GIS Tools For 3D Surficial Mapping In Ohio

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ABSTRACT

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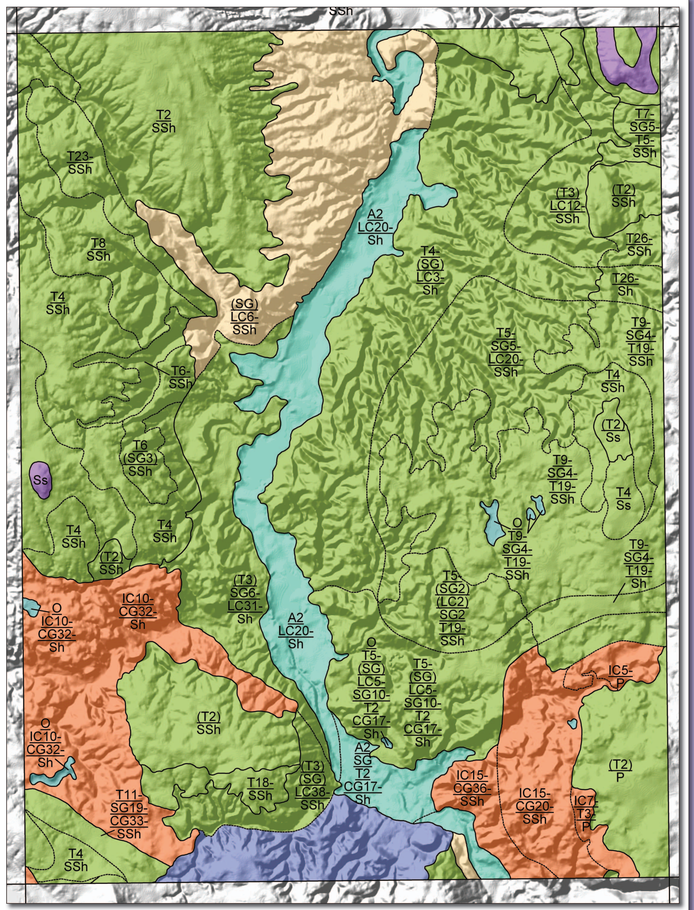
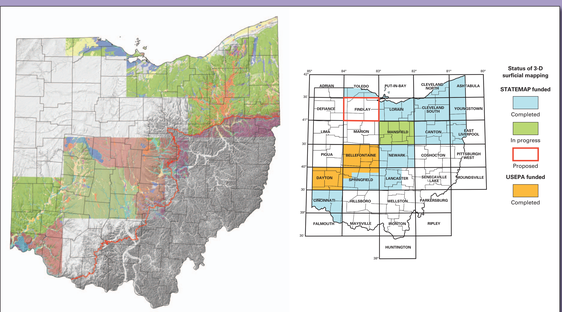
The Ohio Division of Geological Survey is currently mapping the surficial geology of Ohio in three dimensions (3D), using a modified version of the stack-mapping technique of Berg and Kempton (1988). The stack-mapping technique depicts the geology for an area in 3D, by listing the geologic units from the surface to bedrock, the thickness of those units, and the bedrock unit lying underneath the unconsolidated glacial-drift deposits. The new mapping of the surficial geology is intended to replace the older and smaller-scale mapping that was based upon generalized, two-dimensional, geomorphic-based surficial-mapping techniques.

To help automate the production of surficial-geology stack maps in the GIS, there are two software applications used to help create the GIS data layers. The first software application creates stratigraphic columns for water well locations, using the driller's logs. These columns are then used to assist the geologist in drawing the stack-map polygons. The second software application consists of a number of different tools used to attribute and label the stack-map polygons. The first tool of the second software application attributes the one-to-many lithology table. Another tool labels the polygons with the stack text. A third tool performs queries against the lithology table. These two applications allow the efficient creation of 3D surficial-geology polygons and labels within a GIS database. Once created, derivative products can be generated, using custom queries against the one-to-many relationship lithology table.

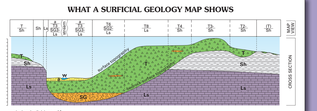


Map showing the surficial geology of the Peninsula Quadrangle, Cuyahoga and Summit Counties, Ohio. Till units are colored in green (T), Ice-Contact units are colored orange (IC), Lake Clay units are colored tan (LC), Alluvium and Organic units are colored blue (a and O), Sand and Gravel units are colored dark blue (SG), and Pennsylvanian Pottsville Group sandstones are colored purple (Ss).



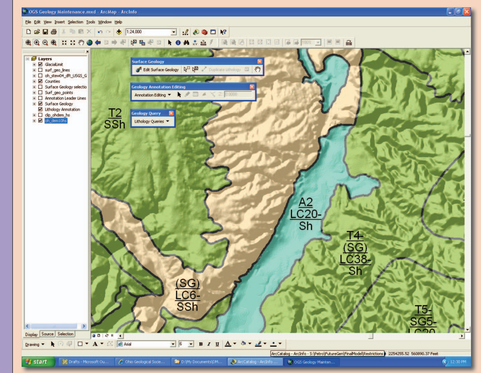
Index to the status of surficial geology mapping in Ohio. The map on the left shows the surficial geology of the quadrangles that have been completed. The map on the right shows the 30' x 60' quadrangles that have been completed, are in progress, or are proposed for mapping in the near future.

WHAT A SURFICIAL GEOLOGY MAP SHOWS

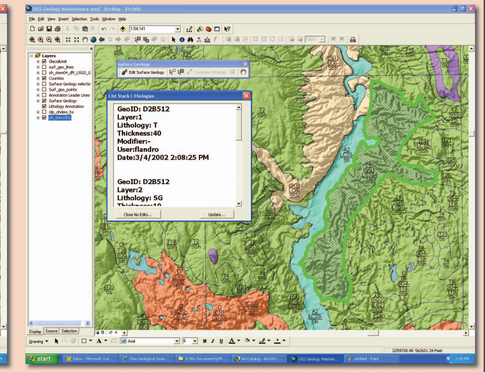


Surficial Geology maps characterize the distribution and thickness of Ohio's glacial, post-glacial, and related deposits from the surface down through the uppermost buried bedrock unit. The surface to bedrock sequence is depicted via a lithologic material stack enclosed within a polygon of probability.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

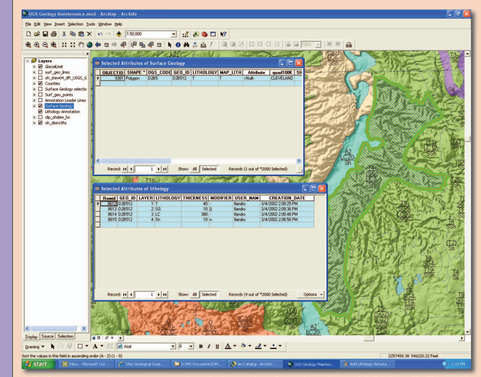
STACK-MAP APPLICATION



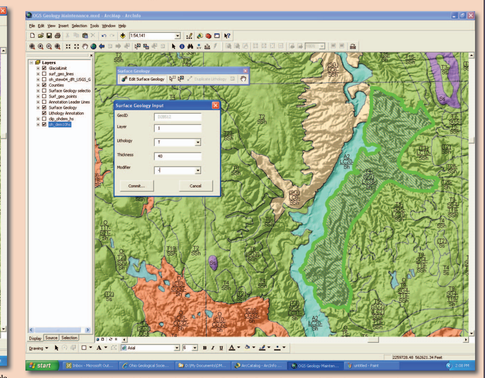
The stack-map application consists of three different toolbars, with each toolbar having a number of different tools. The first toolbar is the ***Surface Geology*** toolbar. This toolbar is used to attribute the surface-geology polygons and its associated one-to-many relationship lithology table. The second toolbar, ***Geology Annotation Editing***, is used to label the surface geology polygons, by reading associated one-to-many relationship lithology table, and creating the stacked text labels. The third toolbar, ***Geology Query***, is used to create custom queries, using the one-to-many relationship lithology table.



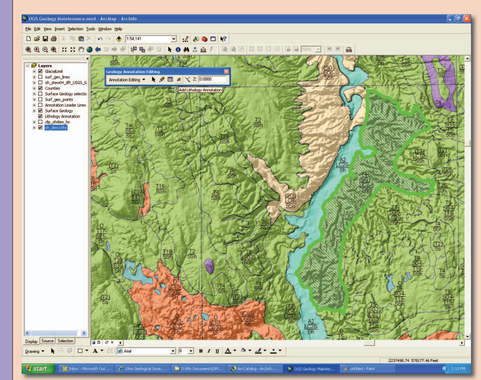
The primary tool used to list the lithology attributes and to edit the lithology attributes is the ***Edit Surface Geology*** tool, on the ***Surface Geology*** toolbar. By selecting the tool, and then selecting the desired polygon, different forms will appear that will either list the stack-unit lithologies in stratigraphic order, or allow the GIS user to attribute one or more of the stack-units for the selected surface-geology polygon. In this figure, the selected surface-geology polygon has been attributed, and the ***Edit Surface Geology*** tool will activate the ***List Stack Lithologies*** form. This form lists all the stack-unit lithologies, along with the name of the GIS user who has edited the stack-unit lithology, and the date and time the last edit has occurred.



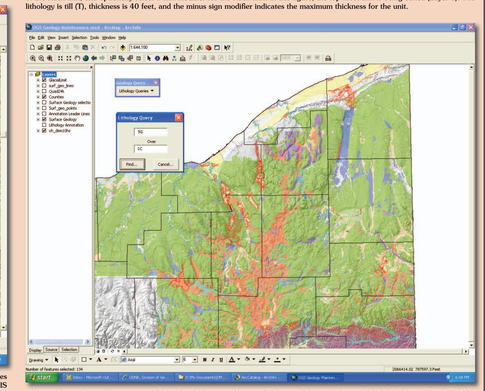
This figure is an example of the one-to-many relationship between the surface-geology polygon and the lithology table. The top table is the feature-attribute table of the surface-geology polygon, showing the selected record of the polygon to the right. The bottom table is the lithology table, showing the four records related to the selected surface-geology polygon.



To edit any of the stack-unit lithologies, the ***Surface Geology Input*** form is used. This form is accessed automatically if a surface-geology polygon has not been attributed, or it can be accessed through a command button on the ***List Stack Lithologies*** form. Once the form has been activated, the GIS user can select the stack-unit sequence number, select a new lithology, input the thickness of the stack-unit, and optionally select a unit modifier for the stack unit. In this figure, the top-most unit is being edited (Layer 1). The lithology is till (T), thickness is 40 feet, and the minus sign modifier indicates the maximum thickness for the unit.

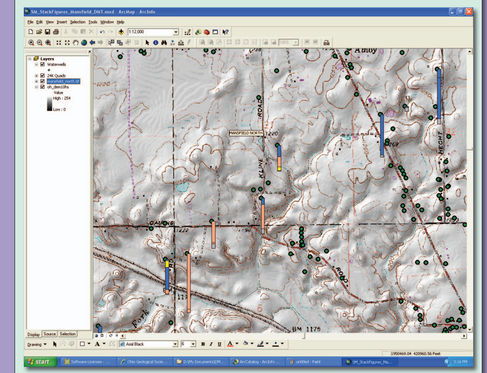


The labels for the surface-geology polygons can be placed using the ***Geology Annotation Editing*** toolbar. This toolbar uses the ***Annotation Editing*** tool, along with a custom ***Add Lithology Annotation*** tool to place the labels for the polygons. The GIS user first turns on the annotation editing using the ***Annotation Editing*** tool. Second, the GIS user selects the ***Add Lithology Annotation*** tool, and then selects the surface-geology polygon to be labeled. The custom ***Add Lithology Annotation*** tool, using the GEOID for the polygon, reads the related records for the polygon in the Lithology table. The tool then finds the center of the polygon, builds the text for the label in correct stratigraphic order, and then snaps the label to the center of the polygon.

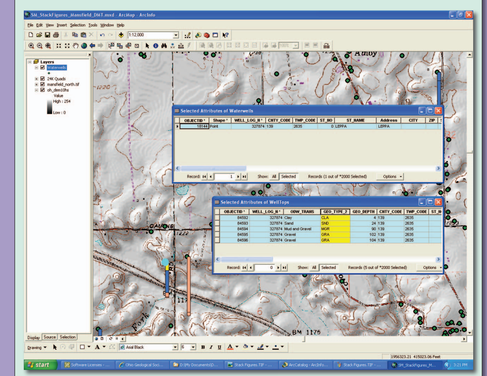


Complex queries can be generated using the ***Lithology Query*** toolbar and the two tools provided within the toolbar. The first tool, shown in this figure, can select polygons that have one type of lithology overtop another type of lithology. The second tool can select polygons that have a combination of thicknesses and lithologies overtop one another. In this figure, we have queried for Sand and Gravel (SG) overtop of Lake Clays (LC). The selected polygons are then highlighted in red.

STACK-FIGURE APPLICATION



In order to draw the stack-unit polygons, many different sources of information are used. The most numerous source of information is water-well logs from the Ohio Division of Water (Jones and Barrett, in press). A second application was written that draws a stratigraphic column for selected water wells, based on the water-well log data. In this example, eight water wells have been selected, and stack-figure application has drawn stratigraphic columns for the selected water wells. The geologist can then start using these stratigraphic columns to aid in the delineation of the surface-geology polygons. Before this application was created, a college intern required approximately three months to draw these stack-figures for the STATEMAP grant. Using this application, the amount of time necessary to create the stack figures has decreased to only a few days.



Much like the relationship between the surface-geology polygons and the lithology table, there is a one-to-many relationship between the water-well location and the water-well log table. The top table is the feature-attribute table of the water-well location, showing the selected record of the water well to the bottom left of the map. The bottom table is the water-well log table, showing the five stratigraphic records related to the selected water-well location.

REFERENCES CITED

Berg, R.C., and Kempton, J.P., 1988, Stack-unit mapping of geologic materials in Illinois to a depth of 15 meters: Illinois State Geological Survey Circular 542. 23p., 4 pl.

Jones, A.W., and Barrett, K.A., accepted, Building a water well database for GIS analysis, *in* Digital Mapping Techniques '06—Workshop Proceedings, Columbus, Ohio, June 11-14, 2006: U.S. Department of Interior, U.S. Geological Survey; Reston, Virginia.

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