

Major element variations of Hawaiian parental magmas: Mantle source or melting control?

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The abundances of the major element oxides (SiO_2 , TiO_2 , Fe_2O_3 , MnO , MgO , CaO , NaO_2 , K_2O , P_2O_5) in Hawaiian lavas are subject to change due to variation in (1) the amount of crystal fractionation or accumulation or (2) the pressure (depth) and degree of partial melting of the mantle, and (3) differences in the composition of the mantle source. Since isotope ratios (e.g. $^{206}\text{Pb}/^{204}\text{Pb}$ or $^{87}\text{Sr}/^{86}\text{Sr}$) are not subject to the effects of crystal fractionation or partial melting, they are thought to be good indicators of the mantle source composition. Literature data shows that there is a correlation between the isotope ratios and major elements abundances of Hawaiian lavas when the latter are corrected for the effects of crystal fractionation. This suggests a relationship between the major element chemistry and the mantle source composition. However, another possibility is that the variations are related to changes in the depth of melting. Hawaiian volcanoes been categorized into two main geographic trends: the northeastern Kea trend (named after Mauna Kea) and the southwestern Loa trend (named after Mauna Loa). In this study, I summarized major element data for both Kea and Loa lavas from the scientific literature. The Kea trend lavas include Mauna Kea and Kilauea and the Loa trend lavas include Mauna Loa, Koolau, and Kahoolawe. Prior to this study, Loihi lavas were grouped with the Loa trend (based on geography), but I found that their chemistry is actually more similar to the Kea trend. To correct for the effect of crystal fractionation and accumulation, sample data were adjusted to a constant MgO value. This was achieved by running the data through a computer program which added or subtracted small increments of equilibrium olivine to each sample composition until 13 wt. % MgO was reached. My results show that there are significant variations in the major elements chemistry between Kilauea, Kahoolawe, Mauna Kea, Mauna Loa and Loihi lavas. The Kea trend lavas are relatively low in SiO_2 and abundant in CaO. The Loa trend lavas have higher SiO_2 and lower CaO. Some of the most significant variations are a range greater than 3% in both SiO_2 and CaO. A 2% range in SiO_2 can possibly be explained by variations in the pressure (depth) of melting. However, these same pressure differences cannot explain the 3% variation in CaO. Thus, these major elements variations are better explained by differences in the mantle source composition of these volcanoes. The lower SiO_2 and higher CaO lavas are consistent with melting mantle peridotite, whereas the higher SiO_2 and lower CaO lavas are not. These lavas are likely formed by melting of pyroxenite derived from ancient, recycled oceanic crust within the Hawaiian mantle plume.