Environmental Controls on Abiotic Trace Gas Production via Low-Temperature Brine-Rock Interactions

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Nitrous oxide (N_2O) and methane (CH_4) are important trace gases. Both are greenhouse gases that are mainly produced by microbial processes (at least on Earth); hence, their presence in alien atmospheres is a potential bioindicator sought after by exobiologists. However, Samarkin et al. (2010, Nature Geoscience 3:341) recently reported a previously undescribed natural, abiotic mechanism for N_2O generation involving the reduction of nitrite and nitrate in cold, hypersaline Antarctic brine by iron in ferrous minerals. This brine-rock interaction N_2O emission (BRINE) process appears to involve serpentinization-type reactions, and releases molecular hydrogen, which can serve as an energy source for microbes and may further react with carbon dioxide (CO_2) to produce CH_4. BRINE could be responsible for abiotic N_2O production wherever brines containing nitrates contact mafic or ultramafic rocks; such conditions are reminiscent of the shallow subsurface of Mars and potentially elsewhere in the solar system (e.g., on icy moons, on early Earth.). We seek to better characterize the BRINE reaction, assess its kinetics, investigate its environmental controls and place constraints on its potential impact on N_2O and CH_4 production on Earth and other planetary bodies. To this end, we will carry out a series of controlled laboratory experiments using commercially available ultramafic minerals, synthetic brines and rock and natural brine samples collected at selected evaporitic sites in the southwestern U.S. Our preliminary results will build a foundation for more comprehensive future research into low-temperature abiotic trace gas production mechanisms and their implications for the presence and detection of extraterrestrial life.

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