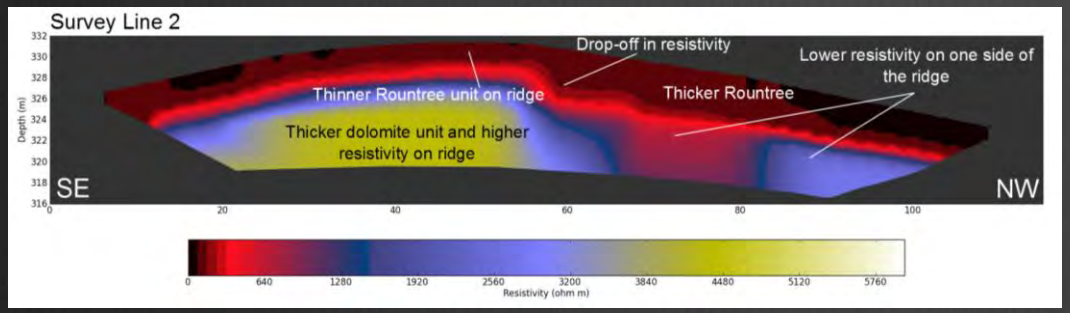
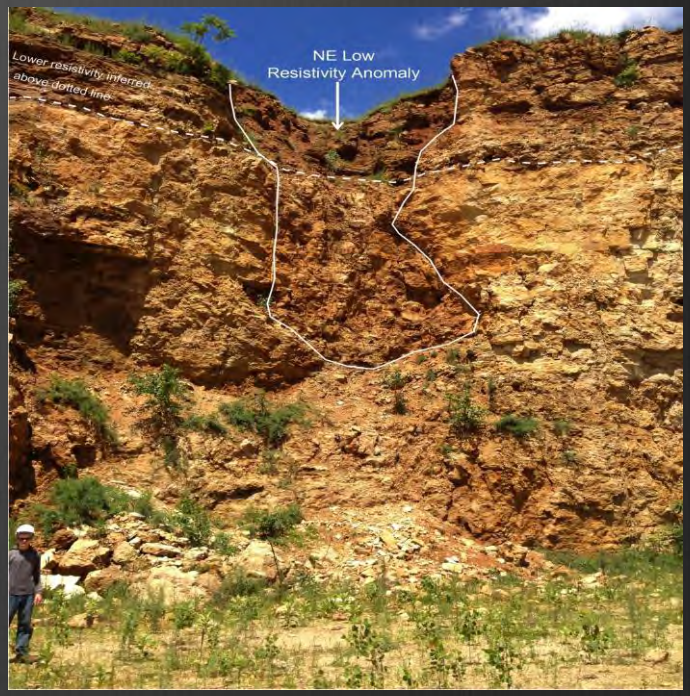
Mapping Tools for Locating Karst Features: Geophysical

Dave Hart



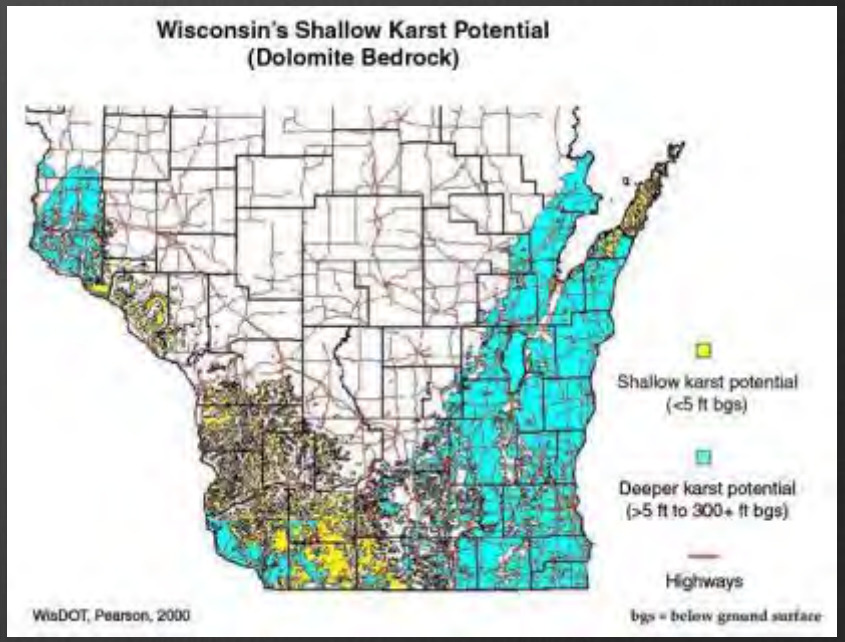


UW Extension
Wisconsin Geological and Natural History Survey

Statement of Problem

- Groundwater is highly susceptible in areas of fractured carbonate rock .

Madeline Gotkowitz - WGNHS



Statement of Problem

Tools are needed to assess and reduce risk from surface activities in these areas.

Geophysical methods

- Advantages
  - Non-invasive,
  - Cover larger areas
  - Collected quickly
- Disadvantages
  - Indirect measurement
  - Equipment costly
  - Requires Analysis and Interpretation

Fractured Carbonate Rock Sinkholes and Karst

- Well connected conduits and fractures in the rock.
- Sinkholes indicate highly connected fractured rock
- There must be good "plumbing" to move the overlying sediments.
- Surface contaminants are quickly transported.

Minnesota Geological Survey

Carbonate rock

- If carbonate rock is upper most rock, then it is very likely to be fractured.

- Geophysics good at finding depth to bedrock.
  - If bedrock is known to be fractured, depth to bedrock is more important than finding individual conduits and sinkholes.

- Maps (geologists) good at showing location of carbonate rock.

Silurian Dolomite

Highway F,
Calumet Co.

Quarry south of Chilton, WI

Sinnipee Dolomite

Sinnipee Quarry near Ripon, WI

Core from the Galena Formation

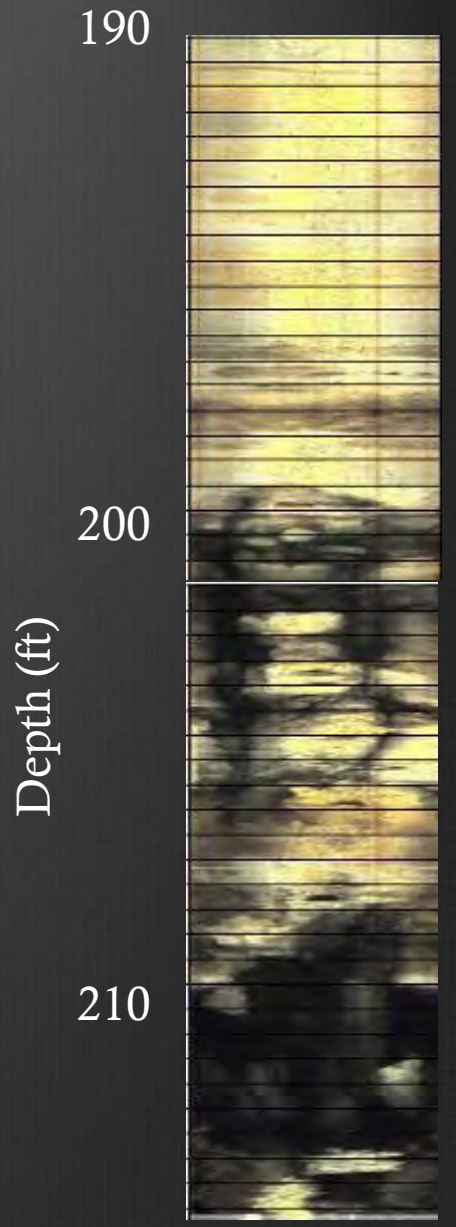
Core from the Decorah Formation

Sinnipee Group composed of the Galena, Decorah, and Platteville Formation

Prairie du Chien Dolomite

East Quarry, Highway 71, Monroe Co.

West Quarry near Highway 71, Monroe Co.



Borehole Video near Pine Lake, St Croix Co. Voids in Prairie du Chien at depths from 190 - 213 feet

Depth to Bedrock

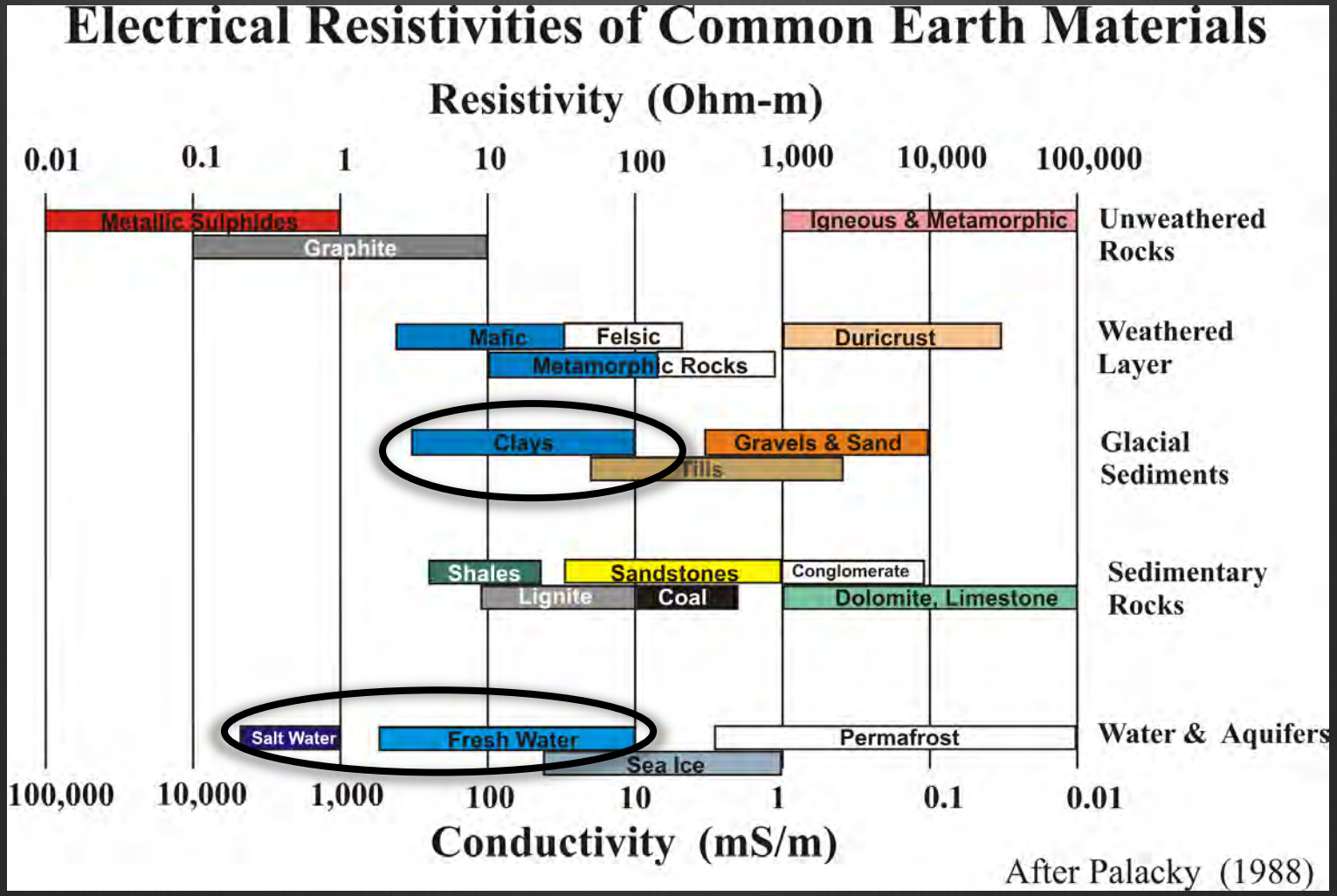
- Basic data for lots of land use planning and decisions
  - a search on depth and bedrock in WDNR's code gave 650 hits

- How to determine best geophysical method (criteria)
  - Fast (< 2 hours to collect data)
  - Equipment relatively inexpensive (< $15K)
  - Doesn't require too much training (technical person)
  - Reliable results (within 20 % of actual depth)
  - Detects depths of interest (0 – 50 feet depth)
  - Non invasive (no holes or disturbing crops)
  - Portable (1 to 2 persons can carry)

Electrical Resistivity Imaging

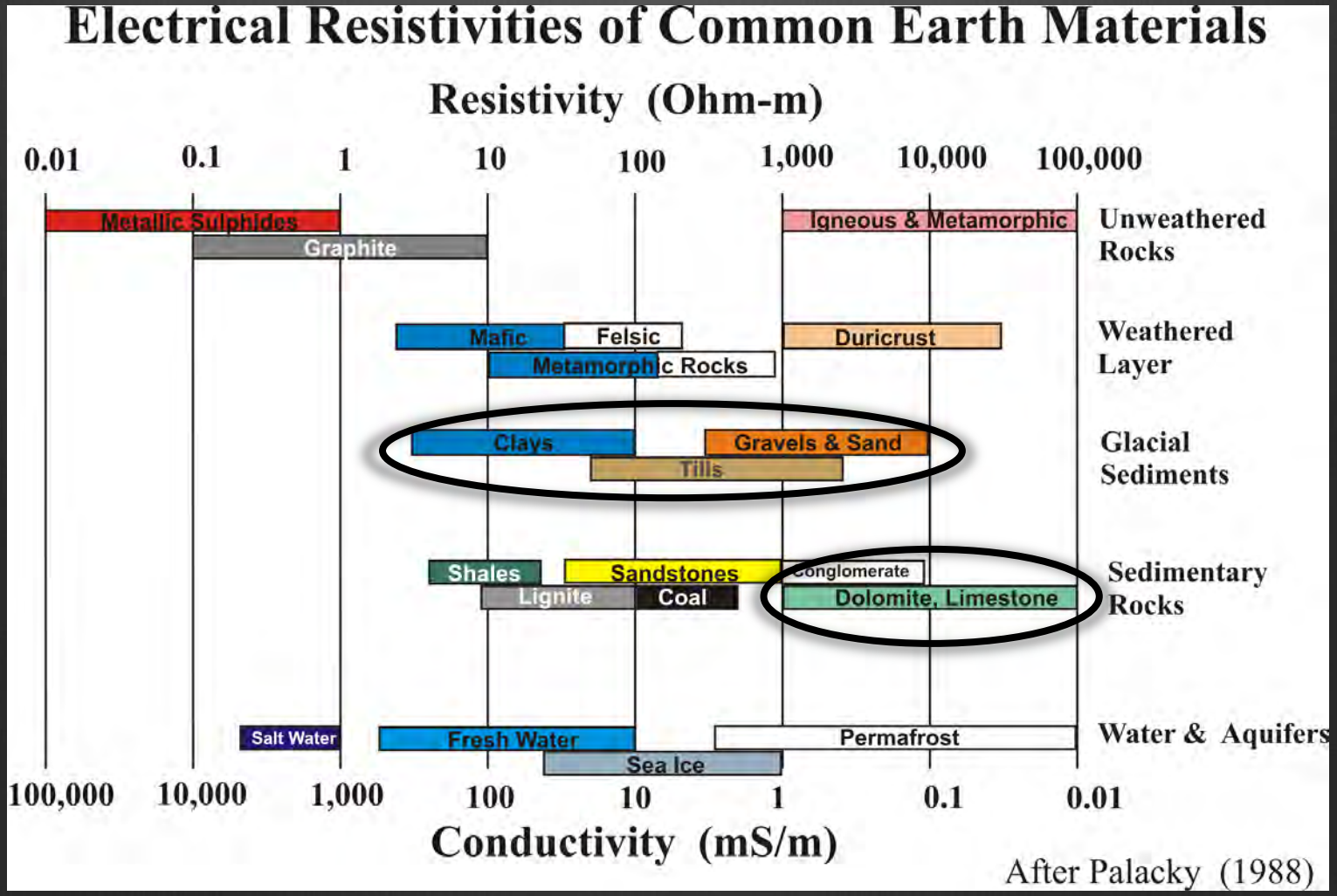
Electrical Resistivity

- How well a material conducts electricity
  - Water and clay strong controls on resistivity.



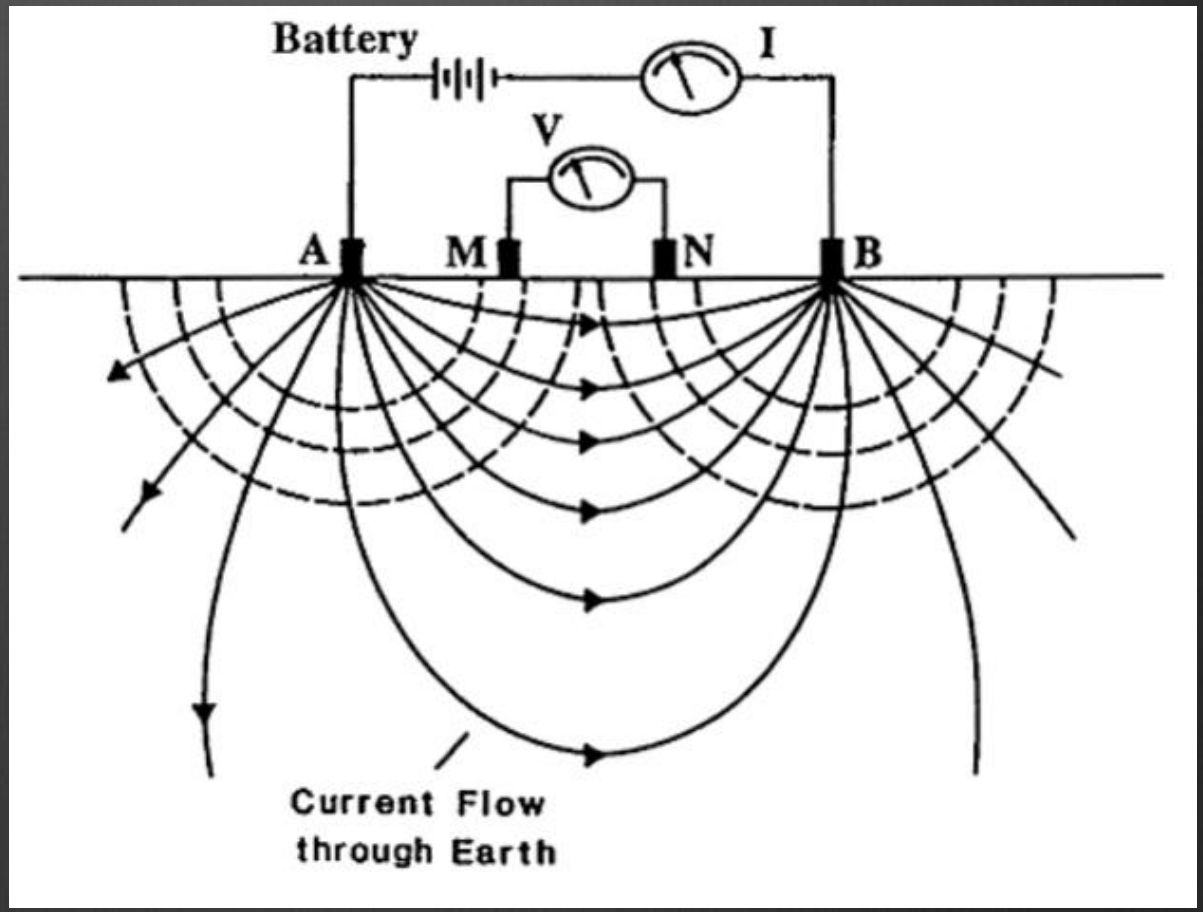
Electrical Resistivity

- Often overburden conducts electricity better than bedrock.
  - Need to be in general area where this is true.



Electrical Resistivity Imaging

- Analogous to groundwater flow
- Current electrodes like injection and pumping wells
- Voltage electrodes like piezometers
- Variations in materials cause flow lines to warp that can be seen in the voltages.
- Multiple sets of electrodes allow image or tomography of subsurface.



We can move the connectors by hand to get the different electrode combinations to image the subsurface…

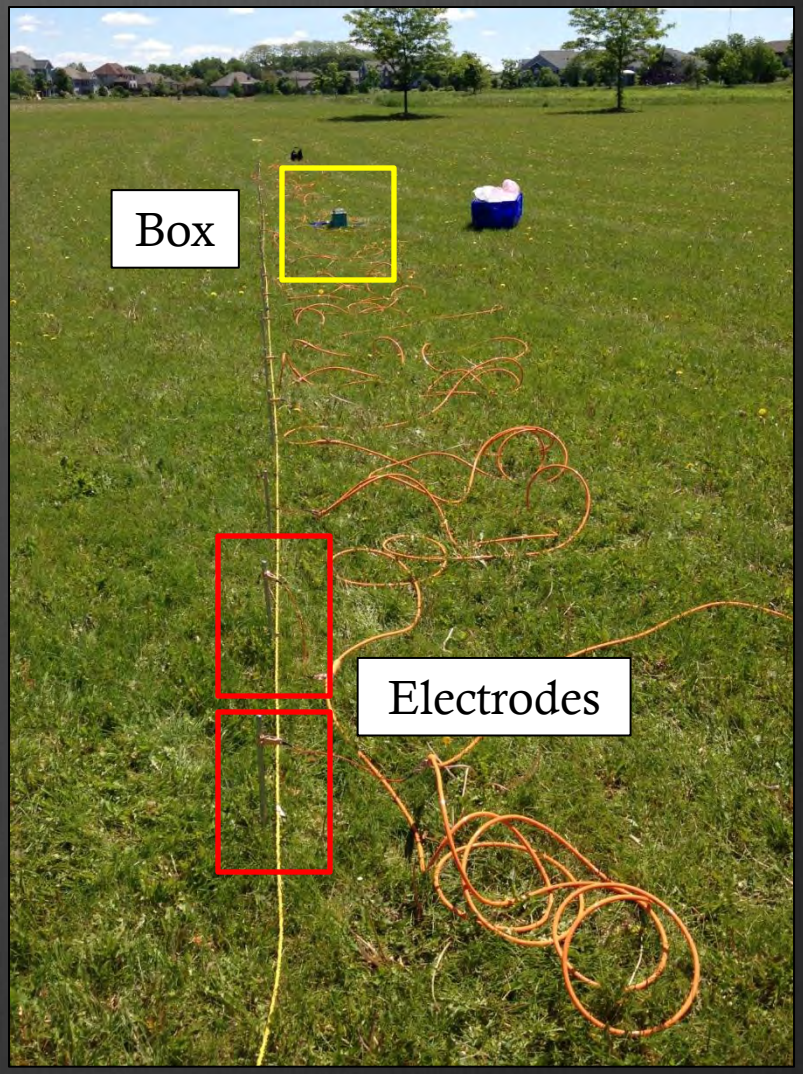
Or we can let the box with a built-in computer and switches do it

Current Electrodes: Send and receive an input current into the ground

Potential Electrodes: Measure the difference in the input current

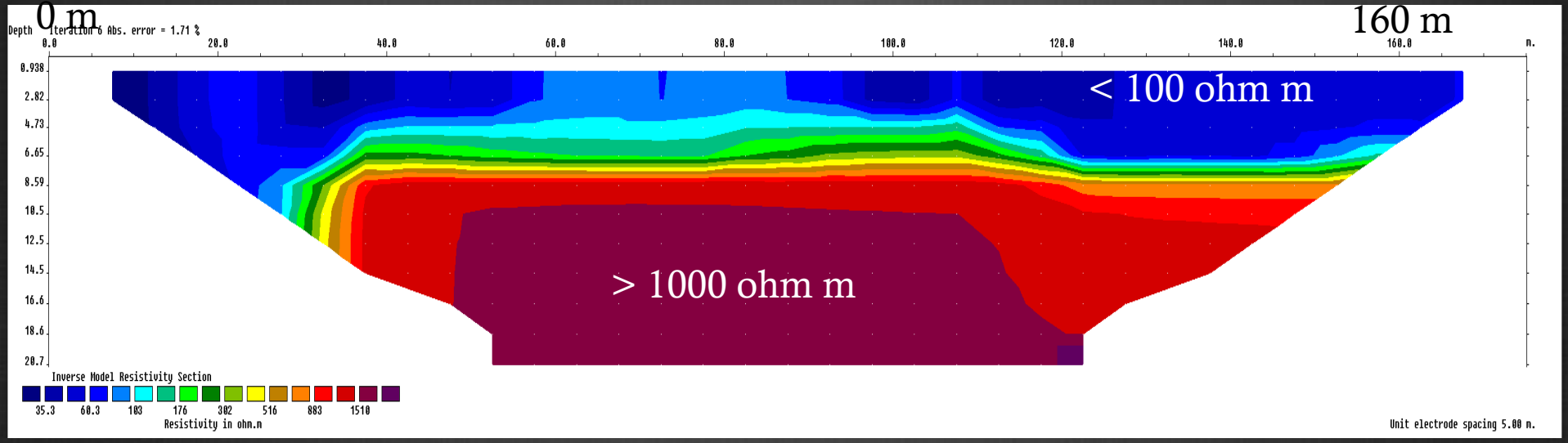
Moving these electrodes provides resistivity measurements at different depths and distances along the survey line.

Box can do either dipole-dipole or Wenner electrode combinations



Data Analyzed

Software automatically matches resistivities w/data



- Sharp transition form blue to red (low to high) indicates quick change in geology from sediment to bedrock.
- Seen at around 5 meters depth (16 feet)
- Depth to bedrock around 15 to 20 feet here.

Two Examples over Fractured Bedrock in Wisconsin

- Till – Calumet County

- Rountree sediment – Southwest Wisconsin

Calumet Co. – Horicon Till

- Depth to bedrock varies
- Fractured dolomite beneath till making shallow bedrock areas very susceptible to contaminants
- Till is sometimes very hard and will seem like bedrock to hand auger.

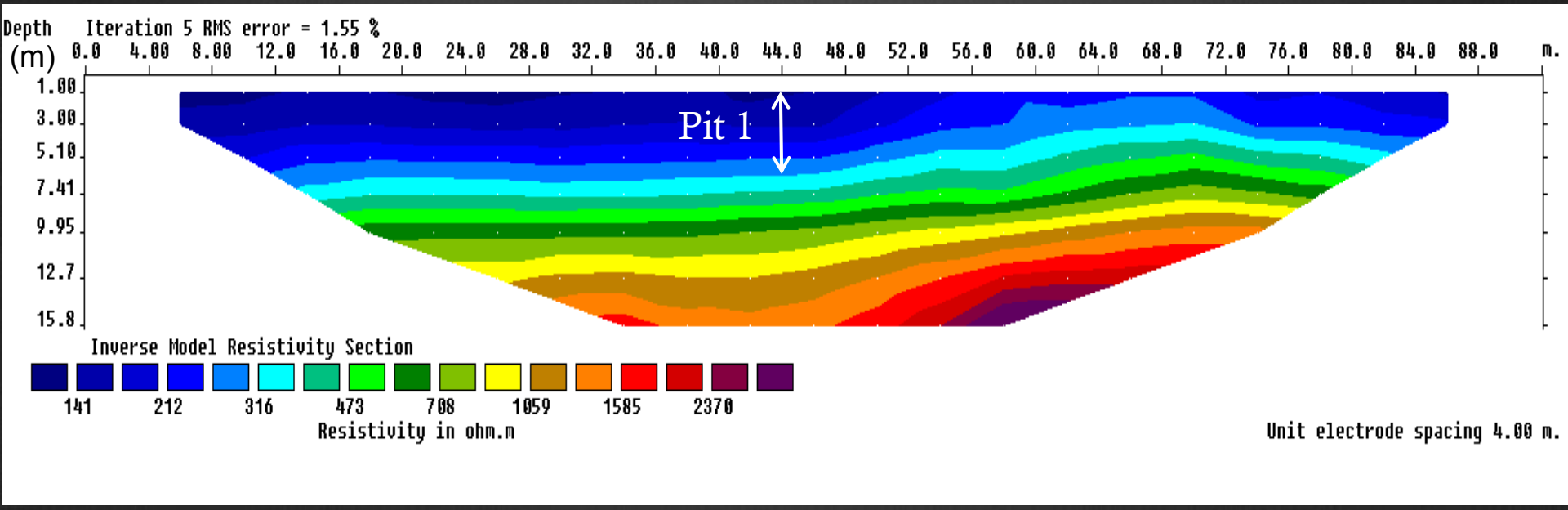
Shallow Bedrock in Ditch

Flow in Fractured Bedrock

One way to check depth to bedrock

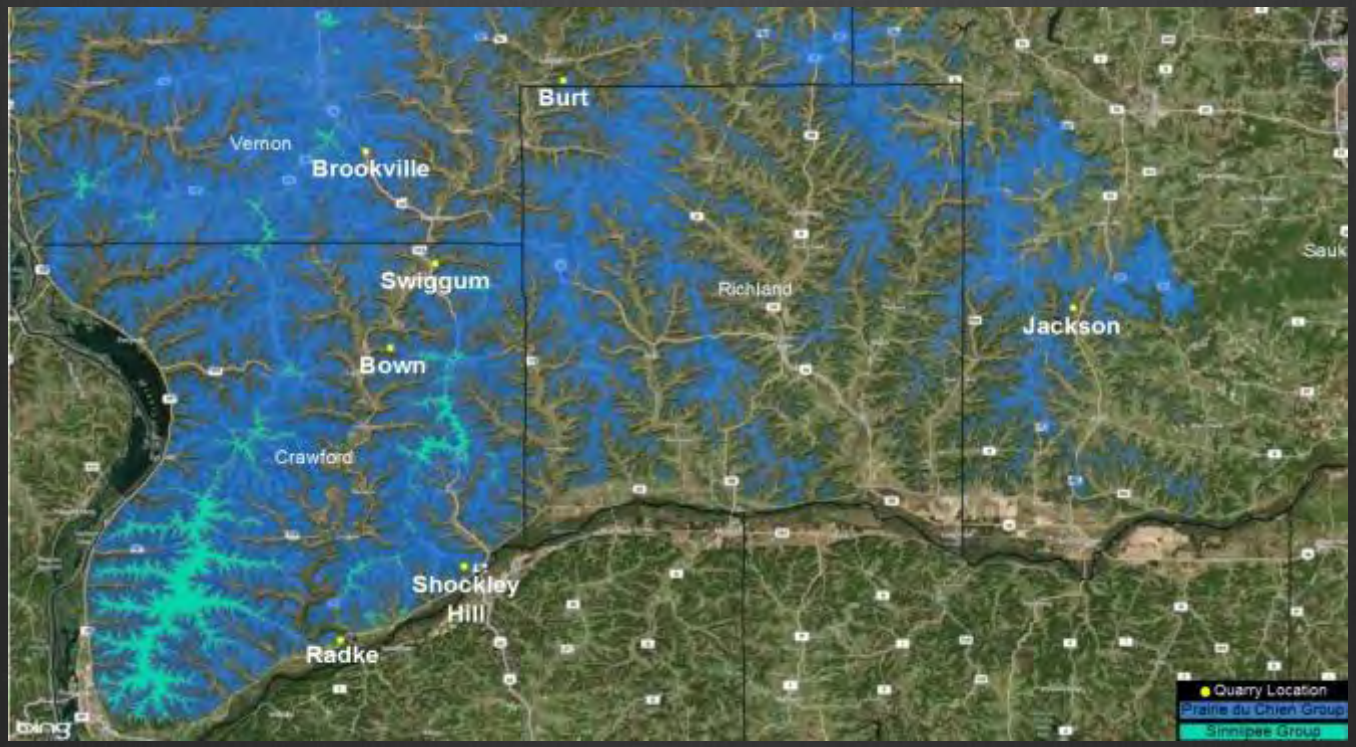
Results of Survey

- Transition is not as sharp.
  - Bedrock has a weathered zone and till is very hard.
  - Still, bedrock is more than 10 feet along most of line.
  - Pit helps confirm results here.
  - Good practice to have some confirmation.

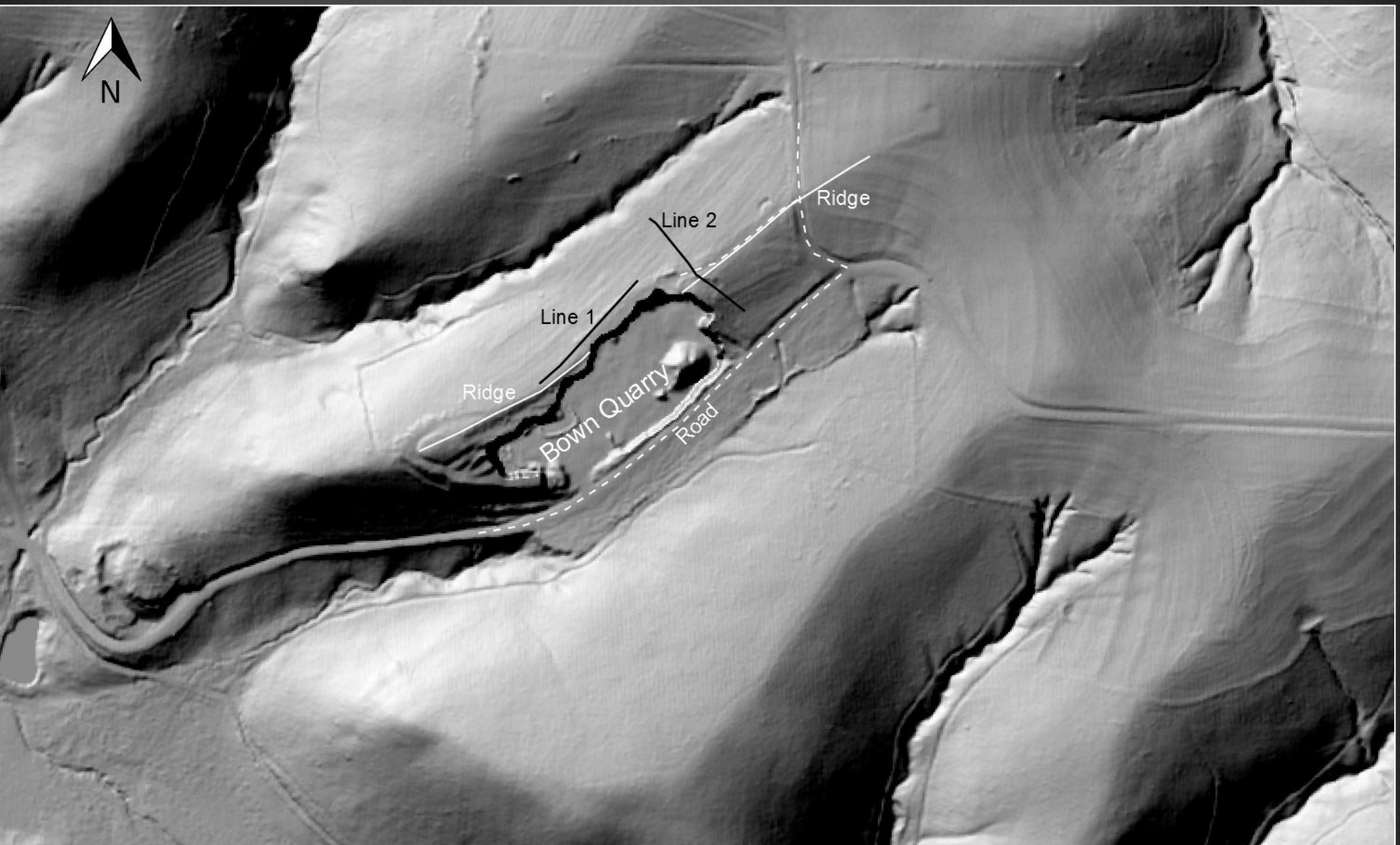


Depth to bedrock in Southwest Wisconsin

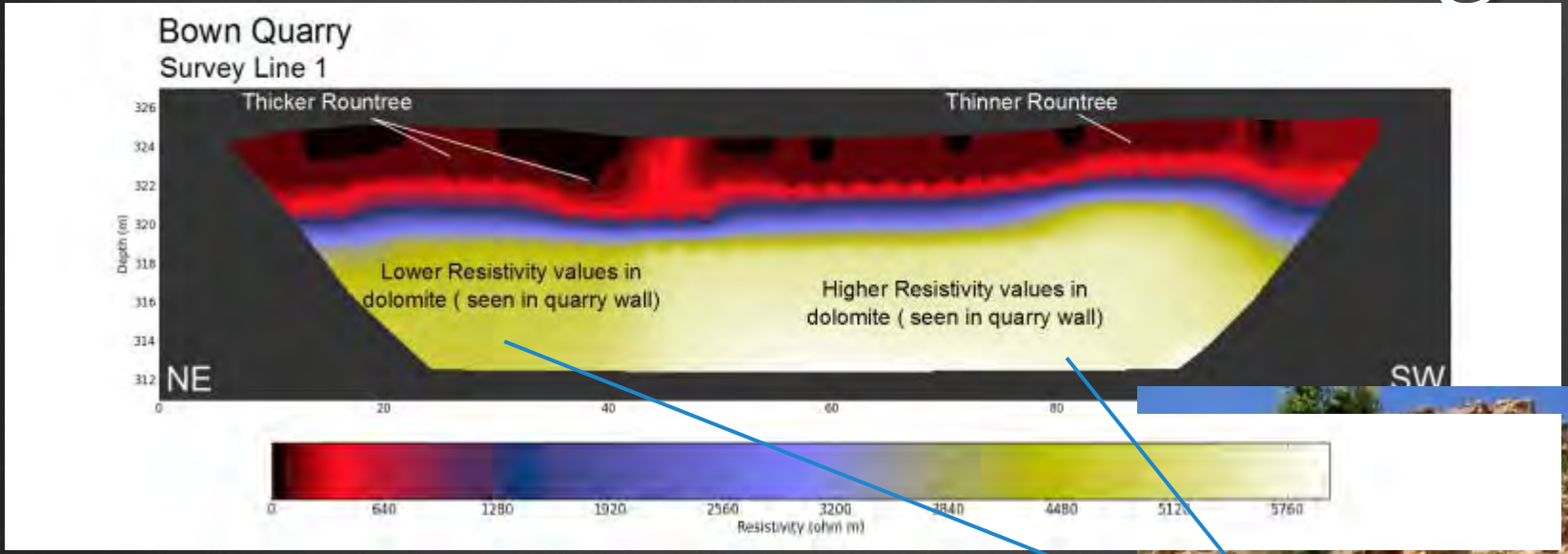
- Rountree formation caps many of the dolomite hills.
- Mostly clay with varying thickness
- Completed a study of dolomite quarries and Rountree

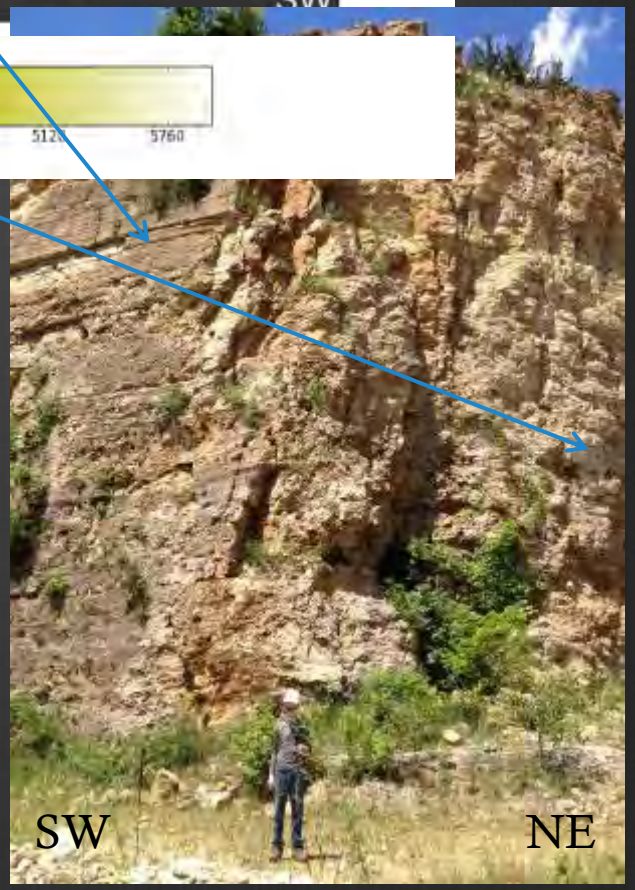


Bown Quarry



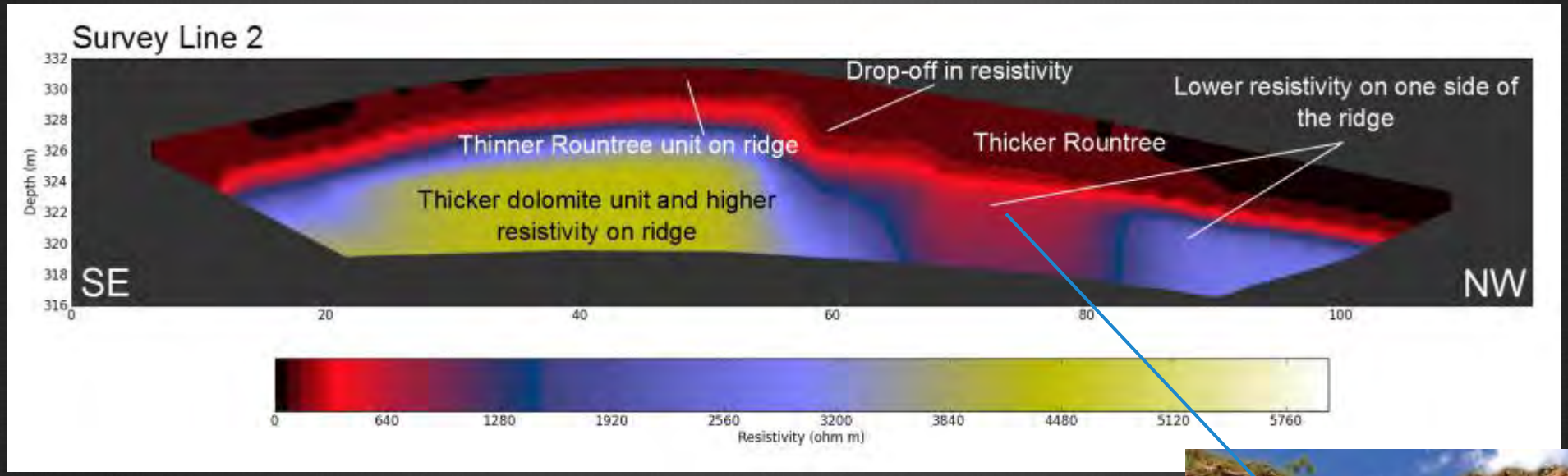
Line 1 – Parallel to Ridge





- Sharp contact
- Depth varies from 6 to 12 feet (2 – 4 meters)
- Can also variation in bedrock

Line 2 – Perpendicular to Ridge



- Rountree can sometimes follow fractures
- By filling and/or altering dolomite and enlarging the fractures.

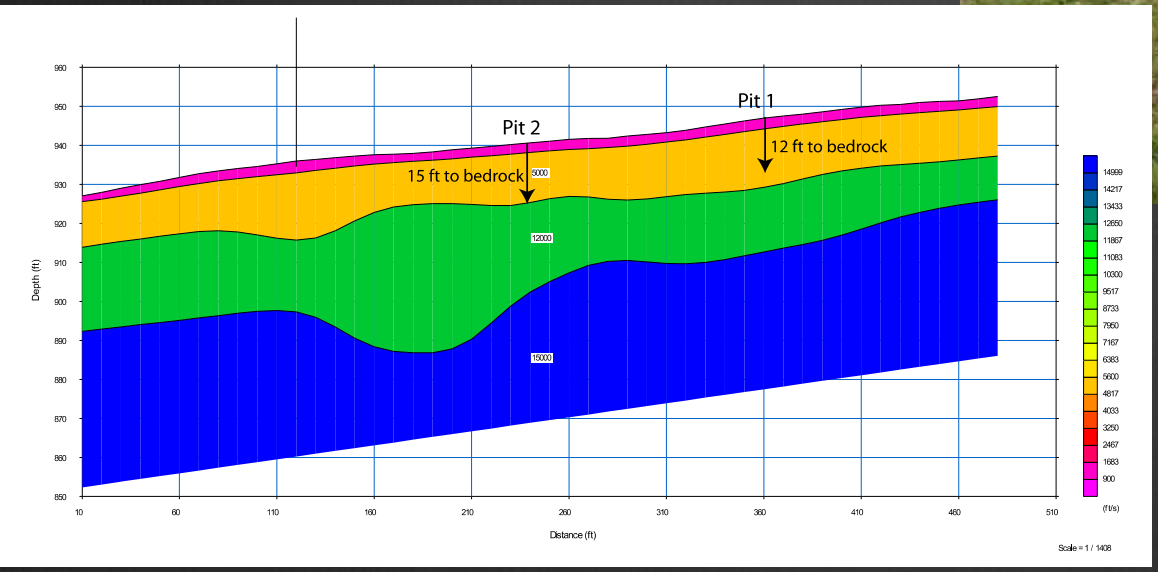
Other Geophysical Methods

- Seismic – Expensive and takes twice as long but gives good data
- Ground Penetrating Radar – Expensive and won't image into clays but sometimes gives good data.
- Passive Seismic –Very quick and easy to collect data. We are now using. Only gives depth to bedrock.

Other Geophysical Methods

- Refraction Seismic – Expensive and takes twice as long but gives good data

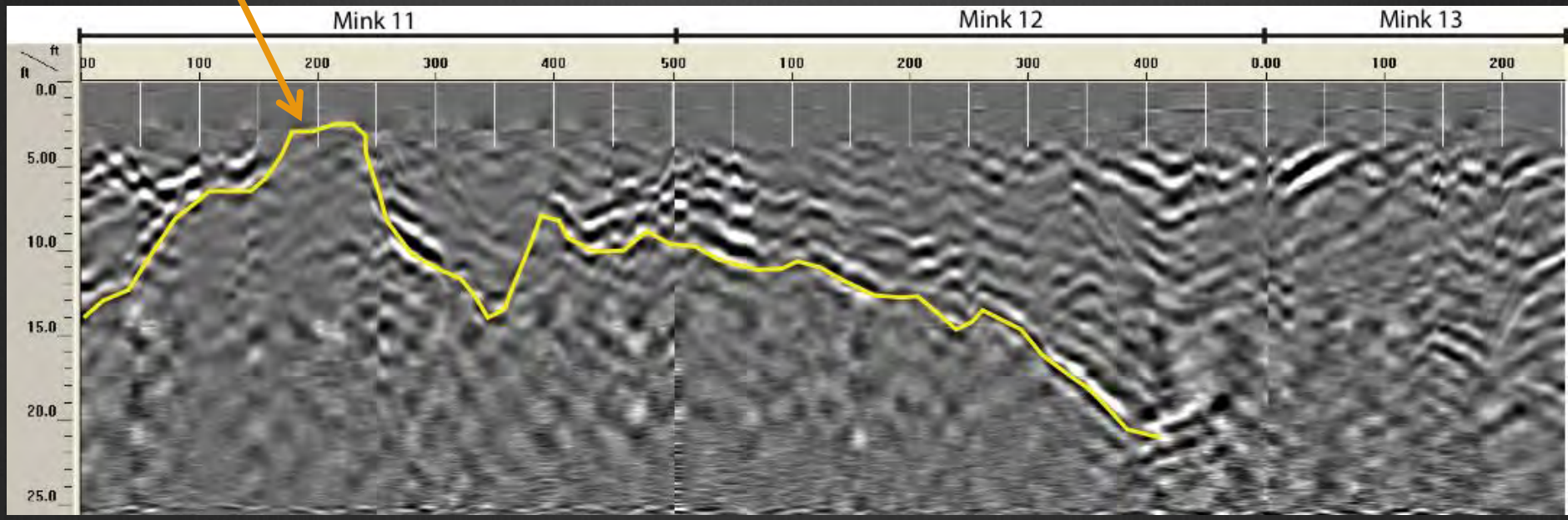
Seismic Results from Gold Star Farms, Calumet Co.



Other Geophysical Methods

Ground Penetrating Radar – Expensive and won't image into clays but sometimes gives good data.

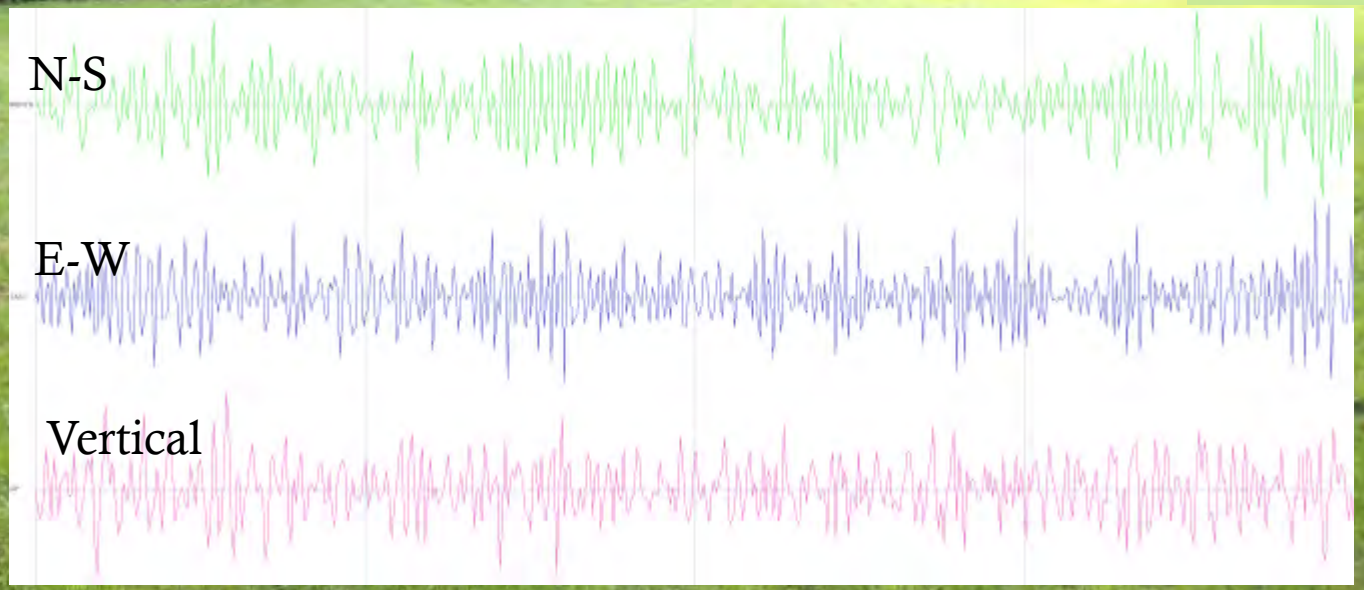
Bedrock seen at surface



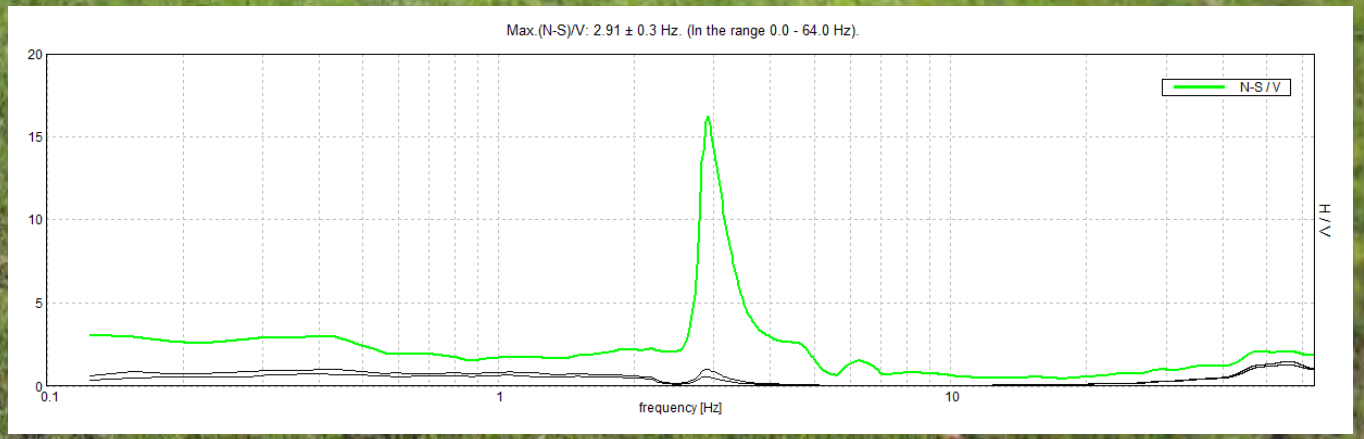
Other Geophysical Methods

- Passive Seismic –
- Just started to use in the central sand plains.
- Lower cost ($10,000) alternative.
- Fast data collection (20 minutes)
- Some expertise to recognize good/bad data.

Vibration Data
8 seconds shown,
Total is 20 minutes



Peak Ratio –
2.91cycles/second
➡ 73 feet depth



Questions?