



## Tectonic Setting of South Vancouver Island

- Vancouver Island lies adjacent to a convergent tectonic margin where the denser oceanic Juan de Fuca plate is subducting beneath the lighter continental North American plate, (Figure 1a) at a rate of ~45 mm/yr (Balfour et al., 2011).
- The last major megathrust earthquake on the margin was over 300 years ago, and the interface is now locked. The edge of the North American plate (including Vancouver Island) is being pushed northeast. The resulting elastic strain is shown by GPS velocity vectors (Figure 1b).
- Shallow Faults within the overriding North American plate may help to accommodate these stresses. The largest (on-shore) Canadian earthquake during the era of instrumentation was the Mw 7.3 Beaufort Range earthquake, which caused two deaths and extensive damage (Lynch et al., 2025).

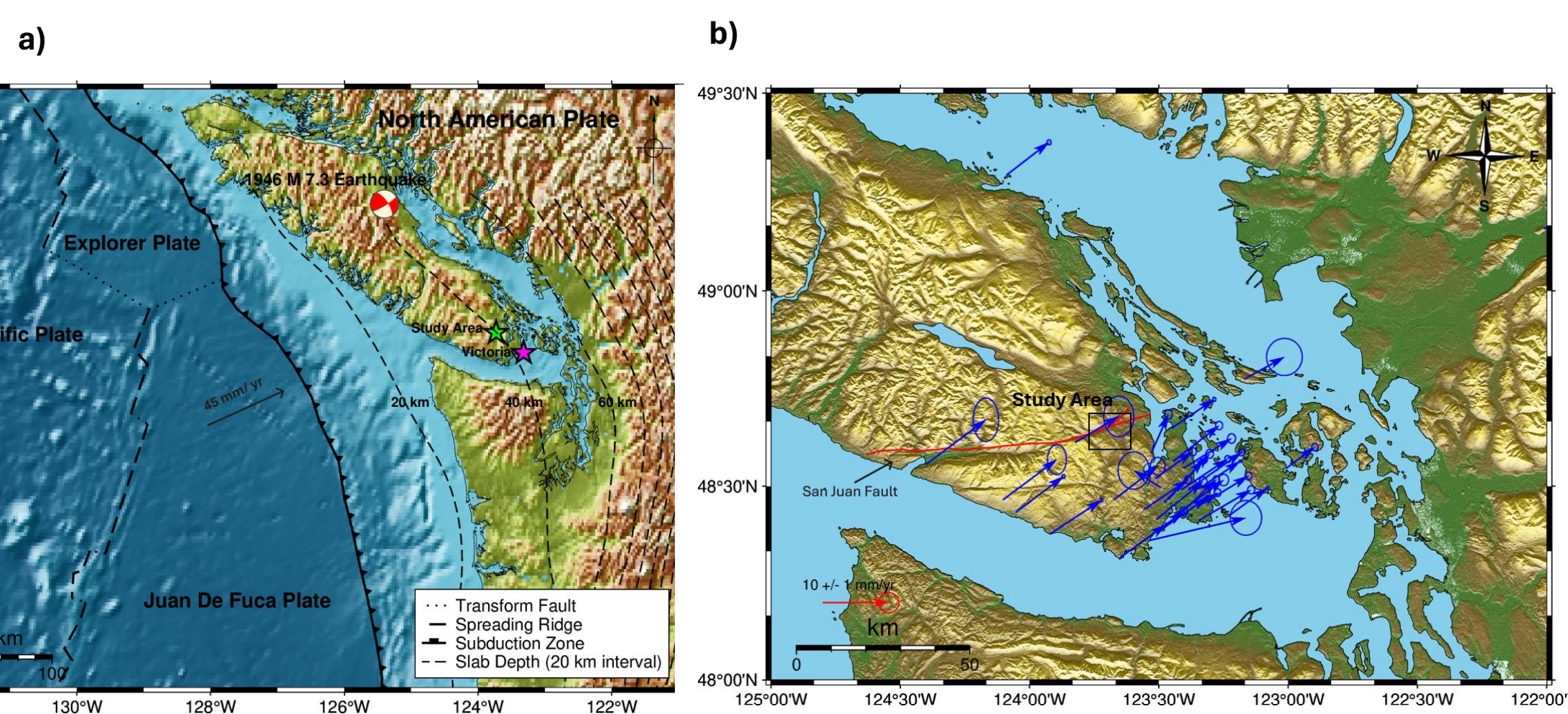


Figure 1: a) Map of Cascadia subduction zone. Plate boundaries and slab contours adapted from (Staisch & Walton, 2022) b) Velocity field of southern Vancouver Island, with respect to stable North America

## Why study the San Juan Fault?

- Vancouver Island is comprised of a sequence of terranes, large formations of oceanic crust which collided into the North American plate at tens of millions of years ago. There are distinct bedrock groups within each terrane.
- The San Juan Fault (figure 1b) runs ENE-WSW across most of Vancouver Island, in some parts forming the boundary between two terranes.
- Evidence has been found of earthquakes of Mw > 6 on other crustal faults near Victoria during the Holocene (< 12,000 yr BP) (Harrichhausen et al., 2023; Morell et al., 2018), giving reason to consider the activity of the nearby San Juan Fault
- Previous work on the San Juan Fault and has shown evidence of Quaternary fault rupture (Salomon et al., 2026)
- This study focuses on the eastern San Juan Fault, testing the hypothesis: Has the San Juan Fault been active in the Holocene?

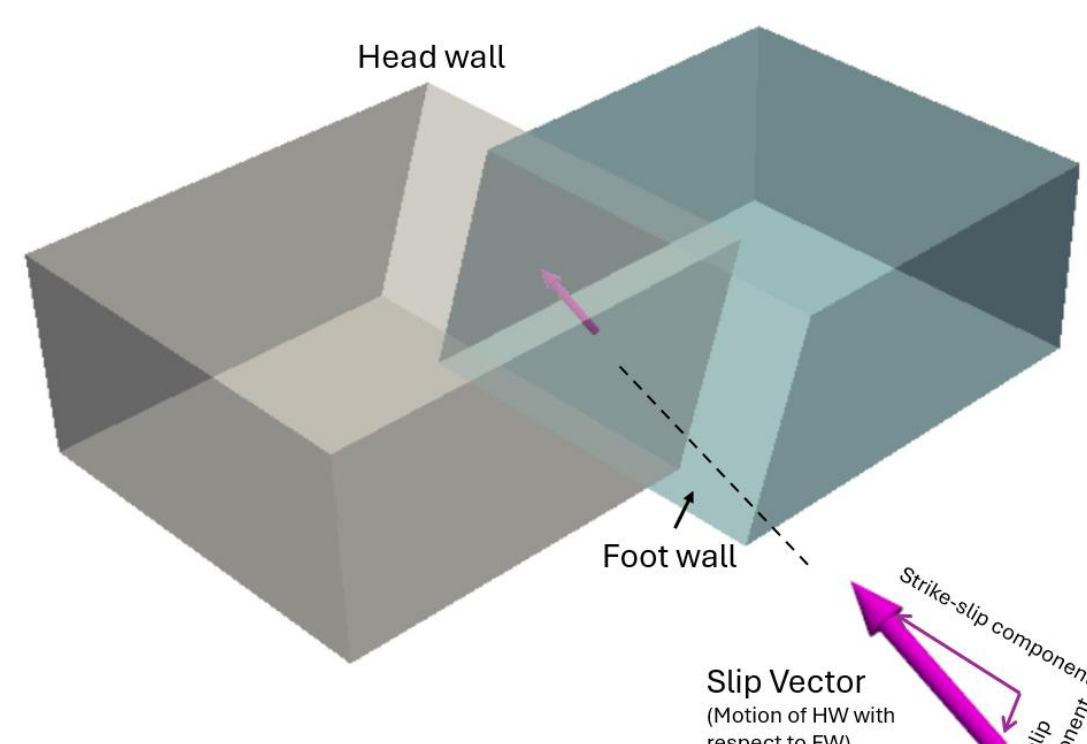


Figure 2: Block model of fault rupture due to earthquake. Slip vector characterizes fault motion, divided into strike-slip (lateral) and dip-slip (up- or down- dip) motion. (Right-lateral strike-slip dominant motion is shown here)

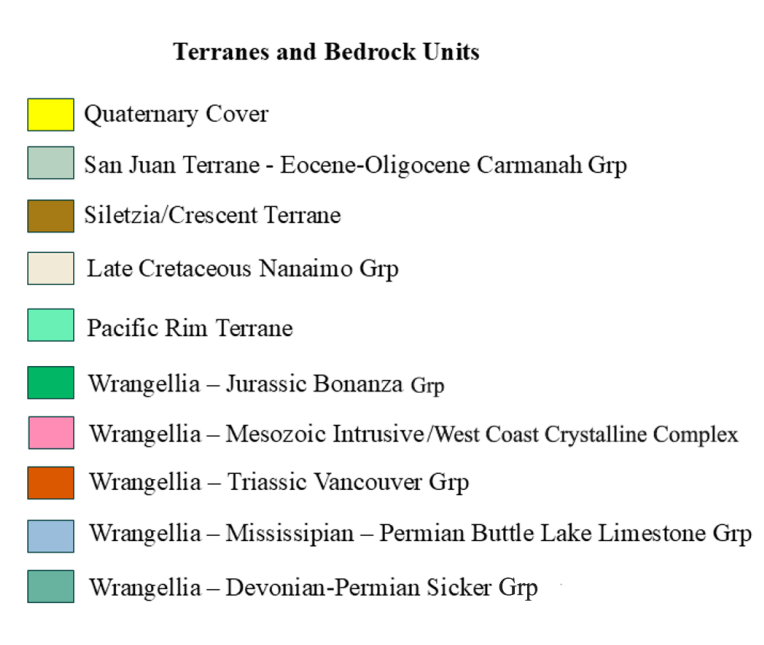
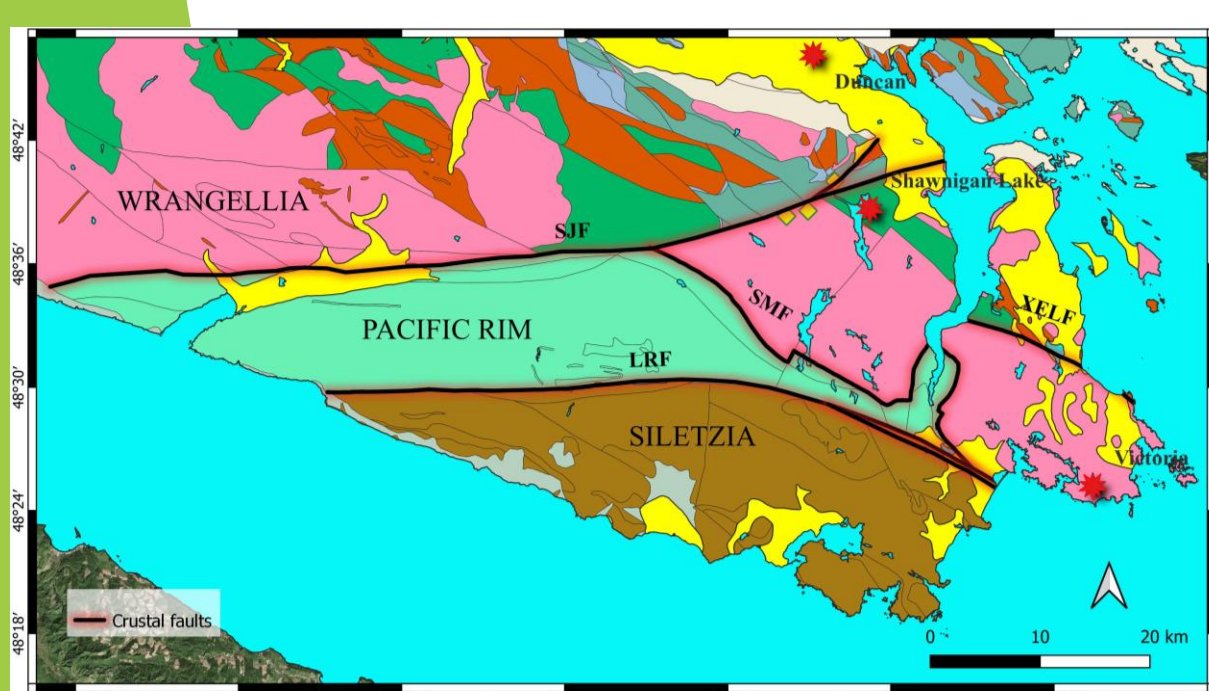


Figure 3: Regional terrane-bounding crustal faults of southern Vancouver Island, with corresponding terranes and bedrock units. Faults shown are San Juan (SJF), XEQXLELEK - Elk Lake (XELF), and Leach River (LRF). XELF and LRF have been demonstrated to be Holocene-active. Bedrock units and extent, as well as fault traces adapted from Cui et al., 2017. Terrane boundaries adapted from Harrichhausen et al., 2022.

## Objective of Research:

1. Accurately map out the trace of the eastern San Juan Fault Using Lidar
2. Determine if the fault is Holocene-active using geophysical survey methods (ERT, Gravity, Magnetic)

## Fault Hunting With LiDAR

- Light detection and ranging (LiDAR) makes use of laser signals broadcast from an aircraft (or drone) to map topography.
- By distinguishing laser returns off vegetation from those off ground, vegetation cover can be removed from the data. The result is a clear image of the ground surface topography. (Fig 4b)
- Using QGIS software, I analyzed data from BC LiDAR portal and drew profiles across linear features thought to be fault scarps. (Fig 5c)

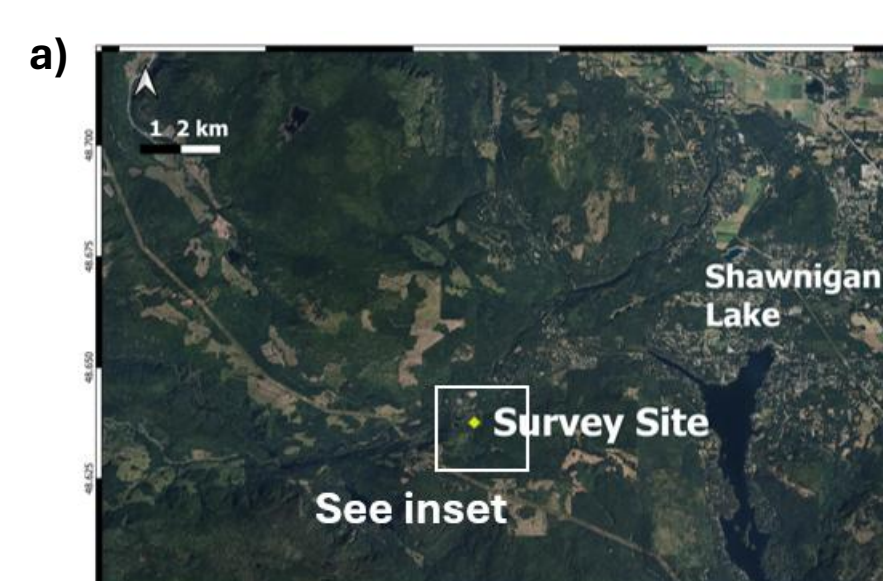
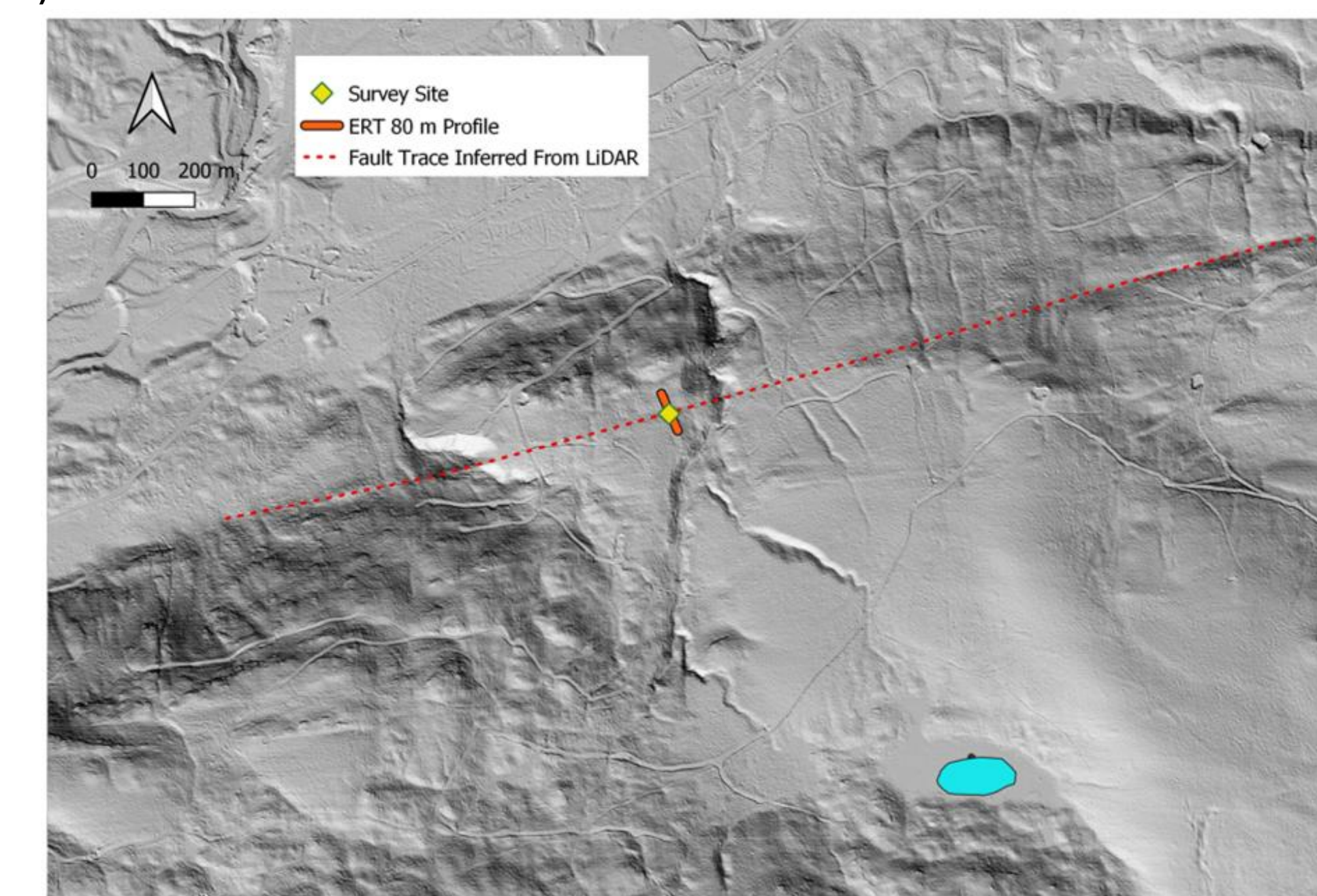


Figure 4: a) Satellite map of study area. b) Shaded relief map of study area using 1 m resolution LiDAR data, showing inferred fault traces and study location, processed on QGIS software. Profile of ERT survey is shown in orange and can be seen in Fig. 5b.



## Electrical Resistivity Tomography

- Electrical resistivity tomography (ERT) has proven effective geophysical tool for detecting geological offsets beneath suspected fault scarps. (Harrichhausen et al, 2023)
- Shallow lithologies will differ in their ability to conduct electricity
- ERT surveys model the subsurface as an electric circuit. A known current (I) is "injected" (through metal electrodes) into the ground, a voltage drop (V) is measured at a known distance away, and resistivity is obtained through Ohm's Law. (See figure 5 below)
- The instrument obtains apparent resistivity data from a linear array of electrodes along a survey line, which are inverted to obtain a 2D subsurface model of actual resistivity

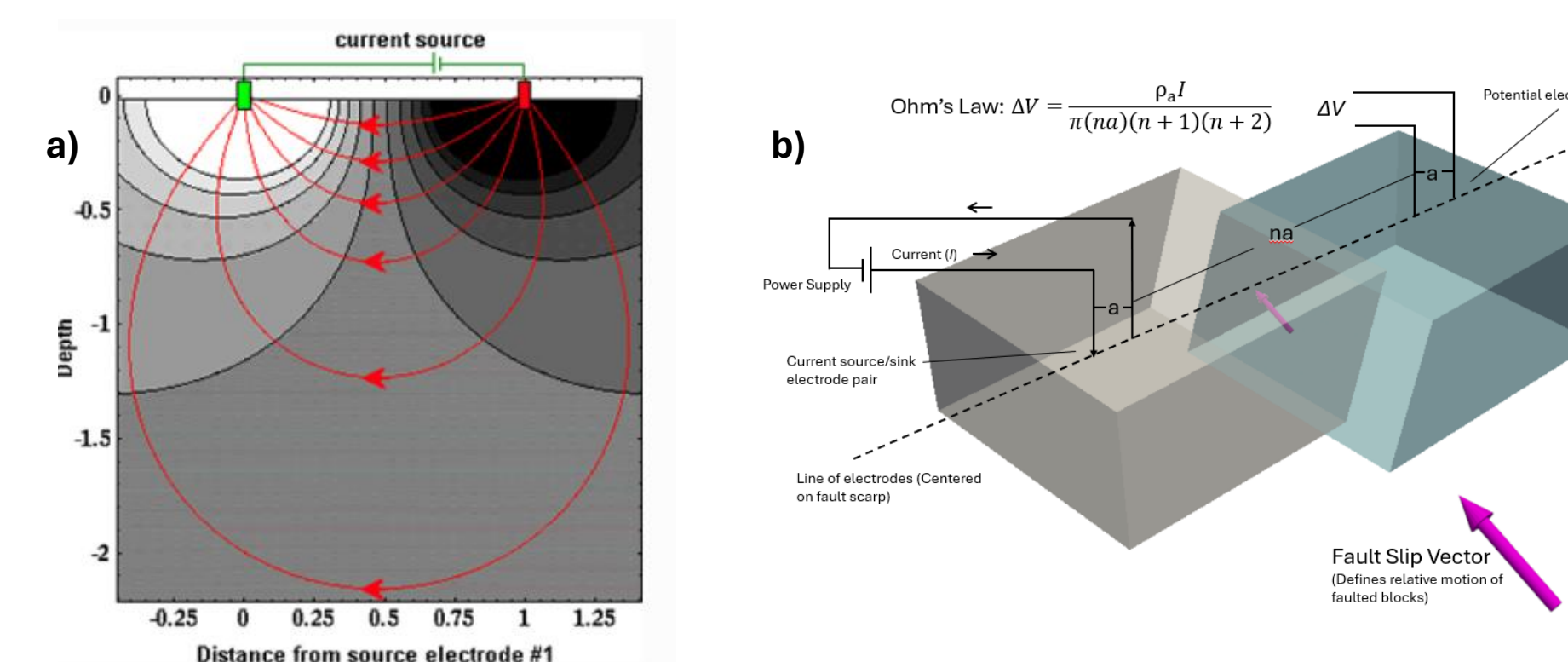
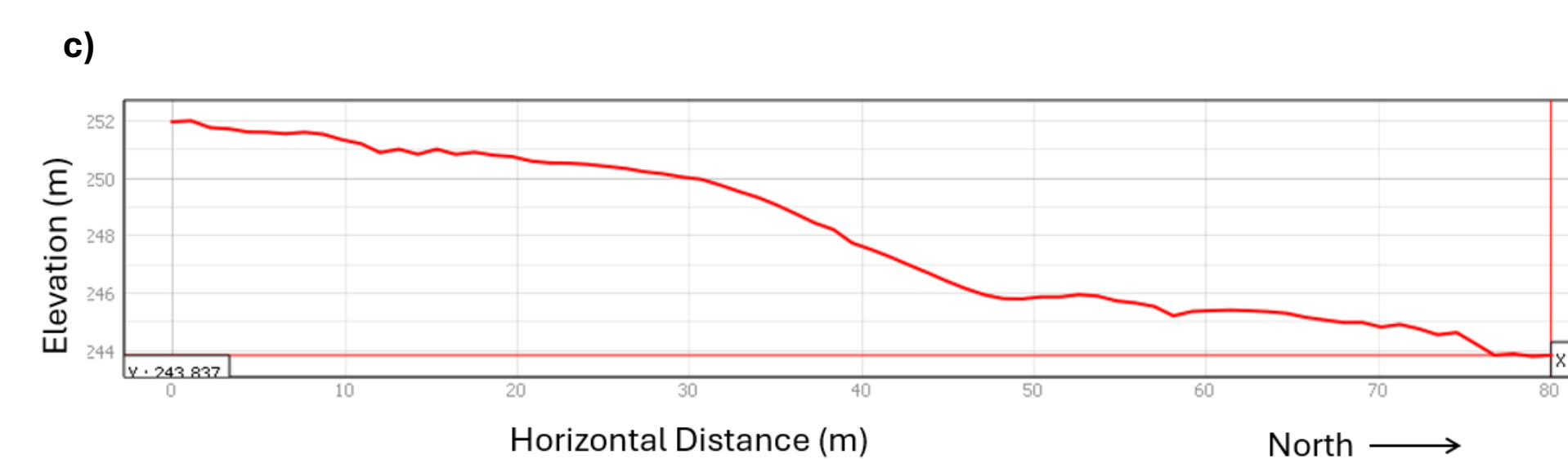


Figure 5: a) Dipole subsurface model of DC current injection. Shades of gray represent magnitude of equipotential, with darker shades mapping higher potential. Red lines represent current flow. Figure adapted from [https://ggg.geosci.xyz/content/DC\\_resistivity/](https://ggg.geosci.xyz/content/DC_resistivity/) b) Model of ERT array overlying suspected fault c) Elevation profile of ERT line obtained from LiDAR data



## Results

### Inverted Resistivity Section

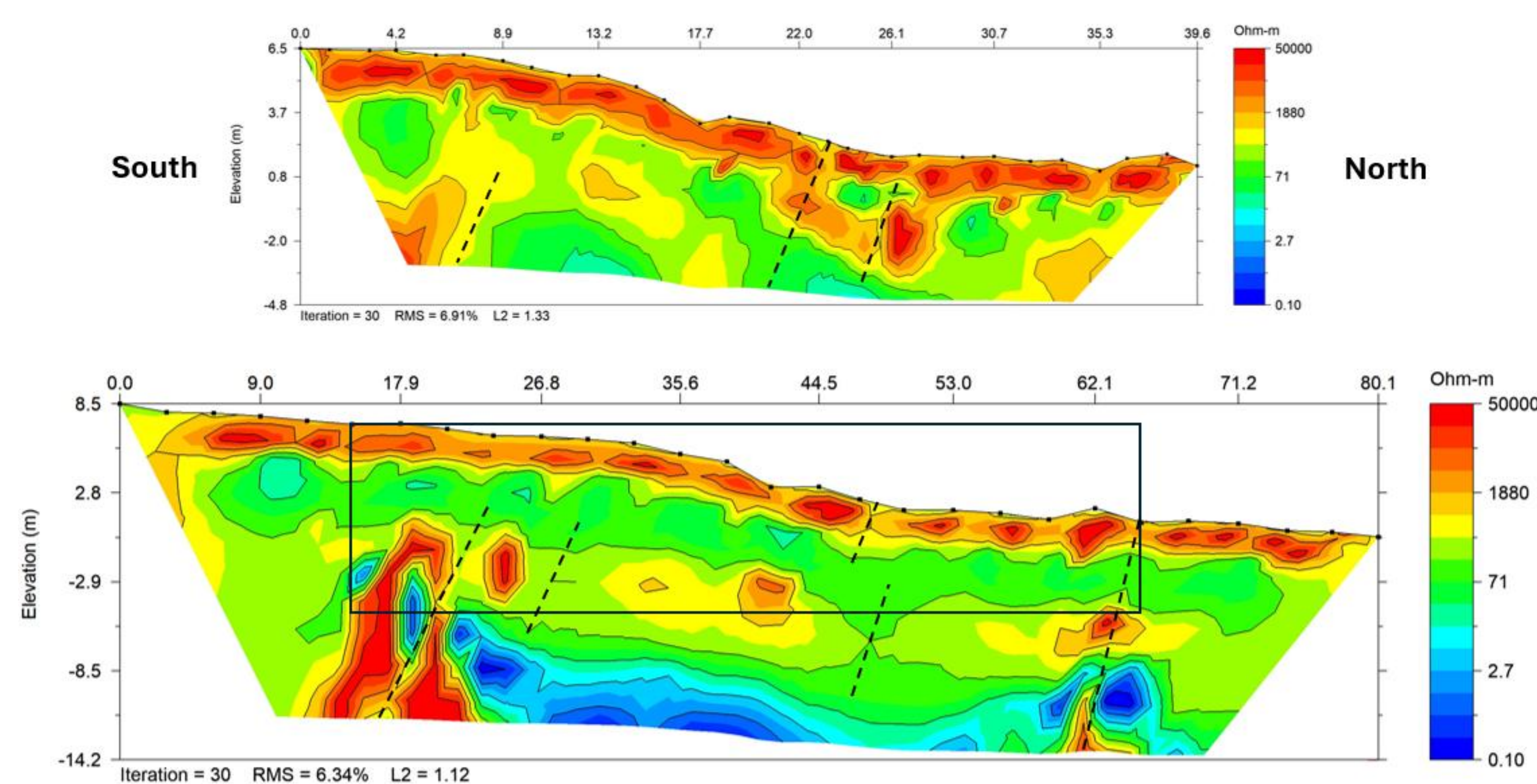


Figure 6 : ERT profiles across the San Juan fault scarp. 40.5 m (top) with 1.5 m electrode spacing gives a shallow, hi-resolution profile. 81 m (bottom) with 3 m electrode spacing shows deeper, lower resolution profile. Dashed lines indicate preliminary interpretation of subsurface discontinuities/faults.

## Interpretation of LiDAR/ ERT Results

- A section of suspected fault scarp several km west of Shawigan Lake was chosen as ERT survey site because of its clear trace on the LiDAR.
- Ground observations at the survey location showed glacial till, with an exposed basaltic outcrop North of the survey line.
- Both ERT profiles show strong rough layering with resistivity, with most resistive materials near the surface, likely corresponding to till overlying bedrock.
- Each profile also shows steeply-dipping discontinuities in the subsurface resistivity structure. This is strong evidence of a subsurface fault structure, but the geometry and motion are not overly clear from the data.
- A possible interpretation of motion would be a rupture with mostly strike-slip dominant motion, with secondary strands of a "flower structure" accommodating a lesser shortening component.
- These discontinuities appear to affect the shallowest layer. If they are faults, **this would imply that they have been active since the glacial deposition of the till** (assumed to be Holocene in age).
- It could also be interpreted that there is not a rupture, and the glacial till was deposited after the earthquake happened.
- Future paleo seismic trenching may be required to prove either way.

## Future Work – Other Geophysical Surveys

- The same survey location was visited the following week to conduct gravity and magnetic surveys, in order to supplement the ERT data.
- Plots of gravity and magnetic anomalies across a fault can be telling about the subsurface fault geometry.
- These data have been collected but are currently still being analyzed

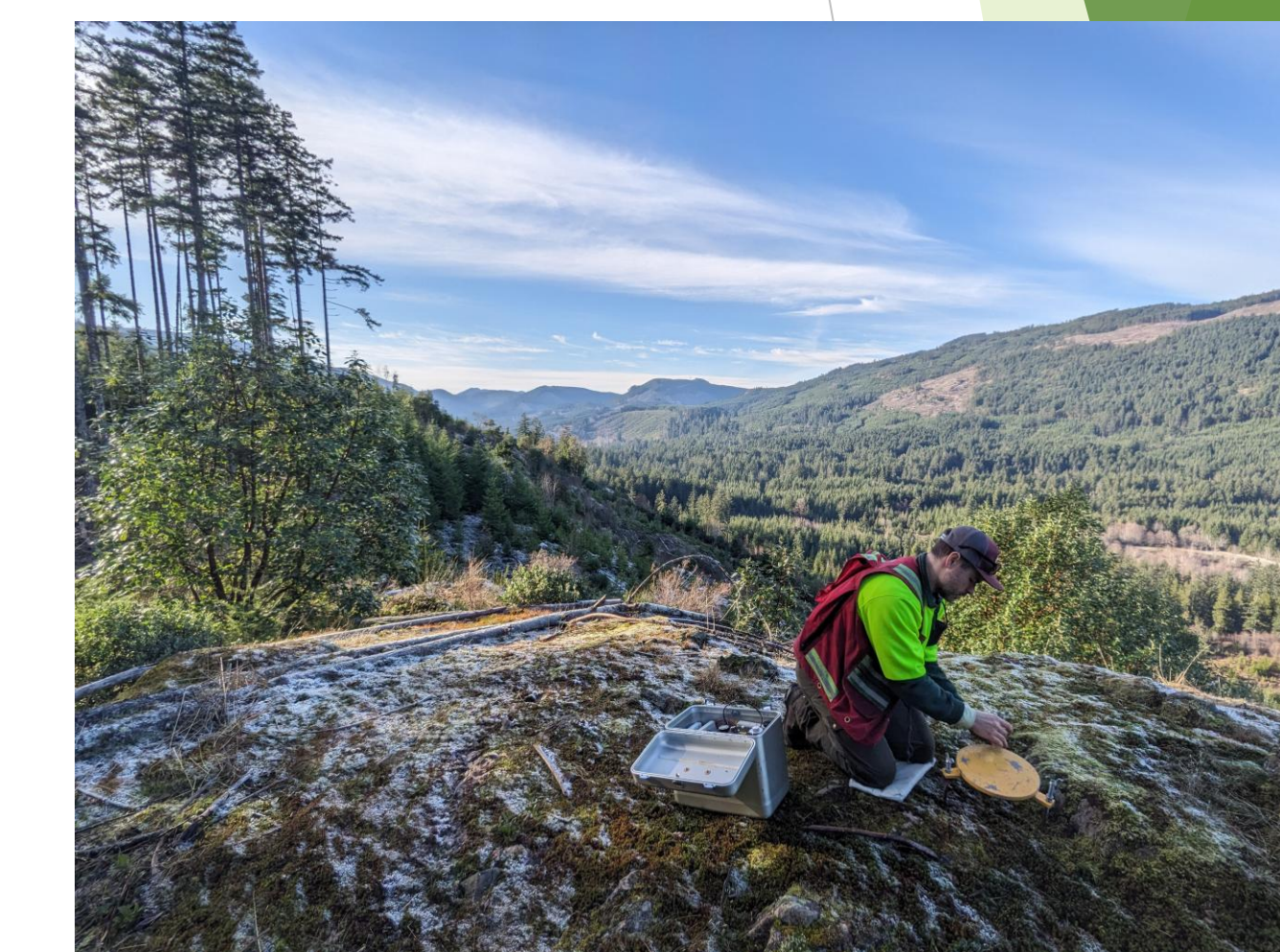


Figure 7: Performing gravity survey at study area. (Photo credit to Lucinda Leonard)

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