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Old Mapping and New LiDAR……a Reality Check

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ABSTRACT

The Commonwealth of Pennsylvania has begun a state-wide mapping program called PAMAP; this will be a new digital map of Pennsylvania, available as a seamless, consistent, high resolution set of digital, geospatial data products. PAMAP data is being compiled from new, high-resolution aerial orthoimagery, LiDAR (Light Distancing and Ranging) elevation data, and existing digital map data developed by state and federal agencies, counties, regional agencies, and municipalities. PAMAP is part of The National Map, a cooperative effort of the U. S. Geological Survey (USGS) and the Commonwealth of Pennsylvania.

One of the components of the PAMAP project is flying high resolution, 1:2400, color orthoimagery on a four year cycle. The objective is to have maps and imagery available that are no more than four years out of date. More recently, LiDAR was added to the data acquisition flight contracts.

During the 2006 flight program, several counties that were contracted to be flown for orthoimagery also were flown for LiDAR as a test. One of the counties, Luzerne, had an ongoing STATEMAP cooperative mapping project. The surficial geology of the Harveys Lake 7.5-minute quadrangle had just been compiled using traditional mapping methods by a very experienced author, Dr. Duane D. Braun, professor of Geology at Bloomsburg University of Pennsylvania.

The Pennsylvania Geological Survey (PAGS) obtained a beta version of the Luzerne County LiDAR DEMs (Digital Elevation Model) based on the “bare-earth” classified elevation points. These DEMs had not completed the Q/A process when this comparison was done so they may have some errors.

We decided to compile and print a raster hillshade of the Harveys Lake quadrangle from the DEMs and compare it to the surficial geology recently compiled. We also considered comparing the hillshade data-set to the bedrock geology of the area, but because this quadrangle has only three bedrock formations identified, 95% of which is the Devonian aged Catskill Formation (Dck), the resulting comparison would not have been too informative.

For the original poster shown at the DMT’07 meeting, we printed the DEM-derived hillshade on glossy photopaper. We then printed the surficial geology polygons on a clear mylar overlay. Figure 1 is a rendition of the poster, and shows the raster hillshade data-set and surficial geology overlay as a single image.

MAP PREPARATIONS

In mapping the Harveys Lake quadrangle, Braun used a variety of sources and methods. Soils maps, aerial photography, previously published and unpublished mapping efforts, and good old-fashioned field work were his main sources of data. Combinations of digital and analog methods were used to compile the digital data-sets into ESRI geodatabases.

The map overlay (refer to Figure 1), is a de-constructed map of surficial geology that is part of the PAGS Open File Series of Surficial Materials (OFSM) report for the Harveys Lake quad. Normally, the surficial geology and supporting Digital Raster Graphic (DRG) files are printed on the map area. For the purposes of this demonstration, we printed the surficial geology and DRG on clear film to act as an overlay, dropping the colors for the mapped Bedrock (R) and Urban (U) areas just to show the glacial deposits and some obvious manmade disturbances. We then compiled a raster hillshade from the LiDAR DEMs using ArcGIS 9.2 and printed it with our HP 5500 UV plotter on HP Durable High-Gloss photo paper.

For obvious reasons, we could not reproduce the clear film overlay in the PDF version of this poster, shown in Figure 1. But, we did produce a reasonable facsimile. We took the same surficial geology data-set used in making the clear film overlay, set a 50% transparency, and applied it as a layer over the hillshade raster data-set. Some color changes were necessary so certain features would be visible against the grays of the hillshade. Although the visual effects are not as spectacular as described below, they do get the point across.

OBSERVATIONS

Our initial visual analysis was done on a light table. We placed the photo paper plot of the hillshade on the light table, and then laid the clear film plot of the surficial geology on top. The simulated 3-D appearance was stunning. The higher elevation hilltops are clearly shown, surrounded by the glacial deposits. The poster and PDF file’s attempt to illustrate this 3-D effect is good, but nothing like the backlighting of a light table.

At first glance, Braun did an excellent job mapping the surficial geology. The last advances of the Wisconsinan ice sheet were from the NNE with glacial striations ranging from S 05°W to S 30°W. Many of the preglacial valleys oriented parallel to ice flow are significantly scoured while valleys oriented perpendicular to ice flow would have the least scour and be the most back-filled, sometimes becoming completely buried. The overall glacial deposit pattern is one of ridges with a thin, discontinuous till mantle rising above valleys partly filled with 30 to more than 100 feet of glacial till. The many lakes, wetlands, and peat bogs are naturally formed by glacial activity, with many of the lakes dammed by piles of glacial till. As the glacial ice retreated to the northeast, drainage channels (sluiceways) from the ice margins opened up through the ridge tops. These sluiceway channels tend to follow the southwesterly curve of the Allegheny Front. Periglacial activity is also observed in the quadrangle including frost-shattering of the bedrock ridges and mobilization of some of the glacial deposits by gelifluction. Modern day deposits of alluvium, alluvial fans and terraces are also influenced by the previous glacial activity (Braun 2007).

Looking carefully, the observer can see where the till was deposited as ice flowed down the valleys, and where the topography influenced how other deposits were emplaced. In the northeastern corner (Figure 2) of the quad, one can see just how a meltwater sluiceway sliced through the ridge top. Just to the north and west, the hillshade shows another “gap” in a ridge top indicating another possible, but not mapped, sluiceway. Also notice how the bedrock outcrop ridges follow the ridge contours. Keep in mind that these ridges were mapped prior to LiDAR availability.

The rock pit (Rp) quarry in the southwest part of the quad (Figure 3) is accurately placed, despite the lack of identifiable features on the original topographic map. One can also see some glacial outwash (Qwo) against the ridge on the southwest shore of Harveys Lake (Figure 4). In the northwestern corner of the quad (Figure 5), on the eastern slope of Kocher Mountain, multiple level sluiceway benches can be observed descending east into the valley to its floor. A till shadow on the opposite (eastern) side of the valley remains where the glacier dropped its load on the lee side of the mountain. LiDAR verifies each of these examples.

PRELIMINARY CONCLUSIONS

Overall, the LiDAR DEM hillshade rendering and the traditional surficial geologic mapping of the Harveys Lake quad indicate that Braun did an excellent job of mapping the area. In fact, Braun was given a copy of the data presented here. He said he wished he had this data available while he was mapping. The LiDAR DEM hillshade has given him more insight not only to what glacial processes were involved in creating the Harveys Lake geomorphology, but on the regional processes involved. Braun is currently analyzing this LiDAR data-set, and in all probability will be making revisions and refinements to this map. If I may quote him, “There are so many things I missed.” Fortunately, GIS data is easily revised when an author changes interpretations.

One of the biggest advantages of LiDAR derived DEMs is the level of detail of the ground surface. There is more detail than even the USGS 10-meter DEMs offered previously. They also have the distinct advantage of having all the vegetation, trees, buildings, etc., effectively filtered out and removed. Even in this very limited experiment, LiDAR has proven its worth as another valuable tool in a geologist’s arsenal.

REFERENCE

Braun, D. D., 2007, Surficial geology of the Harveys Lake 7.5-minute quadrangle: Luzerne County, Pennsylvania: Pennsylvania Geological Survey, 4th series, Open-File Report OFSM 07-08.0, 19 p., Portable Document Format (PDF), accessed at http://www.dcnr.state.pa.us/topogeo.

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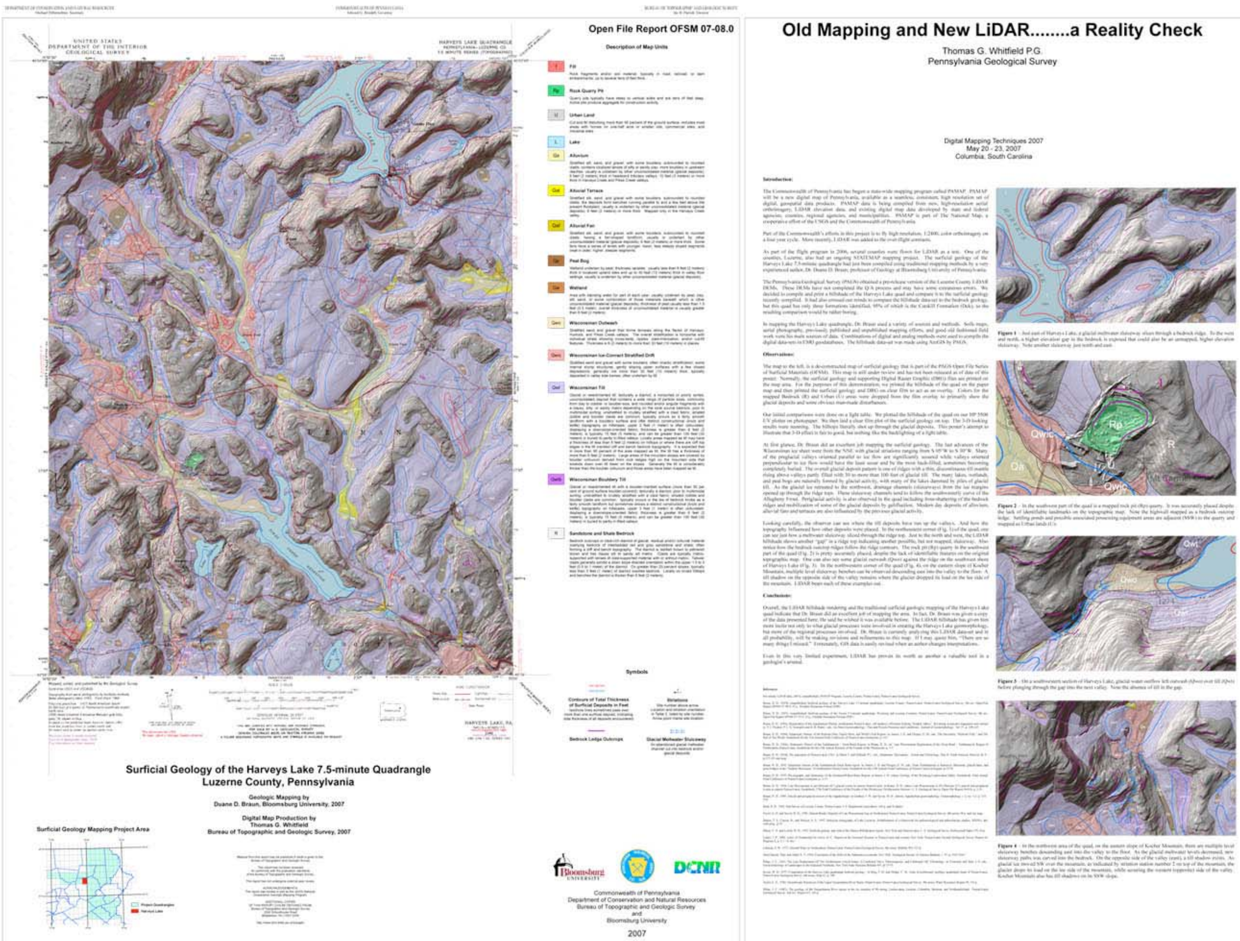

Figure 1. Old Mapping and New LiDAR........a Reality Check (presented as a poster; see full-resolution image at http://ngmdb.usgs.gov/Info/dmt/docs/whitfield07.pdf).

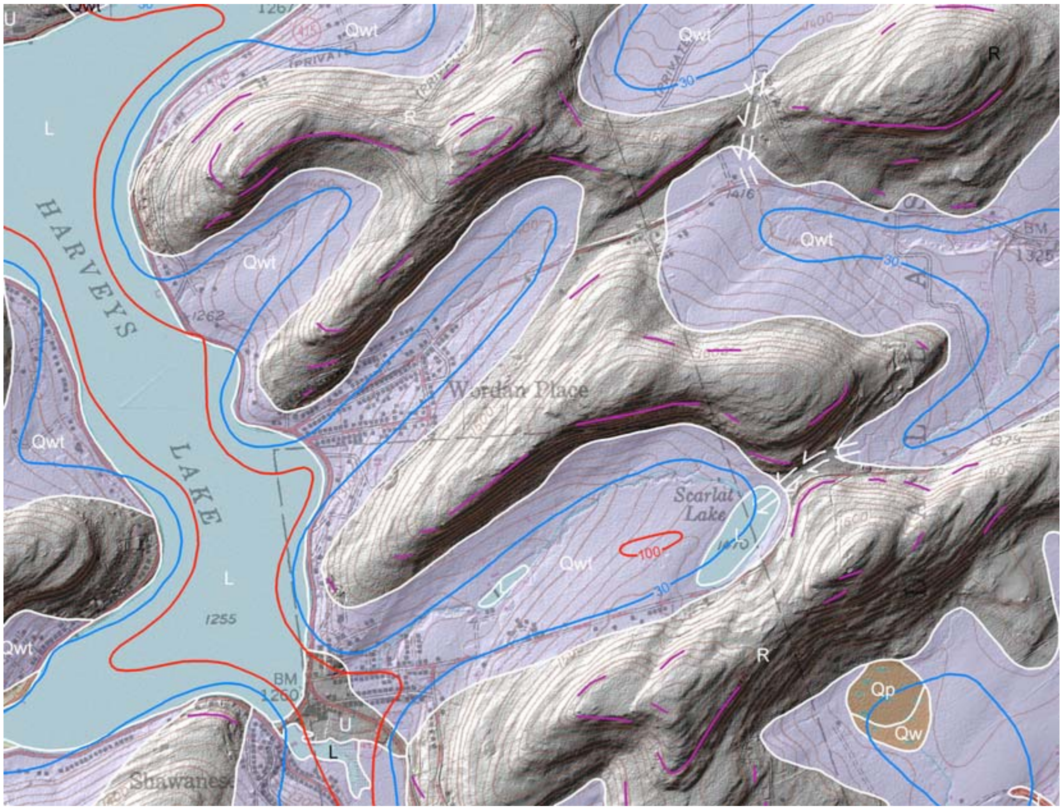

Figure 2. Just east of Harveys Lake, a glacial meltwater sluiceway cuts through a bedrock ridge. To the west and north, a higher elevation gap in the bedrock is exposed that could also be an unmapped, higher elevation sluiceway. Note another sluiceway just north and east.

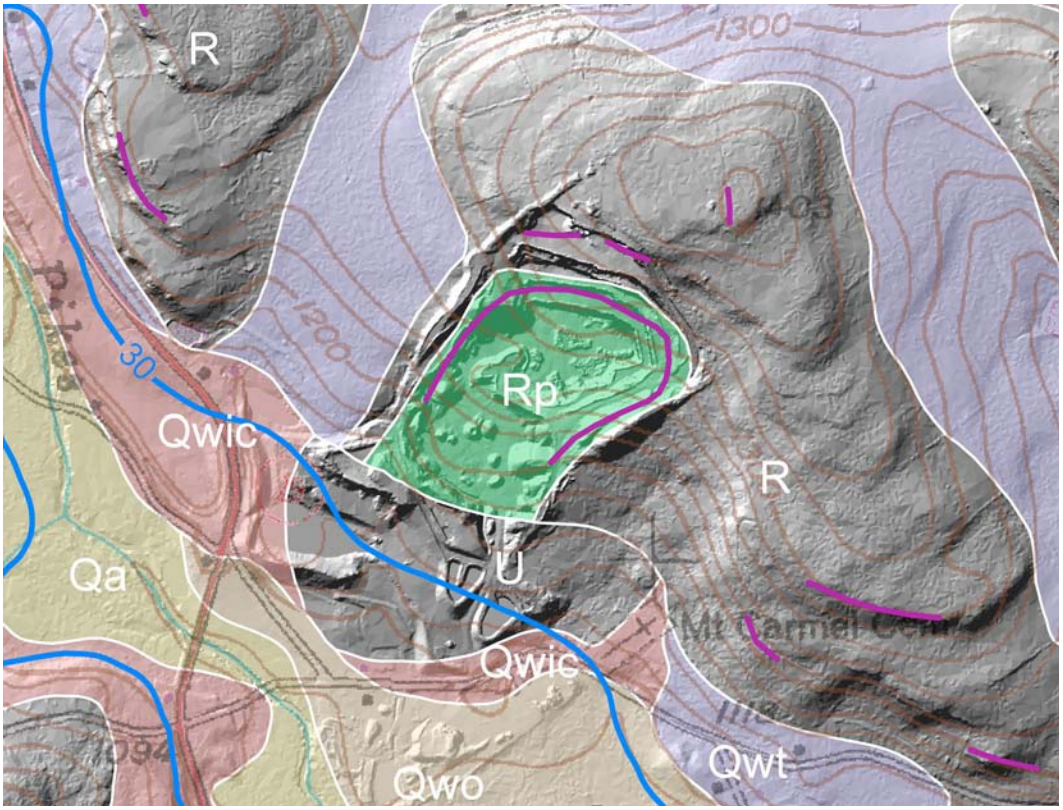

Figure 3. In the southwest part of the quad is a mapped rock pit (Rp) quarry. It was accurately placed despite the lack of identifiable landmarks on the topographic map. Note the high-wall mapped as a bedrock outcrop ledge. Settling ponds and possible associated possessing equipment areas are adjacent (SSW) to the quarry and mapped as Urban lands (U).

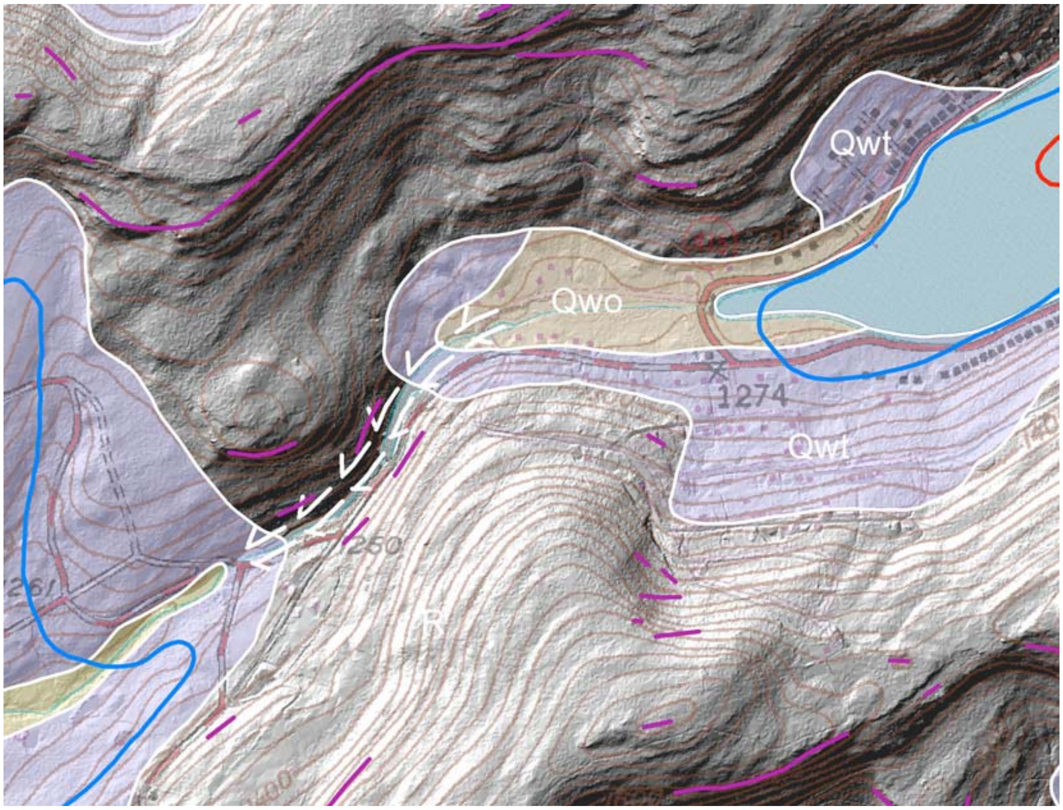

Figure 4. On a southwestern section of Harveys Lake, glacial water outflow deposited outwash (Qwo) over till (Qwt) before plunging through the gap into the next valley. Note the absence of till in the gap.

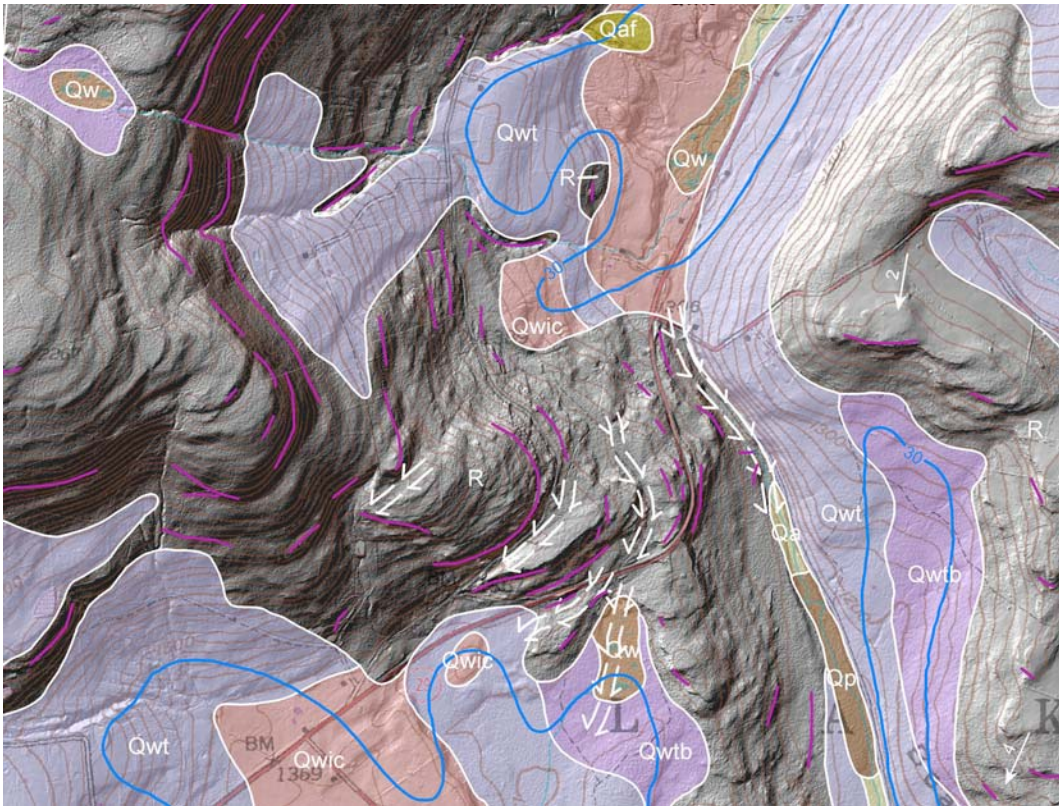

Figure 5. In the northwest area of the quad, on the eastern slope of Kocher Mountain, there are multiple level sluiceway benches descending east into the valley to the floor. As the glacial meltwater levels decreased, new sluiceway paths were carved into the bedrock. On the opposite side of the valley (east), a till shadow exists. As glacial ice moved SW over the mountain, as indicated by striation station number 2 on top of the mountain, the glacier drops its load on the lee side of the mountain, while scouring the western (opposite) side of the valley. Kocher Mountain also has till shadows.