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Numeric modeling of plume-lithosphere interaction and the magmatism associated with the Yellowstone hotspot track

V.C. Manea (1,2), M. Manea (1), W. Leeman (3), and D. Schutt (4)

(1) Laboratory of Computational Geodynamics, Centro de Geociencias, UNAM, Juriquilla, Mexico (vlad@geociencias.unam.mx), (2) Seismological Laboratory, Caltech, Pasadena, USA, (3) Earth Science Division, National Science Foundation, 4201 Wilson Blvd, Arlington, VA 22230, (4) Department of Geology and Geophysics, University of Wyoming, Laramie, WY 82071-3006

The relative contributions of lithosphere vs. upwelling sub-lithospheric mantle to formation of Snake River Plain-Yellowstone (SRPY) basaltic magmas is still an ongoing debate. The association of this province with initially thick and cold Archean lithosphere (Wyoming craton) poses a problem in that this lid will probably hinder and possibly prevent melting of rising plume hot material. However, petrologic modeling indicates that SRPY primitive basalts last segregated from mantle at $\sim$1450°C and $\sim$100 km depth, suggesting that their source is only slightly warmer than MORB-source mantle and significantly cooler than sources of oceanic hotspot magmas. In the light of such evidence melting can only occur if the lid can be substantially thinned over geologically reasonable time. We developed a series of 3D time-dependent geodynamic models to study lithospheric thinning processes and to investigate the extent and rate of lithosphere thinning assuming an initial structure representative of the Wyoming craton. Modeling results show that thermal erosion, on a lithosphere initially more than 200 km thick, by plume impingement alone appears incapable of providing the required lithospheric thinning. Thinner lithosphere (150 km) models also hinder the melting for a wide rage of plume parameters (chemical buoyancy $\Delta\rho = 30 - 50 kg/m^3$ and temperature contrasts $\Delta T = 150 - 300°C$). On the other hand, alternative models (e.g., low-angle Laramide subduction, delamination) do not apply because of the conflict with geochemical evidence that SRPY basalts contain a dominant contribution of old, isotopically evolved mantle material - presumably derived from subcontinental lithospheric mantle (SCLM). Our conclusions are that SCLM is likely to be preserved, that the thick SCLM lid prevents substantial melting of rising plume material (tomographically imaged), and SRPY basalts are predominantly derived by melting of lithospheric mantle.