Temporal variation of Hawaiian plume composition: Evidence from Hana Ridge (Submarine Haleakala Volcano), Hawaii

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The mantle source generating the Hawaiian Islands is chemically heterogeneous from volcano to volcano as is well documented in numerous studies. Moreover, growing evidence suggests that the source also varies over time within a single volcano [*Takahashi and Nakajima*, 2002; *Tanaka et al.*, 2002]. New data from the submarine shield stage of Haleakala volcano on Maui also suggest temporal variation of the Hawaiian plume source and contribute to new ideas on the structure, geometry, and composition of the plume itself.

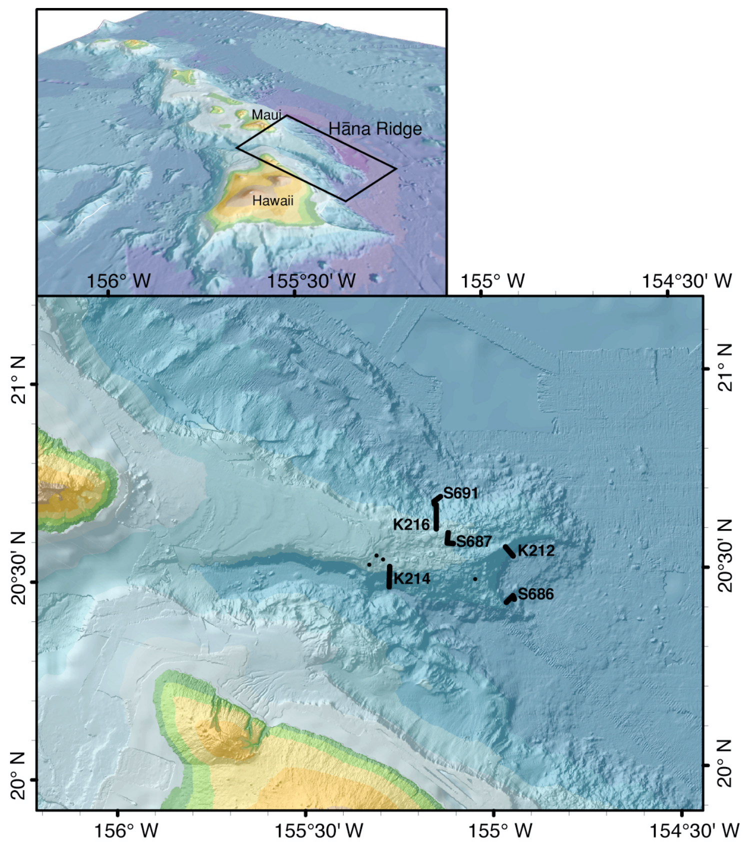

Figure 1. Perspective view of the Hawaiian Islands (top) showing the location and relative size of the Hāna Ridge. Hāna Ridge is shown (bottom) along with existing dredge sites (small dots; Moore et al., 1990) and JAMSTEC dive sites (Kxxx - ROV *Kaiko*, Sxxx - *Shinkai 6500*). Broad, smooth area uprift of sample sites is drowned coral reef.

Hana Ridge is the submarine portion of the east rift zone of Haleakala Volcano, Hawaii. At 140 km long, Hana Ridge is the longest submarine rift zone in the Hawaiian Island chain and has developed a complex morphology compared to other Hawaiian rift zones, such as Puna Ridge. The main ridge comprises three subparallel ridges related to distinct accretionary periods within the shield-building phase of Haleakala volcano. In order to investigate the variability of Hawaiian plume compositions over time and the geochemical evolution of Haleakala shield-building, we sampled several sections of Hana Ridge on six dives with ROV *Kaiko* and *Shinkai 6500* submersible, both operated by JAMSTEC, in 2001 and 2002 [*Johnson et al.*, 2002] (Figure 1).

All recovered rocks are tholeiitic basalts and more than half of them, those obtained in the deeper portions of the ridge, are picrites. This contrasts with the transitional to alkalic compositions from the subaerial shield stage of Haleakala (Honomanu stage) sparsely exposed in isolated outcrops [*Chen et al.*, 1991]. Major and trace elements of the submarine Hana ridge rocks are similar to modern Kilauea and unlike subaerial Haleakala shield lavas. Each of the three subparallel ridges has a distinct trace element and rare earth element signature and their variations are geochemically self-consistent. This distinction carries over to radiogenic isotope compositions as well. The chemical variations defined by the sub-ridges plot within the general field for Kilauea lavas, but show consistent trends in trace element and isotope space from strongly "Kilauea-like" to transitional with "Mauna Loa-like" compositions; all subaerial Honomanu shield lavas plot within the Mauna Loa trace element and isotope fields (Figure 2).

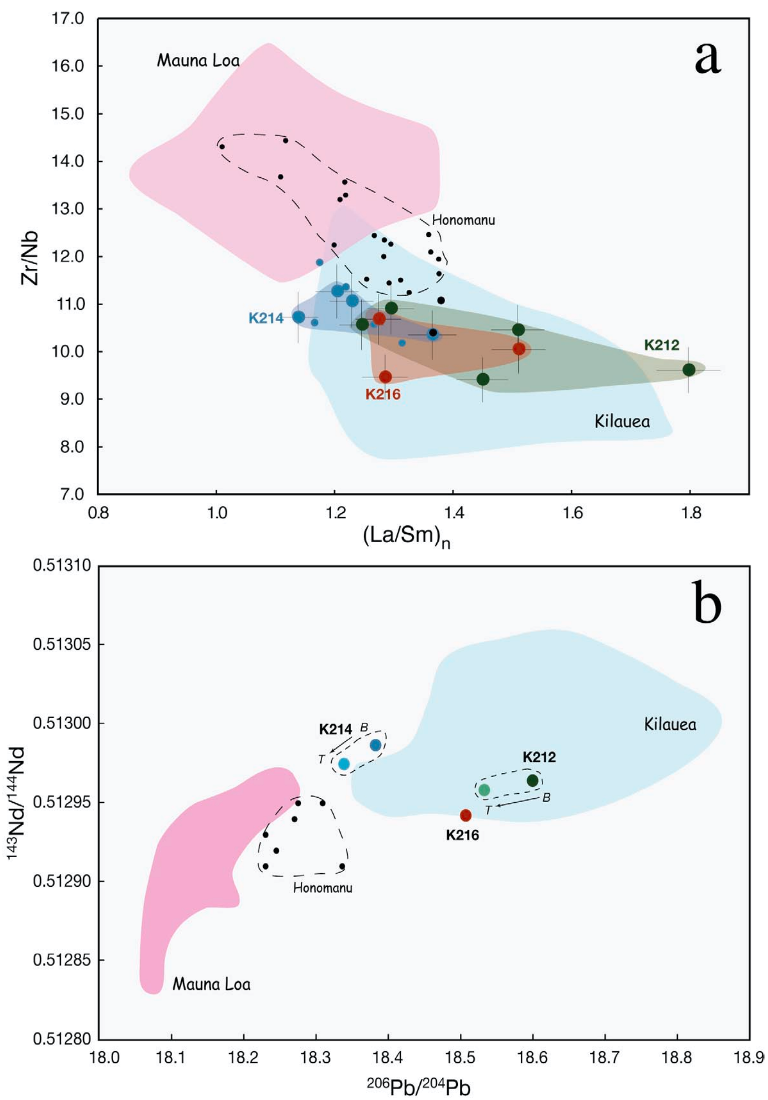

Figure 2. Variation diagrams for trace elements and isotopes in Hāna Ridge samples analyzed to date [*Johnson et al.*, 2002]. Fields for Kīlauea and Mauna Loa are well separated in these plots. The Hāna Ridge $(La/Sm)_n$-Zr/Nb (a) and Nd-Pb isotope (b) data plot within the field for Kīlauea basalts, while the Honomanū data (subaerial Haleakalā) extend strongly into the Mauna Loa field. The clustering and relative positions of data points are consistent in both plots. *B* and *T* indicate bottom and top of dive track.

Our results indicate that the mantle plume source for the Haleakala shield has changed over time from Kilauea-like compositions (high La/Sm, low Zr/Nb) in the submarine lavas to Mauna Loa-like compositions (lower La/Sm, higher Zr/Nb) in the subaerial Honomanu shield lavas. Moreover, the subparallel ridges comprising the greater Hana Ridge show a trend from higher to lower La/Sm and $^{206}Pb/^{204}Pb$ with location. We infer that Haleakala shield volcano originally had tholeiite magma compositions whose source material was similar to present-day Kilauea volcano and that the magma source became more Mauna Loa-like during growth of Haleakala volcano. Whether this temporal variation is consistent with that observed at Koʻolau volcano [*Tanaka et al.*, 2002] awaits further analysis. It is hoped that the data from this study, coupled with work on other Hawaiian shields, can improve our understanding of the structure and melting processes of the Hawaiian plume.

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