Magnesium isotopic constraints on alkalic basalt evolution: A case study at Mauna Kea, Hawaii

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Mauna Kea volcano at Hawaii is one of the best-studied ocean islands, with well documented geochemical variations throughout its eruptive history. Significant changes occur during the transition from shield building tholeiitic lavas to post-shield stage alkalic lavas. At Mauna Kea, magma chambers deepen, magma supply drops, and pyroxenite-rich cumulates form. These alkalic lavas have phenocrysts of olivine and plagioclase, while clinopyroxene and Fe-Ti oxide minerals such as ilmenite and magnetite exist in the groundmass. Mg is a major element in these igneous minerals, with ilmenite and magnetite crystallized when the melt has low MgO content. At high temperatures, stable isotope fractionation is primarily controlled by temperature and ion-oxygen bond strength in crystal lattices. Ab initio calculations and measurements of peridotites and cumulates show that ilmenite and magnetite are characterized by different Mg isotopic signatures compared to silicate minerals, such as olivine and clinopyroxene. In detail, ilmenite is heavier and magnetite is lighter when compared to the typical mantle value (-0.25‰ ± 0.07‰), with calculated ilmenite δ^{26}Mg = 0.05‰ to -0.05‰ and magnetite = -0.35‰ to -0.38‰.

Our data on Mauna Kea lavas show that at MgO > 8%, Mauna Kea shield stage lavas have relative homogeneous, mantle-like δ^{26}Mg (-0.25‰ ± 0.05‰, n = 70). At MgO < 8% when magma compositions are controlled by multiple-phase fractionation including magnetite and ilmenite, δ^{26}Mg in Mauna Kea lavas vary to both heavier (-0.1‰) and lighter (-0.4‰) values. At Mauna Kea, δ^{26}Mg does not correlate with radiogenic isotopic compositions, or trace elemental ratios that are controlled by partial melting. Instead, the Mg isotopic variation likely results from crystal fractionation, especially ilmenite and magnetite, from the shield to post shield stage of Mauna Kea volcano, which will be moded by using thermodynamic modeling (MELTS).