Long geochemical streaks in the Hawaiian plume

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We report the radiogenic isotopic and trace element compositions of a suite of Mauna Kea shield stage tholeiites, which are characterized by high CaO content at a given MgO content. Mauna Kea high-CaO tholieiites, with a modal age of ~0.5 Ma, have the same isotopic compositions as the highly alkalic lavas erupted during Hawaiian secondary volcanism, including on-island rejuvenated stage lavas and offshore Hawaiian arch lavas, whose ages range from <0.1 to 2.5 Ma. In detail, high-precision Pb isotopic data show that Mauna Kea high-CaO tholieiites fall on the same $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ trends as those defined by lavas and high-pressure pyroxenite cumulates associated with the 0.1-0.8 Ma rejuvenated stage Honolulu Volcanics on Oahu. Our trace element modeling show that Mauna Kea high-CaO tholieiites can be explained as higher degree partial melts of the mantle sources that contributed to Hawaiian secondary volcanism. That is, our isotopic and trace element data show that Mauna Kea shield stage high-CaO tholieiites and Hawaiian secondary volcanism sample the same isotopically depleted mantle sources at almost the same time. At Mauna Kea, these isotopically depleted mantle sources melted to larger degrees to produce the high-CaO tholeiites, and they melted to smaller degrees during Hawaiian secondary volcanism to produce the highly alkalic lavas.

We propose that the Hawaiian mantle plume consists of enriched shield stage components embedded as ‘plums’ inside a refractory matrix that is the source of the isotopically depleted secondary volcanism lavas. These isotopically depleted refractory components are typically not sampled during shield stage volcanism, and they are sampled during the secondary volcanism caused by the flexural arch decompression melting. In the case of Mauna Kea high-CaO tholeiites, it is possible that the portion of the plume that contributed to high-CaO lavas did not contain a significant amount of enriched shield components. That is, the mantle source of high-CaO tholeiites is dominated by the isotopically depleted components. It is also possible that these isotopically depleted source components occur as long compositional streaks, in the Hawaiian plume, i.e., the spaghetti model, so that they can be sampled simultaneously by Mauna Kea and Honolulu Volcanics. In this case, the length of the isotopically depleted streaks is over 300 km.