Erebus: A laboratory volcano in Antarctica

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Erebus, the only presently erupting phonolite volcano, offers an exceptional opportunity to examine the complexities that accompany degassing and the evolution of magmas from deep to shallow levels. These include aspects of magmatic differentiation, redox chemistry and eruptive transitions widely relevant to understanding other volcanoes. Its long-lived anorthoclase phonolite lava lake, sustained degassing and hyperarid environment provide uncommonly favourable circumstances for direct measurement of the lava lake – the uppermost portion of the magmatic system.

Several features distinguish Erebus: the decadal persistence of the lava lake; evidence for continuous fractionation (the Erebus Lineage) from basanite to phonolite; episodic Strombolian activity at the lava lake (which provides samples for analysis); and the abundance of megacrysts (up to 10-cm-long) of anorthoclase feldspar in the lava lake. The longevity of the lava lake implies counterflow of vesicular and degassed magma within the (<10 m) feeder conduit. Flow instabilities and diffusional processes allow complex transfers of gas, melt and crystals up and down the conduit.

This contribution focuses on integration of field measurements of volcanic gas emissions (composition and flux) and the vigour of lava lake motion, and how the observations map to characteristics of magma flow and degassing. It aims to showcase key findings of recent annual field seasons on Erebus, to review some of the challenges of volcano surveillance in the extreme Antarctic environment, and to stimulate comparative studies of Erebus and volcanoes such as Vesuvio, Stromboli, Nyiragongo, and others, with shared characteristics.

Halophilic microorganisms: Modern and ancient, on Earth and in Space

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Salt-saturated environments on Earth are inhabited by a great diversity of halophilic microorganisms. They are found in all three domains of life: Bacteria, Archaea, and Eucarya. Many can thrive not only at low water activities, but are also adapted to high divalent cations concentrations (the Dead Sea) and to extremes of pH and temperature. Different groups of halophiles can be detected using biomarkers such as the archaeal isoprenoid ether lipids, pigments (the archaeal C-50 bacterioruberins, β-carotene from the alga *Dunaliella salina*), and osmotic solutes such as glycine betaine and ectoine in Bacteria, glycerol in *Dunaliella*.

When halite crystallizes from salt-saturated brines, microorganisms are often trapped within fluid inclusions in the crystals, where they can survive for prolonged periods. Live microorganisms have been recovered from ancient halite, e.g. *Virgibacillus marismortui* from Permian salts of New Mexico, Archaea (*Halobacterium*, *Natronobacterium*) from Cretaceous halite crystals from Brazil. DNA encoding bacterial and archaeal rRNA genes was recovered from Cretaceous (Brazil) and Silurian (Michigan) salt. Salt crystals deposited 35,000 years ago in Death Valley, CA, contained microscopically recognizable prokaryotes, as well as *Dunaliella*, which may have provided the prokaryotes with glycerol and other organic compounds as a source of energy for survival. In spite of the earlier scepticism, compelling evidence for long-term survival of halophilic microorganisms within salt crystals has accumulated in the past decade.

Some species of halophilic Archaea can survive large doses of UV radiation, desiccation and exposure to low temperatures, but not all halophiles are equally adapted. Some strains of halophiles have survived flights on the Biopan facility of the space shuttle, including a species named *Halorubrum chaoviator*, 'the traveller of the void'.

Halite has been detected on Mars and in meteorites. In view of the ability of some halophiles to survive in salt at low water activity, high radiation levels, and in a broad range of pH, salt crystals are promising material to search for life elsewhere in the universe, using a combination of techniques: microscopy, gene-based approaches, and detection of specific biomarkers. Model systems on Earth – recent and ancient – provide plentiful material to evaluate the different methods.