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From Mantle to Surface: Integrated Geochemical Exploration of Deception Island Active Volcano

ANTONIO CARACAUSI[1], ANTONIO POLO[2], ANTONIO ÁLVAREZ-VALERO[3], JABRANE LABIDI[4], EDWARD D. YOUNG[5], HIROCHIKA SUMINO[6], CONXITA AVILA[7], DARIO BUTTITTA[1], ADELINA GEYER[8] AND PAOLO RANDAZZO[1]

[1]Istituto Nazionale di Geofisica e Vulcanologia-Sezione di Palermo

[2]Departamento de Geología, Universidad de Salamanca, Plaza de la Merced s/n, 37008, Salamanca, Spain

[3]University of Salamanca

[4]Institut de Physique du Globe de Paris

[5]University of California, Los Angeles

[6]University of Tokyo

[7]Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Universitat de Barcelona, Av. Diagonal 643, 08028 Barcelona, Spain

[8]Geosciences Barcelona (GEO3BCN), CSIC, Lluís Solé i Sabarís s/n, 08028 Barcelona, Spain

Fluids are key tracers of subsurface processes; thus, geochemical monitoring in active volcanic and tectonic regions is vital for understanding eruptions and seismic events. While technological advances in field instrumentation and data processing favor nowadays for acquiring high-frequency and real-time databases, many remote regions still lack the fundamental baseline data required for effective monitoring.

Polar regions exemplify these challenges, where logistical and environmental constraints hinder the application of modern technologies. This study presents the geochemical exploration at Deception Island volcano (last eruption 1970) conducted during the 2022-23 Spanish Antarctic campaign. By focusing on fluid geochemistry, we defined the preliminary baseline parameters essential for establishing a robust monitoring network in such an extreme environment.

In 2023 we explored the gas emissions of the whole island and collected fluids emitted from fumaroles (T up to 104°C) and bubbling in seawater (< 10 m depth) along the Port Foster bay shore to decipher the outgassing of magmatic volatiles in different areas of the entire island. We discovered that sampling the bubbling gases is strongly conditioned by the tidal waves, which in turn reduces the time efficiency to finalize the gas collection. This increases the extreme difficulties in exploring and monitor this active polar volcano.

The helium (He) isotopic signature is in the range of the MORB mantle values (8.0±1R_a; R_a as the ratio in air). Combining our data with those of two previous surveys, all the He isotopic data in the outgassing fluids over time (1999-2023) indicate a variability that could reflect magma dynamics within the volcanic plumbing system.

The C_{CO2}-He systematics allow recognizing that magma degassing and water-gas interaction at depth modified the pristine gas chemistry. Moreover, our study demonstrates that the $C/^3He$ and the $d^{13}C_{CO2}$ values of the mantle source feeding the DI volcanic gases is MORB-type.

Finally, we also used the informative $^{15}N^{15}N$ isotopologue of N_2 as a novel tracer of the air contamination in the volcanic gases, and noticed excess of N_2 respect to air in the north Antarctica mantle that is due to processes of subduction transporting crustal materials down into the mantle.