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COMPLETE 1:100,000-SCALE COVERAGE OF THE SURFICIAL GEOLOGY OF OHIO'S LAKE ERIE COAST

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The Ohio Department of Natural Resources, Division of Geological Survey has completed the five 1:100,000-scale surficial geology maps covering Lake Erie's coastline. The maps, from west to east, are the Toledo, Lorain/Put-in-Bay, Cleveland South, Cleveland North, and Ashtabula 30 x 60 minute quadrangles. Surficial geology maps characterize the distribution and thickness of Ohio's surficial deposits from the surface down to the uppermost bedrock unit. Data from county soil maps, water wells, ODOT and EPA geotechnical borings, bedrock geology and topography maps, and field observations were collected, and recorded on 1:24,000-scale topographic quadrangles. The map interpretations were originally drawn on Mylar overlays that were scanned and digitally compiled at the 1:100,000-scale. The vertical sequence of lithologic materials from the surface to bedrock is depicted within a polygon of probability by a descriptive stack. The resulting maps show the lateral and vertical variations of unconsolidated material and the underlying bedrock lithology for a polygon and between adjacent polygons. By using these five surficial geology maps, in combination with Ohio's new 1:500,000-scale bedrock geology map, it is possible to determine the composition of the unconsolidated material and the bedrock at any location along Ohio's Lake Erie coast. These maps will enhance the understanding of the geologic framework for use in land-use planning and coastal-erosion management both along Lake Erie's coastline and within Ohio's northern tier of counties.

Shrake, D.L., Swinford, E.M., Schumacher, G.A., Larsen, G.E., Venteris, E.R., and Pavey, R.R., 2007, Complete 1:100,000-scale coverage of the surficial geology of Ohio's Lake Erie coast [Abs]: The Ohio Journal of Science, vol. 107, n. 1, p. A-14.

Acknowledgments

Base map derived from Ohio Department of Transportation data sets. Projection of data is Ohio coordinate system, south zone, North American datum, 1983

Surficial Geology compiled at 100,000 by Richard R. Pavey, E. Mac Swinford, C. Scott Brockman, and Douglas L. Shrake.

Data acquisition and map digitization assistance provided by Mary E. Cannon, Christopher F. Cassle, Jeffery L. Fox, Marshall H. Goodman, Christopher P. Gordon, Timothy L. Hawthorne, Korrie Justice, Stephanie Konfal, James F. Lain, Scott Leopold, Rick Link, Jay Lisk, Noelle Logan, David C. Loveday, and Richard J. Wynkoop.

Cartography by Kelli L. Vogt.

OHIO DIVISION OF GEOLOGICAL SURVEY

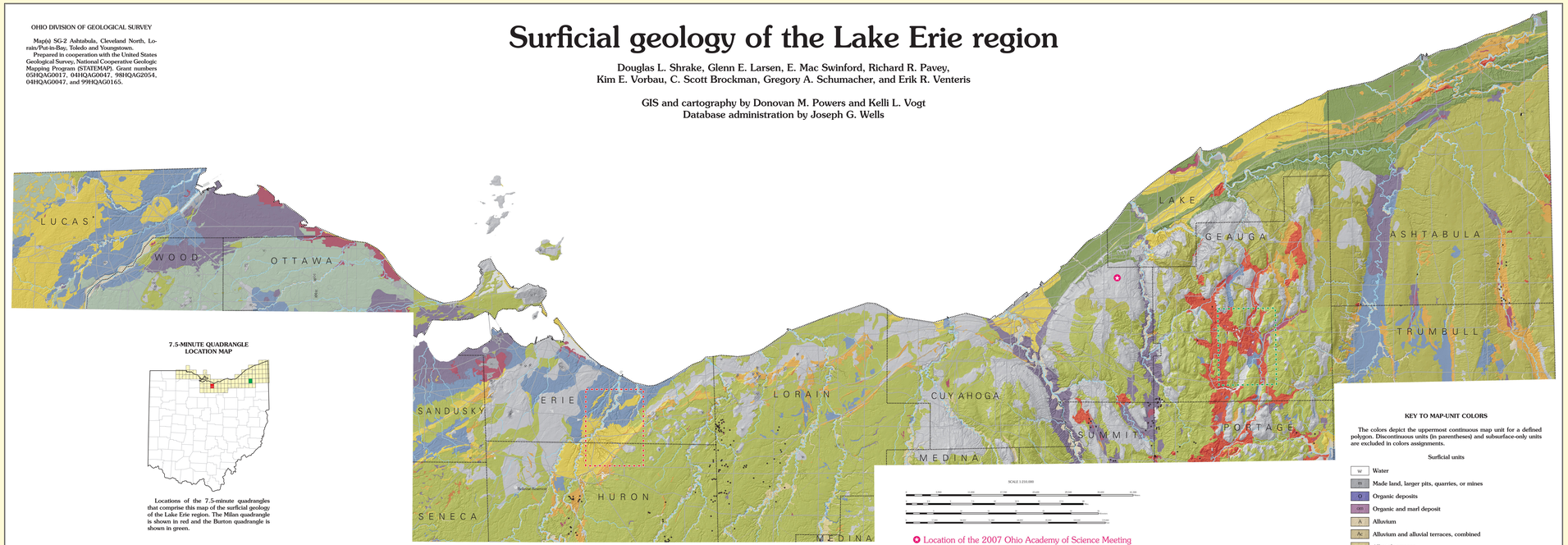
Map(s) SG-2 Ashtabula, Cleveland North, Lorain/Put-in-Bay, Toledo and Youngstown.

Prepared in cooperation with the United States Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP). Grant numbers 05HQAG0017, 04HQAG0047, 98HQAG2054, 04HQAG0047, and 99HQAG0165.

Surficial geology of the Lake Erie region

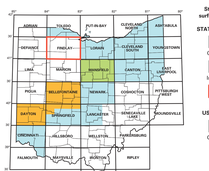
Douglas L. Shrake, Glenn E. Larsen, E. Mac Swinford, Richard R. Pavey, Kim E. Vorbau, C. Scott Brockman, Gregory A. Schumacher, and Erik R. Venteris

GIS and cartography by Donovan M. Powers and Kelli L. Vogt
Database administration by Joseph G. Wells



7.5-MINUTE QUADRANGLE LOCATION MAP

Locations of the 7.5-minute quadrangles that comprise this map of the surficial geology of the Lake Erie region. The Milan quadrangle is shown in red and the Burton quadrangle is shown in green.



Status of 3-D surficial mapping.

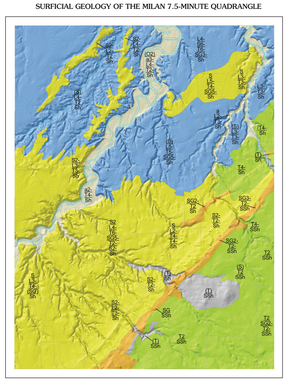
STATEMAP funded

- Completed
- In progress

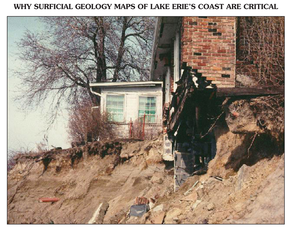
USEPA funded

- Proposed
- Completed

SURFICIAL GEOLOGY OF THE MILAN 7.5-MINUTE QUADRANGLE



WHY SURFICIAL GEOLOGY MAPS OF LAKE ERIE'S COAST ARE CRITICAL



Damage caused by an eroding bluff in Lake County (1986)

- Economic losses exceed tens of millions of dollars per year.
- Nearly 2,500 structures are within 50 feet of destruction.
- 95% of Ohio's Lake Erie shore is eroding.
- Erosion rates have been as high as 110 feet in one year.
- Protection structures often increase erosion rates.
- Manmade shoreline structures trap sand supply, causing 43% of the shore to lack a beach.
- Effective erosion-control efforts require quantification of the geologic processes that cause erosion.

OHIO LAKE ERIE EROSION STATISTICS

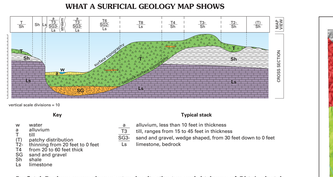
Recession data	Long-term: 1877-1973		Short-terms: 1973-1990	
County	Long-term distance (ft)	Long-term rate (ft/yr)	Short-term distance (ft)	Short-term rate (ft/yr)
Ashtabula	82	0.9	28	1.6
Lake	160	1.7	32	1.9
Cuyahoga	60	0.6	8	0.4
Lorain	80	0.8	12	0.7
Erie (lake)	103	1.6	42	2.5
Erie (bay)	241	2.8	32	1.9
Ottawa (lake)	208	2.0	27	1.6
Ottawa (bay)	61	2.0	21	1.2
Lucas	520	5.4	46	2.7

The state geological surveys of Illinois, Indiana, Michigan, Ohio and the U.S. Geological Survey (USGS) agreed in 1997 to form the Central Great Lakes Geologic Mapping Coalition [CGLGMC]. The mission of the Coalition is to produce detailed, three-dimensional geologic maps, support information, and related digital databases, needed to facilitate informed decisions regarding:

- Quality, quantity, distribution, and accessibility of surface and ground water
- Environmental management and mitigation of land and water contamination
- Acceleration of the permitting processes of regulatory agencies
- Industrial, commercial, residential, and infrastructure siting and construction
- Agricultural land loss, erosion, sedimentation, and agrichemical use
- Coastal erosion, landslides, radon, floods, and earthquakes
- Habitat alteration and biodiversity
- Aggregate sources for construction

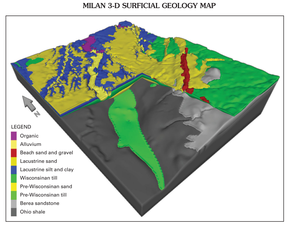
Ohio's CGLGMC pilot project is to produce a 3-D map of the Milan 7.5-minute quadrangle. The goal of this project is to acquire the technology and knowledge to develop efficient methodologies for production of three-dimensional geologic frameworks. For this work, various tools within ArcGIS are being used to construct the bounding surfaces of each geologic unit and to produce grids that allowed depiction of the three-dimensional framework of surficial and bedrock geologic units. Data sources used for this effort included archival field sections and other legacy data, NRCS soils maps, new seismic-refraction surveys, and boring logs from ODOT, OEPA, BUSTR, Division of Water, and engineering firms. The three-dimensional model (see 3-D View) can be manipulated to produce a range of derivative products to address the wide variety of water-management, land-use, environmental, and resource issues that are crucial to local, state, and federal agencies, private industry, and the public.

WHAT A SURFICIAL GEOLOGY MAP SHOWS



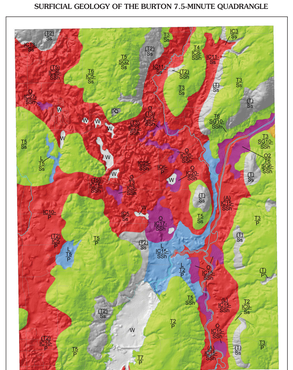
Surficial Geology maps characterize the distribution and thickness of Ohio's glacial, post-glacial, and related deposits from the surface down through the uppermost buried bedrock unit. The surface to bedrock sequence depicted via a lithologic material stack enclosed within a polygon of probability. These maps provide information on lateral material changes on the surface and the lateral and vertical material variations between adjacent polygons in the subsurface.

MILAN 3-D SURFICIAL GEOLOGY MAP



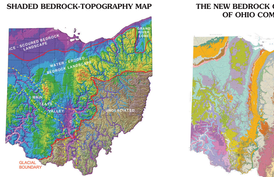
An example of a subsurface model generated from the data set for the Milan 3-D surficial geology map. The perspective is rotatable and alterable to permit an interactive study of the subsurface structure.

SURFICIAL GEOLOGY OF THE BURTON 7.5-MINUTE QUADRANGLE



The surficial geology map of the Burton 7.5-minute quadrangle contains the northern end of interlobate deposits [red areas; IC = ice contact] formed between the Killbuck and Grand River Lobes. The ice sheet's southward movement impeded by the Chardon bedrock highland bifurcated into the aforementioned lobes. This is similar to bifurcation of the ice sheet into the Miami and Scioto Lobes by the Bellefontaine bedrock highland in west central Ohio. This series of interlobate or ice contact deposits extends to the glacial margin near Massillon, Ohio.

SHADED BEDROCK-TOPOGRAPHY MAP



The Ohio shaded bedrock-topography map depicts the configuration and elevation of the bedrock surface. Spectral hues depict elevation intervals of the buried-bedrock surface and the topography of the bedrock surface if the overlying glacial sediment was removed.

Prior to and during glaciations, the north-flowing Teays River system dominated surface-water drainage patterns in western and southern Ohio. Water flowed north in the main Teays valley from Wheelersburg (W; Scioto County) to Circleville (C; Pickaway County where it turns and flowed northwest to Mercer County where it exits the state.

In northwestern Ohio, the generally smooth buried-bedrock surface is the result of repeated scouring by glacial ice advancing westward out of the Lake Erie Basin. Another distinctly scoured bedrock surface is in the Grand River Lobe in northeastern Ohio where smooth north-south trending valleys mirror ice-flow direction. South of the ice scour-dominated surface of northern Ohio, the water sculpted bedrock drainage pattern beneath the glacial drift is evident. The map also shows drainage patterns in the unglaciated portion of the state.

THE NEW BEDROCK GEOLOGIC MAP OF OHIO COMPLETED

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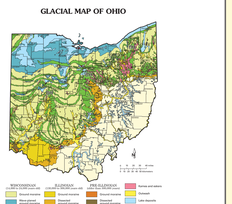
The newly completed revision of the Bedrock Geologic Map of Ohio is the result of twenty-three years of cooperative bedrock-geology mapping initiated between the Ohio Division of Geological Survey and the U.S. Geological Survey STATEMAP component of the National Cooperative Geologic Mapping Program (formerly COGEOMAP), the U.S. Environmental Protection Agency's nonpoint-source pollution program, Ohio Department of Transportation's initiatives, and revenue from mineral industry severance tax. This map is the first detailed geologic map for Ohio since 1920, and the first to illustrate and delineate the characteristics of individual map units, their regional correlation within Ohio, and the economic commodities and geologic hazards of specific stratigraphic intervals depicted on the map. About 50 bedrock units, versus 14 on the 1920 map, are delineated on the 2006 map. Moreover, the 2006 map depicts the spatial distribution pattern of bedrock units in glaciated regions of the state by mapping on the bedrock-topography surface that lies buried beneath Pleistocene-age glacial materials. Furthermore, the clarity, distribution, and configuration of regional and local structural elements within Ohio are shown. Newly created products used to complete this map—788 bedrock-geology and bedrock-topography maps as well as over 1,951 structure-contour horizons compiled on 7.5-minute quadrangle base maps—were converted to GIS. The published bedrock Geology Map of Ohio is available in paper form and a digital version is being compiled.

Swinford, E.M., Slucher, E.R., Shrake, D.L., Schumacher, G.A., Larsen, G.E., Powers, D.M., and McDonald, J., 2007, The new bedrock geologic map of Ohio completed: The Ohio Journal of Science, vol. 107, no. 1, p. A-31

GLACIAL MAP OF OHIO



Glacial map of Ohio showing the distribution of glacial sediments and their relative ages. Note glaciated northern and western Ohio, unglaciated southeastern Ohio, and the position of ridge moraines and the lake deposits and wave-planed ground moraine of the Lake Erie Basin. Bedrock highlands (BH) impeded the southward advance of glacial ice causing the moraines to form a lobate configuration (modified from Pavey and others, 1999).

LITHOLOGIC UNIT DESCRIPTIONS

Unit descriptions represent an amalgamation of those for the Toledo, Lorain/Put-in-Bay, Cleveland South, Cleveland North, Ashtabula, and Youngstown 100,000-scale surficial geology maps. Map-specific units noted in the individual descriptions.

SURFICIAL UNITS

w Water; large lakes and reservoirs only. Circular feature in northwest Huron County is the Bellevue, Ohio upland reservoir.

m Made land. Large areas of cut and fill such as dams, landfills, and urban areas; may include reclaimed strip mine areas. Underlain by bedrock or other lithologic units.

o Organic deposits, Holocene age. Muck and peat, may contain clay at depth. Generally less than 20 feet thick. Formed in poorly drained depressions. Organic deposits too small to map at 1:100K-scale indicated by an asterisk [*] and underlain by material shown in surrounding map-unit area. Occurs on the landward margin of the Lake Erie coast and associated estuaries. Present also on outwash trains, ice-contact areas, and bunnocky moraines.

om Organic and marl deposits, Holocene age. Found only in the area north and west of Castalia, where groundwater rich in calcium carbonate discharges from springs at the base of the Columbus Limestone escarpment. Precipitation of carbonate [marl] around plants on poorly drained Lake Plain sediments has constructed these "upland bogs".

a Alluvium, Holocene age. Includes a wide variety of textures from silt and clay to boulders; commonly includes organic material; generally not compact; rarely greater than 20 feet thick. Found in floodplains of modern streams throughout entire map area. Mapped only where areal extent and thickness are significant.

Ac / Af Alluvium and alluvial terraces, combined. Shown in areas where insufficient space is available to delineate separate units.

Al Alluvial terraces, Wisconsinan age. Old floodplain remnants along streams that flowed into high, proglacial lake predecessors of Lake Erie. Highly variable textures; commonly found tens of feet above modern floodplains.

C Clay, Wisconsinan age. Massive to laminated; may contain interbedded silt, and fine sand; clay content can exceed 80%. Laminated clay commonly contains thin silt or sand partings. Carbonate-cemented concretions occur in some areas. Commonly contains fractures 6 to 12 inches apart. Distributed throughout the Toledo and Lorain/Put-in-Bay map area as leveled surface deposits, terraces, and as deep-water deposits of high, proglacial predecessors of Lake Erie. Distributed in southern portion of Cleveland South and Cleveland North map areas as leveled surface deposits. Present as surface and subsurface proglacial-lake deposits in Ashtabula and Youngstown map areas.

LC Silt and clay, Wisconsinan age. Laminated to interbedded; may contain thin fine sand or gravel layers. Occurs as thick lacustrine valley fill deposits of high, proglacial predecessors of Lake Erie in the Cleveland South and Cleveland North map areas. Found as leveled surface deposits, terraces, and thick, deltaic deposits of proglacial predecessors of Lake Erie and as thick, deltaic deposits in Ashtabula and Youngstown map areas. Present as thick, deltaic deposits of proglacial predecessors of Lake Erie and as thick, deltaic deposits, outwash deposits in upland depressions and proglacial lake deposits in the Ashtabula, and Youngstown map areas. Can be up to 340 feet thick in the Cleveland South and Cleveland North map areas southeast of the Burke Lakefront Airport.

L Silt, Wisconsinan age. Massive or laminated; commonly contains thin sand partings. Carbonate-cemented concretions occur in some areas. May contain localized clay, sand, or gravel layers. Clay content commonly increases with depth. Found throughout the map area as leveled surface deposits, terraces, and thick, deltaic deposits of proglacial predecessors of Lake Erie. It is also present as thick proglacial lake deposits in the Ashtabula and Youngstown map areas.

S Sand, Wisconsinan age. Contains minor amounts of disseminated gravel or thin lenses of silt or gravel; grains well to moderately sorted, moderately to well rounded; finely stratified to massive, may be cross bedded; locally may contain organics. In deep buried valleys, may be older than Wisconsinan age. Found in terraces and buried valleys throughout the map area, as nearshore dune and beach ridge deposits of proglacial predecessors of Lake Erie, and in association with deltaic deposits or outwash throughout map area.

SG Sand and gravel, generally Wisconsinan age. Intermixed and interbedded sand and gravel commonly containing thin, discontinuous layers of silt and clay; grains well to moderately sorted, moderately to well rounded; finely stratified to massive, may be cross bedded; locally may contain organics. In deep buried valleys, may be older than Wisconsinan age. Found as valley wall terraces and in buried valleys throughout the map area, and as beach ridge deposits of proglacial predecessors of Lake Erie. Present in the Ashtabula and Youngstown map areas as widespread fluvial deposits.

G Gravel, Wisconsinan age. Contains intergranular sand, some sand and silt beds or lenses; unit well to moderately sorted, subangular to well rounded; may be massive, cross-bedded, or horizontally bedded. Larger clasts and majority of gravel of variable lithology but are commonly derived from bedrock within the immediate area. In deep buried valleys, may be older than Wisconsinan age. Mapped only in the Lorain/Put-in-Bay map area.

GA Basal gravel. Highly variable, poorly sorted gravel and sand, with significant amounts silt and clay. Found in the southwest part of the Lorain/Put-in-Bay map area; deposited at or near the front of the ice sheet directly on bedrock. Presumably of Wisconsinan age, but may be older.

IC Ice-contact deposits, Wisconsinan age. Highly variable deposits of poorly sorted gravel and sand; silt, clay, and till lenses common; may be partially covered or surrounded by till. Deposited directly from stagnant ice as kame or esker bedforms. Commonly associated with thick deltaic deposits in southwestern Cleveland South and throughout Cleveland North, Ashtabula and Youngstown map areas; can be up to 250 feet thick.

T Unsorted mix of silt, clay, sand, gravel, and boulders, fractures common, Wisconsinan age. May contain silt, sand, and gravel lenses. Fractures common. At depth includes a patchy basal till as well as unspecified till units of various lithologies. Commonly surface till on lake plain in northern map area; bounded to south by Lake Escarpment Moraine. Mapped only in the Cleveland North and Ashtabula map areas.

CG Complexly interbedded deposits of clay, silt, sand, gravel, and till in deeper parts of buried valleys, unspecified age. Unit identified from well logs; data insufficient for more detailed differentiation or age assignment. Up to 300 feet thick in the Lorain/Put-in-Bay and Ashtabula map areas. Present in deeper buried valleys in southern portion of the Cleveland South and throughout the Youngstown map area.

BEDROCK UNITS

P Vertically and horizontally variable sequences and of sandstone, shale, siltstone, claystone, limestone, and coal bedrock of the Pennsylvanian age Pottsville and Allegheny Groups. Includes associated colluvium. Sandstone nonbedded to massive; may be conglomeratic and contain abundant quartz pebbles and granules; portions weakly to moderately cemented; shale and claystone dominant unit. Mapped as surface unit throughout Ashtabula, Youngstown, and in the southeastern portion of Cleveland North map area. The Pennsylvanian-age Pottsville Group composed of primarily of sandstone and conglomerate, with subordinate amounts of shale, siltstone, clay, and coal is mapped in the southern and eastern third of the Cleveland South map area. The basal Pottsville Group is predominantly very light- to light-gray, medium to coarse grained, nonbedded to massive sandstone with abundant rounded quartz pebbles and quartz pebble conglomerate lenses;lenses designated as Sa, not P5, forming resistant hills and cliffs. Rapid horizontal and vertical stratigraphic changes of shale, siltstone, coal, and clay are common in the upper portion of the Pottsville Group that averages 256 feet in thickness but can locally exceed 300 feet.

Sa The Sharon Sandstone and conglomerate, and associated colluvium, of the Pennsylvania age Pottsville Group mapped as a surface unit in the southern portion of the Cleveland North and the eastern Cleveland South map area. The lithologic unit is a nonbedded to massive, medium to coarse-grained sandstone with abundant rounded quartz pebbles and granules; portions weakly to moderately cemented; shale and claystone dominant unit. Sandstone forms resistant hills and cliffs. Present in the southeastern Portage County and is gray to white, coarse to medium-grained, porous, and friable with weak silica and iron oxide cementation. A conglomeratic facies is generally present at the base of the unit and consists of well-rounded quartz pebbles and granules within a sand matrix. This lenses of fluidic, gray to gray-black clayey shale present locally. The Sharon ranges locally from being absent up to 250 feet in thickness. The unit noted for its high silica content is locally quarried. Its basal contact with the underlying blue-gray shale and siltstone and sandstone of Mississippian age strata is unconformable and can have 200 feet of relief in channel cuts. Sandstone mapped in the northeastern portion of the Cleveland South and the eastern Lorain/Put-in-Bay map area is Development Quarry Member of the Sharon Sandstone. Sandstone is medium to coarse grained, massive, and cross bedded; color is light gray to brown, medium to fine-grained to silty, and thin to massive bedded. Unit is generally 40 to 60 feet thick, but can vary from 0 to 230 feet in thickness because of an erosional surface at the base of the unit. Historic and active quarries located near Amherst and Elyria.

SSb *Variable sequences of sandstone, shale, siltstone, and infrequently limestone. Key stratigraphic units broken out by formations and map area occurrences.*

In the extreme northwestern portion of the Toledo map area Sub comprised of Mississippian age Coldwater Shale and the Mississippian/Devonian age Sunbury and Bedford Shales undivided. The Coldwater Shale (Lower Mississippian) is shades of gray to greenish black; clayey; calcareous, with carbonate nodules at base. Sunbury and Bedford Shales undivided (Upper Devonian to Lower Mississippian age). Sunbury Shale, brownish black to greenish black to olive black; carbonaceous, pyritic. Bedford Shale, shades of gray to olive gray; fossiliferous; shale and siltstone dominant; contains calcareous and dolomitic concretions. Present in southwest corner of map area.

In the Lorain/Put-in-Bay, Cleveland South, and Youngstown map areas SSb comprised of Berea Sandstone and Bedford Shale undivided (Upper Devonian age) and the Cussewago Sandstone. Berea Sandstone, gray to shades of brown; medium grained to silty; Bedford Shale, gray, red, and brown; silty to clayey; locally abundant siltstone and sandstone interbeds. Cussewago Sandstone mapped in Ashtabula and Trumbull Counties is brown; pebbly; massive to crossbedded; quartzose. The uppermost stratigraphic unit in the map area is the Berea Sandstone. Sandstone is light gray to brown, medium to fine-grained to silty; shale and siltstone dominant and rapidly change vertically and horizontally. Sunbury Shale, present in the south central portion of the Lorain/Put-in-Bay map area, is black to brown, fissile parted, silty, carbonaceous shale. Berea Sandstone, a resistant unit that forms hills and cliffs at or near the northern edge of the Lorain/Put-in-Bay map area, is light gray, medium to fine-grained, and thin to massive bedded. Unit is generally 40 to 60 feet thick, but can vary from 0 to 230 feet in thickness because of an erosional surface at the base of the unit. Berea is thicker in central Lorain and western Medina counties. Bedford Shale, exposed in the northern portion of the study area, is predominantly soft, red, clay shale that grades downward into gray shale. Thick siltstone and sandstone beds are common in the upper part of the Bedford Shale.

Logan and Cuyahoga Formations, undivided (Upper and Lower Mississippian age) Shale, siltstone, sandstone, conglomerate, and limestone. Unit consists mainly of the Logan and Cuyahoga Formations, in descending stratigraphic order. Logan Formation, sandstone and siltstone; shades of gray, yellow, and brown. Sandstone, mainly silty to medium grained, locally contains lenses and beds of coarse sand grains to fine-pebble conglomerate; siltstone, clayey to sandy; locally contains shale interbeds and partings; locally fossiliferous; absent east of central Medina County. Cuyahoga Formation mainly shades of gray, olive, brown, and yellow sandstone, siltstone, and shale. Sandstone, silty to conglomeratic, occurs in thin to massive beds. Siltstone and shale occur as thin to thick beds; shale locally fissile parted; locally fossiliferous; siltstone and sandstone dominant unit. Mapped in southern Cleveland North and western Ashtabula and Youngstown map areas is comprised of the sandstone and shale bedrock and associated colluvium of the Mississippian age Logan and Cuyahoga Formations. SSb in the Ashtabula and Youngstown map areas also includes the Shenango sandstone and shale occurs only in eastern Trumbull County, pinches out westward, is shades of brown, yellow, gray, to almost white; medium to coarse-grained sandstone, with clayey shale interbedded with siltstone.

Sh *Variable shale stratigraphic formations across mapped area Primarily reflects areas underlain by black shale. Key stratigraphic units broken out by formations and map area occurrences.*

Antrim Shale mapped in the western portion Toledo map area. Shale, Upper Devonian age, brownish black, dark brown to black, carbonaceous; thinly laminated, hard, fissile; with beds and laminations of greenish gray, soft shale. Unit not exposed, occurs beneath undifferentiated Quaternary and Neogene (?) deposits; data from core holes.

Ohio Shale, including associated colluvium, Devonian age. Black to brown, silty; organic-rich, carbonaceous, fissile parted shale; commonly pyritic; locally fossiliferous. Ohio Shale is the dominant bedrock unit in the Lorain/Put-in-Bay map area and Erie County to eastern Ashtabula County. Shale present along a 12 mile-wide north-south belt in western Huron and central Erie Counties (Lorain/Put-in-Bay) and eastward along and inland from the front central Huron County's Lake Erie shoreline to Ashtabula County and in buried valleys in the Cleveland North, Cleveland South, Ashtabula, and Youngstown map areas.

SL Mapped only in a one to three mile-wide, north-south oriented belt in western Huron County and central Erie County in the Lorain/Put-in-Bay map area. Shale with thin limestone, Devonian age. Units in descending stratigraphic order: Prout Limestone, Middle Devonian, a hard, olive gray to brown, siliceous, fossiliferous; locally dolomitic bed 3 to 10 feet thick, absent in the southern part of the study area. Plum Brook Shale, Middle Devonian, shale and siltstone; brownish gray to greenish gray; soft, fossiliferous, calcareous, clay shale 50 to 80 feet thick. The Prout and Plum Brook grade into the Olentangy Shale in the southern part of the study area. Olentangy Shale is a greenish-gray, calcareous, sparsely fossiliferous, clay shale.

Ls Limestone, Devonian age. Bois Blanc and Columbus Limestones, present in a ten-mile wide belt in eastern Seneca, Sandusky, and Ottawa Counties, western Erie County and on Kelleys Island. Delaware Limestone is medium brown, fine to medium crystalline, fossiliferous, cherty limestone containing shale laminae. Columbus Limestone is light to medium gray to brown, fine to coarse crystalline, fossiliferous, cherty limestone containing shale laminae. Bois Blanc Formation, light gray to brown, fine grained, cherty, massive bedded, sparsely fossiliferous and contains quartz grains in the basal ten feet. The combined Delaware and Columbus is 200 feet thick. This unit is susceptible to dissolutioning and contains significant areas of well-developed karst topography.

D Dolomite bedrock, undifferentiated throughout the Toledo map area except in northwest corner in Devonian and Silurian age. Stratigraphic names in descending order: Devonian age Ten Mile Creek Dolomite, Silica Formation, Dowlee Limestone, Detroit River Group, the Silurian age Sodus Group undifferentiated, and Tyrrelloo. Greenfield, Lockport Dolomites. Ten Mile Creek Dolomite, shades of gray; mostly in thin to medium beds; contains some irregular layers and nodules of chert. Silica Formation, calcareous clayey shale and limestone; bluish gray; very fossiliferous. Dowlee Limestone (Middle Devonian)—limestone, shades of blue, gray, and brown; occurs in thin to medium beds; sparsely fossiliferous. Lower part contains chert nodules. Detroit River Group, dolomite, shades of gray and brown; very fossiliferous; massive bedded. Silurian age Sodus Group undivided. Unit consists of the Bass Islands and Salina Dolomites, in descending order: Lucas and Amherstburg Dolomites and Sylvania Sandstone, where present. Lucas and Amherstburg Dolomites, brown to gray; mostly in medium to thick beds; carbonaceous laminae. Sylvania Sandstone, white; fine grained, quartzose, grains well rounded; locally dolomitic; known mainly in Lucas and northern Wood Counties. Holland Quarry Shale, gray to black; crudely laminated; sparsely fossiliferous; rarely occurs as dolomitic silt upon palmkarder developed on pre-Devonian age strata; known only in central Lucas County. Salina Group undifferentiated (Upper and Lower Silurian) comprised of dolomite, anhydrite, gypsum, salt, and shale; in descending order: Upper Salina Group, Upper Salina Dolomite, Upper Salina Shale, Lower Salina Dolomite, Lower Salina shale, anhydrite, and/or gypsum beds and laminae; salt restricted to subsurface of eastern portion of map area; salt and anhydrite unit brecciated in northern portion of state, locally brecciated elsewhere in state. Tymochtee and Greenfield Dolomites, undivided (Upper and Lower Silurian), and the Tymochtee Dolomite shades of gray and brown; very finely crystalline; occurs in thin to massive beds with carbonaceous shale laminae and beds. Greenfield Dolomite shades of gray and brown; very finely to coarsely crystalline; occurs as massive beds to laminae; argillaceous; locally brecciated in lower portion. Unit intermingles and intergrades with Salina Group in western portion of state; thins southward. Lockport Dolomite (Upper and Lower Silurian), dolomite, shades of gray and brown; very finely to coarsely crystalline; mostly in medium to massive beds; fossiliferous; vuggy; locally cherty in lower portion of unit.

Dolomite bedrock in the Lorain/Put-in-Bay map area is Silurian age and present in a northeast-trending belt in eastern Sandusky County, on Marblehead Peninsula in northeastern Ottawa County, and the Bass Islands in Lake Erie. Dolomites as the Bass Islands Dolomite and Salina Dolomite undifferentiated, the dolomite in the Lorain/Put-in-Bay map area is now considered the Salina Dolomite undifferentiated. See description above for Salina Group undifferentiated.

EXPLANATION

Sand and gravel pit. Pit bottom generally underlain by unconsolidated lithologic units of surrounding polygon(s). May contain reclaimed areas.

Quarry, mine, or strip mine; floored in bedrock; may contain reclaimed areas.

Small area of organic deposits.

Boundary between map-unit areas having different uppermost continuous lithologies; underlying lithologies may or may not differ.

Boundary between map-unit areas having the same uppermost continuous lithology but different thickness or different underlying lithologies.

KEY TO MAP-UNIT COLORS

The colors depict the uppermost continuous map unit for a defined polygon. Discontinuous units (in parentheses) and subsurface-only units are excluded in colors assignments.

Surficial units

- w Water
- m Made land, larger pits, quarries, or mines
- O Organic deposits
- (O) Organic and marl deposit
- A Alluvium
- Ac Alluvium and alluvial terraces, combined
- Al Alluvial terraces
- C Clay, Wisconsinan age
- LC Silt and Clay, Wisconsinan age
- L Silt, Wisconsinan age
- S Sand, Wisconsinan age
- SG Sand and gravel, Wisconsinan age
- G Gravel, Wisconsinan age
- IC Ice contact deposits, Wisconsinan age
- T Till, unsorted mix of silt, clay, sand, gravel and boulders, Wisconsinan age
- TE Clayey to loamy till, low carbonate content, Wisconsinan age
- TF Silty clay till, high carbonate content, Wisconsinan age
- TG Clayey to silty till, low carbonate content, Wisconsinan age

Bedrock units

- P Sandstone, shale, siltstone, claystone, limestone, and coal bedrock, and associated colluvium, Pennsylvanian age
- Sa Sandstone, Pennsylvania and Mississippian age
- SSb Sandstone and shale bedrock, and associated colluvium, Mississippian age
- Sh Shale and associated colluvium, Devonian age
- S-L Shale with minor limestone and associated colluvium, Devonian age
- Ls Limestone and associated colluvium, Devonian age
- D Dolomite or Dolostone and associated colluvium, Devonian and Silurian age

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