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

OHIO DIVISION OF GEOLOGICAL SURVEY
Map BG-1, version 6.0

BEDROCK GEOLOGIC MAP OF OHIO

By
E. R. Slucher, *principal compiler*; E. M. Swinford, G. E. Larsen, G. A. Schumacher, D. L. Shrake, C. L. Rice[1], M. R. Caudill[1], and R. G. Rea[1]
[1]*Geologist Emeritus, United States Geological Survey*
[2]*current address: Hocking College, Nelsonville, Ohio*
[3]*Retired*
D. M. Powers, *Cartographer*

2006

INTRODUCTION

The Bedrock Geologic Map of Ohio is based mainly on 788 7.5-minute quadrangles that were geologically mapped between 1985 and 1997. This milestone in geologic mapping in Ohio represents the first time bedrock-geology maps have been available for all 788 7.5-minute quadrangles covering Ohio; it also distinguishes the state as one of only a select few states in the nation to have complete 7.5-minute bedrock-geology map coverage. Furthermore, these maps, for about 75 percent of Ohio, are the first new bedrock-geology maps produced since the 1870s and, in fact, for most of Ohio, the first bedrock-geology maps produced by modern topographic base maps. This newly compiled bedrock-geology map of Ohio, which is based on the 788 7.5-minute bedrock-geology maps, is a generalized representation of the bedrock geology that is portrayed on the Ohio Division of Geological Survey since 1920 and the first to properly portray the bedrock geology that exists beneath the extensive deposits of Quaternary sediments that cover much of Ohio. Moreover, for the first time, a statewide overview of the geologic attributes of individual map units, the contribution of geology to the development of Ohio, and potential geological hazards are presented.

Completion of this mapping program resulted in numerous derivative products that significantly expand our understanding of the geology of Ohio. Swinford (1997) and McDonald and others (2003) discuss the history and processes employed to complete this project as well as summarize many of the derivative products. These new products have enabled the Division of Geological Survey to provide citizens, industries, and public officials of Ohio up-to-date information for sound geologic evaluations. Most products developed during the bedrock-mapping program are available from the Division of Geological Survey in GIS format.

GENERAL GEOLOGY

The bedrock geology of Ohio consists of flat lying to gently dipping carbonate, siliciclastic, and evaporite strata of sedimentary origin that range in age from Upper Ordovician to Upper Carboniferous-Lower Permian (see Geologic Time Scale). An irregular veneer of mainly unconsolidated Quaternary sediments, mostly of glacial origin, and possibly Neogene-age sediments of continental origin, conceal most bedrock units in approximately three-quarters of the state (fig. 1).

Strata of the Ordovician System, exposed only in southwestern Ohio, consist mainly of alternating shale and limestone sequences and are renowned worldwide for the fossils contained within (for examples, see Feldmann and Hackathorn, 1996). Silurian System strata, typically covered by Quaternary-age sediments, are mostly dolomites with lesser amounts of shale and are infrequently exposed in northern, western, and southern Ohio.

Rocks of the Devonian System consist of two contrasting sequences. Lower and Middle Devonian-age strata are mainly limestones whereas Upper Devonian-age rocks consist mostly of shales and siltstones. Exposures of Devonian strata occur, with some frequency, within surface drainage networks in northern, east-central, and southern Ohio, but rarely crop out in northwestern Ohio. Devonian rocks occur also on a small erosional remnant, known as the Bellefontaine Outlier by geologists, in Champaign and Logan Counties (see cross section); the highest topographic point in Ohio (Campbell Hill—1,549 feet above sea level) coincidentally occurs also in this area.

The Carboniferous System is divided into two Subsystems, the Mississippian and Pennsylvanian. Mississippian strata are mostly shales and sandstones that occur locally in various proportions. Pennsylvanian strata consist mainly of a diverse array of alternating sandstones, siltstones, shales, mudstones, limestones, and underclays; economic coal beds occur also in portions of this sequence. Exposures of Carboniferous rocks occur sporadically in glaciated regions of central and eastern Ohio, but are common south of the glacial margin. Thick glacial deposits conceal Carboniferous-age strata in northwestern Ohio (fig.1).

The youngest interval of sedimentary rocks in Ohio, the Dunkard Group, occurs only in southeastern Ohio and consists of strata similar in composition to the underlying Upper Pennsylvanian-age rocks; yet, the age of the Dunkard Group has been debated since the late 1800s. Dunkard strata contain a well-studied late Pennsylvanian-age fossil flora with infrequent early Permian forms (Fontaine and White, 1880). However, spores found in coal beds in the interval only support a late, but not latest Pennsylvanian age (Clendening, 1974; 1978). Moreover, Blake and others (2002) concluded early workers placed unwarranted emphasis on few occurrences of extrabasinal forms (for example, *Callipteris (Autunia) conferta*) now known to have been contemporaneous with, and sporadically occupying specific paleoenvironments within, typical Dunkard (walchian) flora settings. However, the Carboniferous-Permian transition was a period of tectonically induced climatic change in this portion of the North American craton; thus, occurrences of these highly climate-sensitive extrabasinal plant fossils are suspect. Further age refinement is possible, however, if specific marine fossils can be identified within the interval, correlated to the Permian time scale of Wardlaw and others (2004), and tied to the plant fossils found only with only limited biostratigraphical usefulness. Thus, until more definitive fossils are found, the exact age of the Dunkard Group cannot be refined beyond a Permian-Pennsylvanian age assignment (Martin, 1998; R.M. Blake, Jr., pers. comm.).

The spatial distribution of the bedrock in Ohio is controlled by three variables: erosion, structure, and original depositional environment. Complex patterns of ancient and modern drainage networks, created through the erosive forces of the ancestral Teays River system and related drainages (Melhorn and Kempton, 1991), several major continental glacial events, and modern streams, are overprinted on the bedrock surface in most areas of Ohio (Ohio Division of Geological Survey, 2003; Swinford, 2003).

The ancient Teays River system extended across much of Ohio during the late Neogene to early Quaternary Periods and sculptured an extensive network of deeply dissected valleys into the bedrock surface. However, beginning in the early Quaternary, multiple continental glaciers repeatedly advanced southward from Canada and subsequently covered much of Ohio with thick, widespread sheets of ice. These glacial events altered the existing paleotopographic landscape and drainage patterns, and filled most valleys formerly part of the Teays network with extensive accumulations of unconsolidated rock debris. Hence, the topography of the present-day land surface in most areas of Ohio previously overlain by glaciers is now a mostly low-relief surface with little vertical expression. Nonetheless, the topography of the bedrock surface preserved beneath these glacial sediments still reflects the configuration of the former Teays River and other drainage networks (fig. 1). This contrast between the present and former topographic surfaces is best illustrated in the cross section.

The spatial configuration of many geologic units on this map clearly reflects the major channel networks of these former drainage systems, as well as other glacially altered bedrock-topography features. Spatial placements of the contacts between bedrock lithologic units are based on bedrock-topography maps, specifically constructed to illustrate the elevation of the bedrock surface as it presently exists beneath unconsolidated sediments deposited during the Quaternary Period. In most of these areas, present-day surface drainage patterns do not align with drainage networks illustrated by the bedrock-topography maps. However, in nonglaciated areas, mainly eastern Ohio, the position of the geologic contacts mostly mimic present-day surface topographic maps. Thus, in glaciated regions of Ohio, most drainage networks, as portrayed by the distribution of geologic units on this map, have little or no relationship to surface drainage networks shown on the base map of this product.

Four major regional structural geology elements also affect the spatial distribution of rocks in Ohio: the Appalachian and Michigan Basins, and the Cincinnati and Findlay Arches (fig. 2). The Serpent Mound Impact Structure in southern Ohio and several high-angle normal faults are other structural elements that displace rocks locally.

The Cincinnati Arch is a broad stable region, extending from Tennessee to southwestern Ohio, where the rocks are uplifted relative to strata of surrounding areas. In northern Ohio, another structurally positive feature, the Findlay Arch, occurs and separates the Michigan and Appalachian Basins. West-central Ohio is an area of minimum structural relief and is commonly called the Indiana-Ohio Platform.

Rocks along the crest of the Cincinnati and Findlay Arches and in the area of the Indiana-Ohio Platform are mostly flat lying. The presence of numerous unconformities, and some changes of lithologic trends within strata of this region (for example, see Correlation of Map Units) strongly suggests the area was a slightly elevated topographic feature that periodically influenced the deposition of sediments during parts of Ordovician through Mississippian Periods. Uplift of these arches and uplift in other regions of the Cincinnati Arch concurrent with Paleozoic Era tectonic events that occurred along the eastern margin of the North American craton are discussed in Ettensohn (1992). On the eastern and northwestern flanks of the Cincinnati and Findlay Arches, bedrock units dip gently into either the Appalachian or Michigan Basins, respectively.

Eastern Ohio is located on the western flank of the Appalachian Basin, an area of structural downwarping that extends from Alabama to east-central New York where almost continuous sedimentation occurred during the Paleozoic Era. Rocks in the Ohio portion of the Appalachian Basin dip mostly to the southeast and generally thicken into the basin. The youngest bedrock unit in Ohio, the Dunkard Group, is preserved in the southeastern portion of the state within the Appalachian Basin.

A small portion of the southern margin of the Michigan Basin is preserved in northwestern Ohio. Strata in this area, mostly concealed beneath thick deposits of glacial sediments, dip mildly to the northwnorthwest towards the interior of the basin. Lower Carboniferous rocks of the Mississippian Subsystem are the youngest preserved strata in the Ohio portion of this basin.

Baranoski (1990) redefined the north-northwest trending linear structure in southeastern Ohio as the Cambridge Monocline; historically this trend was designated the Cambridge Arch and Parkersburg-Lorain Syncline. Development of the monocline is attributed to either structural inversion developed over faulted Proterozoic basement rocks (Baranoski, 1993) or to movement within Silurian-age evaporite beds during post-Paleozoic and Paleozoic time (Clifford and Collins, 1974; Janssens and Olds, 1993). Regardless of its origin, newly completed and preexisting structure contour maps of various Upper Paleozoic surfaces (for example, see Vinziguera and Slucher, 2001; Gray and others, 1982) corroborate the use of monocline to accurately characterize this regional structural irregularity.

The Ashley Anticline (newly recognized) is a low-amplitude, northwest to southeast-trending structural element in north-central Ohio. Even though some minor surface displacements within the Ohio Shale were observed near the southeastern end of the feature, the relationship between it and other regional structures is unknown.

The Serpent Mound Impact Structure (fig. 3), a circular area approximately four and one-half miles in diameter, contains completely deformed Upper Cambrian through Lower Mississippian strata; the area was mapped in detail by Rodd (1973). Baranoski and others (2003) concluded the feature is the result of a meteorite impact that Wyatt (2004) suggests occurred between 256 and 330 million years ago. Baranoski and others (2003) noted also that the area has a complex geologic history and postulate reactivation of preexisting basement faults may account for some of the deformation and mineralization zones found within the structure.

The Bowling Green, Outlet, and Middleburg Fault systems, as well as several other unnamed fault systems, displace Paleozoic bedrock units, but are mostly concealed beneath glacial deposits and rarely exposed. Wickstrom and others (1992) discuss the Bowling Green and Outlet Fault systems and postulate other structural systems, that locally displace Paleozoic bedrock units, may exist in crystalline basement rocks underlying the state. Gray and others (1982) summarize the Middleburg Fault system in northeastern Ohio. The unnamed fault system in Delaware County is discussed by Westgate (1926).

Cross section A-A' traverses Ohio from the northwest to the southeast and intersects portions of the Michigan and Appalachian Basins, respectively. The stratigraphic units shown in this profile illustrate the broad, arching geometric distortion to the bedrock in Ohio created mainly by periods of tectonic subsidence within these regional basins.

ECONOMIC GEOLOGY

Oil and natural gas were first discovered in Ohio in 1814, yet commercial development of these resources did not occur until 1860 (Hansen, 1993a). Initial production was from shallow wells drilled mainly in eastern Ohio into the Devonian-age Berea Sandstone and other sandstones of Pennsylvanian age. In the1880s, the Lima-Indiana trend, the first giant petroleum field in the nation, was discovered in northwestern Ohio (Wickstrom and others, 1992). This field produced, from Ohio alone, more than 300 million barrels of oil (Harper, 1995). Ohio ranks 15th among the 30 oil-producing states in the nation and also the largest petroleum-producing region in the nonoil-and-gas 19th-century oil in the Trenton Limestone region (Wickstrom and Wolfe, 1995). Subsequent exploration has systematically targeted and discovered hydrocarbon reserves in additional geologic units in Ohio. The Devonian-age Ohio Shale and Cambrian-age Knox Dolomite, as well as other Silurian- and Devonian-age units typically referred to as the "Big Lime," "Clinton," "Packer Shale," and "Medina" by drillers, have produced significant volumes of oil and gas. Riley and others (2004) provide historical and production data on known Ohio petroleum fields in the state.

Coal for domestic and industrial use has been mined in Ohio since the area was first settled; it also facilitated in elevating the state to one of the major industrial centers in the nation (Croswell, 1995a). Economic coal beds occur mainly in the Allegheny and Monongahela Groups and locally in the Pottsville, Conemaugh, and Dunkard Groups. Presently, most mining is for the Meigs Creek (No.9; Sewickley) and Pittsburgh (No.8) coal beds of the Monongahela Group, and the Lower Freeport (No. 6a), Middle Kittanning (No. 6), and Lower Kittanning (No.5) coal beds of the Allegheny Group (Wolfe, 2005). The Waynesburg (No. 11) and Pomeroy (No. 5a, Redstone) coals of the Monongahela Group, the Mahoning (No. 7a) coal of the Conemaugh Group, the Upper Freeport (No. 7), Clarion (No.4a), and "Newland (No. 4 Brookville) coal beds of the Allegheny Group, and the Lower Mercer (No. 3) coal of the Pottsville Group are viable resources locally (Wolfe, 2005). The coal is mainly of high-volatile A or B bituminous rank and bended varieties, most Ohio coals also contain high percentages of sulfur. Mining is by underground and surface methods. Resource investigations demonstrate Ohio contains considerable deposits of undeveloped coal. Future technological advances may increase the ability to utilize many of these deposits currently unexploited. Almost all coal mined in Ohio is utilized for electrical generation within the state.

Limestone and dolomite are quarried at numerous locations mainly throughout northern and west-central portions of Ohio. Production is from, primarily the Lockport, Greenfield, Bisher, Deer Creek, Cedarville, Springfield, Dayton, Bellefontaine, Columbus, Delaware, Sunbury, Berea, Bedford, Maxville, Amsden, and the Salina Formations of the Great Lakes Group (Wolfe, 2005). Marketable limestone occurs also at several intervals in the mostly sandstone and shale dominated Carboniferous-age sequence of eastern Ohio—principally the Macoville Limestone, the Vanport, *Olryan, and Putnam Hill limestones (Allegheny Group), and the Pittsburgh and Fishpot limestones (Monongahela Group) (Wolfe, 2005). Indigenous limestone and dolomite deposits provided early settlers with a durable material for construction of buildings, mills, canals, and the like, especially in central and western portions of the state (Stout, 1941). Indeed, the Ohio Statehouse was constructed from Columbus Limestone quarried locally on the west bank of the Scioto River. Limestone and dolomite base and continue to be a resource for flagstone, curbing, road metal, riprap, Portland cement, concrete aggregate, fertilizer, soda ash, and agricultural lime. Locally, intervals of high-calcium limestone (>95 percent calcium carbonate), a requirement in many industrial and agricultural applications, occur in the Bisnettill and Columbus Limestones. Stout (1941) provides chemical analyses of various carbonate rocks found in the state. Ohio annually ranks as one of the top producers of crushed stone and lime in the nation.

Shale supplies material for a large brick-and tile-manufacturing industry that first emerged in Ohio in the late 19th century. Goods produced, mainly fire, paving, face, and chimney brick, and sewer, building, roofing, and drain tile, have been used in buildings, urban infrastructures, and for agriculture needs throughout the eastern and midwestern region of the United States for over 100 years. Most shale utilized is of high quality, thus allowing producers to process the material as received from mines without the addition of other materials in order to enhance the durability of the final product. Geologic intervals exploited, both past and present, include the Bedford Shale, the Chagrin Member of the Ohio Shale, and numerous shale-rich intervals in the Cuyahoga and Logan Formations as well as those in the Conemaugh, Allegheny, and Pottsville Groups. Production has occurred locally also from the Kope and Silica Formations, and the Olentangy Shale. Lamborn and others (1938) summarize the physical and chemical characteristics of raw and fired shale sampled from various units in the state. Ohio consistently ranks as one of the top producers of shale in the nation. Modern utilization of shale is mainly for building and paving bricks, roofing and sewer tiles, lightweight aggregate, for liners, covers, and barrows in the landfill industry, and as cement manufacturing (Wolfe, 2005).

Clay derived from weathered, clay-rich bedrock units has been used to fashion utilitarian pottery since occupation by American Indian tribes. During early statehood, numerous small potteries, mostly in eastern Ohio, supplied stoneware for inhabitants throughout the region (Stout and others, 1952). Deposits of high-quality ceramic underclay were discovered in the Allegheny and Pottsville Groups near East Liverpool in the 1830s, and by the 1850s, exploitation of these deposits elsewhere in eastern Ohio propelled the state to one of the nations leading producers of stoneware, yellow ware and Rockingham, white ware, and porcelain as well as bricks and tiles (Stout and others, 1952; Ketchum, 2000). Extensive ceramic manufacturing centers developed in almost every county where Allegheny, Conemaugh, or Pottsville rocks crop out. Output varied from doorknobs, jugs, and spittoons to electrical porcelain and hotel china. Clay from eastern Ohio supplied much of the raw material for the Art Pottery movement that began in 1875 in Cincinnati, and later expanded to other regions in the state (Stout and others, 1952). Examples of Ohio art ware can be found in museums throughout the world and collectors still prize pieces of Art Pottery, Rockingham, Rookwood, Roseville, Weller, and others. Currently, minor underclays of the Allegheny and Pottsville Groups are used mostly for bricks, tiles, and in the landfill industry; only a small portion is utilized for stoneware, white ware, and other vitrified products.

Sandstone and conglomerate from Devonian and Carboniferous-age rocks have been utilized since the region was first settled. Quarries were developed mainly in the Berea Sandstone, the Black Hand and Buena Vista Members of the Cuyahoga Formation, and sandstone beds within the Bedford Shale. Numerous operations were located also where Pennsylvanian-age rocks occur, especially regions containing the Sharon conglomerate and Massillon sandstone. The many small abandoned sandstone quarries found today at one time supplied local residences with a single source from which a diverse array of construction materials could be produced. Sandstones where used for building, mill, bridge, and canal construction, curbing, flagging, sidewalks, ballast, fence posts, as grind, pulp, and whetstones, plus architectural purposes. A few large quarries and underground mines were developed in sandstones of such exceptional quality that products produced were utilized well beyond Ohio. At one time about 85 percent of all grindstones marketed in the United States where produced from Berea Sandstone quarried in northern Ohio; the market extended also to Asia, Europe, and South America (Bownocker, 1915). More recently, utilization of sandstone, and sand derived from crushed sandstone, includes dimensional and architectural stone, rip rap, aggregate, and refractory linings (Wolfe, 2005). Locally, conglomeratic zones in the Black Hand, Sharon, and Massillon are or have been utilized as a source for roofing granules and aggregate and Silica Flint (Stout and others, 1947; Wolfe, 2005).

High-quality silica sand (>97 percent quartz) occurs in the Sylvania Sandstone, the Black Hand Member of the Cuyahoga Formation, and the Sharon conglomerate and locally, Massillon sandstone of the Pottsville Group. Most production has been utilized as foundry, glass, and filtration sands, abrasives, and to produce silica flour for the ceramic industry, fertilizers for seed manufacturing, and as hydraulic fracturing proppant in the petroleum industry (Fuller, 1947; Wolfe, 2003). Today, many of the picturesque regions of eastern Ohio—for example, Hocking Hills, Black Hand Gorge, and Nelson-Kennedy Ledges—are the result of thousands of years of differential slackwater between resistant quartzose sandstones and surrounding, less-resistant rock types.

Extensive deposits of rock salt are present in eastern Ohio at depths ranging from 1,300 feet to slightly more than 6,500 feet below the surface (Clifford, 1973). The salt occurs in several zones within the Salina Group, either as individual beds or as interbeds within dolomite, shale, and anhydrite sequences (Clifford, 1973). Salt has been one of the most important mineral resources utilized in Ohio. American Indian tribes used natural brine springs to obtain salt at least 8,000 years ago and, since the late 1790s, commercial salt production in the state has been virtually unabated (Hansen, 1993). Beginning in the late 1880s, large quantities of salt have been produced by modern brine wells, and since about 1960, by underground mines; both extraction methods center mainly in the Cambridge and Carrollton counties. Historic and modern uses of salt include food preservation and processing, agricultural requirements, snow and ice mitigation, water treatment, and in the manufacturing of ceramics, soda ash, and glass, as well as in numerous chemical industries (Hansen, 1993).

Mining operations for gypsum have occurred nearly continuously in the vicinity of Sandusky Bay since the 1820s (Lattman, 1948; Wolfe, 2005). The gypsum appears to be the hydrous form of same-face deposits, anhydrite, a mineral that occurs naturally as interbeds or disseminated lenses and nodules in the upper part of the Salina Group (Janssens, 1977). Gypsum is used for wallboard, plaster, agricultural applications, as a retarder in Portland cement, as filler in paper, chemical additive in the manufacturing of glass and Portland cement, and for the production of wallboard (Wolfe, 2001, 2005).

Ironstone deposits, mainly in the Allegheny and Pottsville Groups, were extensively mined on a small scale for iron ore from 1804 to 1923 (Stout, 1944). The ironstone occurs as bedded and nodular deposits composed primarily of impure siderite or as ironstone, a weathering by-product of siderite. In the mid-1800s, Ohio led the nation in pig iron production and it is reported iron produced in southern Ohio was used during the Civil War to construct the Union ironclad *Monitor* (Gollahon, 1986). Today, these deposits are no longer of commercial value. Buckeye Furnace, a restored iron-furnace complex, and a few vestiges of other furnace stacks are historic sites in southeastern Ohio and are all that remain of the once thriving industry.

Flint and chert occur in Silurian, Devonian and Carboniferous-age rocks in many regions of the state. American Indian tribes shaped drills, points, knives, and other tools from flint, and early settlers fashioned hubstones from flint, mostly of Pennsylvanian age (Stout and Schoenlaub, 1943). Archaeological artifacts made from Ohio flint have been found as far away as the Atlantic Coast, Louisiana, and Kansas (Hansen, 2004a). Flint is the official gemstone of Ohio and today is used mainly for lapidarian goods.

Bedrock containing natural deposits of gold and diamonds does not exist in Ohio. The few documented occurrences of these minerals in Ohio have been within or close to glaciated regions of the state; none are of commercial value (Hansen, 1985a,b). However, deposits of these minerals do occur north of Ohio in Canada. Undoubtedly, the rare discoveries and occurrences of gold and diamonds in the state can be attributed to the numerous episodes of continental glaciation that advanced southward from Canada during the Pleistocene. Upon melting, the glaciers left behind very small particles of these minerals, as well as other foreign rocks and minerals native to Canada, in glacial sediments found today in Ohio. (Minerals native to Ohio are discussed by Carlson (1991).

Ground water from bedrock aquifers in amounts sufficient for domestic, municipal, and industrial uses can be found throughout Ohio. Water yields from porous carbonate rocks, sandstones, and/or conglomerates or from other highly fractured bedrock units can be large. The Lockport Dolomite and its equivalents, the Cuyahoga Formation, and the Black Hand Member of the Cuyahoga Formation are particularly favorable sources of potable ground water (W. Jones, Ohio Division of Water, pers. comm.). Also, the Berea Sandstone and Sharon conglomerate in northeastern Ohio are substantial aquifers (Winslow and White, 1966). Other geologic intervals may locally produce water suitable for domestic use, mainly the Salina Group, the Tymochtee and Greenfield Dolomites, as well as various intervals within Carboniferous-age rocks, particularly porous and fractured sandstones. Statewide, the majority of productive water wells drilled into bedrock extend no more than 300 feet below the surface (W. Jones, Ohio Division of Water, pers. comm.). Wells drilled into relatively impervious shales rocks, and in areas where the bedrock is older than the Lockport Dolomite, usually lack water yields sufficient for utilization. Generally, wells drilled into, or in the proximity of, the Ohio Shale or similar types of organic-rich rocks, contain objectionable water because of high concentrations of iron minerals, sulfates, and salts (Stout and others, 1943).

GEOLOGIC HAZARDS

Landslides of colluvium and rockfalls from jointed bedrock pose as geologic hazards in regions of steep topography and artificial exposures, especially in southern and eastern portions of the state. Particularly susceptible are areas underlain by mudstones and shale-rich bedrock, typical of the Kope Formation, Bedford Shale, and the Allegheny, Monongahela, and Dunkard Groups, as well as overexpanded slopes created for construction, mining, or building purposes (Hansen, 1986). Annual insurance losses from landslides in southeastern Ohio are, on a per-capita basis, one of the highest in the nation (Hansen, 1986; Hansberg and others, 1992). Rockfalls occur instantaneously with little or no advance warning and, although rare, have proved fatal in the past. Conversely, most landslides have precursors that develop prior to total slope failure. The appearance of ground or masonry cracks, broken underground utility lines, and/or progressively inclining fences, poles, and trees signal potential problem areas. Periods of high precipitation, are typical indicators suggesting a landslide may be imminent and warrant further investigation.

Abandoned underground mines are prone to collapse and are a significant geologic hazard in regions of Ohio underlain by mine workings. Particularly susceptible are the historic coal and clay mining districts of eastern Ohio, a region where underground mining has occurred for over 200 years (Crowell, 1995a). The onset of ground failure from the collapse of an underground mine can be rapid. Sudden changes in the shape of the ground or the appearance of ground and/or masonry cracks deserve further investigation. Crowell (1995b) discusses factors controlling mine subsidence as well as counties with known underground workings. Maps of individual mines known to occur in these counties can be viewed at the Division of Geological Survey or accessed via its website.

Although limited in distribution, karst terrains exist in northern, west-central, and southern areas of Ohio and are a slight geologic hazard locally (Hull, 1999). Preservation of karst indicators—caves, sinkholes, and underground drainage—occurs mostly where the quantity of glacial materials overlying bedrock is absent or thin and the underlying rocks consist of carbonates and/or anhydrites. Karst terrains can pose a threat to local ground-water supplies, construction and road sites, as well as be a hazard for animals and humans. Contamination from waste improperly disposed in karst terrain, primarily sinkholes, can quickly enter and disperse through local ground-water systems and render the water unfit for consumption. Structures built in karst terrains may be prone to damage from surface subsidence created by the sudden collapse of cave passages or from sinkhole expansion. Hull (1999) discusses, in detail, karst regions of the state as well as factors essential for determining the associated geologic hazards. Locally, a few commercially operated caves, mostly in rocks of Devonian age, are located in karst regions.

Earthquakes, although relatively infrequent, are a potential geologic hazard in Ohio. Most documented earthquakes in the state are shallow seismic events of low intensity that produce no damage; however, a few have been of high enough magnitude to cause minor to moderate structural damage (Hansen, 2004b). Most areas of the state, at one time or another, have experienced low magnitude earthquakes; yet, the frequency of occurrence is highest in western, northeastern, and southeastern Ohio (Hansen, 2004b). All earthquakes appear to be associated with zones of structural weakness in the crust of the earth. No evidence exists attributing any seismic events with mapped faults or structural elements found at the surface (Hansen, 2004b; see fig. 2). Since 1999, OhioSeis, a network of seismic observation stations, has monitored earthquake activity in Ohio and surrounding regions (Hansen, 2000; OhioSeis is accessible via the Division of Geological Survey website.

Radon, a naturally occurring radioactive gas, may occur at concentrations considered unsafe in structures built at various locations in the state. Harrell and others (1993) suggest some regions of elevated radon concentrations occur where bedrock, particularly the Ohio Shale and cherty carbonate rocks, occur close to the surface. Specific information on radon occurrences in Ohio is discussed by Harrell and others (1993) and Hansen (1993b). Long-term monitoring for indoor radon is advised in these areas.

*Revised stratigraphic nomenclature (Rice and others, 1994)

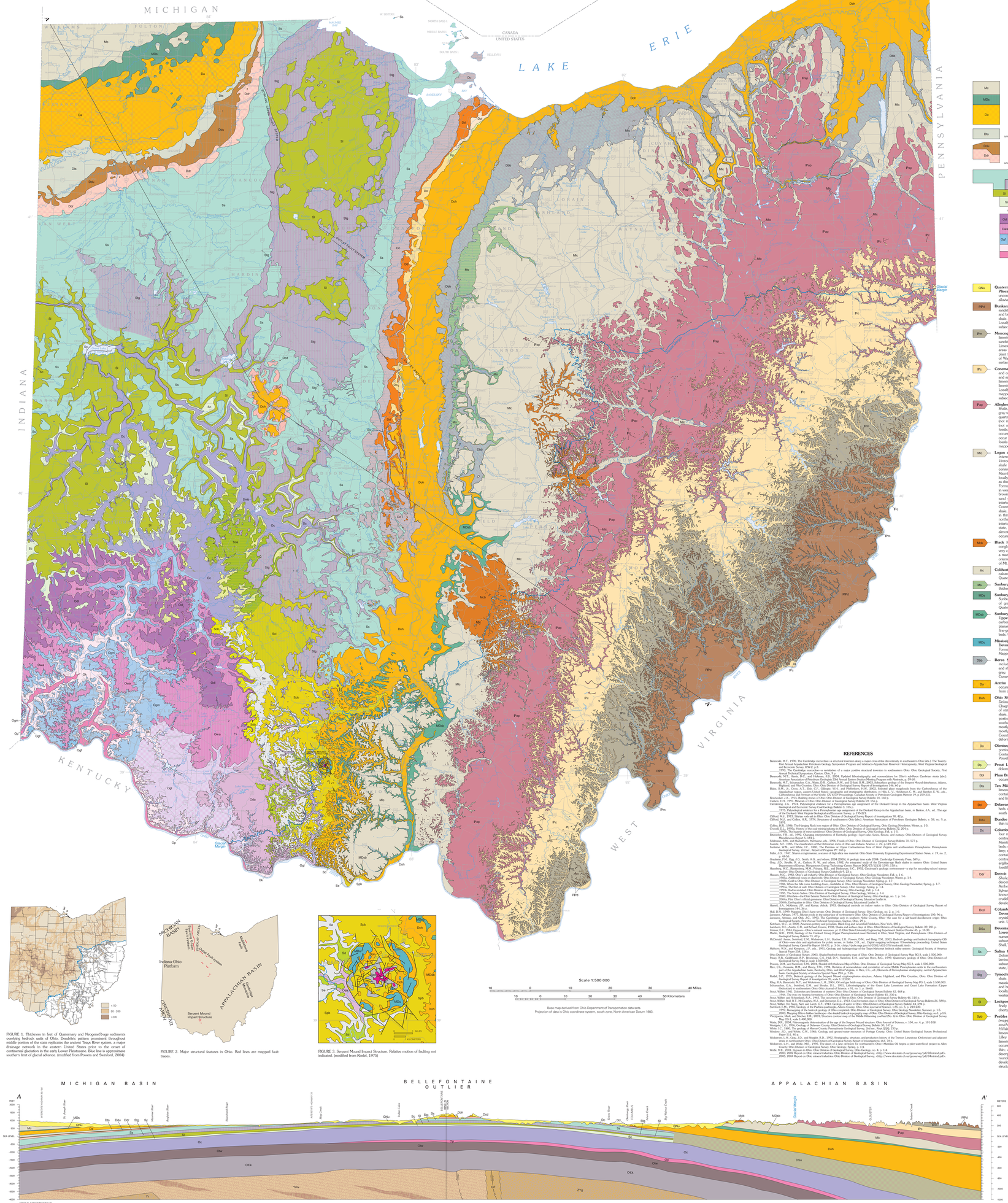

FIGURE 1. Thickness in feet of Quaternary and Neogene(?)-age sediments overlying bedrock units of Ohio. Dendritic pattern prominent throughout middle portion of the state delineates the ancient Teays River system, a major drainage network in the eastern United States prior to the onset of continental glaciations during the Quaternary Period. Blue line is approximate southern limit of glacial advance. (modified from Powers and Swiford, 2004)

FIGURE 2. Major structural features in Ohio. Red lines are mapped fault traces.

FIGURE 3. Serpent Mound Impact Structure. Relative motion of faulting not indicated. (modified from Rodd, 1975)

This product of the Ohio Department of Natural Resources, Division of Geological Survey is intended to provide general information only and should not be used for any other purpose. It is not intended for resale or to replace site-specific investigations. These data were compiled by the Ohio Division of Geological Survey, which reserves the publication rights to this material. If these data are used in the compilation of other data sets or maps for distribution or publication, this source must be referenced.

Recommended bibliographic citation:

Slucher, E.R., [principal compiler], Swinford, E.M., Larsen, G.E., and others, with GIS production and cartography by Powers, D.M., 2006, Bedrock geologic map of Ohio: Ohio Division of Geological Survey Map BG-1, version 6.0, scale 1:500,000.

The information contained herein may be updated or edited in the future. Future releases of this material, if altered, will display a revision date. Users should check to ensure they have the latest version and reference the appropriate revision date if it is being used in other works.

Neither the Ohio Department of Natural Resources, nor any agency thereof, nor any of their employees, contractors, or subcontractors, make any warranty, expressed or implied, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of this product. Any use thereof for a purpose other than for which said information or product was intended shall be solely at the risk of the user.