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A noble gas study of rift zone volcanism and magma evolution at Haleakala Volcano, Hawaii

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Noble gas isotope ratios were determined for submarine basalts from the rift zone of the Haleakala Volcano (Hana Ridge) in order to constrain the mantle plume magma sources and investigate sequential changes in the magma during formation of the rift zone. The rift zone forms an elongated ridge extending ∼200km from the centre volcano, Haleakala, with a relative height of 2000m. Rock samples were collected from six sites on the flank of the ridge by the submersibles Kaiko and Shinkai during JAMSTEC scientific cruises in 2001-2002. For noble gas analyses, olivine-rich basalts were selected and olivines were separated by handpicking. Noble gases were extracted from olivine samples by in-vacuo crushing. He, Ne, Ar and Xe isotopes were analysed using a sector-type mass spectrometer.

Samples from the lower part of the ridge have $^{3}He/^{4}He$ ratios between 18 and 23Ra (1Ra; atmospheric ratio). In contrast, samples from the upper part of the ridge have 3He/4He ratios between 13 and 15 Ra, comparable to the values observed for subaerial Haleakala lavas.

The $^{3}He/^{4}He$ ratios of Hawaiian magmas generally decrease as the volcanic stages proceed from the pre-shield stage (20-35Ra) toward the post-shield stage (about 8Ra). The relatively high $^{3}He/^{4}He$ ratios of the samples from the deeper part of the Hana Ridge thus demonstrate that the magma building the base of the ridge was derived from a mantle source with a strong plume signature. This also suggests that volcanic activity along the ridge started during the early stage of Haleakala volcanic activity. The ridge volcanism presumably lasted until shield volcanism terminated at the centre, as the upper part of the ridge has 3He/4He ratios as low as the late stage subaerial shield lavas, suggesting simultaneous establishment of the rift zone and the centre volcano

at Haleakala.