15 Theobold	Monroe	35-1S-10W	666	2,768	Precambrian	+276	-414	-2,093
30	Panhandle Eastern Pipeline No. 7-15 Whitlock	Morgan	15-13N-8W	661	4,250	Mt. Simon	-787	-1,439	
31	Sanders No. 1 Harrison	Moultrie	22-15N-5E	681	6,526	Mt. Simon	-2,824	-3,519	
32	Herndon No. 1 Campbell	Pike	15-4S-5W	716	3,207	Precambrian	+150	-374	-2,488
33	Panhandle Eastern No. 1-21 Mumford	Pike	21-5S-4W	812	2,226	Precambrian	+451	-58	-1,409
34	J & L Steel Corp. No. 1 Waste Disposal	Putnam	3-32N-2W	527	4,877	Precambrian	-430	-945	-4,315
35	Leverton No. 1 Mills	Schuyler	7-1S-1W	435	2,650	Knox	-296	-937	
36	N.E.A. Yes INC. No. 1 Stoggsdill	Shelby	19-14N-2E	632	4,500	Knox	-2,368	-3,091	
37	Humble No. 1 Pickel	Union	21-13S-2W	424	8,490	Mt. Simon	+196	-1,448	
38	Union Oil of Calif. No. 1 Cisne Comm.	Wayne	3-1S-7E	504	11,614	Precambrian	-5,830	-7,056	-11,010
39	Superior No. C-17 Ford et al.	White	27-4S-14W	386	7,679	Knox	-6,033	-7,123	
40	Reed No. 1 McCoy	Will	20-35N-9E	632	4,300	Precambrian	+385	-141	-3,593
41	Seele No. 1 Seele	Winnebago	24-44N-2E	870	3,385	Precambrian	+818*	-255	-1,786
42	S.B. Geiger No. 1 Automatic Electric Co.	Cook	31-40N-12E	655	1,900	Mt. Simon	+192	-315	
43	J. S. Young No. 1 Midland Electric Coal	Fulton	2-8N-3E	700	2,777	Eau Claire	-364	-930	
44	Milaeger Well & Pump Co. No. 5 Galena City	Jo Daviess	13-28N-1W	840	1,600	Mt. Simon	+800*	+430	
45	J.H. Forester No. 1 Forester	Perry	5-6S-1W	465	5,256	St. Peter	-3,827		

*Top of Trenton eroded.

TABLE 2 - SELECTED DEEP TESTS IN INDIANA

Well no. on map	Well	County	Sec.-T.-R.	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)					
							Top of Hunton	Top of Trenton	Top of Knox	Top of Eau Claire	Top of Mt. Simon	Top of basement
46	Tecumseh Oil & Gas Co. No. 1 Gibson	Allen	33-29N-12E	822	3,517	Precambrian		-413	-849	-1,583	-2,249	-2,654
47	No. Ind. Pub. Serv. Co. No. 1 Leuenberger	Allen	14-29N-14E	797	3,672	Precambrian		-551	-1,033	-1,713	-2,333	-2,692
48	Gulf Oil Corp. No. 1 Scott	Fayette	32-13N-13E	959	3,955	Precambrian		+63	-446	-1,921	-2,460	2,955
49	No. Ind. Pub. Serv. Co. No. 2 Pheil	Fulton	32-29N-1E	750	4,056	Precambrian		-178	-600	-1,256	-2,015	-3,170
50	Ohio Oil Co. No. 1 May	Henry	12-16N-11E	1,060	3,664	Precambrian		+191	-310	-1,655	-2,258	-2,589
51	Kokomo Gas & Fuel Co. No. 1 Greentown Well	Howard	32-24N-5E	821	3,996	Precambrian		-103	-530	-1,524	-2,254	-3,124
52A	Farm Bureau Oil Co., Inc. No. 1 Binegar	Jay	29-24N-13E	949	3,395	Precambrian		-72	-501	-1,343	-2,049	-2,384
52B	Petroleum Development Corp. No. 1 Binegar	Jay	29-24N-13E	948	3,404	Precambrian		-62	-484	-1,364	-2,066	-2,403
53	Inland Steel Co. No. WD-1 Inland Steel Co.	Lake	14-37N-9W	608	4,363	Precambrian	+442	-183	-851	-922	-1,832	-3,742
54	Indiana Farm Bur. Coop. Assoc. Inc. No. 1 Brown	Lawrence	20-5N-2E	800	6,806	Precambrian	+24	-961	-1,560	-3,875	-4,565	-5,850
55	No. Ind. Pub. Serv. Co. No. 1 Ames	Marshall	21-34N-3E	789	4,082	Precambrian	+512	-573	-971	-1,536	-2,216	-3,105
56	Stoltenberg Construct. Co. No. WD-1 Ind. General	Porter	16-35N-5W	784	4,548	Precambrian	+466	-347	-714	-1,114	-2,031	-3,749
57A	Bethlehem Steel No. WD-1 Bethlehem Steel	Porter	28-37N-6W	625	4,304	Precambrian	+425	-325	-683	-1,050	-1,910	-3,638
57B	Bethlehem Steel No. WD-2C Bethlehem Steel	Porter	29-37N-6W	624	4,301	Precambrian		-314	-731	-1,038	-1,894	-3,641
58	Midwest Steel No. WD-1 Midwest Steel	Porter	25-37N-7W	615	4,308	Precambrian		-315	-730	-1,030	-1,871	-3,644
59	Swager, William No. 1 Swager, William	Steuben	15-38N-14E	1,058		Precambrian			C O N F I D E N T I A L			
60	Ashland Oil & Ref. Co. No. 1 Collins & Eichler	Switzerland	4-2N-1W	880	4,000	Precambrian			-337	-2,201	-2,803	-3,094
61	Ashland Oil & Ref. Co. No. 1 Hudson	Wabash	25-29N-6E	787	3,685	Precambrian		-296	-672	-1,498	-2,213	-2,880
62	Gordon No. 1 Doddridge	Wayne	23-15N-13E	957	3,907	Precambrian		+122	-383	-1,643	-2,246	-2,478
63	No. Ind. Pub. Serv. Co. No. 1 Boezman	Jasper	6-31N-7W	668	3,658	Mt. Simon		-238	-657	-1,307	-2,118	
64	Food Mach. & Chem. Co. No. WD-1 Newport Chem. Plant	Vermillion	9-16N-9W	650	6,160	Mt. Simon	-671	-1,540	-2,169	-3,770	-4,610	
65	Crawford No. 1 Galloway	Fountain	22-20N-8W	652	3,758	Eau Claire	-192	-1,023	-1,598	-2,977		
66	Hassett, J.L. et al. No. 1 Lagrange	Johnson	4-12N-4E	772	4,092	Eau Claire	+452	-391	-968	-2,726		
67	Wilkey No. 1 Boyer	Boone	15-19N-2E	949	2,240	Knox		-109	-616			

TABLE 2 - Continued

Well no. on map	Well	County	Sec.-T.-R.	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)					
							Top of Hunton	Top of Trenton	Top of Knox	Top of Eau Claire	Top of Mt. Simon	Top of basement
68	Louisville Cement Corp. No. 1 Louisville Cement Corp.	Clark	Gr. 131-1S-7E	465	1,806	Knox			-982			
69	Hyslope & Simpson No. 1 Bishop	Hendricks	12-14N-1E	763	1,972	Knox	+377	-456	-1,042			
70	Moses & Stewart No. 2 Curts	Jay	25-22N-12E	969	1,452	Knox		0	-391			
71	Jefferson Oil Dev. Co. No. 2 Nay	Jefferson	22-4N-8E	693	2,016	Knox		-287	-786			
72	Carlock No. 1 Newby	Jennings	8-6N-7E	602	1,793	Knox		-331	-883			
73	Poe & Elliott No. 1 Guerrettaz	Knox	Loc. 97-3N-10W	491	5,470	Knox	-2,676	-4,081	-4,899			
74	Indiana Gas & Water Co. Inc. No. 1 Fleener	Monroe	8-9N-1E	870	2,470	Knox	+70	-858	-1,463			
75	Highland Oil Co. No. 1 Seng	Orange	19-1S-2W	505	3,284	Knox	-955	-2,148	-2,770			
76	Sun Oil Co. No. 1 Chambers	Owen	23-10N-5W	712	3,185	Knox	-699	-1,629	-2,288			
77	Sun Oil Co. No. 1 Gibson	Perry	17-4S-1W	748	3,534	Knox	-1,006	-2,114	-2,716			
78	Stanolind Oil & Gas Co. No. 1 Wells et al.	Putnam	15-14N-5W	755	2,829	Knox	-336	-1,165	-1,771			
79	Felmont Corp. No. 1 Riggs	Sullivan	36-8N-9W	458	4,160	Knox	-1,805	-2,958	-3,676			
80	Continental Oil Co. No. 1 Warren	Tippecanoe	8-23N-5W	683	1,743	Knox	+329	-488	-1,001			
81	Brown No. 1 Bingham	Gibson	16-1S-11W	398	6,198	Chazyan	-3,358	-4,908				
82	Citizens Gas & Coke Utility No. 1 Hudson	Greene	4-7N-5W	560	3,214	Chazyan	-952	-1,962				
83	Uland No. 1 Leistner	Pike	6-1S-6W	481	4,508	Chazyan	-1,940	-3,265				
84	Wilkey No. 1 Stultz	Vigo	14-13N-8W	562	3,000	Chazyan	-876	-1,782				
85	Midwest Dev. Corp. No. 1 Keifner	Daviess	2-2N-5W	510	3,129	Black River	-1,302	-2,469				
86	Texas Co. No. 1 Luebbehuesen	Dubois	35-3S-5W	568	3,803	Black River	-1,685	-3,117				
87	Continental Oil Co. No. 1-D Cooper Estate	Gibson	13-3S-14W	376	6,408	Black River	-4,256	-5,800				
88	Harrison Development Corp. No. 1 Holliday	Harrison	4-6S-4E	673	2,000	Black River	-27					
89	Wires No. 1 McBride	Martin	16-4N-3W	494	2,314	Trenton	-792	-1,779				
90	Indiana Southwestern Gas Corp. No. 1 Gudgel	Gibson	25-2S-9W	473	4,006	Devonian limestone	-2,732					
91	Superior Oil Co. No. 1 Comm. Braselton et al.	Gibson	24-2S-12W	404	4,260	Devonian limestone	-3,551					
92	Indiana Farm Bur. Coop. Assoc. Inc. No. 1 Rowe	Posey	36-5S-13W	385	4,985	Devonian limestone	-4,302					
93	T & H Corp. No. 1 Princeton Mining Co.	Vanderburgh	10-6S-10W	383	4,318	Devonian limestone	-3,679					

TABLE 3 - SELECTED DEEP TESTS IN OHIO

Well no. on map	Well	County	Township	Location within township	Elev. (ft)	T.D. (ft)	Deepest unit pene-trated	Elevation in ft (Datum is mean sea level.)			
								Top of Trenton	Top of Knox	Top of Potsdam	Top of basement
94	Cabot Corp. No. A-1 Bailey	Adams	Jefferson	VMSL2662	714	3,790	Precambrian	-716	-1,280	-2,412	-3,026
95	H.H. Prod. No. 1 Pohlman	Allen	Spencer	22(NE)	807	3,207	Precambrian	-411	-985	-1,705	-2,379
96	W. Ohio Gas No. 1 Hoelsher	Auglaize	St. Marys	22	887	3,066					
97	Armco-Steel No. 1 Armco	Butler	Lemon	8	667	3,296	Precambrian	+27	-484	-1,753	-2,570
98	Hodges Ind. No. 1 Ropp	Champaign	Goshen	VMSL6349	1,267	3,323	Potsdam	-343	-846	-1,613	
99	Hodges Ind. No. 1 Elcamere	Clark	Harmony	3(SE)	1,187	3,570	Precambrian	-338	-895	-1,683	-2,360
100	Friend No. 1 Mattison	Clark	Madison	L2026?	1,089	4,647	Precambrian	-326	-856	-1,741	-2,277
101	Continental No. 1 Wickoff	Clermont	Stonelick	VMSL681	817	3,436	Precambrian	+145	-403	-1,767	-2,480
102	Kewanee No. 1 McVey	Clinton	Wayne	MS808	1,087	3,465	Precambrian	-120	-673	-1,761	-2,363
103	Brown No. 1 Haver	Defiance	Mark	11	702	3,606	Potsdam	-1,040	-1,658	-2,198	
104	Kewanee No. 1 Hopkins	Fayette	Union	VMSL663	965	4,708	Precambrian	-419	-925	-1,873	-2,582
105	Continental No. 1 Brisbin	Hamilton	Crosby	13	815	2,750	Potsdam	+147	-377	-1,915	
106	Shannon O. No. 1 Frazier	Hancock	Union	24(SE)	824	3,017	Precambrian	-486	-1,070	-1,576	-2,186
107	Edmund No. 1 Jones	Hardin	Jackson	30	941	2,834	Precambrian	-309	-859	-1,319	-1,873
108	E. Frey No. 1 Frey	Henry	Ridgeville	20-6N-5E	718	3,366	Potsdam	-1,245	-1,803	-2,126	
109	Kewanee No. 1 Pavey	Highland	Fairfield	MS2298	1,043	3,512	Precambrian	-221	-760	-1,867	-2,459
110	Ohio Oil No. 1 Johns	Logan	McArthur	VMSL9930	1,190	3,361	Precambrian	-314	-880	-1,430	-2,050
111	Harner Union No. 2 Yewey	Mercer	Center	4	835	3,176					
112	National Association No. 1 Walker	Miami	Lost Creek	13	1,035	3,513	Precambrian	-167	-714	-1,515	-2,220

TABLE 3 - Continued

Well no. on map	Well	County	Township	Location within township	Elev. (ft)	T.D. (ft)	Deepest unit pene-trated	Elevation in ft (Datum is mean sea level.)			
								Top of Trenton	Top of Knox	Top of Potsdam	Top of basement
113	Kewanee No. 1 Long	Pickaway	Monroe	MS4290	857	3,257	Precambrian	-743	-1,295	-2,027	-2,333
114	Ohio Oil No. 1 Barlage	Putnam	Liberty	29(SW)	740	3,377	Precambrian	-693	-1,296	-1,937	-2,510
115	E. Ohio Gas No. 1 Haff	Sandusky	Townsend	33-5N-17E	644	3,128	Precambrian	-1,217	-1,868	-1,981	-2,474
116	Dunigan No. 1 Ayers	Sandusky	Washington	31-5N-14E	633	2,721	Precambrian	-627	-1,349	-1,627	-2,075
117	Ashland No. 1 Stegamire	Seneca	Adams	31-5N-16E	796	3,175	Precambrian	-998	-1,654	-1,809	-2,332
118	Sun Oil No. 1 Nelson	Shelby	Perry	24(SW)	1,050	3,276	Precambrian	-268	-772	-1,490	-2,093
119	H.H. & R. No. 1 Zenith	Union	Union	MS7474	1,001	3,352	Precambrian	-467	-1,083	-1,711	-2,344
120	Carter Dev. No. 1 Rainey	Warren	Clear Creek	20	1,048	3,444	Precambrian	-42	-580	-1,668	-2,388?
121	Begliner No. 1 Kennerk	Williams	St. Joseph	21-6N-1E	842	4,136	Precambrian	-1,239	-1,868	-2,349	-3,083
122	O'Neil No. 1 Peek	Wood	Liberty	36-4N-10E	698	2,770	Precambrian	-458	-1,182	-1,426	-2,062
123	Texaco No. 1 Bowen	Wyandot	Mifflin	14-3S-13E	846	2,902	Precambrian	-454	-1,168	-1,354	-2,004

TABLE 4 - SELECTED TESTS IN THE MISSISSIPPI EMBAYMENT

Well no. on map	State	Well	County	Sec.-T.-R.*	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation of tops in ft (Datum is mean sea level.)			
124	Ark.	Tennark No. 1 Martin	Craighead	35-14N-3E	350	5,092	Knox	Joachim	-1,325	Roubidoux	-4,472
125	Ark.	Davis No. 1 DeMange	Crittenden	22-8N-7E	215	5,022		Devonian Ordovician	-2,965 -3,175	Silurian	-3,105
126	Ark.	Benedum-Trees No. 1 Mack	Mississippi	3-15N-12E	267	4,535	Eminence	Paleozoic Gasconade	-2,539 -3,338	Roubidoux Eminence	-2,882 -4,051
127	Ark.	Deep Rock No. 1 Sample	White	4-10N-6W	475	5,073	Powell	Mississippian Silurian Powell	-2,205 -2,505 -4,375	Devonian Ordovician	-2,405 -2,515
128	Ark.	Magnolia No. 1 Sturgis	Woodruff	30-9N-3W	217	6,002	Knox	Mississippian? Jefferson City	-1,803 -5,533	Devonian	-3,383
129	Mo.	Mammoth Producing No. 1 Big Oak Farm (Hercules Oil Co.)	Mississippi	7-24N-17E	294	4,909	Knox	Kimmswick Roubidoux	-1,131 -4,366	Everton	-1,606
130	Mo.	U.S. Bureau of Mines No. 1 Oliver	New Madrid	29-22N-11E	278	3,728	Cambrian	Ordovician Bonneterre	-1,018 -3,112	Roubidoux	-1,372
131	Mo.	Strake Pet. No. 1 Russell	Pemiscot	24-19N-11E	271	4,740	Lamotte	Cambrian Lamotte	-1,789 -4,379	Bonneterre	-2,699
132	Mo.	M.H. Marr No. 1 Barnett	Stoddard	3-25N-11E	311	4,580	Lamotte	Ordovician Bonneterre	-157 -3,379	Roubidoux Lamotte	-834 -4,261
133	Tenn.	Big Chief Drlg. No. 1 Taylor	Gibson	19-5S-6E	381	7,146	Precambrian	Gasconade Bonneterre?	-1,839 -4,974	Eminence Precambrian	-2,579 -6,517
134	Tenn.	Pure Oil No. 1 R. R. McGregor	Tipton	14-11S-2W	270	2,753	?	Igneous intrusive	-2,280		
135	Tenn.	Henderson Oil Co. No. F. B. Carroll	Obion	19-3S-2E	460	3,418	Cambrian	Bonneterre	-2,230		
136	Tenn.	Stephens No. 1 Petrie	McNairy	9-18S-13E	585	4,842	Cambrian	Ordovician Everton Eminence	+30 -810 -3,925	Stones River Roubidoux	-100 -2,640
137	Tenn.	Pure Oil No. 1 C.W. Gray	Lauderdale	16-8S-2E	303	4,995	Cambrian	Jefferson City Eminence	-2,135 -4,597	Roubidoux	-3,297
138	Tenn.	Benz No. 1 J.E. Vaughn	Lake	23-3S-1E	280	2,590	Lamotte	Lamotte	-2,160		
139	Tenn.	Henderson Oil Co. No. 1 John Fields	Dyer	25-6S-1W	260	3,240	Cambrian	Bonneterre?	-2,507		
140	Tenn.	Henderson Oil Co. No. 1 A.E. Markham	Lake	21-2S-1E	301	3,990	Cambrian	Bonneterre	-1,929		
141	Tenn.	Dr. Ireland No. 2 Lipps	Henry	20-4S-13E	557	4,600	Cambrian	Plattin	-381	Roubidoux	-2,818
142	Tenn.	Gulf No. 1 Spinks	Henry	25-2S-13E	483	10,748	Cambrian	C O N F I D E N T I A L			
143	Tenn.	Nance & Vivadelli No. 1 J.B. Donaldson	Hardeman	10-16S-8E	357	3,780	Knox	Ordovician	-645	Knox	-673
144	Tenn.	Memphis Equipment Co. No. 1 J. Curtis	Hardin	16-18S-15E	400	3,427	Knox	Stones River	-140	Knox?	-830
145	Tenn.	Memphis Equipment Co. No. 1 H. Cordle	Decatur	15-13S-17E	509	4,806	Knox	Stones River	+347	Knox	-411
146	Ky.	Robinson-Puckett No. 1 Clark Hrs.	Ballard	22-H-5	317	3,415	Knox	Clear Creek Ordovician	-23 -1,245	Silurian St. Peter	-813 -2,683
147	Ky.	South Central No. 1 Cherry	Calloway	8-B-14	583	5,610	Knox	Bailey Roubidoux?	-117 -4,377	Silurian Gasconade Ordovician	-367 -4,817 -637
148	Ky.	Ken-Ten Oil Exploration No. 1 Sanger	Fulton	12-A-3	295	4,010	Knox	Cotter-Powell Roubidoux	-1,612 -3,070	Jefferson City Gasconade	-2,600 -3,615

*Tennessee and Kentucky Carter Coordinate System.

TABLE 5 - SELECTED DEEP TESTS IN TENNESSEE (MINUS MISSISSIPPI EMBAYMENT)

Well no. on map	Well	County	Carter Coord. System	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)			
							Top of Stones River or "Pencil Cave"	Top of Knox	Top of Conasauga	Top of basement
149	California Company No. 1 E. W. Beeler	Giles	4-15S-29E	826	5,750	Precambrian	Surface	+98	-3,564 ?	-4,814
150	Magnolia Petroleum Co. No. 1 W. H. Patterson	Grundy	15-14S-47E	1,893	4,413	Knox	-102	-1,025		
151	C. R. Craft No. 1 Tennessee Products Co.	Wayne	19-15S-22E	1,014	3,003	Knox	+360	-369		
152	Shell Oil Company No. 1 Peterson	Cumberland	2-8S-56E	2,624	5,405	Knox	+409 & -1,341 (Rev. fault)	-2,361		
153	Ben Tate, TR. No. 1 Baker-Pemberton	Morgan	15-3S-59E	1,548	5,517	Knox	-1,222	-2,190		
154	Godfrey L. Cabot No. 1 Rocky River	Van Buren	5-12S-49E	1,798	5,065	Knox	-137	-1,030		
155	Associated Oil & Gas & Penn-zoil No. 1 F & A Sells	Pickett	3-A-54E	895	5,827	Precambrian	+43	-698	-3,629	-4,031
156	Martin Shurin No. 6 J. L. West	Scott	11-1S-61E	1,590	6,100	Lower Knox	-1,688	-2,674		
157	Dupont & Co., Inc. No. 1 Fee (Disposal)	Humphreys	14-6S-19E	388	6,735	Cambrian dolomite	-252	-1,232	-5,262 ?	
158	Texaco, Inc. No. 1 B. A. Haynes	Wilson	10-7S-39E	875	5,534	Precambrian	Surface	+150		-4,620
159	Gordon Street No. 1 R. Holden	Rutherford	13-10S-37E	700	5,616	Precambrian	Surface	+90	-3,390	-4,860
160	Indiana Farm Bureau (Howard Atha) No. 1 Ketchen Coal Co.	Scott	8-A-62E	1,179	7,555	Cambrian Pre-Knox	-1,641	-2,611	-5,551	
161	Stauffer Chemical Co. No. 1 Fee	Maury	16-12S-28E	636	6,473	Precambrian	+571	-276	-4,254 ?	-5,764
162	Dupont (Old Hickory Plant) No. 1 Fee	Davidson	16-3S-35E	504	5,574	Precambrian	+181	-564	-4,176	-4,956
163	Ed Riley Oil No. 1 Louise Lanham	Morgan	11-3S-57E	1,485	8,032	Cambrian basal sandstone	-905	-1,803	-4,965	
164	Dupont & Co., Inc., No. 2 Fee (Disposal)	Humphreys	14-6S-19E	394	7,461	Precambrian ? Arkose	-277	-1,258	-5,276	-7,056 ?
165	Weaver Oil & Gas No. 1 Lewis S. Pope	Sequatchie	20-13S-50E	775	7,410	Basal Cambrian sandstone	-832	-1,745	-4,975	

TABLE 6 - SELECTED DEEP TESTS IN KENTUCKY (MINUS MISSISSIPPI EMBAYMENT)

Well no. on map	Well	County	Carter Coord. System	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)				
							Top of Trenton or "(Pencil Cave)"	Top of Knox	Top of Conasauga	Top of basal sandstone	Top of basement
166	Ryan No. 5 Ryan	Caldwell	19-H-22	692	6,740	Knox or deeper	-4,271	-5,231			
167	Shell No. 1 M.D. Davis	Crittenden	17-L-16	373	8,821	Potosi	-3,112	-4,443			
168	Mid South Explor. Co. No. 1 C.E. Fields	Daviess	15-0-30	400	4,304	Cincinnatian					
169	W.G. Reynolds No. 1 H. Davis	Grayson	15-K-39	730	3,890	Knox	(-2,289)	-3,020			
170	Texaco No. 1 M.E. Allen	Grayson	9-M-36	730	3,150	Trenton	-2,110				
171	Sun Oil Co. No. 1 G. Woods	Grayson	25-M-38	722	3,651	Knox	-663 and -1,700	-1,090 and -2,362 } cut reverse fault at 2,236			
172	J.C. Miller No. 1 M.M. Mason	Hancock	5-Q-33	544	3,121	Laurel dolomite					
173	Royal Globe Oil No. 1 Earl Hughes	Logan	6-C-33	589	2,597	Knox	New Richmond	-1,994			
174	Texas Gas Trans. No. 1 Kerrick	McLean	4-M-28	450	6,830	Knox	(-4,410)	-5,184			
175	Ohio Oil No. 1 R.E. Lee	Muhlenberg	15-I-28	471	5,100	Trenton	(-4,528)				
176	Ohio Oil Co. No. 1 Alvey Oller	Ohio	13-M-34	655	2,503	Cincinnatian					
177	M & N Drlg. No. 1 G. Wiles	Todd	9-E-29	675	2,170	Trenton	New Richmond				
178	Ada Belle No. 2-A Hillman Land & Iron	Trigg	16-D-18	597	3,950	Knox	-1,573	-2,743			
179	Pierce & Flanigan No. 1 Sol Blue	Union	21-0-18	388	5,955	Trenton	-5,307				
180	Ashland No. 1 F-1-F Camp Breckenridge	Union	15-N-21	498	8,626 (8,594)	Knox	-6,271	-7,282			
181	Pure-Ashland No. 1 M.L. Walker	Webster	22-N-24	490	6,686	Knox	-4,254	-5,096			
182	Monitor Pet. No. 1 H. Blades	Adair	8-G-50	846	1,770	Trenton	(-25)	-733			
183	Ashland O & R No. 1 R. Tarter	Adair	24-I-54	858	6,677	Basal sandstone	+118	-586	-4,057	-5,808	
184	Harry No. 1 T. White	Allen	1-B-42	816	1,655	Knox	+57	-721			
185	Reed No. 1 L. Motley	Allen	7-B-40	560	1,912	Knox	(-530)	-1,295			
186	Stoil O. & R. No. 1 B. Bond	Anderson	17-S-56	760	2,838	Knox	(+540)	-65			
187	Rich No. 1 B.B. Houchens	Barren	17-F-43	760	2,859	Knox	(-295)	-996			
188	Judy & Young No. 1 Rose Run Iron	Bath	25-U-71	770	2,001	Knox	(-219)	-826			
189	Ford No. 1 Cecil Conner	Boone	9-EE-58	908	4,089	Precambrian	(+173)	-350	-1,963	-2,517	-2,810
190	William Thompson - Fee	Bourbon	5-T-63	885	969	Knox	(+772)	+113			
191	Monarch O & G No. 1 W.N. Simmons	Bullitt	21-S-45	425	1,820	Knox	(-665)	-1,250			
192	Ashland O & R No. 1 H. Wilson	Campbell	25-DD-62	758	3,604	Precambrian	(+239)	-288	-1,850	-2,632	-2,744

TABLE 6 – Continued

Well no. on map	Well	County	Carter Coord. System	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)				
							Top of Trenton or "(Pencil Cave)"	Top of Knox	Top of Conasauga	Top of basal sandstone	Top of basement
193	Benz O Corp. No. 1 R. Tarter	Casey	24–I–56	850	1,885	Knox	(+32)	-713			
194	Theron Strating No. 1 Hickman	Clinton	4–B–53	1,004	4,720	Knox	(-26)	-775			
195	Pelican Prod. No. 1 W.H. Campbell	Edmonson	9–H–39	579	3,131	Knox	(-1,699)	-2,437			
196	Cinc. Gas & Elec. No. 1 Thomason	Gallatin	8–AA–57	559	1,347	Knox	(+282)	-161			
197	L & M Gas Company No. 1 Causey	Garrard	10–M–61	931	5,495	Basal sandstone	(+372)	-324	-3,266		
198	Clinton No. 1 C. Hale	Garrard	15–O–61	695	5,538	Basal sandstone	(+525)	-154	-2,765	-3,895	
199	Texaco, Inc. No. 1 L. Kirby	Garrard	8–O–59	972	5,745	Precambrian	(+512)	-156	-2,718	-3,640	-4,668
200	R.C. Ford No. 1 E. Delaney	Grant	6–Y–60	867	3,557	Basal sandstone	(+477)	-203	-1,998	-2,523	
201	Moore Oil Co. No. 1 C. Perkins	Green	7–I–48	675	5,385	Conasauga	(-582)	-1,247	-4,585		
202	Texas Gas Trans. & Duff No. 1 Douglas	Hardin	5–O–45	810	2,346	Knox	(-469)	-1,061			
203	Mud Branch O & G No. 1 E. Bryant	Hart	12–K–43	640	3,146	Knox	(-1,091)	-1,759			
204	Du Pont No. 1 Fee	Jefferson	10–U–44	562	6,009	Precambrian	(-580)	-1,151	C O N F I D E N T I A L		
205	Texaco No. 1 T. Sherrer	Jessamine	6–P–60	956	5,800	Precambrian	(+881)	+286	-1,934	-2,051	-2,323
206	Texaco No. 1 Wolfinbarger	Jessamine	1–P–60	972	6,072	Precambrian	(+549)	-95	-2,535	-3,552	-5,038
207	Sohio Oil No. 1 Latonia Ref.	Kenton	12–EE–60	473	1,011	Knox	(+210)	-212			
208	Beaver Dam Coal No. 1 Richard et al.	La Rue	18–M–45	763	2,587	Knox	(-755)	-1,639			
209	Rome O & G No. 1 Foster Morrow	Lincoln	13–M–58	1,032	5,781	Basal sandstone	(+388)	-329	-3,311	-4,373	
210	California Co. No. 1 A.R. Spears	Lincoln	13–I–57	1,138	6,117	Precambrian	(+518)	-172	-3,106	-3,972	-4,622
211	Marion O & G No. 1 J.A. Ball	Marion	20–M–49	596	2,918	Knox	(-198)	-828			
212	United Fuel Gas No. 1 W. Rawlings	Mason	15–Y–71	769	3,314	Precambrian	(-100)	-643	-1,960	New Richmond	-2,506
213	Duchscherer No. 1 Pack	Meade	13–R–41	637	3,380	Knox	(-1,079)	-1,645			
214	Benz Oil Co. No. 1 C. Nunnally	Metcalfe	16–F–46	766	6,113	Precambrian	(-92)	-806	-4,446	-5,051	-5,118
215	Gilbert Thayer No. 1 Emmert Est.	Monroe	9–C–45	765	2,008	Knox	(-88)	-849			
216	Hill & Hill No. 9–A Millard Kerr	Monroe	7–B–49	558	1,533	Knox	(+108)	-491			
217	F & B No. 16-1 Potter	Montgomery	8–R–67	989	4,481	Precambrian	(+813)	+210	-2,409	-3,371	-4,449
218	Norris & Son Supply No. 1 E. Wimsett	Nelson	15–O–48	520	1,650	Knox	-341	-856			

TABLE 6 - Continued

Well no. on map	Well	County	Carter Coord. System	Elev. (ft)	T.D. (ft)	Deepest unit penetrated	Elevation in ft (Datum is mean sea level.)				
							Top of Trenton or "(Pencil Cave)"	Top of Knox	Top of Conasauga	Top of basal sandstone	Top of basement
219	Quasar, Inc. No. 1 G. Gray	Nicholas	5-V-68	692	1,582	Knox	+341	-239			
220	L.G. & E. No. 1 J. Clark	Oldham	12-W-50	765	1,472	Knox	(+37)	-528			
221	T.G. Shaw No. 1 H. Wright	Owen	19-X-59	818	1,500	Knox	(+689)	-89			
222	Kentucky Drilling and Operating No. 1 C.O. Drucker	Pendleton	19-BB-62	705	2,330	Knox	+570	-185			
223	Amerada-Hess Co. No. 1 H. Daulton	Pulaski	14-H-59	1,062	6,725	Precambrian	(-43)	-824	-3,913	-5,308	-5,608
224	Amerada-Hess Co. No. 1 R. Edwards	Pulaski	24-H-60	968	8,868	Precambrian	(-386)	-1,200	-4,602	-6,343	-7,866
225	Johnson Creek Oil Co. No. 1 M. Adamson	Robertson	8-X-67	675	1,270	Knox		-240			
226	Ferguson & Bosworth No. 1 J. Gosser	Russell	2-G-55	1,036	1,934	Knox	(-35)	-798			
227	Hydrick & Huntington No. 4 Fisher	Scott	17-X-60	828	1,337	Knox	(+467)	-457			
228	Beaver Dam Coal Co. No. 1 C. Morris	Shelby	1-T-52	763	2,075	Knox	(+265)	-307			
229	G. Hoffman No. 1 D. Roark	Simpson	21-D-36	663	3,672	Knox	(-787)	-1,546			
230	Stoll Oil Ref. Co. No. 1 Shelborne	Spencer	16-S-50	665	1,700	Knox	(+17)	-592			
231	Lambert No. 1 E. Nance	Taylor	22-J-51	961	2,108	Knox	(-134)	-793			
232	Pittman No. 1 J. B. Davenport	Warren	8-F-38	490	4,018	Knox	(-1,074)	-1,874			
233	Howard Hammond No. 1 Derranger	Washington	17-Q-54	780	970	Knox	+416	-123			
234	Bardill No. 1 Kelsey	Wayne	1-C-54	980	3,000	Knox	(+5)	-785			
235	P. Agrios Explor. Co. No. 1 Gaines	Woodford	21-S-57	859	2,812	Knox	(+683)	+80			
236	Texaco No. 1 Joe Williams	Clark	9-Q-64	661	4,937	Precambrian	(+318)	-296	-2,372	-3,291	-4,120
237	Texaco Inc. No. 1 Glyn Tipton	Estill	21-0-66	647	6,817	Precambrian	(-333)	-1,102	-3,588	-5,606	-6,160
238	Howard Sober No. 3 Cumberland	Laurel	7-F-63	1,171	7,343	Knox	(-1,171)	-2,077	-5,494		
239	United Fuel Gas No. 1 L. Stamper	Carter	3-V-77	857	5,085	Precambrian	(-1,910)	-2,543	-3,708	-4,143	-4,203

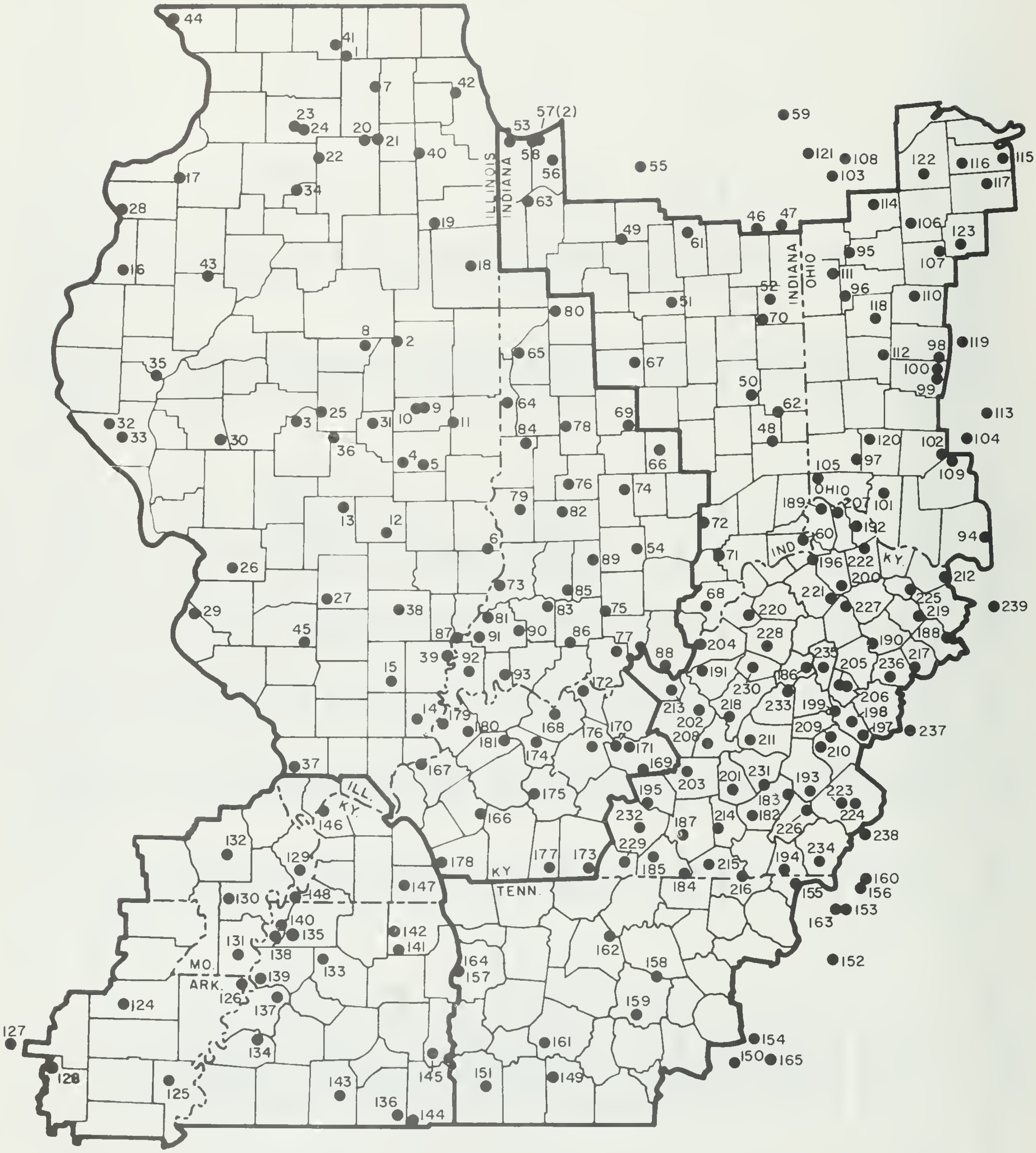

Figure 1 - Locations of selected deep tests listed in tables 1 through 6.

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