Lithospheric control on silicic magma generation associated with the Ethiopian flood basalt province

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Abstract

Most of the Ethiopian flood basalts erupted 30 Ma, during a 1 Ma period, to form a vast volcanic plateau. Inter-layered with the flood basalts, particularly at upper stratigraphic levels, are sequences of felsic lavas and pyroclastic rocks of rhyolitic or less commonly trachytic compositions. Immediately after this peak of activity, shield volcanoes formed on the flood volcanics, after which the volcanism was largely confined to regions of rifting. Geophysical and geochemical data in the region support the presence of one (or more) plume(s) during the formation of the volcanic province.

The Ethiopia-Yemen traps overlie Mesozoic-Paleocene shallow marine sequences, indicating that the traps erupted onto lithosphere stretched to a minor degree during the breakup of Gondwana, which had only partially thermally requilibrated. Thus, the location of the flood basalt province may have been influenced by pre-existing lithospheric structure, but the degree of pre-plume thinning would have been too small to explain the silicic volcanic rocks as products of decompression/adiabatic melting of underplated basic igneous rocks. Instead, the silicic volcanics are consistent with their derivation by processes of fractional crystallization of mantle derived basaltic melts combined with assimilation.

On the other hand, there is abundant evidence that the Mesozoic Karoo-Ferrar, Parana-Etendeka and Deccan flood volcanics were generated beneath thinned lithosphere in response to regional extension. In these regions, sea floor spreading occurred during or shortly after trap emplacement, except in the older Karoo-Ferrar province where full-fledged ocean floor spreading initiated some 13 M.y. following peak flood volcanism. The origin of silicic volcanic rocks in Etendeka-Parana has been attributed to the process of partial melting of underplated basic igneous rocks or continental crust.

Overall, data and observations suggest a broad relationship between lithospheric thickness and the process of felsic melt generation associated with LIPs. In those areas where lithospheric thinning has taken place, extension would have triggered decompression melting of still-hot underplated basalts at the base of previously thinned/stretched continental crust, causing widespread silicic volcanism.

In contrast**,** flood-basalt magmatism under normal or un-stretched lithosphere creates favorable conditions for the development of crustal magma chambers where basaltic magmas pond and evolve toward silicic derivatives by a combination of fractionation processes and assimilation of surrounding basement and/or roof rocks.

Petrological and geochemical investigations can broadly discriminate mantle-derived fractionated silicic volcanics from those originating by partial melting of underplated basalts and crust. This provides a possible tool to infer lithospheric structure at the time of felsic magmatism associated with LIPs.