Reconstructing mantle carbon and ^{3}He contents from degassed MORBs

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The abundance of volatile elements in the mantle reveals 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, volatile element abundances in basalts are usually affected by extensive and variable degassing, complicating inferences about the mantle source volatile contents. Here we use combined CO_2-He-Ne-Ar-Xe compositions in a suite of mid-ocean ridge basalts (MORBs) from the equatorial Mid-Atlantic Ridge to investigate degassing processes.

We find that equilibrium (solubility-controlled) degassing cannot simultaneously fit the measured CO_2-He-Ne-Ar-Xe compositions in MORBs and kinetic (diffusive) fractionation is required to explain the data. We have therefore developed a degassing model [after 1] that explicitly accounts for diffusive fractionation between melt and bubbles.

Our model allows us to simultaneously invert measured carbon and noble gas abundances for the concentrations in undegassed magmas. The model predicts that C/He in MORBs changes during disequilibrium degassing only by a factor of ~2–3 due to the negating effects of solubility and diffusivity. Preliminarily, we find undegassed CO_2 concentrations of ~350–450 ppm and ^{3}He concentrations of ~4–5×10^9 atoms/g in basalts with lithophile characterisitics similar to average MORB. We note that the ^{3}He concentrations overlap the value of 5.7±1.1×10^9 atoms/g independently inferred from the average oceanic He flux [2]. Combined noble gas and carbon measurements coupled with our degassing model therefore allows for investigation of source volatile compositions of individual degassed MORBs. However, the obtained source concentrations are sensitive to model parameters such as volatile element solubilities and diffusivities, which may not be well constrained. Such models therefore also help identify the key physical parameters that should be the subject of further experimental study.

[1] Gonnermann and Mukhopadhyay (2007) *Nature* **449**, 1037–1040. [2] Bianchi *et al*. (2010) *EPSL* **297**, 379–386.