Rift zone magmatism at Puna and Hana Ridges, Hawai‘i

KEVIN T. M. JOHNSON[1], ZHONG-YUAN REN[2],
EIICHI TAKAHASHI[2]

[1]Department of Natural Sciences, Bishop Museum, Honolulu, Hawaii, USA (kjohnso2@hawaii.edu)
[2]Earth and Planetary Sciences, Tokyo Institute of Technology (ren@geo.titech.ac.jp), (etakahas@geo.titech.ac.jp)

Rift zones are fundamental components of Hawaiian volcanoes. They are zones of dike intrusion that are the principal conduits for subsurface magma transport from the magma reservoir and are the loci of along-axis eruptions.

Rift zones on Hawaiian volcanoes can be very long, with most of their length often extending below sea level. Numerous studies have focused on the volumetrically less important subaerial portions of rift zones, but few have looked in detail at the submarine portions. This talk focuses on two pronounced and well-developed submarine rift zones: Puna Ridge, the submarine East Rift Zone of Kilauea volcano (KERZ), Hawaii, and Hana Ridge, the submarine East Rift Zone of Haleakala volcano (HERZ), Maui. The 75-km-long Puna Ridge comprises 60% of the 125 km long KERZ. Hana Ridge, at 125 km long, comprises 86% of the 145 km HERZ. Because most of the length of these rift zones is below sea level, much of the chemical evolution of the shield-building stage of each volcano is recorded in the submarine rift zone lavas.

Puna Ridge lavas are tholeiitic. Most of the lavas contain phenocrysts of olivine, augite ± plagioclase, but some contain only olivine and are modal picrites. The lavas define fractionation trends similar to subaerial Kilauea lavas, with CaO concentrations peaking (@11.3 wt% CaO) at 7.0 wt% MgO, and Al_2O_3 concentrations peaking (@14.1 wt% Al_2O_3) at 6.3 wt% MgO. Several dredges collected on the south flank of Puna Ridge and at the deep, distal end of the ridge axis are enriched in Al_2O_3 and Cl relative to other axial lavas at similar Mg/(Mg+Fe). These liquids reached plagioclase saturation at higher Al_2O_3 concentrations, probably as a result of higher H_2O contents due to incorporation of either seawater or altered crust into the crystallizing magma.

Hana Ridge lavas are primarily tholeiitic with occasional transitional lavas. Hana Ridge is morphologically complex compared to Puna Ridge, with three subparallel ridges comprising the Hana Ridge system. The ages of these subridges differ based on sidescan sonar backscatter and hence they record different stages of shield growth. Lavas from the ridges differ in major and trace element and isotope composition, which reflect chemical changes in plume chemistry through time. In general, the chemistry of lavas from Hana Ridge evolve from Kilauea-like to Mauna Loa-like in terms of isotope and trace element compositions. This may reflect random compositional heterogeneity or a systematic compositional zonation within the plume.

Young volcanism from depleted source regions: A SNC paradox

JOHN H. JONES

SR, NASA/JSC, Houston, TX 77058;
jones2@ems.jsc.nasa.gov

Over the last two decades, there has been impressive documentation of young martian volcanism. As of this writing, there are 14 basaltic SNC meteorites with ages younger than 1 b.y. Of these, 10 are younger than 200 m.y. In addition, high-resolution imaging of the martian surface has identified volcanic terrains with ages of only 10-30 m.y., based on crater counts [1].

A robust heat source is a prerequisite for 4.5 b.y. of continued volcanism and only two such sources appear viable: (i) heating from below as the core cools/crystallizes; and (ii) internal heat from the decay of radioactive nuclides.

Geophysical models indicate that core cooling alone is insufficient to produce young volcanics. Without internal radioactive heating, volcanism on Mars should have ceased about 3.5 b.y. ago. Model calculations suggest that the minimum heat production needed to sustain whole mantle convection (and volcanism) over geologic time is ~1.6 X 10^{-9} μW/g [2] (present-day μW/g; ~0.5X CI).

But radioactive heating may also be problematical, because those shergottites that are believed to be isotopically most representative of the martian mantle are highly depleted in heat-producing elements. For example, the QUE94201 shergottite has an initial ^{87}Sr/^{86}Sr of 0.7013 and an initial ε(^{143}Nd) of +48 [3]. For comparison, the Earth's depleted upper mantle (MORB) has ^{87}Sr/^{86}Sr of ~0.702 and ε(^{143}Nd) of ~+12 [e.g., 4]. Based on ε(^{143}Nd), either the shergottite mantle is ~4X as depleted as the MORB mantle or it has been similarly depleted for 4X as long. Presumably, this depletion has also affected the incompatible heat-producing elements, K, U and Th. And, although the nakhlite mantle appears to be less depleted than the shergottite mantle, ε(^{143}Nd) indicates that even the nakhlite source is either 2X as depleted as MORB mantle or has been similarly depleted for twice as long [e.g., 5].

It is possible to construct an internally consistent model for heat production in the shergottite and nakhlite source regions. Calculated heat production rates are 1.6 X 10^{-9} and 0.6 X 10^{-9} μW/g for the nakhlite and shergottite mantles, respectively. The heat production calculated for the nakhlite source is serendipitously that which is required to produce recent volcanism. If the shergottite mantle lies above the nakhlite mantle and insulates it, the duration of volcanism may be extended.

References

[1] Hartmann W.K. and Neukum G. (2001) *Space Sci. Rev.* **96**, 165-194. [2] Kiefer W.S. (2002) In *Abstracts for Unmixing the SNC's Workshop*. #6006. LPI, Houston. [3] Borg L.E., et al. (1997) *Geochim. Cosmochim. Acta* **61**, 4915-4931. [4] BVSP (1981) *Basaltic Volcanism on the Terrestrial Planets*, p. 998. [5] Shih C.-Y., et al. (1999) *Met. Planet. Sci.* **34**, 647-655.