Petrological evidence for deep lower mantle melting

CLAUDE HERZBERG

Department of Earth and Planetary Sciences, Rutgers University, Piscataway, NJ, U.S.A. (herzberg@rci.rutgers.edu)

Olivine phenocrysts in picrites from Baffin Island and West Greenland (BIWG) have elevated Ni contents consistent with derivation from a Ni-rich peridotite source [1]. Interaction of a silicate melt with the core may have provided the excess Ni [1]. Partial melting is consistent with experimental results on the solidus of peridotite near the core-mantle boundary [2]. Ni/Co in BIWG lavas and olivine phenocryst are also higher than those in MORB, consistent with experiments on liquid silicate/metal systems that show the effect of pressure is to make Ni more lithophile than Co [3]. But experiments at pressures near the core-mantle boundary are needed to confirm or falsify this conjecture. Also, the provenance of metal melt that supplies Ni may not be restricted to the core. Late accretion of dense metal-bearing chondritic bodies at subsonic velocites may have settled as piles on the core-mantle boundary [4].

Olivine phenocrysts in Hawaiian shield lavas have even higher Ni contents than those from BIWG [5]. Ni contents can be elevated by reaction of peridotite with either basaltic crust or partial melts of basaltic crust to make a second stage pyroxenite source. Petrological modeling indicates that the Hawaiian peridotite end-member is likely to be Ni-rich, not MORB-like, similar to BIWG. This petrological evidence supports the presence of partial melt at the base of the Hawaiian mantle plume.

Ultra low velocity zones (ULVZs) may originate by partial melting [6] and appear to be irregularly distributed at the boundaries of large low shear velocity provinces (LLSVPs) [7] which are also the proposed sites of mantle plume generation for both LIPS and ocean islands [8]. ULVZs have been located below BIWG and Hawaii [7,9], consistent with petrological inferences of partial melt.

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Calcium isotope fractionation in vertebrates

A. HEUSER[1]*, A. EISENHAUER[2], K. SCHOLZ-AHRENS[3] AND J. SCHREZENMEIR

[1]Steinmann-Institut, Universität Bonn, Bonn, Germany (*correspondence: aheuser@uni-bonn.de)

[2]GEOMAR, Helmholtz-Zentrum für Ozeanforschung Kiel, Germany

[3]Max Rubner-Institut, Bundesforschungsinstitut für Ernährung und Lebensmittel, Kiel, Germany

Earlier investigations showed that there is considerable biological fractionation of Ca isotopes in vertebrates. Consequently it was suggested that Ca isotope fractionation may be applied as a diagnostic tool for the detection of Ca metablic malfunctions like osteomalacia or osteoporosis. In order to further investigate Ca isotope fractionation in vertebrates, we analyzed the Ca isotopic composition ($\delta^{44/40}$Ca) of diet, feces, blood, bones and urine of Göttingen miniature pigs from an animal trial. Samples of three different groups were investigated: 1. Control group (Con), 2. Glucocorticosteroid induced osteoporosis group (GIO) and 3. Calcium and vitamin D deficiency induced osteomalacia group (-CaD).

While $\delta^{44/40}Ca_{diet}$ values are in average 0.42±0.07 ‰ the observed Ca isotope variations in feces, bones, blood and urine is significantly higher. $\delta^{44/40}$Ca values vary in total by 3.28 ‰ ranging from –0.54 ‰ (feces) up to 2.74 ‰ (urine). It is not possible to distinguish the three groups solely based on $\delta^{44/40}Ca_{urine}$, $\delta^{44/40}Ca_{bone}$ or $\delta^{44/40}Ca_{blood}$ values only. In contrast, group –CaD is clearly marked by their low $\delta^{44/40}Ca_{feces}$ values. Average $\delta^{44/40}Ca_{feces}$ of group –CaD is–0.27 ‰ while it is 0.39 ‰ and 0.28 ‰ for groups Con and GIO, respectively.

The $\delta^{44/40}Ca_{feces}$ represents the unabsorbed fraction of dietary Ca and thus can be used to identify Ca fractionation during intestinal absorption. The $\delta^{44/40}Ca_{feces}$ values of –CaD are lighter than corresponding $\delta^{44/40}Ca_{diet}$ by ~0.6 ‰ which indicates that Ca isotopes are fractionated during intestinal absorption. In contrast, group Con and GIO $\delta^{44/40}Ca_{feces}$ values do not indicate Ca fractionation during intestinal absorption. Observed $\delta^{44/40}Ca_{feces}$ values of group–CaD may be caused by either the addition of isotopically light Ca from intestinal fluids or fixation of light Ca isotopes in unmetabolizable compounds like Ca oxalates or Ca phytates.

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