Revisiting the tectonomagmatic implications of Oregon Plateau basaltic volcanism

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Mid-Miocene volcanism on the Oregon Plateau initiated at ~16.5 Ma with the onset of the Steens flood basalt episode. The contemporaneous Columbia River flood basalts were emplaced to the north as part of this same regional episode. This period of substantial intraplate crustal formation and modification lasted up to 2.5 m.y. followed by volumetrically minor and geochemically distinct eruptions extending the age of Steens-Columbia River activity to ~11 Ma. These 16.5 to 11 Ma lavas and associated dikes typically are high-Fe basalts to basaltic andesites, although small volumes of little differentiated low-K, high-Al olivine tholeiite (HAOT) magma were erupted prior to 11 Ma. HAOT magmas dominate the Oregon Plateau basalt record from 11 Ma to the present, with aggregate volumes far less than those associated with the mid-Miocene flood basalt episode. The HAOT magma type is restricted to a relatively narrow latitudinal band across the Oregon Plateau, is encountered from west of the modern Cascade arc to the Yellowstone region, and intimately is associated with extension at the time of eruption. Combined elemental and Sr, Nd, Pb, O, and Os isotope data suggest that similar petrologic conditions but heterogeneous mantle reservoirs are responsible for HAOT magma generation and evolution. In the context of the above and of previously proposed regional tectonomagmatic models, the following important observations will be discussed: (1) At ~16.4 Ma HAOT and Steens magmas were erupted in close spatial association at the northern end of the Northern Nevada Rift, (2) In the southeastern portion of the Oregon Plateau, Steens basalt eruptive loci are widely distributed, do not define simple age patterns, and fringe a broad area defined as the Owyhee Plateau, (3) Chemically and isotopically diverse monogenetic basalt systems (11 to 0 Ma) characterize the Owyhee Plateau region and their isotopic characteristics are age dependent, and (4) Regardless of age, location, volume or bulk composition the 16.5 to 0 Ma Oregon Plateau basalts provide evidence of primary inputs from two to three geochemical reservoirs; depleted mantle (DMM), subduction modified DMM, and subcontinental lithospheric mantle.

Lithospheric vs. asthenospheric contributions to basaltic magmatism in the Snake River Plain - Yellowstone (SRPY) hot-spot track

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Volcanism along the SRPY hot-spot track comprises (1) early large-volume, age-progressive rhyolitic magmatism, and (2) later basaltic volcanism that emerged late in local rhyolite cycles and persisted intermittently across much of the province. Whereas the rhyolites appear to represent largely crustal melts, their formation requires a significant heat - presumably from even more voluminous mafic intrusions. Origin of the basalts, and the implied production rates and timing are enigmatic and bear on the validity of a mantle plume model as a driving mechanism.

Compositions. Although SRPY basalts are variably evolved, the most primitive slightly Fe-rich olivine basalts (up to 10% MgO, 150 ppm Ni, 200 ppm Cr; Mg# $\leq$ 60) are characterized by 'evolved' Sr-Nd-Pb isotopic compositions unlike those found in most oceanic settings. Also, sharp isotopic discontinuities along the northern and western boundaries of the SRP attest to involvement of distinct lithospheric source domains. And all analyzed basalts have REE patterns consistent with melting of shallow (spinel lherzolite) mantle. These features cannot generally be explained by crustal contamination. Rather, melting of aged (ca. 2.5 Ga) lithospheric mantle is implied. On the other hand, samples spanning the province have high $^3He/^4He$ values (Ra>11) that are characteristic of oceanic hot-spot basalts. Together these observations imply that heat and volatiles may originate in part from sublithospheric depths, but that melting dominantly occurred within an compositionally distinct lithospheric mantle keel.

Melt production. Significant and early melting of lower lithospheric mantle can result from Basin and Range style extension (cf. Harry & Leeman, 1995, JGR) if the mantle contains easily fusible (i.e., eclogitic or pyroxenitic) veins or 'impurities' or is hydrated by earlier subduction processes. However, this process must be augmented by additional heat inputs to account for anomalously high melt production in the SRPY province compared to adjacent regions. Heating from below by ascending plume-like asthenosphere is implied. Melting of the latter material could be repressed by presence of an initially thick (> 100 km) lithospheric lid.