OHIO SURFICIAL GEOLOGY: 3D VISUALIZATIONS FROM 2D MAPS

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SURFICIAL GEOLOGY OF THE WESTERN PORTION OF THE HILLSBORO 30 X 60-MINUTE QUADRANGLE IN OHIO

by
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ABSTRACT

Since 1997, the Ohio Department of Natural Resources, Division of Geological Survey has conducted reconnaissance-style, two-dimensional (2D) mapping with attributes representing the thickness of glacial deposits in the third dimension (3D). Early efforts focused on mapping densely populated urban corridors of the state to provide value-added products or derivative maps. Referred to as "stack maps," each map features a network of polygons individually labeled to identify the "stack" and relative thickness of materials, such as glacial till, sand and gravel, and fine-grained lacustrine deposits, found in each polygon. A multitude of layer files are used to create the stack maps, including bedrock geology, glacial geology, drift thickness, digital elevation models, soils, historic maps, and high-resolution LiDAR imagery. These layers overlay detailed base maps supplemented by detailed point data available from digitized ground-water well logs, oil-and-gas well logs, measured sections, electric wire logs, Ohio Department of Transportation engineering bore-hole logs, and geotechnical logs. Currently, 72 percent of the state is mapped using these techniques.

For 2013–2014, the western half of the Hillsboro 30 X 60-minute quadrangle was mapped. In this project, 2D polygons from the map area were used to create a 3D representation of the extents and thicknesses of lithologic units bounded by the lower bedrock topography and the upper digital elevation model. The 2D polygon attributes from the stack map were used to construct the vertical components (or stacks) filling the 3D environment in ESRI ArcScene. The resulting 3D conceptual models advance understanding of the extents and distribution of geologic materials in the shallow subsurface while also enhancing mineral resource assessment, improving recognition of geologic hazard potential, and aiding ground-water resource management.

2D MAPPING CONVENTIONS

The map at right provides a three-dimensional framework of the area's surficial geology and depicts four important aspects of surficial geology:
(1) The geologic deposits, indicated by letters which represent the major lithologies.
(2) The thickness of the individual deposits, indicated by numbers and modifiers.
(3) The lateral extent of the deposits, indicated by map-unit area boundaries or polygon extents.
(4) The vertical sequence of deposits, shown by the stack of symbols within each map-unit area. In effect, each stack represents a generalized borehole section for each area.

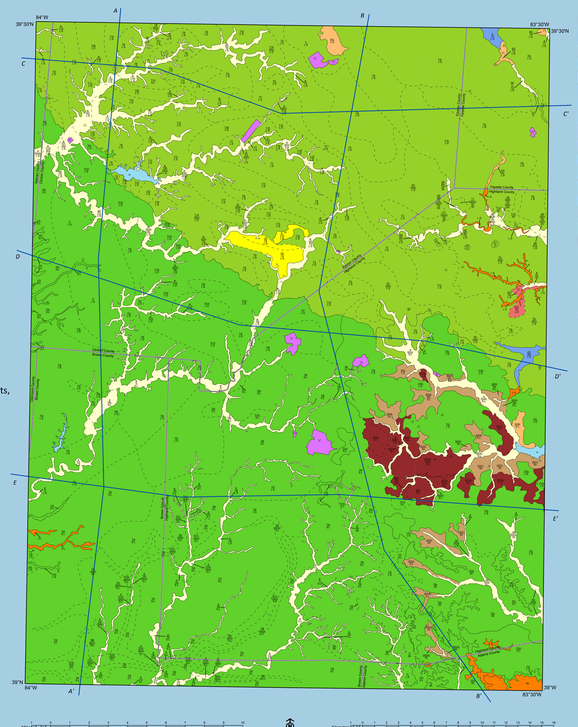
Letters represent geologic deposits. These may be a single lithology, such as sand (S) or clay (C). They may also represent a combination of related lithologies found in specific depositional environments, such as sand and gravel (SG) or ice-contact deposits (IC), representing valley train outwash deposits or kame deposits, respectively. The bottom symbol in each stack indicates the bedrock lithologies that underlie the surficial deposits.

The map legend provides additional information on these components:
(1) Geologic characteristics, such as range of textures, bedding, and age.
(2) Engineering properties attributed to the unit.
(3) Depositional environment.
(4) Geomorphology or geomorphic location.
(5) Geographic location within the map area.

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

Modifiers provide additional thickness and distribution information:
(1) Parentheses indicate that a unit has a patchy or discontinuous distribution or is missing in portions of that map-unit area. For example, *(T2)* indicates that till with an average thickness of 20 feet is present in only part of that map-unit area.
(2) A minus sign (–) following a number indicates a maximum specified material thickness in the unit 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, an *SG9–* map-unit area adjacent to an *SG3* area indicates a sand-and-gravel unit having a maximum thickness of 90 feet that thins to an average of 30 feet 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.

These 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 polygon.



Key to Map Elements

- a — Alluvium (Holocene)
- C — Clay (Wisconsinan)
- IC — Ice-contact deposits (Wisconsinan)
- ICI — Ice-contact deposits (Illinoian)
- S — Sand (Wisconsinan)
- SG — Sand and gravel (Wisconsinan)
- SGI — Sand and gravel (Illinoian)
- T — Loam till (Wisconsinan)
- TI — Loam till (Illinoian)
- D — Dolomite (Silurian)
- Ls — Limestone (Silurian and Ordovician)
- L-S — Shale, limestone, and dolomite (Ordovician)
- Sh — Shale (Silurian)
- w — Water
- x — Quarry or made land
- Counties (Ohio Department of Transportation)
- Boundary between mapped units having different surficial lithologies or significant bedrock lithology change
- Boundary where mapped unit areas share the same uppermost continuous lithology but different thicknesses or underlying lithologies
- A A' — Cross section lines

Location of the western portion of the Hillsboro 30 x 60-minute quadrangle in Ohio

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METHODOLOGY FOR CREATING 3D VISUALIZATIONS

The conventional 2D Ohio Surficial Geology GIS layer was used to construct 3D representations. In order to facilitate the construction of the visualizations, attributes of the 2D map were generalized. The thickness modifiers of the deposits, indicated by the minus sign and parentheses, were generalized to the nearest ten feet. For example, labels on the 2D map represented as *(T2)* or *T2-*, were rounded to depict a constant till thickness of 20 feet.

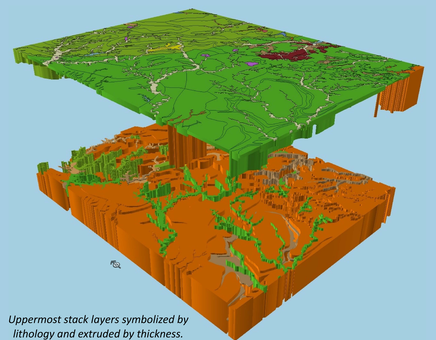
For the *Surficial Geology of the Western Portion of the Hillsboro 30 x 60-Minute Quadrangle in Ohio* (at left), six stacks represent a maximum thickness of 280 feet of unconsolidated deposits. A unique polygon layer, representing lithology and thickness, was created for each stack from the 2D GIS layer. All stack layers were added to ESRI ArcScene, extruded by thickness, and symbolized by lithology. Base height of each uppermost stack was set to zero. Base height elevations for stack layers below the uppermost stacks were set by subtracting the sum of the stack thicknesses for the overlying stacks. Each of the extruded polygon layers, with their set base height elevations, were converted into 3D multipatch features.

Intersecting cross section lines, depicting a fence diagram, were created as a 2D line feature class. A buffer of 100 feet was applied to the cross section feature class. The 2D cross section feature class was added to ESRI ArcScene. A base height of 100 feet and an extrusion of –500 feet were set for the cross section; this permitted the fence diagram to traverse the maximum 280-feet thickness of the 3D multipatch features by approximately 100 feet above and below the unconsolidated block. The extruded cross section lines were converted into a 3D multipatch feature class.

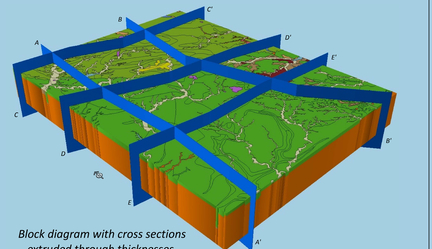
The Intersect 3D tool in ESRI 3D Analyst creates a multipatch feature class that represents the overlapping volumes between input features. The tool was used to create a 3D multipatch fence diagram from the intersection of the 3D multipatch cross section with the stack layers.

CONCLUSIONS AND FUTURE WORK

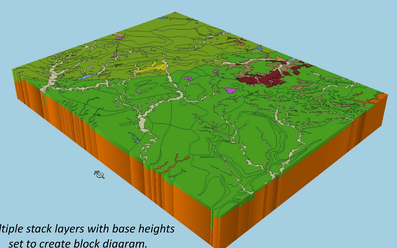
Development and completion of this 3D visualization project has demonstrated the feasibility of transforming 30 X 60-minute surficial-geology quadrangle maps into 3D maps and visualizations. Application of this methodology throughout the completed surficial-geology map series may lead to increased understanding of the occurrences, volumes, and availability of Ohio's unconsolidated mineral reserves. Map improvements under consideration include migrating from 2D polygon extrusions to continuous raster or triangular irregular network surfaces of the unconsolidated deposits. These surfaces would then be extruded between digital elevation models and bedrock topography layers to portray a more representative geologic model.



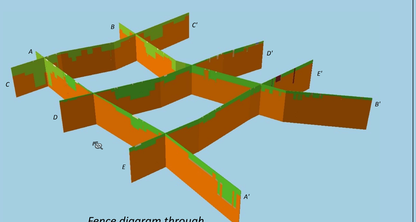
Uppermost stack layers symbolized by lithology and extruded by thickness.
Vertical exaggeration is 75x



Block diagram with cross sections extruded through thicknesses.
Vertical exaggeration is 75x



Multiple stack layers with base heights set to create block diagram.
Vertical exaggeration is 75x



Fence diagram through multiple stack layers.
Vertical exaggeration is 75x

General workflow used to create 3D visualizations.

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