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
• CO₂ and CH₄ degassing output
• Geophysics exploration and petrographic characterization of the soils
• Seasonal trend of CO₂ soil concentration
Permafrost & climate change

Arctic and Antarctic regions store almost twice the carbon currently present in the atmosphere.
Mc Murdo Dry valleys Antarctica
McMurdo Dry valleys Antarctica

- 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

Credit: NASA
Planned activities

- **SOIL GAS: CONTENT AND ORIGIN**
  - CO$_2$, CH$_4$, Rn, and Th
- **DEGASSING OUTPUT**
- **GEOELECTRICAL SURVEY**
- **SOIL: PETROGRAPHY CHARACTERIZATION & PROPERTIES**
- **SEASONAL TREND OF CO$_2$ SOIL CONCENTRATION**

04/05/2020
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 thriving at stagnating waters
Monitoring probes installation

Long range winter monitoring
- \( \text{CO}_2 \)
- Temp
- Atmospheric pressure
Soil $\text{CO}_2 - \text{CH}_4$ 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 CO₂ + CH₄
- Presence of Rn emissions from shallow regions

04/05/2020
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’

04/05/2020
Soil gas survey

Additional 100 m spacing profiles to compare with geoelectric profiles
Soil gas concentration survey

DECEMBER
CO₂ up to 34.389 ppm CH₄ up to 3977 ppm

JANUARY
CO₂ up to 13.259 ppm CH₄ up to 18446 ppm

CH₄ and CO₂ are present in the sediments both during warmer and colder survey

Soil CO₂ – CH₄ flux survey

DECEMBER
CO₂ up to 4.35 g/m²d CH₄ up to 40.2 mg/m²d

JANUARY
CO₂ up to 11.6 g/m²d CH₄ up to 40.8 mg/m²d

Increase in CO₂ flux in January (colder survey). Stable flux of CH₄ in December & January (warmer survey)
Geoelectrics activities
We performed a 2D geoelectrical survey to map the depth of the permafrost and the electrical properties of the subsurface.

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

Mikucki et al., (2014)
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.

- 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
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

- CH₄ and CO₂ present in the thawed permafrost
- Emission rates dependant on T variations
- First ever emission estimate for CH₄ and CO₂ 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