# ELECTRICAL RESISTIVITY IMAGING OF A MULTIPLE ROCKSLIDE, PITTSBURGH, PA


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## Background

- Landslides are a well-documented geologic hazard in the Appalachian Plateau region of western Pennsylvania.
- During construction of I-79 in the 1960s, highway slope excavation reactivated a pre-existing rockslide in Allegheny County, PA (Fig. 1).
- Geology in the region consists of generally flat-lying to gently folded alternating layers of weak and resistant sedimentary rock. Steep slopes have been carved by fluvial erosion and covered with colluvial soil.
- Lithologies in the study area are part of the Conemaugh Group of Pennsylvanian strata.
- Rockslide features include:
  - Vertical exposure of Morgantown Sandstone at head scarp.
  - Detachment and downslope movement of Morgantown Sandstone has created a deep graben-like feature below the head scarp (Fig. 7 and Line 4).
  - Near-vertical stress-relief jointing creating open fractures on the surface that can reach depths of over 100 ft.
  - Large secondary scarp approximately 270 ft downslope from head scarp.
  - Slide dimensions are approximately 1,100 ft wide by 650 ft long down axis.

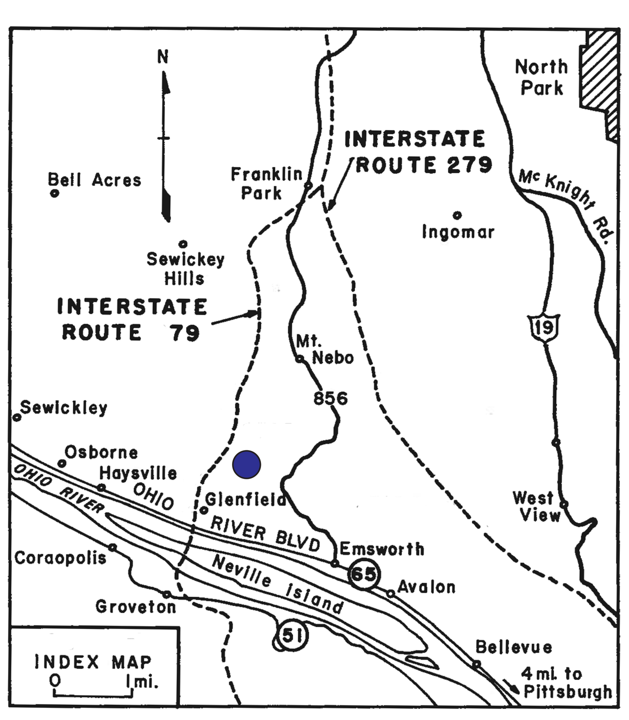



Figure 1. Location map of reactivated rockslide along I-79, northwest of Pittsburgh, PA, indicated by blue dot. Map modified from Flint and Hamel (1971).

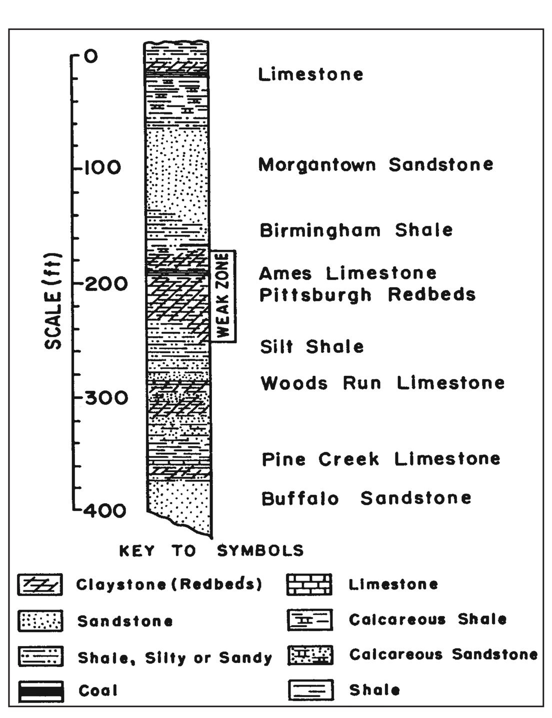



Figure 2. Generalized stratigraphic column showing major lithologies of the Pennsylvanian Conemaugh Group, from Flint and Hamel (1971).

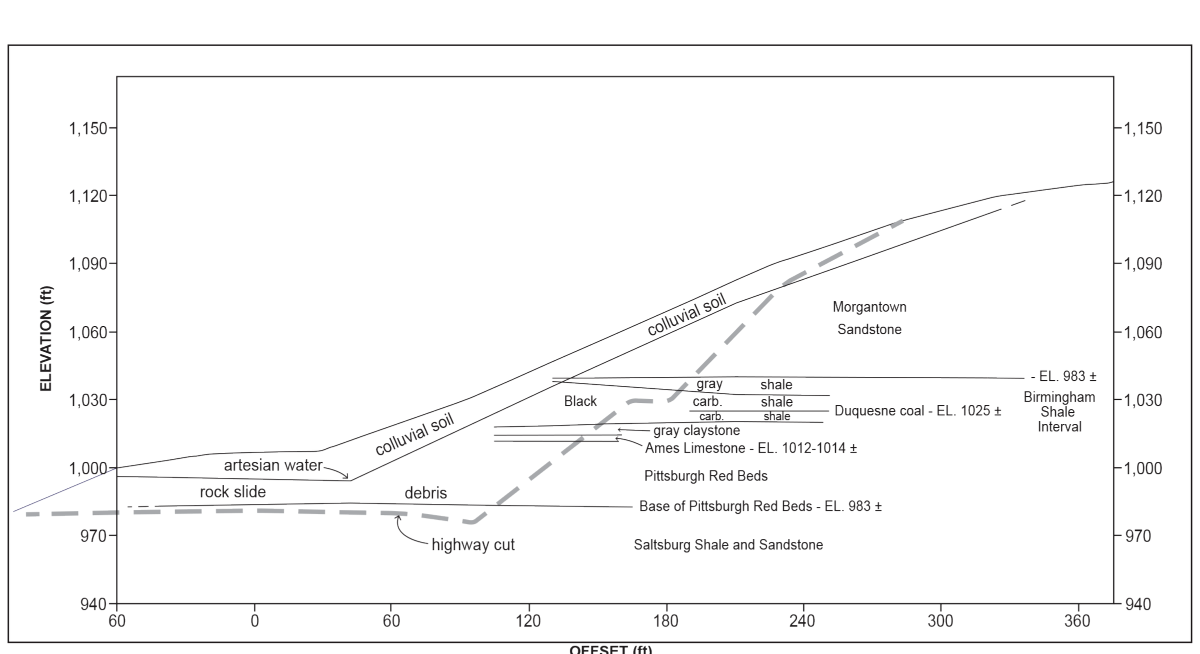



Figure 3. Cross section modified from Gray et al. (2011) showing pre-excavation slide topography, excavated bench associated with I-79 highway construction, and lithologies as determined by borings in 1963. Location of cross section is approximately one mile north along I-79 of our study area.

## Objectives

- Integrate electrical resistivity (ER) data, a priori knowledge of slope movement and stratigraphy, and observable surficial features to characterize subsurface.
- Compare multiple electrode configurations and spacing to determine effectiveness of each.

## Methods

- Electrical resistivity data were collected July 11-12, 2016.
- 1150 feet of ER survey profiles.
- Survey profiles included two longitudinal lines (1 and 4) and two transverse lines (2 and 3) collected across the accessible parts of the slide footprint and where the potential to image rockslide features was maximized.
- Experimented using dipole-dipole, Wenner, and Schlumberger electrode configurations for all profiles, and used different electrode spacing.
- Used Advanced Geosciences, Inc. SuperSting 8-channel resistivity meter.
- Inversions were made using Advanced Geosciences, Inc. AGI EarthImager 2D ver. 2.3.0.

Table 1. Electrical Resistivity Lines, Distance, and Electrode Spacing

| Line | Distance (ft) | Electrode spacing (ft) |
|---|---|---|
| 1 | 365 | 5 |
| 2 | 330 | 10 |
| 3 | 290 | 5 |
| 4 | 164 | 3 |

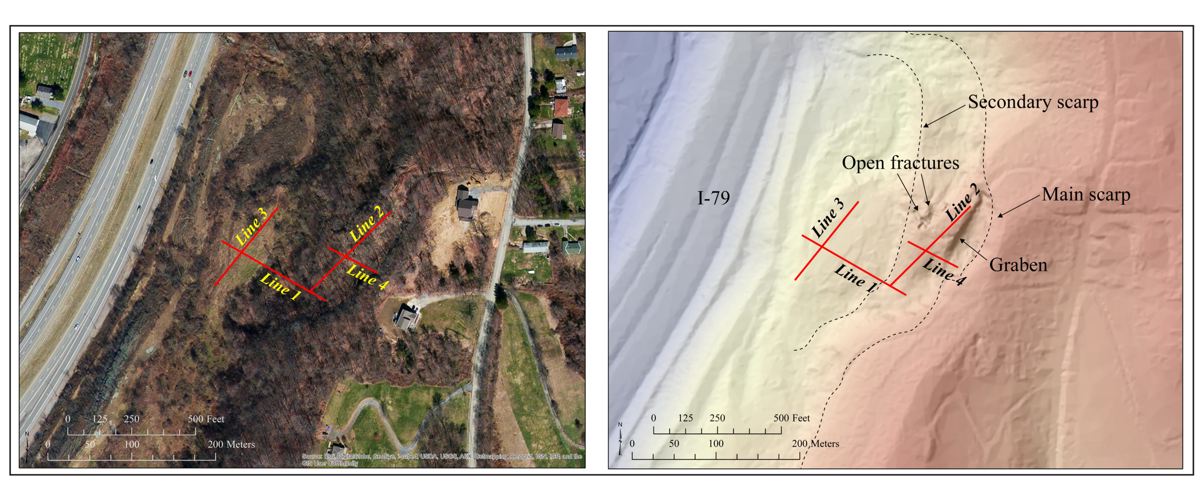



Figure 4. Aerial photo (left) and LiDAR derived hillshade (right) showing electrical survey profile lines and landslide surface features.

## ER Configuration Comparison

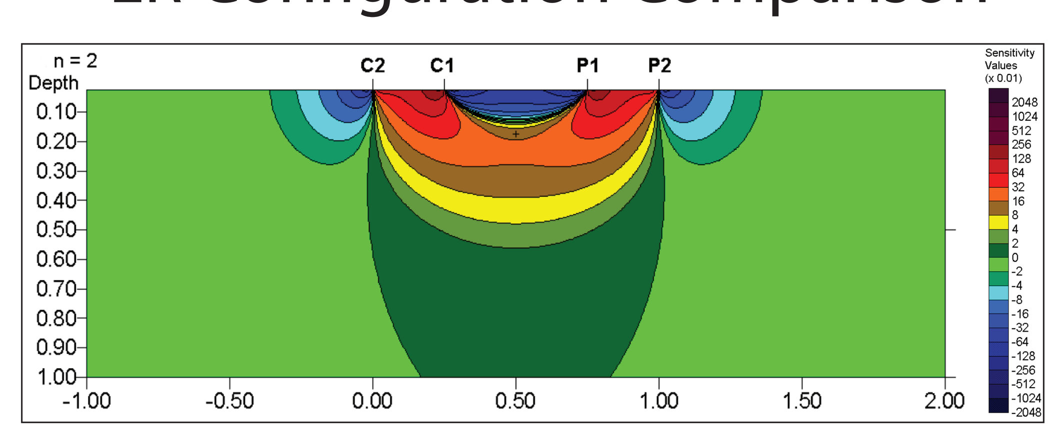



Figure 8. Dipole-dipole configuration diagram and sensitivity section, from Loke (2004). C1 and C2 are current electrodes; P1 and P2 are potential electrodes. In depth sounding, spacing of current electrode pair and of potential electrode pair is held constant, while spacing between the two pairs is increased. Sensitivity is greatest between each electrode pair, and contours are near vertical near electrodes. Dipole-dipole configuration is better suited for resolving lateral variation/vertical features.

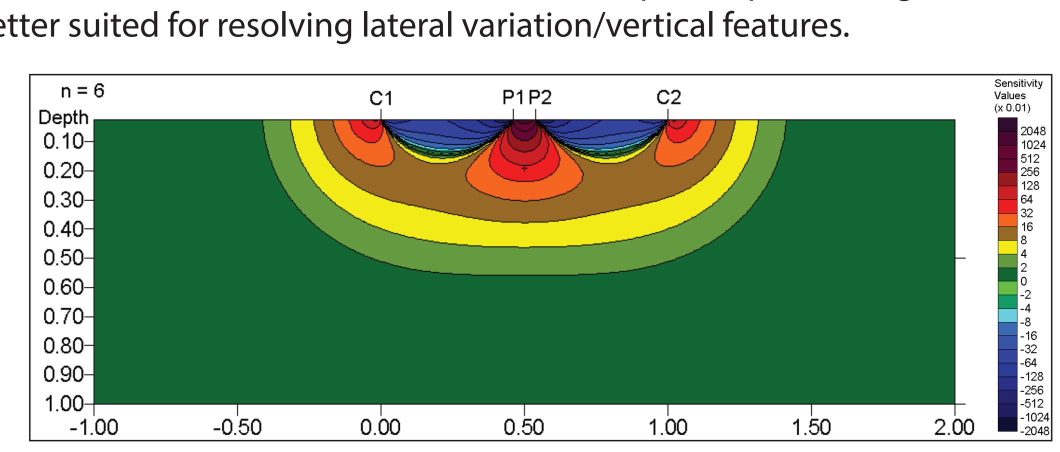



Figure 9. Schlumberger configuration diagram and sensitivity section, from Loke (2004). C1 and C2 are current electrodes; P1 and P2 are potential electrodes. In depth sounding, spacing and location of potential electrodes fixed while current electrodes are moved outwards. Sensitivity is greatest beneath the potential electrode pair. Schlumberger configuration has a slightly greater probing depth than Wenner configuration, and may be able to better capture lateral variation than Wenner configuration. Overall, this configuration is better suited to capture variation between horizontal layers.

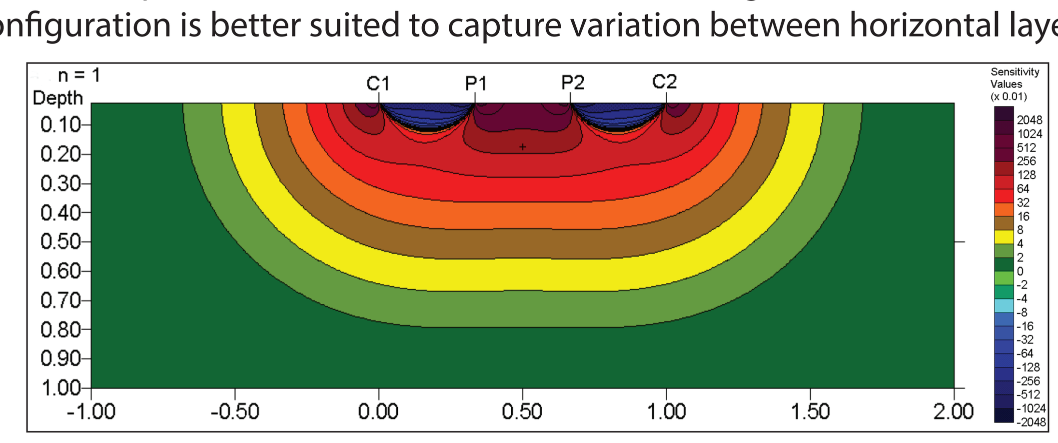
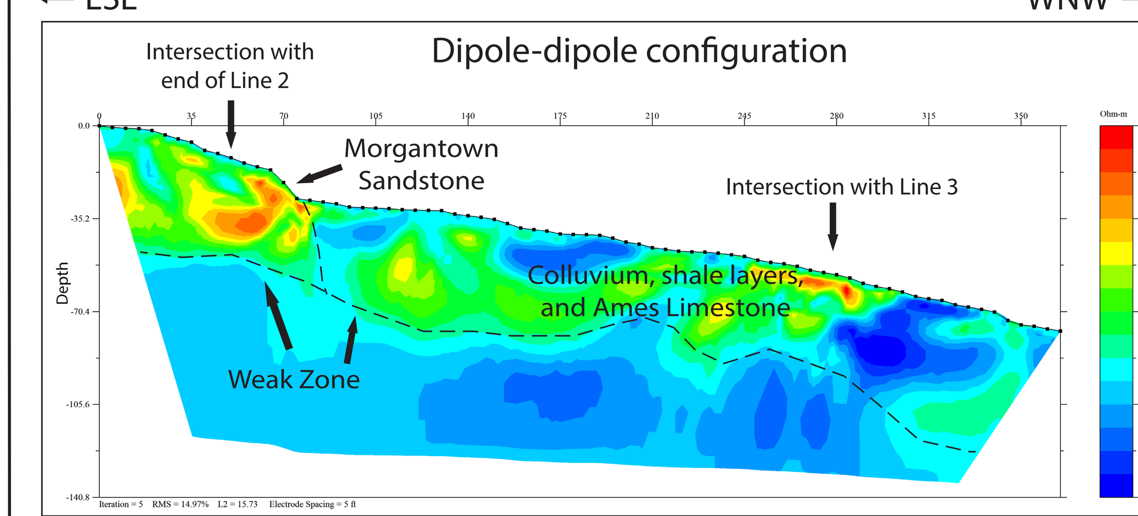
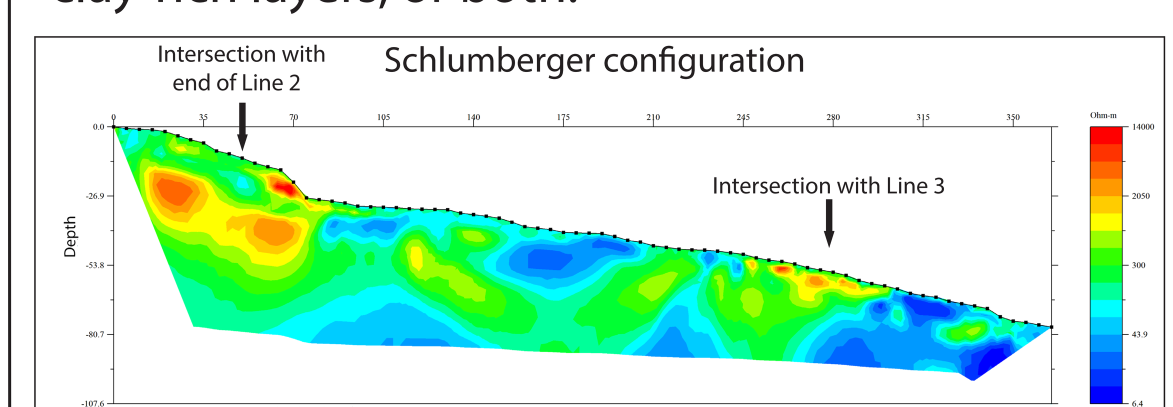



Figure 10. Wenner array diagram and sensitivity section, from Loke (2004). C1 and C2 are current electrodes; P1 and P2 are potential electrodes. In depth sounding, spacing between potential electrodes and current electrodes are uniform, and the array expands outwards about the array midpoint. Sensitivity is greatest beneath the center of the array. Wenner array is best for detecting vertical change and rather than lateral change.

## Line 1: Longitudinal




- 30 to 50 feet below surface is boundary between discontinuous medium to high resistivity zone and underlying lower resistivity zone.
- Depth to this boundary matches the onset of the "weak zone" described by Flint and Hamel (1971) (Fig. 2) and may represent failure surface of slide.
- High resistivity anomaly near secondary scarp corresponds with exposure of Morgantown Sandstone at scarp face.
- High resistivity anomaly near intersection with Line 3 corresponds with observed open fractures at surface. This area is interpreted as a geoelectric unit containing colluvium, thin shale layers, and Ames Limestone.
- Low resistivity zones at the surface near the middle of the line and at the toe of slope may indicate higher moisture content, the presence of clay-rich layers, or both.




- Schlumberger (above) and Wenner (below) configurations capture high resistivity anomalies related to Morgantown Sandstone and observed open fractures.
- Low resistivity zones at the surface near the middle of the line as well as at the toe of slope may indicate higher moisture content, the presence of clay-rich layers, or both.
- Schlumberger and Wenner configurations are more limited in depth and do not fully capture the lower resistivity weak zone.

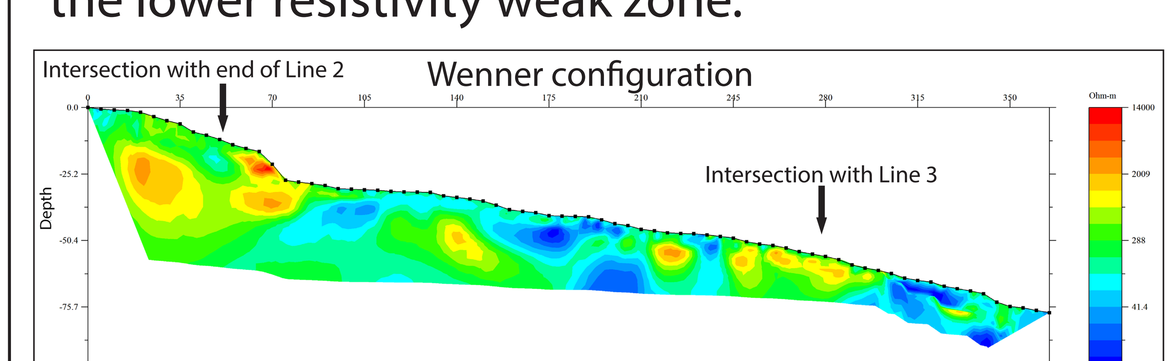



Figure 5. Secondary scarp along Line 1 showing jointed Morgantown Sandstone.

Figure 6. Looking south along Line 3. AGI SuperSting unit is in foreground. I-79 is visible along right side of the image.