STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
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Potential for Mineable Bedrock in the Lima 30 x 60-Minute Quadrangle in Ohio

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INTRODUCTION AND PURPOSE

The Ohio Department of Natural Resources (ODNR), Division of Geological Survey has completed a reconnaissance-level map showing areas of mineable bedrock, including shale, limestone, and dolomite, likely covered by thin surficial materials (glacial drift) in the Lima 30 x 60-minute (scale 1:100,000) quadrangle in Ohio. We sought to create this map from as many existing ODNR Division of Geological Survey maps and GIS datasets as possible. The main purpose of this map is to provide a reconnaissance-level assessment of the potential for mining carbonate and shale bedrock in this quadrangle. The map shows areas of surficial materials in increments of 10 feet (ft) and totaling less than 40 ft overlying Silurian- and Devonian-age dolomite and limestone; it also shows a limited area in the southeastern-most portion of the quadrangle where surficial materials (totaling less than 20 ft) overlie potential Devonian-age shale resources.

The Lima map is a derivative map based directly from the ODNR Division of Geological Survey SG-2 series map, *Surficial Geology of the Lima 30 x 60-Minute Quadrangle in Ohio* (Jones and others, 2011). The SG-2 series features maps based upon polygons that represent a "stack" of mapped unit lithologies and thicknesses. A set of queries is run in ESRI ArcGIS® to illustrate the range of thicknesses of the surficial materials overlying the topmost bedrock units. The primary goal is to target areas where the glacial surficial materials are relatively thin, making quarrying the underlying bedrock economically viable. A secondary goal is to use the SG-2 series of surficial geology "stack maps" as the basis for creating a number of easy-to-construct, reconnaissance-scale derivative maps that allow the user to quickly determine the thickness and nature of the drift and the underlying bedrock for a variety of uses, including the potential for mineable bedrock, sand-and-gravel aggregate resources, and solid-waste disposal sites. The following section below describes surficial mapping units and bedrock units and includes a brief discussion of the potential mineable resources of the bedrock units. A more detailed discussion of the data sources and techniques used for creating the original SG-2 map, *Surficial Geology of the Lima 30 x 60-Minute Quadrangle in Ohio*, can be found in Jones and others (2011).

In addition to the main stack map-based derivative map, this publication includes three useful, smaller-scale inset maps. The first inset map (fig. 1) shows the locations of both bedrock quarries and sand-and-gravel pits located in the Lima 30 x 60-minute quadrangle in Ohio (Wolfe, 2009). The second inset map (fig. 2) shows the bedrock geology of the Lima 30 x 60-minute quadrangle in Ohio derived from the *Bedrock Geologic Map of Ohio* (Slucher and others, 2006). Map-unit symbols used for this inset map appear in bold in the "Bedrock Units" section below. The third inset map (fig. 3) depicts the drift thickness of the Lima 30 x 60-minute quadrangle in Ohio based upon the *Shaded Drift-Thickness Map of Ohio* (Powers and Swinford, 2004).

MAPPING CONVENTIONS

This map provides a three-dimensional framework of the area's surficial geology and depicts four important aspects of surficial geology:

1. Geologic deposits, indicated by **letters** that represent the major lithologies.
2. Thicknesses of the individual deposits, indicated by **numbers** and **modifiers**.
3. Lateral extents of the deposits, indicated by map-unit area boundaries (solid and dashed lines).
4. Vertical sequence of each deposit, shown by the stack of symbols within each map-unit area.

Figure 4 illustrates a hypothetical cross section and mapping conventions. Letters, numbers, and modifiers are arranged in stacks that depict the vertical sequence of lithologic units for a given map-unit area. A single stack of symbols occurs in each map-unit area and applies only to the volume of sediments within that particular map-unit area.

Letters represent geologic deposits (lithologic units) and are described in detail below. Lithologic units may be a single lithology, such as sand (S) or clay (C), or a combination of related lithologies that are found in specific depositional environments, such as sand and gravel (SG) or ice-contact deposits (IC). The bottom symbol in each stack indicates the bedrock lithologies that underlie the surficial deposits. The detailed lithologic unit descriptions below summarize:

1. Geologic characteristics, such as range of textures, bedding, and age.
2. Engineering properties or concerns attributed to the unit.
3. Depositional environment.
4. Geomorphology or geomorphic location.
5. Geographic location within the map area, if pertinent.

Numbers (without modifiers) that follow the lithology designators represent the average thickness of a lithologic unit in tens of feet (for example, *3* represents 30 ft). If no number is present, the average thickness is implied as *1* (10 ft). These unmodified numbers correspond to a thickness range centered on the specified value but may vary up to 50 percent. For example, *T4* indicates an average thickness of till in a map-unit area is 40 ft, but that thickness may vary from 20 to 60 ft.

Modifiers provide additional thickness and distribution information:

1. Parentheses indicate that a unit has a patchy or discontinuous distribution and is missing in portions of that map-unit area. For example, *(T2)* indicates that till with an average thickness of 20 ft is present in only part of that map-unit area.

2. A negative sign (-) following a number indicates the maximum thickness for that unit in an area such as a buried valley or ridge. Thickness decreases from the specified value, commonly near the center of the map-unit area, to the thickness of the same lithologic unit and vertical position specified in an adjacent map-unit area. For example, a *SG9* map-unit area adjacent to a *SG3* area indicates a sand-and-gravel unit having a maximum thickness of 90 ft that thins to an average of 30 ft at the edge of the map-unit area. If the material is not present in an adjacent area, it decreases to zero at that boundary.

The small scale of this reconnaissance map generalizes the great local variability within surficial deposits. That variability is explained in the lithologic unit descriptions and by the use of thickness ranges. Some areas and lithologies are too small to delineate at 1:100,000 scale and have been included in adjacent areas. This map should serve only as a regional predictive guide to the area's surficial geology and not as a replacement for subsurface borings and geophysical studies required for site-specific characterizations.

UNIT DESCRIPTIONS

SURFICIAL UNITS

w — **Water.** Lakes and reservoirs generally larger than 20 acres. Includes Grand Lake St. Marys along the southern margin of the map.

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.

a — **Alluvium (Holocene).** Includes a wide variety of textures from silt and clay to boulders; commonly includes organic material; generally not compacted. Rarely greater than 20 ft thick; unit considered to thin to zero at contact with adjacent polygons. Present in floodplains of modern streams throughout entire map area or in human-made water retention features. Mapped only where areal extent and thickness are significant.

o — **Organic deposits (Holocene).** Muck and peat, may contain clay at depth. Generally less than 20 ft thick; considered to thin to zero at contact with adjacent polygons. Formed in undrained depressions. Organic deposits too small to map at 100K-scale indicated by an asterisk (*) and underlain by material shown in surrounding map-unit area. Occupies depressions between beach ridges, dunes, and on the lacustrine plain; occurs throughout the map area and is common in areas formally occupied by intermorainal marshes.

C — **Clay (Wisconsinan).** Massive to laminated; may contain interbedded silt and fine sand; clay content can exceed 80 percent. Laminated clay commonly contains thin silt or sand partings. Carbonate-cemented concretions occur in some areas. Distributed throughout the map area as lowland surface deposits; terraces; and as deposits of larger, intermorainal lakes. Also associated with the deep water deposits of high, proglacial predecessors of Lake Erie.

LC — **Silt and clay (Wisconsinan).** Laminated to interbedded, may contain thin, fine sand or gravel layers. Present as thick, deltaic deposits; outwash deposits in upland depressions; and intermorainal lake deposits. Also associated with deep water and deltaic deposits of high, proglacial predecessors of Lake Erie.

L — **Silt (Wisconsinan).** Massive or laminated, commonly contains thin sand partings. Carbonate-cemented concretions occur in some areas. May contain localized clay, sand, or gravel layers. Present throughout the map area as lowland surface deposits; terraces; and thick, deltaic deposits in intermorainal lakes. Also associated with moderate-depth water and deltaic deposits of high, proglacial predecessors of Lake Erie.

S — **Sand (Wisconsinan).** 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. Present in association with deltaic deposits, finer-grained ice-contact deposits, or outwash throughout map area. Also associated with nearshore dune and beach ridge deposits of proglacial predecessors of Lake Erie.

SG — **Sand and gravel (generally Wisconsinan).** 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. Present as valley wall terraces and in buried valleys throughout the map area and as beach ridge deposits of proglacial predecessors of Lake Erie.

IC — **Ice-contact deposits (Wisconsinan).** 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 landforms. Commonly associated with large, deep buried valleys.

T — **Unsorted mix of silt, clay, sand, gravel, and boulders (Wisconsinan).** Variable carbonate content, fractures common. May contain silt, sand, and gravel lenses. Deposited directly from several separate ice advances. Undifferentiated and nonspecified age in buried valleys or where separated by intervening nontill units from an overlying, designated till. Surface may be wave planed or modified by lacustrine erosion and deposition.

CV — **Clay in Teays-age valleys (Early Pleistocene).** Includes the Minford Clay. May contain interbedded silt and fine-sand deltaic deposits where main trunk valley joins tributary valleys. May fill main trunk valley to 800 ft mean sea level, slightly higher in tributary valleys. Unit up to 300 ft thick. Unit comprised of lacustrine deposits found only in the subsurface in the largest, deeply buried valleys of the classical Teays Valley System.

BEDROCK UNITS

S-L — **Interbedded shale, limestone, and dolomite.** Cincinnati group (Upper Ordovician). Shale is shades of gray, olive, red, and green; calcareous; dolomitic; locally silty. Limestone is shades of gray and olive; finely to coarsely crystalline; contains thin to medium, irregular, nodular to wavy bedding; argillaceous. Dolomite is shades of olive and yellowish gray; finely to coarsely crystalline; mostly in thin to medium beds; argillaceous. Sparse to abundant fossils. Unit not exposed. Occurs in deep buried valleys.

D — **Dolomite.** Dominant bedrock unit present in the map area. Stratigraphic names of the dolomites in descending stratigraphic order: Salina undifferentiated, Tymochtee and Greenfield Dolomites, and Lockport Dolomite. Salina undifferentiated (Upper and Lower Silurian): shades of gray and brown; very finely crystalline; mostly in thin to medium beds and laminae; locally includes shale, anhydrite, and/or gypsum beds and laminae. Tymochtee and Greenfield Dolomites undivided (Upper and Lower Silurian): dolomite and shale. Tymochtee Dolomite is shades of gray and brown, very finely crystalline, and occurs in thin to massive beds with carbonaceous shale laminae and beds. Greenfield Dolomite is shades of gray and brown; very finely to coarsely crystalline; occurs as massive beds to laminae; argillaceous; locally brecciated in lower portion. Lockport Dolomite (Upper and Lower Silurian): variegated white to shades of gray; finely to coarsely crystalline; mostly in medium to massive beds; fossiliferous; vuggy; locally cherty in lower portion of unit.

MAP SYMBOLS

• Small area of organic deposits.

×/✕ Quarry, mine, or strip mine; floored in bedrock; may contain reclaimed areas. Symbols highlighted in red were active in 2011.

×/✕ Sand-and-gravel pit. Pit bottom generally underlain by unconsolidated lithologic units of surrounding polygon(s). May contain reclaimed areas. Symbols highlighted in red were active in 2011.

Clay pit.

Boundary between map-unit areas having different uppermost, continuous lithologies or significant bedrock lithology change; underlying lithologies may or may not differ.

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

KEY TO DRIFT THICKNESS COLORS

Thin Drift above Dolomite

- 0–10 ft
- 10–20 ft
- 20–30 ft
- 30–40 ft

Other Areas

- Made land, quarries, mines, or large pits
- Surficial materials (drift) >40 ft thick

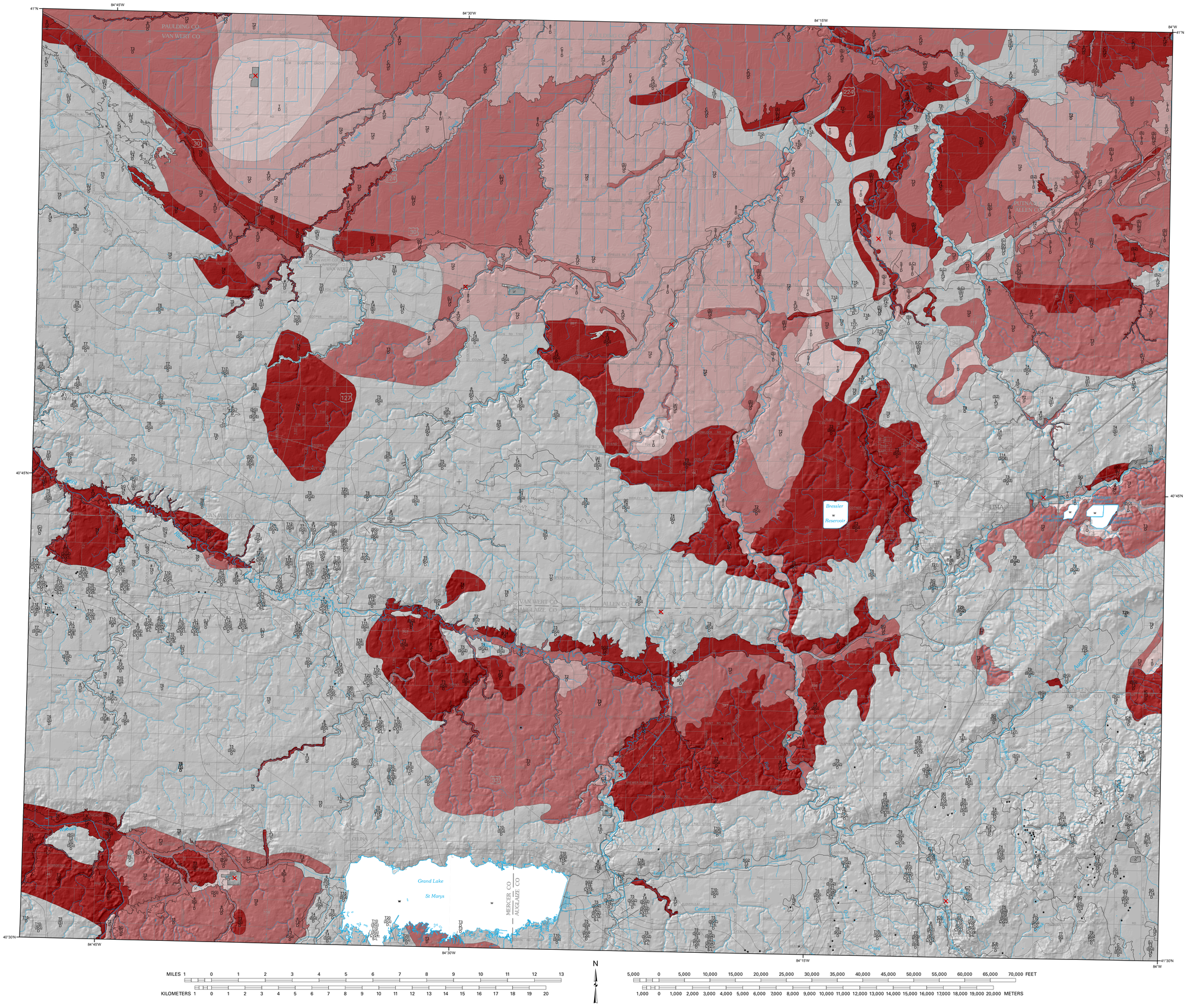
BEDROCK GEOLOGY AND MINING POTENTIAL

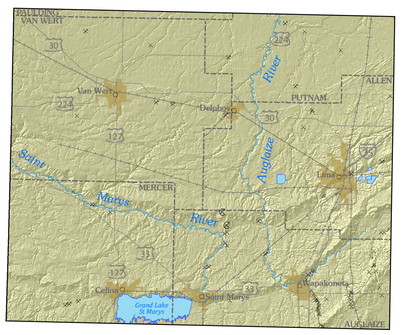
Bedrock geology in the Lima quadrangle ranges from the Ordovician-age Cincinnati group to the Silurian-age Salina Group (Slucher and others, 2006). Derivative mapping shows that four units have potentially economic-quality carbonate rock occurring under thin cover. These units are, in ascending order, Lockport Dolomite, Greenfield Dolomite, Tymochtee Dolomite, and Salina undifferentiated. Most of the carbonate rocks in the Lima quadrangle are considered good to fair in quality for the production of aggregates or other commercial uses, such as extenders or fillers, and agricultural lime. Limestone and dolomite production in 2011 from quarries located in the Lima quadrangle was nearly 3.3 million tons, which is approximately 6.2 percent of the state's total annual crushed stone production (Wolfe, 2012).

The Lima map is intended as a general guide to exploration for potential crushed stone resources. The map also may be useful for land-use planning and zoning. Because the Lima map is based on reconnaissance-level bedrock-topography and bedrock-geology maps, it should not be used for resource leasing purposes. A more detailed geologic and engineering investigation utilizing soils maps, additional water well data, drilling, and laboratory testing of chemical and physical properties would be needed to delineate and evaluate the economic viability of the carbonate resource. Additional studies of possible detrimental geologic conditions, such as reefal structures prevalent in the Lockport Dolomite, shale interbeds, karst development, or the effect of mapped faults on quarrying procedures, also would need to be completed before making mining decisions.

ACKNOWLEDGMENTS

The geologists of the ODNR Division of Geological Survey, Mapping and Industrial Minerals Group used data from records obtained from the Ohio Department of Transportation, Office of Geotechnical Engineering Geotechnical Document Management System, available online at
http://www.dot.state.oh.us/Divisions/Engineering/Geotechnical/Pages/GDocMS.aspx#GRSR.





× Pit ✕ Quarry ℄ Clay pit Urban Areas

FIGURE 1.—Pits and quarries located in the Lima 30 X 60-minute quadrangle in Ohio.

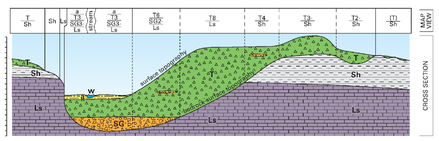
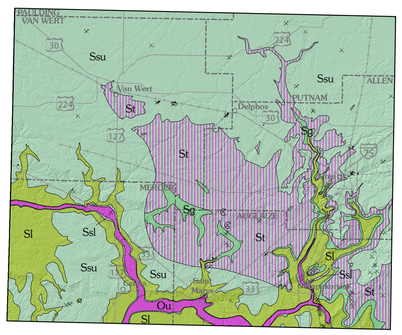


FIGURE 4.—Map view and cross section of a hypothetical stack-unit map. See lithologic-unit descriptions for explanation of symbols. In the map view (top), solid-line boundaries separate map-unit areas having different lithologic units at the surface; underlying lithologic units may or may not differ. Dashed-line boundaries separate map-unit areas having the same surface lithologic unit but different thickness or different underlying lithologic units. The cross section illustrates thickness and mapping conventions. Thickness values are in tens of feet. Values are gross averages that can vary up to 50 percent, except (1) those followed by a minus sign (-), which represent the maximum thickness of a thinning trough- or wedge-shaped sediment body, or (2) units in parentheses ( ), which indicate a discontinuous distribution of that unit. Precise surface topography can be determined from topographic maps that are available from the ODNR Division of Geological Survey at several scales; bedrock-surface topography and bedrock geology are available from the ODNR Division of Geological Survey as 1:24,000 scale quadrangle maps.

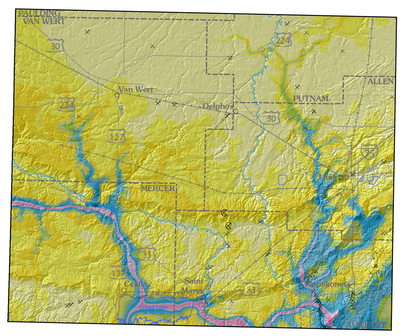


Description of Map Units

- Ssu Salina undifferentiated
- St Tymochtee Dolomite
- Sg Greenfield Dolomite
- Sl Lockport Dolomite
- Ssl Sub-Lockport, undifferentiated
- Ou Orodovician rocks, undifferentiated

× Pit ✕ Quarry ℄ Clay pit

FIGURE 2.—Bedrock geology of the Lima 30 X 60-minute quadrangle in Ohio.



Thickness in Feet

- 0–30
- 30–60
- 60–100
- 100–130
- 130–160
- 160–225
- 225–300
- 300–360
- 360–460
- 460–723

× Pit ✕ Quarry ℄ Clay pit

FIGURE 3.—Drift thickness of the Lima 30 X 60-minute quadrangle in Ohio from Powers and Swinford (2004).

Location of the Lima 30 X 60-minute quadrangle

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

REFERENCES

Jones, D.M., Pavey, R.R., Larsen, G.E., Aden, D.J., and Angle, M.P, 2011, Surficial geology of the Ohio portion of the Lima 30 x 60-minute quadrangle: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Map SG-2-LIM, scale 1:100,000.

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Slucher, E.R., Swinford, E.M., Larsen, G.E., Schumacher, G.A., Shrake, D.L., Rice, C.L., Caudill, M.R., Rea, R.G., and Powers, D.M, 2006, Bedrock geologic map of Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Map BG-1, scale 1:500,000.

Wolfe, M.E., 2012, 2011 Report on Ohio mineral industries—An annual summary of the state's economic geology: Columbus, Ohio Department of Natural Resources, Division of Geological Survey, 35 p., accessed at <http://www.dnr.state.oh.us/Portals/10/pdf/min_ind_report/MinInd11.pdf>.

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