Depleted rejuvenated-stage source component in Hawaiian shield-stage lavas

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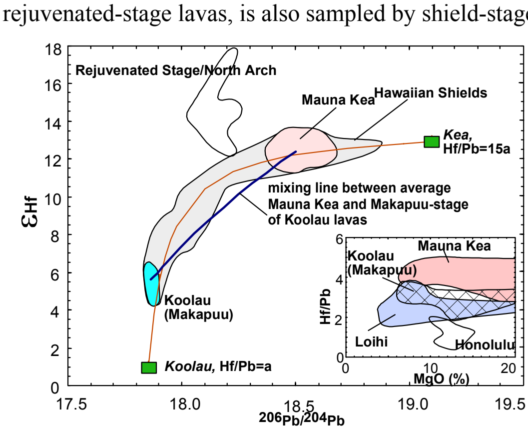
As a well-defined hotspot track the Hawaiian Ridge-Emperor Seamount Chain plays an important role in our understanding of mantle plumes. Geochemical studies on Hawaiian shield-stage lavas indicate considerable heterogeneity in radiogenic isotopic ratios, implying a heterogeneous Hawaiian plume. Specifically, among Hawaiian shield-stage lavas, lavas from the surface of Koolau (Makapuu-stage) have the highest $^{87}Sr/^{86}Sr$, La/Nb and SiO_2 content, and the lowest $^{143}Nd/^{144}Nd$, $^{176}Hf/^{177}Hf$, $^{206}Pb/^{204}Pb$, Th/La and total iron content. Lavas from Loihi are characterized by the highest $^{3}He/^{4}He$. Lavas from Mauna Kea are characterized by the lowest $^{87}Sr/^{86}Sr$ and highest $^{143}Nd/^{144}Nd$, ε_{Hf} and Pb isotopic ratios. Other Hawaiian shield-stage lavas can be explained by variable mixing proportions of these three components (Koolau, Mauna Kea and Loihi). Despite substantial isotopic variations in Hawaiian shield-stage lavas, they have similar trace element ratios such as Hf/Pb (see inset in figure). Consequently, we infer that mixing lines among different source components for Hawaiian shield lavas are near-linear. This inference contrasts with the hyperbolic trend of $^{206}Pb/^{204}Pb$-ε_{Hf} which requires a factor of 15 difference in Hf/Pb for two-component mixing (see figure). A possible explanation could be that an additional source component, similar to that manifested in Hawaiian rejuvenated-stage lavas, is also sampled by shield-stage lavas.



Implications of mantle Fe/Mn for mantle plumes

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Abundances of Fe and Si control the density of the mantle, and thereby the compositionly driven aspects of mantle dynamics. Since elemental abundances in mantle-derived lavas are influenced by many factors, including source composition, degree of melting, etc., elemental ratios of lavas are better indicators of source composition. The Fe/Mn ratio is a planetary constant, published value= 60±20 (2σ), in both mantle peridotites and in lavas. Compositional variations of X_{Fe} ~0.01 (10% change in FeO or 1% change in Mg#) are important in thermochemical convection in the mantle, but have not been recognized in existing geochemical data, probably due to analytical noise (~ ±30%). We have determined the Fe/Mn ratio with higher precision (±0.5%) by magnetic sector ICP-MS. The procedure used at NHMFL determines the ratio $^{54}Fe^{+}/^{55}Mn^{+}$, and converts this to Fe/Mn ratio by comparison against gravimetrically prepared standards. We report new analyses of Kilbourne Hole mantle xenoliths spanning the MgO=38-49% range. We show that there is a systematic increase in the Fe/Mn ratio (61-74) with increasing MgO (melt depletion), which is more restricted than the 60±20 range in the literature. The Fe/Mn ratio in the primitive mantle (PM) is estimated to be $(Fe/Mn)_{PM}$=60.7±1.5 (2σ) at MgO=37.8%, an improvement in precision of an order of magnitude. This implies that the fractionation factor of Fe/Mn upon melting to form MORBs (Fe/Mn~57) is ~0.94. Since olivine modal abundance increases at higher MgO in peridotites, the fractionation factor of Fe/Mn increases such that melts derived from refractory peridotites should still have Fe/Mn~60. Thus, the Fe/Mn ratio of extracted melt is not sensitive to the fertility of the source. Then, the major factors controlling the Fe/Mn of primitive melts are source variations of Fe/Mg and the source olivine/orthopyroxene ratio. Since the olivine/opx ratio is dependent on Mg/Si of the mantle source, Fe/Mn is incidentally sensitive to both Fe and Si variations in the source. Increased Fe/Mn reflects both higher FeO or higher Si in the source. Hawaiian lavas exhibit a uniformly high Fe/Mn of 67, indicating that the source of Hawaii has ~15% more FeO, or <15% olivine.