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Was Yangtze Craton, South China attached to the Trans-Aravalli block of the NW Indian shield during Late Proterozoic?

We highlight here the similarities between the Yangtze Craton (YC) of South China and the Trans-Aravalli block (TAB) of the NW Indian shield in terms of anorogenic, bimodal, 'within plate' magmatism, Strutian glaciation and position of palaeo-poles during Late Proterozoic. The study has implications for plume tectonics and assembly of the Malani supercontinent.

The Indian shield is composed of three main geotectonically different blocks or terranes, the South Indian Block (SIB), the Bundelkhand block (BB) and the Trans-Aravalli block (TAB), which were juxtaposed and sutured during different periods of earth's history. The TAB (west of the Aravalli Mountain) is unique in the geological evolution of the Indian shield as it marks a major period of anorogenic (A-type), bimodal, high heat-producing, 'within plate' magmatism represented by the Malani igneous suite. The Malani magmatism (50,000 sq. km; 732 Ma) comprising peralkaline (Siwana), metaluminous to mildly peralkaline (Jalor) and peraluminous (Tusham and Jhunjhunu) granites with carapace of acid volcanics (welded tuff, rhyolite, perlite, explosion breccia, etc.) is characterized by volcano-plutonic ring structures – Siwana, Jalor, Tusham and radial dykes (Jhunjhunu) (Figure 1). The suite is bimodal in nature with minor amounts of basalt flows, gabbro and dolerite dykes[1]. The Siwana ring structure (25.6 km NS and 31 km EW) is the most spectacular feature of the Thar Desert and it coincides with low-velocity anomaly centred around Sarnu–Dandali and Mer-Mundwara, Rajasthan, representing fossil plume head[2]. The Malani magmatism is controlled by NE–SW trending lineaments of fundamental (mantle) nature and owes its origin to the Malani plume[3,4]. Representatives of Malani magmatism also occur in Kirana Hills, and at Nagarparkar in Pakistan.

South China comprises the YC to the northeast and the Precambrian Cathysia block to the southeast. The YC has a Late Archaean–Proterozoic nucleus surrounded mostly by younger orogenic belts. Both the blocks were sutured during collision of Grenville age[5] (Figure 2).

Neoproterozoic anorogenic magmatism and coeval mafic magmatism are widespread around the YC of South China. The magmatism coincides with NS-trending Kangdian rift and NE-trending Nanhua rift. The first one at ca. 830–795 Ma (pre-rift) and the second one at 780–745 Ma (syn-rift), the Chengjian magmatism. The later granites are younger than 1.0 Ga Siban orogeny and intrude the rift sequence. Both the pre- and syn-rift magmatism have been attributed to superplume because of its intraplate setting, peralkaline to alkaline affinity and association with coeval swarms of mafic dykes. Emplacement of the dyke swarm initiated the break-up of Rodinia. The superplume may represent two normal plumes to account for these two episodes of magmatism[6].

According to Wong and Li[7], at places the ca. 780–750 Ma granites are unconformabaly overlain by Upper Sinian sequence (750 Ma), which is interpreted to have formed a rift cover. Li *et al.*[6] have correlated the syn-rift (780–745 Ma) magmatism with the Malani magmatism besides those of Laurentia, South Africa and Australia.

The APWP palaeomagnetic poles at ca. 800 Ma place South China at 55–70°N at par with high paleolatitudes of India during Malani rhyolite period (ca. 750 Ma)[8,9]. The migration of India to higher paleolatitudes could be the cause of Precambrian glaciation as exemplified by the Pokhran boulder in Rajasthan which is of

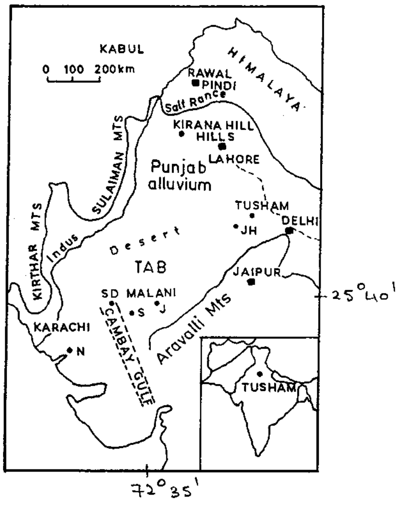

Figure 1. Location map of the Malani igneous suite. SD, Sarnu-Dandali; J, Jalor; S, Siwana; JH, Jhunjhunu; N, Nagarparkar.

glaciogenic origin[10]. Incidentally, the Pokhran diamicitite correlates with other Precambrian diamictites in the Lesser Himalaya such as Blaini boulder bed, Manjir and Bhimdasa in Jammu and Kashmir, Tankaki in Hazara, and Buxa Group (Shergaon pebbled bed) in Arunachal Pradesh[11–13].

Interestingly, Bose *et al.*[14] have reported acid pyroclastics such as welded tuff, ash flow tuff, lapilli tuff, volcanic clasts from the Late Proterozoic formations of Lesser Himalaya, viz. Shimla Group, Blaini Formation, Infrakrol Formation and the Krol Group. The source of these pyroclastics could be attributed to the nearby Tusham acid volcanics of Malani age. It is possible that the precursor to the Lesser Himalyan terrane was a contiguous part of the TAB during Late Proterozoic.

The boulders of Malani granites also occur in the Salt Range. In the YC, Liantua and Nantua (748 Ma) deposits are of glaciogenic origin[8].

Around 700 Ma BP India started drifting towards the tropical latitudes and around 600 Ma, India was near the equator[15]. According to Pooranchandra Rao *et al.*[16] there has been large polar movement between the Malani rhyolite and other lower Cambrian period poles indicating rapid migration of the Indian subcontinent from the northern to southern hemisphere latitudes. During this period, the northern margins of India were subjected to desiccation. The carbonate, mainly dolomite and phosphate deposits of Late Sinian–Late Precambrian age in Yangtze block, corresponds with Hanseran evaporites in the Marwar basin of TAB, SW Punjab, and Bilara phosphorites in Rajasthan. Similar evaporites occur in the Salt Range, Arabia, Iran, Somalia, etc.[3,17]. Recently, Singh *et al.*[18] have described Neoproterozoic evaporite sequence from Lesser Himalaya comprising gypsum and anhydrite, gypsum + carbonate, and halite from the Kashmir sub-basin (Ramban, Assar belt), and Chamba sub-basin (Bathri) respectively, and halite from the Guma-Drang area of Mandi, Himachal Pradesh. According to Illyin[19], the continental margins of Vendian–Early Precambrian supercontinent comprising South China, Kazakhstan, Mongolia and proto-Tethys were the sites of equatorial sedimentation in the form of shallow-water carbonate and phosphorite deposits.

A short-lived positive excursion in carbon isotope values noticed at phosphorite level in the Birmania (Upper Carbonate) Formation in the TAB and in the basal part of Tal Group in Krol basin is also known from Dahal member of the Yuhucun Formation of Meishucunian zone-II[20]. According to Pandit *et al.*[21], extremely low 13 δ-values in the Bilaria carbonate indicate glacial-related cold climatic conditions, while positive shift in the carbon isotope values in the upper formations implies a warmer climatic condition. The Bilara carbonate group carbon isotope profile have close correspondence with global carbon isotopic evolution curve in Haqf, Oman, Siberia, platform, Mongolia and Morocco and elsewhere.

Li *et al.*[8] have proposed a 90° spin of Rodinia that brought the entire supercontinent into equatorial latitudes. The spin was the result of initiation of a subequatorial superplume by ca. 750 Ma. The spin corresponds with reversal of geomagnetic field during the deposition of each group of Vindhyan Supergroup, i.e. Kaimur, Rewa and Bhandar. During the Kaimur period (1400–750 Ma) there have been at least three reversals of geomagnetic field[22]. The combined 800–700 Ma apparent polar wander path implies pole-to-equator rapid velocities of 20 cm/yr for India and South China, which is unlike the other continents such as Australia and Congo.

Kochhar[23] suggested that since the Indian subplate is a mosaic of three major tectonostratigraphic blocks with different magmatic and metamorphic histories, the position of India in the assembly of a Late Proterozoic supercontinent should not be viewed as a single entity. For example, the southern tip of the SIB (south of Palaghat Cauvery shear zone), Sri Lanka and Madagascar along with the Eastern Antarctica formed a supercontinent[24]. In other supercontinent assembly Meghalaya lies SW of Yilgarn craton of Australia, Bungar hills and Wind Mill Islands in an Antarctican contimation of Frazer moloile belt[24].

Due to similarities of bimodal, anorogenic magmatism in South China, India and Australia, Li *et al.*[6] have suggested that the superplume was responsible for the break-up of supercontinent during Neoproterozoic. However, Kochhar[3,17] has suggested the assembly of a Late Proterozoic Malani supercontinent comprising TAB of the Indian shield, Nubian–

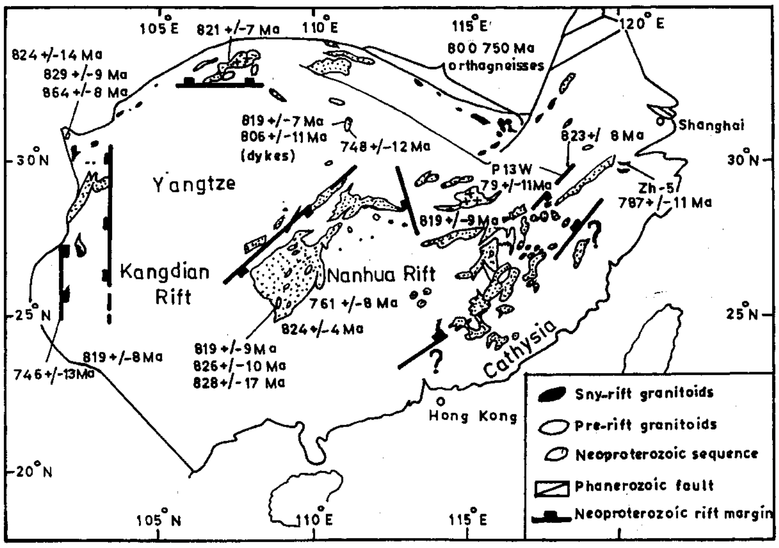

Figure 2. Neoproterozoic tectonic framework of South China. New ages are highlighted bold.

Figure 3. Assembly of the Malani supercontinent at ca. 750 Ma. NB–AB, Nubian–Arabian shield; MD, Madagascar; SY, Seychelles; SC, South China; BB, Bundelkhand block; SIB, South Indian block; TAB, Trans-Aravalli block; SM, Somalia.

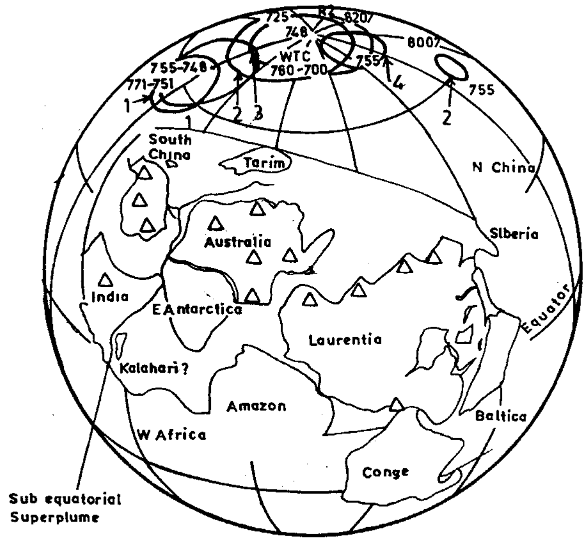

Figure 4. Palaeogeographic reconstruction of Rodinia 'intact' ca 750 Ma. Triangles represent Strutian glaciation deposits. Palaeopoles with ages. 1, India; 2, Australia; 3, South China; 4, Laurentia.

Arabian shield, Central Iran, Somalia, Madagascar and Seychelles (Figure 3). The Malani plume was responsible for the separation of TAB from East Gondwana. The Malani plume may be the present day position of subequatorial plume at 750 Ma BP proposed by Li *et al.*[6,7]. (Figure 4).

In view of the occurrence of widespread bimodal, anorogenic plume-related magmatism, Strutian glaciation and similar palaeolatitude position, the YC of South China fits well in the reconstruction of the Malani supercontinent. The position of South China between Australia and Laurentia is debatable because of an alternate equatorial Rodinia supercontinent, excluding high-latitude cratons in India and South China[6].

Whether the Precambrian glaciation in India and South China was due to the flight of these terranes to high latitudes during the Malani rhyolite period or the glaciation was of low latitude due to increased CO_2 drawdown and global albedo affected by waning of plume volcanism is debatable. The evidences presented here support the idea of polar Strutian glaciation in the TAB and Lesser Himalayan terrane.

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