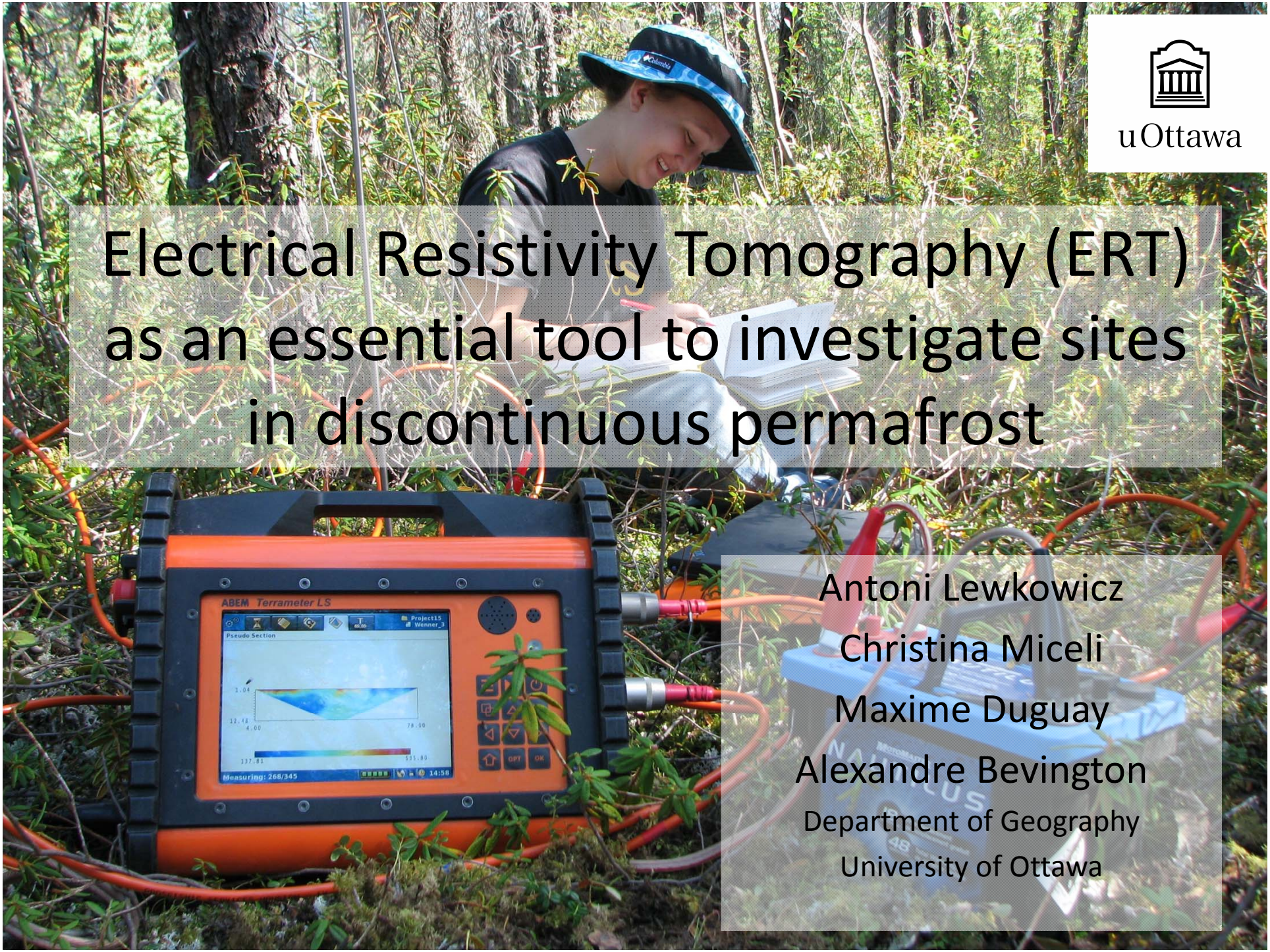

uOttawa

Electrical Resistivity Tomography (ERT) as an essential tool to investigate sites in discontinuous permafrost

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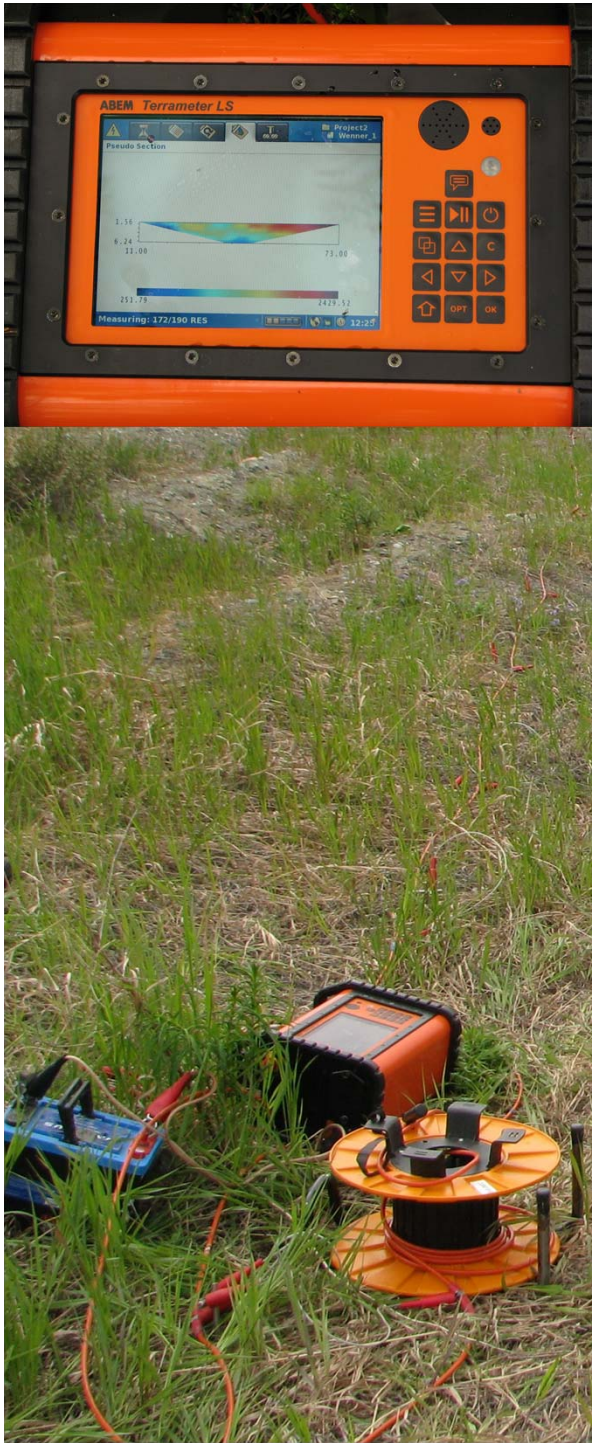
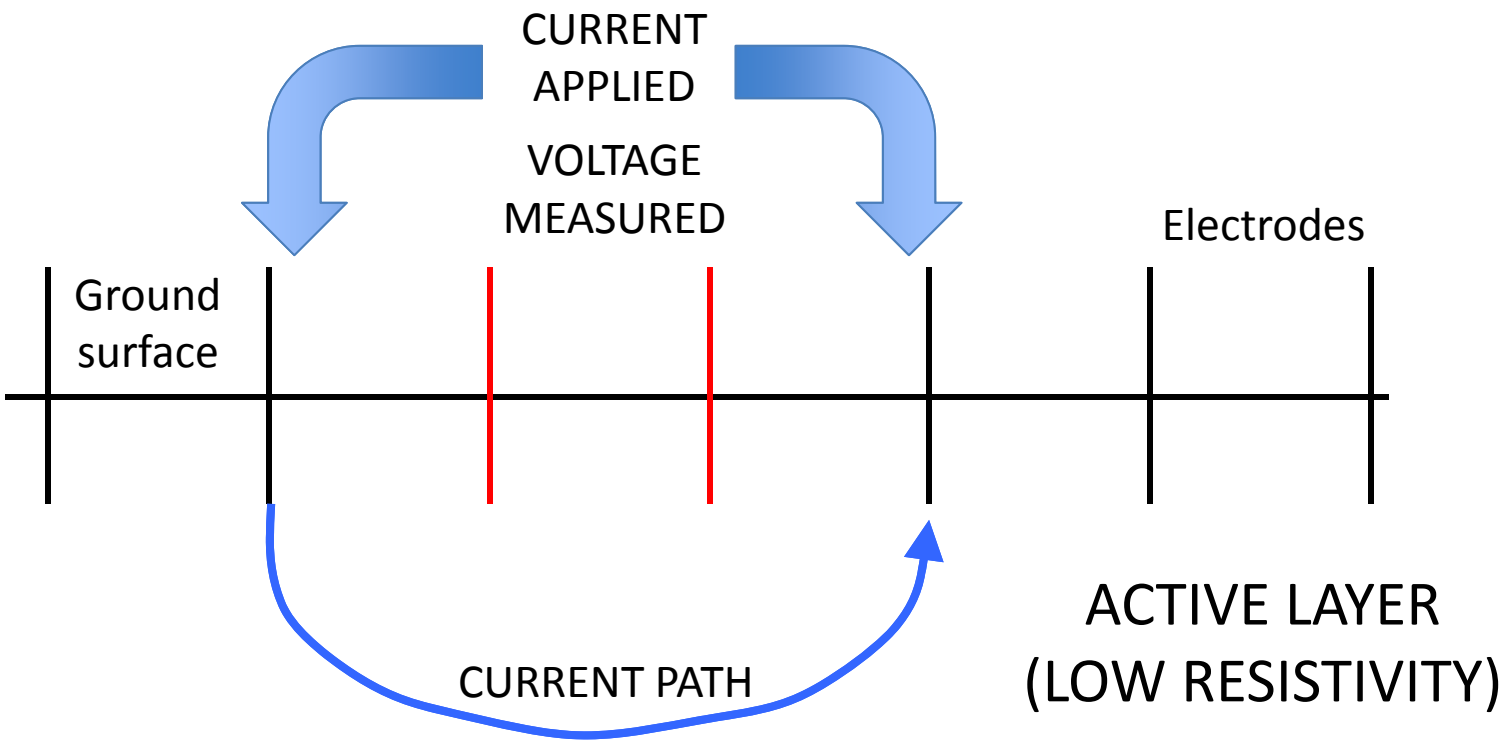


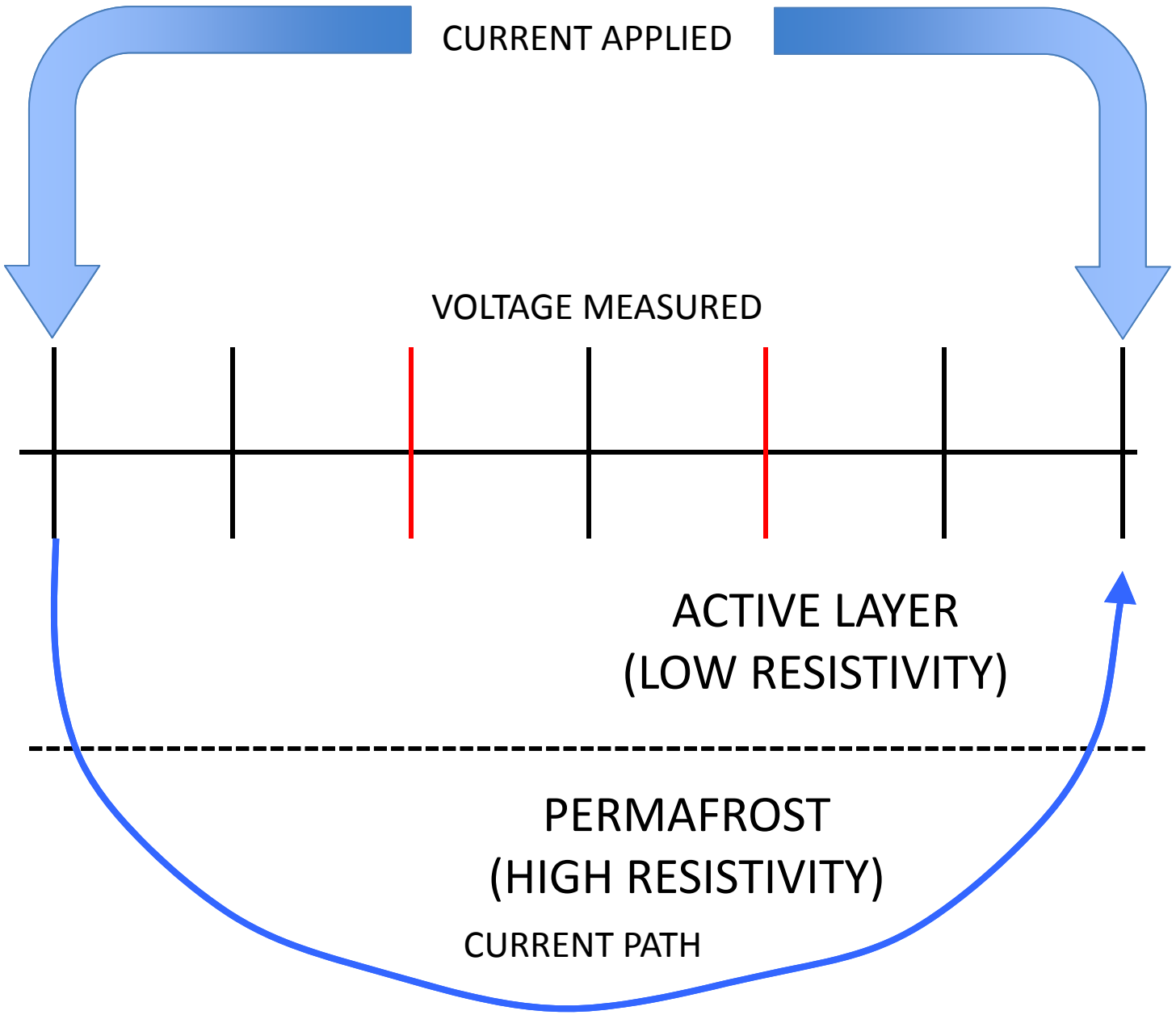
What is Electrical Resistivity Tomography (ERT)?

- ERT is a geophysical technique in which DC electrical current is injected into the ground between one pair of electrodes and the voltage is measured between another pair.
- A line (array) of electrodes is used and an instrument called a terrameter acts as a switch box and a measuring device, sending energy to different sets of electrodes through a set sequence.

Principle of ERT and permafrost



- The electrical resistance of water in the ground is very low.
- The electrical resistance of ice in the ground is up to several orders of magnitude higher.


CURRENT APPLIED
VOLTAGE MEASURED
ACTIVE LAYER
(LOW RESISTIVITY)
PERMAFROST
(HIGH RESISTIVITY)
CURRENT PATH

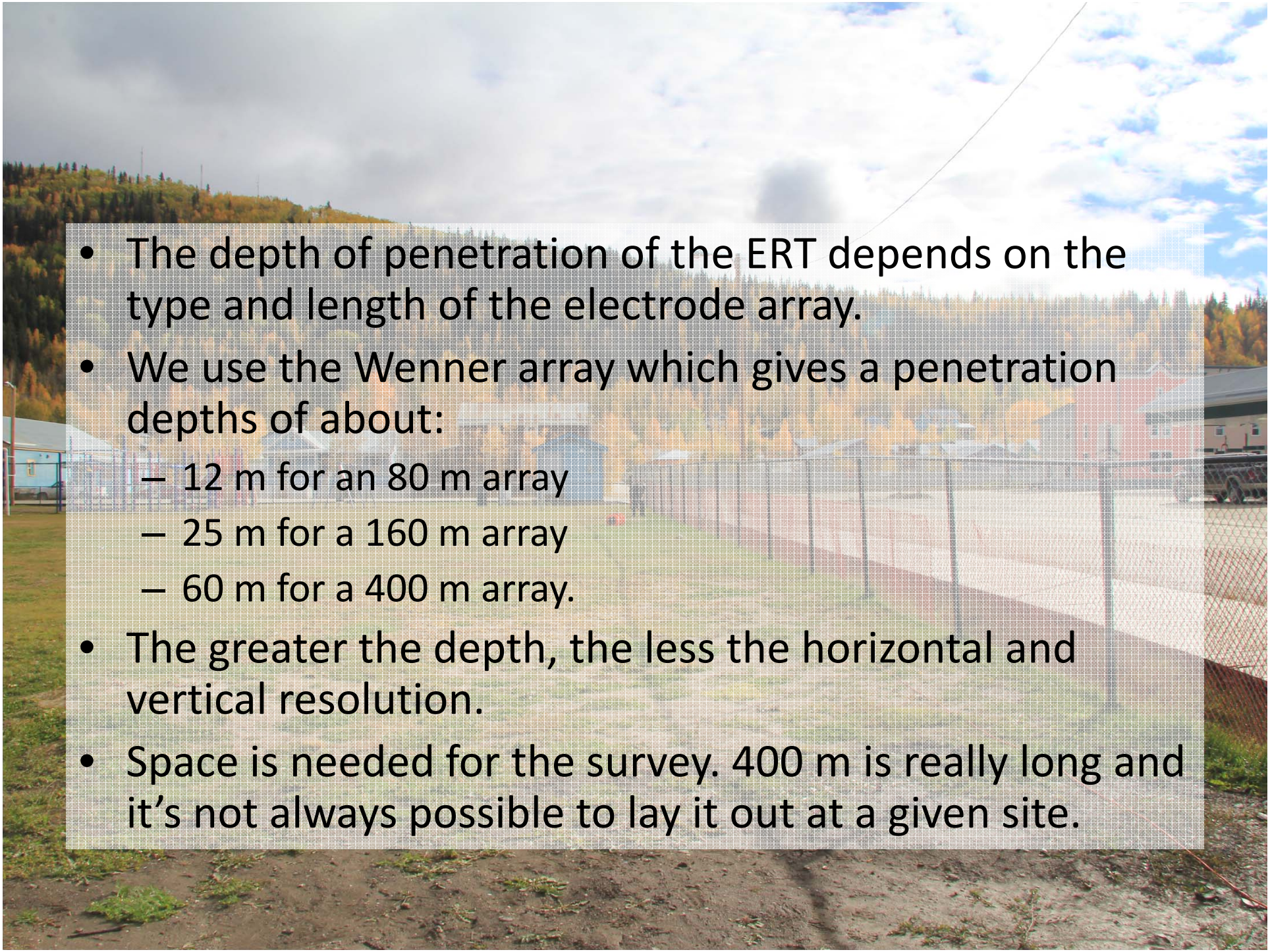
- The ABEM Terrameter LS that we use shows the results of the survey as a coloured section as it takes place.
- When the survey is finished, the measurements stored in the terrameter can be offloaded with a USB key.

Is ERT new?

- Not really.
- But the instrumentation and software needed has become much more user-friendly.
- It's time to treat ERT as an essential and cost-efficient tool for discontinuous permafrost investigations in the Territories.

How do you undertake an ERT survey?

- Choose the spot on your site where you want the deepest measurement – that's the mid-point.
- Move the terrameter and its car battery source to the mid-point and lay out the cables away on both sides.
- Push an electrode into the ground at each contact on the cable and join the cable connections to the electrodes using jumper cables.
- Select the set-up on the terrameter and start the survey.

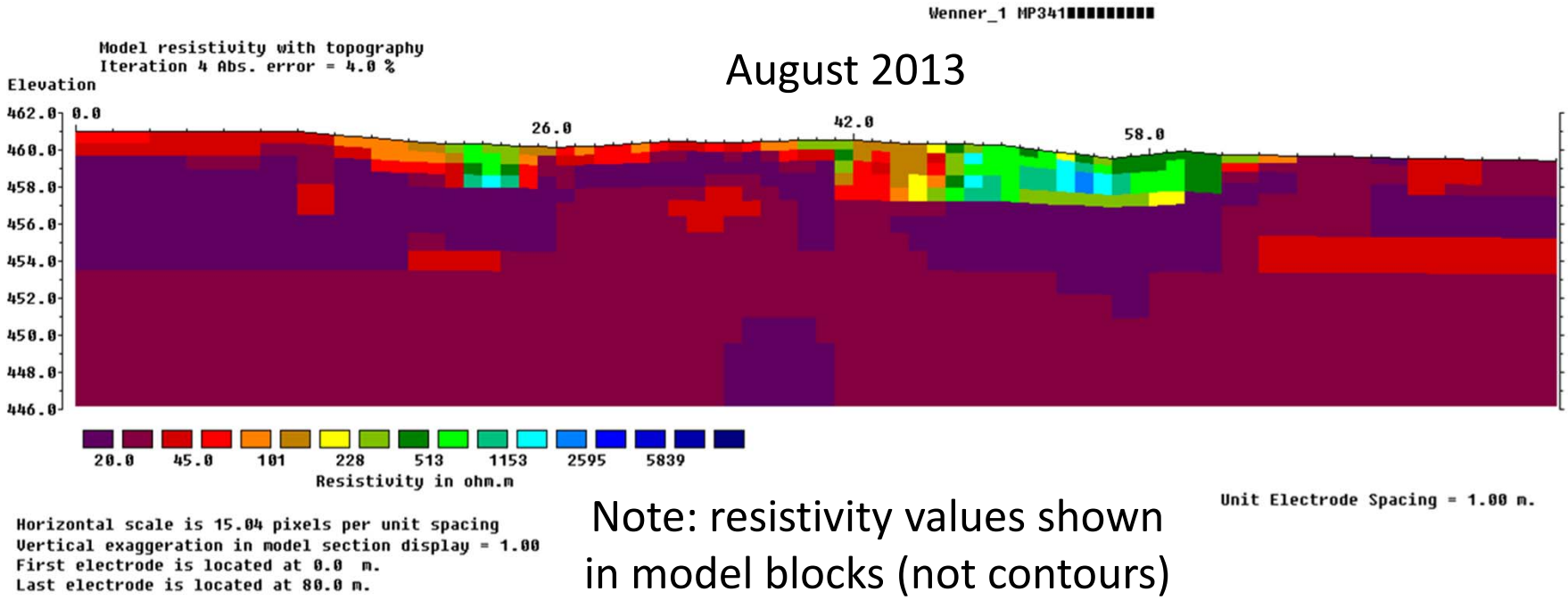


- The depth of penetration of the ERT depends on the type and length of the electrode array.
- We use the Wenner array which gives a penetration depths of about:
  - 12 m for an 80 m array
  - 25 m for a 160 m array
  - 60 m for a 400 m array.
- The greater the depth, the less the horizontal and vertical resolution.
- Space is needed for the survey. 400 m is really long and it's not always possible to lay it out at a given site.

What are the advantages of ERT?

- Adds a second dimension to frozen ground conditions to a single borehole measurement.
- It's possible to create a 3D image using parallel survey lines.
- Non-invasive technique: no disturbance and all equipment removed.
- It's possible to do a survey beneath a raised building and even across water.
- A single person can set up and undertake a typical survey in half a day but several surveys per day can be undertaken with more man-power. Equipment can be carried in roughly 4 person-loads.
- Inexpensive to undertake an ERT survey once equipment purchased (costs about $30-50K).
- ERT surveying is easier to learn and easier to interpret than GPR.

Reproducibility and change through time
MP341 (near Fort St. John, northern BC)

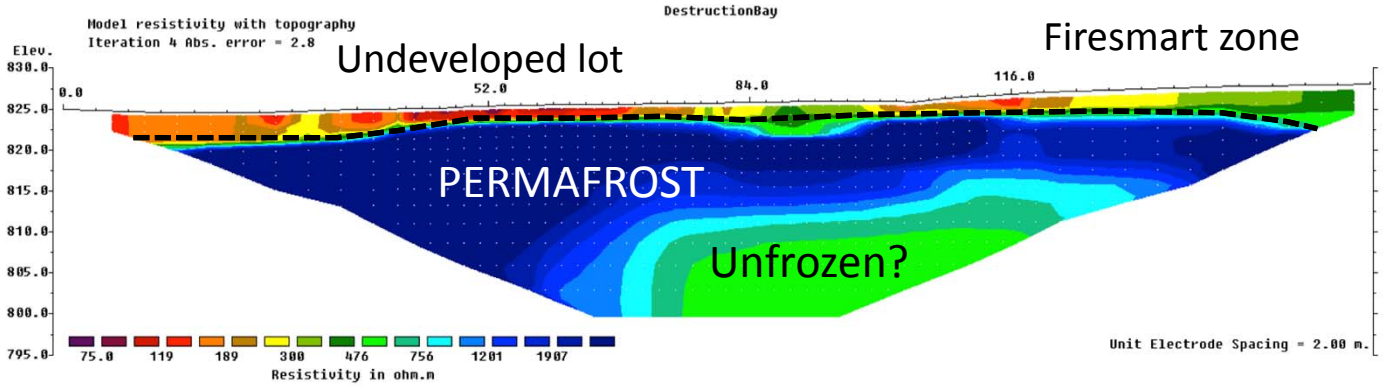


August 2013

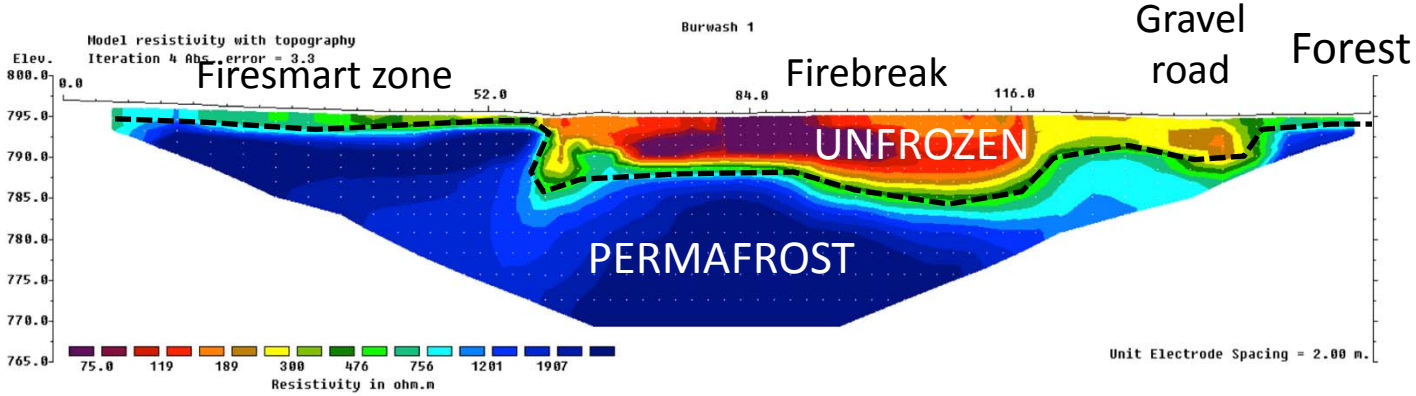
Note: resistivity values shown in model blocks (not contours)

Disturbance impacts at Burwash Landing and Destruction Bay

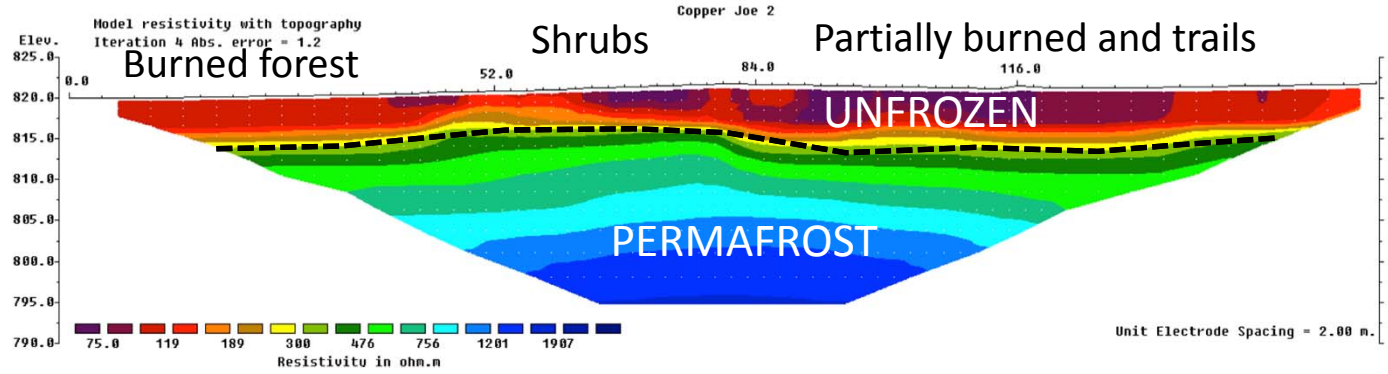
Destruction Bay: firesmart area with deeper active layer but permafrost intact



Burwash Landing: firebreak with talik (unfrozen zone) to 8 m

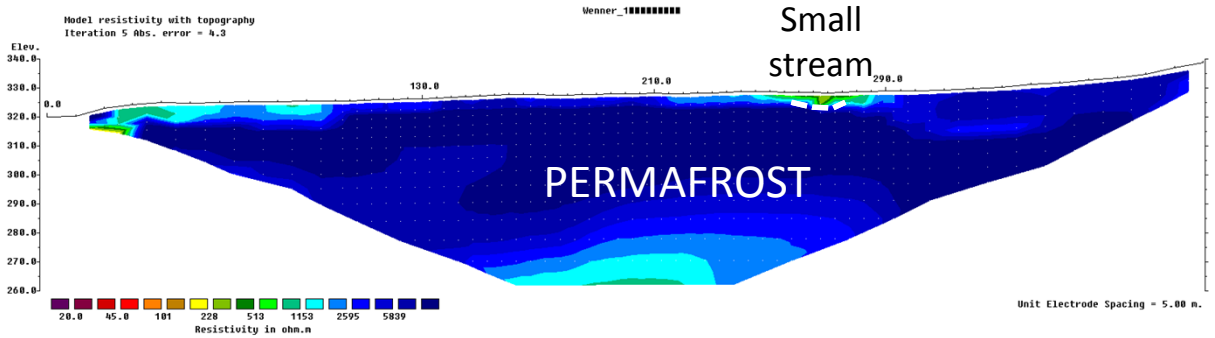


Copper Joe subdivision: effect of 1999 fire – talik to 7 m

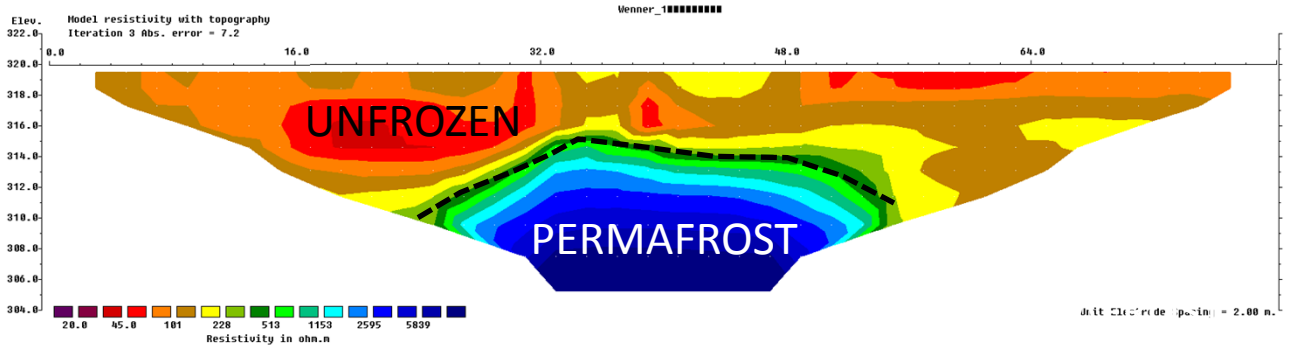


Disturbance impacts, Dawson

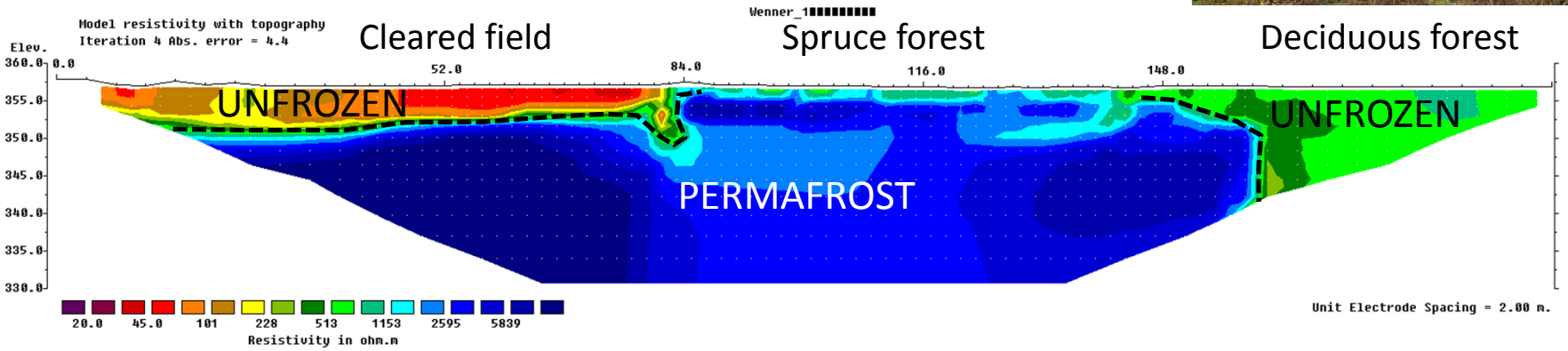
West Dawson: undisturbed (60 m permafrost)



Dawson School field: 5-6 m deep talik over permafrost



Klondike Valley: cleared section with 5 m talik

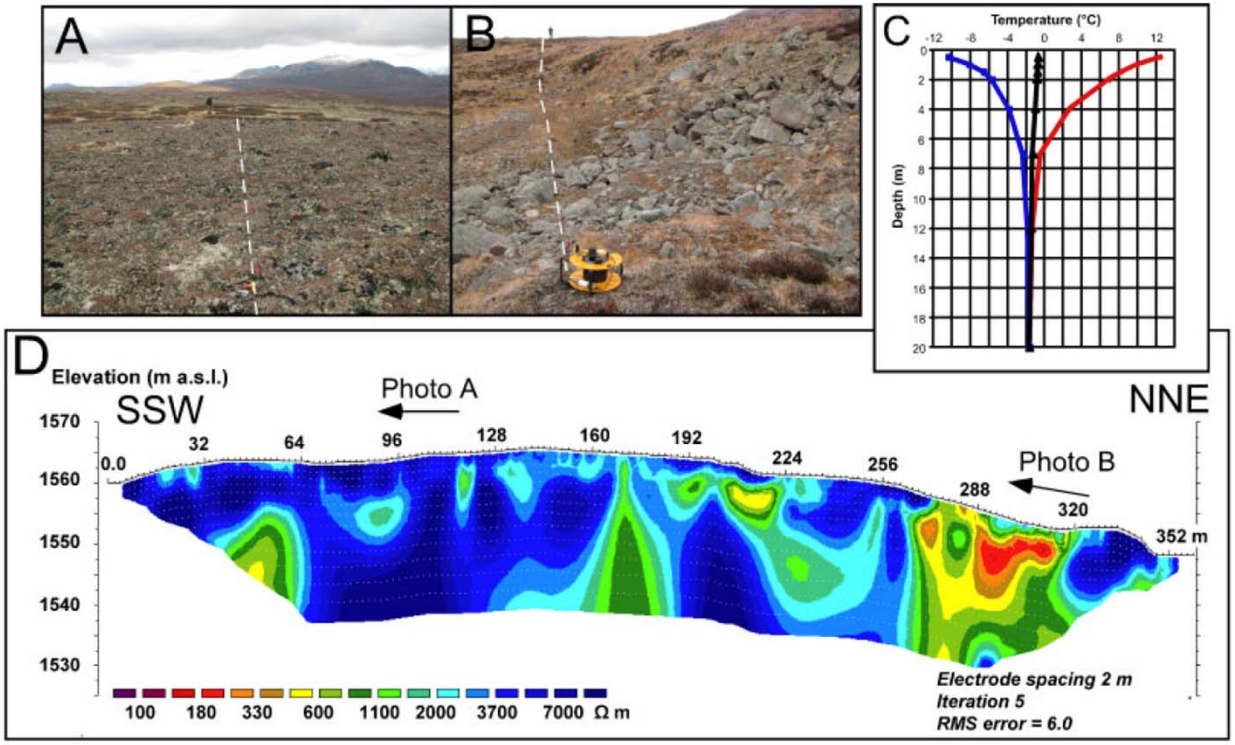


What are the limitations of ERT?

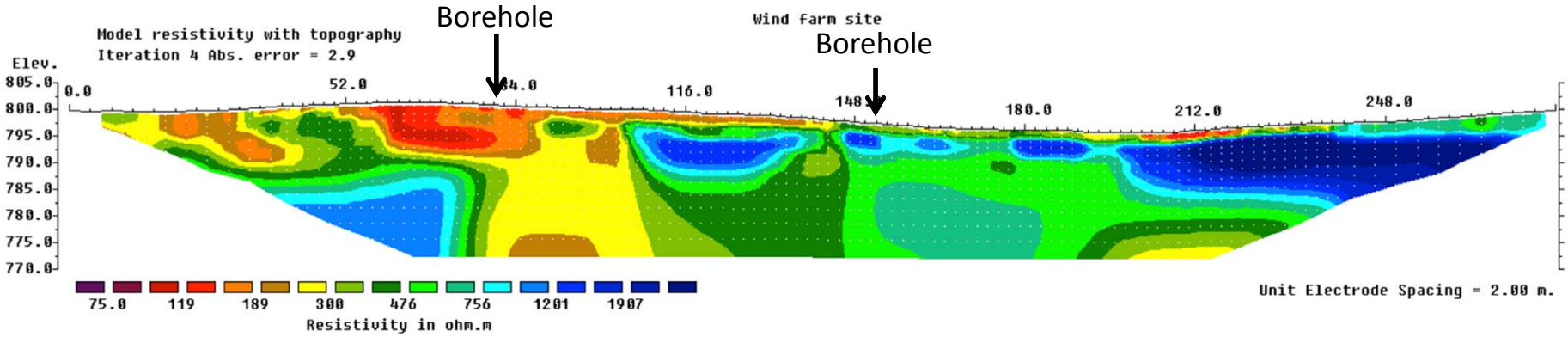
- ERT simply gives you measurements of electrical resistivity. You have to provide the interpretation.
- Like all geophysical techniques, you need some ground-truthing (e.g. frost probing, boreholes (preferably with temperature measurements).
- The contrast is great between colder or coarse-grained frozen and unfrozen ground, but the resistivity of fine-grained permafrost containing significant unfrozen moisture at a temperature just less than 0°C may exhibit a lesser contrast.
- Massive bedrock without water will not show any contrast between frozen and unfrozen conditions.
- Saline permafrost may have low resistivities which could be incorrectly interpreted as unfrozen ground if there is no other information.

Challenging sites require ground-truthing

Bedrock site
Mt. McIntyre
near Whitehorse



Proposed wind generator site, Burwash Landing



Conclusions

- ERT surveys proved invaluable for the hazards mapping project in the Yukon.
- The surveys were able to evaluate conditions to much greater depths than the boreholes which were drilled using a light rig.
- The 2-D sections revealed the lateral changes in permafrost conditions, the presence of taliks and the depth of the base permafrost.
- Where it is suspected that ground freezing conditions vary at a site, a single borehole backed up by ERT surveys could be an economical survey method.
- ERT surveys can also be undertaken beneath buildings providing access is possible.

Acknowledgements

- All the Hazards mapping team members.
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