Volatile abundances in MORBs: Seeing through the veil of degassing

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Mantle volatile abundances reveal critical information about the Earth's origin and evolution such as the chemical constituents that built the Earth and material exchange between the mantle and exosphere. However, due to magmatic degassing, volatile abundances in the solid Earth remain poorly characterized. Rayleigh (open-system) degassing is often used to model the evolution of volatiles in a magma [e.g., 1] and degassing models can constrain volatile characteristics of undegassed magmas [e.g., 1,2]. Here we use combined CO2, radiogenic (4He* and 40Ar*), nucleogenic (21Ne*), fissiogenic (136XeU*) and mantle-derived primordial noble gases (3He, 22Ne, 36Ar, 130Xe) in a suite of MORBs to investigate degassing processes.

We find that equilibrium degassing (either closed- or open-system) cannot simultaneously fit the measured CO2-He-Ne-Ar-Xe compositions in MORBs. An undegassed magma will have 4He*-21Ne*-40Ar*-136XeU* in proportion to their mantle production ratios. We find that starting from the mantle production ratios, equilibrium degassing would fractionate the (4He/40Ar)*, (4He/136XeU)*, (21Ne/40Ar)*, (21Ne/136XeU)*, and (40Ar/136XeU)* ratios to significantly higher values than those observed in MORBs. To fit our observations using equilibriun degassing requires measured solubilities of Ne, Ar, and Xe relative to He [e.g., 3] to be a factor of ~2, ~5, and ~15 too high, respectively; i.e., the heavier the noble gas the more the deviation of the measured solubility from the true solubility. While we cannot rule out such systematic bias in measured solubilities, a more likely explanation is that kinetic fractionation between bubbles and melt lowers the dissolved ratios of light to heavy noble gas species in the melt.

To test this hypothesis, we will present a degassing model [after 2] that explicitly accounts for diffusive fractionation between melt and bubble. The model also allows us to simultanously invert the measured carbon and noble gas abundances for the concentrations in undegassed magmas.

[1] Colin *et al* (2013) *EPSL* **361**, 183–194 [2] Gonnermann and Mukhopadhyay (2007). *Nature* **449**, 1037–1040 [3] Jambon *et al* (1986) *GCA* **50**, 401–408