Evolution of whole-mantle plumes: Consequences for hotspot volcanism

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Hotspot volcanism commonly displays bilateral asymmetry of geochemical signatures and temporal variability of volcanic flux. For example, the bilateral expression of volcanism as the "Loa-Kea" double chain is mostly restricted to the young end of the Hawaiian ridge, coinciding with a recent surge of volcanism. Using geodynamic models, we here link the ascent of plumes (form the core-mantle through the entire mantle to the base of the lithosphere) to surface characteristics of hotspot volcanism. Plumes can entrain intrinsically dense mafic heterogeneity as they rise from the tops or sides of thermochemical piles (or "LLSVP") in the deep mantle. The competition of negative buoyancy related to this mafic load with positive thermal buoyancy leads to characteristic plume pulsations. The associated timescales depend on whether pulsations rise out of the lower mantle or transition zone. Bilateral asymmetry of (mafic) heterogeneity across the conduit may emerge as the plume rises from the edge of a LLSVP, but whether it can be expressed in hotspot volcanism depends on the interaction of the plume with the transition zone and lithosphere. For the Hawaiian ridge, we interpret the data as evidence for the arrival of a lower-mantle plume pulse. The related long-term increase of volcanic flux over 30-40 Ma is interspersed by intermittent decrease(s) that are predicted to occur due to changes in Pacific plate speed. Higher plate speeds tend to damp plume-lithosphere interaction and decrease volcanic flux. A lower-mantle pulse may have been crucial to carry bilateral heterogeneity from the edge of the LLSVP to the base of the lithosphere. Integrated trans-disciplinary studies of plume ascent and volcanism can help to constrain mantle composition and dynamics.