STATE OF OHIO
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DIVISION OF GEOLOGICAL SURVEY
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STRUCTURE CONTOUR MAP ON THE PRECAMBRIAN UNCONFORMITY SURFACE IN OHIO AND RELATED BASEMENT FEATURES

A description to accompany Division of Geological Survey Map PG-23

by Mark T. Baranoski

Columbus
2002

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MAP PG-23

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ABSTRACT

The Precambrian unconformity surface in Ohio is defined in eastern Ohio by the top of Grenville Province metamorphic and igneous rocks and in western Ohio by the top of East Continent Rift Basin sedimentary and volcanic rocks and Granite-Rhyolite Province igneous rocks. Map PG-23 was generated by a combination of computer-assisted and manual methods using well data, seismic data, and fault information for control. The dominant structural feature on the map is a north-south-trending break in slope, or increase in eastward dip, that extends from Ottawa County to Brown County and defines the western limit of the Appalachian Basin. This ridgelike structural feature is coincident with a zone of higher frequency magnetic data. The emplacement and subsequent deep erosion of Grenville Province rocks profoundly affected Appalachian Basin architecture. Other major structural features that can be recognized on the map include the Bowling Green Fault System, the Findlay Arch, and the Ohio Platform separating the Appalachian, Illinois, and Michigan Basins.

INTRODUCTION

More than 30 years have elapsed since the Ohio Division of Geological Survey (ODGS) last published a statewide interpretation of the Precambrian unconformity surface (Owens, 1967). The large number of wells drilled to the Precambrian since Owens' (1967) map, including two continuously cored holes drilled by the ODGS in Seneca County (Wickstrom and others, 1985) and Warren County (Shrake and others, 1990), have greatly increased our knowledge of Precambrian geology. Along with new knowledge come new questions. This report and the accompanying map (PG-23) do not attempt to interpret Precambrian geologic history nor resolve questions surrounding this complex subject. This report does present structural data currently available for the Precambrian surface in Ohio, and the map shows the interpreted Precambrian unconformity surface. Appendix A lists the names of faults and other structural features thought to be related to movement and/or boundaries in the Precambrian basement. Appendix B lists data for wells used in compiling Map PG-23. Appendix C lists the seismic lines shown on Map PG-23.

GEOLOGIC SETTING

Structural features in Ohio are known primarily from the mapping of bedrock-geology contacts and the interpretation of oil and gas drilling data. Although a detailed discussion of all features is beyond the scope of this report, major features are briefly discussed to show that the underpinning Precambrian basement affected deposition and structure of overlying Paleozoic sedimentary rocks. Bass (1960), and subsequently many others, interpreted a boundary in Ohio, referred to as the Grenville Front or Grenville Front Tectonic Zone, that separates the Grenville Province from the older Granite-Rhyolite Province (see inset on Map PG-23). Summerson (1962) recognized the coincidence of a break in slope on the top of the Precambrian surface with variations in Precambrian lithology noted by McCormick (1961) and with trends of contours on gravity maps of Heiskanen and Uotila (1956). Calvert (1974) speculated that Grenville Province metasedimentary rocks were less resistant to erosion than the igneous rocks to the west, thus resulting in a resistant ridge along the province boundary.

Later workers, using regional gravity and magnetic data, speculated on the presence of various Precambrian rifts in western Ohio (McGuire and Howell, 1963; Lidiak and Zietz, 1976; Halls, 1978; Keller and others, 1982, 1983; Cable and Beardsley, 1984; Denison and others, 1984; Black, 1986; Hinze and others, 1987; Lucius and von Frese, 1988). The discovery (Shrake and others, 1990) of the Middle Run Formation, a thick pre-Mount Simon sedimentary unit, in Warren County provided impetus to re-examine Precambrian well records of the region. Drahovzal and others (1992) used well control and geophysical data to interpret a regional Precambrian rift system, which they named the East Continent Rift Basin; this rift basin postdated the Granite-Rhyolite Province and predated the Grenville Province. Drahovzal and others (1992) estimated that the East Continent Rift Basin contains sequences of sedimentary and volcanic rocks greater than 20,000 feet thick in areas adjacent to the Grenville Front. Some workers have debated the existence of a Precambrian rift basin

beneath the Paleozoic rocks of western Ohio, preferring to interpret the Middle Run Formation and associated strata as a Grenville-age foreland-basin fill (Hauser, 1993) or a Cambrian-age rift-basin deposit (Wolfe and others, 1993). Stark (1997) recognized the regional importance of rifting in the eastern midcontinent, which he referred to as the East Continent Rift Complex. Dean and others (1998) interpreted reprocessed Consortium for Continental Reflection Profiling (COCORP) seismic lines across Ohio and confirmed the Precambrian chronology of Drahovzal and others (1992). Dean and others (1998) proposed a model in which basin-fill strata of the East Continent Rift Basin, as well as underlying rocks of the Granite-Rhyolite Province, were thrust as far west as Indiana.

Figures 1 and 2 depict major deep "pre-Ordovician" and relatively shallow "post-Cambrian" structural features, respectively, in Ohio and the surrounding region. These structural features evolved as sediments were deposited on the Precambrian basement. Four major structural elements are recognized in Ohio during "pre-Ordovician" time: the Ohio Platform (Summerson 1962), and the early Illinois, Michigan, and Appalachian Basins (fig. 1). The Bowling Green Fault System affected deposition and structure in northwestern Ohio, and the Rome Trough affected Cambrian deposition and structure in northern Kentucky and adjacent West Virginia. Isopach maps of Cambrian units by Janssens (1973) and Harris (1975)

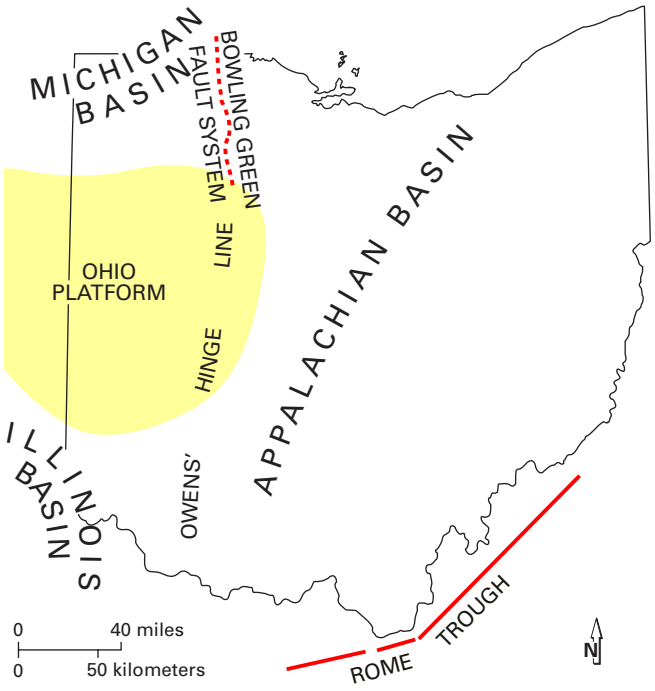

FIGURE 1.—*Major deep "pre-Ordovician" structural features in Ohio and surrounding region.*

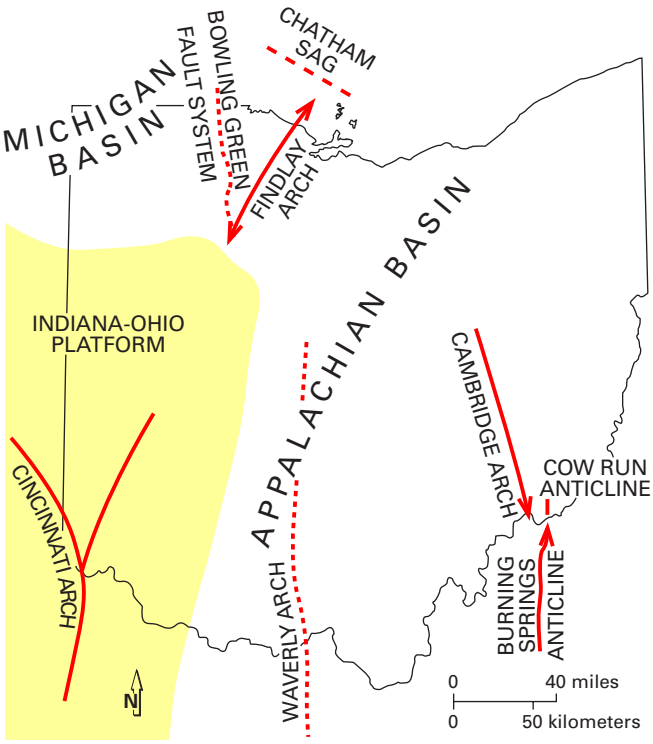

FIGURE 2.—*Major shallow "post-Cambrian" structural features in Ohio and surrounding region.*

show thickening of Cambrian units in southwestern Ohio, indicating the Illinois Basin was subsiding in southwestern Ohio during Cambrian deposition.

Following Late Cambrian time, the Waverly Arch (Woodward, 1961) and other features developed (fig. 2). Later, during the Ordovician, the Ohio Platform expanded into the more extensive Indiana-Ohio Platform (Green, 1957) and displaced the early Illinois Basin in southwestern Ohio. The Cincinnati Arch is part of this Platform (fig. 2). Orton (1887) described the Cincinnati Arch ("Anticlinal") as a "low fold" that includes the "line of sharp descent" (Bowling Green Fault System) in Findlay in western Ohio. Wasson (1932), Lafferty (1941), Lockett (1947), and McGuire and Howell (1963) speculated that a Precambrian ridge lies beneath the Cincinnati Arch as mapped on the Middle Ordovician Trenton Limestone. However, Freeman (1951), Green (1957), Summerson (1962), Owens (1967), Janssens (1967), and Shearrow (1987) determined that the Cincinnati Arch as defined by structure on the Trenton does not appear on structure as mapped on the Precambrian unconformity surface. The Cincinnati Arch is interpreted to have developed after deposition of the Trenton on the basis of thinning of post-Ordovician units (Janssens, 1967; Shearrow, 1987). Detailed stratigraphic and paleontologic work by Kolata and others (2001) indicates that

the Cincinnati Arch did not have a significant presence during Middle and Late Ordovician time.

The Findlay Arch and the Bowling Green Fault System, situated northeast of the Indiana-Ohio Platform, separate the Michigan and Appalachian Basins (fig. 2). The Chatham Sag is a structurally low area, located where the Findlay Arch plunges northeast toward Ontario, Canada. The Bowling Green Fault System has had recurrent movement since the Precambrian (Wickstrom and others, 1992; Onasch, 1995). Isopach maps of Cambrian units by Janssens (1973) do not show thinning of units along the Findlay Arch, indicating the feature was not present during Cambrian deposition. Shearrow (1987) interpreted the Findlay Arch as having formed during Middle Ordovician Trenton-Black River time. Isopach maps of Cambrian units by Janssens (1973) and Shearrow (1987) show subsidence in southwestern Ohio during Cambrian deposition, indicating that the Cincinnati Arch was not present.

The Cambridge Arch, Cow Run Anticline, and Burning Springs Anticline of southeastern Ohio and adjacent West Virginia are shallow features that formed at the end of or following Appalachian Basin deposition (Late Permian or post-Permian time?). Shumaker (1986) and Baranoski (1990, 1993c) have interpreted deep Precambrian faulting to have been associated in part with these shallow features. The reader is referred to Appendix A for references that provide more detail on the above features as well as other features on Map PG-23.

PREVIOUS MAPPING OF THE PRECAMBRIAN SURFACE IN OHIO

The first detailed statewide structure map on the top of the Precambrian unconformity surface in Ohio was that of Summerson (1962), which was based on only 38 wells. He recognized three major structural features: the Ohio Platform, Michigan Basin, and Appalachian "geosyncline" (Appalachian Basin). Summerson (1962) discussed the effects of fault systems on patterns of sedimentation and suggested that faults in the Precambrian basement influenced overlying Paleozoic sedimentation, especially in northern Kentucky and western Ohio. He reaffirmed Green's (1957) observation that the Cincinnati Arch, as mapped on the Ordovician Trenton surface, does not correlate to a basement high on the Precambrian. Summerson (1962) interpreted the Ohio Platform as a smaller area than the Indiana-Ohio Platform of Green (1957). He suggested, on the basis of work by Heiskanen and Uotila (1956), Bass (1960), and McCormick (1961), the presence of a major "hingelike" structural boundary at the break in slope on the Precambrian structure map at the eastern edge of the Ohio Platform and western edge of the Appalachian Basin. He also suggested that variations in local Precambrian topographic relief are, in part, related to lithology and differential erosion. Summerson (1962) and later workers (Owens, 1967; Shearrow, 1987) recognized the difficulty in separating the effects of erosion from structure when mapping the top of the Precambrian surface. Summerson (1962), and later Owens (1967) and Shearrow (1987), hypothesized that Precambrian basement structures would become important to locating and producing oil and gas.

Owens' (1967) Precambrian structure map was based on 94 wells in Ohio and an additional 39 wells from surrounding states and Ontario, Canada. He recognized Summerson's (1962) three major structural elements, as well as the absence of the Cincinnati Arch. In addition, he discussed a structural high, which he termed a hingeline, that separates the Indiana-Ohio Platform from the Appalachian Basin (see fig. 1). Although Owens discussed localized areas of faulting in his text, his map does not depict faults. He noted the presence of locally steep surfaces on the top of the Precambrian, which he attributed to faulting and/or erosion. He discounted the Precambrian origin of Woodward's (1961) Waverly Arch. Contour lines on Owens' (1967) map suggest that the Illinois Basin extended into extreme southwestern Ohio, thus limiting the area Summerson (1962) termed the Ohio Platform.

Shearrow's (1987) Precambrian structure map was based on 106 wells in Ohio. Like Summerson (1962) and Owens (1967), Shearrow recognized the absence of a basement structural high beneath the Cincinnati Arch as mapped on the Trenton Limestone. In his text, Shearrow stated that the Findlay Arch "came into existence during Trenton-Black River time (Middle Ordovician)." On his map, the Findlay Arch is a narrow feature east of the Bowling Green Fault System. Although he does not mention it in his text, contours on Shearrow's map in extreme southwestern Ohio suggest the Illinois Basin extended into Ohio. His map is the first statewide Precambrian structure map that indicates faults; the Bowling Green Fault System is most prominent.

Lucius and von Frese (1988) also published a structure map on the Precambrian of Ohio and surrounding areas. Their map does not indicate faults, possibly due to the scale of the map. They recognized the regional structural elements discussed above and interpreted a "Keweenawan rift zone" in western Ohio.

Baranoski and Wickstrom (1991) canvassed literature and open-file reports to compile a map showing statewide Precambrian basement structures in

Ohio. Map PG-23 incorporates most of the features from this earlier compilation and replaces their map.

METHODS

Data sources for this report and map include published and unpublished literature, deep-well data, and seismic-reflection data. All structural features noted during the literature search were documented and compiled into a master list for correlation to similar named and unnamed features. Features were deemed legitimate if documented by well control and/or geophysical data (gravity/magnetic/seismic). Appendix A lists structural features, their map reference numbers, and literature citations.

Well data were gathered from published and unpublished literature, ODGS records, and records from the surrounding states and Ontario. Structure contours on Map PG-23 are based on 207 wells from Ohio and 47 wells outside Ohio. An additional 56 wells beyond the map area also were used for control. Approximately 500 miles of public-domain and restricted seismic-reflection data were interpreted and incorporated as additional control for the map. The actual data points for the seismic shot points are not plotted on Map PG-23, but the approximate seismic-line locations are shown. Appendix C lists the seismic lines shown on Map PG-23. Approximately 100 additional miles of proprietary and published (for example, Wickstrom and others, 1992) seismic data also were used to delineate or verify faults and structures but are not shown on the map. Potential-fields data mapped by Hildenbrand and Kucks (1984a, b) were used in a generally qualitative fashion to constrain the interpretation in some areas.

Where possible, the structural tops of the Precambrian were taken directly from wells listed in published and unpublished literature. Geophysical logs, sample-cuttings descriptions, and sample-cutting examination were used to identify the Precambrian contact, but were not available for all wells shown on the map. Drillers' tops were used to identify the contact in some wells lacking borehole logs. Appendix B lists the sources of the data used. Anomalous tops were investigated during the computer-contouring phase of the project. Unresolved subsea values are noted by a question mark on Map PG-23 and in Appendix B.

The top of the Precambrian surface may be difficult to recognize in sample cuttings because of sedimentation, weathering, and diagenesis of rock material at the unconformity (Summerson, 1962; Janssens, 1967). This problem is exacerbated by mixing of overlying Paleozoic sample cuttings and iron-pipe fragments with Precambrian cuttings during the drilling process.

The contact also may be difficult to determine using surface and borehole geophysical tools. Thick sequences of sedimentary rocks in the East Continent Rift Basin complicate defining the top of the Precambrian on seismic profiles in western Ohio. Borehole geophysical detection of the contact depends on many factors, including the depth and condition of the "rat hole" at the bottom of the well, lithology of the Precambrian rocks, and degree and depth of weathering of the Precambrian surface. Furthermore, even though a well may have been drilled into the Precambrian, the actual Precambrian-Cambrian contact may not have been geophysically logged.

The top of the Precambrian and the presence of faulting were interpreted on public-domain and proprietary seismic data on file at the ODGS. Well data were entered into a spreadsheet and then computer contoured. Anomalous "bulls-eye" contoured areas were investigated and adjusted. The computer-contoured data set was exported into a computer-aided-design (CAD) software package in which depth-converted migration seismic data, faults, and hand-contoured areas were digitized. The migration seismic data were correlated, where possible, to synthetic seismograms and the top of the Precambrian reported from nearby oil and gas wells. In general, the top of the Precambrian on seismic profiles is represented by a "peak" or positive seismic reflection. The peak that was correlated to well data was used as the reference time to estimate an average velocity of the entire rock column from the surface to the Precambrian peak. The subsea values for the Precambrian reflectors were then calculated using the following formula:

Subsea depth of Precambrian = average velocity (feet per second) x seconds (time of peak on seismic line/2)

Where multiple seismic lines were available, the Precambrian peak was correlated from line to line at the tie point and the time value was adjusted to the relative zero time. If necessary, two-way time was added or subtracted before depth conversion.

The structural features interpreted from literature, including most features on the map of Baranoski and Wickstrom (1991), and from seismic lines were digitized and included on Map PG-23. These features are categorized on the map according to interpreted validity: a solid line indicates a feature that has an approximate mappable extent, a dashed line indicates a feature that is inferred, and a dotted line indicates a feature that exists as a trend but is questionable. Where known, fault throw is noted with an appropriate **U** (up) or **D** (down) symbol. Features are numbered for identification and correlation to Appendix A.

Map PG-23 is a hand-contoured interpretation that honors all well data, seismic data, and significant faults. Well locations in which the entire Cambrian Mount Simon Sandstone is missing indicate Precambrian paleotopographically high areas and are noted on the map. Three contour intervals are shown on Map PG-23: 100 feet in the western three-fourths of the state, 500 feet in the eastern one-fourth of the state and adjacent areas, and 1,000 feet in the Rome Trough.

DISCUSSION

Map PG-23 generally is very similar to previously published maps of the Precambrian unconformity in Ohio (Summerson, 1962; Owens, 1967; Shearrow, 1987) and shows the extent of the Appalachian, Illinois, and Michigan Basins and a north-south-oriented ridgelike feature (Owens' hingeline) in the west-central portion of the state. The Grenville Front Tectonic Zone, defined by a zone of higher frequency magnetic data, follows Owens' hingeline and is bounded on the west by the East Continent Rift Basin (including the Bowling Green Fault System to the north) and on the east by the break in slope. In the western portion of the mapped area, crystalline basement rocks are interpreted to be as deep as 25,000 feet (15,500 meters) beneath sedimentary and volcanic rocks of the East Continent Rift Basin (Drahovzal and others, 1992).

The most significant difference in Map PG-23 from earlier published maps is the level of detail, which is a result of the availability of more wells, as well as interpreted faults and seismic data. The map includes 101 more Ohio wells than Shearrow's (1987) map. However, there are still 23 Ohio counties in which no wells have been drilled into the Precambrian. Twenty wells drilled into the Precambrian lack the Cambrian Mount Simon Sandstone over paleotopographically high areas. Hydrocarbon production from the Cambrian is associated with these high areas along an unnamed fault in north-central Licking County and adjacent Knox County and the Killbuck Dome in south-central Holmes County. Relief on the basement at Killbuck Dome is more than 500 feet (152 meters). Wicks (1996) attributed the Killbuck structure to reactivated fault movement along pre-existing Grenville thrust faults. An area approximately 4 miles (2.5 kilometers) across in northwestern Logan County has been interpreted from the reprocessed COCORP OH-1 seismic line as a faulted horst block missing the Mount Simon. This is the most extensive area of paleotopographically high Precambrian rocks in the region, where the Mount Simon was either not deposited or was eroded prior to the deposition of the Cambrian Eau Claire Formation. The northern and southern extents of this feature have not been determined owing to a lack of deep well control and additional seismic data. Another interesting localized structural feature is the Serpent Mound disturbance of northern Adams County and adjacent areas. This circular, faulted depression is more than 700 feet (213 meters) deep and bounded by north-northwest-trending faults on the east side. Baranoski and others (in prep.) have interpreted the depression as the result of the impact of an extraterrestrial object along a pre-existing fault zone.

Investigations for this map and report indicate that the complex arrangement of reactivated East Continent Rift Basin and Grenville faulting affected the evolution of the Appalachian Basin and portions of the neighboring Illinois and Michigan Basins. The author speculates that Grenville thrust faults east of the Grenville Front Tectonic Zone relaxed during early Cambrian time with the opening of the Iapetus Sea, thus establishing the underpinning structural architecture for the development of the Appalachian Basin. The relaxation of Grenville faults continued throughout Paleozoic deposition as the Appalachian Basin evolved. This hypothesis is manifested by the series of structural terraces that step downward into the basin, as shown on regionally mapped Paleozoic units (Gray and others, 1982; Riley and others, 1993). Pre-existing Precambrian structure has had important implications for the accumulation of oil and gas (Riley and others, 1993; Wickstrom, 1990; Wicks, 1996).

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Division of Geological Survey did the final computer drafting of Map PG-23, and Lisa Van Doren of the Ohio Division of Geological Survey created the final versions of figures 1 and 2. This work was supported, in part, by funding from the Injection Well Review Fund and was performed in cooperation with the Ohio Environmental Protection Agency, Division of Drinking and Ground Waters.

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APPENDIX A.—REGIONAL STRUCTURAL FEATURES IN THE PRECAMBRIAN BASEMENT OF OHIO AS DEPICTED ON MAP PG-23.

Type of structure	Map number	Named feature	References
anomaly	47	Seneca Anomaly	Lucius and von Frese, 1988
	50	Southwestern Ohio Anomaly	Lucius and von Frese, 1988
cross-strike-structural discontinuity (CSSD)	3	Cambridge CSSD	Schumaker, 1986; Coogan and Reeve, 1985; Baranoski, 1989, 1990, 1993a, 1993b, 1993c; Riley and others, 1993; Root, 1996
	11	Pittsburgh-Washington CSSD	Harper and Laughrey, 1987; Riley and others, 1993
fault	27	Akron Fault	Gray and others, 1982; Root and MacWilliams, 1986; Schumaker, 1986; Coogan, 1991; Riley and others, 1993
	31	Anna-Champaign Fault	McGuire, 1975; Schwartz and Christensen, 1986; Wickstrom, 1990; Wickstrom and others, 1992
	33	Auglaize Fault	Schwartz and Christensen, 1986; Wickstrom, 1990; Wickstrom and others, 1992
	41	Bellefontaine Outlier Faults	Steck, 1997; portion of Union Fault from Wickstrom, 1990
	8	Bowling Green Fault System	Orton, 1888; Carman and Stout, 1934; Stout, 1941; Green, 1957; Worthing, 1965; Janssens, 1973; Shearrow, 1987; VanWagner, 1988; Wickstrom, 1990; Wickstrom and others, 1992; Onasch, 1995
	6	Burning Springs Fault System	Shumaker and others, 1982; Calvert, 1983; Shumaker, 1986; Baranoski, 1989
	34	Crawford Faults	Wickstrom, 1990; Wickstrom and others, 1992
	21	Harlem Fault	Wickstrom, 1990
	30	Highlandtown Fault	Gray and others, 1982; Root and MacWilliams, 1986; Schumaker, 1986; Coogan, 1991; Riley and others, 1993
	35	Kentucky River Fault System	McGuire and Howell, 1963; Rudman and others, 1965; Lidiak and Zietz, 1976; Ammerman and others, 1979; Webb, 1980; Black and others, 1983; Cable and Beardsley, 1984; Black, 1986; Harris and Drahovzal, 1996; Drahovzal and Noger, 1995; Stark, 1997
	36	Killbuck Dome	Wicks, 1996
	32	Logan Fault	McGuire, 1975
	37	Marion Fault	Wickstrom, 1990; Wickstrom and others, 1992; Shrake, 1997
	38	Maumee Fault	Wickstrom, 1990
	10	Middleburg Fault	Gray and others, 1982; Root and MacWilliams, 1986; Coogan, 1991
	7	Ohio River Fault	Calvert, 1974; Baranoski and Riley, 1988
	39	Outlet Fault	Wickstrom, 1990; Shrake, 1997
	40	Plum Run Quarry Fault	Schmidt and others, 1961; Reidel and Koucky, 1981; Reidel and others, 1982; Baranoski and others, in preparation
	2	Rome Trough Fault System	Lockett, 1947; Thomas, 1960; Woodward, 1961; McGuire and Howell, 1963; Rudman and others, 1965; Webb, 1969, 1980; Silberman, 1972; Heyl, 1972; Harris, 1975; Wagner, 1976; Schumaker and others, 1982; Beardsley and Cable, 1983; Cable and Beardsley, 1984; Keller and others, 1983; Baranoski, 1993b; Kulander and Dean, 1986; Harper, 1989; Coogan and Peng, 1993; Riley and others, 1993; Harris and Drahovzal, 1996; Stark, 1997
	29	Smith Township Fault	Gray and others, 1982; Root and MacWilliams, 1986; Coogan, 1991; Riley and others, 1993; Schumaker, 1986
	24	Starr Fault System	Brannock, 1993
	28	Suffield Fault System	Gray and others, 1982; Root and MacWilliams, 1986; Coogan, 1991; Riley and others, 1993; Schumaker, 1986
	19	Tiffin Fault	Sitler and Wehmeyer, 1962; Shearrow, 1987

APPENDIX A.—REGIONAL STRUCTURAL FEATURES IN THE PRECAMBRIAN BASEMENT OF OHIO AS DEPICTED ON MAP PG-23 (cont.).

Type of structure	Map number	Named feature	References
fault (cont.)	42	unnamed faults (Adams Co.)	Foerste and Lamborn, 1918,1919; Harper, 1939; Bucher, 1921, 1933, 1935, 1936, 1963; Galbraith, 1968; Galbraith and Koucky, 1969; Reidel, 1972, 1975; Koucky, 1975; Reidel and Koucky, 1981; Reidel and others, 1982
	44	unnamed fault (Ashtabula Co.)	this report
	45	unnamed fault (Ashtabula Co.)	Seeber and Armbruster, 1993
	4	unnamed fault (Belmont Co.)	Berryhill, 1963
	9	unnamed faults (Delaware Co.)	Galey, 1964; Rudman and others, 1965; Swinford and Slucher, 1995
	22	unnamed faults (Fayette Co.)	Mayhew, 1969
	20	unnamed faults (Fayette, Ross, Pickaway Cos.)	Mayhew, 1969; Shearrow, 1987
	18	unnamed faults (Hancock Co.)	Shearrow, 1987
	26	unnamed faults (Highland Co.)	Shearrow, 1987
	1	unnamed fault (Lake Co.)	Nicholson and others, 1988
	14	unnamed faults (Madison Co.)	Mayhew, 1969
	12	unnamed fault (Sandusky Co.)	this report
	15	unnamed faults (Scioto Co.)	this report
	23	unnamed fault (Seneca Co.)	Shearrow, 1987
	17	unnamed fault (Warren Co.)	Shrake and others, 1991
	13	unnamed faults (Washington Co.)	Baranoski, 1989; Deyling, 1993
	43	unnamed fault (Wyandot Co.)	this report
	25	unnamed faults along COCORP seismic lines	Dean and others, 1998; this report
	5	W. Hickman Creek-Bryan Station Fault	Harper, 1939; McGuire and Howell, 1963; Worthing, 1965; Galbraith, 1968; Lidiak and Zietz, 1976; Ammerman and Keller, 1979; Patterson, 1980; Webb, 1980; Black and others, 1983; Swinford, 1983; Harper, 1989; Black, 1986; Hinze and others, 1987
miscellaneous structure	46	Akron Magnetic Boundary	Aggarwal, 1987; Seeber and Armbruster, 1993
	16	Serpent Mound disturbance	Locke, 1838; Orton, 1871; Foerste and Lamborn, 1918; 1919; Harper, 1939; Bucher, 1921, 1933, 1935, 1936, 1963; Stout, 1941; Lockett, 1947; Schmidt and others, 1961; Sappenfield, 1950, 1951; Summerson and others, 1963; Worthing, 1965; Bull and others, 1967; Galbraith, 1968; Galbraith and Koucky, 1969; Reidel, 1972, 1975; Koucky, 1975; Reidel and Koucky, 1981; Reidel and others,1982; Langford, 1984; Koucky and Reidel, 1987; Baranoski, 1993c; Baranoski and others, in preparation
	48	Coshocton Zone	Pratt and others, 1989; Culotta and others, 1990
	49	Fort Wayne Rift	Denison and others, 1984; Hinze and others, 1987; Lucius and von Frese, 1988; Coogan and Peng, 1993
shallow Paleozoic structure		Burning Springs Anticline	Lockett, 1947; Woodward, 1961; Rodgers, 1963; Shumaker and others, 1982; Calvert, 1983; Shumaker, 1986; Baranoski, 1989, 1990, 1993a, 1993b
		Cow Run Anticline	Collins and Smith, 1977; Baranoski, 1989, 1990, 1993a, 1993b
		Cambridge Arch/Monocline	Lockett, 1947; Lamborn, 1951; Dolly and Busch, 1972; Coogan and Reeve, 1985; Baranoski, 1989, 1990, 1993a, 1993b, 1993c; Riley and others, 1993; Root, 1996
		Cincinnati Arch	Orton, 1887, 1888; Foerste, 1906; Wasson, 1932; Carman and Stout, 1934; Harper, 1939; Lafferty, 1941; Stout, 1941; Lockett, 1947; Lamborn, 1951; Freeman, 1951; Green, 1957; McGuire and Howell, 1963; Rudman and others, 1965; Janssens, 1967; Bayley and Muehlberger, 1968; Mayhew, 1969; Dolly and Busch, 1972; Lidiak and Zietz, 1976; Black and others, 1983; Keller and others, 1983; Cable and Beardsley, 1984; Lucius and von Frese, 1988; Ryder, 1991

APPENDIX A.—REGIONAL STRUCTURAL FEATURES IN THE PRECAMBRIAN BASEMENT OF OHIO AS DEPICTED ON MAP PG-23 (cont.).

Type of structure	Map number	Named feature	References
shallow Paleozoic structure (cont.)		Findlay Arch	Orton, 1888; Phinney, 1891; Carman, 1928; Carman and Stout, 1934; Stout, 1941; Cohee, 1945; Lockett, 1947; Fettke, 1948; Green, 1957; McGuire and Howell, 1963; Rudman and others, 1965; Janssens, 1967; Mayhew, 1969; Dolly and Busch, 1972; Calvert, 1974; Beardsley and Cable, 1983; Sandford and others, 1985; Lucius and von Frese, 1988; Ryder, 1991; Carter and others, 1996
		Waverly Arch	Woodward, 1961; McGuire and Howell, 1963; Janssens, 1967; Mayhew, 1969; Dolly and Busch, 1972; Cable and Beardsley, 1984; Riley and others, 1993; Baranoski, 1993b; Ryder and others, 1996
		Central Ohio Platform	Coogan and Peng, 1993; Dean and others, 1998
		Indiana-Ohio Platform	Green, 1957; Rudman and others, 1965; Owens, 1967; Lucius and von Frese, 1988
		Ohio Platform	Summerson, 1962
province		Granite-Rhyolite Province (Central Granite-Rhyolite Province/ Eastern Granite-Rhyolite Province)	Bass, 1960; Denison and others, 1984; Bickford and others, 1986; Lucius and von Frese, 1988; Pratt and others, 1989; Cullotta and others, 1990; Drahovzal and others, 1992; Hauser, 1993
		Grenville Province	Bass, 1960; Rudman and others, 1965; Webb, 1980; Black and others, 1983; Keller and others, 1983; Beardsley and Cable, 1983; Bickford and others, 1986; Black, 1986; Lucius and von Frese, 1988; Green and others, 1988; Pratt and others, 1989; Cullotta and others, 1990; Hoehn, 1991; Hoehn and Hinze, 1992; Carter and others, 1996; Coogan and Peng, 1993; Hauser, 1993; Riley and others, 1993
	51	Grenville Front Tectonic Zone	McGuire and Howell, 1963; Rudman and others, 1965; Bayley and Muehlberger, 1968; Mayhew, 1969; Lidiak and Zietz, 1976; Hinze and others, 1987; Lucius and von Frese, 1988; Pratt and others, 1989; Culotta and others, 1990; Hoehn, 1991; Hoehn and Hinze, 1992; Coogan and Peng, 1993; Hauser, 1993; Lidiak and Hinze, 1993; Wolfe and others, 1993; Riley and others, 1993; Richard and Wolfe, 1995; Stark, 1997; Steck, 1997
		East Continent Rift Basin	Shrake and others, 1991; Drahovzal and others, 1992; Riley and others, 1993; Wolfe and others, 1993; Coogan and Peng, 1993
		East-central midcontinent rift system	McGuire and Howell, 1963; Lidiak and Zietz, 1976; Halls, 1978; Keller and others, 1982, 1983; Cable and Beardsley, 1984; Hinze and others, 1987; Hoehn, 1991; Hoehn and Hinze, 1992; Stark, 1997
		Kentucky-Ohio Trough	Black, 1986

APPENDIX B.—WELL DATA FOR CONTROL POINTS ON MAP PG-23.

Precambrian-top data source: C = core; D = driller; E = electric-log interpretation, by Baranoski unless otherwise noted; S = sample-cuttings interpretation, by Baranoski unless otherwise noted

American Petroleum Institute well number	County	Lease name	Well no.	Company name	Well total depth (feet)	Formation at total depth	Well elevation above sea level (feet)	Along-hole depth to top of Precambrian (feet)	Precambrian-top data source	Precambrian subsea value (feet)
3400120004	Adams	Bailey	1-A	Cabot Corp.	3790	Precambrian	714	3778	E	-3064
3400120005	Adams	Covert	1	Commonwealth Gas Corp.	3829	Precambrian	624	3807	E	-3183
3400120011	Adams	Russell-Tener	1	Oxford Oil Co.	3886	Precambrian	852	3865	S, E	-3013
3400320060	Allen	Pohlman	1	H. & H. Producing Co.	3207	Middle Run Formation?	807	3207	E (Wickstrom, 1987)	-2400
3400320064	Allen	Pohlman et al. Unit	3	Alco Oil Co.	3265	Precambrian	811	3208	E (Wickstrom, 1987)	-2397
3400320067	Allen	BP Chemical	1	BP Chemical	3133	Middle Run Formation	872	3133	E (Wickstrom, 1987)	-2261
3400320071	Allen	BP Chemical	2	BP Chemical	3170	Middle Run Formation	853	3143	E (Wickstrom, 1987)	-2290
3400320084	Allen	BP Chemical	3	BP Chemical	3170	Middle Run Formation	856	3138	E	-2282
3400363691	Allen	BP Chemical	4	BP Chemical	3300	Middle Run Formation	874	3153	C, E	-2279
3400523938	Ashland	Fingulin	1	Bass Energy Co.	5163	Precambrian	1083	5060	D	-3977
3400720191	Ashtabula	Rhoa	1-H	Horizon Oil	6750	Precambrian	983	6740	S (Owens, 1967)	-5757
3400720193	Ashtabula	Brayman	1	East Ohio Gas Co.	6907	Precambrian	977	6898	D	-5921
3400720286	Ashtabula	Roulston	1	U.S.Gas & Oil	6659	Precambrian?	861	6606	D	-5745?
3400721847	Ashtabula	Rhoa	3	POI Energy	7136	Precambrian	950	7102	D	-6152
3400722038	Ashtabula	Parobek	2	POI Energy	7127	Precambrian	942	7106	E (Wickstrom, 1987)	-6164
3400722272	Ashtabula	Lautanen	1	POI Energy	7151	Precambrian	973	7120	D	-6147
3400723192	Ashtabula	Dietrich	1	Universal Energy	7008	Precambrian	932	6776	E (Riley and others, 1993)	-5844
3400723948	Ashtabula	Bustamante	2	Bottom Line Prod.	7074	Precambrian	969	6920	D	-5951
3400724113	Ashtabula	Krcal Unit	1-2954	CGAS Exploration	6900	Precambrian	848	6237	E	-5389
3400760010	Ashtabula	Reserve Environmental Services	1	Reserve Environmental Services	6060	Precambrian	650	5972	D	-5322
3401120071	Auglaize	Hoelscher Comm.	1	West Ohio Oil & Gas	3067	Precambrian	896	3040	S (Janssens, 1973)	-2144
3401520006	Brown	Griffith	1	Spencer Petroleum	3350	Middle Run Formation?	946	3260	S, E	-2314
3401720004	Butler	Armco Steel Corp.	1	Armco Steel Corp.	3297	Middle Run Formation	666	3239	E	-2573
3401720005	Butler	Armco Steel Corp.	2	Armco Steel Corp.	3285	Middle Run Formation	671	3233	E	-2562
3402320002	Clark	Brown	1	Edmund Oil & Gas	3649	Precambrian	1249	3624	S (Owens, 1967)	-2375
3402320003	Clark	Elcamere Farms	1	Hodges Industries	3578	Precambrian	1167	3550	E	-2383
3402360004	Clark	Mattison	1	Friend	4647	Middle Run Formation?	1087	3366	S (Janssens, 1973)	-2279
3402520003	Clermont	Wikoff	1	Continental Oil Co.	3436	Precambrian	817	3328	S, E	-2511
3402720002	Clinton	Adams	1	Kewanee Oil Co.	3392	Precambrian	1080	3390	S (Summerson, 1962)	-2310
3402720005	Clinton	Van Pelt	1	Kewanee Oil Co.	3263	Precambrian	1092	3253	S, E	-2161
3402720007	Clinton	McVey	1	Kewanee Oil Co.	3473	Precambrian	1087	3460	S (Janssens, 1973)	-2373
3402720010	Clinton	Coy	1	Stocker & Sitler	3603	Precambrian	1098	3554	S, E	-2456
3402920648	Columbiana	Murray	3	Management Control Corp.	10242	Precambrian?	1194	10200	D	-9006?
3403122053	Coshocton	Lee	1	Tatum	6970	Precambrian	1040	6960	S	-5920
3403123462	Coshocton	Columbus & Southern Ohio Electric	1C	Worthington Oil	7585	Precambrian	879	7550	D	-6671
3403124118	Coshocton	Burrell	1	Pomstone	7363	Precambrian	852	7296	D	-6444
3403320044	Crawford	Spitler-Brown Unit	1	Piggott	3415	Precambrian	977	3410	E (Owens, 1967)	-2433
3403320050	Crawford	Leonhardt	1	Luling Oil & Gas Co.	3774	Precambrian	1008	3770	S (Owens, 1967)	-2762
3403521625	Cuyahoga	Marconi Medical Systems	1	Bass Energy Co.	6550	Precambrian	974	6540	S	-5566
3403920028	Defiance	Haver	1	Brown	3610	Precambrian?	702	3602	E	-2900?
3404120001	Delaware	Vance	1	Chester Wise et al.	4291	Precambrian	920	3845	S (Owens, 1967)	-2925
3404120009	Delaware	Sprain	1	Wehmeyer	4006	Precambrian	988	4010	E	-3022
3404120022	Delaware	Jones	1	Southern Triangle	3426	Precambrian	945	3420	D (Janssens, 1973)	-2475
3404120242	Delaware	Smith	1	McClure Oil Co.	4035	Precambrian	992	3990	S (Owens, 1967)	-2998
3404120269	Delaware	Lindsey	1	Minnesota-Ohio Oil Co.	4071	Precambrian	919	4058	E	-3139
3404120270	Delaware	Gregory	1	Minnesota-Ohio Oil Co.	4685	Precambrian	1205	4685	S (Owens, 1967)	-3480
3404120322	Delaware	Jolliff	1	Funk Exploration	3382	Precambrian	933	3352	E	-2419
3404120329	Delaware	Case	1	Funk Exploration	3569	Precambrian	919	3554	D	-2635?
3404120354	Delaware	Cockrell-Godshall Unit	1	Poling Co.	4873	Precambrian	1118	4450	S, E	-3332
3404120356	Delaware	Sheets	1	NGO Development Corp.	4013	Precambrian	987	3956	E	-2969
3404120358	Delaware	Longshore et al. Unit	1	Poling Co.	4272	Precambrian	1071	4220	E	-3149
3404320007	Erie	Sayler et al.	1	Ohio Fuel Gas Co.	4417	Precambrian	817	4400	S (Summerson, 1962)	-3583
3404320011	Erie	Krysik-Wakefield et al. Unit	1	Sun Oil Co.	4463	Precambrian	828	4455	S (Owens, 1967)	-3627
3404320019	Erie	Herman et al.	1	Sun Oil Co.	4466	Precambrian	829	4449	E (Janssens, 1973)	-3620
3404320171	Erie	Kellstone	1	Kellstone	3436	Precambrian	625	3375	S, E	-2750
3404720001	Fayette	Hopkins	1	Kewanee Oil Co.	4708	Precambrian	965	3545	S (Summerson, 1962)	-2580
3404720002	Fayette	Wilson	1	Kewanee Oil Co.	3494	Precambrian	1017	3340	S (Summerson, 1962)	-2323
3404720004	Fayette	Barnes	1	Kewanee Oil Co.	3410	Precambrian	1044	3332	S, E (Janssens, 1973)	-2288
3404720009	Fayette	Hanawalt	1	Oxford Oil Co.	3375	Precambrian	907	3500	E (Wickstrom, 1987)	-2593
3404720010	Fayette	Braun	1	Oxford Oil Co.	3750	Precambrian	980	3732	E (Riley and others, 1993)	-2752
3404720011	Fayette	Duff	1	Stocker & Sitler	3352	Precambrian	946	3230	D	-2284
3404920014	Franklin	Marble Cliff Quarries	1	Marble Cliff Quarries	3622	Precambrian	697	3620	S (Owens, 1967)	-2923
3405120049	Fulton	Storeholder	1	Liberty Petroleum Corp.	3700	Precambrian	689	3555	S	-2866
3405920782	Guernsey	Marshall Comm.	1	Lake Shore Pipeline Co.	8622	Precambrian	1007	8355	E (Riley and others, 1993)	-7348
3406320139	Hancock	Frazier	1	Dever	3017	Middle Run Formation	824	3008	S (Janssens, 1973)	-2184
3406320140	Hancock	Harris	1	Cowen	2799	Precambrian	833	2795	S (Janssens, 1973)	-1962
3406320152	Hancock	Drummelsmith	1	Kin-Ark Oil Co.	2807	Precambrian	809	2795	S (Janssens, 1973)	-1986
3406367158	Hancock	Norris	1	Fennerty et al.	2980	Precambrian	830	2770	S (Summerson,1962)	-1940

APPENDIX B.—WELL DATA FOR CONTROL POINTS ON MAP PG-23 (cont.).

Precambrian-top data source: C = core; D = driller; E = electric-log interpretation, by Baranoski unless otherwise noted; S = sample-cuttings interpretation, by Baranoski unless otherwise noted

American Petroleum Institute well number	County	Lease name	Well no.	Company name	Well total depth (feet)	Formation at total depth	Well elevation above sea level (feet)	Along-hole depth to top of Precambrian (feet)	Precambrian-top data source	Precambrian subsea value (feet)
3406520074	Hardin	Jones	1	Edmund	2834	Precambrian	941	2840	S (Janssens, 1973) estimated	-1899
3406520079	Hardin	Wolf	1	McMahon-Bullington Drilling	2992	Precambrian?	971	2960	E (Wickstrom, 1987)	-1989?
3406520133	Hardin	Fewell	1-25	Ensign Operating Co.	2928	Precambrian	934	2867	E	-1932
3406720737	Harrison	Zechman Unit	1	Red Hill Development	10625	Precambrian	898	10460	E	-9562
3406920036	Henry	Hall	1	Callander & Kimbrel	3475	Precambrian	683	3440	E	-2757
3407120001	Highland	Pavey	1	Kewanee Oil Co.	3512	Precambrian?	1043	3515	S (Janssens, 1973) estimated	-2472?
3407120007	Highland	Courtney	1	Ohio Valley Oil & Gas Co.	3610	Precambrian?	957	3605	E (Wickstrom, 1987)	-2648?
3407120015	Highland	Carl-Roberts Unit	J-1	Oxford Oil Co.	3442	Precambrian	1041	3380	D, E	-2339
3407120016	Highland	Heyob-Coyne-West Unit	J-1	Oxford Oil Co.	3299	Precambrian	1015	3145	E	-2130
3407321222	Hocking	Hockman	1	Dunigan	6495	Precambrian	970	6469	S (Owens, 1967)	-5499
3407525070	Holmes	Snyder	1	Bakerwell	5988	Precambrian	875	5930	D	-5055
3407720011	Huron	Arting	1	White	4270	Precambrian	749	3901	S (Summerson, 1962)	-3152
3407720103	Huron	Wolf Unit	1	Appalachian Exploration	4574	Precambrian	856	4554	D	-3698
3407720233	Huron	Walcher-Gray	2	NGO Development Corp.	4445	Precambrian	970	4340	D	-3370
3407920076	Jackson	Wood	1	Worthington Oil	6320	Precambrian	816	6218	S (Owens, 1967)	-5402
3407920078	Jackson	Slavens	1	Halbert	5681	Precambrian	665	5575	S (Owens, 1967)	-4910
3407920079	Jackson	Brown	1	Halbert	5991	Precambrian	841	5990	D (Owens, 1967)	-5149
3407920102	Jackson	Trepanier	1	Nucorp Energy Corp.	6050	Precambrian	834	5965	S, E	-5131
3408321413	Knox	Cunningham	1	KST Oil & Gas	5745	Precambrian	1239	5740	E	-4501
3408321468	Knox	Larimore	1	Ohio Fuel Gas Co.	5376	Precambrian	1204	5364	S (Janssens, 1973)	-4160
3408321604	Knox	Huffman	1	Kin-Ark Oil Co.	4907	Precambrian	1183	4773	S (Janssens, 1973)	-3590
3408323915	Knox	Donaldson	1	Edco Drilling & Producing	5354	Precambrian	1086	5235	E	-4149
3408323931	Knox	Carter	1 G-M	B. & J. Drilling Co.	5084	Precambrian	1032	4918	E	-3886
3408323944	Knox	White	1	Cobra Oil & Gas Co.	5023	Precambrian	1212	4990	D	-3778
3408323955	Knox	Parkinson	4	Michigan Geosearch	4920	Precambrian	1060	4920	E	-3860
3408323976	Knox	Parkinson	6	Michigan Geosearch	4886	Precambrian	1028	4853	E	-3825
3408324064	Knox	Ernest	2	Redman Oil Co.	5234	Precambrian	1010	5166	E	-4156
3408520142	Lake	Calhio Chemicals	1	Calhio Chemicals	6072	Precambrian	701	6060	D	-5359
3408520280	Lake	Calhio Chemicals	2	Calhio Chemicals	6110	Precambrian	712	6096	D	-5384
3408520661	Lake	Diamond Alkali Co.	LM 1	Environmental Brine Services	5975	Precambrian	623	5923	D	-5300
3408720174	Lawrence	Payne	1	Goldberg	7002	Precambrian	609	6950	E	-6341
3408921826	Licking	Crowley	1	Lake Shore Pipeline Co.	5991	Precambrian	1060	5978	S (Owens, 1967)	-4918
3408922057	Licking	Roberts	1	Atha	4952	Precambrian	1179	4910	S (Owens, 1967)	-3731
3408922252	Licking	Schmelzer	1	Ashland Oil & Refining Co.	4802	Precambrian	1090	4785	S (Owens, 1967)	-3695
3408924792	Licking	Moran	1	Moran	6237	Precambrian?	806	6215	D	-5409?
3408925489	Licking	Uhde	3-9	Michigan Geosearch	4922	Precambrian	1100	4838	E	-3738
3408925542	Licking	Ellas Unit	1	Clinton Oil Co.	5626	Precambrian	1222	5620	S, E	-4398
3409120018	Logan	Johns et al. Unit	1	Ohio Oil Co.	3361	Precambrian	1190	3255	S (Summerson, 1962)	-2065
3409120096	Logan	Prinkey Unit	1	Ashtola Exploration Co.	3260	Precambrian	1125	3122	S, E,	-1997
3409320794	Lorain	Born	1	East Ohio Gas Co.	4590	Precambrian	850	4573	S (Owens, 1967)	-3723
3409520060	Lucas	Ketring Unit	1	Liberty Petroleum Corp.	3914	Precambrian?	674	3624	D	-2950?
3409720003	Madison	Hume	1	Amerada Petroleum Corp.	3631	Precambrian	995	3610	S (Janssens, 1973)	-2615
3409720007	Madison	Immell	1	Columbia Natural Resources	3476	Precambrian?	1016	3476	Est	-2460?
3410120008	Marion	Mitchell	1	United Producing	3675	Precambrian	1001	3665	S (Owens, 1967)	-2664
3410120085	Marion	Parrish	1	Stadler & Mattix	2984	Precambrian?	980	2985	D	-2005?
3410120165	Marion	McNamara	6	X-Alpha International	3657	Precambrian	965	3603	D	-2638
3410120167	Marion	Herr	1	Delray Oil	2934	Precambrian	905	2924	D	-2019
3410120168	Marion	Gracely Farms	1	Anschutz Corp.	3074	Precambrian	926	3060	E	-2134
3410120173	Marion	Oehler	1	Texas Gas Exploration Corp.	2990	Precambrian	974	2985	D	-2011
3410120174	Marion	Gracely Farms	1	Texas Gas Exploration Corp.	3198	Precambrian	916	3120	E	-2204
3410120175	Marion	Wenig et al.	1	Delray Oil	2935	Precambrian	909	2935	E	-2026
3410120176	Marion	Gracely Farms	1	Texas Gas Exploration Corp.	3075	Precambrian	924	3062	E	-2138
3410120207	Marion	Forry et al.	OH-377	Equitable Resources	3142	Precambrian	913	3092	E	-2179
3410321143	Medina	Smith	1-A	Wiser Oil Co.	7040	Precambrian	1200	6580	S (Janssens, 1973)	-5380
3410321201	Medina	Warner	1	Wiser Oil Co.	6731	Precambrian	1116	6662	S, E (Janssens, 1973)	-5546
3410321819	Medina	Wandel Unit	1	Moore	5667	Precambrian	1092	5650	E (Wickstrom, 1987)	-4558
3410720141	Mercer	Yewey	2	Harner Union Oil	3135	Middle Run Formation?	837	3150	S (Janssens, 1973)	-2313
3410920001	Miami	Levering	1	Sun Oil Co.	3412	Middle Run Formation?	994	3282	S (Summerson, 1962)	-2288
3410920003	Miami	Walker	1	National Associated Petroleum	3510	Precambrian	1035	3255	S (Summerson, 1962)	-2220
3411720012	Morrow	Myers	3	Ashland Oil & Refining Co.	4090	Precambrian	1016	4002	S (Owens, 1967)	-2986
3411720033	Morrow	Henry	1	Wehmeyer	4044	Precambrian	995	4009	S (Janssens, 1973)	-3014
3411720047	Morrow	Windbigler	1	Poston	4888	Precambrian	1398	4870	S (Janssens, 1973)	-3472
3411721388	Morrow	McBee	1	Wray	4411	Precambrian	1140	4445	S (Janssens, 1973)	-3305
3411721681	Morrow	Shaver-Neff Unit	5	Kin-Ark Oil Co.	4195	Precambrian	1007	4195	E	-3188
3411722550	Morrow	Irey	1	Otter Creek Exploration	3876	Precambrian	1004	3875	S (Janssens, 1973)	-2871
3411723737	Morrow	Brewer	1	Star Exploration Corp.	5000	Precambrian?	1399	4938	D, E	-3539?
3411724012	Morrow	Morris	7	Ohio Production Corp.	5258	Precambrian	1331	4792	E	-3461
3411724043	Morrow	Hickok	1-14	EEI	4707	Precambrian	1398	4682	D	-3284

APPENDIX B.—WELL DATA FOR CONTROL POINTS ON MAP PG-23 (cont.).

Precambrian-top data source: C = core; D = driller; E = electric-log interpretation, by Baranoski unless otherwise noted; S = sample-cuttings interpretation, by Baranoski unless otherwise noted

American Petroleum Institute well number	County	Lease name	Well no.	Company name	Well total depth (feet)	Formation at total depth	Well elevation above sea level (feet)	Along-hole depth to top of Precambrian (feet)	Precambrian-top data source	Precambrian subsea value (feet)
3411927076	Muskingum	Consolidation Coal	CR 400	Carless Resources	7381	Precambrian	928	7373	E (Riley and others, 1993)	-6445
3412121278	Noble	Ullman	1	Amoco Corp.	11442	Precambrian	1035	11410	S (Janssens, 1973)	-10375
3412520013	Paulding	Arend	1	Mt. Pleasant Mines	3100	Precambrian?	725	3392	D	-2667?
3412726595	Perry	Rush Creek Partners et al.	1	Poling Co.	6395	Precambrian	828	6302	E (Riley and others, 1993)	-5474
3412920002	Pickaway	Long	1A	Kewanee Oil Co.	3257	Precambrian	857	3245	S (Summerson, 1962)	-2388
3412920004	Pickaway	Croman	1	McMahon-Bullington Drilling	3731	Precambrian	797	3740	S (Janssens, 1973) estimated	-2943
3412920006	Pickaway	Miller	1	Midwest Oil & Gas Co.	4179	Precambrian	693	4148	S (Owens, 1967)	-3455
3412920020	Pickaway	Higgy	1	Minuteman Exploration Co.	3816	Precambrian	799	3803	D	-3004
3412920024	Pickaway	Kerns	1	Ramco Oil & Gas Corp.	4446	Precambrian	770	4310	E (Riley and others, 1993)	-3540
3413120089	Pike	Hurless	1	Hill Drilling	4011	Precambrian	578	3972	D, E	-3394
3413322860	Portage	Viking Resources	1	Viking Resources	8797	Precambrian	1061	8720	D	-7659
3413720031	Putnam	Barlage	1	Ohio Oil Co.	3377	Precambrian	740	3350	S (Summerson, 1962)	-2610
3413920431	Richland	Scott	2	Tri-State Producing	5503	Precambrian	1458	5497	S (Janssens, 1973)	-4039
3413920448	Richland	Empire Reeves Steel Division	D-1	Empire Reeves Steel Division	5085	Precambrian	1176	5061	S (Janssens, 1973)	-3885
3414120009	Ross	Clark	1	Crest Oil Co.	3863	Precambrian	1033	3845	S (Janssens, 1973)	-2812
3414120021	Ross	Irvine	1	Oxford Oil Co.	3880	Precambrian	985	3870	E (Riley and others, 1993)	-2885
3414300001	Sandusky	Bruns	1	Ohio Oil Co.	2822	Precambrian	590	2602	estimated	-2012
3414320001	Sandusky	Hetrick	1	Montgomery	2796	Precambrian	590	2701	S (Summerson, 1962)	-2111
3414320077	Sandusky	Haff	1	East Ohio Gas Co.	3123	Precambrian?	644	3095	S (Janssens, 1973)	-2451?
3414320117	Sandusky	Ayers	1	Dunigan	2716	Precambrian	633	2706	S (Janssens, 1973)	-2073
3414320126	Sandusky	Recker	1	C. & E. Oil Co.	2675	Precambrian?	673	2597	D	-1924?
3414320146	Sandusky	Aleshire	1	Maguire	2759	Precambrian	706	2756	E (Owens, 1967)	-2050
3414320147	Sandusky	Kerbel	1	Maguire	2785	Precambrian	647	2760	S, E (Janssens, 1973)	-2113
3414320210	Sandusky	Vickery Environmental	1	Vickery Environmental	2932	Precambrian	620	2932	D (Janssens, 1973)	-2312
3414320224	Sandusky	Vickery Environmental	2	Vickery Environmental	2960	Precambrian	616	2930	D	-2314
3414320225	Sandusky	Vickery Environmental	3	Vickery Environmental	2902	Precambrian	618	2890	D	-2272
3414320235	Sandusky	Vickery Environmental	1A	Vickery Environmental	2980	Precambrian	616	2936	D	-2320
3414320238	Sandusky	Vickery Environmental	6	Vickery Environmental	2955	Precambrian	605	2930	D	-2325
3414520212	Scioto	Aristech Chemical Corp.	1	Aristech Chemical Corp.	5617	Precambrian	557	5595	E	-5038
3414520252	Scioto	Aristech Chemical Corp.	2	Aristech Chemical Corp.	6024	Precambrian	NA	NA	directional well	NA
3414520257	Scioto	Smith	1	Adobe Oil & Gas Corp.	4432	Precambrian	1213	4382	E	-3169
3414560033	Scioto	Aristech Chemical Corp.	3	Aristech Chemical Corp.	6109	Precambrian	NA	NA	directional well	NA
3414720128	Seneca	Stigamire	1	Ashland Oil & Refining Co.	3170	Precambrian	796	3147	S (Owens, 1967)	-2351
3414720211	Seneca	Shults	1	American Standard Energy	2847	Precambrian	720	2790	E (Wickstrom, 1987)	-2070
3414720212	Seneca	Watson	1	American Standard Energy	2960	Precambrian?	741	2766	D	-2025?
3414720214	Seneca	Hoover	1	American Standard Energy	2600	Precambrian	766	2493	E	-1727
3414720216	Seneca	Watson	2	American Standard Energy	2796	Precambrian	759	2762	D	-2003
3414720244	Seneca	Watson	4	American Standard Energy	2830	Precambrian?	751	2804	D	-2053?
3414760840	Seneca	M & B Asphalt	GB-4	ODNR Div. Geol. Survey	2870	Precambrian	697	2811	C, E (Wickstrom and others, 1985)	-2114
3414760890	Seneca	Watson Heirs	2	Sun Oil Co.	2935	Precambrian	710	2780	S	-2070
3414920012	Shelby	Nelson	1	Sun Oil Co.	3275	Precambrian	1050	3184	E	-2134
3414920013	Shelby	Fogt	1	Gump Oil Co.	3360	Precambrian	1037	3298	E	-2261
3414920103	Shelby	Borland	1	Funk Exploration	3227	Precambrian	1074	3213	D	-2139
3415320907	Summit	Northampton Board of Trustees	2	KST Oil & Gas	7199	Precambrian	1006	7150	D	-6144
3415321591	Summit	KST Oil & Gas	5	KST Oil & Gas	7225	Precambrian	1005	7168	D	-6163
3415920002	Union	Zenith Holding & Trading Corp.	1	H. H.& R. Operating	3348	Precambrian	1001	3350	S (Janssens, 1973)	-2349
3415920013	Union	Lane	1	T. & W. Oil Co.	2990	Precambrian?	996	2985	D (Owens, 1967)	-1989?
3415920067	Union	Graver	1	Funk Exploration	3435	Precambrian	966	3430	E (Wickstrom, 1987)	-2464
3415920069	Union	Yoder	1	Funk Exploration	3500	Precambrian	971	3450	E (Wickstrom, 1987)	-2479
3415920070	Union	Kindig	1	Funk Exploration	3340	Precambrian	962	3340	E	-2378
3415920071	Union	Black	1	Funk Exploration	3395	Precambrian	987	3390	E (Wickstrom, 1987)	-2403
3415920074	Union	Low	1	Funk Exploration	3438	Precambrian	974	3419	D	-2445
3415920083	Union	Inskeep	1	Titan Energy	3115	Precambrian?	971	3059	D	-2088
3416120044	Van Wert	Miller	5	West Ohio Oil & Gas	3240	Precambrian	820	3214	D	-2394
3416560005	Warren	American Aggregates	DS-2	ODNR Div. Geol. Survey	5380	Middle Run Formation	1025	3458	C, E (Shrake and others, 1990)	-2433
3416920071	Wayne	Steiner	2	East Ohio Gas Co.	6919	Precambrian	960	6904	D (Summerson, 1962)	-5944
3416921419	Wayne	Drake	1	Waldron	6897	Precambrian	1151	6728	S (Janssens, 1973)	-5577
3417120034	Williams	Kennerk	1	Beglinger	4167	Precambrian	842	3922	S (Janssens, 1973)	-3080
3417320229	Wood	Knauss	1	Southern Triangle Oil Co.	2764	Precambrian	694	2720	S (Owens, 1967)	-2026
3417320231	Wood	Peek	1	O'Neill	2770	Precambrian	698	2760	E (Owens, 1967)	-2062
3417320236	Wood	Smith	1	Kin-Ark Oil Co.	2785	Precambrian	677	2775	E	-2098
3417320237	Wood	Carter	1	Kin-Ark Oil Co.	2821	Precambrian	673	2825	D (Janssens, 1973)	-2152
3417320239	Wood	Asmus et al.	1	J.R.S.	2825	Precambrian	670	2805	S (Janssens, 1973)	-2135
3417320423	Wood	Kramer	1-A	Anschutz Corp.	2880	Precambrian?	691	2860	E	-2169?
3417320432	Wood	Freehan	1	Texas Gas Exploration Corp.	2867	Precambrian?	690	2862	D	-2172?
3417360438	Wood	Killian	1	Brailey	2927	Precambrian	688	2884	S (Summerson, 1962)	-2211
3417520072	Wyandot	Heck	1	Ohio Oil Co.	2801	Precambrian	860	2800	S (Owens, 1967)	-1940

APPENDIX B.—WELL DATA FOR CONTROL POINTS ON MAP PG-23 (cont.).

Precambrian-top data source: C = core; D = driller; E = electric-log interpretation, by Baranoski unless otherwise noted; S = sample-cuttings interpretation, by Baranoski unless otherwise noted

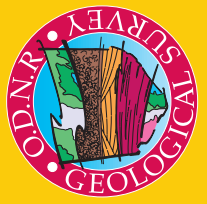
American Petroleum Institute well number	County	Lease name	Well no.	Company name	Well total depth (feet)	Formation at total depth	Well elevation above sea level (feet)	Along-hole depth to top of Precambrian (feet)	Precambrian-top data source	Precambrian subsea value (feet)
3417520173	Wyandot	Frey	1	Comanche Oil Co.	2875	Precambrian	868	2860	S (Janssens, 1973)	-1992
3417520174	Wyandot	Bowen	1	Texaco	2900	Precambrian	846	2850	S (Owens, 1967)	-2004
3417520211	Wyandot	Eyestone	1	Minnesota-Ohio Oil Co.	3260	Precambrian	942	3250	S (Janssens, 1973)	-2308
3417520259	Wyandot	Kuenzli	1	Berea Oil & Gas Corp.	3149	Precambrian	893	3066	E (Wickstrom, 1987)	-2173
3417560610	Wyandot	Parsell	1	Dibble & Miller	5632	Precambrian	910	3040	S (Summerson, 1962)	-2130
Indiana #133540	Allen	Leuenberger	1	Northern Indiana Public Service	3672	Precambrian	797	3484	S, E (Rudman and Rupp, 1993)	-2687
Indiana #135957	Fayette	Scott	1	Gulf Oil	3955	Precambrian	959	3914	S, E (Rudman and Rupp, 1993)	-2955
Indiana #141771	Jay	Binegar	1	Petroleum Development	3404	Precambrian	948	3351	S (Summerson, 1962)	-2403
Indiana #147781	Wayne	Doddridge	1	Porter Gordon	3907	Precambrian	857	3435	Indiana Geological Survey (Owens, 1967)	-2578
1601500000 KY	Boone	Conner	1	Ford	4089	Middle Run Formation	908	3695	Kentucky Geological Survey	-2787
1601920459 KY	Boyd	Inland Gas	533	Inland Gas Co.	9595	Precambrian	862	8505	Kentucky Geological Survey	-7643
1601920876 KY	Boyd	McKeand	535	Inland Gas Co.	9449	Precambrian	868	9385	Kentucky Geological Survey	-8517
1601921652 KY	Boyd	Fannin	537	Inland Gas Co.	7828	Precambrian	709	6757	Kentucky Geological Survey	-6048
1603718051 KY	Campbell	Wilson	R-1	Ashland Oil & Refining Co.	3604	Precambrian	757	3502	Kentucky Geological Survey	-2745
1604316235 KY	Carter	Stapleton	11-1	Ashland Oil & Refining Co.	5251	Precambrian	956	5219	Kentucky Geological Survey	-4263
1604322935 KY	Carter	Inland Gas	538	Inland Gas Co.	7272	Precambrian	796	7176	Kentucky Geological Survey	-6380
1604326995 KY	Carter	Duncan	547	Inland Gas Co.	5062	Precambrian	985	5042	Kentucky Geological Survey	-4057
1604398E9 KY	Carter	Stamper	8807T	United Fuel Gas Co.	5085	Precambrian	857	5048	Kentucky Geological Survey	-4191
1608921256 KY	Greenup	Newell	1	Commonwealth Gas Corp.	5193	Precambrian	1053	5128	Kentucky Geological Survey	-4075
1612724502 KY	Lawrence	Young	542	Inland Gas Co.	12712	Precambrian	884	12544	Kentucky Geological Survey	-11660
1613500000 KY	Lewis	Adams	1	Thomas	4190	Precambrian	560	4166	Kentucky Geological Survey	-3606
1613502579 KY	Lewis	Shephard	9060	United Fuel Gas Co.	4550	Precambrian	908	4529	Kentucky Geological Survey	-3621
1613521132 KY	Lewis	Wolfe, Dewey et al.	1	Ashland Oil & Refining Co.	5082	Precambrian	1113	5050	Kentucky Geological Survey	-3937
1616103990 KY	Mason	Rawlings	9061T	United Fuel Gas Co.	3314	Precambrian	769	3290	Kentucky Geological Survey	-2521
2102337569 MI	Branch	Atlantic Richfield Co. & Johnson	1-3	Atlantic Richfield Co.	5252	Precambrian	911	5210	Michigan Geological Survey	-4299
2102338045 MI	Branch	Atlantic Richfield Co.	1-13	Atlantic Richfield Co. & Gaglio	5377	Precambrian	918	5146	Michigan Geological Survey	-4228
2109110448 MI	Lenawee	Taylor	1	Eckert	3902	Precambrian	715	3865	Michigan Geological Survey	-3150
2111507702 MI	Monroe	Sancrant	1	Beck	5465	Precambrian	669	3595	Michigan Geological Survey	-2926
2111511221 MI	Monroe	Chapman	1	Sturman	3377	Precambrian	597	3342	Michigan Geological Survey	-2745
2111525494 MI	Monroe	Shimp	1	Ferguson & Garrison	3671	Precambrian	686	3640	S (Janssens, 1973)	-2954
2111535948 MI	Monroe	Cousino	1-1	Reef Petroleum	3512	Precambrian	646	3470	Michigan Geological Survey	-2824
3703920007 PA	Crawford	Kardosh	1	Benedum & Ark-La Gas	8031	Precambrian	1337	7924	Pennsylvania Geological Survey	-6587
3708520036 PA	Mercer	Temple	1	Peoples Natural Gas	9919	Precambrian	1344	9820	Pennsylvania Geological Survey	-8476
3708520116 PA	Mercer	Fleck	1	Peoples Natural Gas	9246	Precambrian	1339	9088	Pennsylvania Geological Survey	-7749
4701120537 WV	Cabell	Kingery	1	Cyclops	8552	Precambrian	667	8515	E	-7848
4703521366 WV	Jackson	Stalnaker	1	Exxon USA	17675	Precambrian	943	17659	West Virginia Geological and Economic Survey	-16716
4704321469 WV	Lincoln	McCormick	1	Exxon USA	19124	Precambrian	727	19060	West Virginia Geological and Economic Survey	-18333
4705320069 WV	Mason	Arrington	1	United Fuel Gas Co.	8635	Precambrian	609	8565	West Virginia Geological and Economic Survey	-7956
4705320297 WV	Mason	Jividen	1	Union Drilling	10598	Precambrian	626	10564	West Virginia Geological and Economic Survey	-9938
4709921572 WV	Wayne	Smith	1	Exxon USA	14625	Precambrian	594	14548	West Virginia Geological and Economic Survey	-13954
4710700351 WV	Wood	Power Oil	1	Hope Natural Gas	13331	Precambrian	1050	13272	West Virginia Geological and Economic Survey	-12222
4710720756 WV	Wood	Deem	1	Exxon USA	13266	Precambrian	694	13253	West Virginia Geological and Economic Survey	-12559
Ontario #102843	Essex	Government of Ontario	2	Amerada Hess Essex	3071	Precambrian	618	3020	Janssens (1973)	-2402
Ontario #534	Essex	unknown	23	Lewis	3223	Precambrian	581	3190	Ontario Ministry of Natural Resources	-2609
Ontario #6369	Essex	unknown	33683	Consumers et al.	3471	Precambrian	585	3466	Ontario Ministry of Natural Resources	-2881
Ontario #6539	Essex	unknown	33817	Consumers et al.	3484	Precambrian	587	3415	Ontario Ministry of Natural Resources	-2828
Ontario #6540	Essex	unknown	33818	Consumers et al.	3504	Precambrian	592	3446	Ontario Ministry of Natural Resources	-2854
Ontario #6897	Essex	unknown	34102	Consumers et al.	3478	Precambrian	594	3423	Ontario Ministry of Natural Resources	-2829
Ontario #7201	Essex	unknown	34335	Consumers et al.	3514	Precambrian	601	3467	Ontario Ministry of Natural Resources	-2866
Ontario #7575	Essex	unknown	14	Ram-BP	3535	Precambrian	579	3487	Ontario Ministry of Natural Resources	-2908
Ontario #4772	Kent	Government of Ontario	13501	Consumers	4365	Precambrian	594	4300	Ontario Ministry of Natural Resources	-3706
Ontario #5353	Kent	Government of Ontario	13730	Consumers	4357	Precambrian	595	4290	Ontario Ministry of Natural Resources	-3695

APPENDIX C.—SEISMIC REFLECTION PROFILES ON MAP PG-23.

Map reference	Availability[1]	Company	Number of lines	Total miles
COCORP OH-1	PD/R	Consortium for Continental Reflection Profiling	1	172.0
COCORP OH-2	PD/R	Consortium for Continental Reflection Profiling	1	57.0
A	PD	ODNR, Division of Geological Survey	1	3.6
B	PD	Columbia Natural Resources	1	5.2
C	PD	BP Chemical (formerly Vistron Corp.)	11	72.0
D	PD	Reserve Environmental Services	7	25.8
E	PD	AK Steel Corp. (formerly Armco Steel Corp.)	4	15.0
F	R	NGO Development Corp.	1	6.5
G	PD/R	CGAS Exploration, Inc.	1	7.5
H	PD	Tomen Agro Inc. (formerly Calhio Chemicals)	3	5.3
I	R	Excalibur Exploration	4	11.3
J	PD	Waste Management of Ohio (formerly Vickery Environmental)	8	62.0
K	PD	Aristech Chemical Corp. (formerly U.S. Steel)	7	80.7
L	PD	ODNR, Division of Geological Survey	1	7.8

[1]PD, public domain; R, restricted.

Baranoski—STRUCTURE CONTOUR MAP ON THE PRECAMBRIAN UNCONFORMITY SURFACE IN OHIO AND RELATED BASEMENT FEATURES—Ohio Division of Geological Survey Map PG-23

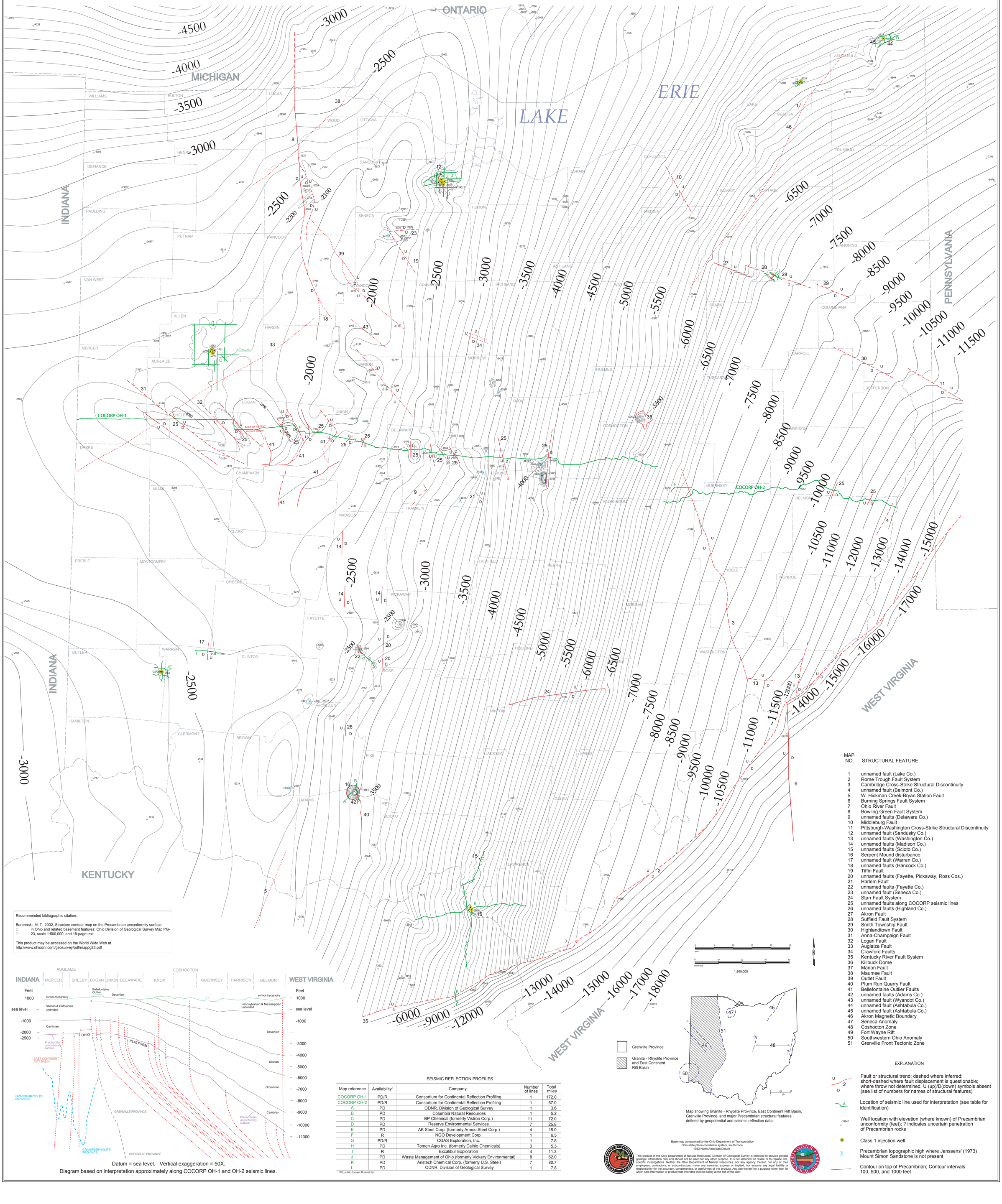


STATE OF OHIO
Bob Taft, Governor
DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director
DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

STRUCTURE CONTOUR MAP ON THE PRECAMBRIAN UNCONFORMITY SURFACE IN OHIO

Mark T. Baranoski
Assisted by Timothy Brown, Nadine Piatak, Amy Russell, and Christian Steck

OHIO DIVISION OF GEOLOGICAL SURVEY
Map PG - 23
06/2002



Datum = sea level. Vertical exaggeration = 50X.
Diagram based on interpretation approximately along COCORP OH-1 and OH-2 seismic lines.

Recommended bibliographic citation:

Baranoski, M. T., 2002, Structure contour map on the Precambrian unconformity surface in Ohio and related basement features: Ohio Division of Geological Survey Map PG-23, scale 1:500,000, and 18-page text.

This product may be accessed on the World Wide Web at http://www.ohiodnr.com/geosurvey/pdf/mappg23.pdf

SEISMIC REFLECTION PROFILES

Map reference	Availability[1]	Company	Number of lines	Total miles
COCORP OH-1	PD/R	Consortium for Continental Reflection Profiling	1	172.0
COCORP OH-2	PD/R	Consortium for Continental Reflection Profiling	1	57.0
A	PD	ODNR, Division of Geological Survey	1	3.6
B	PD	Columbia Natural Resources	1	5.2
C	PD	BP Chemical (formerly Vistron Corp.)	11	72.0
D	PD	Reserve Environmental Services	7	25.8
E	PD	AK Steel Corp. (formerly Armco Steel Corp.)	4	15.0
F	R	NGO Development Corp.	1	6.5
G	PD/R	CGAS Exploration, Inc.	1	7.5
H	PD	Tomen Agro Inc. (formerly Calhio Chemicals)	3	5.3
I	R	Excalibur Exploration	4	11.3
J	PD	Waste Management of Ohio (formerly Vickery Environmental)	8	62.0
K	PD	Aristech Chemical Corp. (formerly U.S. Steel)	7	80.7
L	PD	ODNR, Division of Geological Survey	1	7.8

[1]PD, public domain; R, restricted.

1:500,000

Grenville Province

Granite - Rhyolite Province and East Continent Rift Basin

Map showing Granite - Rhyolite Province, East Continent Rift Basin, Grenville Province, and major Precambrian structural features defined by geopotential and seismic reflection data.

MAP NO. STRUCTURAL FEATURE

1 unnamed fault (Lake Co.)
2 Rome Trough Fault System
3 Cambridge Cross-Strike Structural Discontinuity
4 unnamed fault (Belmont Co.)
5 W. Hickman Creek-Bryan Station Fault
6 Burning Springs Fault System
7 Ohio River Fault
8 Bowling Green Fault System
9 unnamed faults (Delaware Co.)
10 Middleburg Fault
11 Pittsburgh-Washington Cross-Strike Structural Discontinuity
12 unnamed fault (Sandusky Co.)
13 unnamed faults (Washington Co.)
14 unnamed faults (Madison Co.)
15 unnamed faults (Scioto Co.)
16 Serpent Mound disturbance
17 unnamed fault (Warren Co.)
18 unnamed faults (Hancock Co.)
19 Tiffin Fault
20 unnamed faults (Fayette, Pickaway, Ross Cos.)
21 Harlem Fault
22 unnamed faults (Fayette Co.)
23 unnamed fault (Seneca Co.)
24 Starr Fault System
25 unnamed faults along COCORP seismic lines
26 unnamed faults (Highland Co.)
27 Akron Fault
28 Suffield Fault System
29 Smith Township Fault
30 Highlandtown Fault
31 Anna-Champaign Fault
32 Logan Fault
33 Auglaize Fault
34 Crawford Faults
35 Kentucky River Fault System
36 Killbuck Dome
37 Marion Fault
38 Maumee Fault
39 Outlet Fault
40 Plum Run Quarry Fault
41 Bellefontaine Outlier Faults
42 unnamed faults (Adams Co.)
43 unnamed fault (Wyandot Co.)
44 unnamed fault (Ashtabula Co.)
45 unnamed fault (Ashtabula Co.)
46 Akron Magnetic Boundary
47 Seneca Anomaly
48 Coshocton Zone
49 Fort Wayne Rift
50 Southwestern Ohio Anomaly
51 Grenville Front Tectonic Zone

EXPLANATION

U / 2 / D — Fault or structural trend; dashed where inferred; short-dashed where fault displacement is questionable; where throw not determined, U (up)/D(down) symbols absent (see list of numbers for names of structural features)

A — Location of seismic line used for interpretation (see table for identification)

-3394? — Well location with elevation (where known) of Precambrian unconformity (feet); ? indicates uncertain penetration of Precambrian rocks

Class 1 injection well

X — Precambrian topographic high where Janssens' (1973) Mount Simon Sandstone is not present

Contour on top of Precambrian; Contour intervals 100, 500, and 1000 feet