The following was presented at DMT'11 (May 22-25, 2011).

The contents are provisional and will be superseded by a paper in the DMT'11 Proceedings.

See also earlier Proceedings (1997-2010)
http://ngmdb.usgs.gov/info/dmt/

GIS DATA ACCESS AND DISTRIBUTION USING A MAP APPLICATION TOOL

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ABSTRACT

The Ohio Department of Natural Resources, Division of Geological Survey has created and released a number of statewide geoscience datasets in geographic information system (GIS) format. These datasets include (1) bedrock-surface topography, (2) bedrock geology, (3) bedrock structure, (4) abandoned-underground mines, and (5) oil- and gas-well locations. Moreover, to make these datasets user friendly, a GIS map application tool was created so that over 4,000 different maps and GIS data layers can be extracted for stand-alone use or printing.

The GIS map application tool has a number of different functions. For example, the tool allows the GIS user to select a specific map theme and scale, such as a 1:24,000-scale bedrock-geology map. Once a theme has been selected, a quadrangle map can be extracted either by selecting from a list of quadrangle names or by selecting the desired quadrangle from a quadrangle index map. Upon extraction of the data from its statewide database, the user can edit the data, export the data, or set up a map for printing. If a user is editing the GIS data, all relevant data sets are displayed. For exporting purposes, a function exists that allows for compression of the extracted data into a ZIP file. Another beneficial function allows for traditional display and printing of geologic maps. These functions were designed to serve two primary purposes: to move the user towards using digital map-making practices and analyses and to facilitate an easy production-and-distribution method for print-on-demand maps and GIS data.

INTRODUCTION

The Ohio Department of Natural Resources (ODNR), Division of Geological Survey Map Application is designed to easily create a map from a number of different map themes at 1:24,000 and 1:100,000 scales. Currently, these map themes include bedrock geology (BG), bedrock topography (BT), bedrock-structure contour (BS), abandoned-underground-mine (AUM) maps, and the oil- and gas-well location maps (OG). The Map Application was designed for two different end users. First, with very little training, any novice user could operate the Map Application and easily generate a standardized map. Second, data is gathered up into packages that make it easy for the beginning user to edit the maps and data in the GIS. Using the Map Application, over 4,000 different maps can be extracted and displayed.

From 1991 through 1997, the bedrock geology, bedrock topography, and the structure contours associated with the bedrock-geologic units were mapped at 1:24,000 scale. Conversion of the bedrock-geology and bedrock-topography maps was performed over a 10-year period. Initially, division staff members digitized the bedrock-geology maps of western and part of southern Ohio between 1992 and 1998. Staff members and interns digitized the bedrock-geology maps of the central part of the state under a U.S. Geological Survey grant in 1996. Finally, the Ohio Penal Industries digitized the bedrock-geology maps of the eastern part of the state in 2001–2002. Division staff members digitized the bedrock-topography maps for northwestern Ohio in 1992 and the central part of the state in 1996. The Ohio Penal Industries digitized the remaining bedrock-topography maps, in southwestern and eastern Ohio, in 2001–2002. The bedrock-structure contour maps were digitized by Ohio University in 2002–2003.

As the bedrock-geology and bedrock-topography GIS-conversion projects neared completion, it became apparent that a methodology had to be developed for data management and data distribution of these large, statewide GIS data sets. As part of a contract with the Ohio Department of Transportation for the completion of the GIS conversion, a multiuse application was created to help manage, distribute, and edit the data and maps. The application was designed with a number of different goals in mind. First, the application had to be able to extract and set up individual quadrangles for plotting and to extract digital data for public distribution for all 1,576 bedrock-geology and bedrock-topography maps. Second, the application had to enable dynamic updating and editing of the data so that versions released to the public are always current.

As part of the original conversion of the geologic map data into a GIS, two different contractors created a map application for the division. The first contractor, Bluegrass GIS, created the initial map application. The second contractor, Taratec Corp., added in the structure-contour maps and also significantly modified the application, making the software code more object-oriented and flexible. Further modifications extended the application. For example, other map themes were added, such as the abandoned-underground mines and the oil- and gas-well location maps. Also, the ability to dynamically select the data sources was added, along with the ability to use data stored in an enterprise database, such as ArcSDE. Finally, the application was modified to create maps that are close to publication quality. All of the modifications allow the division flexibility in deployment and the ability to easily create print-on-demand maps that reflect current understanding of the geology of Ohio.

There are six basic workflows that can be used for each of the maps. The first workflow is the extraction and display of map data, at either 1:24,000 or 1:100,000 scales. All the other workflows use the first workflow as the starting point. The second workflow, a variation of the first, is the display of the structure-contour maps. The third workflow displays bedrock-geology or bedrock-topography maps at 1:100,000 scale using a floating window. The fourth workflow creates publication-quality maps for print-on-demand (POD) distribution. The fifth workflow is the exporting of GIS data. The sixth and final workflow is the creation of custom images for presentations and for distributing to the public.

WORKFLOW: DISPLAY OF MAPS

1. Open ArcMap and choose "A new empty map." Click OK.
2. Make sure that the MAP Application is located on the blank ArcMap (Fig. 1). This is known as DATAVIEW.

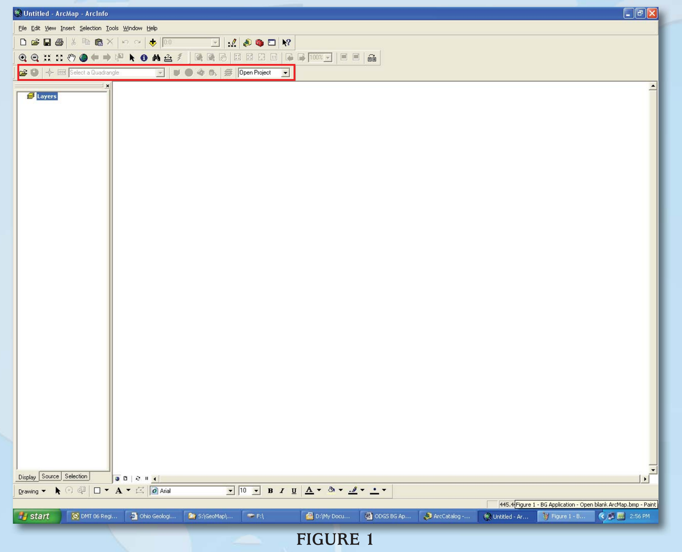

FIGURE 1

3. On the MAP Application, select a map project, such as BG 24K, BT 24K, BS 24K, etc. (Fig. 2). The resulting map should display either all the 1:24,000-scale or 1:100,000-scale quadrangles in Ohio (Fig. 3, with BG24K selected).

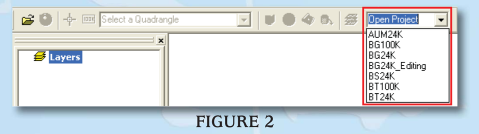

FIGURE 2

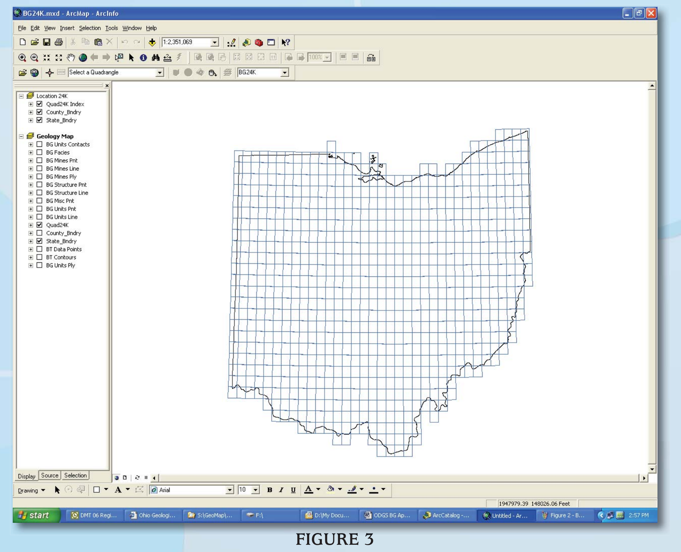

FIGURE 3

4. Next, select a quadrangle either by pointing and clicking on a quadrangle or by selecting the quadrangle by name.
   a. If using the point-and-click method, first select the PICK QUADRANGLE button (Fig. 4), then go to the map area and select the quadrangle to display (Fig. 5).
   b. If selecting the quadrangle by name, select the QUADRANGLE NAME list, and scroll down the list to select the desired quadrangle (Fig. 6).

FIGURE 4

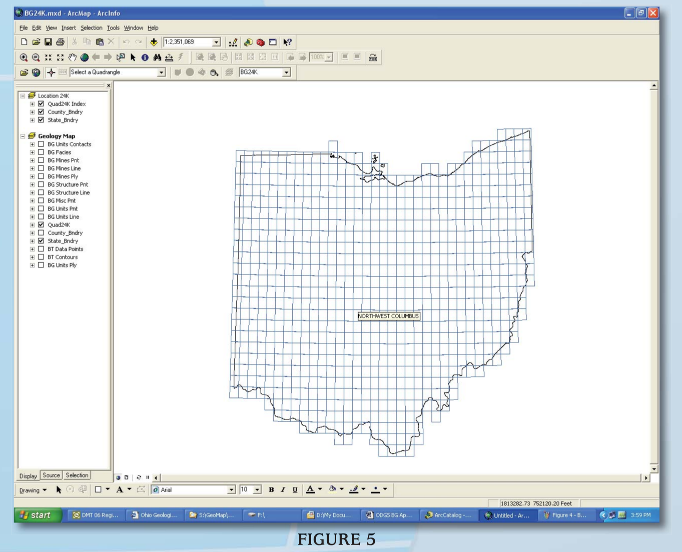

FIGURE 5

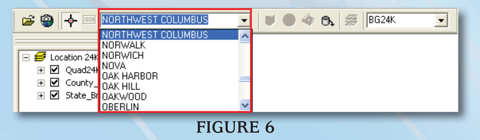

FIGURE 6

5. After selecting the quadrangle, wait about 10–30 seconds while all data is collected and prepared for display. Messages in the lower left-hand corner will display data being gathered and what is happening to the data.
   a. Right before the display of a geologic map, the last message will state: "Drawing Quads Geology Units Ply."
6. At this point a geologic map should display (Fig. 7).
7. To select another quadrangle, select the "Zoom to Ohio" icon (Fig. 8).

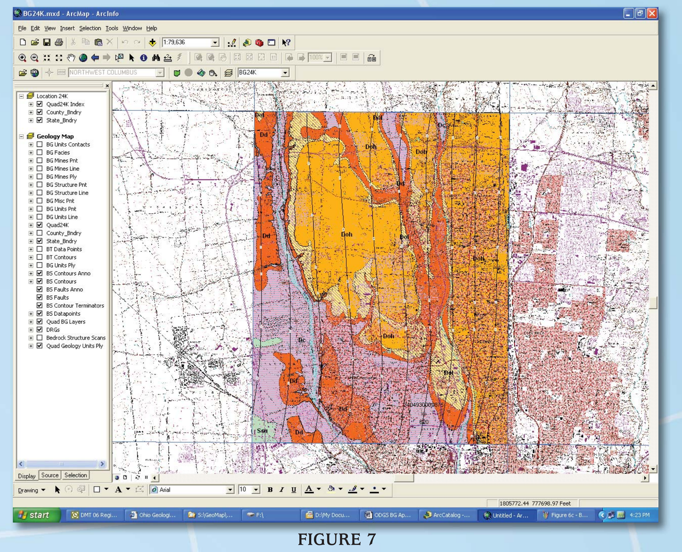

FIGURE 7

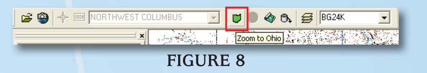

FIGURE 8

WORKFLOW: DISPLAY OF STRUCTURE-CONTOUR MAPS

This workflow is very similar to the Display of Maps workflow. A few additional steps are necessary to display individual surfaces within each quadrangle.

1. Open a blank ArcMap.
2. Make sure that the MAP Application is located on the blank ArcMap (see Fig. 1).
3. On the MAP Application, select map project BS 24K (Fig. 9). The resulting map should display all the 1:24,000-scale quadrangles in Ohio (see Fig. 3).

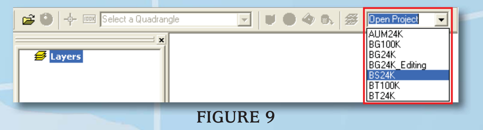

FIGURE 9

4. Next, select a quadrangle either by pointing and clicking on a quadrangle or by selecting the quadrangle by name.
   a. If using the point-and-click method, first select the PICK QUADRANGLE button (see Fig. 4), then go to the map area and select the quadrangle to display (see Fig. 5).
   b. If selecting the quadrangle by name, select the QUADRANGLE NAME list and scroll down the list to select the desired quadrangle (see Fig. 6).
5. After selecting the quadrangle, wait about 10–30 seconds while all the data is collected and prepared for display. Watch the messages in the lower left-hand corner. The messages will describe what data is being gathered and what is happening to the data.
   a. Right before the display of a structure-contour map, the last message will state: "Loading DRGs…" Note: the DRG is turned off at start-up for the structure-contour maps.
6. At this point a structure-contour map should display (Fig. 10).

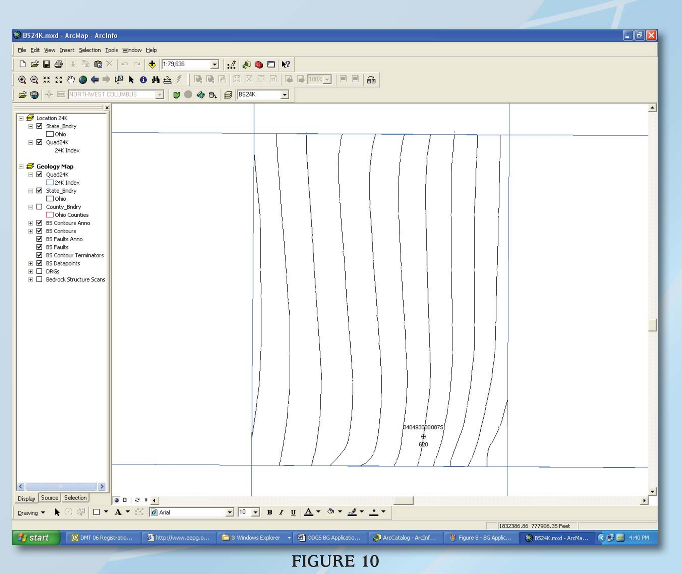

FIGURE 10

7. The final step is to select the structure-contour surface to display. Select the CHANGE VISIBLE BEDROCK LAYERS button (Fig. 11).
8. A form will appear. In that form, select the surface to display (Fig. 12).
9. Click OK to select a different surface.
10. At this point a different structure-contour map should display.
11. Only one map can be displayed at a time.

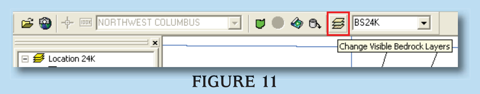

FIGURE 11

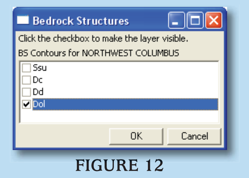

FIGURE 12

WORKFLOW: DISPLAY OF MAPS USING FLOATING WINDOW

1. Open a blank ArcMap.
2. Make sure that the MAP Application is located on the blank ArcMap (see Fig. 1)
3. On the MAP Application, select a map project, either BG100K or BT100K (see Fig. 2). The resulting map should display either all the 1:24,000-scale (see Fig. 3) or 1:100,000-scale quadrangles in Ohio.
4. Next, select a quadrangle. If using the floating window, first select the SELECT 30 x 60 AREA button (Fig. 13). To activate a floating 30-x-60 area box, drag the box to the area of interest and **double click** to display a map (Fig. 14).

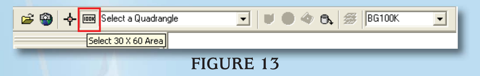

FIGURE 13

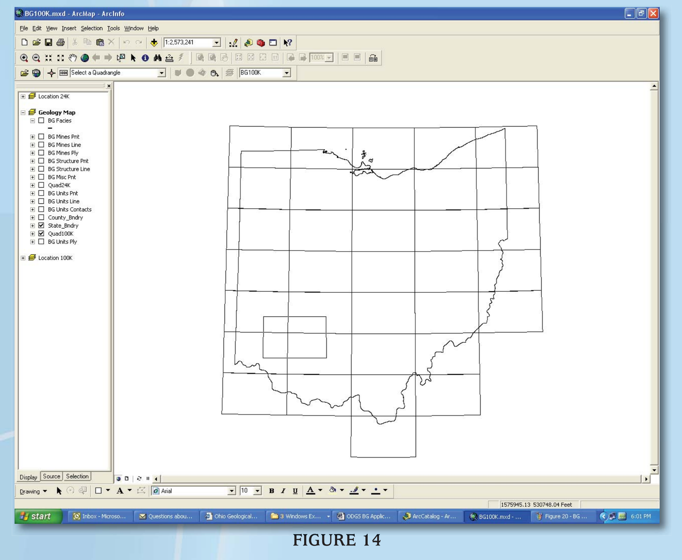

FIGURE 14

5. After selecting the quadrangle, wait about 10–30 seconds while all the data is collected and prepared for display. Watch for the messages in the lower left-hand corner. The messages will describe what data is being gathered and what is happening to the data.
   a. Right before the display of a geologic map, the last message will state: "Drawing Quads Geology Units Ply…"
6. At this point a geologic map should display.

WORKFLOW: PRINTING OF MAPS

1. Start with the Display of Maps workflow.
2. Once a map is displayed, the map is almost ready for printing. Display the map in a LAYOUT VIEW by selecting the GO TO GEOLOGY LAYOUT button on the MAP Application (Fig. 15).

FIGURE 15

3. At this point a geologic map should be ready for printing (Fig. 16). Notice that the title, authors, revision date, and lat/long values are correct, and that the legend is in correct stratigraphic order for the map.

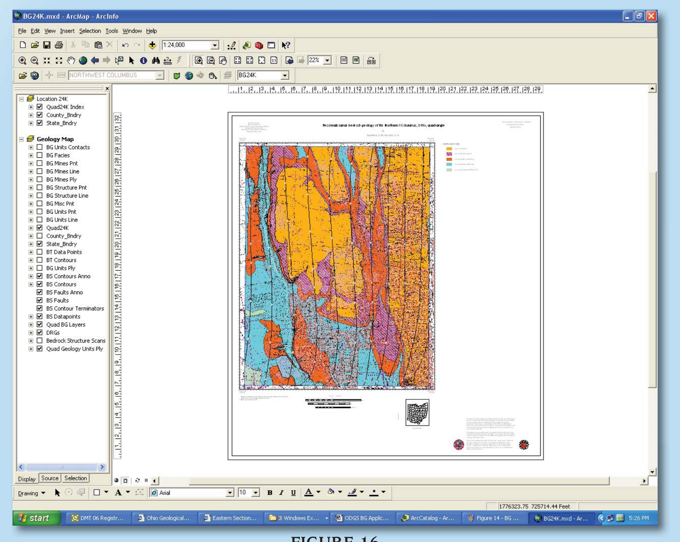

FIGURE 16

WORKFLOW: EXPORTING GIS DATA

1. Start with the Display of Maps workflow.
2. Once the map is displayed in the DATAVIEW, select the EXPORT DATA TO SHAPEFILE button (Fig. 17).
3. After the button is selected, an Export Quads to Shapefiles form will display (Fig. 18).

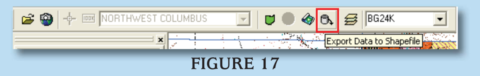

FIGURE 17

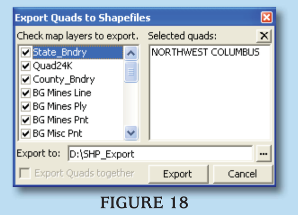

FIGURE 18

4. On the left hand side of the form, all the layers that will be exported are checked. Deselect any layer(s) that does not need exported.
5. Notice the directory in which the exported data will be sent.
6. Click on EXPORT.
7. The data will be exported to a subdirectory, which will be named by the date and time. Inside that directory will be a ZIP file containing the GIS data (Fig. 19). The ZIP file will be named after the quadrangle.

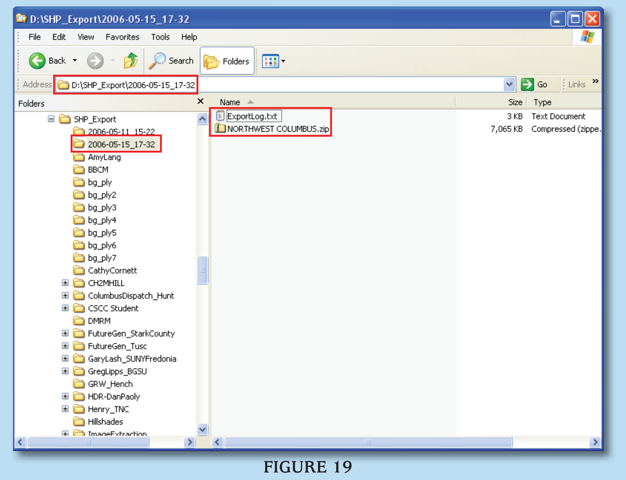

FIGURE 19

WORKFLOW: CREATE CUSTOM IMAGES

1. Start with the Display of Maps workflow.
2. Decide whether to create an image for a PowerPoint presentation or to create a PDF of a map that can be given to someone and printed later.
   a. To create an image that will be used in a PowerPoint presentation:
      i. Select the EXPORT IMAGE button (Fig. 20).
      ii. An Export Map form will display (Fig. 21).
         1. Select the directory.
         2. Select the file type. JPG format is recommended.
         3. Select the resolution. Try using 96 dpi.

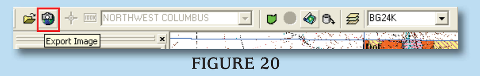

FIGURE 20

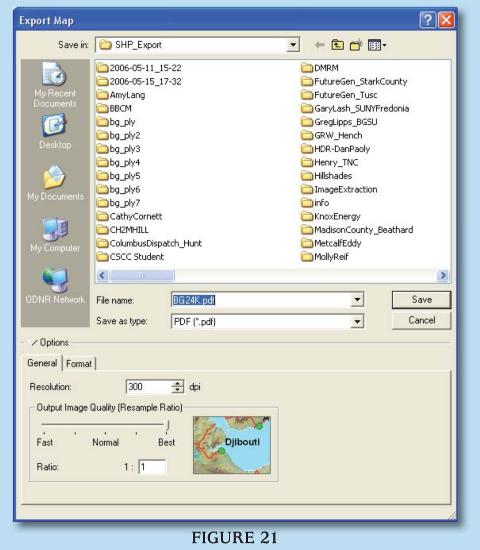

FIGURE 21

         4. Export the image.
   b. To create a PDF version of a printed map:
      i. Select the LAYOUT FRAME button (see Fig. 15).
      ii. Select the EXPORT IMAGE button (see Fig. 20).
      iii. An Export Map Form will display (see Fig. 21).
         1. Select the directory.
         2. Select the file type. Use PDF format.
         3. Select the resolution. Try using 300 dpi.
         4. Export the image.

TECHNOLOGY INNOVATIONS

The ODNR Division of Geological Survey Map Application includes a number of innovative technologies. These technologies include the serving of map documents as binary large objects (BLOBs), automatic repathing and repair of data sources and data layers, the multiple use of map-level metadata, and the generation of dynamic legends specific to the map. Each of these technologies is unique and is not available "straight out of the box" from ESRI. Each of these technologies is created using ArcObjects, the COM specification from ESRI.

DELIVERY OF VIRTUAL MAPS

One of the most interesting technology developments is the use of binary large objects (BLOBs) to serve ArcMaps to the desktop users. Using BLOBs to serve an ArcMap has a number of advantages.

1. There is only a single deployment of the map. When updates are made to the map, there is no need to install the new maps on all the desktop machines. The original map is loaded into the Projects geodatabase, and any GIS user operating the Map Application can access the virtual map (Fig. 22).
2. Users cannot accidentally change a map, save the changes, and inadvertently change the meaning of the map. For the Map Application to properly work, certain objects within the ArcMap must remain constant. The title must remain constant, so the Map Application can find the correct text in the layout and replace that standard text with the updated title from the metadata database. The same goes for the authors, the revision date, and the legend. Since the BLOB resides only in memory, the BLOB provides essentially read-only access.
3. Using BLOBs in memory allows multiple users to use the same ArcMap. An alternative would be to use an ArcMap template. Upon creating a new ArcMap using an ArcMap template, a new ArcMap will not have a title. The Map Application uses the title to determine the map theme. Each map theme has different properties, and certain operations need to be applied so that the map theme had the proper look and function (e.g., labeling of polygons, layer order in the table of contents, or adding additional layers). One way around this problem would be to save the map with the correct title (hopefully spelled correctly), but this is an additional step that an end user does not need to perform.
4. The map is stored as a BLOB in a Projects geodatabase. The Projects geodatabase also stores the definitions of the valid layers for the map. If a user accidentally deletes a required map layer, the Map Application automatically checks the Projects geodatabase and if necessary, adds the missing layer back into the ArcMap. These layers are also stored in the Projects geodatabase as BLOBs.
5. Further customizations will be built into the Projects geodatabase. These will include layer behavior and symbolizations. Currently, the layer behavior (e.g., custom labeling, such as based upon polygon size for the abandoned-underground mine maps) is done through the code. Any changes to the layer behavior need to be done through the code. Moving the layer behavior and symbolization into the Projects geodatabase will remove the behavior and symbolization from the software code. This will allow for easily customizable maps and for additional map themes to be easily deployed without changing the software code.

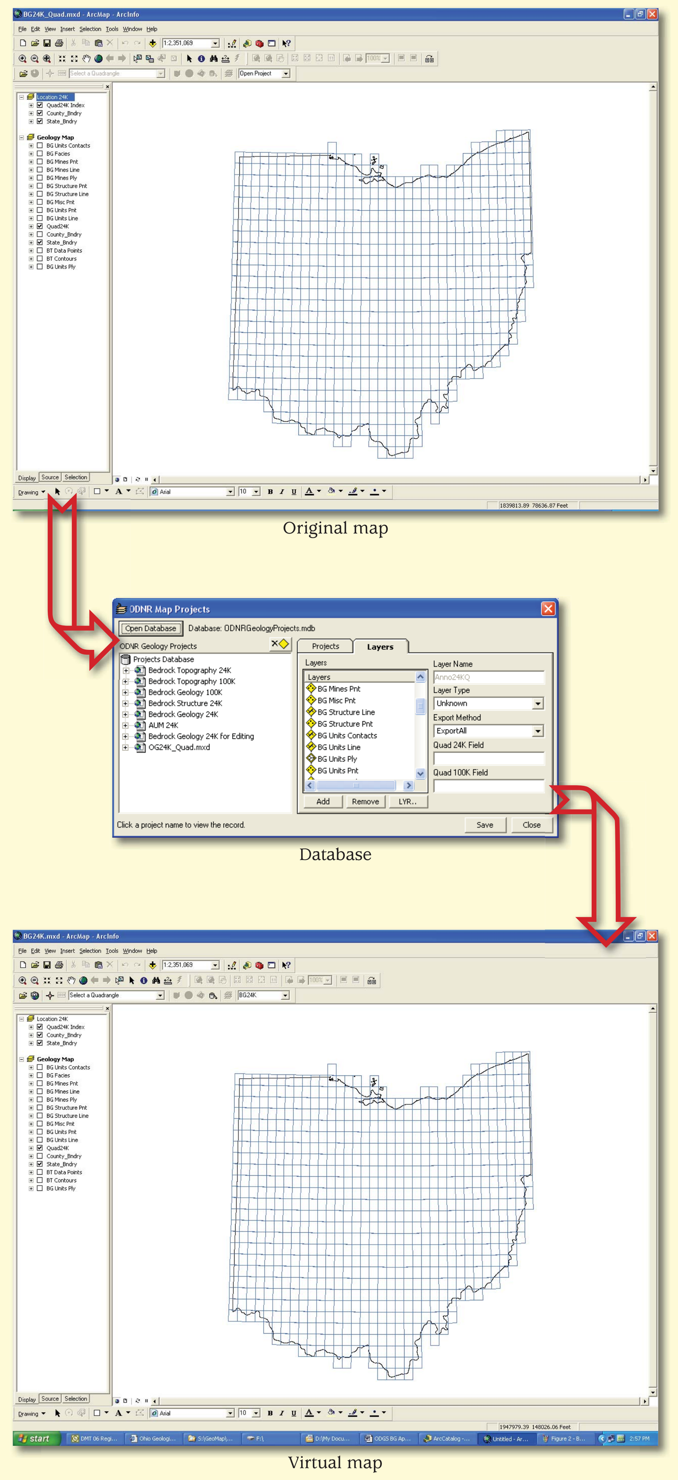

FIGURE 22

MULTIPLE DATA SOURCES

In a typical heterogeneous computing environment, data and applications can reside in many different servers, desktops, and physical locations. The Map Application can switch easily between different data sources, without having to manually reset any of the layers in the ArcMap. This eliminates the need for the end user to know where the data resides and for teaching the end user about the storage of GIS data in SQL databases. In addition, having the Map Application easily switch between data sources allows for easy installation of the Map Application on laptops and remote office locations.

The Map Application does not use ArcCatalog to access the data sources; the data source path and related information are stored as registry settings. Setting the data source paths and storing them in the registry is done using a form (Fig. 23) in the Map Application. The user easily can switch between data sources from a personnel geodatabase or data from the enterprise server, ArcSDE. Once a data source has been selected, the Map Application builds data source paths, which can be either file based or ArcSDE based. The paths are then compared to data source paths for the layers as the ArcMap opening. If the data source paths are different, then the layer's old data source paths are replaced with the new paths. All of this is transparent to the GIS user, who never has to reset a data source path.

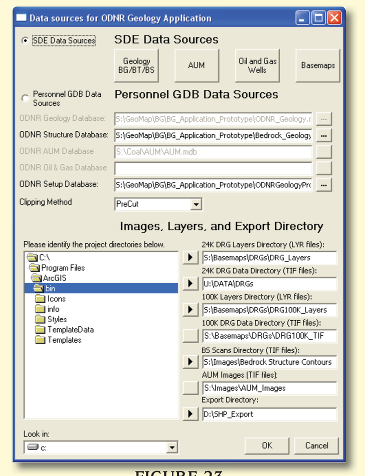

FIGURE 23

METADATA

A quadrangle-metadata database (Fig. 24) is used to supply the titles, authors, and revision dates to maps generated by the Map Application (Fig. 25). The quadrangle-metadata database can be used for additional purposes, such as updating the National Geologic Map Database (NGMDB) Map Catalog. Future functions of the application may include placing a standard bibliographic citation on the maps, as obtained from the quadrangle-metadata database. Another function may create individual metadata records, so when the map data is exported, customized metadata records can be exported with it.

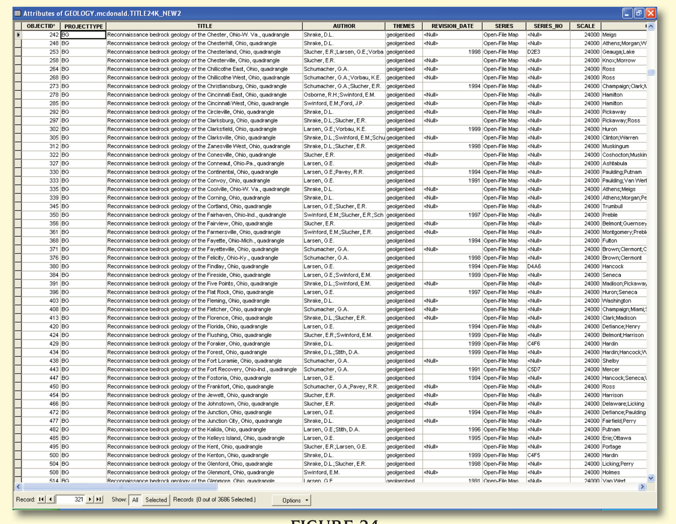

FIGURE 24

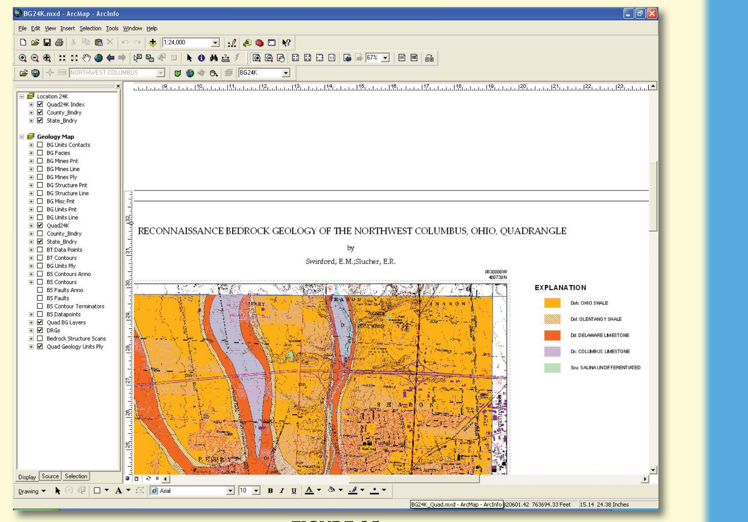

FIGURE 25

STRATIGRAPHIC ORDER

The legend on the bedrock-geologic maps has the geologic units displayed in the correct stratigraphic order. Each geologic unit in Ohio has been assigned a numeric code, based on a modified version of the AAPG Committee on the Statistics of Drilling (AAPG-CSD) coding standard. As a geologic map is extracted from the geodatabase, the polygons for the geologic map are examined for the unique occurrences of the geologic units. These unique geologic units are sorted by their AAPG-CSD codes, and the legend is generated based upon the sort order (Fig. 26).

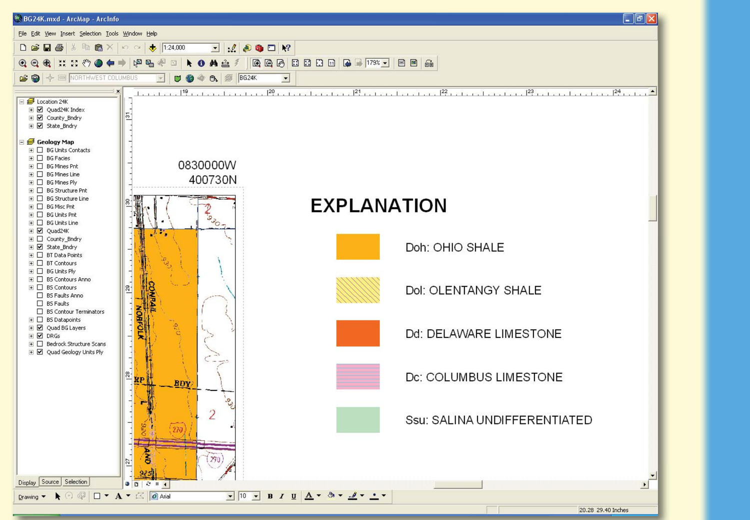

FIGURE 26

FUTURE ENHANCEMENTS

A number of future enhancements are being considered for implementation within the Map Application:

1. A full dynamic legend, specific for each geologic map.
2. Full metadata for each map during export.
3. Closing of the neatline to the quadrangle boundary.
4. Generating irregularly shaped maps, such as geologic maps of counties and cities.
5. Easy addition of new map themes.
6. Metadata form for editing.
7. A database structure that is compliant with the North American Geologic Map Data Model (NADM).

CONCLUSIONS

The ODNR Division of Geological Survey Map Application has proved to be successful in its initial deployment. The application is used on a daily basis in the Geologic Records Center (GRC). Sales of print-on-demand maps are made from the Map Application since its deployment in September 2006. The GRC sales staff had no GIS experience, but with just a two-hour training course, the staff was able to create print-on-demand maps for sale without any additional support. The supervisor of the Geologic Mapping & Industrial Minerals Group had limited GIS experience. Again, with only a two-hour training course, the supervisor was able to generate custom maps to help answer public-service requests. Initial feedback indicates novice GIS users find the Map Application easy to use for generating maps from standard map themes and for building custom maps derived from those standard map themes. The Map Application should allow novice GIS users to build confidence in their GIS map-making and analytical abilities.

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