Electrical Imaging of Mine Voids: Lessons Learned

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CONTINUOUS VERTICAL ELECTRICAL SOUNDING

- VES profiles using multicore cable and switching box
- Microprocessor produces geo-electric model
- Rapid and inexpensive
- Image depth of 40 m
- Function:
  - Lithology
  - Porosity
  - Permeability
  - Fluids
“NON-UNIQUENESS”

• Term that plagues the application geophysicist
• Lack of recognition not knowledge
• Interpretation
COMMON ARRAYS

- Wenner – shallow, coarse data
  \[ \rho_a = 2\pi a R \]

- Schlumberger – deeper, denser data
  \[ \rho_a = \frac{\pi a^2}{b} \left[ 1 - \frac{b^2}{4a^2} \right] R; \ a \geq 5b \]

- Dipole-dipole – deepest, densest data
  \[ \rho_a = \pi n(n + 1)(n + 2)aR \]
WENNER ARRAY
GEOLOGIC MATERIAL
APPARENT RESISTIVITIES

- Clay = 1 Wm
- Soil = 10 Wm
- Coal/Lignite = 50 Wm
- Sand (wet) = 100 Wm
- Conglomerate = 20,000 Wm
- Sandstone = 100,000 Wm
- Quartz = 1,000,000 Wm
- Granite = 3,000,000 Wm
- Basalt = 13,000,000 Wm
- Limestone = 50,000,000 Wm
SITE 1 - OHIO

- 100-Home subdivision
- 7-m thick Massillon Sandstone
- 2-m thick Pennsylvanian coal
- Shallow late 1800s coal mine
- Recent subsidence
SITE 1 - OHIO

~100 Homes overlie mine

- 47 Borings
  - 25 Voids
  - 12 coal
  - 10 non-coal

- ~56 Homes impacted
BARBERTON COAL MINE
CONCLUSIONS

• 69 homes within footprint
• 46 homes appear safe
• 25 homes at risk
  • 9 low risk
  • 10 medium risk
  • 6 high risk
HOUSES NEAR ANOMALIES
SITE 2 - PENNSYLVANIA

- Recent road cut
- Pennsylvania Warrior Fm
- Steeply dipping
- Clay-filled void in limestone
- 100-meter dipole-dipole array
SITE 2 - PENNSYLVANIA
SITE 3 - INDIANA

- Pennsylvanian-aged 1.2-m coal seam
- Coal at 15 – 20 m below grade
- Horizontal bedding
- Room-and-pillar and retreat mining
- 1,500-m Schlumberger array
SITE 3 - INDIANA

ROOM-AND-PILLAR MINING
SITE 3 - INDIANA

DEEP COAL MINE
SITE 3 - PENNSYLVANIA

- Pennsylvanian-aged coal
- 2-m thick coal/clay unit
- Split seam (0.4 meters each)
- 1.2-m thick Mercer Coal underclay
- 25-m of shale/ss overburden
- Shallow 1870-1920 clay mine
- 100m Schlumberger array
CROSS SECTION

BORING

POTTsville GROUP

BROOKVILLE COAL

HOMEWOOD SANDSTONE

UNDERCLAY

UPPER MERCER COAL

FI AMSL

1910

1900

1890

1880

1870

1860

1850

1840

1830

1820

1810
SITE 4 - PENNSYLVANIA

Apparent Resistivity
(Ohm-meters)

100 150 200 300 400 550 735 1000
SITE 5 - PENNSYLVANIA

- 2.5-m thick Pennsylvanian-aged coal
- Surface-mined
- Deep-mine
- Abandoned highwall
- Hill-topping and cut burial
- 150-m Schlumberger array
CONCLUSIONS

- Subsurface voids can be resolved through CVES (>40 m depth)
- Air- and clay-filled voids w/ contrast
- Non-uniqueness – resolved through
  - Site knowledge
  - Experience and training
  - Deductive and inductive reasoning
  - Interpretation
- CVES is effective screening tool

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