Tracing recycled volatiles in MORB with halogens

*Ray Burgess[1], Lorraine Ruzie-Hamilton[1], Patricia Clay[1], Bastian Joachim[2], Christopher Ballentine[3]

1. School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL UK, 2. Institute for Mineralogy and Petrography, University of Innsbruck, Innrain, 52A-6020, Innsbruck, Austria, 3. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, OX1 3AN UK

Interactions between the Earth's mantle and the surface have controlled the evolution of the crust, the oceans, and the atmosphere. The mantle is by many orders of magnitude the largest silicate reservoir for volatiles, and volcanic release of these species has played a major role throughout Earth history in global chemical cycles. Understanding the distribution and geochemical evolution of volatiles in the terrestrial mantle is therefore central to understanding the unique planetary history of Earth. The input and output of volatiles at plate boundaries provides major controls on the cycles of many important elements and exerts long-term controls on habitibale conditions at the surface.

Noble gases have provided key insight into the processes controlling the mantle system. Primordial heavy noble gases in the MORB-source mantle are accompanied by atmosphere noble gases with an elemental composition consistent with subduction of an ocean/pore-fluid signature into the mantle (1). Pore fluid subduction represents an important opportunity to use halogens, in particualr iodine which is highly enriched in marine pore fluids, in conjunction with noble gases as sensitive tracers of water and volatile enrichment processes in the mantle.

To assess the control of subduction zones on the mantle halogen budget we have investigated basaltic glass samples from the Manus Back-Arc Basin as some of the volatiles may survive forearc to subarc devolatilization to depths beyond arcs/back-arcs and contribute to the long term volatile budget of the mantle. We also investigated two sets of samples: one from the Central Indian Ridge (2) containing D(epleted)-MORB, N(ormal)-MORB and E(nriched)-MORB and one from the Siqueiros Transform Fault (STF) known for sampling the depleted upper mantle (3). In contrast to axial MORB, lavas from STF are tapping smaller mantle melt without mixing in large magmatic chambers. These melts provide better estimates of the volatile contents of the potential mantle sources.

Based on new halogen determinations, we show that the volatile budget in the mantle sampled by the mid oceanic ridge basalts is a mixture between the depleted upper mantle and a fluid-modified mantle enriched during its residency in subduction zone. This enables us to revisit the global halogen budget and assess how subduction of halogens has affected the habitability of our planet.

1. Holland & Ballentine, Nature 441, 186-191, 2006.

2. Nauret et al. Earth Planet. Sci Lett. 245, 137-152, 2006.

3. Saal et al., Nature 419, 451-455, 2002.

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