

Volatile composition in ocean island basalts

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Volatile reservoirs and transport mechanisms in the mantle are one of fundamental questions in mantle geochemistry. The atmosphere and hydrosphere are major volatile reservoirs in the Earth. Portions of volatiles in the surface layers can be incorporated into oceanic crust and sediment by fluidal reaction and organic and inorganic sedimentation, and then they are delivered to the mantle via slab subduction. However, the efficiency of volatile transport against subduction barrier is poorly constrained. Studies of volatiles in ocean island basalts (OIBs) should document the origin and distribution of volatiles in the deep mantle. This presentation provides an overview of previous studies of volatiles on OIBs using submarine quenched glasses and olivine-hosted melt inclusions.

Whether the mantle source of OIBs is enriched in H₂O is measured by taking H₂O/Ce ratio, where Ce is a lithophile element that has similar incompatibility to H₂O during partial melting. While many OIBs exhibit H₂O/Ce that overlap with the MORB range, OIBs with robust EM1, EM2, and HIMU signatures have significantly lower H₂O/Ce. The fact that H₂O/Ce decreases proportionately with increasing ⁸⁷Sr/⁸⁶Sr for Pitcairn, Kerguelen (EM1), and Society (EM2), and with decreasing ²⁰⁷Pb/²⁰⁶Pb for Tuvalu (HIMU) documents that the mantle components with robust EM1, EM2, and HIMU signatures are commonly depleted in H₂O relative to Ce [1-3]. If their precursor was any type of subducted material, fluid or hydrous melt extraction from the subducted slab reasonably explains the low H₂O/Ce. However, an alternative explanation is a contribution from pyroxenite components in the magma sources, where Ce is more efficiently partitioned into pyroxene than H [4].

Enrichment in F (i.e., F/Nd) in the EM1 and EM2 OIBs from Pitcairn and Samoa is equivocal [2,5]. In contrast, melt inclusions from Mangaia HIMU basalts have high F/Nd (~30) as a group relative to the average MORB value (~21) [1,6], which is best explained by the efficient transfer of F to the mantle by F-bearing minerals such as amphibole, serpentinite, mica, and clinohumite in subducted slabs [7]. Detecting Cl enrichment is not always straightforward because shallow-level magma assimilation with seawater, brines, and altered oceanic crust easily alter the Cl composition [8]. Submarine glasses from Pitcairn and Society exhibit decreasing Cl/K with increasing ⁸⁷Sr/⁸⁶Sr [2]. Such covariation precludes assimilation as the principal cause of Cl/K variation, and therefore low Cl/K is the source feature of EM1 and EM2. Chlorine loss from subducted components due to fluid release or hydrous melt extraction accounts for low Cl/K. In contrast, HIMU OIBs show increase of Cl/K and Cl/Nb along with decreasing ²⁰⁷Pb/²⁰⁶Pb (more robust HIMU signature from ancient altered oceanic crust) as observed in olivine-hosted melt inclusions in Raivavae basalts from Austral Islands [9]. Because such correlation is not ascribed to shallow-level assimilation, this fact requires a mechanism to return Cl from the hydrosphere to the HIMU mantle source via altered oceanic crust against subduction dehydration. Although Cl-hosting minerals beyond the sub-arc depth have not been thus far identified, the lattice defects in major minerals or mineral grain boundaries may be a carrier of small amounts of Cl in subducted oceanic crust. Subduction of altered oceanic crust would transfer Cl from seawater to the deep mantle, forming Cl-rich HIMU mantle reservoir in the deep mantle.

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