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Geochemistry of Magmatic Rocks of the Malani Igneous Suite

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Abstract
The northwest Indian shield is covered by the Neoproterozoic (750 Ma) Malani magmatic province, which covers a sizable area (around 50,000 km2). It is mostly composed of felsic (rhyolitic) lava flows and granitic plutons, with mafic lavas and felsic and mafic dykes acting as supporting structural elements. Some researchers have referred to the Malani province as a mantle plume since it is a significant, intraplate, anorogenic felsic event. But according to geological data, the parallel crustal fissures that resulted from extensional tectonics are where the Malani volcanism took place. An intra-cratonic rift scenario is suggested, and a deep mantle plume is neither required nor feasible.
Keywords- *Malani, Granitic plutons, Mantle plume, etc*

I. Introduction

Igneous Suite of Malani at the foot of the majestic Mehrangarh Fort in Jodhpur City, the second largest city in Rajasthan after Jaipur, is the geological structure known as the Contact of Aravali Range, which represents the final stage of Precambrian igneous activity on the Indian Subcontinent. The Geological Survey of India (GSI) designated Jodhpur as a National Geological Monument as a result of the site's distinctive geological characteristic.

Etymology

A district in the erstwhile state of Marwar (Jodhpur) known as Malani was named for volcanic rocks that gave rise to the term "Malani beds." The Malani Volcanics Series name experienced a number of revisions over time. Volcanic Suite, Malani System, and Malani Granite. The Malani Igneous Suite is the final term given to the entire magmatic series. The igneous suite represents the final stage of Precambrian igneous activity on the Indian subcontinent. In western Rajasthan, the Pali, Sirohi, Jodhpur, Barmer, Jaisalmer, Jalore, and Siwana districts are all included in the 44,500 square kilometer (17,182 square mile) Malani Igneous Suite, which is a crucial element of the Thar Desert. The impressive Mehrangarh Fort in Jodhpur is built on a rhyolite rock exposed atop a hillock that is 120 meters (394 feet) high and was formerly known as the "Mountain of Birds." The area has a harsh desert climate with sweltering summers, hot, dry winds, and arid conditions. It becomes really cold in the winter. The sparse rainfall occurs from late June until September. The age of the granite was 735 Ma, which was younger than the ages of 840 Ma for Sandra Granite, 830 Ma for Erinpara Granites, and 820 Ma for the Pali Granites. The average rainfall is reported to be 360 millimeters (36 cm), but it is extremely variable, with a minimum recorded of 24 millimeters (2 cm) during the famine year of 1899 and a maximum of 1,178 millimeters (118 cm) during the floods of 1917. However, the age was stated as 600–70 Ma by the Geological Survey of India in their publication National Geological Monuments.

Malani Magmatism's geodynamic importance

The mantle plume is responsible for the 732 million years old anorogenic, A-type magmatism of the North-Western Indian shield, which is distinguished by volcano plutonic ring formations. The configuration of the Malani Supercontinent, which includes the trans-Aravalli block of the North-Western Indian shield, the Arabian-Nubian shield sessions, Madagascar, South China, Tarim, Mongolia, and Siberia, is greatly influenced by this magmatism.

The geology

Malani magmatism, which spans the Aravalli craton, one of several ancient continental nodules from which India was formed, is the greatest felsic magmatic event to have happened in India. In the Rajasthan and Haryana regions of northwest India, the Malani rocks are found forming linear hills, tors, inselbegs, rings, and hammocks. In some locations, younger sediments, such as wind-blown sands from the Thar Desert, cover the Malani rocks (Figure 1). Three phases have been identified in the magmatism of Malani. Bimodal volcanism makes up the first phase, which begins with basic lava flows and is followed by rhyolites, ignimbrites, and ultrapotassic rhyolites. Although the majority of the eruptions were subaerial, there were a few locations where aqueous conditions existed, as shown by pillow basalts, conglomerate and arkose beds beneath the lavas, and the emergence of sedimentary characteristics in the volcanics. The second phase is distinguished by granite bosses and plutons. Along the rift margin, basic and felsic dykes were introduced during the third phase. The secondary rift cracks that ran transverse to the linear basins are where these dykes formed (Figure 2). Although Rathore et al. have argued for a period of 100 m.y., from 780 Ma to 680 Ma, there is universal agreement that the Malani magmatism occurred at around 750 Ma and had a very brief lifetime of approximately 20 m.y.

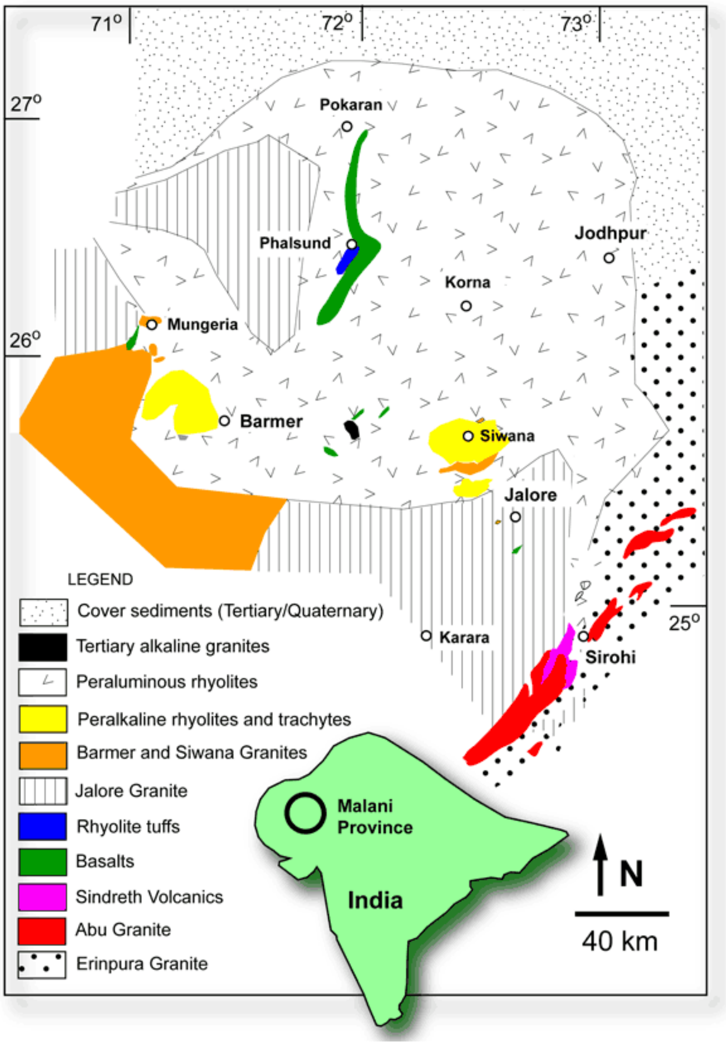

Figure 1: Geological sketch map of western Rajasthan showing the area occupied by the Malani magmatic rocks (modified from Bhushan, 1995). Click on figure for enlargement.

Hotspot modeling

Malani magmatism was linked by Kochhar to hotspot activity. He proposed that the Malani magmatism was connected to at least two unsuccessful attempts by the Indian lithosphere to rift during the Proterozoic, one around 1,500-1,100 Ma and the second at 750 Ma. In addition, he claimed that between 1,500 Ma and 750 Ma, the Indian plate did not move in relation to the hotspot. He suggested the Malani Supercontinent, a Neoproterozoic supercontinent, and viewed the Malani event as a component of the Pan-African thermal event.

The hotspot theory proposed by Kochhar for the anorogenic Malani magmatism was also backed by Bhushan Raval and Roy.

The hotspot model was under doubt.

The metasediments of the Aravalli Suprgroup (Archean-early Proterozoic) in western Rajasthan were characterized by Pareek and Srivastava. The Banded Gneissic Complex (Achaean) basement rocks, according to Bhushan, are what lay beneath the Malani rocks. Geological investigations show that the Malani tectonic grain rotates quite a bit, as may be seen, for instance, in the Sindreth region.In close proximity to the Malani volcanics, conglomerates and other sedimentary structures are arranged linearly (Figure 2). This suggests that igneous activity was regulated by lineaments.

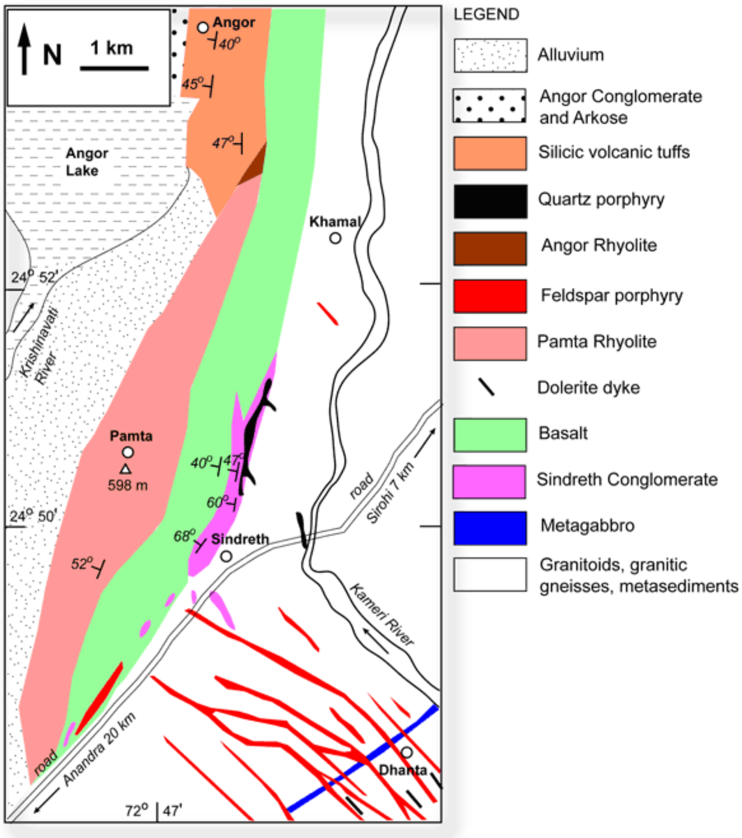

Figure 2: Geological map of the Sindreth region showing the linear rift basin structural setting of the Malani rocks

II. Discussion

Pareek believed that there is a connection between volcanism and tectonic lineaments and that the primary tendency of the Malani outflow is fissure-controlled. Additionally, Srivastava hypothesized that the weak lines through which the Malani lavas poured during the Aravalli mountain range's uplift in the late Proterozoic period were formed parallel to the mountain range. An intra-cratonic rift setting with an extensional tectonic regime is indicated by the crustal cracks. Segments of the basement rocks, which are visible in Undwaria, Sindreth, Bambholai, Miniari, and other locations, divide these N-S trending subparallel rifts. The clearest illustration of this is the Undwaria-Sindreth-Miniari linear outcrop pattern (Figure 2). Due to the shallow and constrained basins in which the bimodal Malani volcanism occurred, the volcanics exhibit angular connections with the Sirohi Group and other basement rocks. Granite is deposited during the plutonic activity, which can be seen in places like Jalore, Siwana, Isra, and other places.

The crustal melting that formed the Malani felsic volcanics. After the end of the orogenic cycles in the Aravalli craton and before the Malani event, the crust was stable for a considerable amount of time. If the mantle made any contribution, it would be the basalts and the ultramafic cumulate rocks contained in the related granites (e.g., at Jalore, Isra, and Siwana).This crust's long-term stability and thermal insulation would have caused heat to build up, which would have then caused an extensional tectonic regime and crustal melting.

Therefore, despite being intraplate and anorogenic, the mostly felsic Malani magmatism is incompatible with the deep mantle plume/hotspot concept.

III. Conclusion

An improvement has been made to the paleogeographic reconstruction of the Indian subcontinent between the dispersal of the Mesoproterozoic supercontinent Rodinia and the late Neoproterozoic assembly of Gondwana thanks to new paleomagnetic and geochronologic data from the Malani Igneous Suite (MIS) in Rajasthan, northwest India. The MIS is composed of extensive felsic and mafic volcanism that contributes little to volume, followed by granitic plutonism. A large felsic and mafic dike represents the final stage of magmatism, which can be up to 5 m broad. A rhyolitic tuff's zircon U-Pb age limits the MIS's earliest volcanism to 771 5 Ma. Four mafic dikes were used to determine the paleomagnetic direction, which had a declination of 358.8° and an inclination of 63.5° (with = 91.2 and 95 = 9.7). It is consistent with earlier findings from felsic MIS rocks. This direction shows an overprint of normal polarity from the bigger dikes as well as a fine-grained mafic dikelet that displayed a reversed direction with declination = 195.3° and inclination = 59.7° (= 234.8 and 95 = 8.1°). By combining the VGP from this study on mafic dikes with earlier research on the Malani suite, a mean paleomagnetic pole of 67.8°N, 72.5°E (A95 = 8.8°) has been determined. We argue that this pole is main, which allows for a better reconstruction of the Indian subcontinent for 771–750 Ma, supported by a tentative baked contact test. Paleomagnetic data from the 755 3 Ma Mundine Well dikes in Australia are compared with data from the MIS and analogous data from the Seychelles at 750 3 Ma to show a latitudinal separation of over 25° between the Indian and Australian plates. These indicate that East Gondwana was not united at around 750 Ma and that these two cratonic blocks were put together later, around 550 Ma, to form the Gondwana supercontinent.

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