Fluid flows in the mantle inferred from "mantle He"

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On the basis of extensive compilation of recent high quality He isotopic data on mantle-derived materials, we conclude that there exists pertinent fluid flow from the deeper region in the mantle to the shallower region. Assuming the He content in inclusions in diamonds (He4 = 10^-3 ccSTP/g) for mantle fluid, we can estimate a total flux of mantle fluid to be about 3 x 10^15 grams/a.

Extensive compilation of recent high quality noble gas data on mantle-derived materials revealed several interesting characteristics of mantle noble gases which have escaped our attention or even contradict our commonly held views (1,2). Especially, the data on elemental and isotopic compositions of He observed in MORB and OIB (hereafter we call mantle He) impose important constraints on mantle dynamics. These studies showed that mantle He is totally decoupled from the heavier noble gases, and the elemental abundance of He is complementary between MORB and OIB, that is, He is excess in MORB, but deficient in OIB. Moreover, as has been pointed out by many authors, mantle He is characterized by its enormous uniformity in isotopic composition. We propose that all these characteristic features of mantle He is most reasonably explained by assuming migration of mantle fluids, which transported He from the deeper region in the mantle or OIB mantle source region to the upper mantle or MORB mantle source.

Existence of fluids (mantle fluid) in the mantle has been concluded from common occurrence of fluid inclusions in coated diamonds from wide localities (3). Decomposition of subducted hydrate minerals would be responsible to the pertinent water in the mantle. The recent experimental study of dihedral angle of olivines under mantle conditions further suggests upward migration of fluid in the mantle (4). All these empirical observations are consistent with the upward migration of mantle fluid, which we suggested from mantle He characteristics. Assuming the He content in inclusions in diamonds (He4 = 10^-3 ccSTP/g) for mantle fluid, we can estimate a total flux of mantle fluid to be about 3 x 10^15 grams/a. The value is very favorably compared with the degassing flux of water from the mantle estimated from the production rate of ocean floor (5) and with subducted water flux into the mantle (6).

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