Geochemistry and morphology of submarine terraces from the southwestern Galápagos platform

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The southwestern margin of the Galápagos Platform consists of large, stepped submarine terraces between depths of 800 and 3500 m. The terraces form the foundation for the southwestern part of the archipelago and provide indications of how the Galapagos platform has developed over time. The terraces are topped by plateaus and bound on their upper and lower sides by steep escarpments. Scarps average ~300 m in height, with an average slope of ~24°. Distal edges of the terraces extend tens of kilometers from current volcanic centers. Young submarine lava flow fields to the west of Fernandina and Isabela Islands have dimensions similar to the terraces, and it is possible that the terraces are constructed by eruptions similar to those that produced the large flow fields. The stepped morphology and sinuous continuity of the platform edges suggest that the terraces reflect episodic volcanic construction that builds the archipelagic platform.

A comparison of trace element contents and Sr, Nd, Pb, and He isotopic ratios of basalts dredged from the terraces indicate that most terraces are chemically similar to subaerial lavas erupted from Sierra Negra volcano on Isabela Island. A few of the basalts resemble subaerial Volcán Cerro Azul compositions, and one sample is comparable to Floreana Island lavas. Basalts from a ridge that extends south from Floreana Island have a strong Sierra Negra signature, which is interpreted as an older phase of volcanism and provides evidence for compositional evolution at Floreana.

These findings suggest that volcanism in the southern Galápagos consists of three phases; 1: construction of terraces by voluminous eruptions with a Sierra Negra-like composition; 2: eruptive activity focuses to form shield volcanoes; 3: a rejuvenation phase, producing Floreana and related submarine lavas.

The depleted Galápagos mantle: Plume or upper mantle?

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Recently, researchers have hypothesized that the depleted sources at the Iceland, Hawaii, and now Galápagos hotspots are intrinsic parts of the mantle plumes and not the ambient upper mantle. This hypothesis is evaluated by comparing the compositions of two of the most depleted volcanoes in the Galápagos (Wolf on Isabela island and Genovesa) to MORB from the Galápagos Spreading Center (GSC).

Wolf volcano lavas have similar Nd, Sr, Pb, and Hf isotopic ratios to GSC lavas erupted 250 km east and 400 km west of the area of maximum plume influence. $^{208}Pb/^{204}Pb$ ratios of Wolf basalts are slightly lower (by 0.05 to 0.30) than those from the GSC with equivalent $^{143}Nd/^{144}Nd$ and $^{206}Pb/^{204}Pb$. Highly incompatible trace element ratios (e.g. Ba/La and Ba/Nb) are also identical between the two suites. Genovesa has Sr, Nd, Pb, and Hf isotopic ratios that are indistinguishable from GSC MORB erupted 700 to 800 km away from the peak of plume influence. Helium isotopic ratios are higher at Wolf volcano than anywhere along the GSC (average of 9.0 Ra vs. 5.9 to 8.6 Ra). A submarine sample from Genovesa is also higher than any measured lava from the GSC. This pattern is consistent with extreme incompatibility and preferential extraction of helium near the plume center, which has been attributed to multistage melting during the ascent of the Galapagos plume (Kurz and Geist, 1999). Major element compositions of Wolf volcano and Genovesa lavas indicate melt extraction from greater depths than GSC magmas. Wolf magmas have higher La/Sm, Nb/Zr, and K/Ti than GSC rocks, indicating lower extents of melting at Wolf. Nb-Zr-Y relationships between the three suites are consistent with differences in the extent of partial melting from a similar source.

These observations are consistent with derivation of Wolf, Genovesa, and the GSC magmas from the ambient mantle that has been contaminated with plume material. The differences in depth of melt extraction and degree of melting are attributed to progressively thicker lithospheric lids with distance from the GSC.