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REGIONAL BEDROCK GEOLOGY OF THE BELLEFONTAINE, OHIO, 30 X 60 MINUTE QUADRANGLE

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INTRODUCTION

This regional bedrock-geology map of the Bellefontaine, Ohio, 30 x 60 minute (scale: 1:100,000) quadrangle is a product of the cooperative Ohio Department of Natural Resources, Division of Geological Survey/U.S. Geological Survey COGEOMAP (now known as STATEMAP) geologic mapping program. The goal of this program is to replace the current bedrock-geology map of Ohio, produced in 1920, with updated bedrock-geology information. Additional products of the program include: (1) development of a statewide digital bedrock-geology database, (2) production of open-file regional structure-contour maps of all mapped geologic units, (3) production of open-file bedrock-geology, bedrock-topography, and structure-contour maps for each 7.5-minute (1:24,000-scale) topographic quadrangle within the state, and (4) publication of regional bedrock-geology maps for the thirty-four 30 x 60 minute quadrangles covering Ohio. The area of the Bellefontaine 30 x 60 minute quadrangle includes all or portions of Auglaize, Champaign, Clark, Delaware, Franklin, Logan, Madison, Marion, Morrow, and Union Counties in west-central Ohio.

METHODS

Bedrock-geology maps of the thirty-two 7.5-minute quadrangles within the Bellefontaine 30 x 60 minute quadrangle were generated using published and unpublished data on file at the Division of Geological Survey (OGS), supplemented with minimal field work. Sources included: geophysical logs and drillers' cards for oil and gas wells, continuous bedrock core (some with geophysical logs), water-well logs (some with geophysical logs), measured stratigraphic sections, and data from field notes and existing geologic maps.

Structure-contour maps were digitally produced at a scale of 1:250,000 for all the mappable bedrock units in west-central Ohio (Larsen and others, 1992a-i). Structure-contour maps at 1:24,000 scale (digitally extracted from the 1:250,000-scale maps) and bedrock-topography maps at 1:24,000 scale were used to draw geologic contacts of the mapped rock units in the Bellefontaine quadrangle at a scale of 1:24,000. Bedrock in the Bellefontaine quadrangle is commonly buried beneath thick deposits of glacial drift or alluvium. Consequently, geologic contacts are drawn on buried bedrock topography throughout most of the area. For some areas, bedrock-topography maps already existed at 1:24,000 scale; for other areas, existing manuscript maps at various scales were photographically enlarged to a scale of 1:24,000. Bedrock contacts from the thirty-two 1:24,000-scale bedrock-geology quadrangles were digitally compiled to create this regional bedrock map of the Bellefontaine 30 x 60 minute quadrangle.

GEOLOGIC SETTING

The Bellefontaine quadrangle lies within the Till Plains Section of the Central Lowland Physiographic Province (Fenneman, 1938). Topography is generally flat to gently undulating. Topographic relief ranges from 1,549 feet above sea level at Campbell Hill, in Logan County—the highest point in Ohio—to approximately 720 feet above sea level at the southeastern corner of the quadrangle. The area of the Bellefontaine quadrangle is drained by the Great Miami River and its tributaries in the western portion and the Scioto River and its tributaries in the eastern portion. The divide between the two basins trends north-south through eastern Logan and Champaign Counties.

The Teays River (Tight, 1903), a major early Pleistocene(?) or older drainageway of the Appalachian region, flowed through Ohio prior to Pleistocene glaciation, which covered the northern and western two-thirds of Ohio. The valley of the Teays River is projected to have entered Ohio east of Portsmouth in Scioto County, extended north to Pickaway County, then northwestward through Madison, Clark, Champaign, and Shelby Counties, then exited Ohio in northwestern Mercer County (Ver Steeg, 1936; Goldthwait, 1991). Erosion of bedrock surface by the Teays River and its tributaries controls the areal distribution of bedrock formations at the surface in west-central Ohio.

In the Bellefontaine quadrangle, the Teays Valley trends northwestward from northern Clark County to western Champaign County. Resistant Silurian- and Devonian-age carbonates create steep walls within the Teays Valley, whereas less resistant interbedded shale, limestone, and dolomite of Ordovician age form the broad, flat valley floor (fig. 1). The Teays Valley is filled with Pleistocene-age clay, silt, sand, and gravel that is more than 700 feet thick in places. Teays tributaries deeply dissected the bedrock surface in the western half of the Bellefontaine quadrangle and are generally oriented northwest-southeast or northeast-southwest coincident with the deep-seated structural pattern of the area (Wickstrom, Gray, and Stieglitz, 1992).

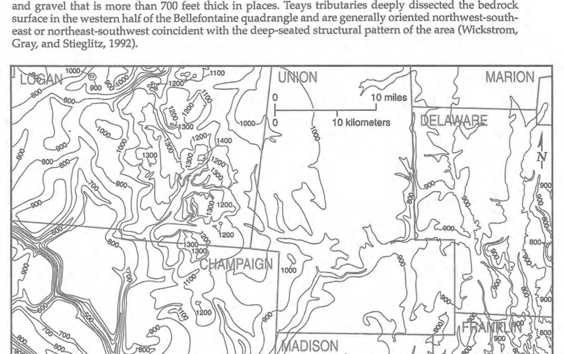

FIGURE 1.—Bedrock topography of the Bellefontaine 30 x 60 minute quadrangle. Contour interval is 100 feet (modified from Bunner, 1993).

Wisconsinan-age ground and end moraines, outwash, and lake deposits dominate the surface topography throughout the Bellefontaine quadrangle (Goldthwait and Pavey, 1993). Regional evidence indicates pre-Wisconsinan materials may be preserved at depth in areas of thick drift (Forsyth, 1967). Near-surface bedrock on the Bellefontaine Outlier and along the drainageways of the Scioto and Olentangy Rivers and Big Darby and Little Darby Creeks locally influence present-day topography.

Western Ohio is structurally dominated by the Ohio-Indiana Platform and the broad crests of the Cincinnati, Findlay, and Kankakee Arches. The Ohio-Indiana Platform and the arches separate the Appalachian, Michigan, and Illinois Basins (fig. 2). The western portion of the Bellefontaine quadrangle is structurally dominated by the Cincinnati and Findlay Arches. The broad crests of both features are oriented approximately N 30° E through central Champaign and Logan Counties. The Cincinnati and Findlay Arches gently plunge to the north-northeast.

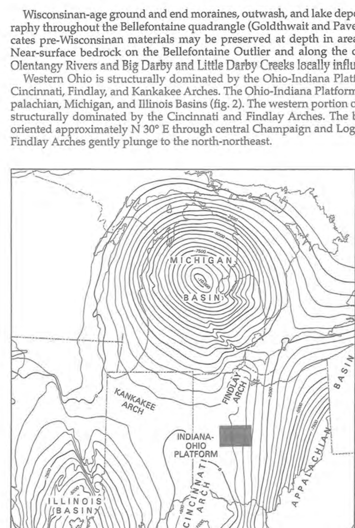

FIGURE 2.—Generalized regional structure-contour map drawn on top of the Trenton Limestone (Middle Ordovician) (modified from Wickstrom, Gray, and Stieglitz 1992). Contour interval is 500 feet. Location of the Bellefontaine 30 x 60 minute quadrangle is indicated.

The western margin of the Appalachian Basin structurally influences rocks in the eastern portion of the quadrangle. Bedrock strikes approximately N 10° to 15° E and gradually increases in dip eastward, from 15 feet per mile in the central portion to 45 feet per mile at the eastern margin of the quadrangle. Bedrock dips as much as 70 feet per mile in northern Delaware and southern Marion Counties; this increased dip may be related to the northwest-trending Marion fault inferred by Wickstrom, Gray, and Stieglitz (1992). Faults shown on the map in central Delaware County are based on a known fault, observed in the Delaware Limestone at Blue Limestone Park (Westgate, 1926), and inferred from oil and gas well data. Numerous exposures of the Delaware Limestone in the vicinity of the city of Delaware commonly exhibit randomly oriented broad flexures with local dips as great as 3°.

BEDROCK GEOLOGY

PREVIOUS WORK

Bedrock-geology maps or summary discussions have been published for Champaign County (Hill, 1878b), Clark County (Norris and others, 1952), Delaware County (Winchell, 1874a; Westgate, 1926), Franklin County (Orton, 1878a; Schmidt and Goldthwait, 1958), Logan County (Hill, 1878a), Madison County (Orton, 1878b; Norris, 1959), Marion County (Winchell, 1873a), and Union County (Winchell, 1874b). The Columbus 15-minute quadrangle and the Bellefontaine Outlier were mapped by Stauffer and others (1911) and Moses (1922), respectively. Development of the Silurian and Devonian lithostratigraphic nomenclature for central-western Ohio is summarized by Larsen (1991). The bedrock geology of the Bellefontaine Outlier is discussed separately in this report.

ORDOVICIAN UNDIFFERENTIATED

Ordovician rocks are not exposed at the land surface in the Bellefontaine quadrangle but are mapped in subcrop beneath the glacial deposits. Lithostratigraphic nomenclature for Upper Ordovician rocks exposed in southwestern Ohio consists of 13 formal and informal formations and five formal members (Schumacher and others, 1991). However, subsurface data were insufficient to divide this sequence in the Bellefontaine quadrangle, and the strata are mapped as an undifferentiated unit.

Rocks of the Ordovician undifferentiated are dominated by calcareous shale and subordinate amounts of fossiliferous limestone, dolomitic shale, and argillaceous dolomite. As much as 320 feet of Ordovician rocks subcrop in the buried valleys associated with the Teays River system in the southwestern portion of the quadrangle.

The contact between the Ordovician undifferentiated and the overlying Silurian sub-Lockport undifferentiated, as observed in core, ranges from a gradational zone 2 to 13 feet thick to a sharp contact. Where the contact is gradational, it was arbitrarily placed in the middle of a zone of greenish- to medium-gray, argillaceous dolomite to dolomitic shale. Where sharp, the contact is placed at the base of a nonargillaceous limestone/dolomite that overlies an argillaceous, fossiliferous dolomite interbedded with shale.

Regionally, the Ordovician-Silurian contact represents a period of nondeposition or erosion in the Cincinnati Arch region. Paleontological investigations west and south of the area of the quadrangle indicate that the uppermost Ordovician and lowermost Silurian rocks are missing in this region (Rexroad, 1967; Gray and Boucot, 1972; Sweet, 1979; Grahn and Bergström, 1985). The major hiatus that is present on the east side of the Cincinnati Arch in Kentucky diminishes northward into Ohio (Rexroad, 1967).

SUB-LOCKPORT UNDIFFERENTIATED

Silurian rocks overlying the Ordovician undifferentiated and underlying the Silurian Lockport Dolomite in the Bellefontaine quadrangle have been designated sub-Lockport undifferentiated as used by Janssens (1977). This interval includes these traditional formations, in ascending order: Brassfield, Cabot Head, Dayton, and Rochester.

The sub-Lockport undifferentiated consists of dolomite and limestone interbedded with shale in the eastern portion of the quadrangle and dolomite and minor limestone and shale in the western portion. The sub-Lockport subcrops beneath glacial drift in buried valleys in the southwestern portion of the quadrangle. The sub-Lockport undifferentiated is as much as 175 feet thick near the eastern boundary of the study area. However, it thins to 60 feet at the western boundary of the study area because of a westward-trending pinchout of the shale-rich intervals.

The contact between the sub-Lockport undifferentiated and the overlying Lockport Dolomite ranges from sharp to gradational. Geophysical logs indicate a sharp break between the shale and argillaceous dolomite of the sub-Lockport undifferentiated and the overlying nonargillaceous Lockport Dolomite. However, in OGS core 3242 (Madison County), shale and thin dolomite beds of the sub-Lockport grade upward into dolomite and thin shale beds typical of the basal Lockport Dolomite. The contact is placed at the base of the lowest dolomite-dominant interval within this 2.7-foot-thick zone of gradation.

LOCKPORT DOLOMITE

Janssens (1977) designated rocks overlying the sub-Lockport undifferentiated as the Lockport Dolomite or Lockport Group in northwestern and north-central Ohio. His designation of "group" rank is based on the presence of a chert-bearing interval identified as Goat Island Dolomite. Where the Goat Island is present the Lockport is subdivided into, in ascending order, the Gasport, Goat Island, and Guelph Dolomites. Where the chert-bearing Goat Island Dolomite is absent, Janssens designates the entire interval as a formation, the Lockport Dolomite. In the Bellefontaine quadrangle, the chert-bearing Goat Island Dolomite cannot be recognized with confidence or is absent, thus the Lockport Dolomite as used by Janssens (1977) is the mapped unit.

The Lockport is not exposed at the surface, but subcrops in buried valleys in the western and south-central portions of the Bellefontaine quadrangle. The Lockport ranges from 63 to 113 feet in thickness across the Bellefontaine quadrangle. Core and geophysical logs show the unit generally thickens to the north without consistency. Lockport rocks more than 100 feet thick have been attributed to local reef development within the unit (Norris, 1975). The contact with the overlying rocks of the Salina Group is sharp or placed midway in a 3-foot-thick zone of gradation. Paleontological evidence (Kleffner, 1992) indicates the contact between the Lockport and overlying units ranges from a major unconformity to a conformable facies relationship in western Ohio.

SALINA GROUP

Rocks of the Salina Group overlie the Lockport Dolomite and are divided, in ascending order, into the Greenfield Dolomite, Tymochtee Dolomite, and Salina undifferentiated (Janssens, 1977). In the southwestern portion of the map area, a line indicates the approximate western limit of mappable Greenfield and Tymochtee Dolomites and the Salina undifferentiated strata. South and west of this line, rock within this interval is mapped as the Salina Group. The Salina Group is characterized by finely crystalline, laminated, argillaceous gray to brown dolomite. The Salina Group subcrops in the uplands between buried valleys in the western portion of the Bellefontaine quadrangle. The upper portion of the unit is lost to erosion, but approximately 200 feet of the Salina Group is estimated to be present.

Greenfield Dolomite

Orton (1871) described the Greenfield Dolomite from exposures near the town of Greenfield in Highland County, Ohio. The Greenfield is a finely crystalline, laminated dolomite. The Greenfield does not crop out in the Bellefontaine quadrangle, but subcrops in buried valleys in the western and south-central portions of the area. The unit averages 45 feet in thickness and thickens slightly to the south and west.

The contact with the overlying Tymochtee Dolomite, as observed in core, is sharp to locally gradational. Where sharp, the contact is placed at the top of a laminated dolomite that is overlain by an argillaceous dolomite or, locally, a dolomitic shale of the Tymochtee Dolomite. Where gradational, the upper contact is placed midway in a 6-foot-thick zone of gradation between typical Greenfield and typical Tymochtee strata. Because the Greenfield Dolomite is commonly friable and porous near its upper and lower contacts, caliper logs of drill holes show zones of washout at these intervals.

Tymochtee Dolomite

Winchell (1873b) described and named the Tymochtee Dolomite from exposures in Wyandot County, Ohio. The Tymochtee Dolomite as defined by Janssens (1977) is used in all but the southwestern portion of the Bellefontaine quadrangle. In that area neither the Greenfield nor the Tymochtee Dolomite is recognizable and the equivalent interval is included in the Salina Group.

The Tymochtee is a finely crystalline, argillaceous dolomite containing thin beds and laminae of dolomitic shale. A shale-rich zone, ranging from 3 to 9 feet in thickness and located approximately 35 feet below the upper contact, was a key marker bed used for regional correlation in the eastern half of the quadrangle. The Tymochtee Dolomite is exposed in a quarry in the northwestern portion of the Bellefontaine quadrangle and subcrops in buried valleys in the western two-thirds of the quadrangle. The unit is generally 100 feet thick and thickens slightly to the north and west. However, in the eastern quarter of the map area the unit thickens to the south.

The contact of the Tymochtee with the overlying Salina undifferentiated is commonly gradational, but can be sharp. The contact is placed at the base of the lowest laminated dolomite of the Salina undifferentiated that overlies an argillaceous dolomite typical of the Tymochtee.

Salina undifferentiated

Janssens (1977) used the term Salina undifferentiated for rocks overlying the Tymochtee Dolomite in northwestern Ohio, and that use is followed in the Bellefontaine quadrangle. Thin beds of evaporites are present in the central-eastern portion of the quadrangle but are too poorly developed to apply Landes' (1945) letter designations for the Salina Group.

The Salina undifferentiated is a microcrystalline to finely crystalline, laminated dolomite. Internally, the unit has a large degree of lateral lithologic variation. In the western portion of the quadrangle, an interval of argillaceous dolomite and thin beds of dolomitic shale ranging from 25 to 70 feet thick is present approximately 70 to 135 feet below the top of the Salina undifferentiated. This shale-dominant unit is distinct in cores and on geophysical logs and represents a recognizable lithologic interval which appears to be equivalent to the C unit of Janssens (1977).

Salina undifferentiated strata are exposed sporadically along drainageways where glacial drift is thin, particularly along the tributaries west of the Scioto River in Delaware and Franklin Counties. The Salina is also exposed in numerous active and abandoned quarries. Extensive areas of subcrop exist beneath the glacial drift in the central and western portions of the Bellefontaine quadrangle. In Delaware and Franklin Counties, the Salina undifferentiated thickens east-southeastward from 235 to 335 feet. In the area of the Bellefontaine Outlier in central Logan and northern Champaign Counties, the Salina undifferentiated is 130 to 137 feet thick. This regional westward decrease in thickness of the Salina undifferentiated between the Delaware-Franklin County area and the Logan-Champaign County area is the result of a regional unconformity and erosional truncation of progressively older Salina rocks westward across the study area prior to deposition of Devonian-age carbonates (Janssens, 1977).

The contact with the overlying Devonian-age carbonates is sharp and generally is placed at the top of a laminated, microcrystalline dolomite that underlies a thin layer of dolomite-pebble conglomerate containing quartz sand (Summerson, 1959). Where the conglomerate layer is absent, the contact is placed at the change from the laminated, microcrystalline dolomite of the Salina undifferentiated to sandy, medium-crystalline to coarsely crystalline, brownish-gray carbonate or a thin grayish-black shale of the overlying Devonian-age strata.

COLUMBUS LIMESTONE

The Columbus Limestone (Newberry, 1873) overlies the Salina undifferentiated. The type area for the Columbus Limestone is in central Ohio. The unit consists of two distinct rock types. The basal Bellepoint Member is a slightly argillaceous dolomite. The overlying Delhi Member is typically a very fossiliferous limestone and contains greater than 80 percent calcium carbonate. Chert nodules are locally abundant in both members but are more common in the Delhi Member. Quartz sand may be present in the basal 5 feet of the Bellepoint Member.

The Columbus Limestone crops out or subcrops beneath glacial drift in a north-south-trending belt 3 to 14 miles wide in Franklin, Delaware, Union, and Madison Counties. Surface exposures are present along the Scioto River in Franklin and Delaware Counties as well as along Big Darby and Little Darby Creeks in Madison and Franklin Counties. The Columbus ranges in thickness from 80 to 105 feet in the Bellefontaine quadrangle; the unit thins northward from Franklin County to Delaware County.

The contact between the Columbus Limestone and the overlying Delaware Limestone is gradational to sharp and may represent a break in deposition (Sparling, 1983). In Franklin County, the top part of the Columbus is commonly characterized by a 0.7-foot-thick zone containing phosphatic fish remains. This phosphatic zone thins northward into Delaware County or may be absent (Westgate, 1926; Westgate and Fischer, 1933). Where the phosphatic zone is absent, the contact is placed arbitrarily within a zone of gradation between nonargillaceous, massive bedded, light-gray Columbus Limestone and argillaceous, thin bedded, medium- to dark-gray Delaware Limestone. Past investigations of the Columbus Limestone of central Ohio include Stauffer (1909, 1957), Stauffer and others (1911), Westgate (1926), Wells (1947), Stewart (1955), Summerson and others (1957), Summerson and Swann (1970), and Chapel (1975).

DELAWARE LIMESTONE

The Delaware Limestone (Winchell, 1874a) overlies the Columbus Limestone and is restricted to the eastern portion of the Bellefontaine quadrangle. The type section of the Delaware Limestone is in Blue Limestone Park, an abandoned quarry in the city of Delaware.

The Delaware Limestone contains thin shale beds, chert, and zones of abundant whole and fragmental fossils, in particular tentaculitoids. Shale content increases southward from Delaware County to Franklin County, especially in the basal 5 feet of the unit. Thin layers containing phosphatic fish material are locally present. The Delaware is exposed in a north-south-trending belt 1 to 6 miles wide in the valleys of the Scioto and Olentangy Rivers and their tributaries. The Delaware is generally 35 feet thick in the quadrangle and thins from north to south.

The contact of the Delaware with the overlying Olentangy Shale is sharp and placed at the abrupt change from limestone to shale. Locally, the top of the Delaware is cherty, pyritic, phosphatic, and contains vertical borings of biogenic origin. Past investigations of the Delaware Limestone of central Ohio include Stauffer (1909), Stauffer and others (1911), Westgate (1926), Westgate and Fischer (1933), Wells (1947), Stewart (1955), Chapel (1975), and Sparling (1983).

OLENTANGY SHALE

The Olentangy Shale (Winchell, 1874a) was described and named for exposures on the east bank of the Olentangy River southeast of the city of Delaware. Tillman (1970) presented paleontological and lithological evidence that the Olentangy Shale consists of two distinct units, a lower shale of Middle Devonian age and an upper shale of Late Devonian age. The lower unit of the Olentangy Shale thins southward and is not present in southern Delaware County.

The Olentangy is a sparsely fossiliferous, greenish-gray to medium-gray shale containing limestone nodules and laminae in the lower unit and thin beds of carbonaceous shale in the upper unit. In the Bellefontaine quadrangle, the Olentangy Shale is typically 30 feet thick but thickens to 55 feet near the eastern edge of the study area. The Olentangy Shale is exposed along the Olentangy River and its tributaries in central Delaware and northwestern Franklin Counties. Regionally, the Olentangy crops out or subcrops beneath glacial drift in a north-south-trending belt 1 to 5 miles wide in the extreme eastern portion of the Bellefontaine quadrangle.

The contact of the Olentangy Shale with the overlying Ohio Shale is sharp. It is placed at the top of the highest soft, greenish-gray shale that underlies a hard, carbonaceous, brownish-black shale of the Ohio Shale. Thin brownish-black shale beds in the upper portion of the Olentangy, similar to the Ohio Shale, make the contact appear intertonguing and may be the result of continuous deposition. However, Tillman (1970) suggested a possible depositional hiatus in central Ohio at the Ohio-Olentangy contact. Other investigations of the Olentangy Shale of central Ohio include Stauffer and others (1911), Stauffer (1916, 1938), Grabau (1917), Westgate (1926), Baker (1942), Stewart and Hendrix (1945), Hoover (1960), and Schwietering (1979).

OHIO SHALE

The Ohio Shale (Andrews, 1871) overlies the Olentangy Shale in the eastern part of the Bellefontaine quadrangle and is the youngest bedrock unit in the area. The Ohio Shale is predominantly black, petroliferous, carbonaceous, and includes some gray shale and thin beds of siltstone and limestone. Carbonate concretions as much as 6 feet in diameter are characteristic of the basal 50 feet of the formation.

The Ohio Shale is divided into three members, in ascending order: the Huron Member (Newberry, 1870), the Chagrin Member (Prosser, 1903; modified by Pepper and others, 1954), and the Cleveland Member (Newberry, 1870). The Huron Member is a well-indurated, carbonaceous, brownish-black shale and contains the fossil pelagic alga *Foerstia (Protosalvinia)*, which is an important basinwide marker (Schopf and Schwietering, 1970). Conversely, the Chagrin Member contains abundant beds of silty, greenish-gray shale along with the carbonaceous, brownish-black shale beds. Only the Huron Member and the lower portion of the Chagrin Member are present in the Bellefontaine quadrangle but are not mapped separately; the upper part of the Chagrin Member and the Cleveland Member have been removed by erosion. The Huron is generally 100 feet thick and the Chagrin is as much as 220 feet thick.

The Ohio Shale crops out in a north-south-trending belt 1 to 5 miles wide at the eastern edge of the Bellefontaine quadrangle. It is exposed in numerous stream cuts along the Olentangy River and its tributaries and in road cuts along Interstate Route 270 west of the intersection of U.S. Route 23 in Worthington. Discussions of the Ohio Shale in central Ohio include Stauffer and others (1911), Westgate (1926), Lamborn and others (1938), Schmidt and Goldthwait (1958), Hoover (1960), Gray and others (1982), and de Witt and others (1993).

BELLEFONTAINE OUTLIER

The Bellefontaine Outlier is an oval-shaped area of elevated topography in central Logan and north-central Champaign Counties. The area rises approximately 500 feet above the general elevation of the surrounding region to 1,549 feet above sea level at Campbell Hill, the highest point in Ohio. Bedrock units mapped on the outlier are the Silurian-age Salina undifferentiated, the Devonian-age Columbus-Lucas undifferentiated, and the Devonian-age Ohio Shale. The Olentangy Shale and the Delaware Limestone are absent on the Bellefontaine Outlier. Approximately 25 miles separate Devonian-age rocks on the outlier from similar-age strata which crop out in the Olentangy and Scioto River valleys to the east. Relatively few investigations have been conducted exclusively on the bedrock geology of the Bellefontaine Outlier. Deposits of glacial drift limit bedrock exposures, making study of the bedrock difficult. Past investigations concerning the bedrock geology of the outlier have been conducted by Hill (1878a, 1878b), Stauffer (1909), Moses (1922), Jackson (1952), Summerson and others (1957), Summerson and Swann (1970), and Chapel (1975). Hansen (1991) and Wickstrom, Drahovzal, and Towey (1992) summarized possible structural origins for the outlier.

SALINA UNDIFFERENTIATED

The Salina undifferentiated in the outlier region is a microcrystalline, laminated dolomite ranging from 130 to 137 feet in thickness. The discussion of the Salina in the previous section on the Salina undifferentiated applies to the outlier as well. The upper contact of the Salina undifferentiated is not exposed in the Bellefontaine Outlier area. On the basis of descriptive logs of continuous core from the Bellefontaine area, the contact is placed at the top of microcrystalline dolomite that underlies a finely crystalline dolomite commonly containing quartz sand or rounded to angular dolomite clasts at the base.

COLUMBUS-LUCAS UNDIFFERENTIATED

The term Columbus-Lucas undifferentiated is used herein to describe dolomite to sandy dolomite that overlies the Salina undifferentiated and underlies the Ohio Shale on the Bellefontaine Outlier. The Lucas Dolomite (Lane and others, 1909), which crops out northwest of the Bellefontaine quadrangle along the southeastern margin of the Michigan Basin, was identified on the outlier by Moses (1922). His identification of the unit relied more on the presence of key fossils than lithologic characteristics. The Columbus Limestone was first described on the outlier by Stauffer (1909). Moses (1922) separated the Columbus into three divisions on the basis of fossils and lithology. These three divisions were time-transgressive units that migrated to the northwest and successively overlapped the Lucas Dolomite. Using lithologic criteria alone, we could not reliably differentiate the Lucas Dolomite from the Columbus Limestone on the outlier. Therefore, the Lucas Dolomite and the Columbus Limestone are mapped as one unit.

The Columbus-Lucas undifferentiated consists of microcrystalline to medium-crystalline dolomite and scattered chert nodules and local petroliferous zones. The lower one-third of the unit contains silt and rounded quartz sand as disseminated grains or concentrated in discontinuous lenses. In the upper two-thirds of the unit several phosphatic-rich zones contain abundant fossil fish teeth and plates. Numerous solution features, such as sinkholes and caves, are present in this unit throughout the outlier. Sandstone, dolomite containing quartz sand, or dolomite conglomerate typically marks the base of the Columbus-Lucas undifferentiated. OGS core 3065, on the west side of the outlier, contains a 0.20-foot-thick interval of fine-grained, moderately sorted, well-rounded quartz sandstone and pebble- to cobble-size dolomite clasts immediately above the contact. In contrast, OGS core 3327, on the east side of the outlier, contains a 0.06-foot-thick zone of pebble-size, subangular clasts of light-gray dolomite in a matrix of dark-gray dolomitic shale. Sand was not observed immediately above the contact in this core.

The Columbus-Lucas undifferentiated is sporadically exposed in short sections throughout the outlier. However, a number of these exposures, particularly in small abandoned quarries, are now covered by vegetation, reclaimed, or inaccessible. Continuous core and outcrop information indicate the unit ranges from approximately 85 to 100 feet in thickness, thinning to the northwest.

The contact of the Columbus-Lucas undifferentiated with the overlying Ohio Shale is sharp and disconformable. This contact is commonly marked by a 0.05- to 0.3-foot-thick bed of pyritic dolomite or medium- to coarse-grained, argillaceous sandstone commonly containing chert and phosphatic material. Chapel (1975) described pyritized quartz-sandstone lenses just below the Ohio Shale which filled scours and bioturbations on the upper surface of the underlying Columbus-Lucas undifferentiated.

Paleontological and lithofacies investigations indicate partial time equivalence of the type Columbus Limestone of central Ohio with the Lucas Dolomite of northwestern Ohio (Fagerstrom, 1971; Chapel, 1975; Sparling, 1983). The sandy to laminated dolomite, identified as Lucas by Stauffer (1909) and Moses (1922), may be a tongue or facies of the Lucas Dolomite exposed in northern Ohio, but correlation is uncertain. Local topography and structure of the region during deposition may have controlled these facies (Chapel, 1975). The petrologic similarities of the Devonian carbonates on the outlier to those in central Ohio suggest that they are more closely related to Appalachian Basin deposition than to Michigan Basin deposition (Chapel, 1975). The reconnaissance nature of this report precludes a thorough investigation of the Middle Devonian carbonates of the outlier and their correlation.

OHIO SHALE

The Ohio Shale on the outlier is black, carbonaceous, pyritic, and contains laminae and thin beds of silty, dark-greenish-gray shale and finely crystalline to medium-crystalline limestone. Carbonate concretions are present in the lower 50 feet of the unit. The Ohio Shale is commonly exposed in streams eroding the steep, bedrock-controlled terrain surrounding the Mad River and its tributaries in the vicinity of Zanesfield. The thickest section of Ohio Shale on the outlier is located 0.5 mile southeast of New Jerusalem in Jefferson Township, Logan County. There, approximately 200 feet of the Ohio Shale is projected to be present beneath approximately 70 feet of glacial drift. Only the Huron Member of the Ohio Shale has been identified on the outlier (de Witt and others, 1993). The upper part of the Ohio Shale has been removed by erosion.

ORIGIN OF THE OUTLIER

Sharp (1932) suggested that the Bellefontaine Outlier may have resulted from the well-lithified carboniferous portions of the Ohio Shale preserving the outlier's relatively moderate relief compared to the surrounding region. Smith (1935) suggested the outlier may have been the result of a favorable location with respect to preglacial erosion. Alternatively, Hansen (1991) proposed that the Logan-Champaign County area was downdropped by post-Devonian-age reactivation of deep-seated basement faults. Basement faults have been interpreted from a COCORP (Consortium for Continental Reflection Profiling) seismic profile located at the north edge of the outlier (Wickstrom, Drahovzal, and Towey, 1992). Some of these faults are mapped in rocks of Ordovician age by Wickstrom, Gray, and Stieglitz (1992) and in crystalline basement rocks by Drahovzal and others (1992). Basement-controlled downdropped blocks in the outlier region may have protected Devonian and younger sediments from erosion, although near-surface faulting or other geologic structures in this region are not evident.

Buried valleys west and northwest of the outlier have a preferred orientation to the north-northwest/south-southeast and northeast-southwest. Joints and/or faults in near-surface bedrock may have controlled the orientation of these valleys because of preferential erosion along pre-existing zones of weakness. Furthermore, coincidence of buried-valley trends with inferred fault traces suggests that valley locations were ultimately controlled by basement structure (Wickstrom, Gray, and Stieglitz, 1992).

ECONOMIC GEOLOGY

Bedrock-related economic resources extracted in the Bellefontaine quadrangle include dolomite, limestone, shale, oil, natural gas, and ground water (Weisgarber, 1994; DeBrosse and Vohwinkel, 1974). In 1993, 11 active quarries mined limestone and dolomite of Silurian and Devonian age. Five of these quarries extract stone from the Delaware and/or Columbus Limestone adjacent to the Scioto River between Radnor, Delaware County, and Upper Arlington, Franklin County. This stone is used for portland cement, road metal, dimension stone, and agricultural lime. The Delhi Member of the Columbus Limestone typically contains 80 to 90 percent calcium carbonate (Stout, 1941) and is well suited for all types of building and construction aggregate, including high-quality portland cement concrete. The Columbus-Lucas undifferentiated was formerly mined by small operations in the Bellefontaine Outlier region. Currently, one commercial operation mines stone from this unit for use as road metal.

A small abandoned underground shale mine is located in the city of Delaware, 1,500 feet southeast of the intersection of U.S. Route 36 and the Olentangy River. The upper portion of the Olentangy Shale was mined at this location and used in the manufacture of tile and brick until 1922 (Westgate, 1926).

Small commercial quantities of oil and gas have been produced from several fields in the Bellefontaine quadrangle. Oil has been produced from the Cambrian-age "Copper Ridge" dolomite in the Delaware field, located north-northeast of Delaware, at a depth of about 2,600 feet. The North Greenfield field has produced oil from the Ordovician-age Trenton Limestone and gas from the "Utica" shale (DeBrosse and Vohwinkel, 1974). Gas has been produced from five additional fields in the quadrangle. The Northwest Radnor field (DeBrosse and Vohwinkel, 1974), located north-northwest of Radnor, Delaware County, is reported to produce from the Silurian-age "Clinton" sandstone, which is included in the sub-Lockport undifferentiated of this report, at a depth of 510 feet and in a separate well from the Tymochtee Dolomite at a depth of 460 feet. An unnamed gas field northwest of Rushsylvania, Logan County, produced gas from the Trenton Limestone, but is now abandoned. The Bloom Center, Huntsville, and Indian Lake South fields in northwestern Logan County have produced gas from the Ordovician-age Trenton Limestone at an average depth of about 1,400 feet.

Oil and gas production may locally be related to small structural features such as faults. Faults associated with the Delaware field, as well as the fault shown on the map southwest of Delaware, are interpreted primarily from drill-hole data. The Northwest Radnor field occurs on a small anticlinal feature (see structure contours on the map). This feature lies along the projected strike of one of the suggested northwest-trending faults north of Delaware and may reflect an extension of this structure. Both features may be part of a large regional northwest trend of deep en echelon faults which have local control on economic oil and gas accumulations (Wickstrom, 1990). This trend extends from the Harlem field in southeastern Delaware County to Findlay in Hancock County. Other small hydrocarbon-producing fields in the Bellefontaine quadrangle, in particular those in the outlier region, may reflect the presence of presently unknown deep structural features, including reactivated basement faults.

Silurian and Devonian limestone and dolomite are the primary bedrock aquifers in the region. Potential yields can be in excess of 1,000 gallons per minute in wells less than 300 feet deep (Schmidt, 1979). Wells less than 125 feet deep typically yield water supplies of 10 to 15 gallons per minute (Schmidt, 1983). A zone of highly permeable bedrock capable of producing in excess of 1,000 gallons per minute in Madison and Union Counties, termed the "Newburg" zone by Norris (1959) and Schmidt (1978), roughly corresponds to the upper surface of the Lockport Dolomite. The Ohio and Olentangy Shales are considered to be nonwater-bearing formations, although yields less than 3 gallons per minute have been reported in wells developed along joints or on the weathered upper surface of these shale formations (Schmidt and Goldthwait, 1958). Thick deposits of gravel and sand associated with buried valleys and present-day drainage can yield as much as 1,000 gallons per minute (Schmidt, 1985). The water-bearing units in the area are summarized by Schmidt (1985) for Champaign County, Schmidt (1982) for Clark County, Schmidt (1979) for Delaware County, Schmidt and Goldthwait (1958) for Franklin County, Schmidt (1983) for Logan County, Norris (1959) and Hallfrisch (1990) for Madison County, Crowell (1979) for Marion County, and Schmidt (1978) for Union County. Hallfrisch (1987) discusses the ground-water pollution potential for Madison County.

ENVIRONMENTAL GEOLOGY

The Bellefontaine quadrangle lies within an area of low seismic risk and has experienced few seismic events (Hansen, 1975; Stover and Coffman, 1993). Small tremors were felt in the cities of Urbana in 1875 and in Bellefontaine in 1929 and 1930 (Pawlowicz, 1975). A tremor, which registered IV to V on the Modified Mercalli intensity scale, was recorded in July 1986 in the western portion of the study area (Hansen, 1987). West of the study area is the Western Ohio Seismic Zone (also called the Anna Seismogenic Zone), which falls within an area of moderate seismic risk (Hansen, 1994).

Solution enlargement of joints is common in the Devonian carbonates. Numerous caves and sinkholes are present along the Scioto River valley in western Delaware and Franklin Counties where the Columbus and Delaware Limestones are exposed or lie close to the surface (Stauffer and others, 1911; Westgate, 1926). Karst features also are present in portions of the Bellefontaine Outlier where the Columbus-Lucas undifferentiated is exposed or lies near the surface (unpublished manuscript, compiled by Warren Luther, on file at the Division of Natural Areas and Preserves). Commercial caverns developed in Devonian-age carbonates in the Bellefontaine quadrangle include Olentangy Indian Caverns in Liberty Township, Delaware County; Ohio Caverns in Salem Township, Champaign County; and Zane's Cavern in Jefferson Township, Logan County.

Radon, a naturally occurring radiogenic gas, results from the natural radioactive decay of uranium and radium. Once inhaled, the breakdown of radon gas causes cell damage which is linked to lung cancer. Variability in local geology as well as home construction and ventilation methods make it extremely difficult to predict areas of potentially high radon concentrations in enclosed areas (Harrell, McKenna, and Kumar, 1993).

The Ohio Shale contains higher than average amounts of uranium and is considered a main source of radon gas (Hansen, 1986, 1993; Harrell, McKenna, and Kumar, 1993). The Ohio Shale is present in the eastern portion of the Bellefontaine quadrangle and in central Logan and northern Champaign Counties. Another major source of radon is recrystallized limestone and dolomite, including the weathering residue called terra rossa, present throughout much of the study area. Uranium-bearing particles of Ohio Shale and Silurian and Devonian carbonates were eroded by glaciers and incorporated in the clayey glacial drift that mantles a majority of the quadrangle. The geology of the Wisconsinan glacial deposits largely controls the distribution of radon in the Bellefontaine quadrangle (Harrell, McKenna, and Kumar, 1993). Glacial and alluvial deposits of sand and gravel may be weak radon sources but can, because of great permeability, serve to elevate indoor radon levels by acting as efficient conduits for the relatively small amounts of gas generated (Harrell, McKenna, and Kumar, 1993).

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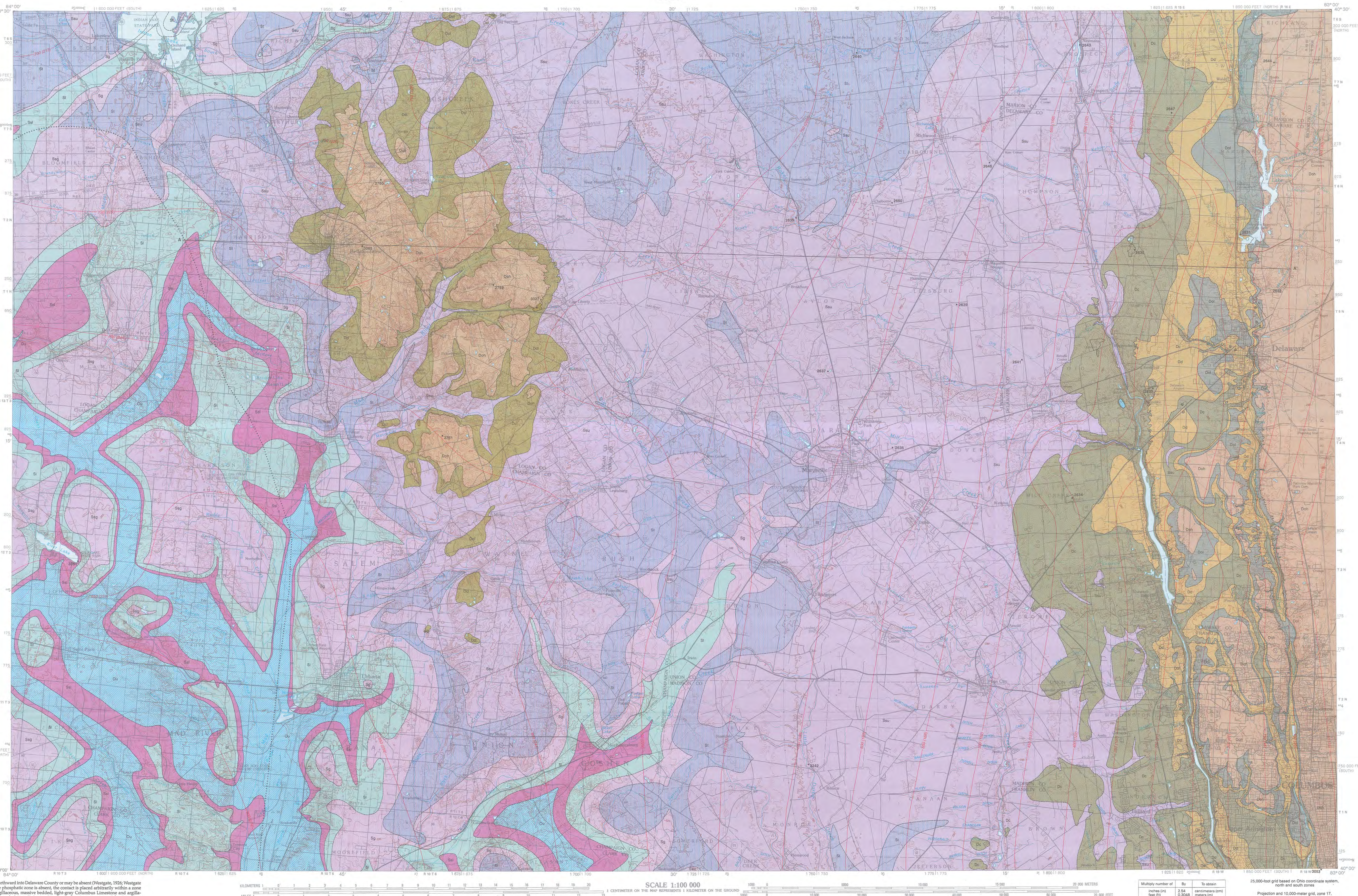


SCALE 1:100 000
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
MILES 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13

FEET 1000 0 5000 10 000 15 000 20 000 30 000 40 000 50 000 60 000 70 000
METERS 1000 0 5000 10 000 15 000 20 000

Base compiled by U.S. Geological Survey from 1:24,000-scale topographic maps dated 1960-1982; planimetry revised from air photos taken in 1989; map edited 1992

TOPOGRAPHIC CONTOUR INTERVAL 5 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

ELEVATIONS SHOWN TO THE NEAREST METER
THIS BASE MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS

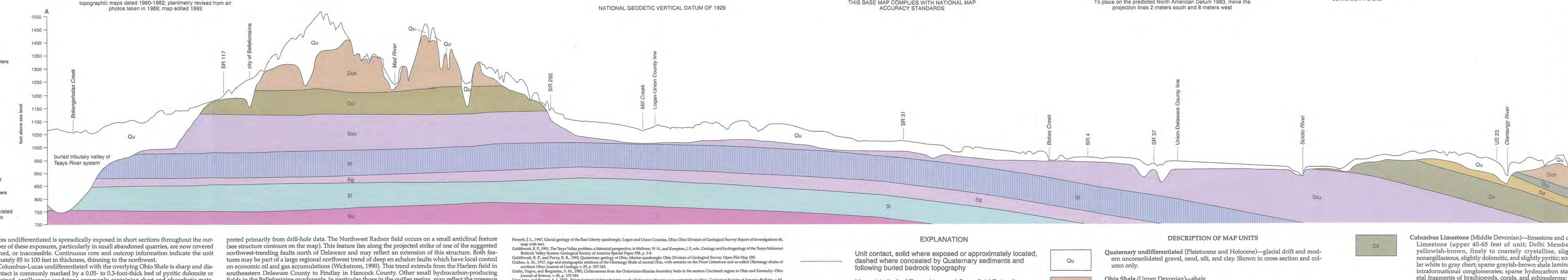
1927 North American Datum
To place on the predicted North American Datum 1983, move the projection lines 2 meters south and 8 meters west

Multiply number of	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

CONVERSION FACTORS

25,000-foot grid based on Ohio coordinate system, north and south zones

Projection and 10,000-meter grid, zone 17, Universal Transverse Mercator



EXPLANATION

Unit contact, solid where exposed or approximately located, dashed where concealed by Quaternary sediments and following buried bedrock topography

Mappable limit of Tymochtee and Greenfield Dolomites

100 (30) — Structure contour, drawn on top of sub-Lockport undifferentiated. Contour interval 50 feet; metric equivalents in parentheses

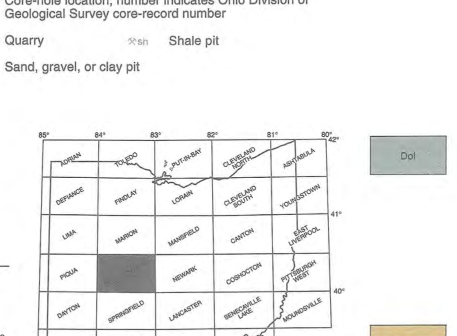
U / D — Fault, dashed where approximately located. U = upthrown side, D = downthrown side

2630 • Core-hole location, number indicates Ohio Division of Geological Survey core-record number

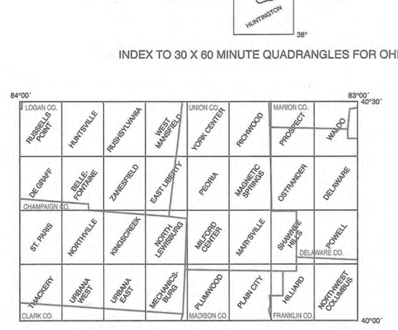
Quarry — Shale pit

Sand, gravel, or clay pit

UTM grid convergence (GN) and 1992 magnetic declination (MN) at center of map
Diagram is approximate



INDEX TO 30 X 60 MINUTE QUADRANGLES FOR OHIO



INDEX TO 7.5-MINUTE TOPOGRAPHIC QUADRANGLES IN THE BELLEFONTAINE 30 X 60 MINUTE QUADRANGLE

Cartographic drafting by Michael R. Lester, Robert L. Stewart

DESCRIPTION OF MAP UNITS

Qu — **Quaternary undifferentiated** (Pleistocene and Holocene)—glacial drift and modern unconsolidated gravel, sand, silt, and clay. Shown in cross section and column only.

Doh — **Ohio Shale** (Upper Devonian)—shale.
Shale, brownish-black, dusky-yellowish-brown, carbonaceous, petroliferous, silty, slightly micaceous, well-indurated; laminae, nodules, and thin beds of pyrite; sparsely fossiliferous, including some plant fragments, fish bones, pelecypods, and gastropods; slickensides; well-developed joints; fissile parted; thin discontinuous beds of finely crystalline to medium-crystalline, argillaceous, medium-gray to brownish-black limestone or dolomite having locally well-developed cone-in-cone structures. The Chagrin Member contains more thin beds of silty, pyritic, faintly laminated to mottled, soft, calcareous, light-greenish-gray to dark-greenish-gray shale and siltstone than the underlying Huron Member. Basal 50 feet of the Huron Member contains concretions of finely crystalline, argillaceous, silty, pyritic, brownish-black to medium-gray limestone and dolomite that are as much as 6 feet in diameter. Basal portion of the Huron Member contains the fossil pelagic alga *Foerstia (Protosalvinia)*, an important regional biostratigraphic marker. The Huron Member ranges from 90 to 105 feet in thickness. The Chagrin Member is as much as 220 feet thick in the eastern portion of the quadrangle. In the Bellefontaine Outlier region, only the Huron Member is present and is estimated to be 200 feet thick. Upper portion of unit not preserved in the Bellefontaine quadrangle.

Dol — **Olentangy Shale** (Middle and Upper Devonian)—shale.
Shale, greenish-gray, medium-dark-gray, pyritic, soft, sparsely fossiliferous (primarily brachiopods, pelecypods, and gastropods); calcareous in part; thinly laminated, fissile to flaggy parted, minor bioturbations and slickensides; nodules and laminae of micritic, pyritic, olive-gray limestone locally present in the lower one-third of the unit; thin beds of well-indurated, carbonaceous, brownish-gray shale present in upper two-thirds or throughout unit. Locally present in lower third of unit is 0.08-foot-thick bed of soft, greenish-gray to light-gray shale containing abundant unsorted, rounded fish-bone fragments and teeth and fragmental conodonts (Tillman, 1970). Unit ranges from 22 to 55 feet in thickness, is typically 30 feet thick, and is thickest along the eastern edge of the quadrangle. Upper contact is sharp and placed at top of the highest soft, greenish-gray shale that underlies the carbonaceous, brownish-black shale of the overlying Ohio Shale; contact may exhibit pyrite-filled burrows and phosphatic fragments.

Dd — **Delaware Limestone** (Middle Devonian)—limestone.
Limestone, medium-gray, pale-yellowish-brown, finely crystalline; sparse intervals microcrystalline and medium crystalline; locally argillaceous in basal 5 feet; shale streaks; white, gray, or black chert locally present; locally pyritic; rounded to angular intraformational conglomerates; petroliferous odor common on fresh surface; zones of rounded, pebble-size fragmental and whole brachiopods, pelecypods, trilobites, and tentaculitoids; local thin beds containing phosphatic fish bones, teeth, and plates; thin to massive bedding; some wavy bedding; laminated or mottled in part; sparse stylolites; zones of vuggy and intercrystalline porosity. Unit thins southward from 45 feet in Delaware County to 23 feet in the southeast portion of the quadrangle and averages about 35 feet in thickness. Shale content increases, particularly at the base, from north to south. Upper contact is sharp and placed at top of the highest crystalline, medium-gray limestone that underlies medium-gray shale of the Olentangy Shale. A thin bioturbated zone of pyritic, phosphatic, cherty limestone may be present at the upper surface of the Delaware and represents a disconformity.

Dcl — **Columbus-Lucas undifferentiated** (Middle Devonian)—dolomite (Bellefontaine Outlier region only).
Dolomite, brownish-gray, dark-yellowish-brown, light-gray, microcrystalline to medium-crystalline, slightly to moderately argillaceous; chert nodules and thin beds; rounded, well-sorted quartz sand and silt in thin lenses or disseminated grains particularly in the lower 30 feet of the unit; pyritic; petroliferous in part; fossiliferous (brachiopods, corals, pelecypods, and gastropods); massive bedded; mottled, brecciated, or laminated in part; stylolitic in part; moderate to abundant intercrystalline to moldic porosity, well developed in the sandy portion of the unit. Base of unit contains a thin bed (observed in core to be 0.20 foot thick) of fine-grained, moderately sorted, well-rounded quartz sand containing rounded, pebble- to cobble-size clasts of microcrystalline dolomite. Several phosphatic zones containing abundant fragments of fossil fish teeth and plates are present, particularly at the top of the unit. Unit ranges from 85 to 100 feet in thickness. Upper contact is sharp, undulatory, and placed at upper surface of the crystalline dolomite that underlies the carbonaceous, black Ohio Shale. A 0.05- to 0.3-foot-thick bed of pyritic dolomite or medium- to coarse-grained sandstone containing chert and phosphatic material may be present at the top of the unit.

Dc — **Columbus Limestone** (Middle Devonian)—limestone and dolomite.
Limestone (upper 40-65 feet of unit; Delhi Member), light-gray, pale-yellowish-brown, finely to coarsely crystalline, slightly argillaceous to nonargillaceous, slightly dolomitic, and slightly pyritic; zones of abundant nodular white to gray chert; sparse grayish-brown shale laminae; rounded limestone intraformational conglomerates; sparse hydrocarbon staining; abundant skeletal fragments of brachiopods, corals, and echinoderms; massive bedded with intervals of irregular to nodular bedding; stylolites; mottled in part; ripple marks; intercrystalline to vuggy porosity; 80 to 92 percent calcium carbonate. Dolomite (lower 35-40 feet of unit; Bellepoint Member), dark-yellowish-brown, pale- to grayish-brown, finely crystalline; calcareous in part; slightly argillaceous; shale laminae; white to gray chert nodules; sparse hydrocarbon staining; poorly preserved fossil molds; massive bedded; burrowed in part; stylolites; intercrystalline and moldic porosity. Lowermost 5 feet of unit commonly contain medium- to fine-grained, well-rounded to subangular quartz sand and a basal tan to gray dolomite-pebble conglomerate containing chert. The Columbus Limestone thins to the north from 105 feet in Franklin County to 80 feet in Delaware County. Upper contact is gradational to sharp and commonly is marked by a 0.7-foot-thick bed of light-brown shale or cherty, argillaceous limestone containing abundant phosphatic fish plates or teeth. This phosphatic zone thins northward into Delaware County. Where gradational, contact is placed arbitrarily within a zone of transition between the nonargillaceous, crystalline, massive bedded, light-gray limestone and the argillaceous, thin bedded, medium- to dark-gray limestone containing shale laminae of the overlying Delaware Limestone.

Ssg — **Salina Group** (Upper Silurian)—dolomite (only in western portion of quadrangle where Greenfield and Tymochtee Dolomites and the Salina undifferentiated are not separated).
Dolomite, yellowish-brown, medium- to light-gray, finely crystalline to microcrystalline, argillaceous to nonargillaceous, laminated to massive-bedded; thin zones of intraformational conglomerate; zones of intercrystalline, vuggy, or fracture porosity. Only the lowermost approximately 200 feet of the unit are present. Upper portion not preserved where mapped in the Bellefontaine quadrangle.

Ssu — **Salina undifferentiated** (Upper Silurian)—dolomite.
Dolomite, yellowish-gray, pale-yellowish-brown, microcrystalline to finely crystalline, slightly to moderately argillaceous, slightly cherty and pyritic; thin beds to laminae of dolomitic to calcareous, fossil-fragmental, brittle to soft, dark-gray shale; rare hydrocarbon staining; sparse thin beds of limestone; thin bedded to massive; abundant faint to distinct laminations; mottled; stromatolites; birdseye structures; desiccation cracks; slickensides; dolomite intraclasts; minor contorted bedding; sparse intercrystalline and vuggy porosity and zones of well-developed fracture porosity. Thin zones of light-olive-gray to translucent gypsum/anhydrite present in the extreme eastern portion of the study area. Argillaceous dolomite containing thin beds of dark-greenish-gray dolomitic shale and ranging from 25 to 70 feet in thickness is present 70 to 135 feet below the upper contact. This zone is distinct in cores and geophysical logs and probably correlates to the C unit of Janssens (1977). The Salina thickens eastward from 235 to 335 feet in the eastern portion of the quadrangle. The unit ranges from 130 to 137 feet in thickness in the vicinity of the Bellefontaine Outlier. Upper contact is sharp and undulatory and marks a regional unconformity. Contact is placed at top of the highest laminated, microcrystalline, yellowish-gray dolomite that underlies (1) a dolomite-pebble conglomerate bed with abundant sand; (2) a sandy, medium-crystalline to coarsely crystalline, brownish-gray dolomite; or (3) a thin, brittle, grayish-black shale.

St — **Tymochtee Dolomite** (Upper Silurian)—dolomite.
Dolomite, light- to medium-dark-gray, yellowish-brown, finely to very finely crystalline, argillaceous; sparse disseminated pyrite; abundant to moderately abundant thin beds and laminae of dolomitic, clayey, dark-gray shale; uniform texture; hydrocarbon stained in part; sparse thin layers of coarse-grained skeletal material; massive to thin planar bedding; faintly laminated; thin zones of intraformational conglomerate; sparse stylolites; poor intercrystalline porosity and zones of vugs lined with dolomite and evaporite crystals. Locally, a 3- to 9-foot-thick interval of dolomite and abundant dark-gray shale beds as much as 0.6 foot thick is present approximately 35 feet below the top of the unit. This interval is distinct in core and on gamma ray logs and is a useful marker for correlation in the eastern part of the quadrangle. In central Delaware County, dolomite and interlaminated granular to fibrous gypsum/anhydrite is present in the lower 30 feet of the unit. Locally, a soft, dolomitic shale as much as 2.5 feet thick is present at the base of the unit. Core and geophysical data indicate the unit ranges from 83 to 115 feet in thickness but is typically 100 feet thick. The unit thickens slightly to the north and west; in the eastern portion of the quadrangle the unit thickens to the south. Upper contact with the Salina undifferentiated is generally gradational but locally can be sharp. It is placed midway in the zone of gradation or at the abrupt change between the massive, uniform, argillaceous, light-gray dolomite containing shale laminae and the overlying laminated, yellowish-brown to yellowish-gray dolomite of the Salina undifferentiated.

Sg — **Greenfield Dolomite** (Upper Silurian)—dolomite.
Dolomite, light-olive-gray, light- to medium-dark-gray, pale-yellowish-brown; finely crystalline, intervals medium-crystalline or microcrystalline; sucrosic in part; sparse disseminated pyrite; intraformational conglomerate; hard to friable; thin to massive bedded; sparsely stylolitic; slightly argillaceous; shale laminae containing slickensides in part; moldic to intercrystalline porosity containing euhedral calcite or hydrocarbon filling; poorly preserved fossils, primarily corals. Near upper and lower contacts, unit is commonly porous, friable, and contains abundant solution-enlarged fractures and local thin beds of dolomite. Unit ranges from 23 to 62 feet in thickness and averages approximately 45 feet. Upper contact is sharp, but may be locally gradational. Where sharp, contact is placed at the top of a porous, laminated, yellowish-gray dolomite that underlies the argillaceous, light- to dark-olive-gray dolomite containing shale laminae or soft, dolomitic, dark-gray shale characteristic of the overlying Tymochtee Dolomite. Where gradational, contact is arbitrarily placed midway in a 6- foot-thick zone of transition between porous, laminated, medium-gray dolomite that grades upward into light-gray shaly dolomite or dark-gray dolomitic shale.

Sl — **Lockport Dolomite** (Lower Silurian)—dolomite and sparse shale and chert.
Dolomite, light-gray to light-bluish-gray, coarsely to finely crystalline, slightly argillaceous to nonargillaceous; sparsely disseminated pyrite; poorly preserved corals, brachiopods, and echinoderms; massive to thick bedded; uniform; stylolites; abundant to moderate amounts of well-developed moldic and intercrystalline porosity. Sparse zones of laminated, argillaceous, dark-gray dolomite; sparse light- to medium-gray shale laminae; chert nodules locally in lower and upper quarter of unit; locally brecciated near upper contact. Unit ranges from 63 to 113 feet in thickness. Local reef development causes thickening and well-developed massive bedding. Upper contact is commonly sharp, but may be gradational. Where sharp, contact may be stylolitic or undulatory and is placed at the top of highest massive-bedded dolomite that underlies lowest laminated, finely crystalline dolomite of the overlying Greenfield Dolomite or Salina Group. Where gradational, contact is placed midway in a 3-foot-thick zone where the massive-bedded, crystalline Lockport Dolomite grades upward into the laminated dolomite of the overlying Greenfield Dolomite.

Ssl — **sub-Lockport undifferentiated** (Lower Silurian)—dolomite, limestone, and shale.
Dolomite, light-olive-gray, yellowish-gray, microcrystalline to coarsely crystalline, moderately argillaceous to nonargillaceous, locally glauconitic and pyritic; sparse laminae and thin beds of olive-gray shale; thin to thick bedded; irregular to nodular bedding; mottled in part; sparsely fossiliferous; stylolites; intercrystalline to moldic porosity. Limestone, light-gray, greenish-gray, to grayish-red, coarsely to finely crystalline; nonargillaceous at base, becoming argillaceous upward; pyritic, hematitic, to phosphatic in part; thin to medium, planar to wavy bedding; echinoderm, brachiopod, bryozoan fragments; thin beds and laminae of glauconitic shale in lower 3 feet of unit. Limestone and dolomite present in eastern portion of quadrangle. Shale, olive-gray to dark-greenish-gray, dolomitic, pyritic, glauconitic, moderately indurated, sparsely fossiliferous; thin to medium bedded; bioturbated in part. Lower 30-70 feet of unit is moderately argillaceous to nonargillaceous dolomite and/or limestone. East of central Union and Madison Counties a 10- to 30-foot-thick shale-dominant interval is present within this carbonate interval. The upper 12-85 feet of unit is interbedded, medium- to thin-bedded, dolomitic to calcareous shale and argillaceous dolomite. The unit thins from 175 to 60 feet from east to west across the quadrangle. Upper contact appears to be sharp on geophysical logs, but was observed in a core to be gradational within a zone as thick as 2.7 feet. Upper contact is placed at top of a shale-rich interval that underlies the dolomite-dominant interval.

Ou — **Ordovician undifferentiated** (Upper Ordovician)—interbedded shale, limestone, and dolomite.
Shale, greenish-gray, olive-gray, calcareous to dolomitic, locally silty and pyritic; sparsely to abundantly fossiliferous, including brachiopods, bryozoans, echinoderms, and trilobites; locally bioturbated; thin to thick bedded; planar to irregular bedding. East of western Logan and Champaign Counties a dominantly grayish-red dolomitic shale ranging from 17 to 60 feet in thickness is present 30-50 feet below the Silurian-Ordovician contact. Limestone, medium-gray to light-olive-gray, coarsely to finely crystalline, argillaceous; sparse pyrite; locally abundant coarse to fine skeletal fragments of brachiopods, bryozoans, trilobites, and echinoderms; thin, wavy to nodular bedding and thin to medium planar bedding; commonly bioturbated; sparse graded beds; poorly developed stylolites; sparse vuggy porosity. Dolomite, olive-gray, yellowish-gray, finely to coarsely crystalline, argillaceous; shale clasts; skeletal fragments of bryozoans, brachiopods, and gastropods; thin to medium irregular bedding; intercrystalline to vuggy porosity, some vugs filled with euhedral calcite. Limestone increases in abundance from southwestern to northwestern portion of quadrangle. Interval of wavy, irregular to nodular limestone to dolomitic limestone is present 80 to 120 feet below the Ordovician-Silurian contact in the western half of the quadrangle. This carbonate-dominant unit is 91 feet thick in the southwestern portion of the quadrangle and thins eastward, becoming unrecognizable in central Madison and Union Counties. Lower contact not mapped in the quadrangle. Approximately 320 feet of Ordovician undifferentiated subcrops in the buried valleys of the quadrangle. Upper contact sharp to gradational, not exposed in map area, observed in core only. Where sharp, contact is placed at top of an argillaceous, fossiliferous, greenish-gray dolomite and interbedded shale that underlies a nonargillaceous limestone or dolomite. Where gradational, contact lies in the middle of a zone 2-13 feet thick ranging from dolomitic shale to moderately argillaceous dolomite.

SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	LITHOLOGY	THICKNESS IN FEET	
QUATERNARY	Pleistocene / Holocene		Quaternary undifferentiated (Qu)		0-700+	
DEVONIAN	Upper		Ohio Shale Doh (Chagrin Member; Huron Member)		200+	
DEVONIAN	Middle		Olentangy Shale Dol		22-45	
DEVONIAN	Middle		Delaware Limestone Dd		23-45	
DEVONIAN	Middle		Columbus Limestone Dc (Delhi Member; Bellepoint Member)		80-105	
SILURIAN	Upper	Salina Ssg	Salina undifferentiated Ssu		130-335	200+
SILURIAN	Upper	Salina Ssg	Tymochtee Dolomite St		80-115	
SILURIAN	Upper	Salina Ssg	Greenfield Dolomite Sg		23-62	
SILURIAN	? Lower		Lockport Dolomite Sl		63-113	
SILURIAN	Lower		Sub-Lockport undifferentiated Ssl		60-175	
ORDOVICIAN	Upper		Ordovician undifferentiated Ou		320+	

BELLEFONTAINE OUTLIER

SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNIT	LITHOLOGY	THICKNESS IN FEET
QUATERNARY	Pleistocene / Holocene		Quaternary undifferentiated (Qu)		0-250+
DEVONIAN	Upper		Ohio Shale Doh		200+
DEVONIAN	Middle		Columbus-Lucas undifferentiated Dcl		85-100
SILURIAN	Upper	Salina	Salina undifferentiated Ssu		130-137
SILURIAN	Upper	Salina	Tymochtee Dolomite St		100

KEY TO LITHOLOGIC PATTERNS

Glacial drift and alluvium
Limestone
Argillaceous or shaly limestone
Dolomitic limestone or limy dolomite
Dolomite
Sandy dolomite
Argillaceous or shaly dolomite
Interbedded limestone and shale
Dolomitic shale
Shale
Carbonaceous shale
Gypsum/anhydrite
Chert
Carbonate concretions

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