Extensive magmatic heating of the lithosphere beneath the Hawaiian Islands inferred from Salt Lake Crater mantle xenoliths

IMANI GUEST[1], GARRETT ITO[2], MICHAEL O. GARCIA[2], ERIC HELLEBRAND[3]

[1]Brown University, Providence, RI 02912, USA (imani_guest@brown.edu)
[2]University of Hawaiʻi at Mānoa, Honolulu, HI 96822, USA (gito@hawaii.edu, mogarcia@hawaii.edu)
[3] Utrecht University, Budapestlaan 4, 3584CD Utrecht, Netherlands (e.w.g.hellebrand@uu.nl)

An ongoing challenge in studies of the oceanic upper mantle is how intra-plate hotspots impact the thermal structure of the lithosphere. To address this issue at the Hawaiian hotspot, we analyze mineral compositions for a petrographically diverse suite of garnet pyroxenite xenoliths from the Salt Lake Crater (SLC) rejuvenation stage, volcanic tuff ring in Honolulu. Garnet-clinopyroxene geobarometry and two-pyroxene geothermometry indicate that the xenoliths equilibrated at pressures of 13-18 kbar and temperatures of 1000-1100°C. These pressures place the xenoliths at mid-lithospheric depths of 45-55 km with temperatures 200-300°C hotter than expected for normal 90 Myr-old oceanic lithosphere. Garnet and clinopyroxene occur as discrete primary grains, as well as exsolution blebs or lamellae, having lateral dimensions as large as several hundred microns. Compositions within garnet and pyroxene grains are remarkably uniform and display no systematic variation with distance to the boundaries between the relevant mineral pairs. Together, these observations indicate that the calculated pressures and temperatures reflect the thermal state of the lithosphere under which the xenoliths equilibrated. We attribute the elevated lithospheric temperatures under Honolulu primarily to the heating of the lithosphere by the voluminous magmatism associated with the construction of the Koʻolau shield volcano. We anticipate that such a lithospheric thermal anomaly is likely present beneath the footprint all Hawaiian shield volcanoes, supporting the conclusions of a recent study of earthquakes beneath Hawaiʻi Island. This local magmatic heating may contribute to the enigmatically weak flexural response of the lithosphere due to the loading of the volcanoes.