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Circumventing shallow air contamination in Mid Ocean Ridge Basalts

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Noble gases in mantle-derived basalts provide a rich portrait of mantle degassing and surface-interior volatile exchange. However, the ubiquity of shallow-level air contamination frequently obscures the mantle noble gas signal. In a majority of samples, shallow air contamination dominates the noble gas budget. As a result, reconstructing the variability in heavy noble gas mantle source compositions and inferring the history of deep recycling of atmospheric noble gases is difficult. For example, in the gas-rich popping rock 2ΠD43, $^{129}Xe/^{130}Xe$ ratios reach 7.7±0.23 in individual step-crushes, but the bulk composition of the sample is close to air ($^{129}Xe/^{130}Xe$ of 6.7). Here, we present results from experiments designed to elucidate the source of shallow air contamination in MORBs.

Step-crushes were carried out to measure He, Ne, Ar and Xe isotopic compositions on two aliquots of a depleted popping glass that was dredged from between the Kane and Atlantis Fracture Zones of the Mid-Atlantic Ridge in May 2012. One aliquot was sealed in ultrapure N_2 after dredge retrieval, while the other aliquot was left exposed to air for 3.5 years. The bulk $^{20}Ne/^{22}Ne$ and $^{129}Xe/^{130}Xe$ ratios measured in the aliquot bottled in ultrapure N_2 are 12.3 and 7.6, respectively, and are nearly identical to the estimated mantle source values. On the other hand, step crushes in the aliquot left exposed to air for several years show Ne isotopic compositions that are shifted towards air, with a bulk $^{20}Ne/^{22}Ne$ of 11.5; the bulk $^{129}Xe/^{130}Xe$, however, was close to 7.6. These results indicate that lighter noble gases exchange more efficiently between the bubbles trapped in basalt glass and air, suggesting a diffusive or kinetic mechanism for the incorporation of the shallow air contamination. Importantly, in Ne-Ar or Ar-Xe space, step-crushes from the bottled aliquot display a trend that can be easily fit with a simple two-component hyperbolic mixing between mantle and atmosphere noble gases. Step-crushes in the aliquot left exposed to air display significantly more scatter, which makes it difficult to fit a two-component mixing hyperbola and obtain the mantle source value for this aliquot.

In summary, our simple and inexpensive experiment demonstrates that at least in some samples, significant air contamination is added after dredge retrieval from the ocean floor. Bottling samples in ultrapure N_2 upon dredge retrieval can largely eliminate this component of shallow-level air contamination. As a result, the number of step crushes required to characterize a sample decreases and estimating the mantle source compositions of the basalts becomes significantly easier, which in turn leads to more refined estimates of mantle degassing and regassing rates.