The Yellowstone hotspot in space and time: Evidence from silicic volcanism

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We have compiled a record of over 165 explosive silicic eruptions from the Yellowstone hotspot ranging in age from 16 Ma to the Quaternary. Throughout the history of the hotspot, Nd and Hf isotopic ratios co-vary and span the range of most terrestrial samples, reflecting mixing of crustal and mantle sources, with the *minimum* mantle component in silicic magmas varying between 20 - 40%. Early silicic volcanism was contemporaneous with eruption of Columbia Plateau Basalts. Between 16-15 Ma, silicic centers were widely distributed across SE Oregon and N Nevada, and large eruptions were frequent with over 35 events preserved in the tephra record. Earliest erupted silicic magmas were hot (up to 1080 °C), relatively less evolved (high Fe), and have Nd isotopic ratios within the range of Columbia Plateau flood basalts. Dramatic shifts in epsilon Nd from +4 to -11 and epsilon Hf from +10 to –10 mark the west to east transit of the hotspot across the lithospheric boundary between accreted oceanic terrain and the Precambrian craton. The hotspot was centered on the boundary at 15.2 Ma. The duration of the transit constrains the cratonic lower crustal magma source to a diameter of ~60–80 km in contrast to broadly distributed sources to the west of the lithospheric boundary. The timing and distribution of explosive silicic volcanism is consistent with an upper mantle plume defined by a region of low velocity beneath Yellowstone that extends to the 660 km mantle discontinuity (Jordan et al., 2004). Early, broadly distributed silicic volcanism, contemporaneous with flood basalts is consistent with the arrival of a plume. After approximately 1 million years, the plume head may have been sheared off from its conduit by thicker Precambrian crust, resulting in a focused source of silicic volcanism from 15 Ma to the present.

Reference

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Patterns of rhyolitic volcanism along the track of the Yellowstone hotspot

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The track of the Yellowstone hotspot developed over the last 16 m.y., as a bimodal volcanic province in response to the SW movement of the North American (NA) plate over a melting anomaly. Volcanism, dominated by eruptions of explosive high-silica rhyolite, represents some of the largest eruptions known. Basaltic eruptions signal the final stages of volcanism and cap the voluminous rhyolite. Volcanism progressed from SW to NE in successive volcanic fields comprised of nested caldera complexes. Most caldera-forming eruptions within a field are separated by 0.2 to 1 m.y., similar to the present-day Yellowstone Plateau volcanic field. Volcanic fields may be separated in time and space by as much as 2 m.y. and 50-150 km from center to center. Passage of the NA plate over a melting anomaly resulted in uplift, regional tectonism, massive explosive eruptions and caldera subsidence followed by basaltic volcanism. Southwest of Yellowstone, the Heise volcanic field has four large-volume rhyolitic ignimbrites, constituting a time-stratigraphic framework of late Miocene to early Pliocene volcanism. Field relations and high-precision $^{40}Ar/^{39}Ar$ ages establish that these regional ignimbrites erupted from the Heise volcanic field. The Heise Group includes the Blacktail Creek Tuff (6.62± 0.03 Ma), Walcott Tuff (6.27± 0.04 Ma), Conant Creek Tuff (5.51± 0.13 Ma), and Kilgore Tuff (4.45± 0.05 Ma). These units erupted from separate calderas, each with a set of discrete vents. Major eruptions are separated in time and space while less voluminous minor rhyolitic eruptions are less systematic and fill in the spectrum. Large caldera-forming eruptions and development of individual volcanic fields are related to the rate of movement of the NA plate, amount of material available in crust for melt, the degree of crustal depletion, and flow dynamics in the upper crust.