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Assembly and Break-up of Rodinia and Gondwana – Evidence from India

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In basic structural and tectonic frame-work, the Indian subcontinent is a mosaic of four distinct Archaean to Paleoproterozoic crustal blocks/terranes, viz., the Bundelkhand (BB) extending beyond Himalaya in the north, Dharwar (DB) in the central India, South Indian-Sri Lankan Granulite (SISLGB) in the south and the Trans Aravalli (TAB), probably extending westwards to include Arabian-Nubian Shield or the Central Arabian Craton. Each block has independent geological history till they were juxtaposed and welded along five mobile belts during the Zhongyuean orogenic episode around 1600 Ma and not with episode ca. 1100–1000 Ma as considered by majority of earth scientists. The five mobile belts are the Satpura (SMB) between DB and BB, Eastern Ghat (EGMB) separating DB from Antarctica, Darling (DMB) between BB and Western Australia, Aravalli Delhi (ADMB) between BB and TAB, and the Palghat Cauvery (PCMB) between DB and SISLGB (Ravi Shanker et al., 1998, 1999, 2001). Thus, the Indian subcontinent and its neighbours enumerated above formed a very vast terrestrial world much earlier than thought to be, which can be termed as Protorodinia. Other continents, viz., North and South America, West Africa, Siberia, Baltica etc. joined this assembly gradually in phases up to 1100–1000 Ma, thereby completing the assembly of the Supercontinent Rodinia. These episodes of assembly are represented by thermal reactivation and associated magmatic and metamorphic episodes in earlier formed mobile belts in India. The cover sediments in this time frame justify these conclusions. It is due to this assembly the linear patterns of sea closed and a new physiographic set-up with mountain ranges along mobile belt was formed followed by extensive phase of erosion and peneplanation. This was followed by submergence by a new sea – the Prototethys, which transgressively covered major part of the subcontinent from north.

The Rodinia Supercontinent was a short-lived global geomorphic unit. Its southern part comprising North and South America, Siberia, North China, Baltica etc. started breaking up around 850 Ma which is termed as the West Gondwana. Its eastern part comprising India, Australia, East Antarctica, South China and East Africa remained united and is referred to as the East Gondwana. This breaking event is represented by large-scale thermal reactivation, bimodal magmatism in TAB.

The West Gondwana subsequently collided with the East Gondwana to form again a major Supercontinent called Gondwanaland with Xingkaian (Pan-African) Orogeny around 550 Ma. The imprints of this orogeny are seen in the Indian subcontinent in the form of an uplift and regression of Terminal Proterozoic-Cambrian Sea and reactivation of all the mobile belts. The SISLGB was also involved in the collision of East and West Gondwana. Subsequent evolutionary history is also related to global tectonics with a distinct transgression of sea referred to as the Palaeotethys in Early Ordovician. The Tianshanian (Hercynian) orogenic movements in Late Carboniferous followed by global cooling resulted in wide spread regression.

The breakup of Gondwana Supercontinent took place in several phases, which brought about major palaeogeographic changes. In the first phase ca. 250 Ma (Late Sakmarian), the Cimmerian microcontinents rifted and drifted from the Indian plate. It resulted in opening of a new sea referred to as the Neotethys. The second phase breakup ca. 158 Ma (Callovian) resulted in opening of western shelf. It brought about major changes in the drainage pattern and sedimentation. Some of the rivers, which were flowing towards north and northwest, and draining into the Neotethys, were diverted towards west. This change is clearly demonstrated by reworked fossils in the sediments of the West Coast. In the second phase of fragmentation of Gondwanaland took place around 130 Ma (Valanginian) with opening of the East Coast and initiation of separation of Antarctica and Australia. This also brought about reversal of drainage pattern. All the rivers flowing to the NW, NE or to the west and draining into the Neotethys,

changed their flow direction towards southeast depositing the sediments into newly opened sea – the Bay of Bengal, a part of the Indian Ocean. It is during the third phase of breakup that the Madagascar fragmented from India between 95 (Cenomanian) and 84 Ma (Coniacian). Finally, the Seychelles broke up from Indian subcontinent around 65 Ma (Maastrichtian) followed by rapid northward movement and collision with the Eurasian Plate giving birth to the highest mountain range – the Himalaya and development of the largest foredeep in the world. The present physiographic configuration of the subcontinent is due to reactivation of older lineaments during Quaternary period.

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Response of the North Margin of North China Craton to Breakup Events of the Global Supercontinent in the Proterozoic

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One of the current problems in focus in global earth sciences relates to the formation and breakup events of supercontinents and their implications in the geological history, particularly prior to the Phanerozoic. Existence of a Late Proterozoic supercontinent Rodinia has been extensively supported by recent studies. Ages spanning from 1.050 to 0.725 Ga trace its history and breakup. Some workers have suggested two more Proterozoic supercontinents during the periods 2.7–2.5 Ga and 1.8–1.4 Ga which disrupted during 2.3–2.2 Ga and 1.4–1.2 Ga respectively.

During the prolonged period from 1.8 Ga to 0.23 Ga in the Early Proterozoic, the North China Craton remained quite stable as a whole, allowing the relatively weak thermal events to be reserved and recorded intact. Whether the supposed Proterozoic supercontinental breakup events were reflected and recorded in the North China Craton is still enigmatic. Some possible clues to the supercontinental breakup events are presented in this work based on data from the North China Craton.

It has been shown in previous studies that a thermal event related to convergence and collision existed in the interior North China Craton during 1.9–1.8 Ga. At 1.8 Ga, the North China Craton experienced several extensional events, leaving records of magmatism. From 1.8 Ga to 1.7 Ga, anorogenic rift volcanism was initiated with fault controlled sedimentation at the Ji Xian rift system within the interior North China Craton as well as at the Bayun Obo-Zhaertai rift system towards north. Each formed a suite of potassium-rich trachitic lava with ages of 1.77 Ga and 1.73 Ga respectively. In addition the Damiao gabbro-anorthosite and Miyun rapakivi granite formed during 1.72–1.74 Ga. Subsequently, alkalic carbonatites intruded along the Bayun Obo-Zhaertai rift system in which the alkalic minerals (riebeckite and erikite) are dated 1.692 Ga, 1.683 Ga and 1.648 Ga by U-Pb or U-Th-Pb method.

During 1.2–1.3 Ga, the North China Craton experienced the second extensional event, with a suite of NW strike diabase swarm dykes emplaced in the border area between Shanxi, Hebei provinces and Inner Mongolia. The Ar-Ar age of the dyke swarms is 1.235–1.169 Ga. Previous studies demonstrated that this extensional event is the most extensive one during Proterozoic in this area. Significant alkalic fluid metasomatism is also recognized, with strong potassic metasomatism on the Archaeozoic metamorphic basement in Zhangjiakou area, reflecting a severe crust-mantle interaction in extensional setting. Potash feldspar formed in the potassic metasomatism is dated at 1.238–1.274 Ga by ^{40}Ar-^{39}Ar method. Important rare earth mineralization occurred concurrently in the Bayun Obo area. The Sm-Nd age of the rare earth minerals are 1.286, 1.288, and 1.313 Ga. Furthermore, the 1.250 Ga thermal perturbation is also recorded in ^{40}Ar-^{39}Ar age spectra of metamorphic garnet separated from a high-pressure granulite in Zhangjiakou area. After this extensional event, in the Bainaimiao area at the north margin of the North China platform basic volcanism manifested, with zircon U-Pb concordant ages of 1.130 Ga, reflecting further breakup of the craton.

A third extensional event experienced by the North China Craton was during during 0.7–0.8 Ga. Data are scarce on this event. Diabase dykes of this period (with K-Ar and ^{40}Ar-^{39}Ar ages 0.731–0.90 Ga) have been found in the central Shanxi Province. Basic volcanic rocks of 0.961–0.807 Ga and continent-margin sea-facies carbonatite of 0.772 Ga are also preserved in the north margin of the North China Craton. The ophiolites of 0.665 Ga in the north margin of the North China Plate mark the