Seeing Beneath the Surface

Overview

- Introduction: near-surface geophysics
- Description of geophysical tools*
- Applications
- Case studies
- Conclusions

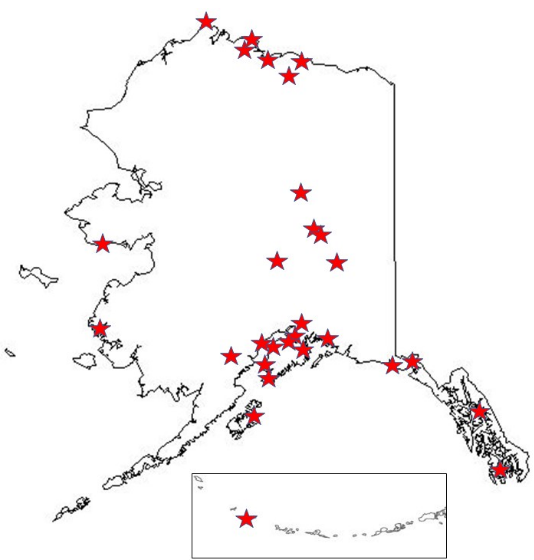
About the company

- Providing near-surface geophysical surveys and data analytics
- Remote-site expertise
  - Arctic: northern Alaska, northern Canada
  - Antarctica: McMurdo Dry Valleys
  - Tropics: Benin, Africa, Hawaii
  - Canyons: Yellowstone National Park
  - Mountains and glaciers: Alaska, the lower 48, and Antarctica
- Ph.D.-level data processing, analysis and interpretation

WOSB
Woman Owned Small Business

SDVOSB
Service Disabled Veteran Owned Small Business
cVE
SERVICE DISABLED VETERAN-OWNED SMALL BUSINESS

AK DOT Disadvantaged
Business Enterprise
#9900800



Tools

- Ground-penetrating radar
- Electrical-resistivity meters
- EM-31, EM-61
- Seismic sensors
- Magnetometers/gravity meters
- GPS/GLONASS

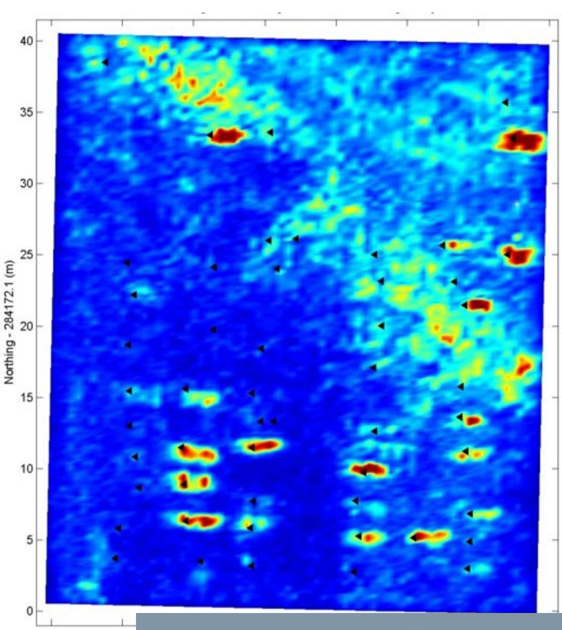
Ground-Penetrating Radar

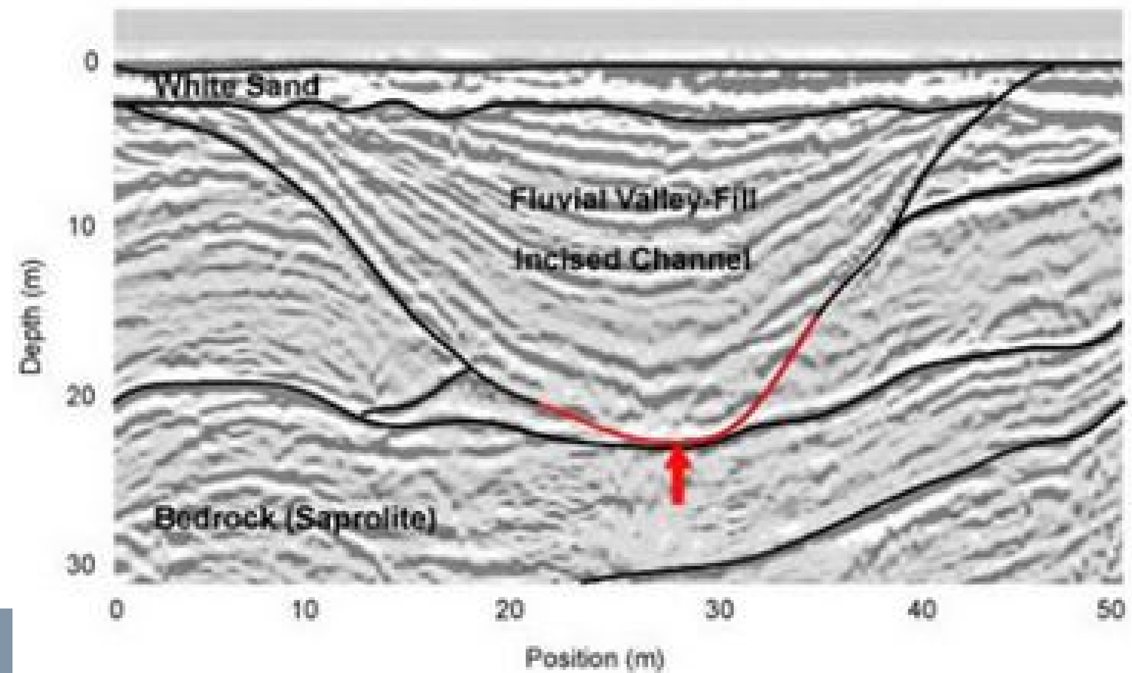
- Called GPR or ground probing radar, georadar
- "Fish finder for the ground"
- Sends electrical energy as waves into the ground
- The waves bounce off objects and get recorded
- Typical system includes control unit, power supply, and the antennas
- Different frequencies of antennas from 10-Mhz to 1-GigaHertz (GHz)
  - Lower frequencies see deeper but larger targets

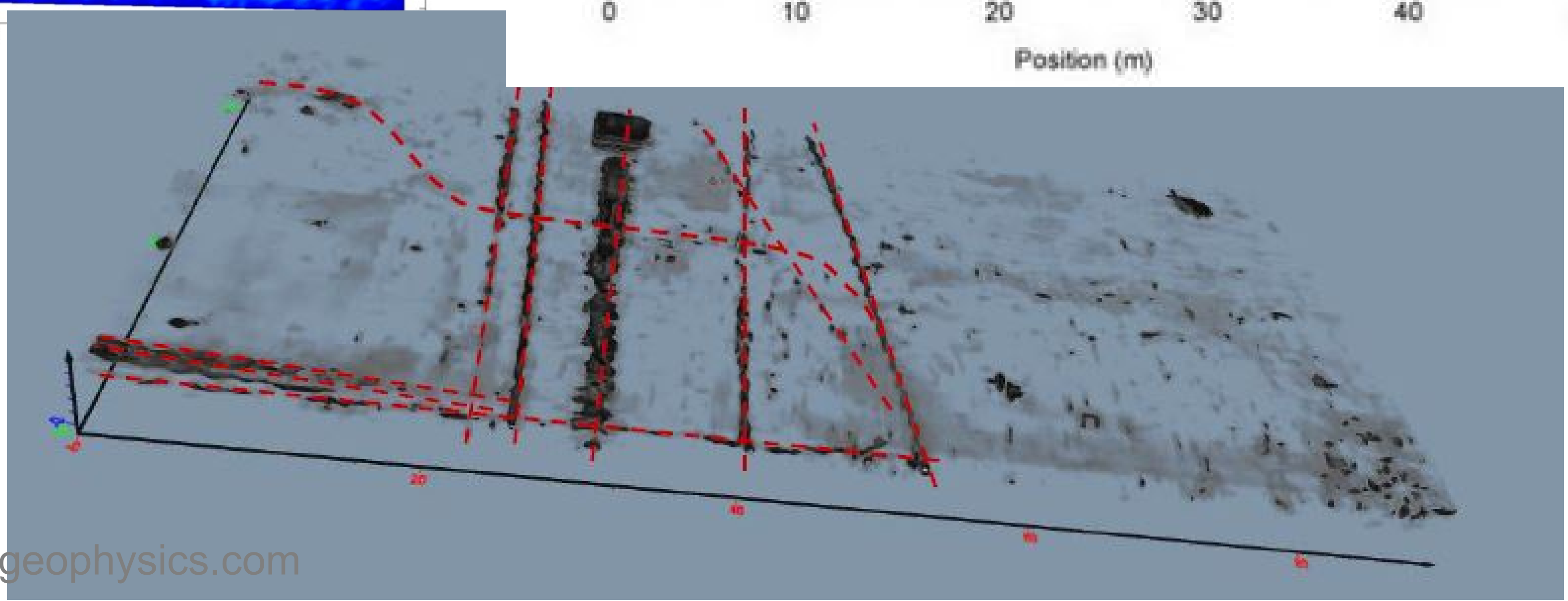
GPR Deployment

- Wheeled cart, sled, skis, manual, truck, snowmachine, Tucker, helicopter

GPR Data Examples







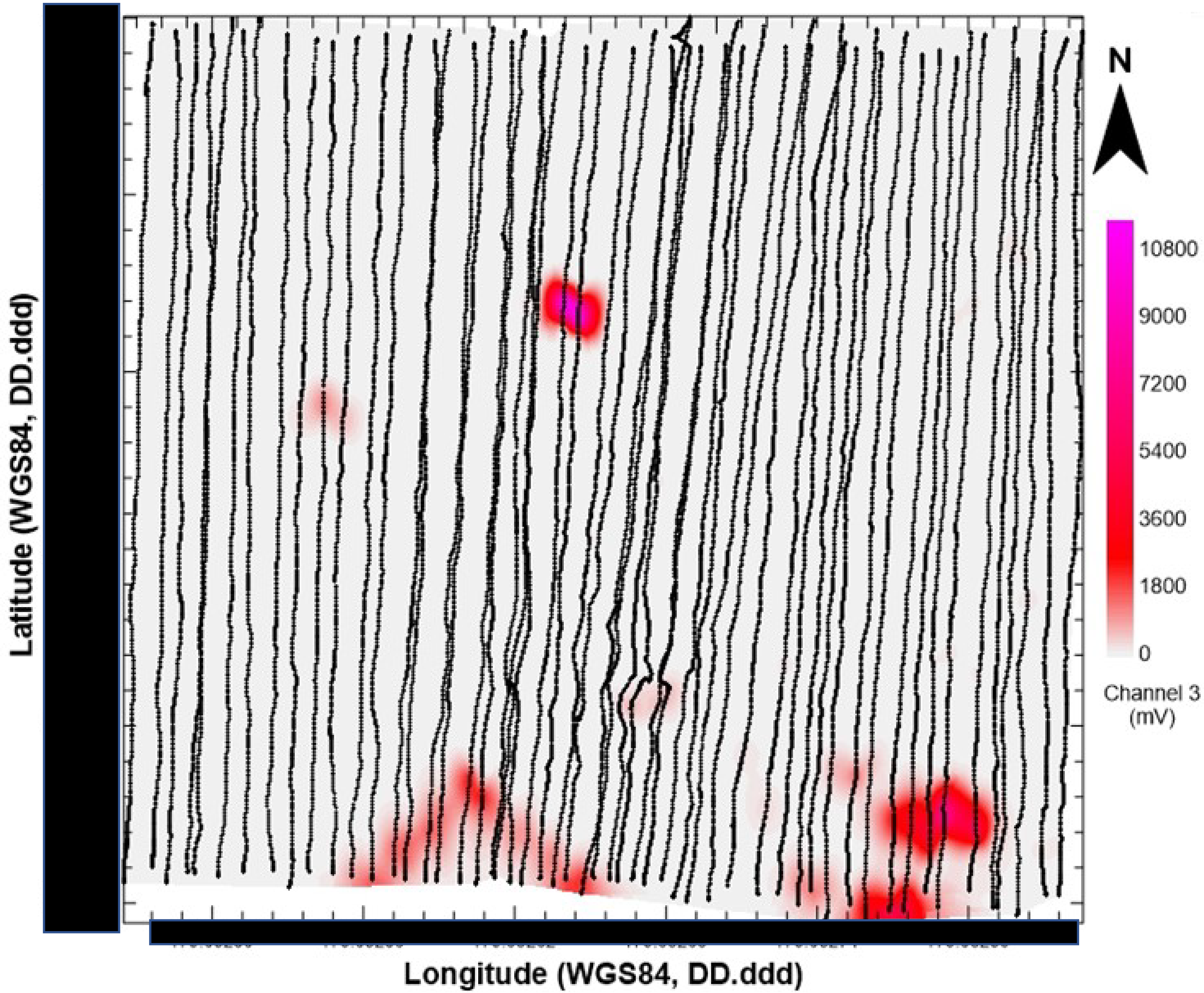
EM61

- Time-domain electromagnetics used to detect metal
- Transmitter coil on bottom generates current and an associated magnetic field
- Metal objects interact with this field such that the response can be measured in the receiver coil
- Can detect a buried 55-gallon drum up to 15 feet below surface
- Good resolution of small metallic targets close to surface
- Rugged and durable for remote sites

EM61 Deployment

- Usually pulled or pushed manually
- Can be pulled behind snowmachine or ATV if project allows
- Not deployed from the air
- Multiple units can be run simultaneously to speed acquisition

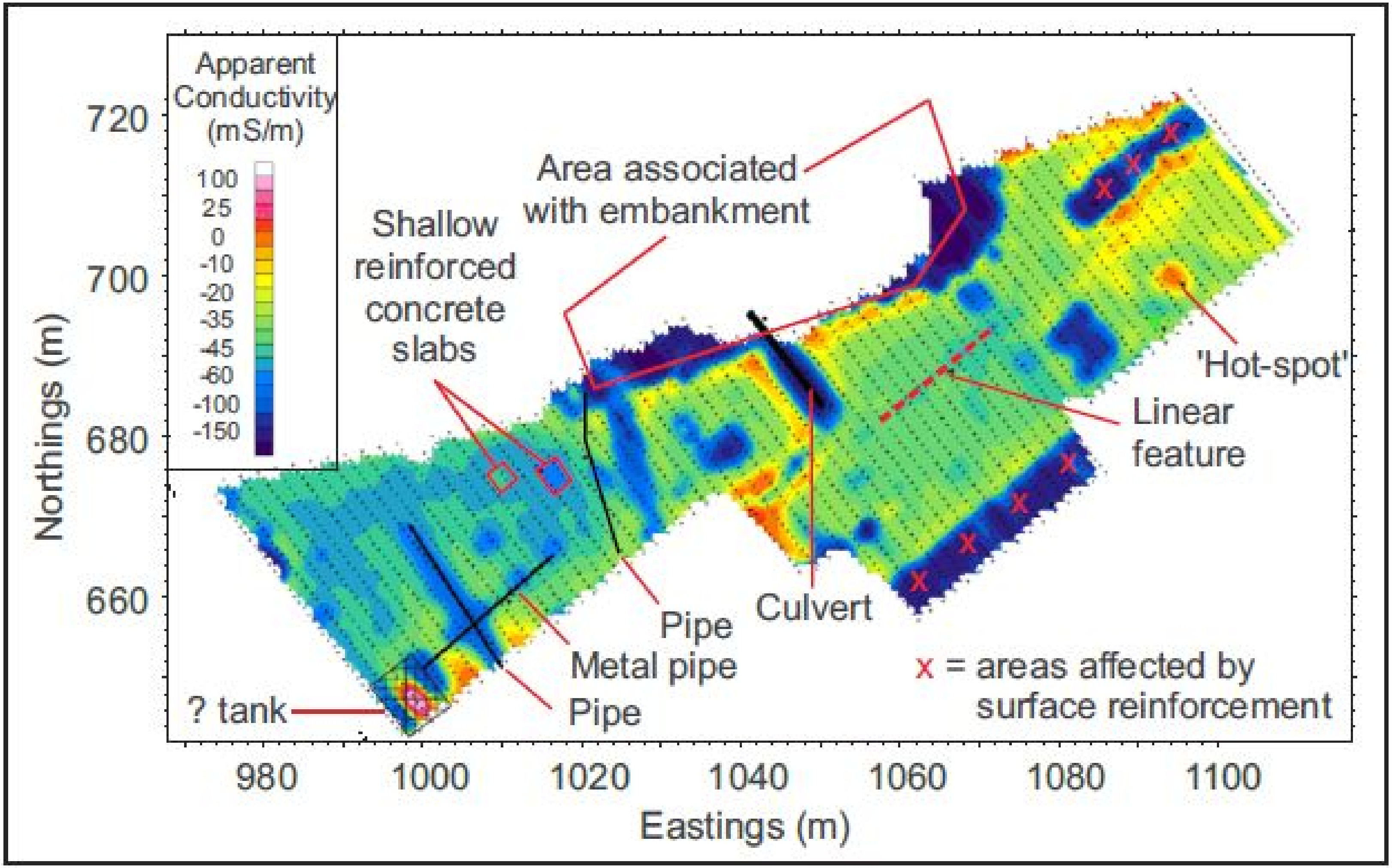
EM61 Data Example



EM31

- Time-domain electromagnetics used to detect metal <u>and</u> subsurface contamination
- Transmitter and receiver are mounted on opposite ends of the boom
- Depth of penetration up to 15 feet
- Generally carried or pulled on a sled
    - Closer to ground provides more depth of investigation

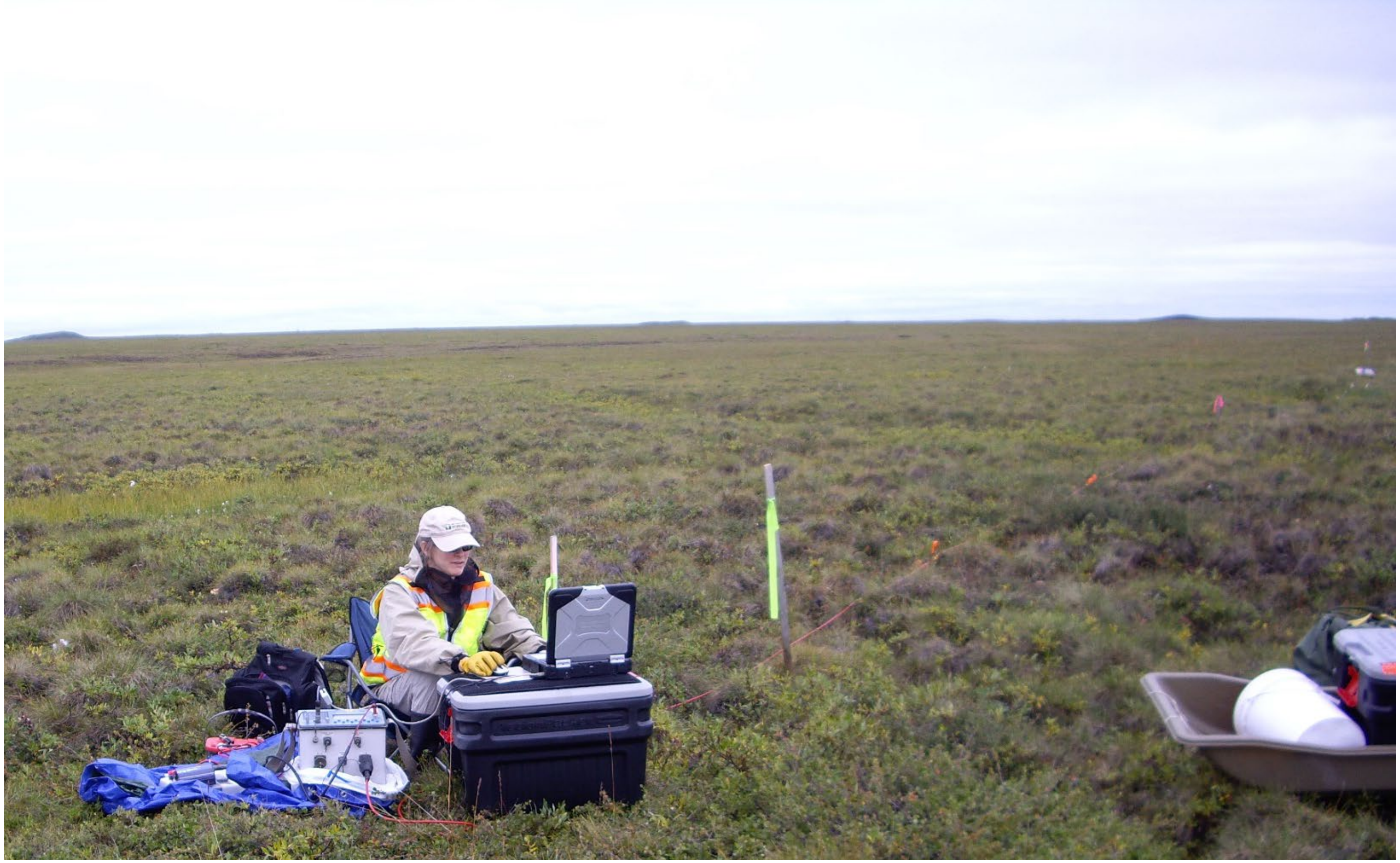
EM31 Data Example



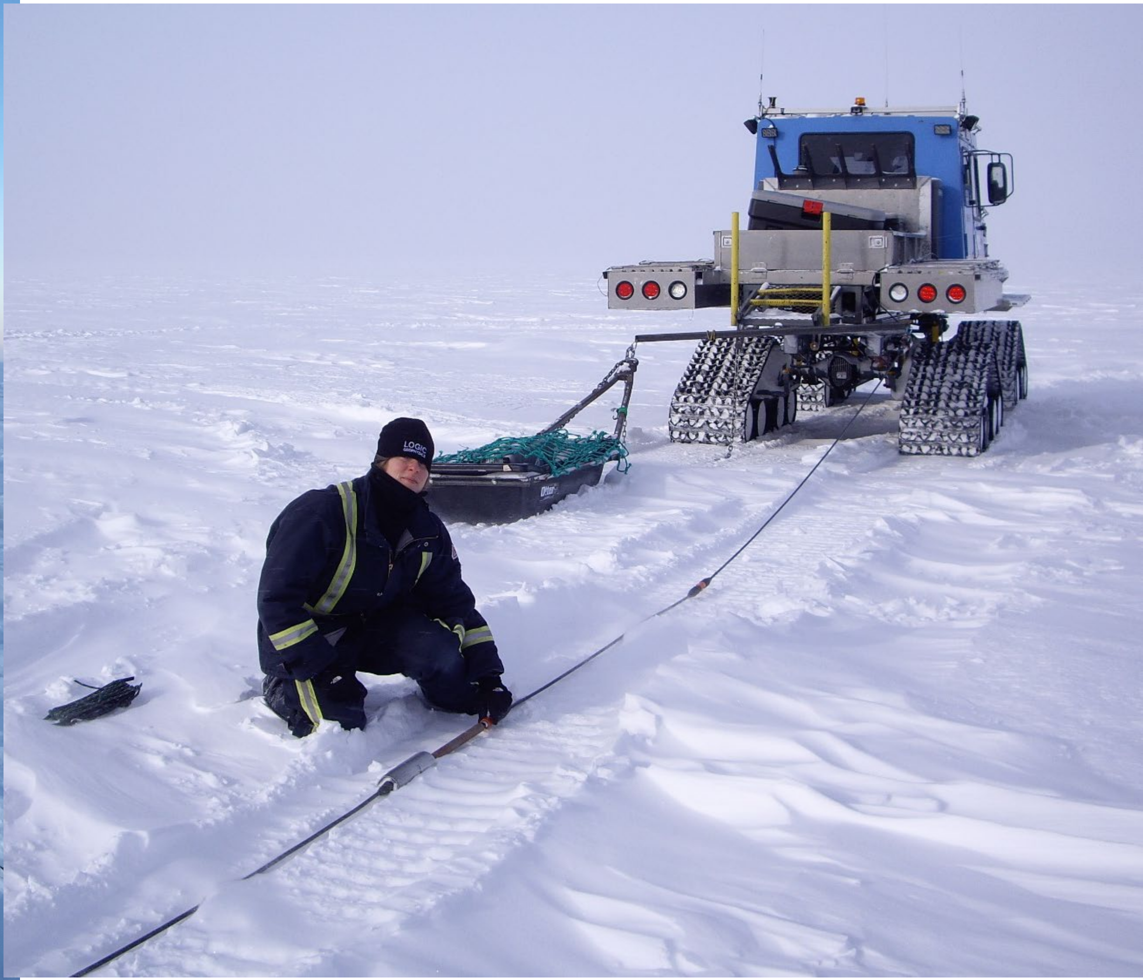
Resistivity Tools

- Resistivity tools try to directly measure the ground resistivity or conductivity
- Often known as “direct-current” (DC) techniques
- Current is injected or couple into the ground between 2 transmitter electrodes
- The current passes through the ground and is measured at receiver electrodes
- The data can be interpreted to identify man-made and lithologic targets

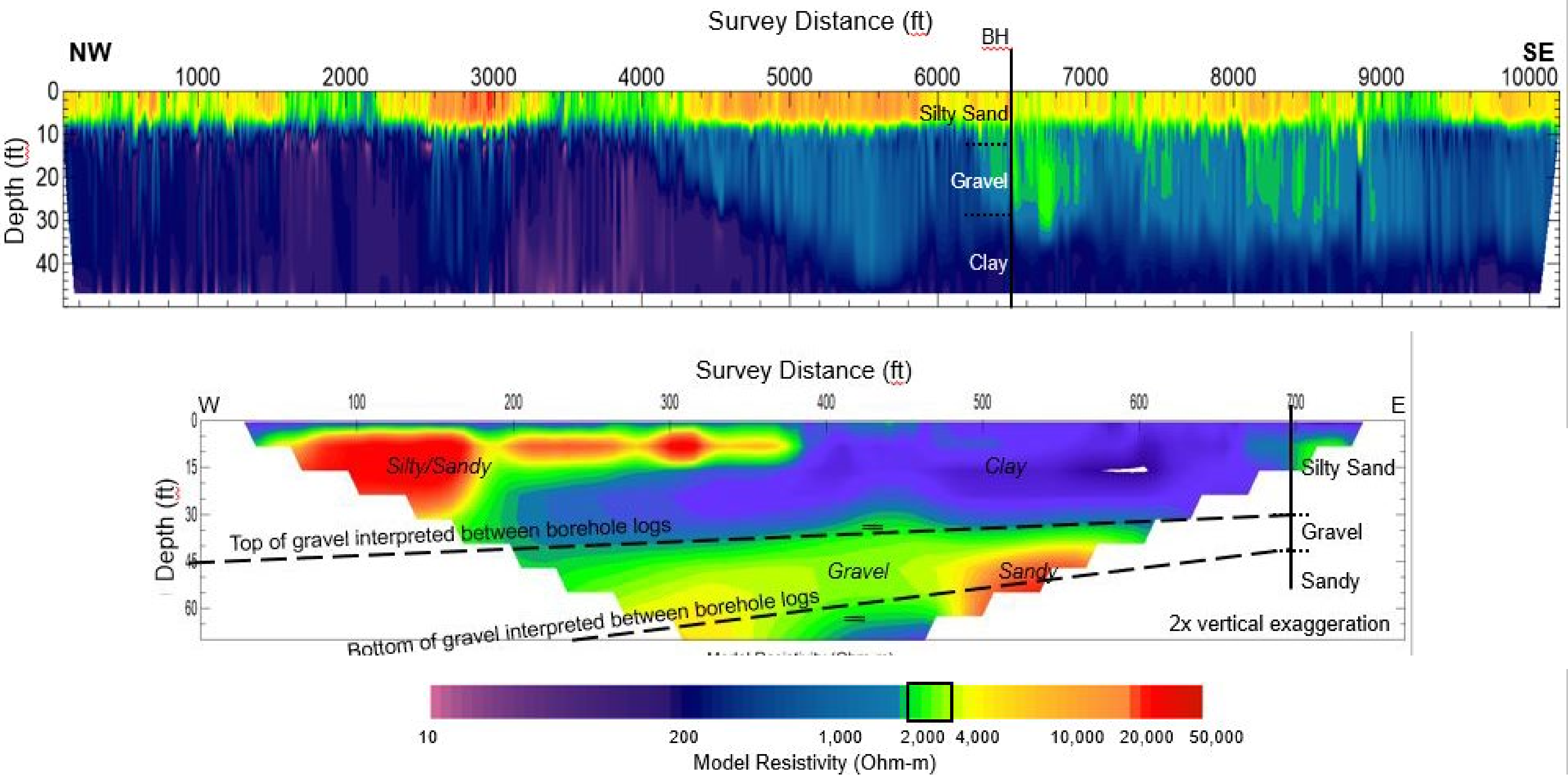
Resistivity Tools: “Conventional”



Resistivity Tools: “Capacitively-Coupled”



Resistivity: Data Examples



Near-Surface Seismic

- Generate a wave in the ground, usually with a sledgehammer or explosives
- Use devises called “geophones” to record the seismic energy:
  - Refractions
  - Reflections
  - Surface waves
- Data can be processed and interpreted to measure the ground velocity with is correlated with material properties and interfaces:
  - Depth to groundwater
  - Depth to bedrock
  - Rippability
  - Stiffness

Seismic Deployment

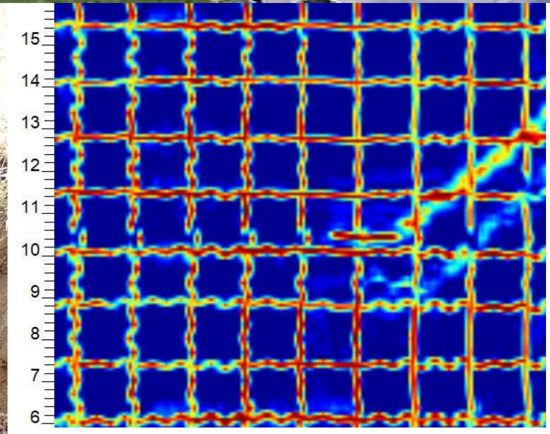
- Usually must plant geophones in the ground
  - Can be difficult and slow in hard ground (road embankments) and frozen ground
- Can use a “drag-along” array on smooth surfaces
- Sledgehammer source requires significant manpower….
- ….but explosives are difficult to deal with and transport
- Optimum configuration depends on site conditions and desired targets

Applications

- "Buried objects"
- Geologic surveys
- Contaminant mapping
- Archaeological surveys

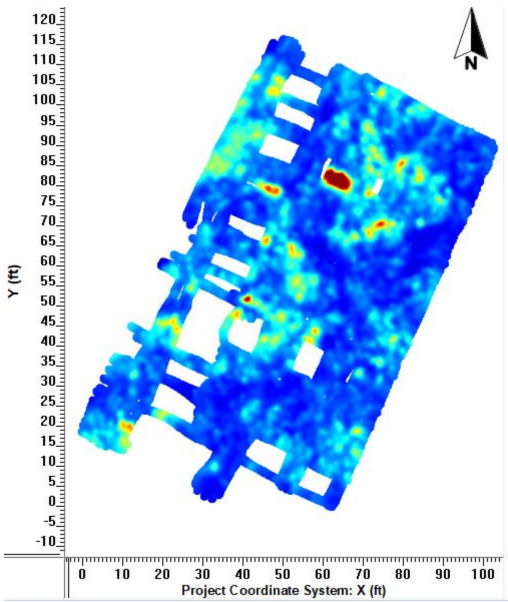
"Buried Objects"

- Utilities (GPR, EM61)
- Tanks (GPR, EM61, EM31)
- Drums (GPR, EM61, EM31)
- Rebar/PT cable/conduit in concrete (GPR)
- Voids (GPR, resistivity)



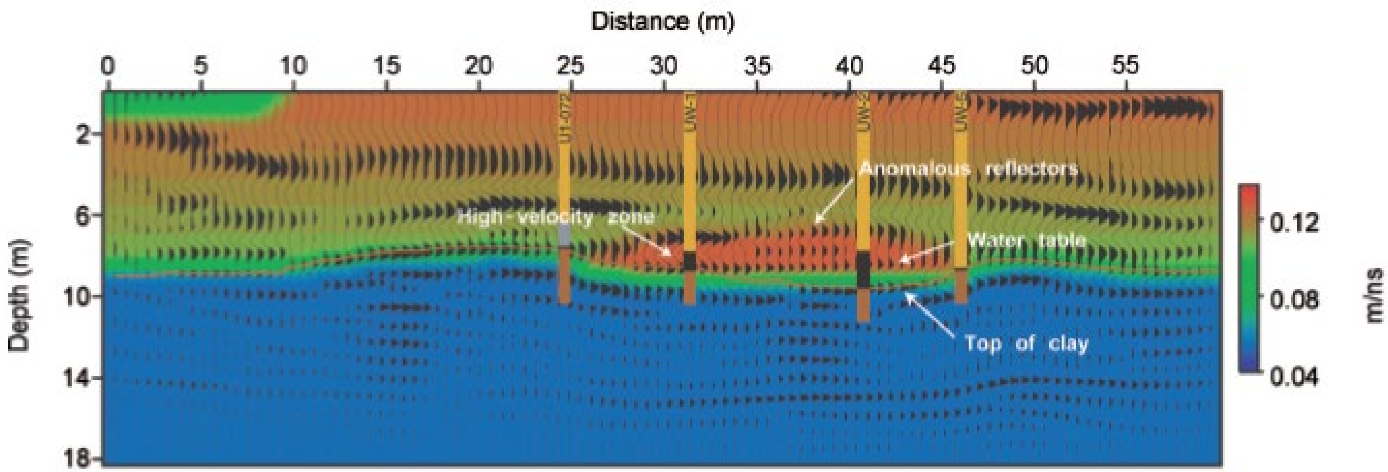
Archaeology

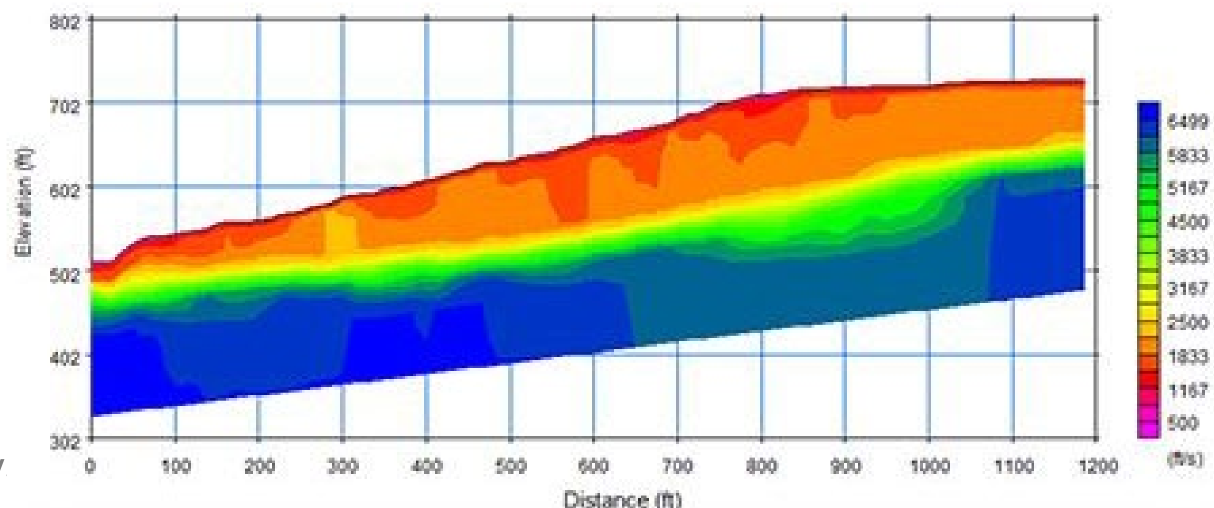
- Detecting grave sites
- Finding other buried objects
- Delineating cultural sites



Geologic Mapping

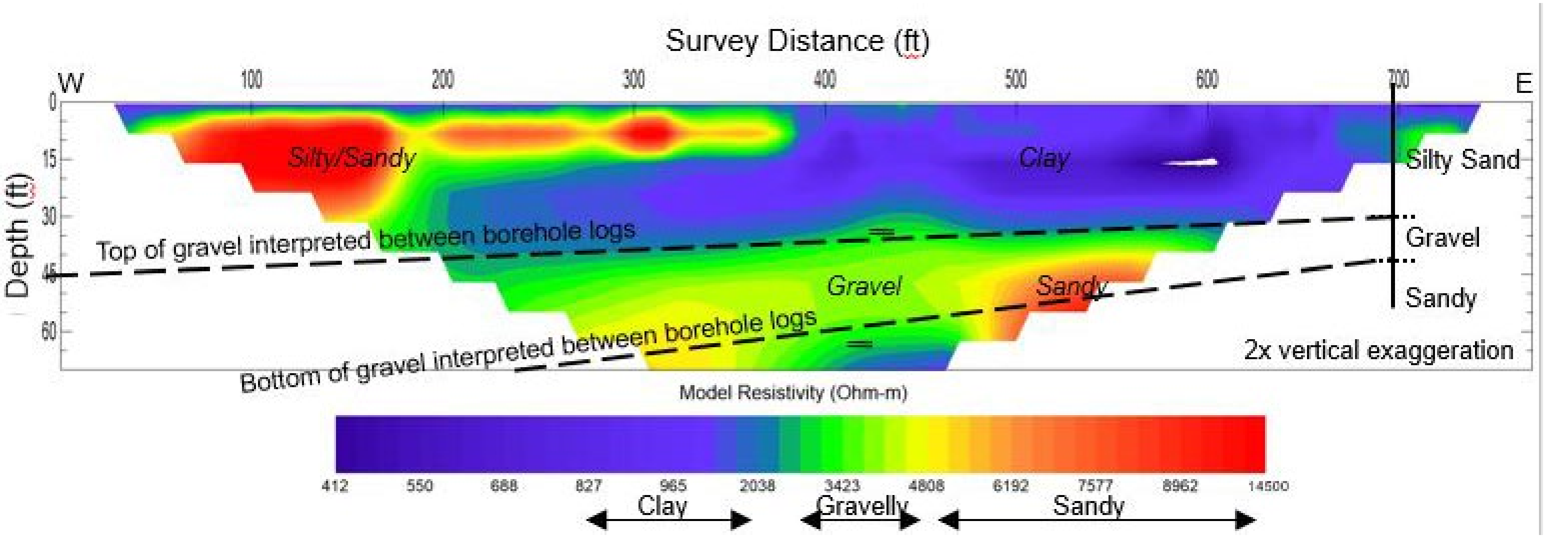
- Depth to bedrock (GPR, resistivity, seismic)
- Depth to groundwater (GPR, resistivity, seismic)





Geologic Mapping

- Buried mass ice/thaw bulbs (resistivity)
- Gravel deposits (resistivity)
- Clay layers (resistivity)
- Permafrost (GPR, resistivity)



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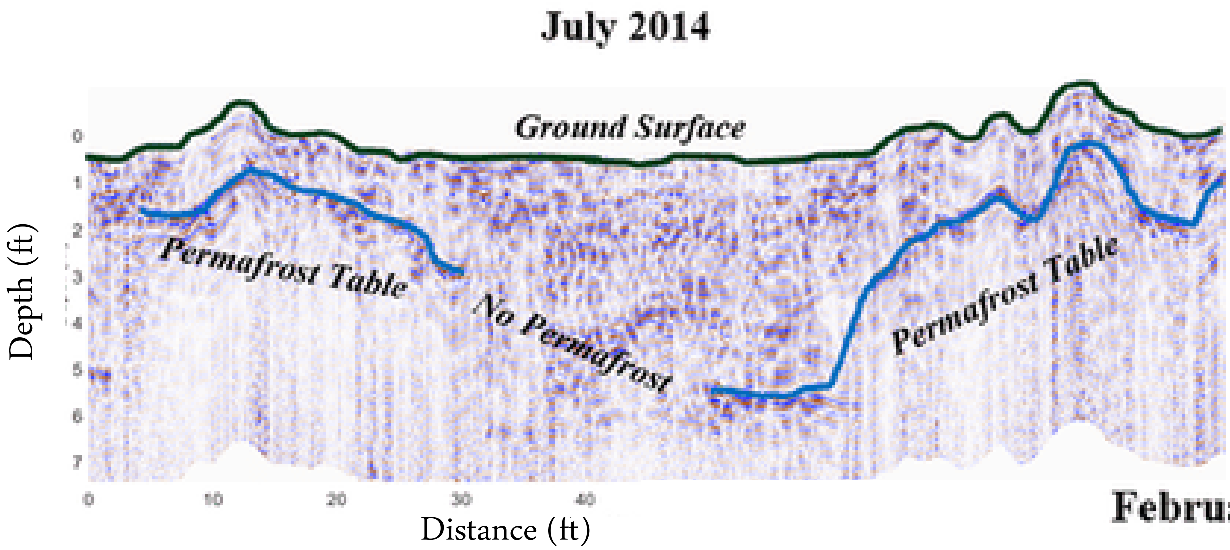
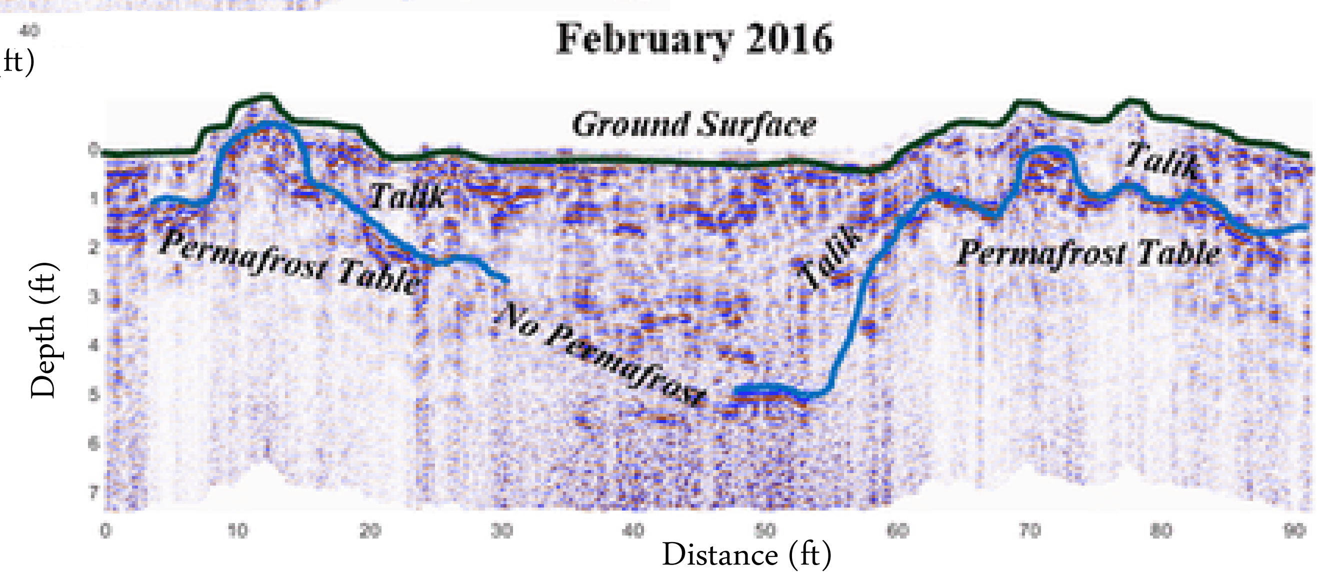
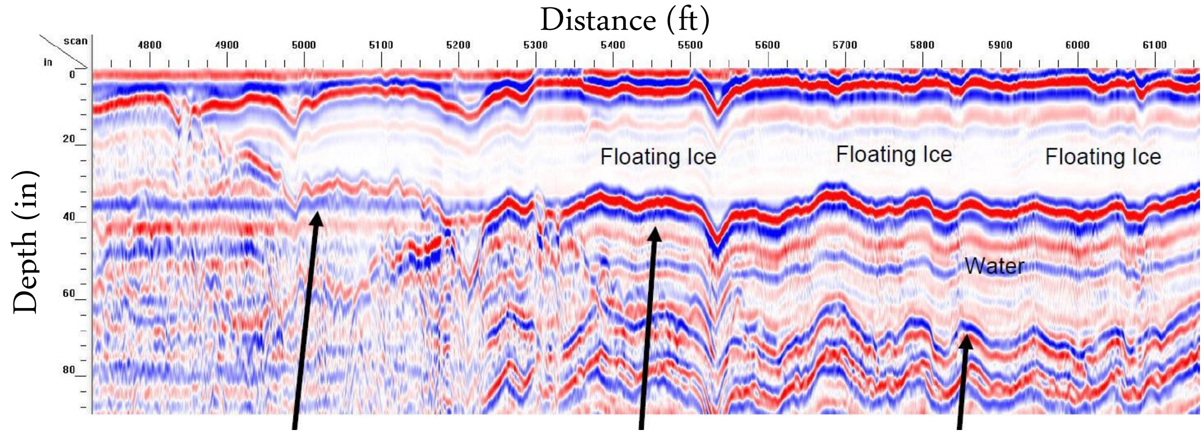
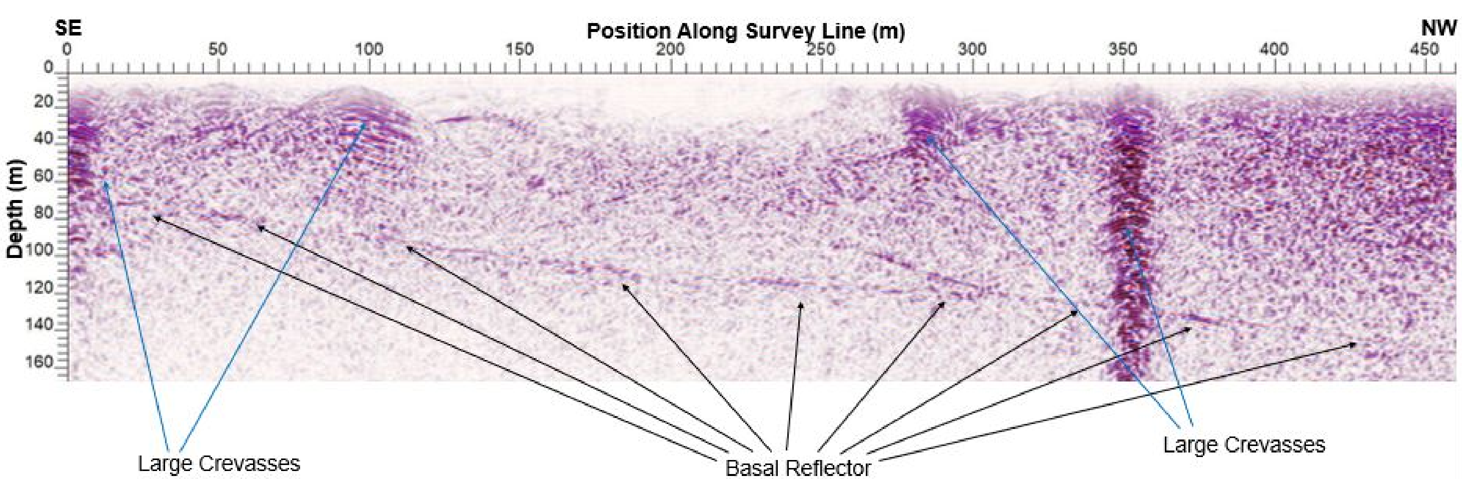




Ice and Snow

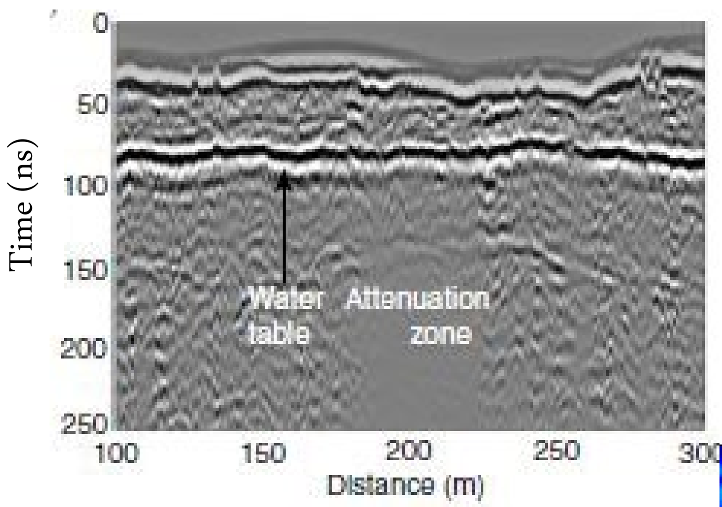
- GPR is an incredibly good tool at providing ice thickness and snow thickness
- Can even be deployed from the air for these applications

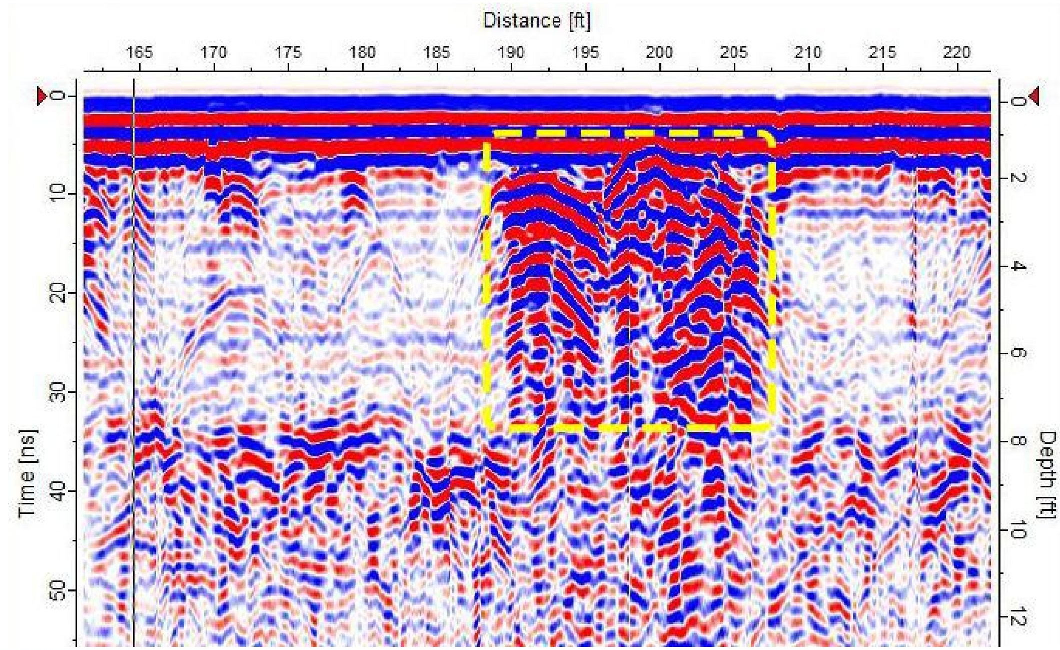


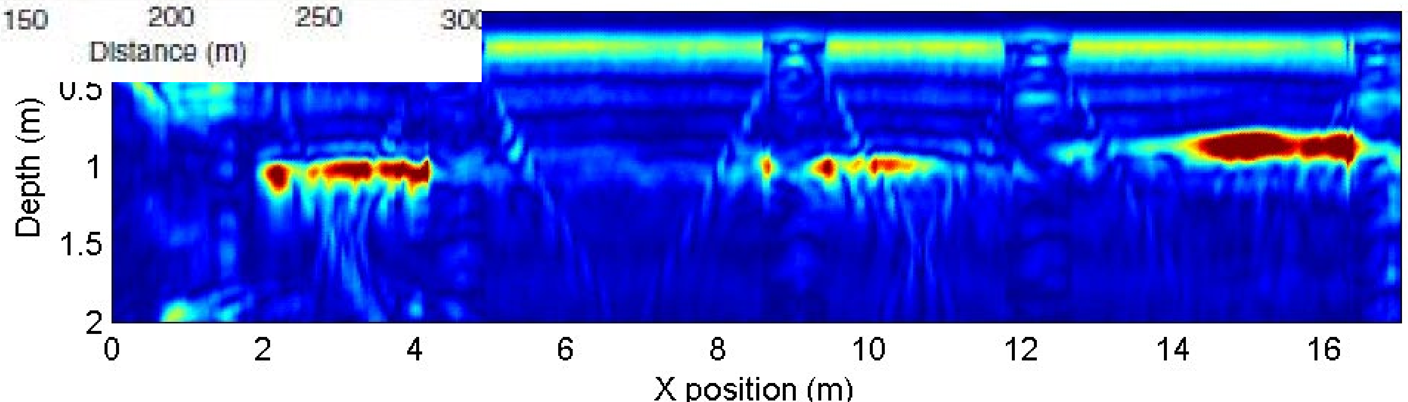


Contaminated Sites

- Mapping landfills
- Mapping subsurface contamination
    - Hydrocarbons
    - Chlorinated solvents
    - Other (?)







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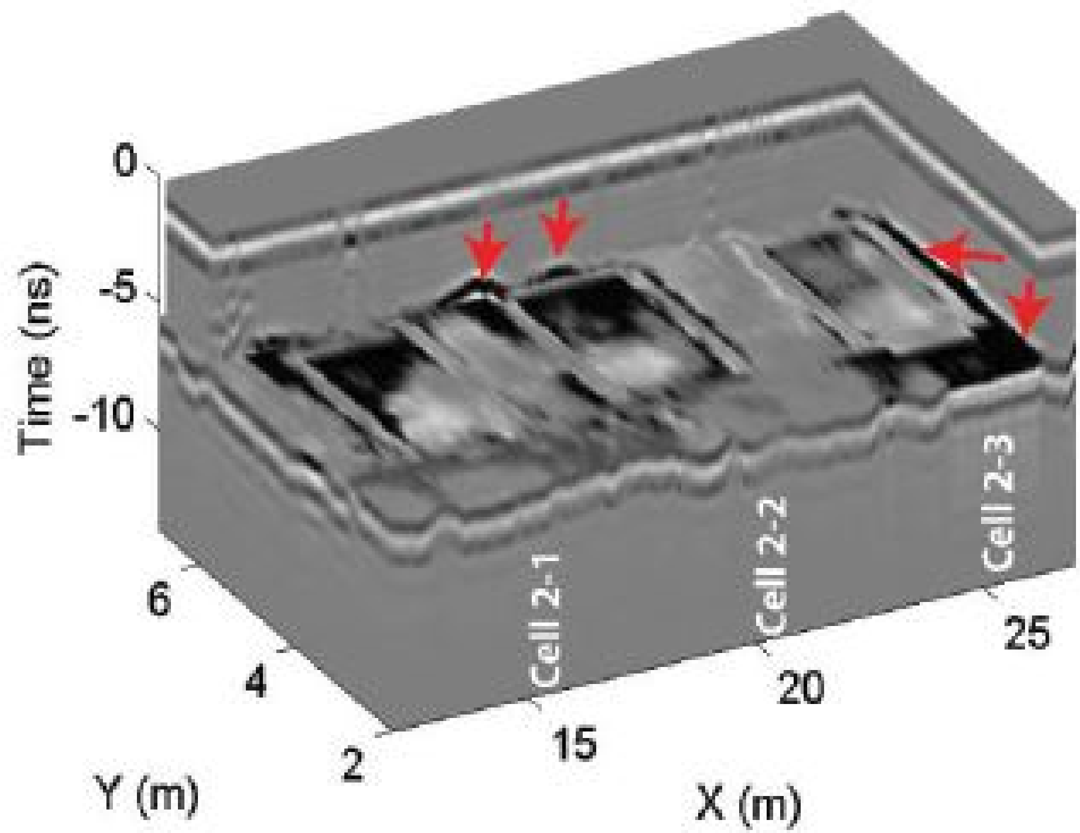

Case Study

Where gravel is gold: Electrical resistivity surveys to find gravel deposits on the North Slope of Alaska

- ~100 miles of data collected pulling resistivity array with tracked vehicle (Tucker)
- Deployed from both mobile and fixed camps on the North Slope west of Nuiqsut in winter
- Conducted jointly with a drilling campaign to verify results
- 60-70% successful results for predicting gravel locations
- Updated information from boreholes enhances interpretation
- Potential plans for gravel delineation with GPR

Case Study

Cemetery surveys in Nome, Alaska, to find unmarked grave locations

- ~5 acres of surveys conducted in both marked and unmarked regions of the City's cemeteries and planned cemeteries
- Antennas often pulled on a sled instead of a cart because of the rough tundra surface
- Rapid data processing and results delivered within 3 weeks of completion
- Anomaly locations marked on site using survey-grade GPS

Case Study

Seismic refraction surveys to measure depth to bedrock on Annette Island, Alaska

- Rapid deployment after project notification
- 10 lines of seismic data collected in difficult conditions: all work completed safely, on-time, and on-budget
- Results delivered within 1 week for rapid integration into larger project for engineering design work
- Results were then corroborated with excavation

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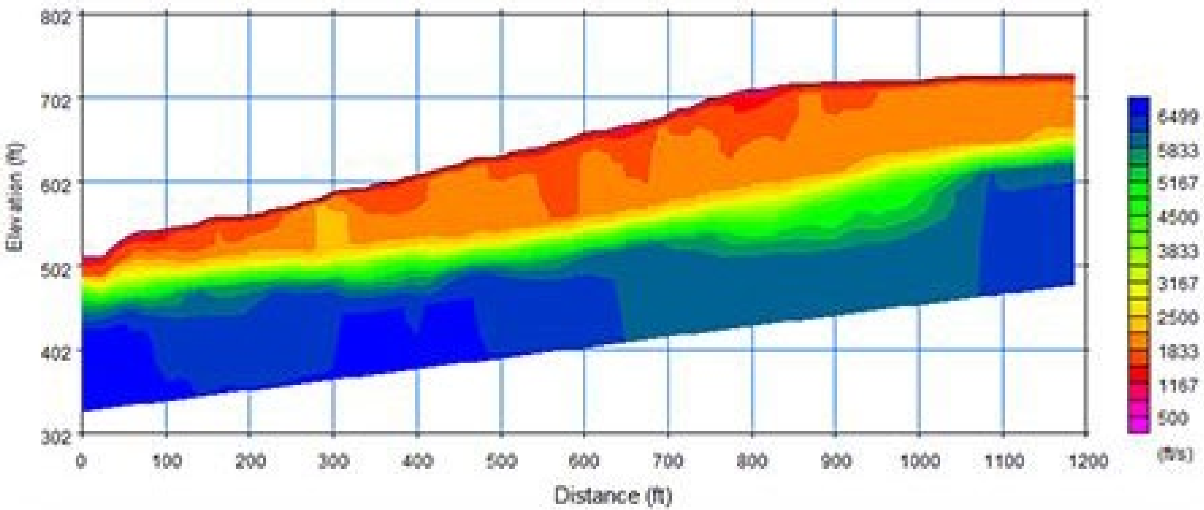


www.logicgeophysics.com

Case Study

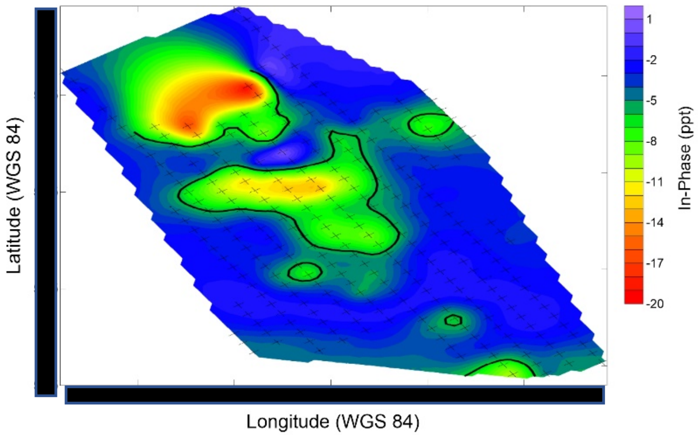
Ground-penetrating-radar surveys to measure ice (and snow) thickness on the North Slope of Alaska

- Hundreds of miles of GPR data collected with equipment towed behind a tracked vehicle
- Work conducted safely in harsh weather and, at times, difficult terrain
- Daily turn-around of data processing enabled following crews to travel safely and avoid dangerous ice locations

Case Study

EM-31 surveys for detecting buried debris and contamination at a former Air Force station in southeast Alaska

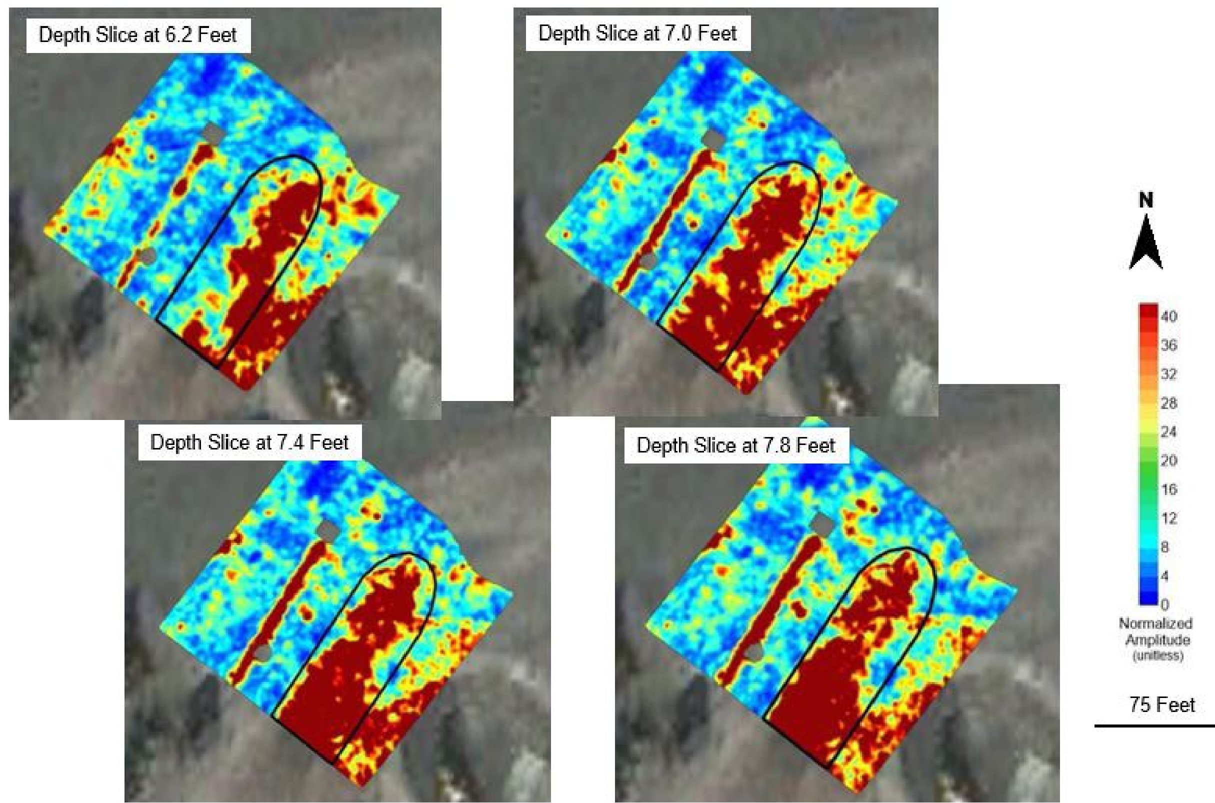
- Surveys conducted in difficult terrain after vegetation clearing
- GPS positioning provided by post-processing due to heavy canopy cover
- Data processing conducted on-site immediately after acquisition to provide results to drilling, excavation, and sampling operations



Case Study

Using ground-penetrating radar (GPR) to find a buried ship

- Liberty Ship buried at the Port of Anchorage during port construction in the 90s
- Ongoing engineering work required accurate ship location
- GPR results matched the orientation and size of the buried ship as shown on old Google Earth imagery, dozens of feet away from the expected location
- Georeferenced results were incorporated into engineering site plans



Caveats and Conclusions

- As you've seen, geophysics can be very useful for a wide range of applications
- However, geophysical methods are NOT infallible
- Geophysics is an exercise in interpretation – you don't get to hold the dirt in your hand!
- Interpretation often requires "ground truth" in the form of boreholes
- Improper choice of equipment, inadequate data processing, and/or poor survey design can cause the methods to fail

Caveats and Conclusions

- The strength of the methods:
  - Reduce overall cost by minimizing the number or boreholes, excavations, etc
  - AND at the same time you get more information: Cheaper and Better = “Win-win”!
  - And safer: for example reduced exposure to hazards encountered while digging
  - Non-invasive: no need for ground disturbance in sensitive areas

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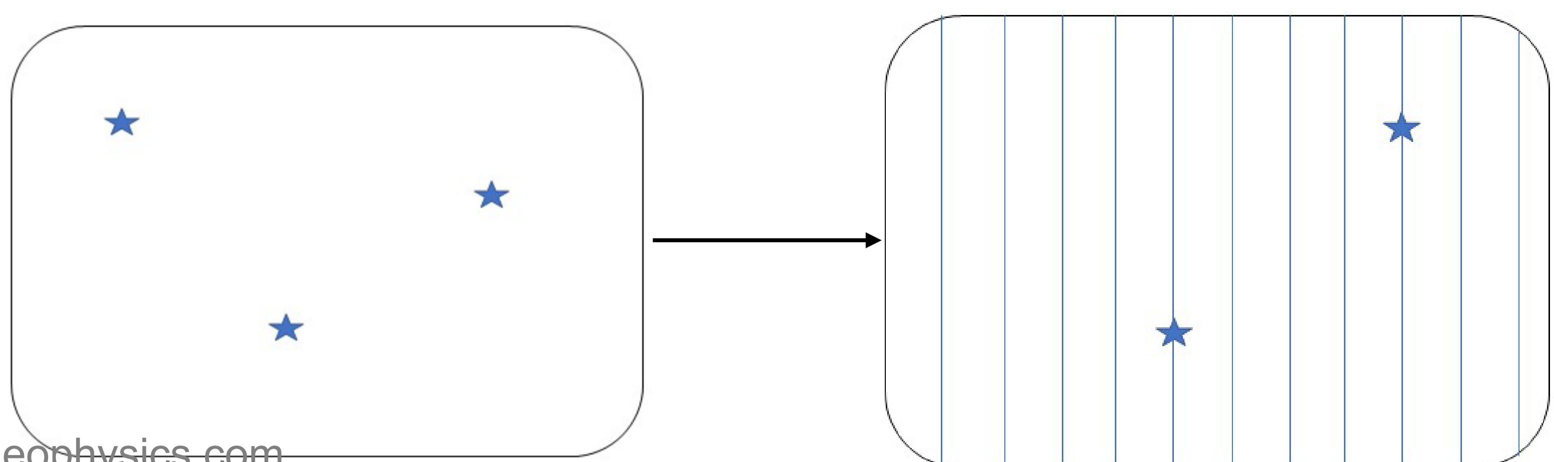

Caveats and Conclusions: Positioning

- Results can all be positioned in real-world coordinates through combined use of GPS systems with the geophysical equipment

Questions?