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H_2O geochemistry in MORB: Origin of intra-segment variations

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Geochemical behaviour of H_2O in normal MORB (NMORB) is similar to La. A study H_2O/La values in NMORB pillow-rim glasses from several ridge segments at fast (8-12°N EPR) and intermediate (127-128°E PAR) spreading centres [1] has demonstrated that 1) H_2O/La is uniform within segments (including such features as propagating tips, overlapping ridges and seamounts) and between adjacent segments, and 2) large-scale regional variations in H_2O/La exist between spreading ridges.

We present H_2O and other incompatible element contents in NMORB pillow-rim glasses from two areas. A 100-km long slow-spreading segment at 26°S, MAR is characterised by a large range of H_2O values, far exceeding the regional differences between EPR and PAR segments. The central parts of this segment have generally higher H_2O/La values (~650) similar to the PAR glasses, whereas glasses from the margins of this segment have lower H_2O/La values (~500) similar to the EPR samples. The seamounts from this segment have anomalously high H_2O/La (750-1000), similar to the high-H_2O North Atlantic province [2].

ODP Hole 896A (5 Ma Cocos Plate, intermediate spreading) penetrated a ~ 250 m suite of NMORB pillow-lavas formed at the axis in a separate erupting event. The majority of the suite has high H_2O/La (~800), however a 3 m thick flow at the bottom of the suite has low H_2O/La (~500).

We suggest that intra-segment variations in H_2O/La do not reflect small-scale mantle heterogeneity on the same scale as represented by regional variations. Instead, they originate during interaction of ascending primitive MORB magmas with the uppermost mantle and/or crustal material within mush-zone dominated plumbing systems.

Our results also demonstrate that MORB magmas relatively enriched in H_2O (high H_2O/La) are not limited to the North Atlantic. Regional variations of H_2O/La in NMORB cannot be explained by different degrees of melting, and can ultimately be related to H_2O recycling process in the subduction zones, although the exact mechanisms remain unclear.

References

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Helium and neon from the deep earth: Submarine Galapagos glasses and global correlations

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High $^3He/^4He$ ratios found in some oceanic islands, such as Hawaii, Iceland and Galapagos, have been interpreted as evidence for deep undegassed reservoirs in the earth. This hypothesis has been challenged by geochemists and geophysists who would prefer to explain geochemical variations by recycling and non-plume processes. New helium and neon isotopic data from Galapagos submarine glasses provide important support for the existence of undegassed reservoirs in the earth. The highest Galapagos $^3He/^4He$ ratios (up to 30 times atmospheric) are found in submarine and subaerial lavas from Fernandina volcano, which is the most active volcano on the western edge of the archipelago, and is inferred to be the center of the hotspot. The Fernandina submarine glasses have $^{21}Ne/^{22}Ne$ ratios that are significantly less radiogenic than mid-ocean ridge basalts (MORB) or Loihi seamount glasses, and the neon data support an undegassed source. Other glasses recovered from the western Galapagos platform, near Cerro Azul and Sierra Negra volcanoes have more radiogenic signatures (i.e. lower $^3He/^4He$ and higher $^{21}Ne/^{22}Ne$ ratios). The data define a curved correlation on a neon-helium isotope diagram which is similar to the trend defined by global data from the literature. This strongly suggests tight coupling of these two isotope systems, and coherent evolution of mantle (Th+U)/Ne and (Th+U)/He ratios, which invalidates models involving "decoupling" of helium from other elements by storage in ancient lithosperic reservoirs or melting proceses. The location of the undegassed mantle reservoirs in the deep earth remain enigmatic but are most likely associated with the core-mantle boundary.