Creation of a New Statewide Bedrock Geologic Map for Missouri

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INTRODUCTION

The previous edition of the 1:500,000-scale *Geologic Map of Missouri* was published in 1979. Since that time, the bedrock geology for approximately 40% of the state has been revised, updated, or mapped in greater detail. Beginning in 1997, ArcView (versions 3 through 3.2) has been used to compose 1:24,000-scale geologic maps. Some 1:100,000-scale maps had been compiled from these, but no statewide digital compilation of existing geologic maps had been attempted. The occasion of the 150th anniversary of the creation of the first Missouri Geological Survey seemed an appropriate time to make a new edition of the 1:500,000-scale map of the bedrock geology of Missouri, and to create an easily updateable digital version.

Development of the Missouri Environmental Geology Atlas (MEGA) was also proposed to be completed for the sesquicentennial. MEGA is a collection of statewide Geographic Information System (GIS) data layers that were produced as a reference resource to aid in environmental evaluations. The shapefile for the 2003 edition of the *Geologic Map of Missouri* was incorporated into the MEGA project.

ASSEMBLING THE DATA

Sixty-five 1:24,000-scale bedrock geologic maps were already available in a digital format in the form of shapefiles. The 1979 version of the *Geologic Map of Missouri* was also available in a digital format. Approximately 22,000 square miles (400 7.5' areas) of geologic contacts needed to be digitized in order to incorporate all new mapping into the sesquicentennial map. These maps were at various scales ranging from 1:24,000 to 1:250,000. Several university students were hired to scan and georeference paper maps, perform heads-up digitizing with ArcView 3.2, and attribute the maps. Old geologic maps that had been hand-drawn on paper or mylar were scanned at 200-300 dots per inch using a 36-inch scanner. Maps were georeferenced, generally with respect to topographic quadrangle boundaries, using ESRI Image Analysis software. In order to be compatible with available USGS digital raster graphics (DRGs) of topographic maps, the location data were stored with the NAD 27 datum.

Most of the existing 1:24,000-scale digital maps had been created solely to place in an ArcView layout to produce a hard copy map of an individual 7.5'quadrangle, with no intent to provide a digital product. Many individual maps were composed of multiple ArcView themes that had been created with one theme per bedrock unit in order to ease editing. These themes had to be unioned and properly attributed.

COMPILATION

The statewide geologic map was compiled using ArcView 3.2. Compilation involved deleting some areas from the 1979 statewide map and then appending the new mapping into the shapefile. Overlapping polygons with the same attributes were unioned together. Mismatches along quadrangle boundaries and abrupt changes in detail were obvious at this stage. Also, irregularities along some of the quadrangle boundaries, such as gaps or holes, and long, thin polygons (which we referred to as slivers) caused resolution problems. Many of these were removed using the Dissolve Adjacent Polygons tool from Jenness Enterprises (http://www.jennessent.com/index.html). Some of the largest of the slivers were found by calculating polygon areas to find small polygons, and having a geologist decide which polygons were slivers and which were legitimate polygons. Other spatial problems were corrected using tools that are within ArcView's Compiled Theme Tools. These include:

Shape Tools
    Detect Intersecting Polygons
    Dissect Intersecting Polygons
    Detect Hole
Miscellaneous Tools
    Simplify Shape by Removing Vertices

At this point, the map needed to be edited by staff geologists who corrected boundary mismatches, and inaccurate attributes, and smoothed the transitions between areas mapped at varying scales. However, the data layer was too big to be edited on any of the geologists' computers. The size of the shapefile needed to be reduced. This was accomplished in four ways.

1. The number of vertices was reduced using a vertex weeding routine.
2. Large, complicated polygons were split into 2 or 3 pieces
3. The theme was "cleaned" in both ArcView 3.2 and ArcInfo 8. (ArcView 3.2 "CLEANS" were made for speed and convienence, to gain a better broad understanding of the effect of splitting on the process. ARCINFO 8 allowed more precise control of "CLEAN" parameters.)
4. The state map was split into 3 pieces.

The fourth step also allowed more than one geologist to edit the map at the same time. The three pieces of the map were later put back together using the Geoprocessing Wizard extension. The final editing process determined the necessary map units and any exaggeration of features for viewing at 1:500,000-scale.

CREATION OF THE CROSS SECTION

ArcView 3D Analyst was used to create a topographic profile from a statewide compilation of USGS DEMs. The location of the cross section was selected to pass through an interesting and representative section of the geology of the state emphasizing some of the major structural features. The locations of deep, logged wells were also considered when selecting the cross section location. These wells would provide the formation tops for the subsurface part of the cross section. The cross section was split into two parts in order for it to fit on the map layout. The state capitol, Jefferson City, was a convenient and significant location to divide the cross section.

The line of cross section was placed on the geologic map in ArcView 3.2. A theme was created that reflected the surface geology along the line of cross section by clipping a narrow polygon strip from the bedrock geology shapefile along that line. This clipped theme retained the formation attributes.

The profile was then scaled to the desired vertical exaggeration and placed on a scaled grid. The strip of surface geology was repositioned and projected onto the profile and the geology was transposed to the profile. Formation tops were added to the wells by posting attributes from a modified well log database. The geologist then drew the cross section as a polygon theme using these data points.

THE LAYOUT

The layout was created in ArcView 8 however; to facilitate labeling, point themes with the label attributes were made in ArcView 3.2. These "labeling themes" were created for roads and rivers, as well as for the bedrock. For these themes, reference points were created for each of the lines and polygons that were to be labeled. These were selected based on size and density of features. These themes were brought into ArcView 8 and the reference points were labeled. In this way the position of labels could be more easily controlled while still allowing the use of autolabeling.

Text was created using Microsoft Word software and was copied and pasted into text boxes on the layout. Multiple "data views" were created for the primary map, the cross section, and the inset maps. Images of the logos for the Department of Natural Resources and the Geological Survey Sesquicentennial were inserted as pictures.

Problems encountered during the layout phase included proximity of objects on the layout. When a graphic or text item was placed too close to the edge of the layout or too close to another item, these graphic and text items did not legibly print. Color selection was a more time consuming process than expected since colors that contrasted well on the computer screen did not always contrast well in print. Many variations in color combinations were selected and printed before the final selection was made.

To allow for easier reference to more detailed mapping, 7.5' quadrangle outlines and names were printed on the map. To improve readability, the township and range lines, present on the 1979 version, were not included. The earthquake epicenters in southeast Missouri from 1973 to 1999, and a map of major tectonic features were added as insets.

Updates and changes to the map explanation column were extensive. For simplicity and accuracy it was decided not to include a graphic representation of the lithology on the geologic column, as had been done on the 1979 version of the map. Series names, particularly in the Carboniferous had changed considerably since 1979.

REVIEW AND RESULTS

The map was printed and reviewed by the geologists involved in producing the map. The map was also posted so geologists throughout the survey could comment on

the map. Several errors were found and corrected. Final changes to the colors were made at this time.

The layout was printed to a postscript file from ArcMap 8 and sent to Adobe Distiller 5.0 with custom settings for the HP3500 printer. Problems encountered at this stage included obtaining the desired fonts and paper sizes. Correcting for this was primarily a matter of trial and error. This required all the fonts in ArcMap to be downloadable. A major obstacle was that the postscript driver did not recognize the landscape format and ArcMap will not create a postscript file if the Windows driver is used. When landscape is attempted, the map will rotate but the right side will be cut off. To work around this situation, the map was given a false paper size, but this required extensive trial and error. After a large amount of experimentation with settings and numerous test prints, the file was sent to the printer for production.

The shapefile that had been created for the 2003 *Geologic Map of Missouri* is included in the Missouri Environmental Geology Atlas, or MEGA. MEGA is a collection of statewide Geographic Information System (GIS) data layers. The variation in scale of the various source maps for the statewide map is noted in the metadata. The bedrock geology shapefile has been updated subsequent to the publication of the 2003 *Geologic Map of Missouri*. In the year since its creation, approximately 200 MEGA CDs and 300 paper geologic maps have been distributed. This is the approximate number that was anticipated.