

U.S. Department of Labor

MSHA

Mine Safety & Health Administration

Mine Waste and Geotechnical Engineering Division

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Technical Support

Quecreek Rescue, Black Wolf Coal Company, Quecreek No. 1 Mine,
Rescue Operations, July 24 – 28, 2002

On July 24, 2002, an accident occurred at the Quecreek Mine where dramatic rescue operations took place from July 24 to 28. The results of those efforts will be discussed along with the technical decisions that were made. MSHA's effort to eliminate the potential for future similar occurrences is by utilizing Geophysical methods to detect mine voids and conducting field demonstration projects. The progress of this request of the proposal and up-to-date information will also be discussed.

Geophysical Methods for Void Detection

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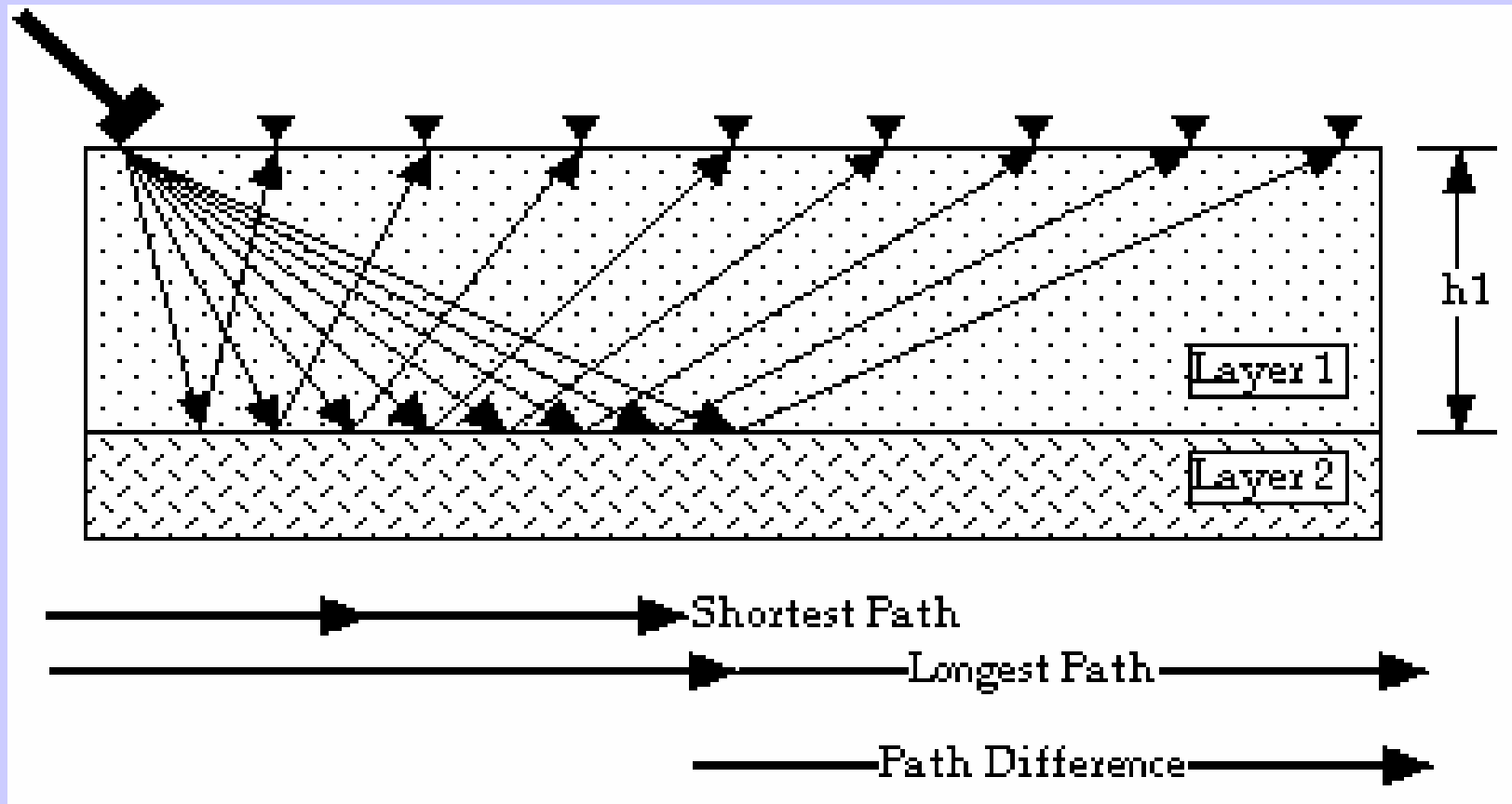
Geophysics

- *Exploring or determining the nature of earth materials by measuring a physical property of the rocks and interpreting the results in terms of geologic features. Physical measurements may be taken on the surface, in boreholes, or from airborne or satellite platforms.*

Available methods

- Seismic Reflection
- Seismic Refraction
- Borehole Seismic Methods
- Electrical Resistivity
- Ground Penetrating Radar
- Microgravity
- Electromagnetic Methods
- Magnetics

Seismic Reflection



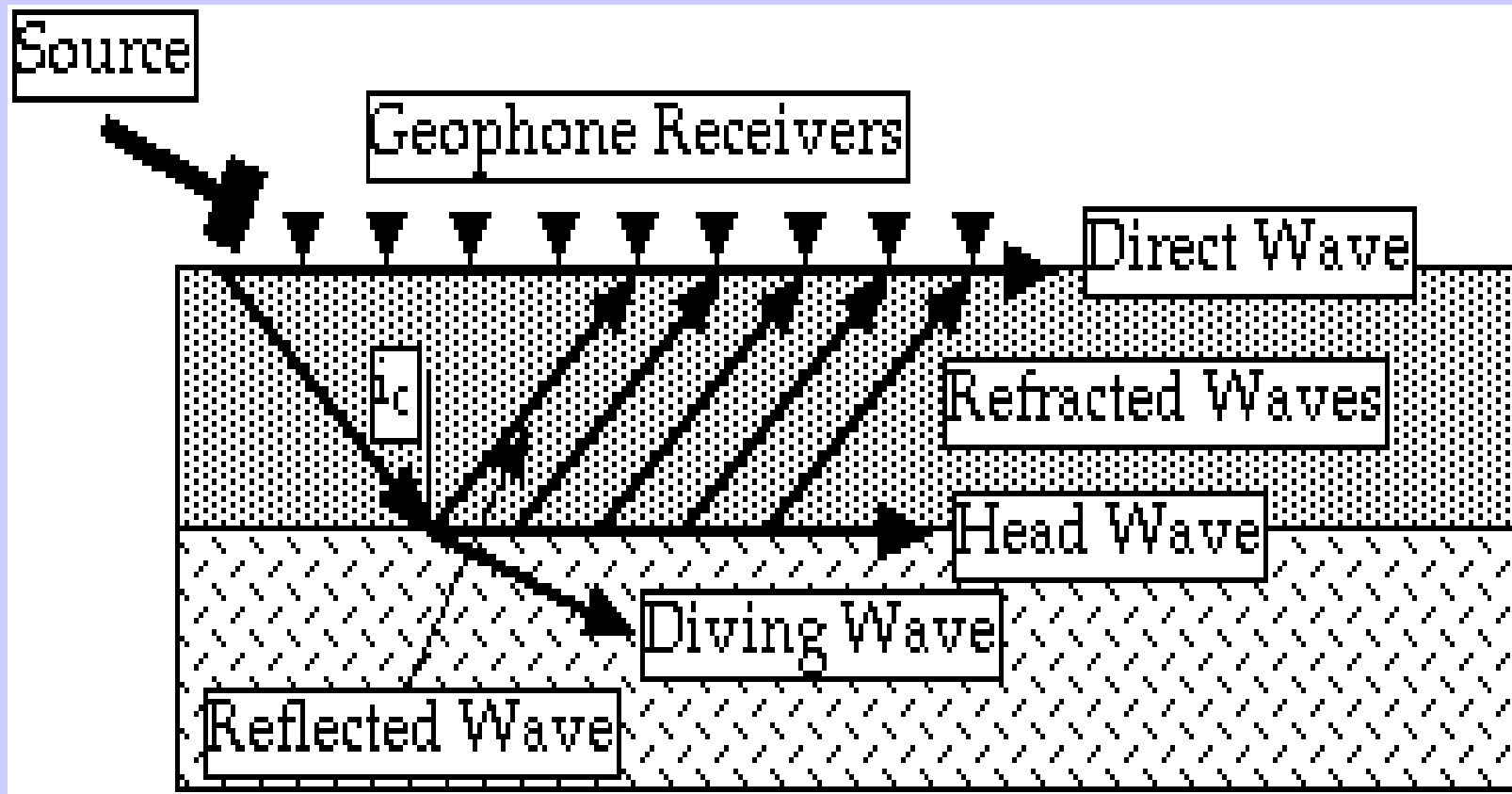
Seismic Reflection

- 70 years of history
- Used for 50 to several thousand feet for oil and gas exploration
- Non-destructive / Non-intrusive

Seismic Reflection

- Difficult to use at shallow depths (less than 50 meters)
- Can be influenced by other vibrations from machinery or nearby mining operations.
- Requires expert interpretation by an experienced geophysicist.

Seismic Refraction



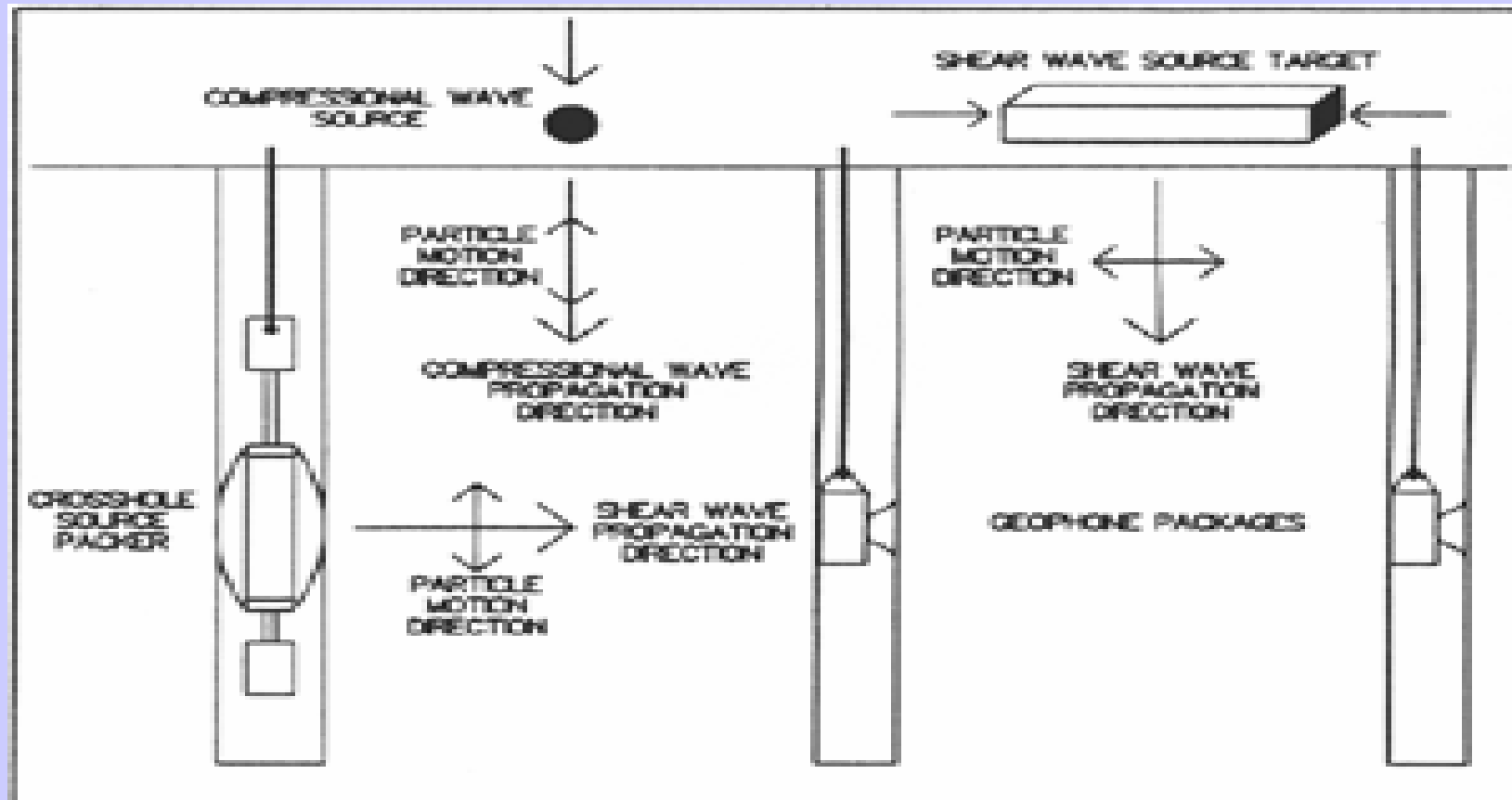
Seismic Refraction

- Has been used from a few feet to several hundred feet
- Non-destructive / Non-intrusive

Seismic Refraction

- Can only be used if the wave velocity increases with increasing depth.
- Can be influenced by other vibrations from nearby mining operations.
- Requires expert interpretation by an experienced geophysicist.

Borehole/Inseam Seismic



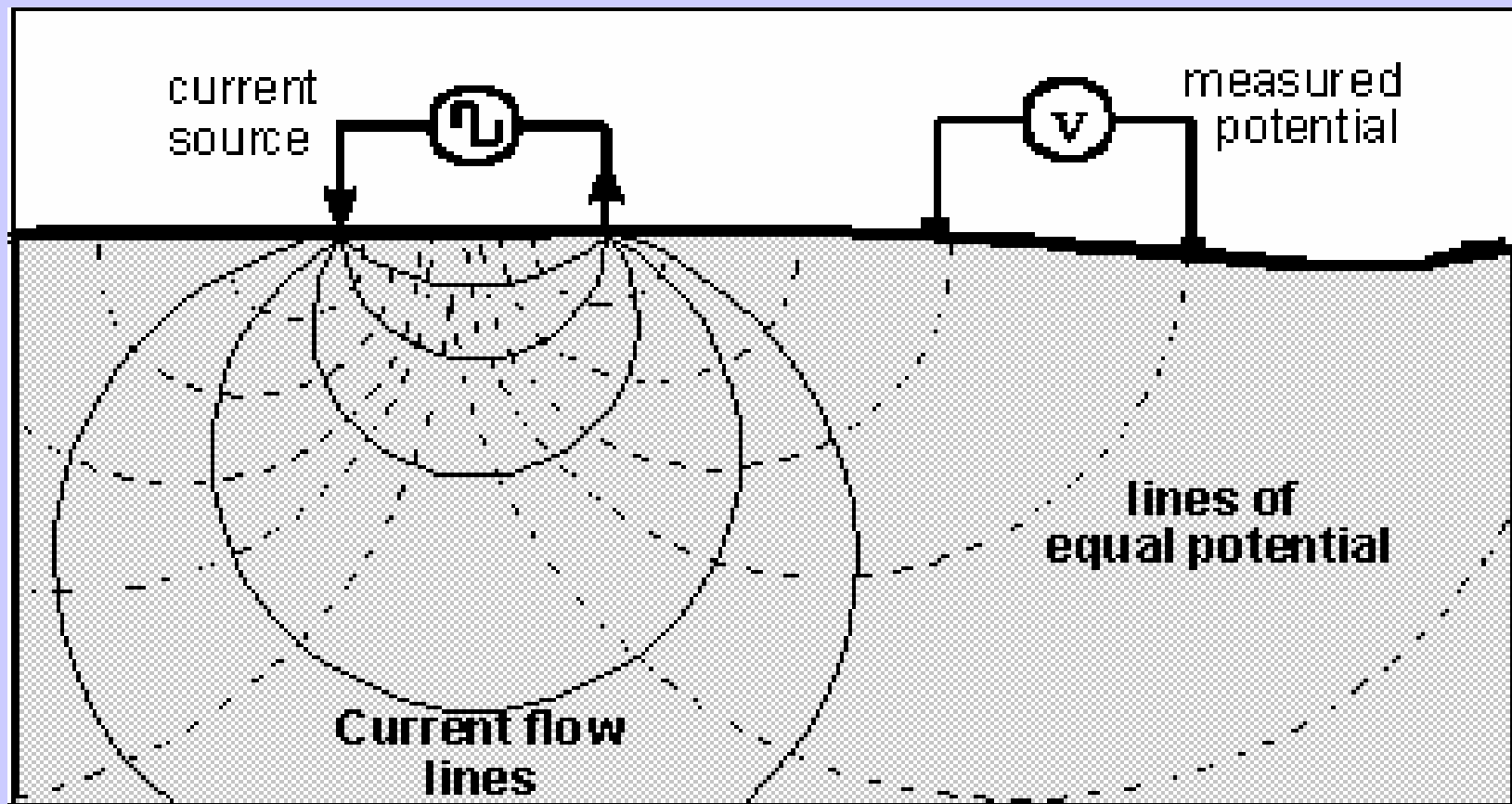
Borehole Seismic

- Has been used successfully to determine the location of abandoned mines ahead of an advancing longwall face
- Virtually unlimited in depth

Borehole Seismic

- Requires expert interpretation by an experienced geophysicist.
- Can be influenced by other vibrations from nearby mining operations.
- Borehole Seismic Requires closely spaced boreholes (\$\$\$)

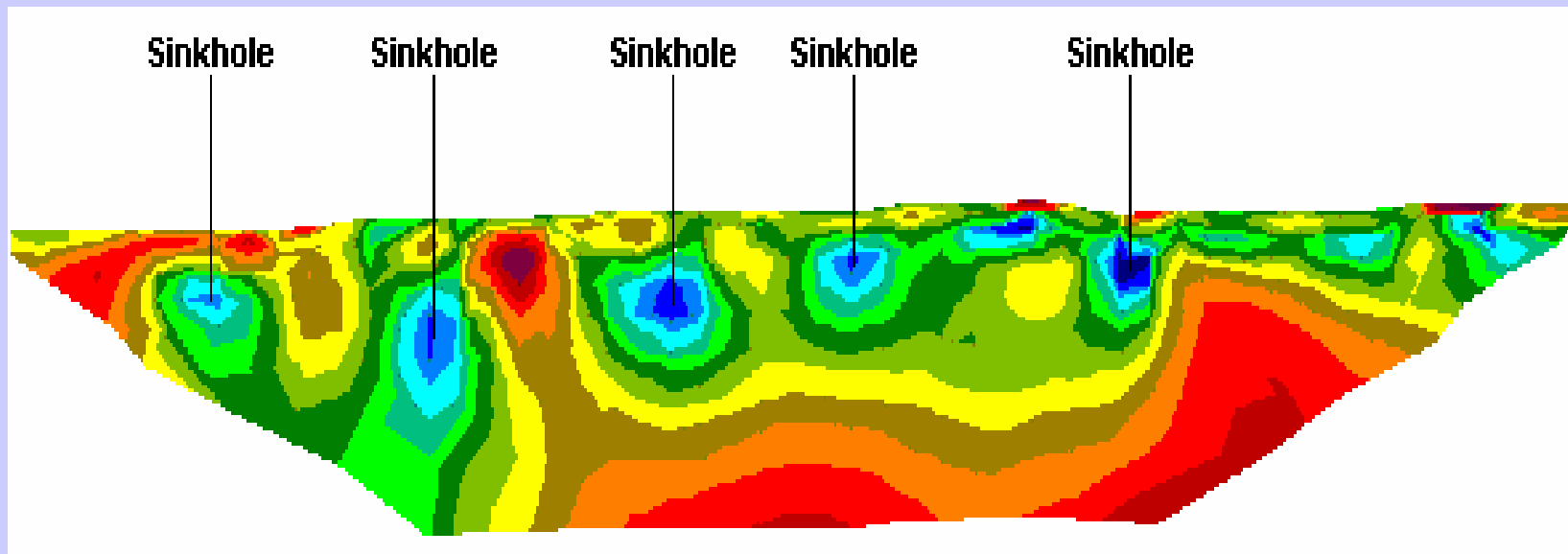
Electrical Resistivity



Electrical Resistivity

- This distribution of resistivity is used to map different strata, voids, groundwater etc. with distinct conductivity/resistivity
- depths of a few feet to several hundred feet can be profiled, depending on conditions

Electrical Resistivity



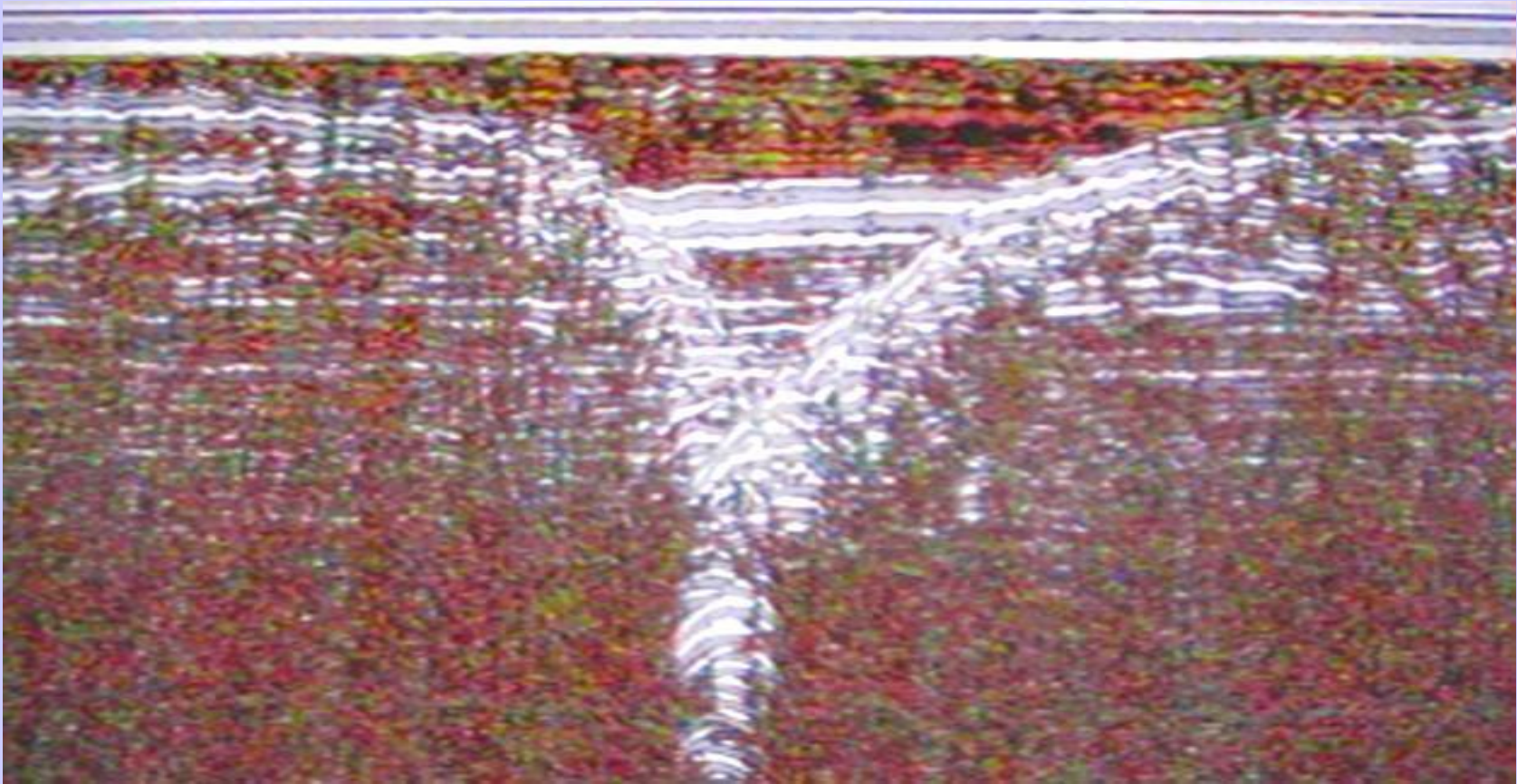
Electrical Resistivity

- Must be far away from power lines or grounded metallic structures
- need a lot of points - labor intensive

Ground Penetrating Radar



Sinkhole Image by GPR



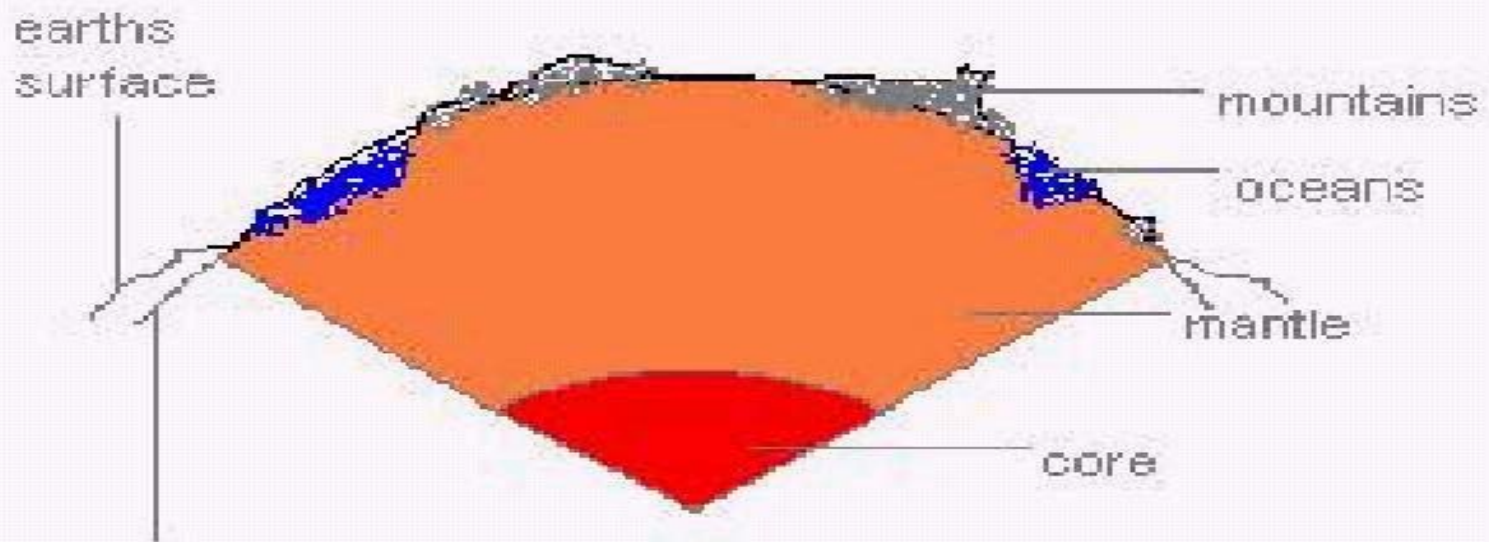
Ground Penetrating Radar (GPR)

- Penetrations up to 30-95 feet deep with accuracy of 0.5 to 3 feet
- Relatively simple to perform and interpret

Ground Penetrating Radar (GPR)

- Best penetration is for dry sandy soils
- Pulse penetration is severely limited by soil or water of high conductivity
- Penetration as small as 3 feet in clayey soils
- Even penetrations at the upper end 90' have limited usefulness for our purposes.

Microgravity



Over the surface is of the earth the geoid is the sea level.

Microgravity

- Detects anomalies in the density of the subsurface by precisely measuring subtle changes in the earth's gravitational field.
- Measurements in billionths of G
- economical
- non-intrusive

Microgravity

- Very limited if the opening is filled with water or fine coal slurry with a density similar to intact coal.
- Can only detect relatively large voids relative to the depth. (one study shows a 6.5' void at 33 feet to be a practical limit). This would appear to severely limit the method for our purposes.

Electromagnetics



Electromagnetics

- Utilize loop antennas to transmit and receive electromagnetic signals.
- Variations of the dielectric, magnetic, and conductive properties will effect the signal response. (metal detector)
- Electromagnetic pulses of much lower frequency than GPR

Electromagnetics

- Lightweight and easily transportable
- Can quickly collect a lot of data
- Good for detecting buried tanks and other metallic objects (perhaps roof bolts?)

Electromagnetics

- Not useful for detecting voids (unless something metallic)
- Can't be used around any metallic interference - pipes, fences, vehicles, etc
- Resolution depends on frequency content of the signal (much lower than GPR - so better penetration but poorer resolution)

Geophysical Issues

- Depth Limitations
- Accuracy
- Precision/Tolerances
- Repeatability
- Degree of Necessary Expert Interpretation
- Reliability

Influence of Environmental Factors to Application of Geophysics

- Site Access
- Pyrites
- sulfur
- magnesium
- water
- clay minerals
- electrolytes in solution
- other chemical components of coal measure rocks

Geophysics Summary

- Application of Geophysics is site specific
- Methods which are successful at one mine will not necessarily be successful at another.
- Results depend on interpretation and should be field-verified by more definitive exploration techniques.