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Geochemical constraints for the origin of the HIMU source mantle from the Polynesian ocean island basalts

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One of the major issues of mantle geochemistry is to decipher heterogeneous nature of the mantle through the studies of the ocean island basalts (OIBs) related with upwelling of hot mantle plumes. In this study, we focus on OIBs from French Polynesia, with unique geochemical characteristics referred to as HIMU. Combined Pb-Sr-Nd-Hf-Os-He isotope analyses using mineral separates provide reliable isotopic information of the basalt source. HIMU source mantle has high Pb isotope ratios (206Pb/204Pb > 21.5), low Nd isotope ratios (epsilon Nd < +4), low Hf isotope ratios (epsilon Hf < +3), low He isotope ratios (3He/4He < 6 Ra), and moderately high Os isotope ratios (187Os/188Os = 0.14-0.15). Low He isotope ratios are consistent with involving recycled materials, most probably, the oceanic crust in the source. However, moderately high Os isotope ratios suggest that HIMU source is not a recycled oceanic crust itself, but a metasomatised mantle by subducted oceanic crust-derived melt. Such the metasomatism can occur at various settings in the recycling process. These would include (a) wedge mantle metasomatism beneath subduction zones by melting of the oceanic plate slab, (b) metasomatism of the upper mantle by melting of stagnant slab, (c) metasomatism of the lower mantle by melting of deep slab near core-mantle boundary, and (d) metasoamtism of mantle peridotite by adiabatic melting of the recycling materials in the upwelling plume. Time-integrated isotopic growth over Giga years is requisite to form the present HIMU source. Such the ancient HIMU source should have particular parent-daughter element fractionation in Sm/Nd, Lu/Hf and U/Pb deduced from the present day Nd, Hf and Pb isotopes. These would constrain when and where the oceanic crust melt metasomatism occurred. We demonstrate a possibility that melting of the oceanic crust in the lower mantle at 2-3 Ga leaving Mg-perovskite as the residual phase adequately fractionates these parent-daughter element ratios. If this is the case, the oceanic crust was subducted and melted to metasomatize the lower mantle to generate HIMU source.

Keywords: slab subduction, mantle endmember, HIMU, isotope, recycling