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Geologic Mapping at the Missouri Division of Geology and Land Survey

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BACKGROUND

The Missouri Division of Geology and Land Survey (DGLS) produces maps that show the distribution of surficial material and bedrock units. The maps are produced for distribution at a scale of 1:24,000. Regional maps are published at smaller scales, such as 1:100,000, and are compiled from the larger scale geologic maps. The maps are provided to the public as paper copies or as digital image files.

Geologists at DGLS began using GIS to produce geologic maps in 1997 by using ArcView™ to recreate maps previously drawn on paper. Since that time, they have transitioned to ArcGIS™, and use GIS to compile the geologic maps. The geology of approximately 110 7.5-minute quadrangle areas has been produced digitally since 1997. The mapmaking and production process has evolved since that time. DGLS is currently in the process of transitioning from paper to electronic field notes.

Most information used to make a new geologic map comes from field work. Geologists collect information about exposures of bedrock and surficial materials and record the locations where the data was collected. To create a bedrock geologic map at a scale of 1:24,000, geologists try to collect at least 11 control points per square mile, or about 660 control points per 7.5-minute quadrangle. A control point consists of the location of a bedrock exposure along with a description that includes formation name, lithology and structural information such as strike and dip measurements. Control points are collected along roadways and on foot traverses. A geologist will walk from 50 to 100 miles during a field season to prepare a geologic map for one 7.5-minute quadrangle. Most field work takes place during the fall, winter and early spring when leaves are down. U.S. Geological Survey (USGS) 1:24,000 scale topographic maps have traditionally been used for data collection and as the base map for the hard copy version of the geologic map. DRG images of these maps currently serve as bases for the geologic maps.

DATA COLLECTION

Databases of well logs and measured sections are maintained at the DLGS. For each area to be mapped, this information is added to an ArcMap™ project prior to the beginning of the field season. Information also is included from published references relating to the study area. Aerial imagery, stored on the department's data server, may reveal lineaments related to geologic structures, and so this information also is incorporated into the GIS project. Standards for data file names and database field names are defined in “Missouri Technical Geological Mapping Standards”, an internal, working document (Middendorf, 2008). A personal geodatabase is developed for outcrop descriptions, spring locations and any other data that may be collected in the field. Ultimately, the goal is to create a centralized database for field data collection. The “Get data for ArcPad” tool is used to check out data for field editing. Panasonic Toughbook™ notebook computers allow the geologists to carry this information to the field.

Field data are collected on the Toughbook™ notebook computers loaded with DRGs and ArcPad™. A Garmin™ GPS receiver communicates with the Toughbook™ via Bluetooth technology. The small GPS receiver is easily held in the hand as the computer is cradled in the crook of an arm just as any notebook would be held. Ease of carrying is important since long hikes are required to collect required information for the geologic map. This equipment allows the geologist to enter field data directly into a GIS while doing a traverse or to collect field data using pen and paper and then to transfer the data in the motel room in the evening. Field data is collected into shapefiles in the ArcPad™ project.

The outcrop database is simple and flexible. It contains four fields – field ID, formation, lithology, and structures. Only the formation field has a specified domain. This domain contains all of the unit names that are expected to be present in the study area. The lithology and structures fields are text fields where the geologist can describe those attributes in 40 characters or less. Supplemental information is collected on paper. At the end of the project, paper field notes are typed into Word™ or scanned. These notes are archived with the ArcMap™ project on the server.

When the geologist returns to the office, the field data is incorporated into the ArcMap™ project by using the “Check in edits from ArcPad” tool. Final interpretation of the field and existing file data is done in the office. This is when geologic contacts and structural features, such as faults and folds are added to the project.

MAP DEVELOPMENT

Summary and interpretation of the data is represented with a map showing the distribution of map units and locations of geologic structures. It also includes text descriptions and cross sectional representations. The line, point and polygon shapefiles that respectively represent geologic structures, strike and dip measurements, and distribution of map units are drawn in ArcMap™ by the geologist that collected the data. Points locating observed contacts are also included on the maps. These shapefiles are archived for smaller-scale compilations.

Map layout includes components such as text description of units, north arrow, cross sections, a correlation chart and a stratigraphic column. The bedrock geologic map, cross sections, stratigraphic column, correlation chart and a map showing data point locations are developed as data frames in ArcMap™. Description of units, structural features, a discussion of economic geology and references are included as text boxes. The legend is a combination of graphics and text boxes.

In 2008, DGLS began using the CrossView™ plug-in for ArcMap™ to construct the geologic cross sections included in the layout (CrossView™ is available from A-Prime Software, http://www.aprimesoftware.com/). CrossView™ significantly reduces the amount of time necessary to create a cross section. With this plug-in, the geologist can display information from well logs and even drape the newly created geologic map across the topographic profile.

Standard USGS DRGs, scanned at 250 dpi, have been used by DLGS as digital base maps for geologic maps for several years. However, the resulting geologic maps were sometimes difficult to read. It was determined that the appearance of the final geologic maps could be improved by starting with better quality base maps. Base map appearance has been improved in two ways. The appearance has been muted by representing contour lines and text as a dark gray color, allowing the geology to be more prominently displayed. In addition, DGLS has begun using DRGs produced in-house at higher resolution than the standard USGS DRGs. To accomplish this, a paper topographic map is scanned at 400 dots per inch. Adobe Photoshop CS3™ is used to convert the TIF file to a 32 index color TIF image and to remove the green (forest) color from the image, as well as to remove some of the map collar. The higher resolution base maps will improve the legibility of the paper product and the appearance of the digital image (Starbuck and Loveland, 2009). Map layouts are exported from ArcMap™ as PDF files for on-demand plotting. Data and maps are archived as shapefiles. A summary of geologic mapping procedures at DLGS is shown in Figure 1.

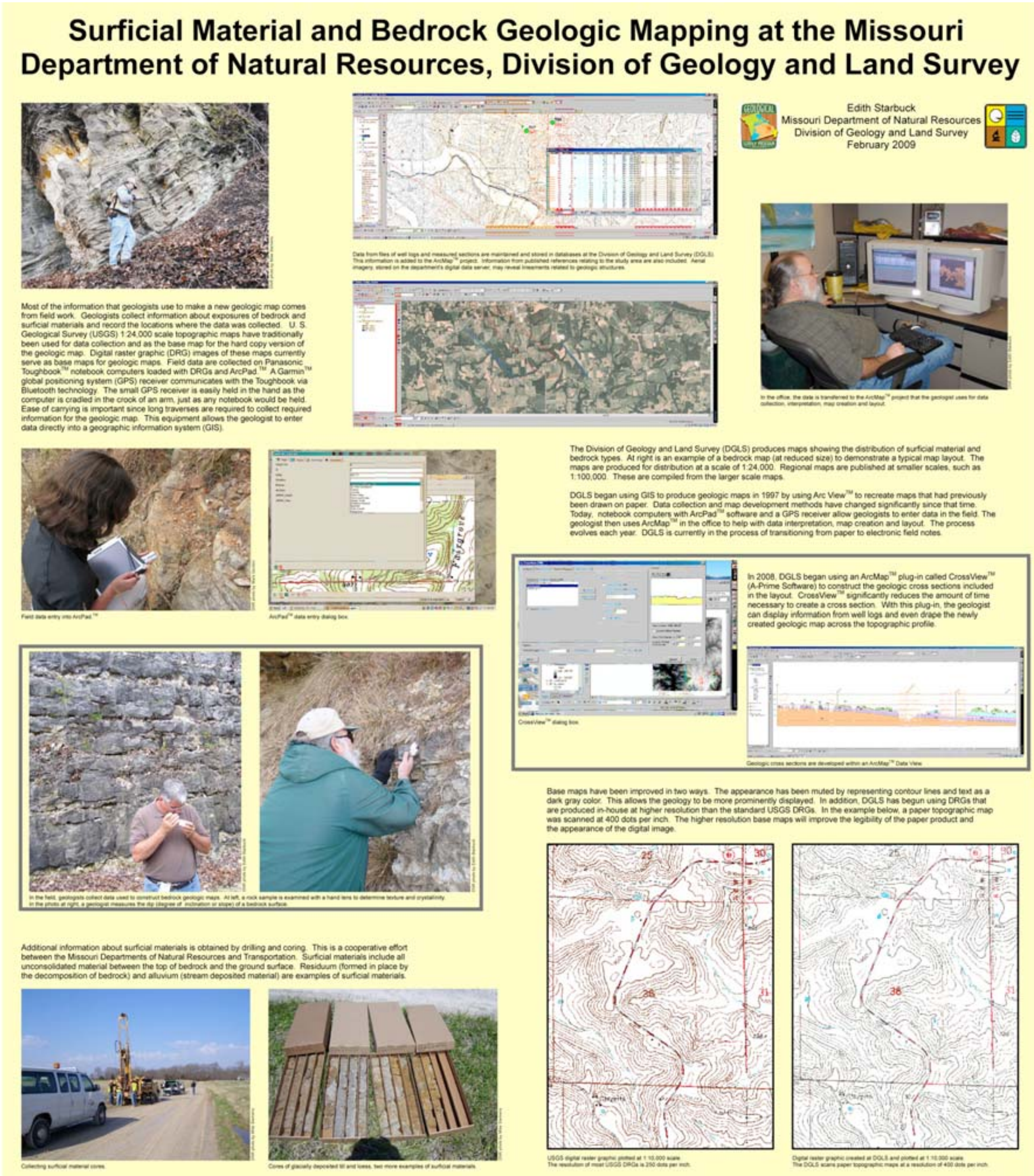

Figure 1. Surficial material and bedrock geologic mapping at the Missouri Division of Geology and Land Survey (a full-resolution copy of this figure is available at http://ngmdb.usgs.gov/Info/dmt/docs/DMT09_Starbuck.pdf).

LOOKING TO THE FUTURE

The geologic mapping process at DGLS continues to evolve. Server limitations will require an archival method that makes full use of geodatabases as well as shorter file and folder names. DGLS is currently looking at methods of creating vector-based base maps in order to obtain a crisper-looking map. Certainly, as the use of field computers becomes routine, mappers will see new ways to use them.

REFERENCES

Middendorf, M.A., 2008, Missouri Technical Geological Mapping Standards: Missouri Department of Natural Resources, Division of Geology and Land Survey, 68 p.

Starbuck, Edith, and Loveland, Karen, 2009, Improving the Legibility of Base Maps for Geologic Mapping at the Missouri Division of Geology and Land Survey *in* Soller, D.R., ed., Digital Mapping Techniques '08 – Workshop Proceedings: U.S. Geological Survey Open-file Report 2009-1298, p. 201-203, http://pubs.usgs.gov/of/2009/1298/.