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Replacing the USGS Topographic Quadrangle: Basemap Alternative for Geologic Maps

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For decades, USGS topographic quadrangle maps have been used by geologists as the base for geologic mapping applications. USGS topographic maps have provided consistently high-quality map data and symbolization (fig. 1). A variety of derived products has been created from these topographic quadrangle maps, including greenline sheets, scans of the paper maps, Digital Raster Graphics (DRG), Digital Line Graphs (DLG), and Raster Feature Separates (RFS).

When the USGS ceased to update and revise the paper topographic maps, the currency of many geographic areas has gradually become unacceptable. For example, "Provisional Edition" USGS maps created with metric contours have not been updated to be consistent with the standard contours in feet. DLG feature layers were never completed for many states, first generation DRGs are too coarse in resolution, second generation DRGs were never completed nationwide,

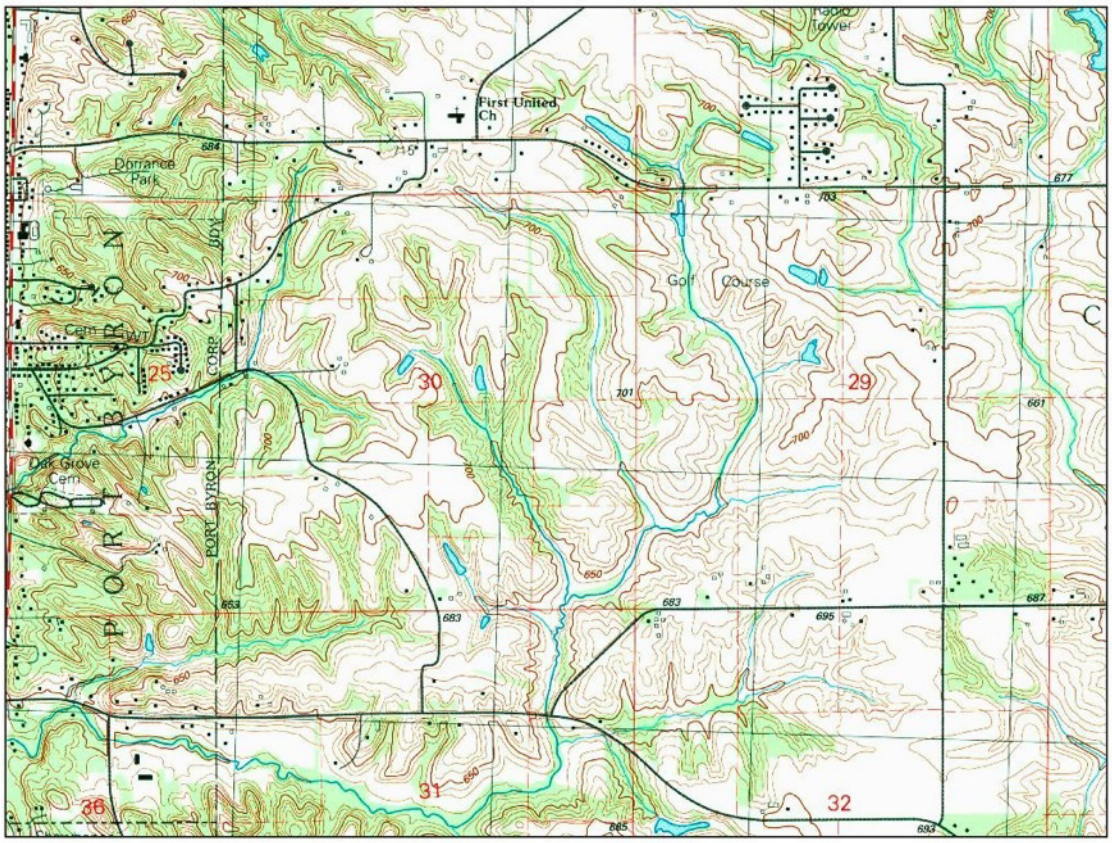

Figure 1. USGS 7.5-minute Port Byron, IL-IA, quadrangle, published in 1991.

and RFS products are no longer produced by the USGS. Many states have been left with incomplete digital base data and quadrangle maps that are significantly out of date.

US Topo

For the past 125 years, the USGS has produced topographic quadrangle maps that have served as the base for geologic mapping applications. In 2009, the USGS introduced the replacement for the lithographic printed 1:24,000-scale topographic map—the US Topo (see fig. 2). US Topo maps have a much different appearance and generally have less feature information than traditional USGS topographic quadrangle maps. US Topo data layers include contours, roads, geographic names, hydrographic features, and an imagery base; additional layers eventually will be added including expanded transportation, boundaries, structures, and land cover feature information. As of April 2012, nearly 55,000 US Topo maps for all or portions of 39 states were available at the USGS Map Store (*http://store.usgs.gov/*).

Figure 2. US Topo version of Port Byron quadrangle, published in 2010.

US Topo maps are only available in GeoPDF format. They include data layers similar to the USGS topographic map, including an imagery base (not shown in figure 2). For those areas for which US Topo coverage is available, there are challenges in using the maps as base information for geologic mapping (fig. 3). For example, it is currently not possible to import a GeoPDF-format file into ArcGIS software; it is also not possible to import the feature data into design software such as Illustrator and retain the critical georeferencing information or maintain the feature data as separated layers. Furthermore, whereas the roads, geographic names, and hydrographic features have been updated, the contour data layer for the majority of the US Topo maps has not been updated, and the appearance of the contours has changed significantly. Finally, as more high-resolution LiDAR (Light Detection And Ranging) topography becomes available, geologists will be faced with the problem that geology mapped using LiDAR will not register to USGS base data.

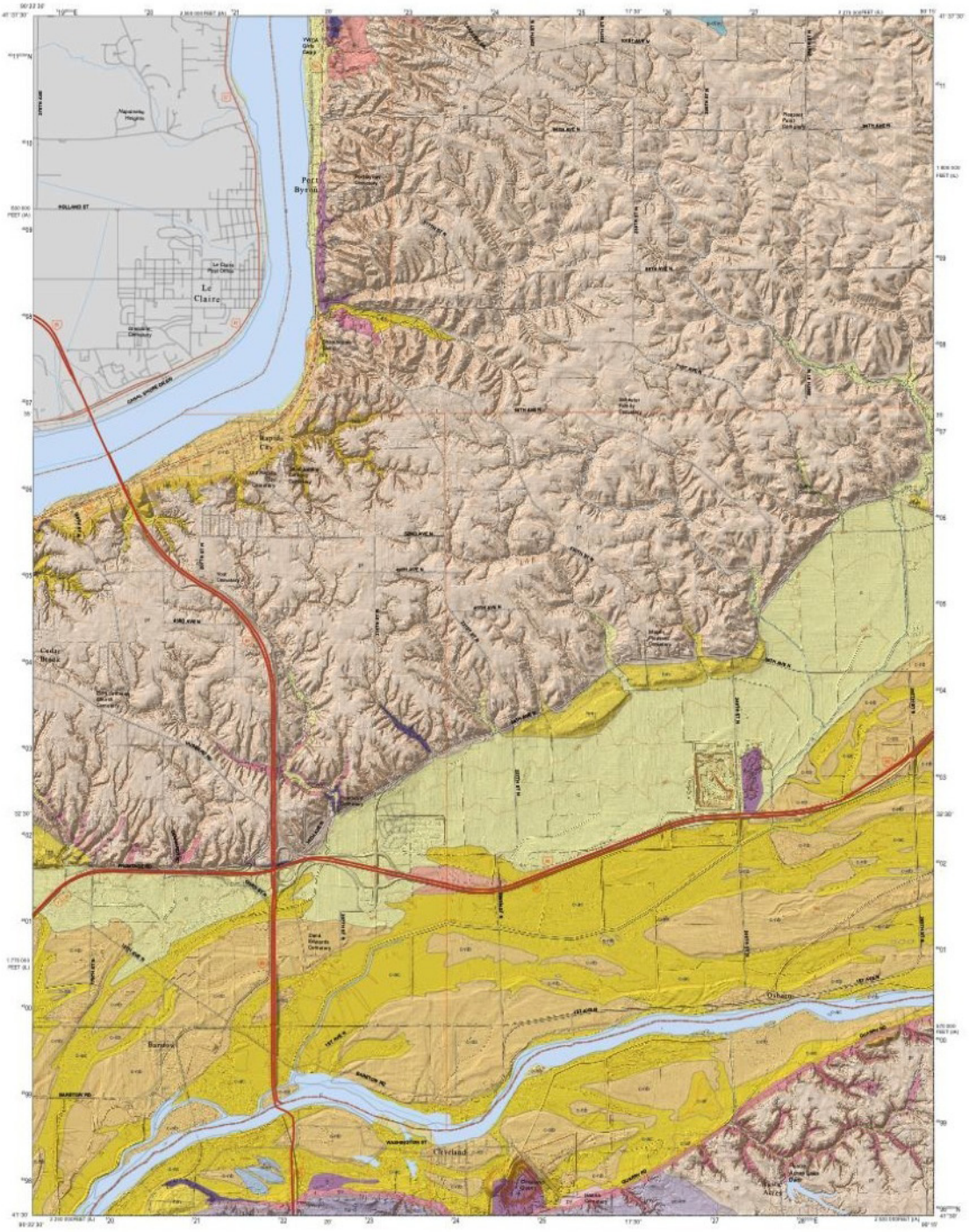

Figure 3. US Topo version of Port Byron quadrangle, with surficial geology.

Because topographic information is a critical input to geologic mapping, it is important to understand the changes to the contour feature data represented on the US Topo maps as compared to the traditional USGS 7.5-minute topographic quadrangle maps. The accuracy and content of the topographic information on US Topo maps is dependent upon the quality of the elevation data within the USGS National Elevation Dataset (NED), which is variable across the United States both in terms of spatial and temporal resolutions. US Topo and NED data are available at *http://nationalmap.gov*. A mixture of mostly one-third arc-second (nominal post spacing (NPS) of 10 meters) digital elevation model (DEM) data and lesser amounts of one arc-second (NPS of 30 meters) DEM data represent the NED source information for the US Topo contours. At this date, LiDAR-enhanced elevation data are completed for approximately one-quarter of the United States, and the majority of one-ninth arc-second (NPS of 3 meters) NED data are produced from LiDAR source information. For those areas where LiDAR data have been ingested into the NED, the original resolution elevation data are first downsampled to one-third arc-second resolution for production of US Topo contours. LiDAR-derived elevation data provide far more current, accurate, and detailed topographic information than has been used for the historical 7.5-minute topographic quadrangles, which are the dominant source for the NED. LiDAR data give us the opportunity to evaluate NED data against a topographic model that is significantly more accurate. This is especially true for geomorphically active areas where the NED source data are several decades old.

The USGS 7.5-minute Port Byron, IL-IA topographic quadrangle was selected for the evaluation (fig. 2). The US Topo for this quadrangle was produced in 2010, and the most recent historical edition was published in 1991 (fig. 1). The contour feature layer for the 1991 edition was produced from photogrammetric compilation of 1986 aerial photography, and a 1:24,000-scale hypsography DLG was created from scanning and conversion of the contour mylar feature separate for the quadrangle. Figure 4 shows the DLG hypsography for a portion of the quadrangle on a shaded relief image produced from NED one arc-second DEM data, which as of this date is still the best available NED source data for the quadrangle.

Figure 5 shows cartographic contours produced from source 2009 LiDAR DEM data with a nominal post spacing of 1.2 meters. The DEM data were resampled to one arc-second resolution to match the NED source data and used to create the shaded relief base image. The original photogrammetric-based contours in figure 4 compare favorably to the contours generated from the resampled LiDAR DEM. Despite the significant downsampling of the original LiDAR DEM, note the enhanced landscape feature detail that is retained as compared to the NED source one arc-second DEM shown in figure 4.

Figure 4. USGS Hypsography Digital Line Graph for a portion of the Port Byron IL-IA quadrangle.

Figure 5. Cartographic contours produced from LiDAR source data for a portion of the Port Byron IL-IA quadrangle.

Figure 6 shows the contour feature layer for the 2010 Port Byron, IL-IA US Topo map, produced by direct generation from the NED one-third arc-second DEM data. The process of interpolating a DEM from contour data and then extracting contours from that DEM necessarily degrades the accuracy and detail of the original contour data. When the US Topo contours are compared to the original source contours (fig. 4) from which the NED was generated, it can be seen that important landscape feature details have been lost. This is more easily seen in figure 7, where the US Topo derived contours and the hypsography DLG-based contours have been superimposed for comparison. Note how finger-tip tributaries are missing, and slope facets are smoothed, resulting in a geometrically smoothed landscape surface. The discrimination of topographic features critical to the interpretation of geologic features has been substantially reduced.

Figure 6. US Topo contour feature layer for a portion of the Port Byron IL-IA quadrangle; contours produced from NED one-third arc-second DEM data.

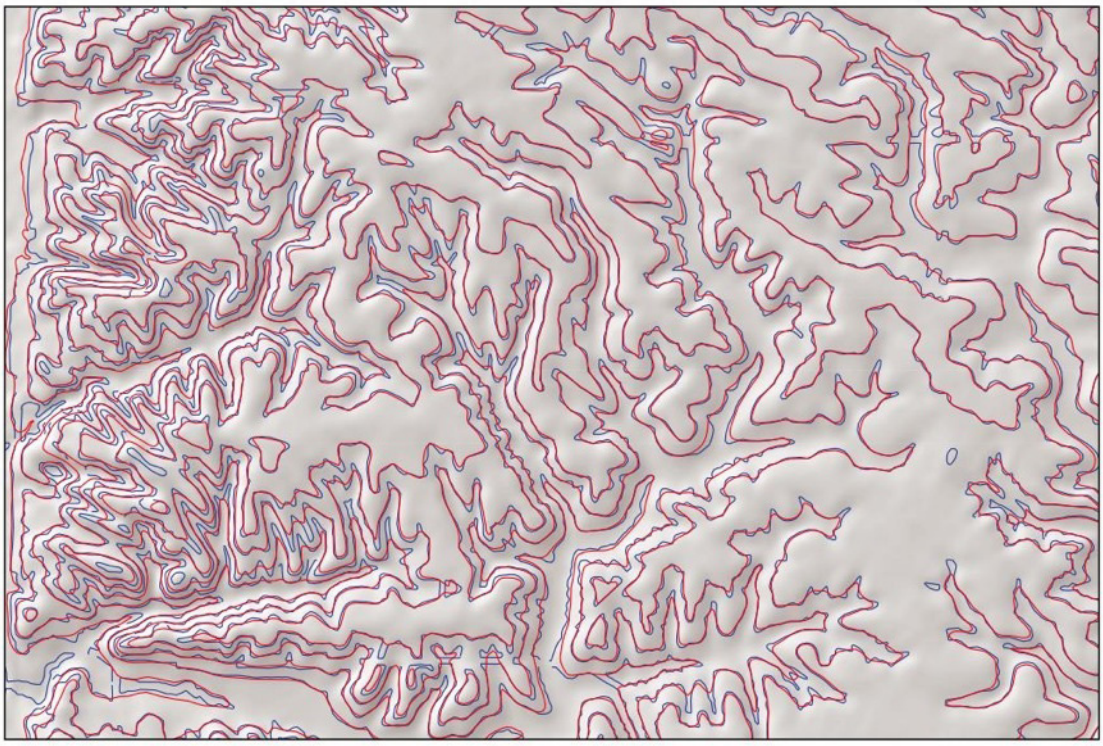

Figure 7. Comparison of contour feature layer from US Topo and Hypsography DLG for a portion of the Port Byron IL-IA quadrangle.

Basemap Alternative

Because of the lack of availability and the outdated status of USGS topographic quadrangle base data products, coupled with data format and quality issues with the US Topo, it makes sense to build custom basemaps for new geologic products. TIGER-based transportation and NHD hydrographic data, LiDAR-produced contours and shaded relief images, and, when available, a USGS scanned lettering feature layer from the original USGS topographic quadrangle maps can be integrated to produce a current and high-quality basemap for geologic mapping applications (fig. 8).

Note: Discussions with USGS and additional investigation since this poster was presented in May 2011 have shown that significantly improved results are possible when NED one-third arc-second source data are used to generate the contour feature layer for the US Topo maps. It is expected that by the end of 2013, all one arc-second elevation source data remaining in the NED will be replaced by one-third arc-second or better source data. New versions of US Topo maps for Illinois will be available in June 2012.

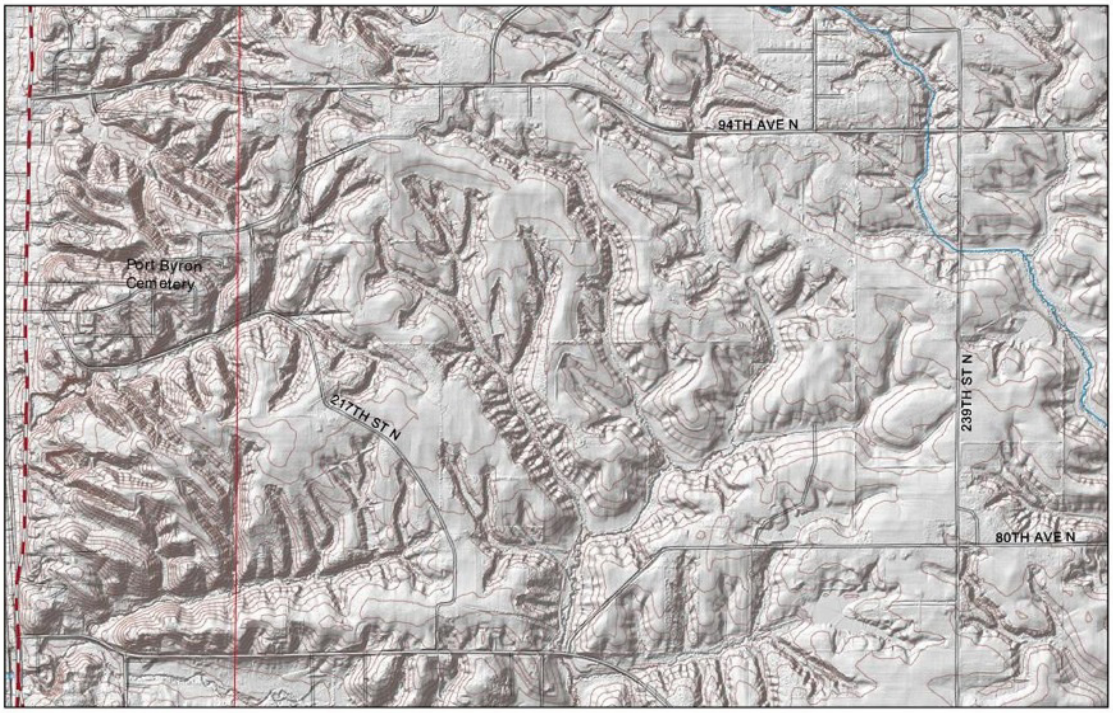

Figure 8. Custom basemap for Port Byron quadrangle; includes 2009 TIGER, LiDAR, and NHD data.