The fate of volcanic ash in marine sediments

RICHARD W. MURRAY[1](*), JULIE C. SCHINDLBECK[2], RACHEL P. SCUDDER[1], STEFFEN KUTTEROLF[2]

[1]Department of Earth Sciences, Boston University, Boston, MA, USA, rickm@bu.edu; rscudder@bu.edu.

[2]GEOMAR, Kiel, Germany, jschindlbeck@geomar.de; skutterolf@geomar.de

Volcanic ash transported to the oceans is one of the main mechanisms by which terrigenous material and nutrients are delivered to the deep sea. Alteration of volcanic glass in the ocean is an important component of marine biogeochemical cycling, with the ash acting as a source and/or sink of many major and trace species.

Ash in marine sediment also provides an important record of explosive subduction zone volcanism. Discrete, visible ash layers are common in the vicinity of subduction zones and have originated from larger explosive eruptions at the volcanic arc. The chemistry and provenance of these visible ash layers are mostly well known and the layers themselves facilitate direct or indirect dating and can therefore be used as marker horizons in marine sedimentology and stratigraphy. Ash layers may also help estimate eruptive volumes, and contribute to the chemistry of sediments and fluids in these regimes. Normal grading and mineral enrichment at the base, glass shard morphology, as well as changes in ash color that are mostly correlated to variations in the chemistry of the primary glass, are features that are relatively easily recognized within the marine sediment column.

The qualitative and quantitative fate of discrete ash layers in sedimentary sequences is only partly known. In theory, bioturbation should destroy layers less than ~10 cm thick, yet well preserved layers of a few cm's thickness are found even in bio-irrigated deposits. By detailed geochemical and sedimentologic study, we here quantify how the incorporation of the primary volcanic ash in marine sediments proceeds above ash layers and with distance from the source. We further discuss how ash is captured within the sediment column and recycled in subduction zones, and quantitatively address how ash layers compositionally affect the hosting sediment column.

Stratigraphic sampling of sequential 1-3 cm slices above primary ash layers from offshore Central America show that densities decrease due to lesser amounts of volcanic glass in the silty clay marine sediments. The bulk rock chemistry reflects this gradation as well and can be quantified for single elements like U, Cr, Zr, V, and Pb, depending on the composition of the volcanic glass (mafic versus felsic). The most important component for those changes is the <32 µm fraction, since ~14 wt% of this is still composed of volcanic glass. Additionally, we see a decreasing frequency of ash layers with increased distance from the source (e.g., 200 vs. 350 km). Quantification of this decrease will help establish a volcanic matter correction factor for chemical and sedimentological parameters with distance from source in subduction zone settings.

Analog studies of brine cryoenvironments in the Canadian high Arctic

NADIA MYKYTCZUK[1*], SUSAN TWINE[2], BOSWELL WING[3], SIMON FOOTE[2], KELLY FULTON[2], CHARLES GREER[4], LYLE WHYTE[1]

[1]McGill University, Natural Resource Sciences, Montreal, Canada, nadia.mykytczuk@mcgill.ca (*presenting author); lyle.whyte@mcgill.ca

[2]National Research Council Canada, Institute for Biological Sciences, Ottawa, Canada, susan.twine@nrc-cnrc.gc.ca; simon.foote@nrc-cnrc.gc.ca; kelly.fulton@nrc-cnrc.gc.ca

[3]McGill University, Earth and Planetary Sciences, Montreal, Canada, boswell.wing@mcgill.ca

[4]National Research Council Canada, Biotechnology Research Institute, Montreal, Canada, charles.greer@nrc-cnrc.gc.ca

The Canadian high Arctic offers several unique cryoenvironments including cold saline springs and extensive permafrost that are working analogs to the conditions that are known, or are suspected, to exist on Mars, and potentially on other astrobiological targets. In particular, fluvial features linked to past and current processes on the surface of Mars suggest that liquid brines near the surface exist and could have been a potential abode for past or extant microbial life. Our recent research focused on detecting and examining microbial life in the unique cold saline/brine springs on Axel Heiberg Island. The microbiology and geochemistry of a habitat found within the Gypsum Hill (GH) spring site will be presented, describing a constant circum-zero saline (7.5 % salinity) habitat that is host to chemolithotrophic sulfur-oxidizing bacterial filaments that flourish in the Arctic winter. The GH spring site is a sulfide (25-100 ppm) and sulfate (2300-3700 mg/L) abundant system serving as an analogue for the abundant sulfate deposits and potential sulfate-rich brines on Mars. The GH springs support viable, active (down to -10°C), and low diversity microbial communities dominated by *Thiomicrospira* spp.. Environmental meta-omic analyses (genomic, proteomic, transcriptomic) were aimed at uncovering insights into: a) the sulfur metabolizing community; b) the diversity of core metabolic genes required to utilize essential nutrients (C, N) within this extreme environment; c) the pathways of energy utilization i.e. CH_4, H_2, sulfur; d) the evolutionary and physiological traits required for microbial life in this subzero, hypersaline cryoenvironment. The meta-analyses provided greater insight into the predominant *Thiomicrospira* metabolic enzymes expressed as part of the active microbial growth, activity and adaptive traits during the late Arctic spring. *In situ* geochemical and isotopic analyses of the fractionation of multiple-sulfur isotopes resulting from bacterial sulfur-metabolism vs. abiotic isotope exchange illustrated the route of biogeochemical sulfur cycling and traced the formation and preservation of potential sulfur-based biosignatures ($\delta^{33}S$, $\delta^{34}S$ and $\delta^{36}S$ stable isotopes). These studies demonstrate how complimentary molecular tools provide a functional link between microbial life and the geochemistry of their environments, how we can predict potential biosignatures of microbial activity and illustrate unique traits linked to microbial survival within these brine cryoenvironments analogous to past or perhaps present conditions on Mars.