The origin of the high $^{3}He/^{4}He$, high temperature early Iceland plume

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Picrites from Baffin Island and West Greenland, erupted as some of the earliest products of the proto-Iceland plume, have extreme $^{3}He/^{4}He$ ratios (up to $50R_a$) associated with a range of incompatible trace element and lithophile radiogenic isotopic compositions that overlap the composition of mid-ocean ridge basalts and most northern hemisphere ocean island basalts. The major element composition of these rocks suggests derivation from mantle that is up to 200°C hotter than ambient mantle. Crustal contamination of a depleted parent with any low-Sm/Nd crustal component cannot account for the full range in Nd isotopes at high $^{3}He/^{4}He$ suggesting that the range in, for instance $^{143}Nd/^{144}Nd$ is due to heterogeneities in the mantle source. We will present new ion microprobe data on melt inclusions in olivine phenocrysts from a subset of high-$^{3}He/^{4}He$ samples covering the full range in $^{143}Nd/^{144}Nd$. REE profiles will be used as a proxy for $^{143}Nd/^{144}Nd$ since measurement of Nd isotopes directly from melt inclusions is beyond current capabilities. If all the melt inclusions have similar LREE-depleted profiles then there would still be scope for models invoking a high-$^{3}He/^{4}He$ end-member with depleted Sr and Nd isotopic composition. However, if the melt inclusions have variable LREE depletion then we will have demonstrated at smaller scale what we show from whole-rock measurements; that the high-$^{3}He/^{4}He$ component dominates the $^{3}He/^{4}He$ of mixtures irrespective of the degree of relative enrichment or depletion of the heterogeneous mantle. This observation would be inconsistent with a discrete, depleted mantle reservoir with high $^{3}He/^{4}He$ that is a residue of ancient mantle extraction. The simplest explanation is that the early Iceland plume sampled an anomalously hot mantle reservoir that had a sufficiently high concentration of high-$^{3}He/^{4}He$ helium to dominate subsequent mixtures with other mantle reservoirs. Seismic evidence for the source of the Iceland plume is the subject of debate, but it is clear that, during its earliest phase, it sampled a hot, He-rich, high-$^{3}He/^{4}He$ mantle reservoir that is apparently not available to steady-state mantle plumes.

Ocean crust alteration: Timing, fluxes, and microbial controls

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The ocean crust generation-alteration-subduction cycle involves large fluxes of heat and chemical components, effectively linking the earth's mantle to its hydrosphere and biosphere. This cycle has substantial consequences for buffering the composition of seawater, for arc mass balances and modifying the chemical composition of the earth's mantle. It also is becoming apparent that this cycle may have important feedbacks with the biosphere. High temperature hydrothermal fluids at seafloor hydrothermal vents are the centers of chemosynthetic life on the seafloor. Much of the upper 1000m of the oceanic crust may be viewed as a bioreactor, where microbes use, mobilize, or sequester chemical components derived from seawater and the oceanic crust. While the relevance of these processes is well established, major uncertainties remain with respect to the overall chemical fluxes, timing, and impact of biology. This limits our ability to understand ocean crust recycling at arc systems, to model the geochemical evolution of the earth, and to understand the feedback between the biological evolution of the earth and the seafloor alteration mass balances.

There is a good, first order correlation between the delivery of convective heat and the amount of secondary minerals produced in the crust. This is likely to imply that microbial life in the oceanic crust may last just as long, at least to about 60 Ma but probably thorugh the entire life cycle of the oceanic crust until it is subducted. This leads to the implication that prograde metamorphism in subduction zones may be biologically mediated, at least up to temperatures of the dehydration of mixed-layer clays.

Much is also known about the chemical changes associated with low and high temperature alteration of the seafloor, and mass balances have been made based on the compositional differences between vent fluids and seawater. Global fluxes, however, have to be carefully reconstructed exploring the diversity of alteration on scale lengths that are significant to large scale fluxes in different tectonic settings. While important advances have been made, overall fluxes have large uncertainties, mostly due to the low recovery rates in crustal deep ocean drill holes (<30%), and relatively few quantitative estimates from ophiolites, whereby the latter is probably the most attractive avenue to pursue in future.