Importance of Historical Elevation Data

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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 are 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 we sometimes need to work with older topographic information, as explained in this paper.

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 inaccesible problem areas. These outcrops are used to construct open file report maps and ultimately to produce GIS datasets. Cross sections for these open-file maps are created by generating profiles of all important horizons using the elevation grids and the DEM.

TOPOGRAPHIC COMPLICATIONS RELATED TO HUMAN ACTIVITY

Selecting the proper topographic data for a geologic mapping project is important because human activities, or the manner in which the DEM was generated, can produce

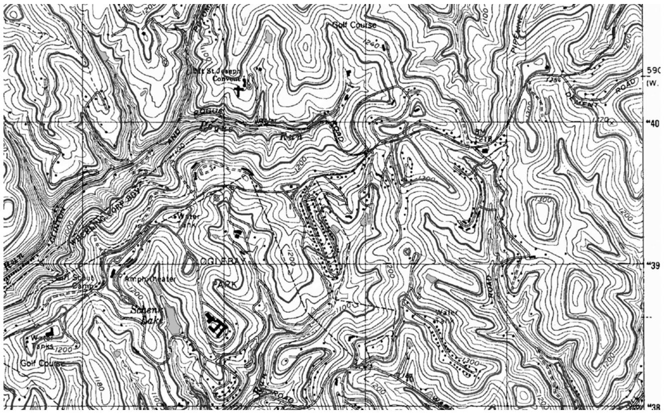

Figure 1. Grayscale image of the provisional geologic field map, Wheeling 7.5-minute quadrangle. The gray lines paralleling the topographic contours trace the outcrops of critical horizons which, in the Appalachian Plateau, commonly are widespread coal beds.

topographic surfaces that cannot be reliably used for prediction of the extent of geologic units.

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 the most recent topographic data could not be used to map the original locations of outcrops. It was therefore necessary to substitute DEMs based on older topography, or use contours based on plane-tabled topography (U.S. Geological Survey, 2005) from a 15-minute, 1:62,500 series map, in order to better identify the correct locations of geologic unit contacts.

Figure 2. The outcrops of the Pittsburgh (dotted line), Waynesburg (solid line), and Washington (dashed line) coals, in the Wheeling-Ohio County Airport area, Tiltonsville 7.5-minute quadrangle. Locations "A" and "B" are discussed in the text.

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 (Figure 2). When the airport was built in the 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. The topography shown on the Tiltonsville quadrangle was produced in 1966 (U.S. Geological Survey, 1997b), and therefore shows the altered landscape. To produce outcrops that show the pre-construction topography, we used pertinent information from the 1:62,500 Wheeling 15-minute topographic map (U.S. Geological Survey, 1902). The outcrop lines of the Pittsburgh, Waynesburg, and Washington coals were delineated from the DEM that was derived from the 1966 topography modified using 1902 vintage 15-minute maps, and is shown on Figure 2 superimposed on a 2003 aerial photo image of the Wheeling-Ohio County Airport area. In the figure, the dashed line represents the outcrop location of the Washington coal, before construction of the airport. 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 outcrop of the Waynesburg coal; it was covered at location B by fill, most of which was apparently removed from location A to construct the runway. The dotted line represents the outcrop of the Pittsburgh coal. Recently, aside from the airport excavation 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 early 1940s, before the airport was constructed.

Another example of profoundly altered topography that required us to use older topographic information is along Browns Run near Benwood, in the Wheeling 7.5-minute quadrangle (Figure 3). 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 it. This facility required a nearby mine dump to receive material cleaned from the coal by the preparation plant. We found two types of topography-related errors that required correction in this area.

The most obvious problem was the incorrectly mapped outcrop lines of the Jollytown coal, which were produced by intersecting the coal's structure contour map with the DEM produced from the 2003 topography (see Figure 3, area "A"). By that time, the valleys had been extensively filled with mine waste, significantly changing the topography. The Shoemaker mine began production in 1966 (West Virginia Department of Mines, 1966) and so we consulted the topography compiled in 1956 (U.S. Geological Survey, 1994) in order to more correctly map the Jollytown coal's original outcrop pattern. For the areas of valley fill, a small part of the 1956 DEM was used to recompute the Jollytown's original outcrop. This was patched into the outcrop for the rest of the quadrangle. The resulting outcrop is shown as the dashed line within area "A" in Figure 3.

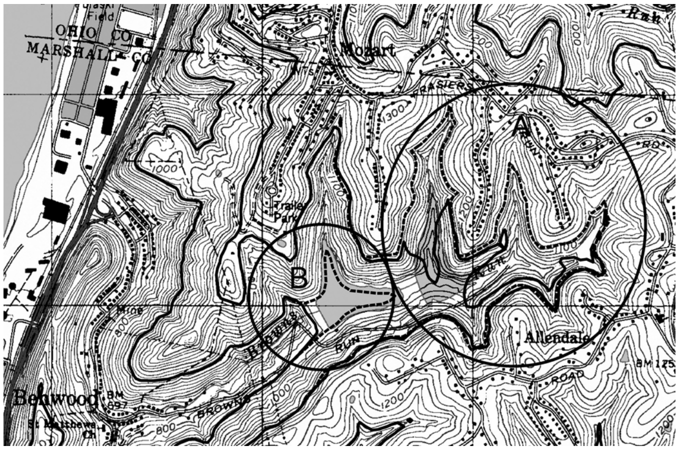

Figure 3. Changes in the topographic surface near Browns Run, Wheeling 7.5-minute quadrangle map. The solid and dashed geologic lines within areas "A" and "B" are discussed in the text

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.

While applying this patch, a problem was found with the projected location of the Waynesburg coal outcrop. Because ponds obscure the underlying topographic contours, they are treated by the algorithm used to produce the DEM as flat surfaces. Therefore, when the Waynesburg coal outcrop locations were generated by intersecting the structure contours with the DEM, the outcrop pattern was affected by the earthen dam instead of extending up the valley, into the settling pond in the area labeled "B" on Figure 3. This error was easily corrected by projecting the topography through the pond area. 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 projected location of a critical horizon 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 built partially 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). The location where the photo in Figure 4 was taken is labeled "E" in Figure 5. 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.

Between 1938, when the first air photos of the area were taken, and 1956, when the first photo-derived topography was produced from the first version of the Valley Grove 7.5-minute quadrangle (U.S. Geological Survey, 1997c), the mine dump appears to have significantly altered the topography. Valley Camp Coal Company has a long and complex history in the area, and it is difficult to determine from available public records an exact date for the construction of the preparation facility. Stereo pairs of the first air photos are unavailable, so the only source that shows the original topography is the 15-minute Wheeling Quadrangle, which was completed in 1902 (USGS, 1902). This topography is imperfect when compared to more recent topographic mapping, but it is good enough to suggest that our outcrops are probably near the original location. The areas labeled "A" and "B" on the left side of Figure 5 illustrate the problem. The solid gray line labeled "B" is the original outcrop of the Jollytown coal, as validated by the 1902 USGS map. The line marked with short dashes labeled "A" is based on the 2003 topography and has been influenced by the mine dump.

Another, less pronounced, but potentially more common, outcrop alteration occurred when I-70 was constructed in the 1970s. Fill has significantly altered the projected outcrop of the Jollytown coal nearby. Two versions of the Jollytown coal outcrop are shown on a small area of the Valley Grove 7.5-minute quadrangle (right side of Figure 5). The solid gray line labeled "D" shows the outcrop derived from the 7.5-minute topography. The dashed black line labeled "C" 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.

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.

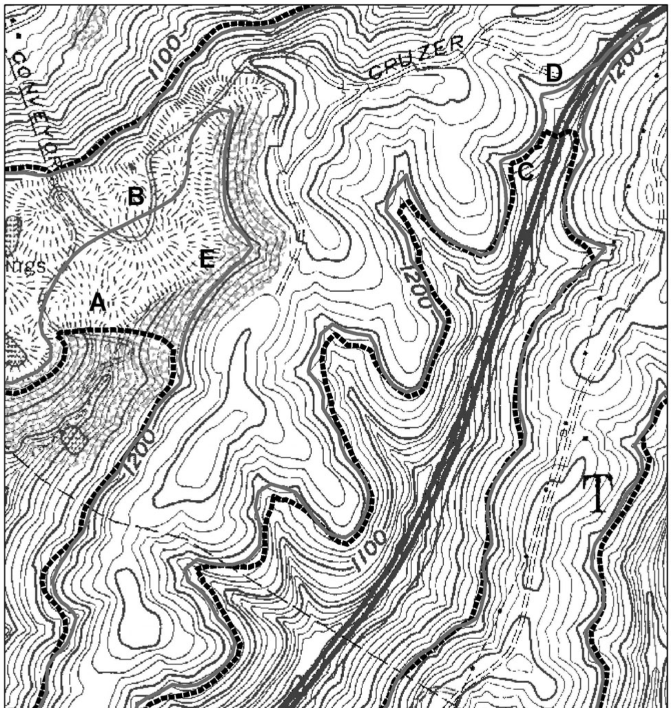

Figure 5. Two versions of the Jollytown coal outcrop are shown on a small area of the Valley Grove 7.5-minute quadrangle including Interstate 70 and the developing area known as the Highlands Complex. Locations A-D are discussed in the text.

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