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Lithospheric Controls on Magma Composition along Earth's Longest Continental Hotspot-track.

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Hotspots are anomalous regions of volcanism at Earth's surface that show no obvious association with tectonic plate boundaries. Classic examples include the Hawaiian-Emperor chain and the Yellowstone-Snake River Plain province. The majority are believed to form as Earth's tectonic plates move over long-lived mantle plumes: buoyant upwellings that bring hot material from Earth's deep-mantle to its surface. It has long been recognised that lithospheric thickness limits the rise height of plumes and, thereby, their minimum melting pressure. It should, therefore, have a controlling influence on the geochemistry of plume-related magmas, although unambiguous evidence of this has, thus far, been lacking.

Here we integrate observational constraints from surface geology, geochronology, plate-motion reconstructions, geochemistry and seismology to ascertain plume melting depths beneath Earth's longest continental hotspot-track, a ~2000 km long track in eastern Australia that displays a record of volcanic activity between ~33 and ~9 Ma, which we call the Cosgrove track. Our analyses highlight a strong correlation between lithospheric thickness and magma composition along this track, with: (i) standard basaltic compositions in regions where lithospheric thickness is less than ~110 km; (ii) volcanic gaps in regions where lithospheric thickness exceeds ~150 km; and (iii) low-volume, leucite-bearing volcanism in regions of intermediate lithospheric thickness. Trace-element concentrations from samples along this track support the notion that these compositional variations result from different degrees of partial-melting, which is controlled by the thickness of overlying lithosphere. Our results place the first observational constraints on the sub-continental melting depth of mantle plumes and provide direct evidence that lithospheric thickness has a dominant influence on the volume and chemical composition of plume-derived magmas.