SOURCE AND IMPACT OF GREENHOUSE GASSES IN ANTARCTICA

THE SENECA PROJECT

(financed by PNRA 2018)

Ruggiero L.[1], Sciarra A.[1], Mazzini A.[4], Romano V.[2], Mazzoli C.[3], Tartarello M.C.[2], Florindo F.[1], Wilson G.[5], Bigi S.[2], Ciotoli G.[8], Ascani M.[1], Graziani S.[2], Lupi M.[6], Fischanger F.[7], Dagg B.[5], Anderson J.[5], Worthington R.[5], Hardie R.[5], Sassi R.[3]

1 INGV - Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy
2 Dipartimento di Scienze della Terra, Sapienza-Università di Roma, DST-Sapienza, Italy
3 Dipartimento di Geoscienze, Università di Padova, Italy
4 CEED University of Oslo
5 GNS - Otago University
6 University of Geneva
7 Geostudi Astier
8 CNR-IGAG, Italy

SENECA Project

source and impact of greenhouse gasses in Antarctica

PNRA / ANZ

Project duration: 24 months

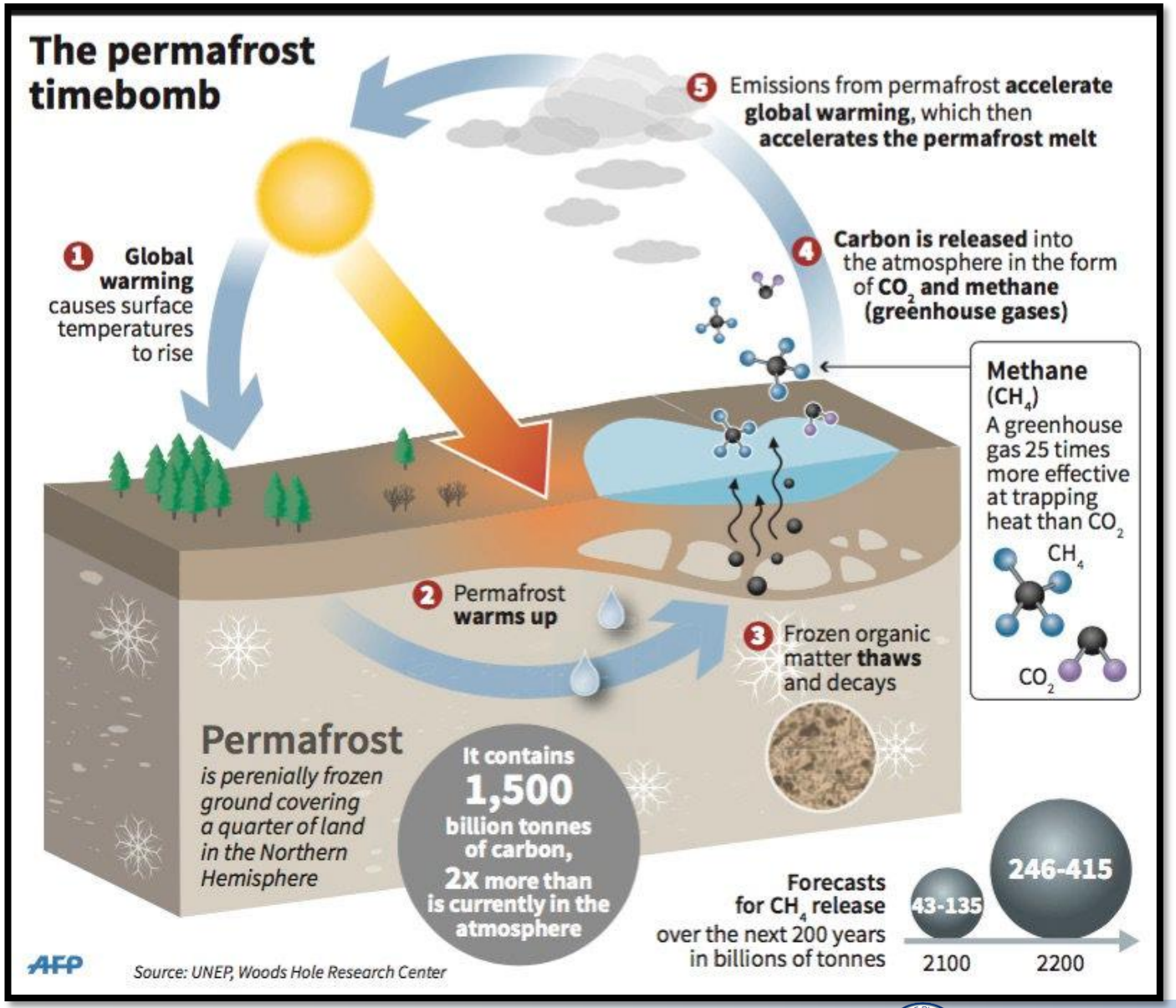
Mission leagues & Targets:

I. December 2019 – January 2020	Taylor Valley
II. December 2020 – January 2021	Wright Valley

The project is developed along four major tasks:

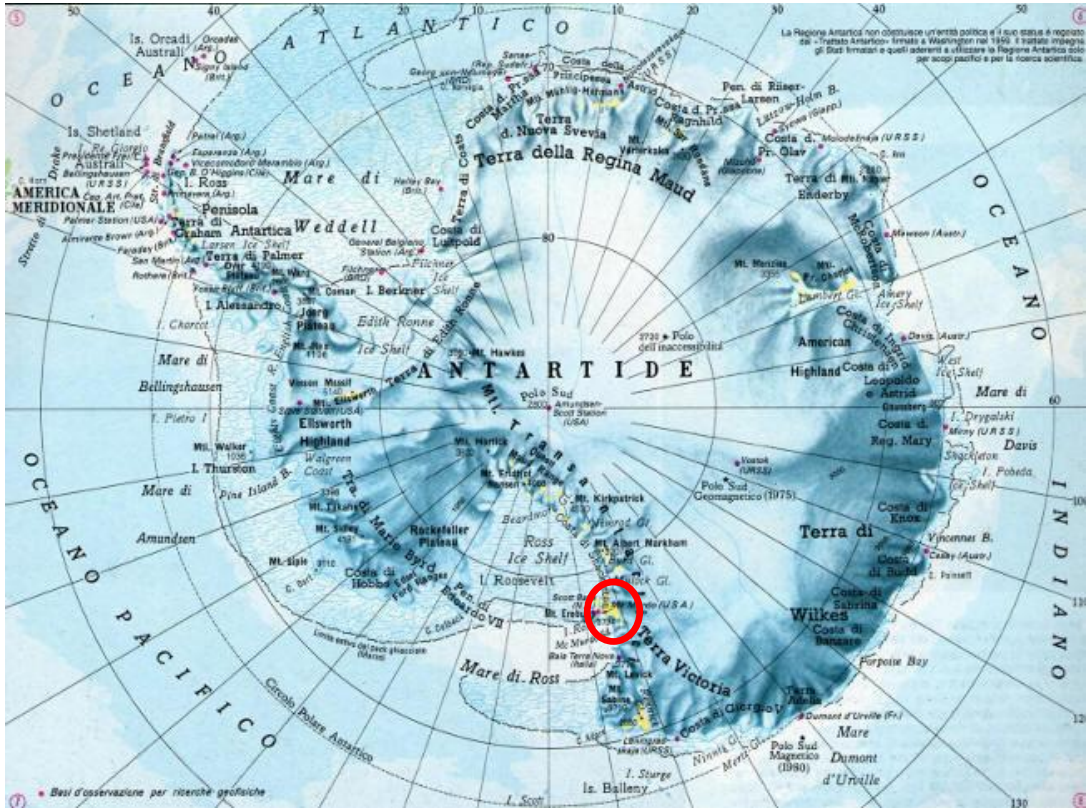
- **Soil gas content and origin**
- **CO_2 and CH_4 degassing output**
- **Geophysics exploration and petrographic characterization of the soils**
- **Seasonal trend of CO_2 soil concentration**

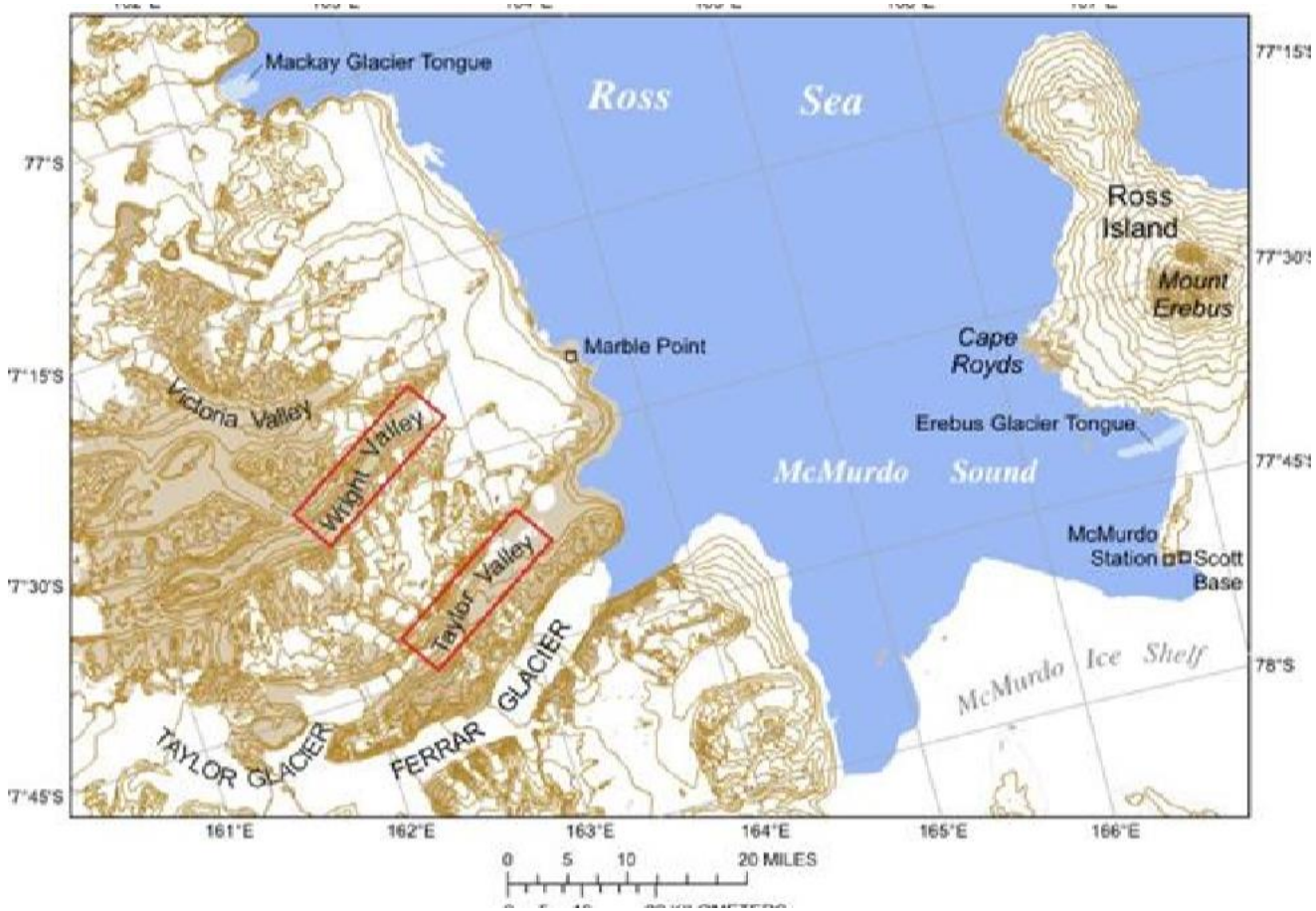
Permafrost & climate change



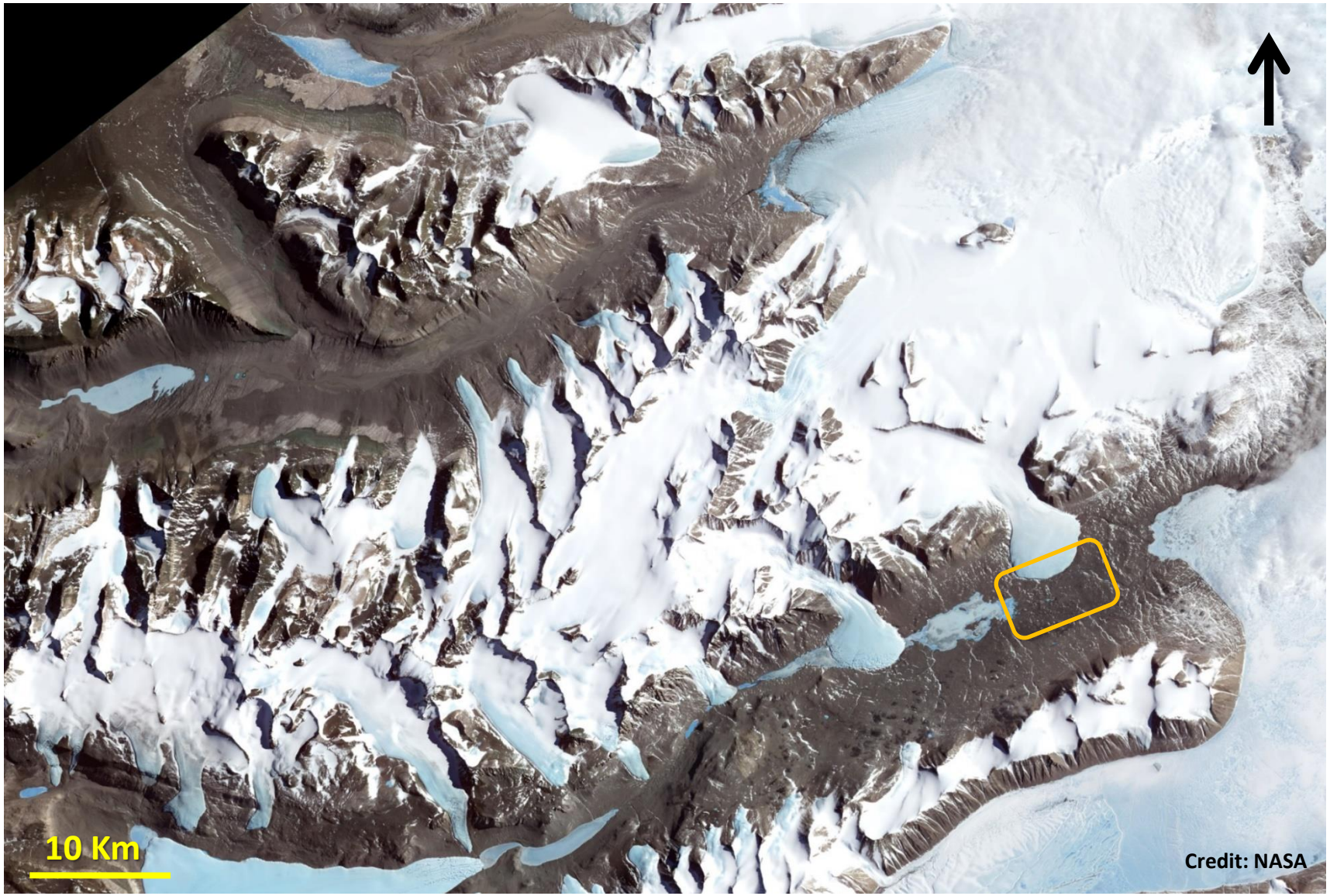
Arctic and Antarctic regions store almost twice the carbon currently present in the atmosphere

Mc Murdo Dry valleys Antartica





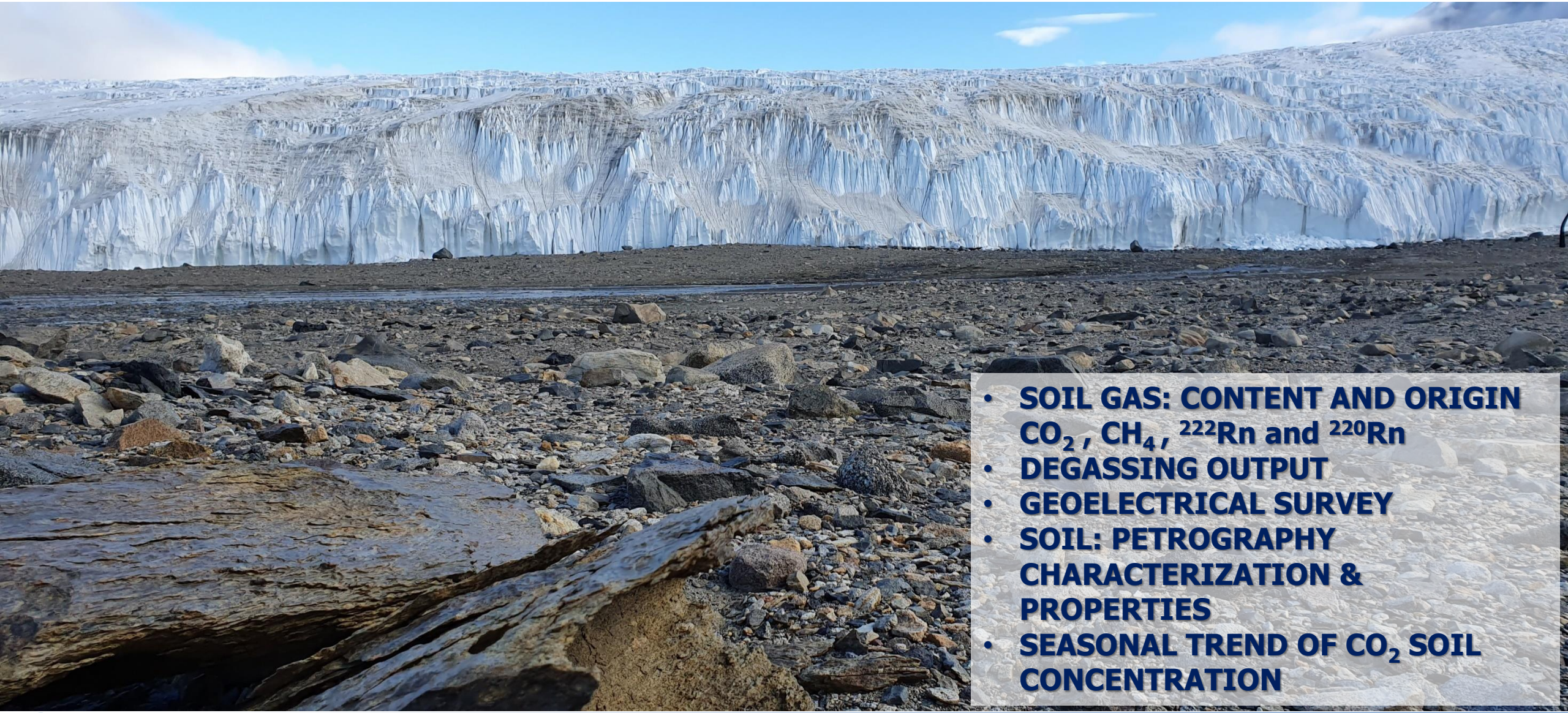
Mc Murdo Dry valleys Antartica



- **Largest ice-free surface in Antarctica 4,800 km².**
- **Mean annual -30<T<-5°C**
- **Annual precipitation < 100 mm water equivalent**
- **One of windiest places on Earth: Katabatic 320 km/h**
- **Climate: cold and extremely arid**

Studied area ≈ 20 km²

Planned activities



- **SOIL GAS: CONTENT AND ORIGIN CO_2 , CH_4 , ^{222}Rn and ^{220}Rn**
- **DEGASSING OUTPUT**
- **GEOELECTRICAL SURVEY**
- **SOIL: PETROGRAPHY CHARACTERIZATION & PROPERTIES**
- **SEASONAL TREND OF CO_2 SOIL CONCENTRATION**

Geochemical activities

Water sampling and in situ measurements

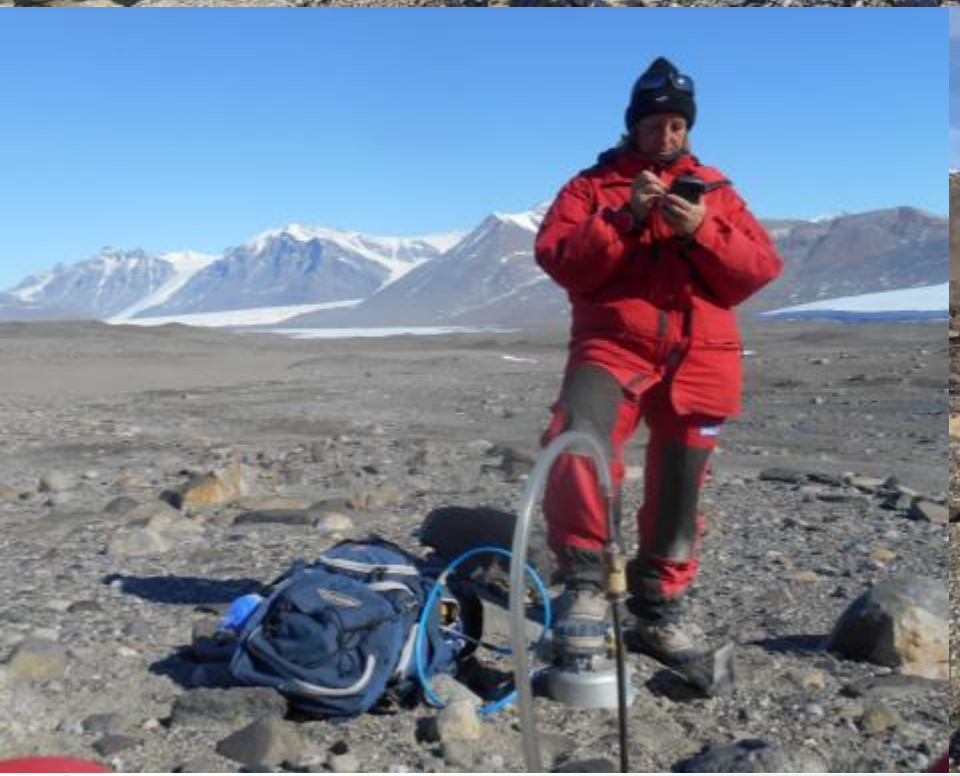
- Isotopes (O, D)
- Anions
- Cations
- pH from 7.2 to 10.3
- Conductivity 93.2 to 4340 μS
- Microbial colonies thrieving at stagnating waters

Monitoring probes installation

Long range winter monitoring

- **CO_2**
- **Temp**
- **Atmospheric pressure**

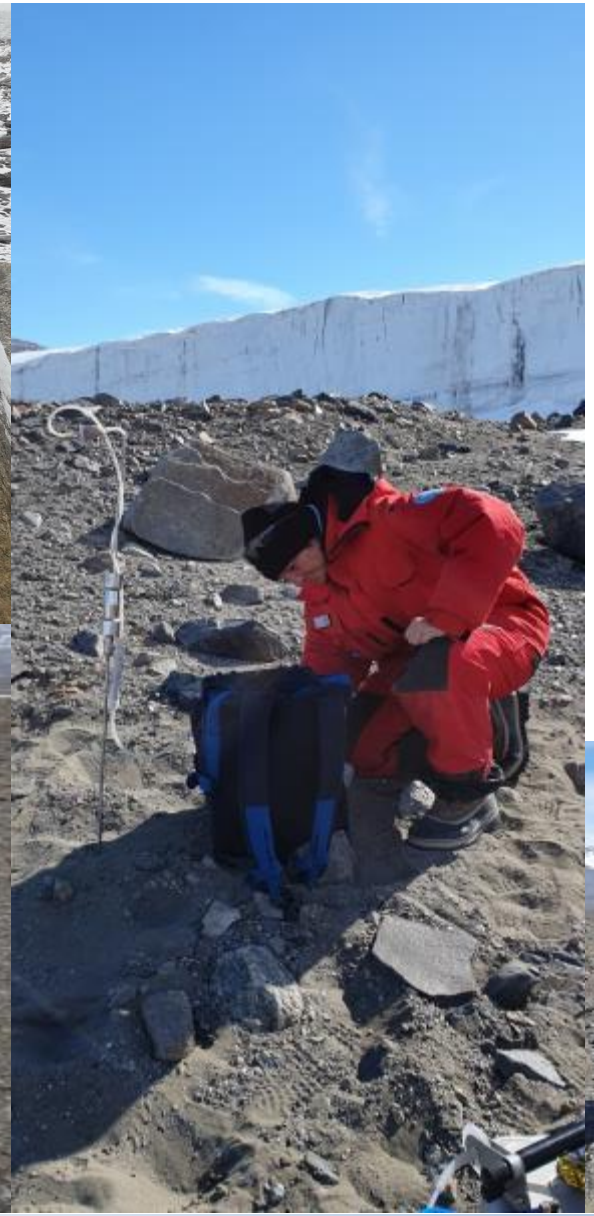
Soil CO_2 – CH_4 flux survey



Soil and Permafrost sampling

- **Sampled sediments for grainsize and petrography**
- **Sampled permafrost for TOC**
- **Permafrost contains CO_2 and CH_4 after thawing**

Gas sampling + Radon-Thoron Survey

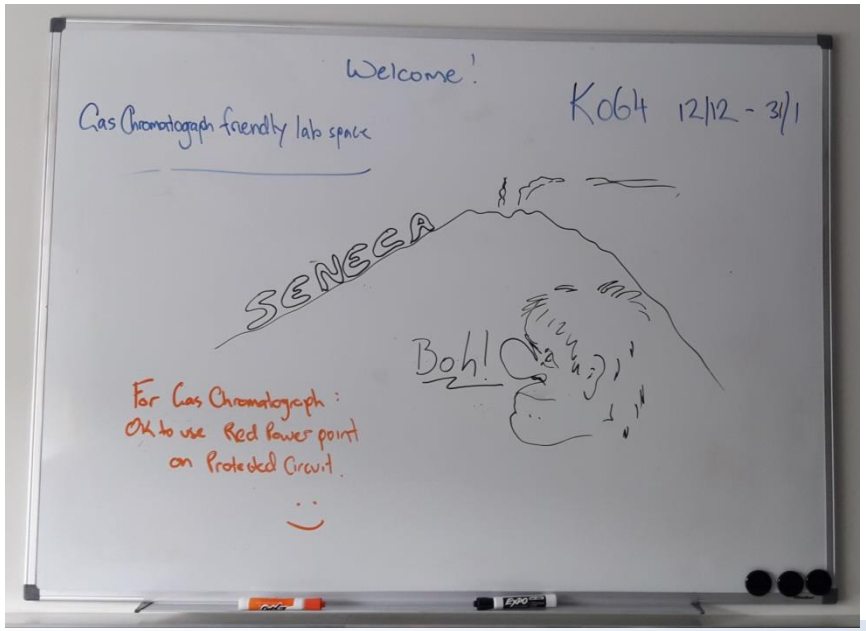


Gas samples from 30-40 cm depth analysed in the laboratory in Antarctica

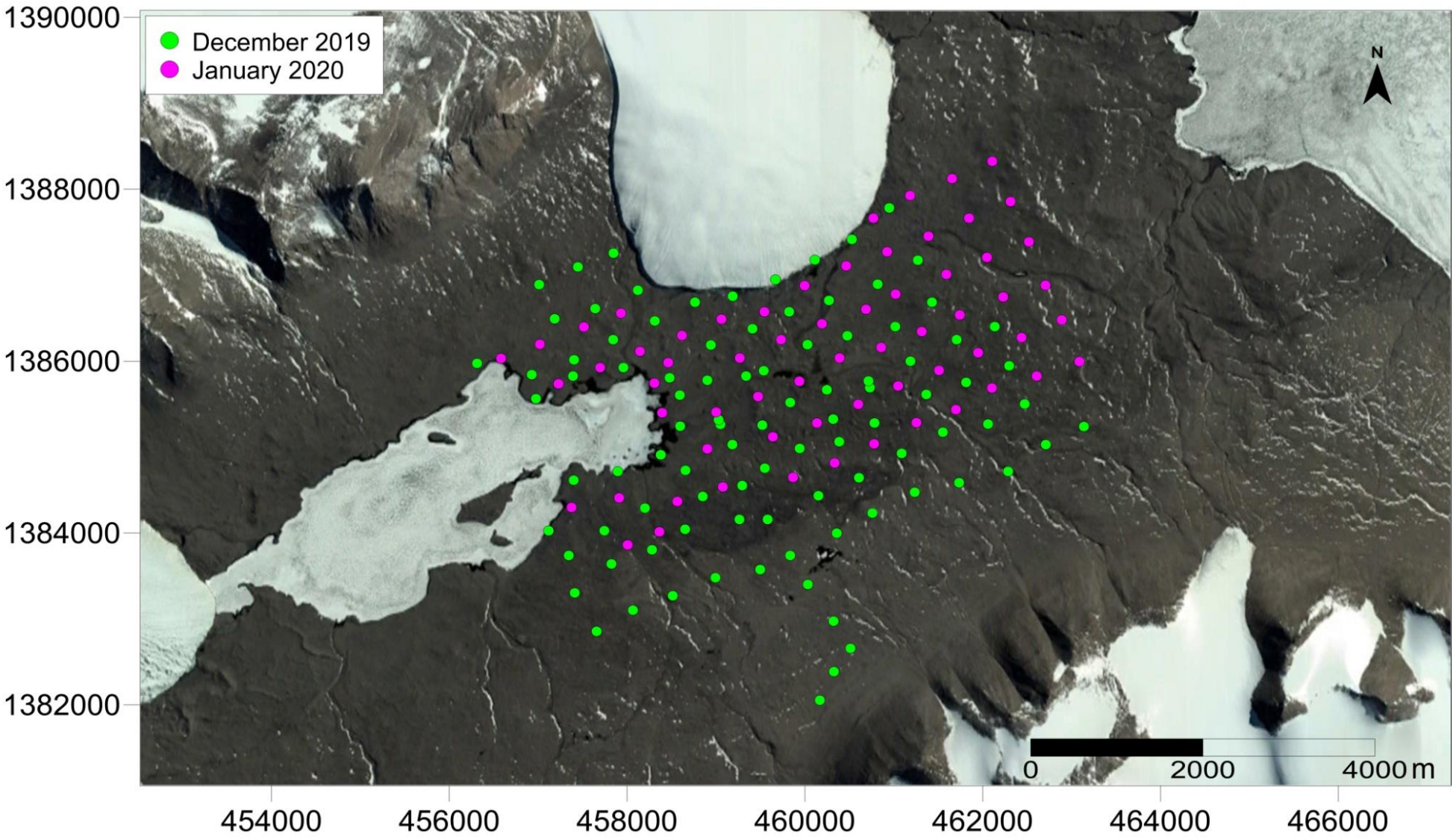
- **Predominant gas CO_2 + CH_4**
- **Presence of Rn emissions from shallow regions**

Scott Base lab

Gas samples, dissolved gas in the waters and permafrost are analysed directly in the Scott Base laboratory in Antarctica



Soil gas survey

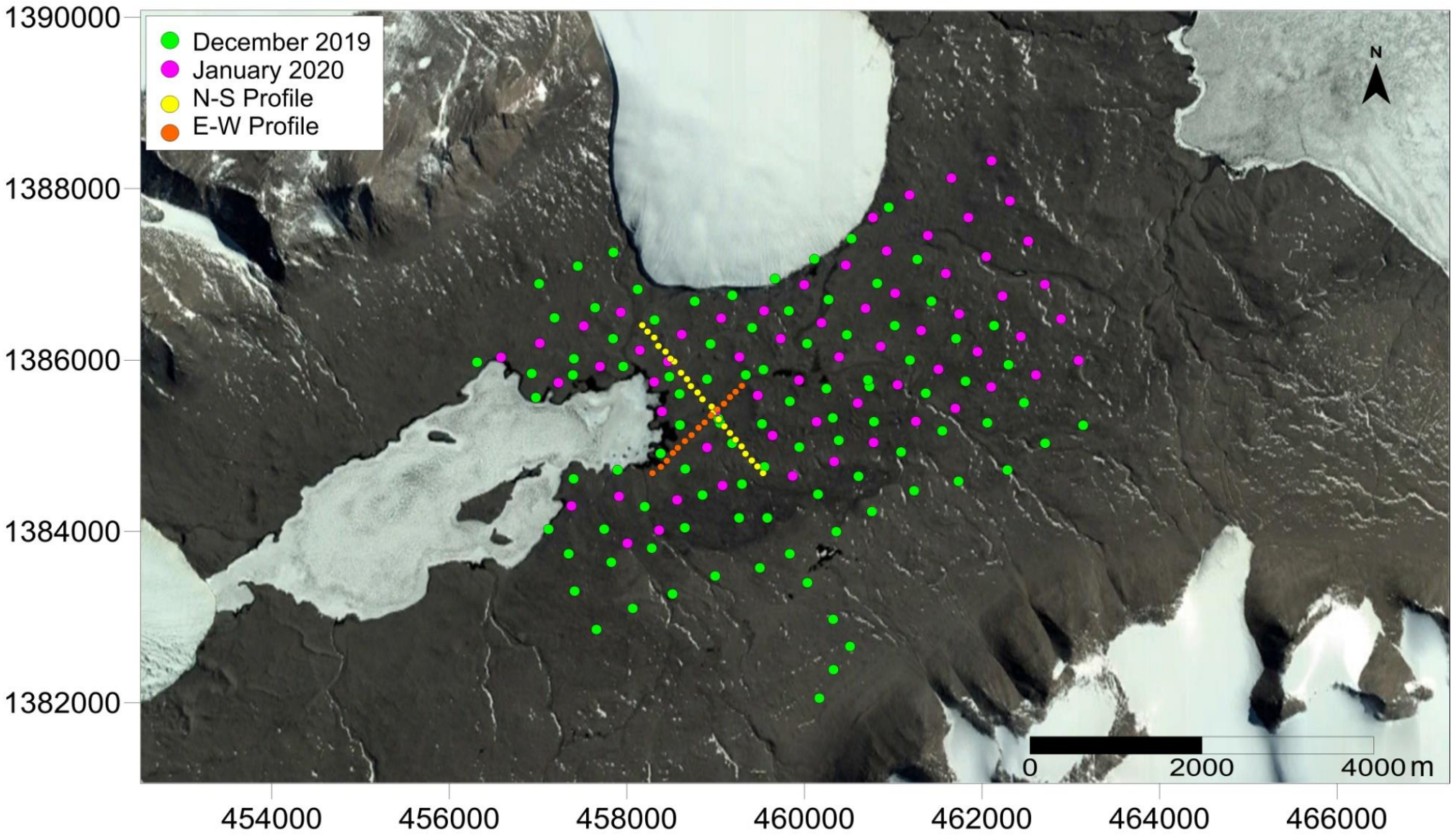


Two grids mesh 500 m each

December 'warmer'

January 'colder'

Soil gas survey



Additional 100 m spacing profiles to compare with geoelectric profiles

Preliminary Results – Geochemical activities

Soil gas concentration survey

DECEMBER

CO_2 up to 34389 ppm CH_4 up to 3977 ppm

JANUARY

CO_2 up to 13259 ppm CH_4 up to 18446 ppm

CH_4 and CO_2 are present in the sediments both during warmer and colder survey

Soil CO_2 – CH_4 flux survey

DECEMBER

CO_2 up to 4.35 g/m²d CH_4 up to 40.2 mg/m²d

JANUARY

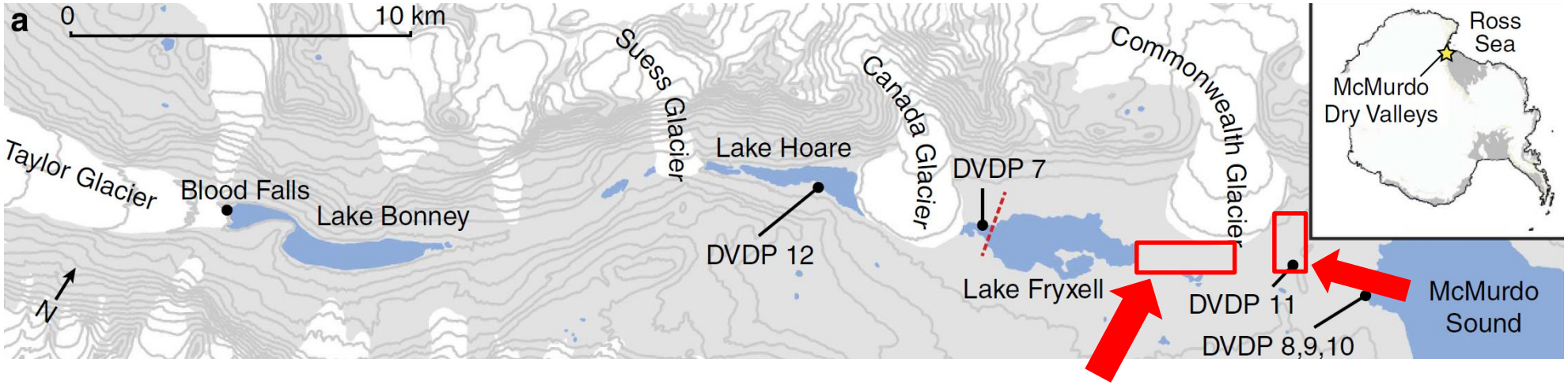
CO_2 up to 11.6 g/m²d CH_4 up to 40.8 mg/m²d

Increase in CO_2 flux in January (colder survey).
Stable flux of CH_4 in December & January (warmer survey)

Geoelectrics activities

GEOELECTRICAL SURVEY IN THE TAYLOR VALLEY (ANTARCTICA)

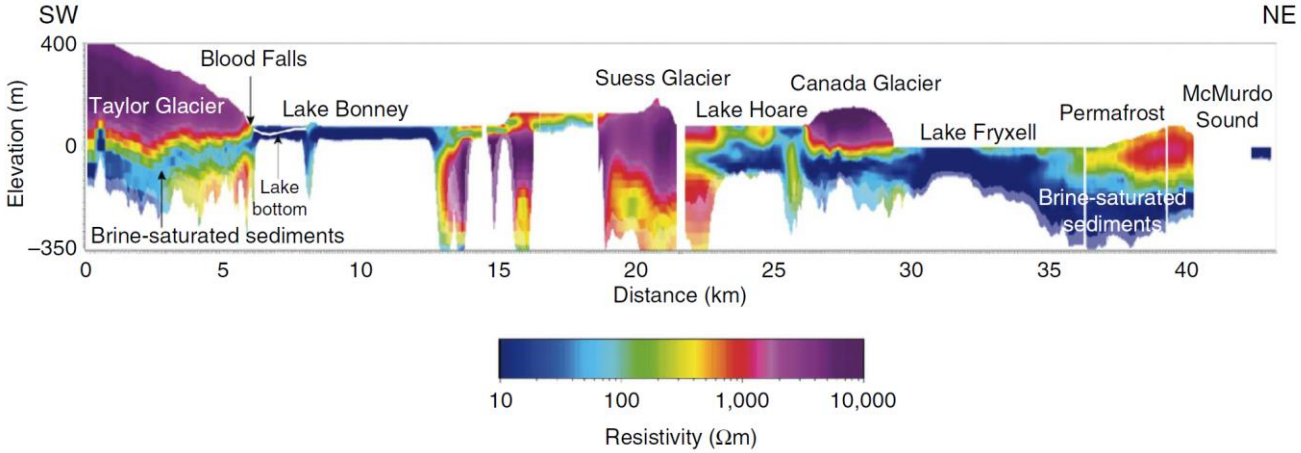
We performed a 2D geoelectrical survey to map the depth of the permafrost and the electrical properties of the subsurface

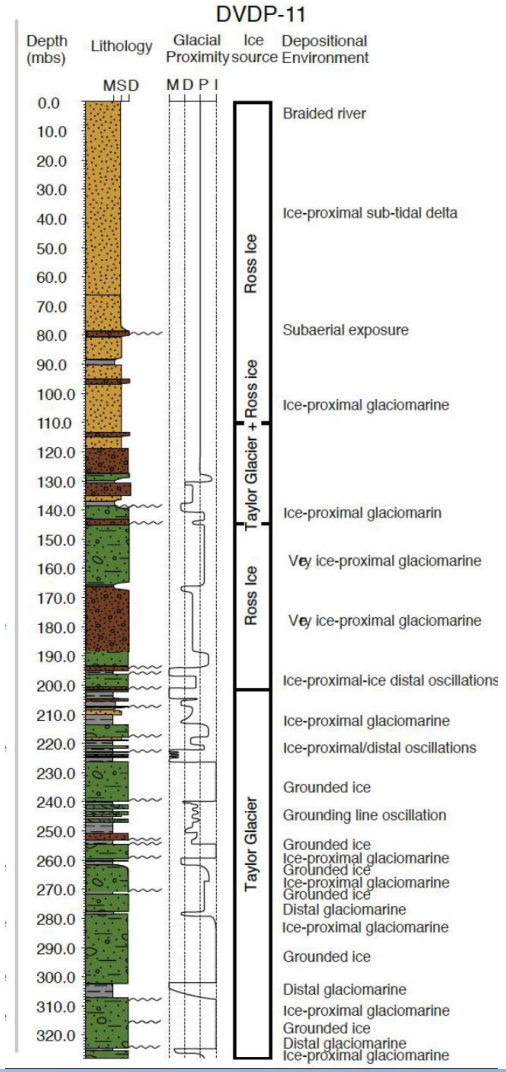


Mikucki et al., (2014)

We selected two survey areas according to:

- The distribution of the resistivity values from previous studies
- Correlation with borehole data (DVDP 11, ~320 m deep)
- Logistic constraints





Field apparatus

We used the Fullwaver system (Gance et al., 2018, Lajaunie et al., 2018).

Current is injected through an induced polarization transmitter, (VIP 5000, IRIS Instruments). An external generator provides current for the VIP. The receiving nodes record continuously the electrical field and the injection electrodes can be moved inside and outside the receiving nodes with any type of electrode array configuration. Injected current is recorded on real time on the I-Fullwaver.

a) Transmitter-VIP

b) I-fullwaver

c) V-fullwaver

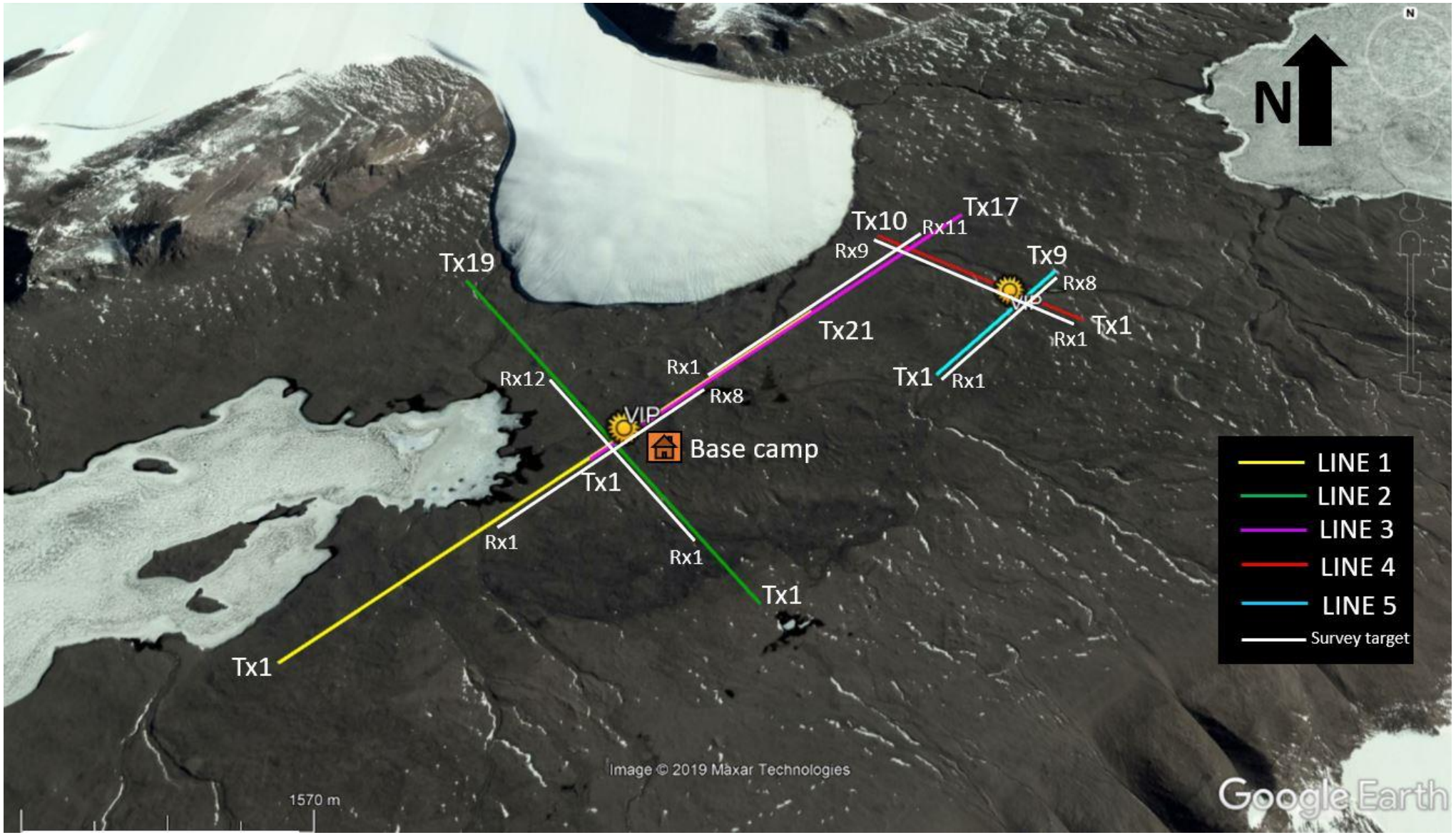
-one induced polarization transmitter (VIP)

-one current measurement unit called I-Fullwaver

-a set of 2-channels independent receiving nodes called V-Fullwavers

-a motor generator

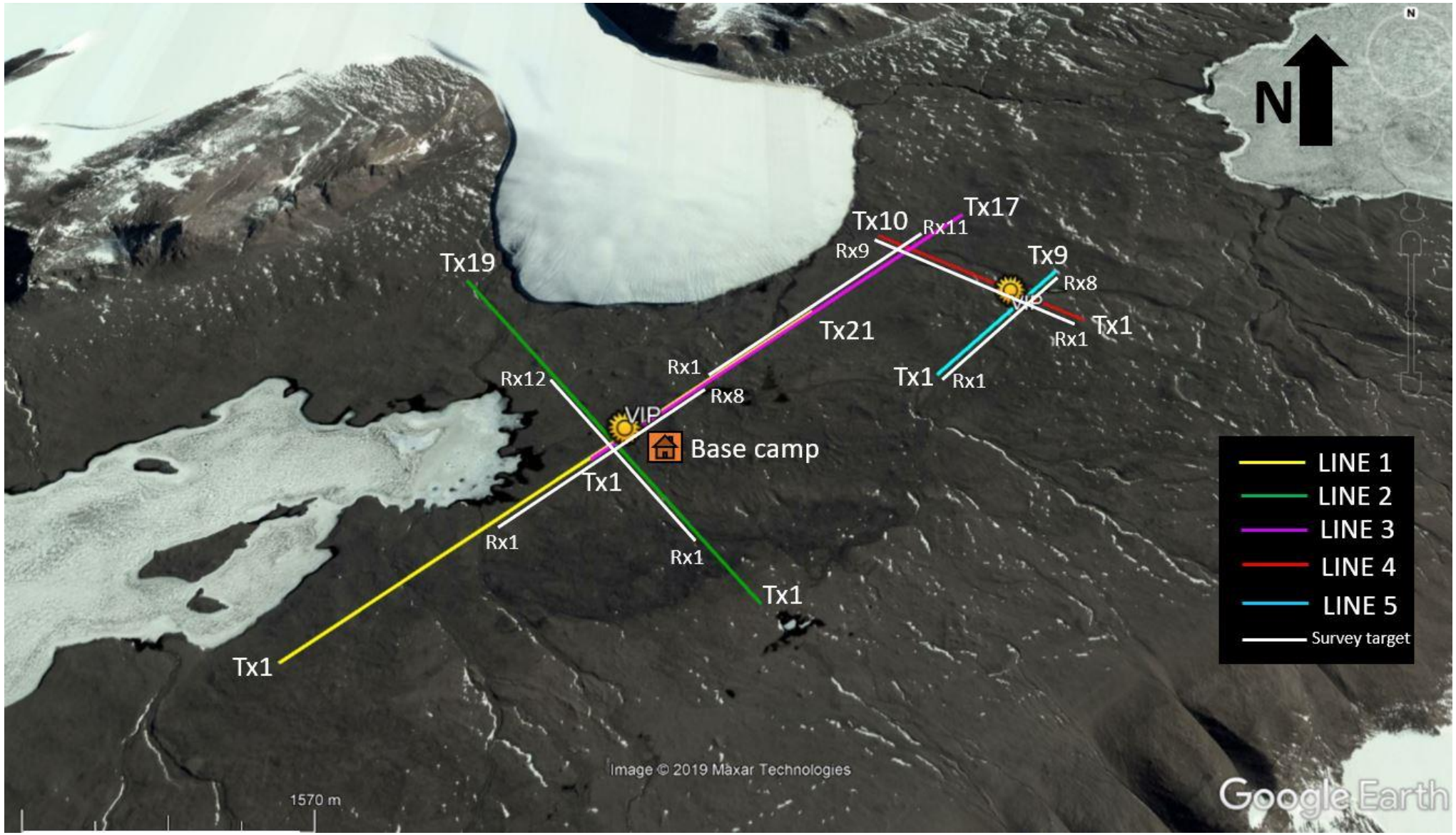
Geoelectrical survey



AIMS

- **Investigate sediments properties**
- **Define permafrost base**
- **Calibrate results with available boreholes**

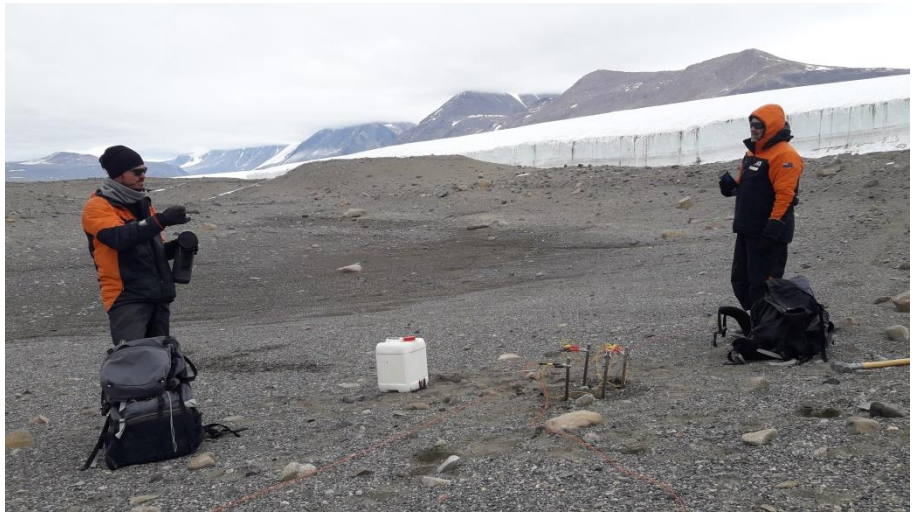
Survey design



Locations of the survey lines, transmission limits, receivers survey lines, VIP and base camp in the Taylor Valley.

P1: 4.5 km
P2: 3.8 km
P3: 3.2 km
P4: 1.8 km
P5: 1.6 km

Geoelectrics deployment



Conclusions

- CH_4 and CO_2 present in the thowed permafrost
- Emission rates dependant on T variations
- First ever emission estimate for CH_4 and CO_2 in Southern Polar Hemisphere
- Benchmark for future measurements
- Map preferential gas release pathways
- Define thickness of permafrost using geoelectrical data
- Investigate mechanisms of gas migration through the shallow sediments

Thank you