DRAFT -- To be published in DMT'07 Proceedings
(see http://ngmdb.usgs.gov/Info/dmt/)

Importance of Historical Elevation Data

By Gayle H. McColloch, Jr. and Jane S. McColloch

West Virginia Geological and Economic Survey
1 Mont Chateau Road
Morgantown, WV 26508-8079
Telephone: (304) 594-2331
Fax: (304) 594-2575
email: mccolloch@geosrv.wvnet.edu, janemc@geosrv.wvnet.edu

INTRODUCTION

Our recent geologic mapping projects are performed as part of the joint AASG/USGS Statemap program. We begin with products of the West Virginia Geological and Economic Survey's Coal Bed Mapping Program (CBMP). This program captures and analyzes mineral resource data to produce a series of GIS data sets that model coal resources statewide. The primary foci of this program are to produce data that can be input into modeling software to establish the value of coal beds to produce mineral tax assessments and, since the Quecreek Mine rescue on July 28, 2002 in Somerset County, PA, capturing mining data geographically and stratigraphically.

Products of the CBMP include:

- Bed structure (vector contours and grids)
- Bed thickness (vector contours and grids)
- Bed partings (vector contours and grids)
- Mined areas
- Bed discontinuities
- Coal boundaries
- Bed thickness point locations
- Bed elevation point locations.

GEOLOGIC MAPPING METHODOLOGY

In Carboniferous rocks of the Appalachian Plateau, formation contacts commonly are widespread coal beds or other persistent horizons. Many, but not all, of these coal beds are economically important. Examples of stratigraphically important, persistent horizons from our current mapping area that are not economic resources include the Ames Limestone and Shale of the Upper Pennsylvanian Conemaugh Group and the Jollytown coal bed of the Upper Pennsylvanian (Basal Permian?) Dunkard Group.

Because one focus of the CBMP is to determine economic coal resources, our first task is to determine if important coal beds have not been mapped or are not considered

economic resources within our study area, and to identify where gaps in CBMP data exist and where additional stratigraphic data is needed.

After analyzing previous work, we collect additional data from new fieldwork, records on file at WVGES, and other sources such as state Division of Highways borings. The new data are used to fill in the gaps in CBMP data products. Our first product is a series of elevation grids representing all important horizons not mapped by CBMP. Outcrop lines are generated by intersecting the horizons with digital elevation models (DEMs). We generally use 2003 1/9 arc second DEMs (USGS et al, 2005a) derived from West Virginia State Addressing and Mapping Board photography completed in the first half of 2003 (USGS et al, 2005b), but for areas where the original topography has been significantly altered since the photography was completed we sometimes need to work with older topographic information. Outcrops of all important horizons, including the CBMP products, are plotted on topographic bases to produce field maps (Figure 1).

The outcrops plotted on these field maps are field checked, and outcrops lines and structure contours are revised as necessary. Revised structure contours are used to generate new grids. Since we also have 2003 digital orthophoto quarter quads (DOQQs) with 2-meter pixel resolution, the final step is to digitally overlay onto DOQQs the final, corrected outcrops and examine the linework for otherwise undetectable problem areas. These outcrops are used to construct open file report maps and ultimately to produce GIS datasets. Cross sections are created by generating profiles of all important horizons using the elevation grids and the DEM.

TOPOGRAPHIC COMPLICATIONS RELATED TO HUMAN ACTIVITY

During field work for our mapping project in the Wheeling, West Virginia area, we found several areas where the topography had been so significantly altered that outcrop generation using the most recent topographic data was erroneous, and it was necessary to revert to DEMs based on older topography and even plane-tabled topography (U.S. Geological Survey, 2005) from a 15-minute, 1:62,500 series map to better identify the correct locations of geologic unit contacts.

An excellent example of geologic mapping problems related to altered topography is the Wheeling-Ohio County Airport area on the Tiltonsville 7.5-minute quadrangle. The topography on this 1:24,000 map was produced in 1966 (U.S. Geological Survey, 1997b). The airport was built in the mid 1940s and dedicated on November 1, 1946 (Quarles, 2008). Cut and fill associated with runway construction and surface mining of coal seams in the immediate vicinity of the airport significantly disturbed the original topography (Figure 2).

Another example of profoundly altered topography that required us to revert to using historical topographic information is along Browns Run near Benwood on the Wheeling 7.5-minute quadrangle. This location is near the Consolidation Coal Company's Shoemaker underground mine. The mine portal is located along the Ohio River, and a coal preparation facility and a barge loading dock are located adjacent to the portal. This facility required a nearby mine dump to receive material cleaned from the coal by the preparation plant. We found two types of errors that required correction in this area.

The most obvious problem was an incorrectly derived outcrop of the Jollytown coal, which was produced by intersecting the most recent topography based on 2003 aerial photography and a grid representing the structure of the Jollytown, shown in the circle labeled A in Figure 3. The Shoemaker mine began production in 1966 (West Virginia Department of Mines, 1966) and the topography was compiled in 1956 (U.S. Geological Survey, 1994). The DEMs derived from this topography proved useful in constructing a patch to correct the Jollytown outcrop. This corrected version is also shown in the A circle (Figure 3). While applying this patch a second problem was found in the Waynesburg coal outcrop. The procedure used to derive the DEM from contour lines assumed that ponds represented flat surfaces, as there were no contours. When the outcrop was generated for the CBMP project, the outcrop of the Waynesburg coal crossed the earthen dam instead of extending into the settling pond in the area labeled B on Figure 3. This error was easily corrected as the area is small and the pond's outline reflects the topography. A similar problem was noted in another area where the outcrop of the Waynesburg coal intersects a farm pond on the Bethany 7.5-minute quadrangle.

Another area where topographic changes have affected the computed location of a critical outcrop is on the Valley Grove 7.5-minute quadrangle, which we encountered during our 2007-08 mapping project. An extensive shopping area, the Highlands Complex, is being partially built on a mine refuse dump associated with a preparation facility near the Valley Camp Coal Company's Number 3 mine in the Pittsburgh coal (Figure 4). A new destination sporting goods store and distribution warehouse anchor this complex, and further development of this area is planned. The site topography has been constantly changing since site development began in 2002 or 2003. We estimate the area affected to be in excess of 300 acres with a maximum fill thickness of as much as 100 feet.

The mine dump appears to have significantly altered the topography between 1938, when the first air photos of the area were taken, and 1956, when the first photo-derived topography were produced on the first version of the Valley Grove 7.5-minute quadrangle (U.S. Geological Survey, 1997c). Valley Camp Coal Company has a complex history in the area, and it is difficult to determine an exact date for the construction of the preparation facility from available public records. The 15-minute topography is good enough to suggest that our outcrops are probably near the original location.

Another, less pronounced, but potentially more common, outcrop alteration occurred when I-70 was constructed in the 1970s. Fill has significantly altered the computed outcrop of the Jollytown coal nearby (Figure 5).

CONCLUSIONS

Today the tendency is to assume that newer data are almost, by definition, better than older data. Although newer data are generally more precise and up to date, many reasons exist to preserve older data. We have found that it is critically important to preserve all versions of historical topographic data for geologic mapping in areas that have been disturbed by human activity.

REFERENCES

Quarles, C.C., 2008, Wheeling-Ohio County Airport (HLG) Wheeling, West Virginia: available at http://www.rfci.net/airliner/wheeling.html, accessed January 15, 2008.

U.S. Geological Survey, 1902, Wheeling Quadrangle West Virginia-Ohio-Pennsylvania, 15-minute series (topographic): Washington, DC, U.S. Geological Survey, scale 1:62,500.

U.S. Geological Survey, 1994, Wheeling Quadrangle West Virginia-Ohio, 7.5-minute series (topographic): Denver, CO, U.S. Geological Survey, scale 1:24,000.

U.S. Geological Survey (2005), Topographic Mapping: Online Edition: available at http://erg.usgs.gov/isb/pubs/booklets/topo/topo.html#top, accessed January 14, 2008.

U.S. Geological Survey, 1997a, Bethany Quadrangle Ohio-West Virginia, 7.5-minute series (topographic): Denver, CO, U.S. Geological Survey, scale 1:24,000.

U.S. Geological Survey, 1997b, Tiltonsville Quadrangle Ohio-West Virginia, 7.5-minute series (topographic): Denver, CO, U.S. Geological Survey, scale 1:24,000.

U.S. Geological Survey, 1997c, Valley Grove Quadrangle Ohio-West Virginia, 7.5-minute series (topographic): Denver, CO, U.S. Geological Survey, scale 1:24,000.

U.S. Geological Survey (USGS), West Virginia Statewide Addressing and Mapping Board (WVSAMB), and West Virginia University GIS Technical Center, 2005a, High Resolution 7.5' Quarter-Quad Orthoimages for the state of West Virginia, UTM Zone 17 for entire state, MrSID Compressed: Sioux Falls, SD, U.S. Geological Survey, available at http://wvgis.wvu.edu/data/dataset.php?action=search&ID=254.

U.S. Geological Survey (USGS), West Virginia Statewide Addressing and Mapping Board (WVSAMB), 2005b West Virginia Statewide Digital Elevation Models: Rolla, MO, U.S. Geological Survey, available at http://wvgis.wvu.edu/data/dataset.php?action=search&ID=261.

West Virginia Department of Mines, 1966, West Virginia Department of Mines Annual Report: West Virginia Department of Mines, 256 p.

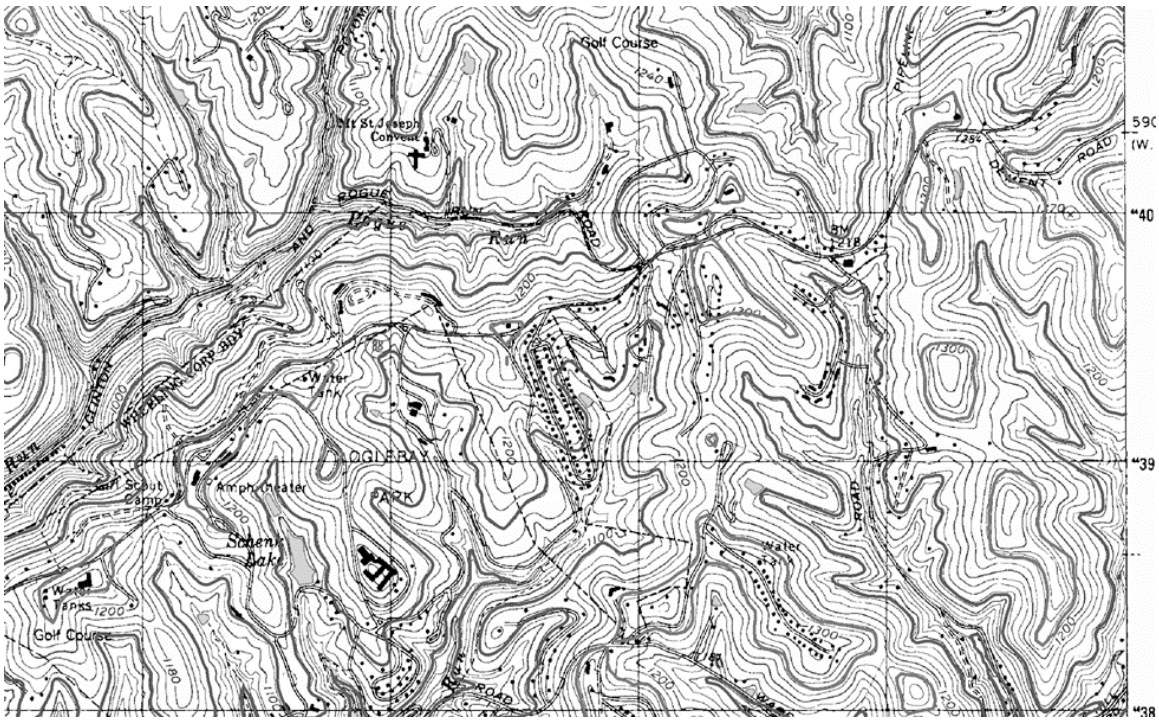

Figure 1. Grayscale image of a portion of the geologic map depicting outcrops of critical horizons of the Wheeling 7.5-minute quadrangle.

Figure 2. The outcrops of the Pittsburgh, Waynesburg, and Washington coals, derived from the 1966 vintage topography of the Tiltonsville 7.5-minute quadrangle (U.S. Geological Survey, 1997b), are superimposed on a 2003 image of the Wheeling-Ohio County Airport. The dashed line represents the original outcrop position of the Washington coal. The Washington was initially surface mined at location A in the mid 1940s to make room for the runway alignment. The solid line represents the cropline of the locally minable Waynesburg coal. It was covered at location B by fill, most of which was apparently removed from location A to construct the runway. The Waynesburg has also been surface mined adjacent to the runways during the 1980s. The dotted line represents the outcrop of the Pittsburgh coal. Subsequently all three coals were extensively surface mined, and the land has been returned to the original contour so the outcrop lines approximate those of the 1940s. The 1:62,500 Wheeling 15-minute topographic map (U.S. Geological Survey, 1902) was also useful in deciphering the excavation and mining history of the area.

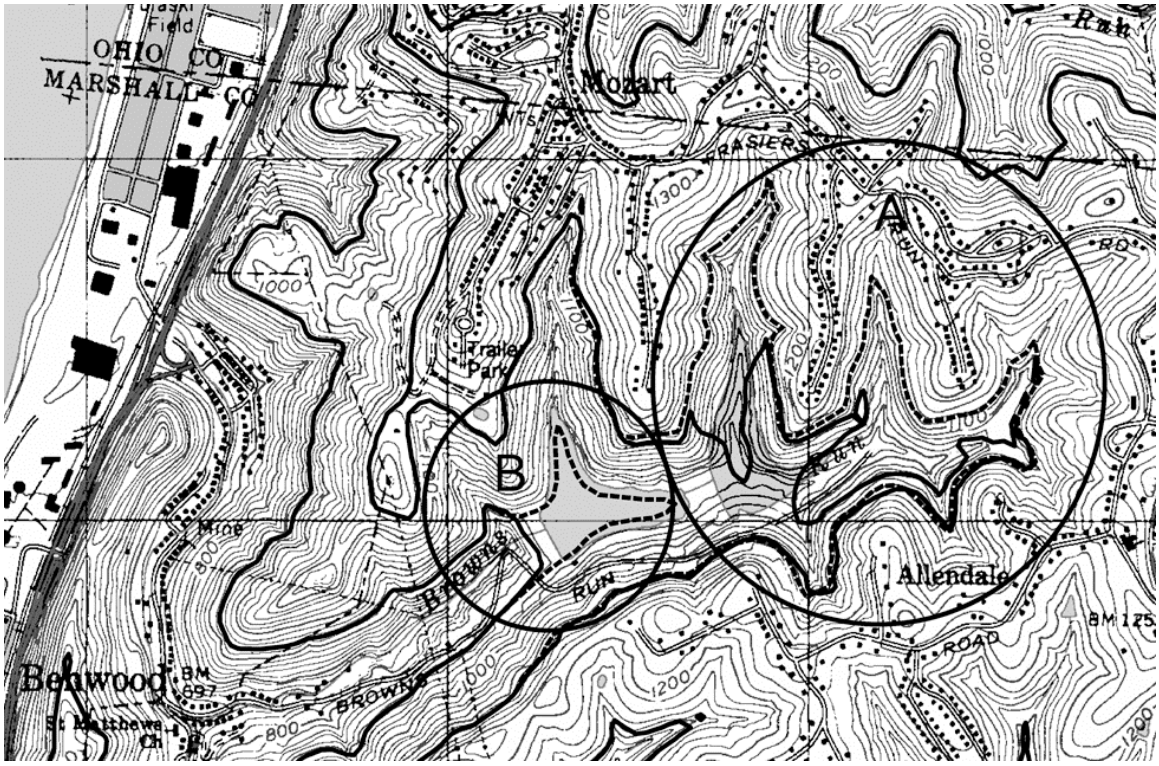

Figure 3. Selecting the proper topographic data is important, because human activities, or the manner in which the DEM was generated, can produce topographic surfaces that cannot be reliably used for prediction of the extent of geologic units. Examples of such errors occur in the Browns Run area of the Wheeling 7.5-minute quadrangle. In Circle A, the solid line shows the incorrect outcrop pattern of the Jollytown coal produced by intersecting a grid representing the structure of the coal with the DEM produced from 2003 topography reflecting the surface of an extensive valley fill. The dashed line represents our depiction of the corrected outcrop. In Circle B, the solid line shows the incorrect outcrop of the Waynesburg coal. The dashed line represents the corrected outcrop. In this case the error was generated when a grid representing the structure of the coal was intersected with an older DEM based on 1954 topography (U.S. Geological Survey, 1994) that portrayed small lakes and ponds as flat surfaces.

Figure 4. View of a small area of the Highlands Complex that is being built partially on a mine refuse dump. The buildings in the background are not located on the mine refuse fill. The area in the foreground is located over part of the refuse dump that has been subsequently filled with material from the current site preparation. During a recent site visit we observed new construction taking place on this filled area.

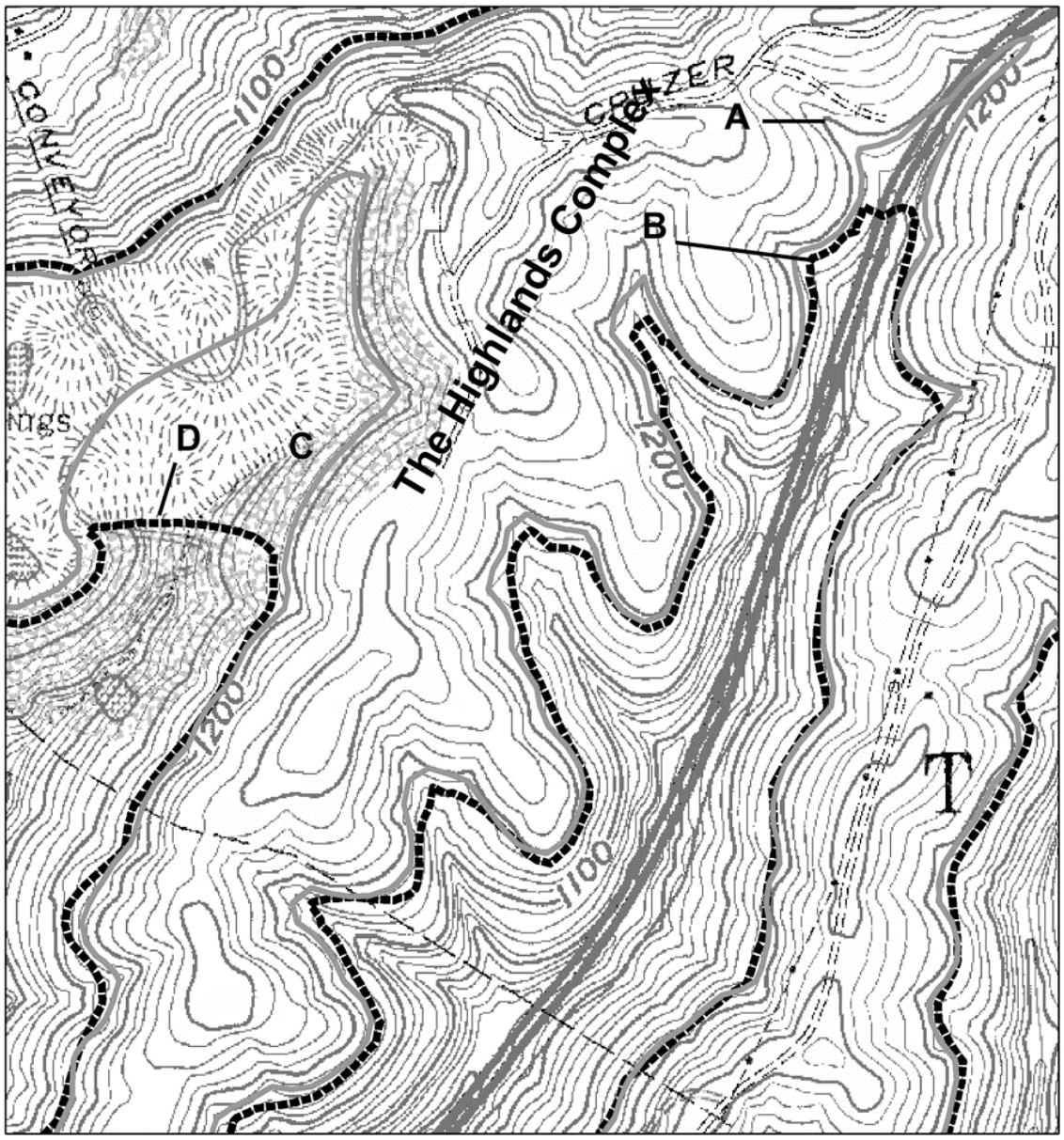

Figure 5. Two versions of the Jollytown coal outcrop are shown on a small area of the Valley Grove 7.5-minute quadrangle. The solid gray line shows the outcrop derived from the 7.5-minute topography. The dashed black line shows the outcrop derived from the 2003 1/9 arc-second data that reflects excavations for I-70 and earliest preliminary site preparation for the Highlands Complex. The camera symbol in the west central part of the map is the location from which the photo for Figure 4 was taken looking to the southeast. The outcrops buried beneath the mine refuse dump adjacent to the photo location fit the 1956 topography of this quadrangle (U.S. Geological Survey, 1997c), but their relation to the original topography cannot be verified, as an accurate representation of the original topography is not available. The position of the dashed black line at A, which is an indication of the amount of material added to the mine refuse dump since 1956, shows an erroneous outcrop generated using the 2003 data.