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Four flavours of orogenic plateau magmatism: what's melting beneath the Turkish-Iranian Plateau?

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Orogenic plateaux are first order topographic features of the continents, occurring in collision zones such as Tibet and Andean-style continental arcs. Plateaux are sites of abundant mantle-derived magmatism, but there is little understanding of its geodynamic cause in spite of widespread assumptions that slab break-off or lithospheric thinning are controlling factors.

Late Cenozoic magmatism is distributed 100s of km from the Arabia-Eurasia suture zone across the modern Turkish-Iranian Plateau (TIP) in the countries of Armenia, Iran, Turkey and adjacent areas. There is huge compositional variation. Here we document four varieties of recent TIP magmas and argue their occurrence is controlled by: geographic location, prior fertilisation of the lithospheric mantle, lithospheric thickness, temperature and stability, and asthenospheric convection. (1) Close to the original Arabia-Eurasia suture in Eastern Turkey, slab break-off is likely to have occurred at $\sim$10 Myr, and the lithosphere is presently thin (45-50 km) with little or no mantle lithosphere present. Magmatism is mostly calk-alkaline, sourced from the asthenosphere or any remaining mantle lithosphere, and is affected by crustal contamination. (2) In the Lesser Caucasus up to $\sim$500 km from the suture, magmatism is more alkaline, less contaminated and is derived from subduction-modified lithospheric mantle. (3) Close to the suture in Iran, the lithosphere has thickened to $>$200 km during collision. Magmatism is volumetrically limited and derived almost exclusively from the lithospheric mantle, with highly enriched alkaline or ultrapotassic compositions. Unlike the Lesser Caucasus, there is little or no magmatism in the Iranian desert up to 500 km from the suture. (4) Beyond $\sim$500 km from the suture zone, magmatism is sparse and varies in composition: dominantly OIB-like in Eastern Iran, alkaline but arc-like in the Alborz, and more felsic above the relatively thick ($\sim$55 km) crust of the Greater Caucasus.

Magmatism in (1) is plausibly caused by asthenospheric upwelling following slab breakoff, whereas magmatism in (2) is dominated by melting of the base of the still-present lithospheric mantle during convective removal or asthenospheric upwelling. Magmatism in (3) is probably triggered by decomposition of hydrous phases within the lithosphere, whereas those in (4) have various triggers: OIB-like magmas may relate to local delamination or thin-spots, more arc-like magmas may be due to lithospheric thickening in the Alborz and Greater Caucasus. Geochemical and geodynamic modelling suggest that at $\sim$500 km distance from the suture there is a cut-off, at which asthenosphere stirring (due to slab break-off) ceases to be an effective cause of decompression melting, small-scale lithospheric delamination and convection. The relative scarcity of magmatism in Western and Central Iran is good evidence that the mantle beneath this region is not being stirred by delamination processes: there is otherwise little difference in the previous Tethyan subduction histories of Iran and Eastern Turkey. Overall, there is no single trigger or source of magmatism beneath the TIP, but two processes appear to dominate: melting due to dehydration of the lithosphere as it is thickened or convectively removed, and decompression melting of upwelling asthenosphere.