Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34252

Permafrost Degassing in the McMurdo Dry Valleys, Antarctica: A Six-Year Investigation Beyond the SENECA and SENECA 2 Projects

LIVIO RUGGIERO[1], ALESSANDRA SCIARRA[2], GARY WILSON[3], FABIO FLORINDO[4], ADRIANO MAZZINI[5], CLAUDIO MAZZOLI[6], JACOB ANDERSON[7], LUCY DAVIDSON[8], JACKSON BEAGLEY[9], CAITLIN BERQUIST[3], VALENTINA ROMANO[10], SALOMON HAILEMIKAEL[10], PAOLA TUCCIMEI[11], GIANFRANCO GALLI[2], LAURA TOSITTI[12], ALESSANDRO ZAPPI[13], ELEONORA BENÀ[14], VALERIO OLIVETTI[14], MARTINA MATTIA[11], CLAUDIO ZACCONE[15], VINCENZO SAPIA[16], PAOLA BACCHESCHI[10], CHRIS M. MOY[8], JOCELYN TURNBULL[17], RICHARD HARDIE[18], THOMAS BRAKERING[19], GRAHAM S LEONARD[20], RAFFAELE SASSI[6], PROF. SABINA BIGI, PHD[21] AND GIANCARLO CIOTOLI[22]

[1]National Research Council
[2]Istituto Nazionale di Geofisica e Vulcanologia
[3]University of Waikato
[4]Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy
[5]Institute for Energy Technology (IFE)
[6]University of Padova
[7]Lamont-Doherty Earth Observatory, Columbia University
[8]University of Otago
[9]Otago University
[10]National Institute of Geophysics and Volcanology, INGV, Rome, Italy
[11]Dipartimento di Scienze, Università di Roma Tre, Rome
[12]Department of Chemistry “G. Ciamician”, University of Bologna
[13]8Department of Chemistry “Giacomo Ciamician”, University of Bologna
[14]Department of Geosciences, University of Padova
[15]Department of Biotechnology, University of Verona
[16]INGV-Istituto Nazionale di Geofisica e Vulcanologia
[17]Earth Sciences New Zealand
[18]Hutt City Council, New Zealand
[19]Earth Science New Zealand
[20]GNS Science
[21]Università Sapienza-Università di Roma, Dipartimento di Scienze della Terra
[22]CNR-IGAG

Antarctic permafrost is often treated as a cold, impermeable seal that limits greenhouse-gas exchange. Yet the ice-free soils of the McMurdo Dry Valleys (MDV) show measurable CO_2 and CH_4 emissions, raising a key question: are these gases produced in the active layer, released by enhanced melt, or supplied from deeper reservoirs (e.g., hypersaline brines) and transported upward through transient pathways? We synthesize six years (2019–2025) of integrated investigations that build on, and extend beyond, the SENECA and SENECA 2 projects. SENECA established the first regional baseline by combining (i) soil-gas surveys and surface flux measurements of CO_2/CH_4 with complementary tracers (e.g., Rn, He, H_2), (ii) continuous in situ monitoring of subsurface CO_2 at selected sites, and (iii) geophysical imaging. Electrical Resistivity Tomography (ERT) was used to map permafrost architecture, active-layer thickness, ice-cemented horizons, and potential brine-rich zones, providing the physical framework needed to interpret where and why degassing concentrates. SENECA 2 advanced this baseline with a hypothesis-driven design targeting three end-members: (1) in situ microbial production, (2) localized thaw/permeability increases in high-degassing areas, and (3) ascent from deep brines along structural pathways. The project repeats flux and soil-gas surveys on the original grids, adds stable- and radiocarbon-isotope fingerprints to constrain source and age of carbon, deploys new-generation probes for continuous monitoring of CO_2, temperature and pressure, and integrates ERT with temporary passive-seismic arrays to identify fractures and anisotropy that may act as preferential conduits. Across repeated surveys and targeted high-resolution hotspot mapping, degassing is highly heterogeneous and shows a marked upward trend, with mean CO_2 fluxes increasing fivefold over five years in key sectors. The combined geochemical-geophysical approach links emission anomalies to evolving subsurface connectivity, delivering a transferable framework for detecting emerging hotspots, testing source mechanisms, and improving projections of permafrost-mediated gas release in a warming polar environment.