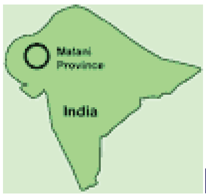

Neoproterozoic Malani Magmatism, northwestern Indian shield: Not a plume product

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Abstract

The Neoproterozoic (~750 Ma) Malani magmatic province occupies a large area (~50,000 km^2) of the northwestern Indian shield. It is dominantly made up of felsic (rhyolitic) lava flows and granitic plutons, with subordinate mafic lavas, and felsic and mafic dykes. The Malani province represents a large, intraplate, anorogenic felsic event, which is why some workers have ascribed it to a mantle plume. Geological observations indicate, however, that Malani volcanism occurred along parallel crustal fractures that developed as a result of extensional tectonics. This suggests an intra-cratonic rift setting, and a deep mantle plume is neither necessary nor viable.

The geology

Malani magmatism represents the largest single felsic magmatic event to have occurred in India, and is spread over the Aravalli craton, one of several ancient continental nuclei of which India is built. The Malani rocks form linear hills, tors, inselbegs, rings and hammocks in the Rajasthan and Haryana regions of northwestern India, and are covered in places by younger sediments, including wind-blown sands from the Thar Desert (Figure 1). Malani magmatism has been divided into three phases. ***The first phase*** comprises bimodal volcanism, with initial basic lava flows followed by rhyolites, ignimbrites and ultrapotassic rhyolites. The eruptions were predominantly subaerial, but aqueous conditions existed in a few places, as is indicated by conglomerate and arkose beds underlying the lavas, pillow basalts, and the development of sedimentary features in the volcanics. ***The second phase*** is characterised by plutons and bosses of granites. ***The third phase*** involved the intrusion of basic and felsic dykes along the rift margin (*Kochhar et al.*, 1995). These dykes developed along secondary rift fractures transverse to the linear basins (Figure 2). There is a general consensus based on, for example, Rb-Sr isotope data (e.g., *Crawford*, 1975; *Choudhary et al.*, 1984) that the Malani magmatism occurred at ~750 Ma and had a relatively short duration of about 20 m.y., though *Rathore et al.* (1999) have argued for a duration of 100 m.y., from 780 Ma to 680 Ma.

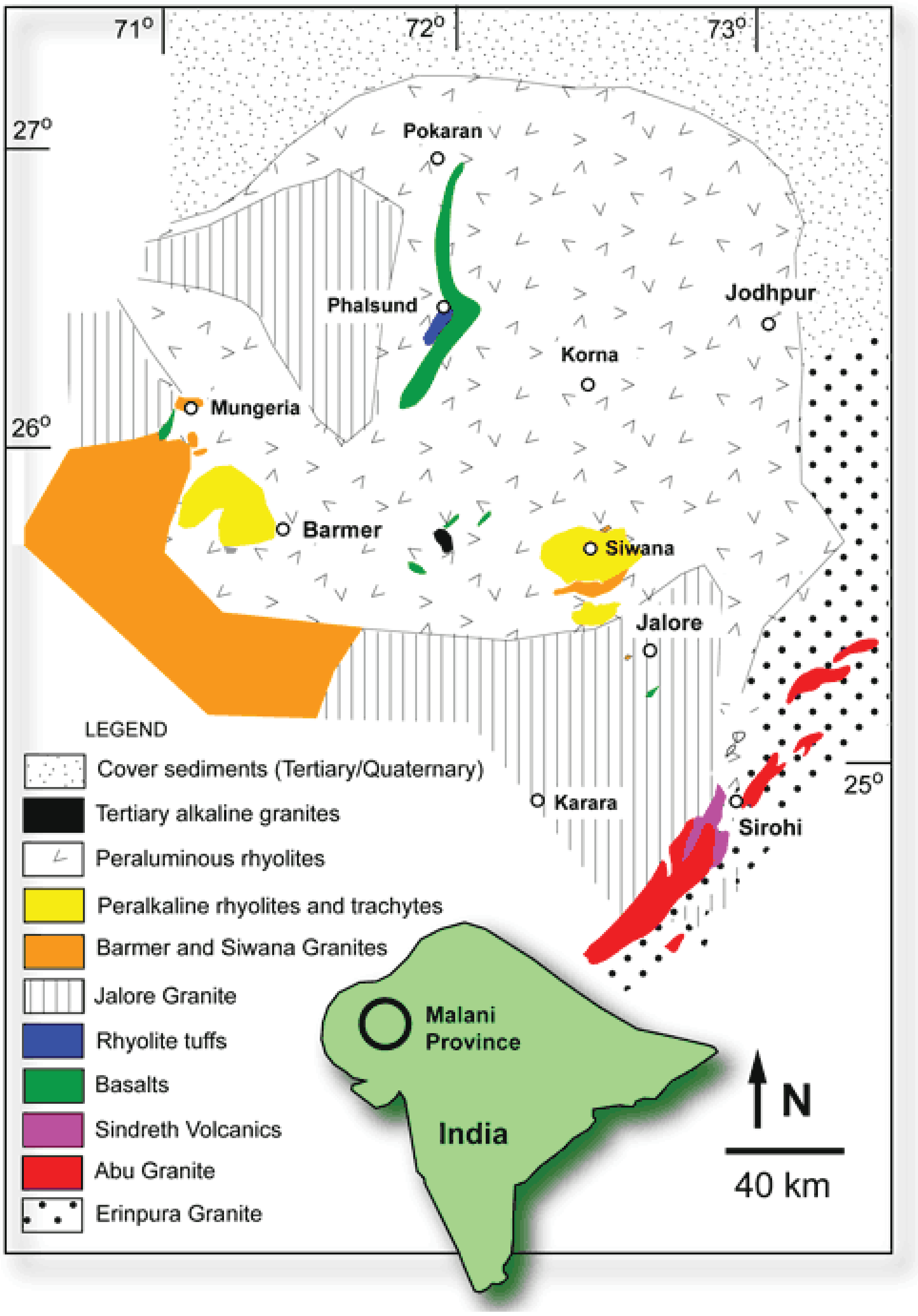

Figure 1: Geological sketch map of western Rajasthan showing the area occupied by the Malani magmatic rocks (modified from Bhushan, 1995). Click on figure for enlargement.

The subduction model

Sinha-Roy & Mohanty (1988) have considered Malani magmatism to be a result of low-angle subduction of the Delhi oceanic\transitional crust below the western Rajasthan/ Aravalli craton under an extensional tectonic regime. *Bhushan & Chittora* (2000) rejected the plate subduction model, however, after considering the setting at Kankani (Jodhpur), where the Malani lavas overlie the basement with a well-defined unconformity in between.

The hotspot model

Kochhar (1984) attributed Malani magmatism to hotspot activity. He suggested that there were at least two abortive attempts by the Indian lithosphere to rift in Proterozoic time, one at 1,500-1,100 Ma, and the other at 750 Ma, related to the Malani magmatism. He further argued that there was no movement of the Indian plate relative to the hotspot between 1,500 Ma and 750 Ma. He proposed a Neoproterozoic supercontinent called the Malani Supercontinent and considered the Malani event to be part of the Pan-African thermal event. *Bhushan* (1999, 2000), *Raval* (2000) and *Roy* (2001) also supported Kochhar's hotspot model for the anorogenic Malani magmatism.

The hotspot model questioned

Pareek (1984) and *Srivastava* (1988) described the metasediments of the Aravalli Suprgroup (Archean-early Proterozoic) in western Rajasthan. *Bhushan* (2000) proposed that basement rocks of the Banded Gneissic Complex (Achaean) underlie the Malani rocks. Geological studies indicate considerable rotation of the Malani tectonic grain, observed, for example, in the Sindreth region (*Sharma*, 1996). The linear disposition of conglomerates and other sedimentary features in close association with the Malani volcanics (Figure 2) indicates lineament-controlled igneous activity.

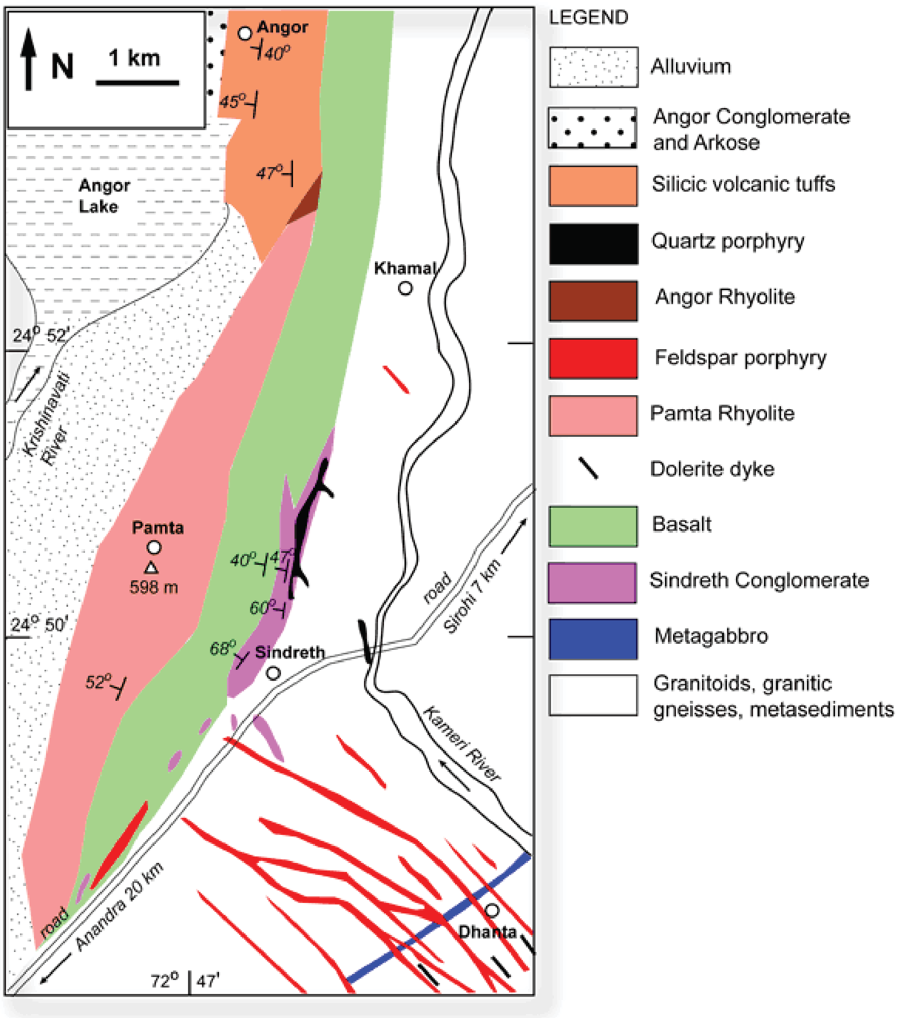

Figure 2: Geological map of the Sindreth region showing the linear rift basin structural setting of the Malani rocks (from Sharma, 1996).

Pareek (1984) considered that the main trend of Malani outpouring is fissure-controlled and there is a relationship between volcanism and tectonic lineaments. *Srivastava* (1988) also proposed that weak lines developed parallel to the Aravalli mountain range during its uplift in late Proterozoic time, through which the Malani lavas poured. The crustal fractures indicate an intra-cratonic rift setting with an extensional tectonic regime. These N-S trending subparallel rifts are separated by segments of the basement rocks, visible at Undwaria, Sindreth, Bambholai, Miniari and elsewhere. The linear outcrop pattern of Undwaria-Sindreth-Miniari is the best example of this (Figure 2). The bimodal Malani volcanism took place in shallow and narrow basins, and the volcanics show angular relationships with the underlying Sirohi Group and other basement rocks. The plutonic activity is marked by emplacement of granites, e.g., at Jalore, Siwana, Isra, and elsewhere.

The Malani felsic volcanics were produced by crustal melting. If there was any contribution from the mantle, it would be the basalts and the ultramafic cumulate rocks contained in the related granites (e.g., at Jalore, Isra, and Siwana) After the close of the orogenic cycles in the Aravalli craton, and prior to the Malani event, the crust was stable for a long time (*Sharma & Roy*, 1997). The prolonged stability and thermal insulation of this crust would have led to accumulation of heat, which then resulted in an extensional tectonic regime and crustal melting. Thus, the dominantly felsic Malani magmatism, though intraplate and anorogenic, is not consistent with the deep mantle plume/hotspot model.

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