Identifying bedrock mineralization & geological faults beneath glacial deposits using real-time soil-gas CO_2 and O_2 analysis .

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AMEBC Toolbox Presentation
Roundup 2021

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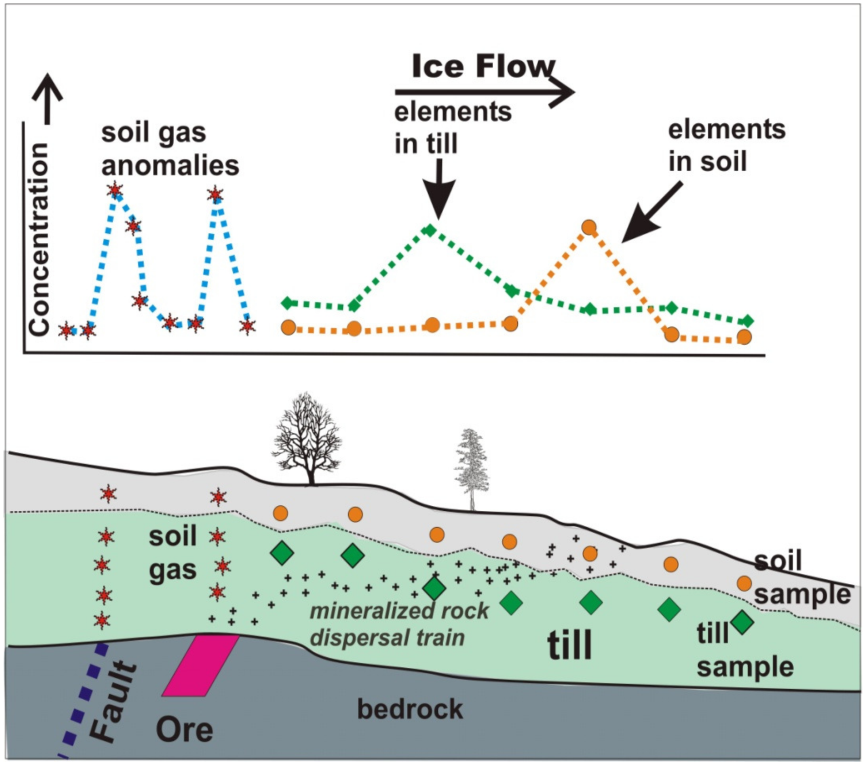
Introduction

The Exploration Challenge

- In BC, repeated glaciations have produced sediments that conceal prospective bedrock
- Geochemical anomalies within these sediments are commonly displaced from their source
- Precise exploration targets can be difficult to determine from displaced anomalies

The Opportunity

- Gases (e.g. CO_2, O_2, He, Ra, Hg) can diffuse through drift from faults and sulphides
- Gas anomalies are more proximal to the source than those in sediments or soils



Conceptual drawing of geochemical anomalies in soil, till and soil gas

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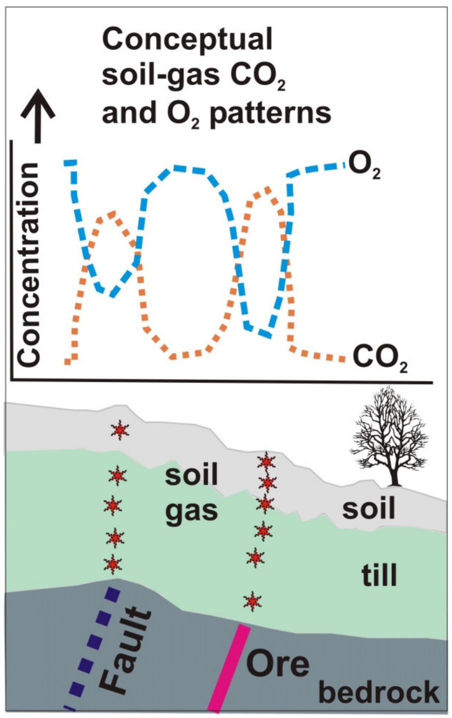
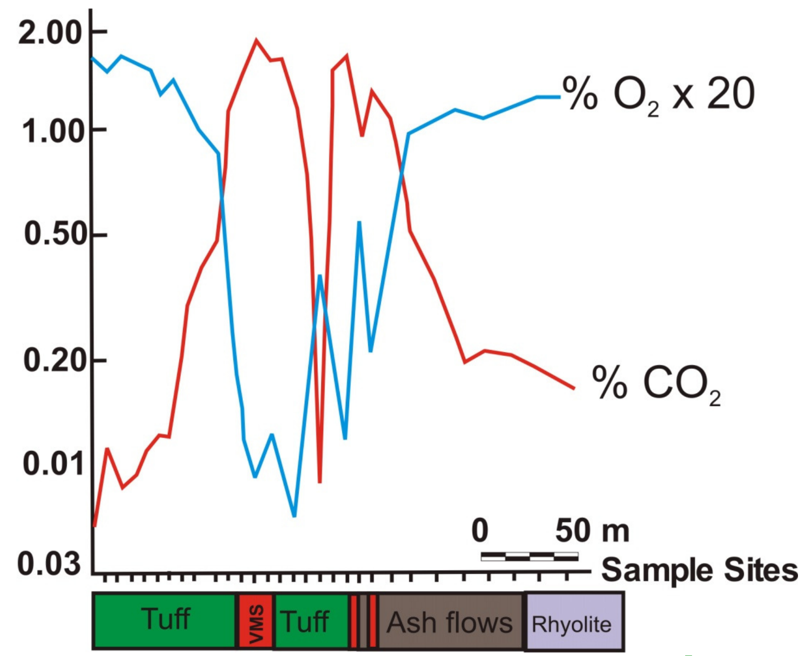
CO_2 and O_2 soil gas chemistry in mineral exploration

Previous research reveals increased soil gas CO_2 & depleted O_2 over faults & sulphide mineralization



Soil gas CO_2 and O_2 anomalies detected above ~ 7 to 30 m of glacial sediments over the Crandon, Wisconsin, massive Zn-Cu-Pb sulphide bodies (McCarthy, 1986)



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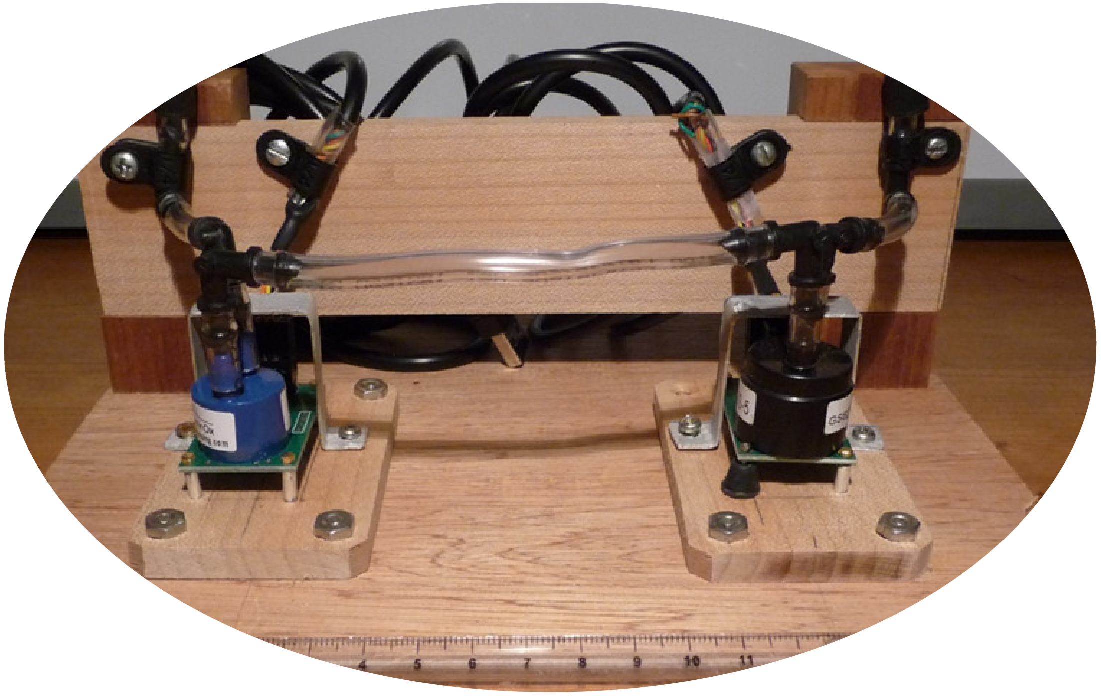
Limitations of soil-gas surveys in the past

- Need to collect, store and transport soil gas sample to lab for analysis
- Analysis can be expensive
- Systems for measuring CO_2 & O_2 can be cumbersome
- Systems often not able to capture data digitally for later analysis

A new option for CO_2 and O_2 measurement

- Made possible by newly available, small and economic sensors from CO_2Inc®, Florida that can measure CO_2 and O_2
- Real-time measurements
- CO_2Inc® Gaslab software can display results in the field on a laptop or tablet & store digital data for later analysis



CO_2 and O_2 sensors mounted on wooden base

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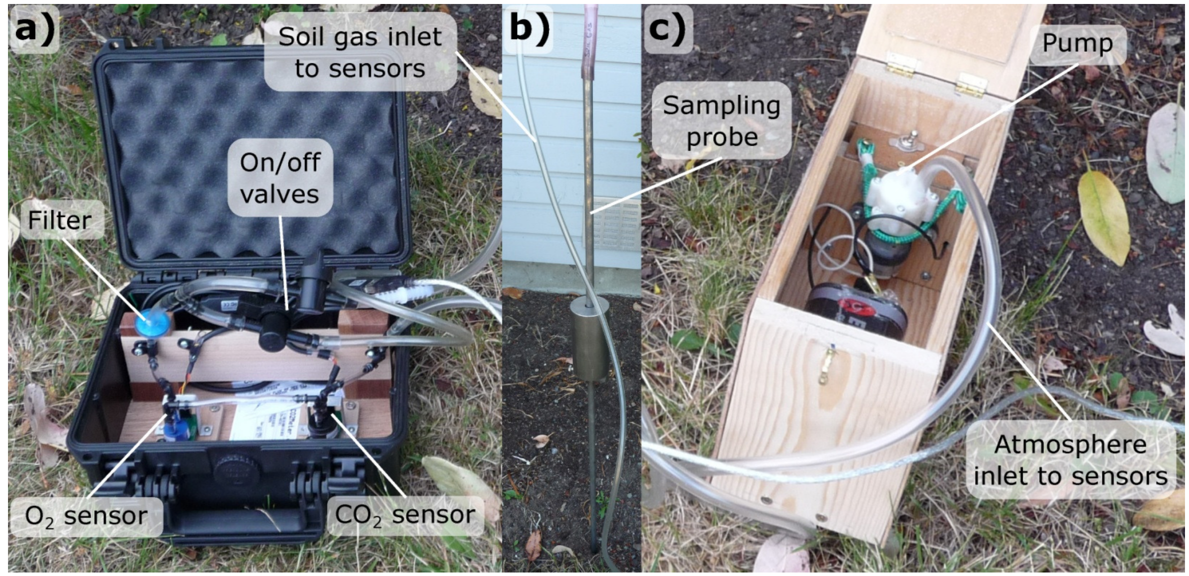
Real-time soil-gas measurement system prototype

- Case with CO_2 & O_2 sensors linked to a laptop (**a**)
- Hollow steel sample probe with open/close valve tip driven into soil to sample soil gas (**b**)
- Battery-powered pump to draw air and soil-gas through sensors to measure CO_2 and O_2 (**c**)



Soil gas measurement system prototype

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Readout from CO_2Inc® Gaslab software for CO_2 sensor

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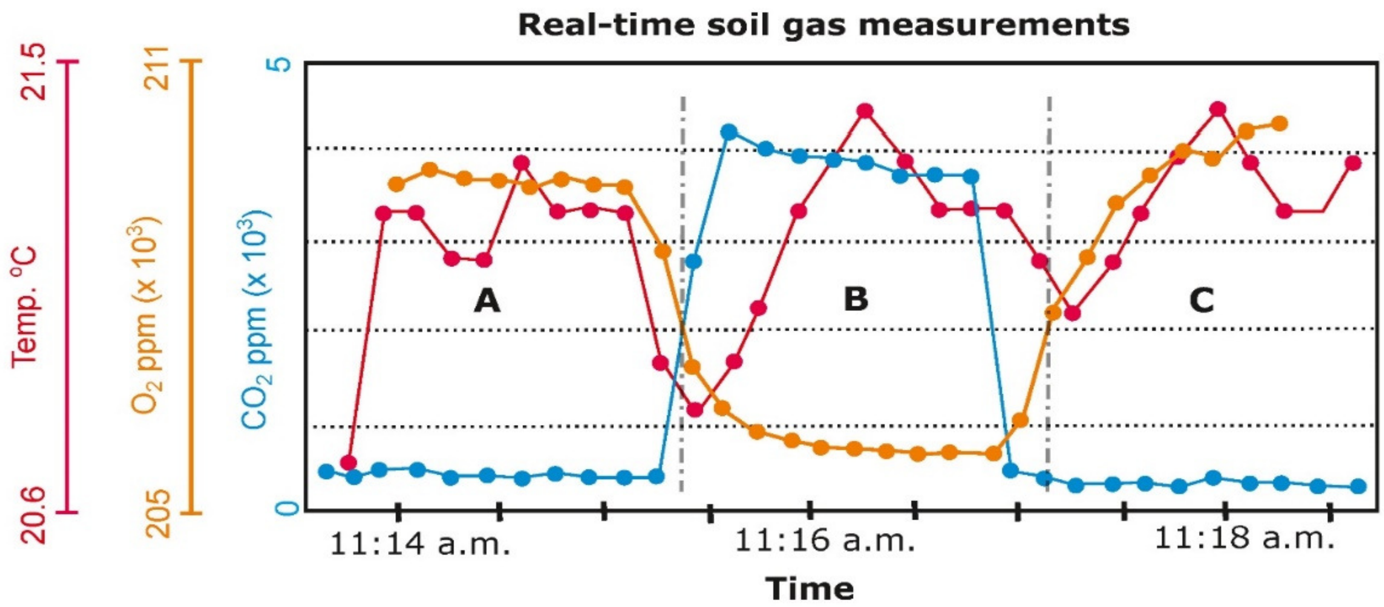
Display and capture of real-time measured CO_2 & O_2

- Sensors are calibrated by pumping atmospheric CO_2 and O_2 for two minutes (**A**)
- System is then switched to the soil probe input to measure soil gas CO_2, O_2, temperature and pressure (**B**). The results are displayed on a CO_2Inc® Gaslab graph
- System switched back to atmosphere to assess potential drift in measurements (**C**)



Simplified, compiled graph for CO_2, O_2 and temperature.

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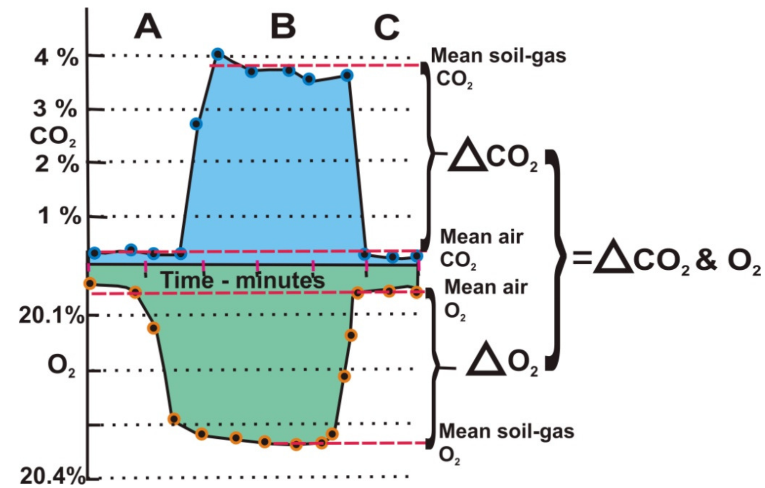
Derivation of soil gas metric

$$\Delta CO_2 = \text{Soil-Gas } CO_2 - \left[\frac{\text{Amosphere (A) mean } CO_2 + \text{Amosphere (C) mean } CO_2}{2} \right]$$

$$\Delta O_2 = \text{Soil -Gas } O_2 - \left[\frac{\text{Amosphere (A)mean } O_2 + \text{Amosphere (C)mean } O_2}{2} \right]$$

$$\text{Soil - Gas } \Delta CO_2 \text{ \& } O_2 = \Delta CO_2 + \Delta O_2$$



- *ΔCO_2 & O_2* are determined from the measured soil-gas CO_2 and O_2 values (B) corrected from the atmospheric CO_2 and O_2 values measured before (A) and after (C) the soil-gas peak (B).
- Measurement precision is estimated from repeat soil-gas and atmospheric CO_2 and O_2 measurements (typically less than 15% relative standard deviation)

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System Testing

Victoria, BC

- functionality and reliability

Jordan River

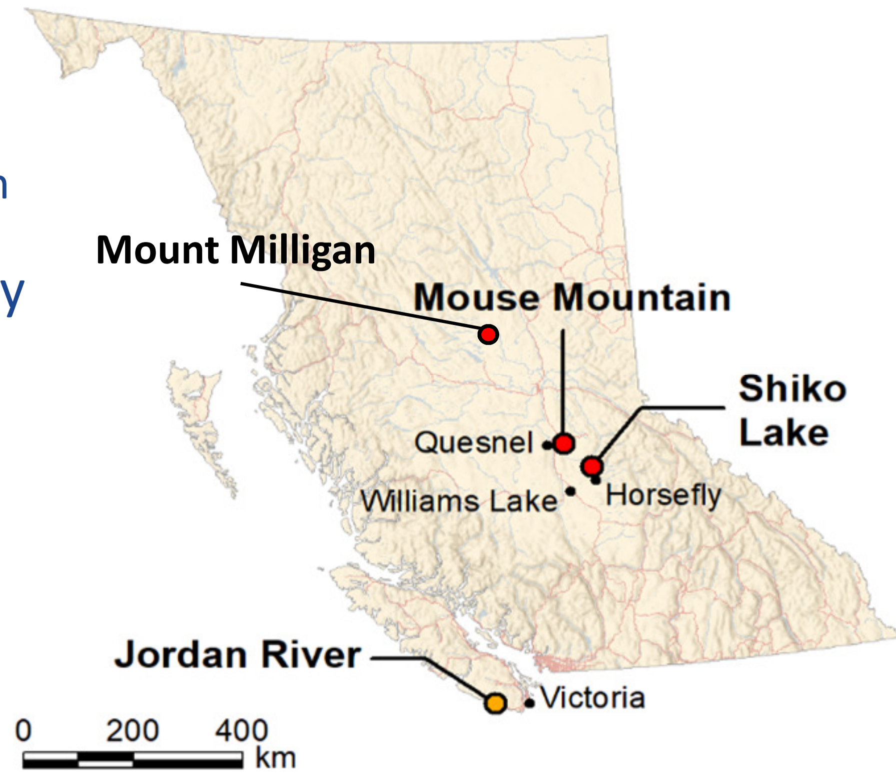
- Soil-gas CO_2 and O_2 measured across the Leach River Fault

Mouse Mtn. - Shiko Lk. Copper-gold porphyry occurrences

- Soil-gas CO_2 and O_2 measured
- Upper B-horizon soil samples analysed for pH, water leach elements.

Mount Milligan - Copper-gold porphyry deposit (ongoing)

- Soil-gas CO_2 and O_2measured
- Upper B-horizon samples analysed for pH
- Survey challenged and postponed by snow



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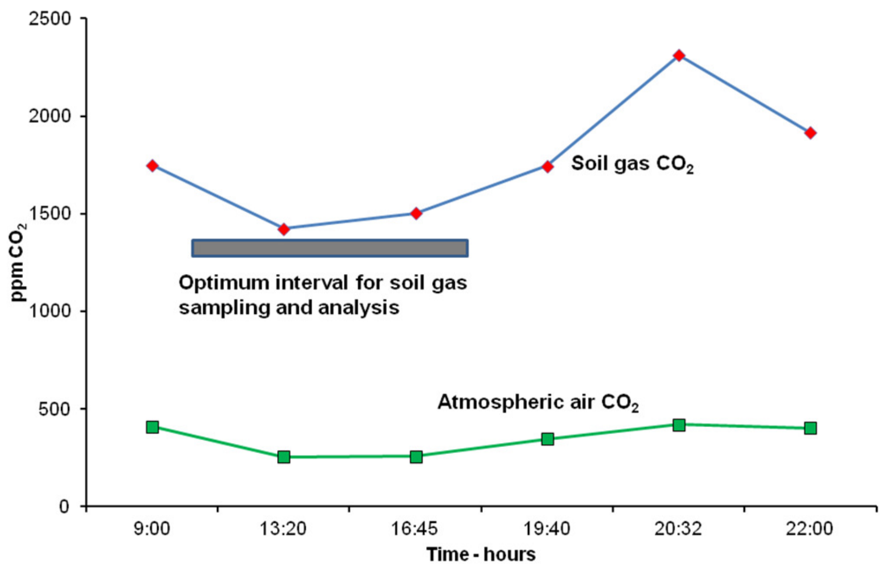
System testing – functionality and reliability

Diurnal variation

- Gas concentrations vary throughout the day
- Results indicate the optimal time between roughly 9 am and 4.45 pm.



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Quality Control

- Sampling precision (6 duplicate sites) expressed as a coefficient of average variation
  - CV_{AVG} (%), is 15.9% at a mean ΔCO_2 & O_2 of 1.702%

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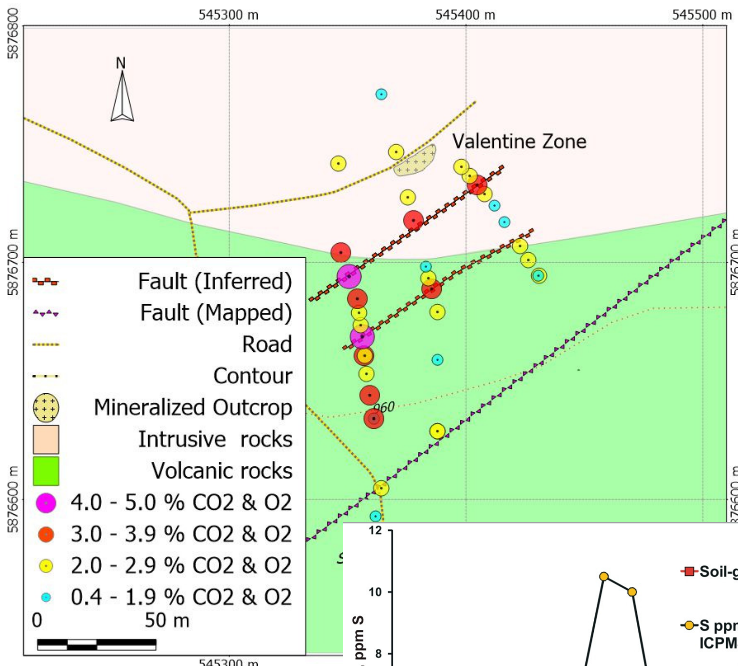
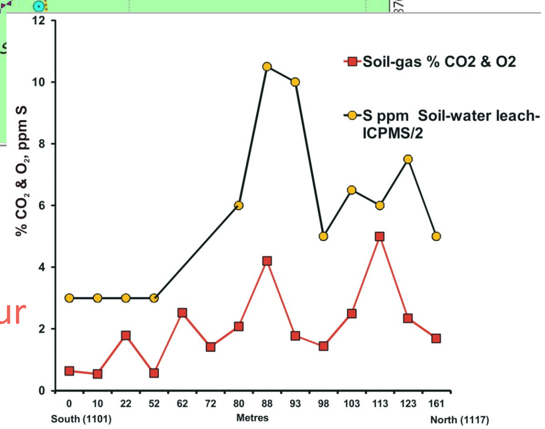
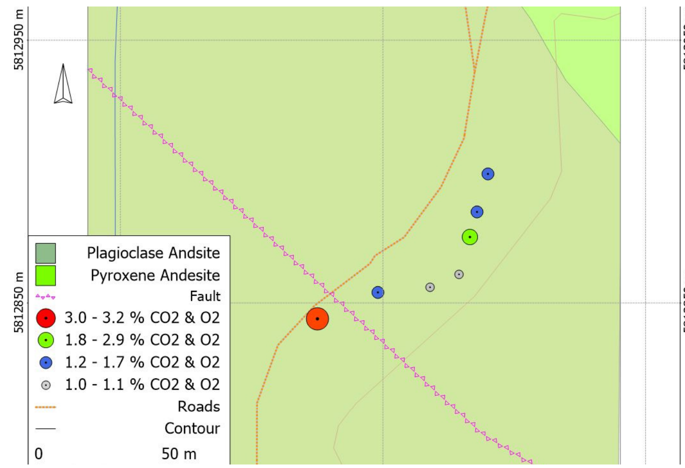
System testing – Mouse Mountain and Shiko Lake





Mouse Mountain soil ΔCO_2 & O_2 and sulphur concentrations



Shiko Lake soil ΔCO_2 & O_2 concentrations

- Mouse Mountain
  - linear trends across transects suggest complex structures and offset from location of mapped fault
  - association of soil gas with soil pH and water leach sulphur
- Shiko Lake
  - Elevated ΔCO_2 & O_2 near mapped fault
- Sub-optimal test sites because precise locations for structure and mineralization uncertain

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System testing - Mount Milligan

- Results appear to reflect structure
- Site selection and system management complicated by adverse weather
- Survey postponed until next year due to weather
- Encouraging results even in challenging conditions

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Current understanding and future work

Current results

- Sensor system reliably measured CO_2 and O_2
- CO_2 and O_2 anomalies are spatially coincident with mapped and inferred faults
- Soil-gas anomalies are associated with elevated water leach sulphur and pH
- System set-up, sampling soil-gas & data recording generally completed in 15 to 20 minutes at each site

Moving forward

- Continue testing:
  - over targets with well-defined structures
  - Over different surficial materials and thicknesses
- Improve system portability by combining sensors and pump into one unit
- Develop longer probe to improve access to material beneath forest detritus
- Include a methane (or other) gas sensor in the system

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Thank you for your interest!

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More information - Lett, R.E., Sacco, D.A., Elder, B. and Jackaman, W. 2020, Real-time analysis of soil gas for carbon dioxide and oxygen to identify bedrock mineralization and geological faults beneath glacial deposits in central British Columbia, Geoscience BC Report 2020-7

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