Miocene magmatic transition in the northern Basin and Range province, western United States

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In the northern Basin and Range province, a change from andesite-dacite-rhyolite to bimodal eruptions of basalt and rhyolite occurred about 20 million years ago. The earlier magmas are dominantly magnesian, alkali calcic andesite to rhyolite; no basaltic magma erupted. Silicic magmas ranged to high SiO_2 rhyolite but most of the rhyolites had low Fe/Mg, high Rb/Nb, and low Rb similar to volcanic arc granites. Beginning about 25 Ma, more mafic magmas started to appear. The oldest known true basalts erupted after about 20 Ma; they are silica-undersaturated and lack significant Nb anomalies. Other mafic magmas also erupted at this time, but most are too potassic to be true basalts and these potassic rocks have negative Nb anomalies. Gradually, the gap between mafic and silicic magmas widened. A-type rhyolites and granites first appeared about 21 Ma.

This sequence is probably the result of the progressive foundering of a shallowly dipping subducting slab that began in the Eocene. This produced widespread dehydration of the subducted lithosphere and generated voluminous arc-like magma which intruded, hydbridized, and differentiated in the crust to make the ignimbrite flareup. Compensating inflow of asthenospheric mantle beneath the Great Basin, along with the development of a transform boundary and lithospheric extension, resulted in decompression melting of asthenospheric and lithospheric mantle. A fraction of this mafic magma stagnated in the lower crust, then remelted and differentiated to create subalkaline and peralkaline silicic magmas of anorogenic affinity.

The Columbia River basalts

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We interpret the Columbia River basalts (CRBG) in terms of a mantle plume (17- 6 Ma) impinging on a long-lived intermontane zone of back-arc extension behind the Cascade subduction zone. Diversion of the plume head northwards against the thicker cratonic lithosphere to the east created an elongate dome within the thinner lithosphere of the accreted oceanic Blue Mountains province. N-S fissures at the base of the crust, enhanced by fractures along the dome, provided the outlet for mafic magma stored in large reservoirs at the base of the crust.

The huge volume of tholeiitic magma erupted through the Chief Joseph dike swarm (approximately 220,000 km^3 in 1.5 m.y.) was derived from an OIB-like mantle source. Variable degrees of fractional melting, crystal fractionation, lower crust assimilation, and magma mixing can be demonstrated for each CRBG formation using the chemical and isotopic data available.

Smaller and subsequent eruptions (Picture Gorge Basalt, the high alumina olivine tholeiites (HAOTs) and silicic volcanics along the Brothers Fault Zone) are a consequence of the expanding severed mantle plume head with increasing components from depleted mantle and lower crustal sources. Th severed plume tail, transgressed by the North American plate, formed the eruptions of the eastern Snake River Plain and the Yellowstone hot spot.