American Mineralogist, Volume 100, pages 2066–2081, 2015

SPECIAL COLLECTION: MANTLE PLUMES: SOURCES, DYNAMICS, AND VOLCANIC EXPRESSION

Oceanic lavas sampling the high-^{3}He/^{4}He mantle reservoir: Primitive, depleted, or re-enriched?†

Gordana Garapić[1,2,*], Ananya Mallik[3], Rajdeep Dasgupta[3] and Matthew G. Jackson[2]

[1]Geology Department, State University of New York New Paltz, New Paltz, New York 12561, U.S.A.
[2]Department of Earth Science, University of California, Santa Barbara, California 93106, U.S.A.
[3]Department of Earth Science, Rice University, Houston, Texas 77005, U.S.A.

Abstract

Helium isotopes are used as a tracer for primitive reservoirs that have persisted in the Earth's mantle. Basalts erupted at several intraplate oceanic islands, including Hawaii, Iceland, Galapagos, and Samoa, have hosted the highest ^{3}He/^{4}He ratios (>30 Ra, where Ra is atmospheric ^{3}He/^{4}He ratio) globally that are far in excess of the ^{3}He/^{4}He typical of the upper mantle sampled at mid-ocean ridges (8 Ra). These lavas have been suggested to be melts of a primitive, or possibly slightly depleted, mantle reservoir, i.e., either fertile or a depleted peridotite. Here we report evidence for geochemical enrichment in the high-^{3}He/^{4}He mantle sampled by lavas with the highest ^{3}He/^{4}He from Hawaii, Samoa, and possibly Galapagos. The titanium concentrations in high-^{3}He/^{4}He lavas from Samoa are too high to be explained by melts of a mantle peridotite, even at infinitesimally small degrees of melting, and the elevated Ti corresponds to elevated Pb-isotopic ratios. The highest ^{3}He/^{4}He lavas from Loihi, Hawaii, also have Ti concentrations that are too high to be melts of primitive mantle peridotite at the degrees of melt extraction proposed for this ocean island. Thus, Ti-rich material must have been added to the high-^{3}He/^{4}He mantle reservoir, and this material is likely to be recycled mafic crust similar to MORB-like eclogite, which is consistent with the elevated Pb-isotopic ratios. We show that fractionation corrected, major element compositions of high-^{3}He/^{4}He alkalic lavas can be satisfactorily modeled by melting and melt-rock interaction scenario in a fertile peridotite-MORB-eclogite hybrid system. Primitive peridotitic and recycled eclogitic reservoirs are suggested to be intimately associated in the deepest mantle and high-^{3}He/^{4}He lavas from several localities may sample a mantle source that hosts a component of recycled oceanic crust.

Keywords: Intraplate volcanism, ocean island basalts, high-^{3}He/^{4}He mantle reservoir, peridotite, MORB-eclogite, recycled crust