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Large Mg and Fe isotopic variations in Hawaiian olivines

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To better constrain and understand the Fe and Mg isotopic variations in Hawaiian olivines, we measured the Fe and Mg isotopic compositions in bulk olivines from two shield volcanoes (Mauna Kea and Kahoolawe) and one postshield stage volcano (Niihau). Combined with published data from Kilauea and Koolau (both at shield stage) and Loihi (preshield), the $\delta^{56}Fe_{IRMM-014}$ in 108 Hawaiian olivines range from -1.71 to +0.49, and $\delta^{26}Mg_{DSM-3}$ from -0.40 to +0.36, much larger than those in MORBs and OIBs ($\delta^{56}Fe_{IRMM-014}$ = +0.07 to +0.14; $\delta^{26}Mg_{DSM-3}$ = -0.25 ± 0.07). The Hawaiian olivine $\delta^{56}Fe$ and $\delta^{26}Mg$ represent the largest Fe-Mg isotope variations ever observed in natural olivines, and show a remarkably linear, negative correlation. The largest Fe-Mg isotope effects ($\delta^{56}Fe_{IRMM-014}$ = -1.71, $\delta^{26}Mg_{DSM-3}$ = +0.36) are observed in postshield stage Niihau olivines. Such large and negatively correlated Fe-Mg isotope effects are best explained as kinetic isotope effect produced by chemical diffusion in olivines during melt-olivine reaction in magma chambers. We use a Monte Carlo technique to constrain the magma chamber residence times to be on the weekly to annual timescales at preshield and shield stages. The times for postshield olivines are on the annual to decadal timescales, which are consistent with a decrease in magma production during this stage.