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The utility of whole-rock Fe isotopic compositions as mantle source and process tracers in Hawaiian shield stage lavas

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We present a comprehensive and large-scale overview of Fe isotopic compositions along the Hawaiian archipelago, including the first Fe isotope data for Kaua‘i, West Ka‘ena, Wai‘anae, Lāna‘i, West Maui, Haleakalā (including Hāna Ridge), Kohala, Hualālai, and Mauna Kea volcanoes. Hawai‘i is an excellent natural laboratory for assessing newer isotopic methods as it is well-studied and thoroughly geochemically characterized. By combining Fe isotopic data with an extensive compilation of Hawaiian shield stage major element, trace element, and radiogenic isotopic data, our aim is to 1) investigate whole-rock Fe isotope ratios as records of primary and secondary igneous processes in Hawai‘i, and 2) test the use of stable Fe isotope ratios as a tool to identify mantle heterogeneities in the source of Hawaiian volcanoes, including whether the isotopically distinct Hawaiian geochemical trends are also distinct in Fe isotopic compositions.

We analyzed 42 carefully selected samples of shield-stage tholeiitic basalt from 14 subaerial and submarine volcanoes representative of ~5 Ma of volcanic activity along the Hawaiian chain. Iron isotope results reported to IRMM-14 vary widely from a δ^{56}Fe (±2SD) of 0.08 (±0.06‰) to 0.33 (±0.09‰). The data corrected for olivine fractionation show a similar range, and the mean δ^{56}Fe of the new data (0.15‰) is within error of the average MORB value (0.10‰). We assess whether outlier isotopic values obtained for several samples result from primary (e.g., Fe-Ti oxide crystallization) or secondary (e.g., seawater and subaerial alteration) processes. Observations include that 1) there is no statistical difference in δ^{56}Fe values between Loa, Kea, and Enriched Loa geochemical groups and 2) δ^{56}Fe and lithophile radiogenic isotopes (Pb, Sr, Nd, Hf) show no correlations. This suggests that the mantle heterogeneities contributing unique radiogenic isotopic signatures to the Hawaiian geochemical groups do not have distinct Fe isotopic compositions and that their lithological nature (e.g., peridotite vs. pyroxenite) cannot be constrained using δ^{56}Fe. Alternatively, if the deep mantle reservoirs sampled by the Hawaiian plume are distinct in Fe isotopic compositions, these signatures are not retained from source to surface and/or have been attenuated by the presence of other recycled materials in the Hawaiian plume.