MEETING REPORT

Singhbhum craton*

Singhbhum craton (SC) is one of the oldest (~3.6 Ga) cratonic nuclei of the Indian shield that presents a complex evolutionary history involving episodic sedimentation, poly-phase magmatism and orogenesis. Reconstructing the evolutionary history of this craton and its peripheral regions is necessary for tracing the history of Archaean continents, their amalgamation, evolution and dispersion. Geochemical studies carried out for SC suggest Neoarchaean and Mesoarchaean ages for the Older Metamorphic Gneiss (OMG), Older Metamorphic Tonalitic Gneiss (OMTG) and the Singhbhum Granite (SG)[1–3]. Geochemical proxies from volcanics and sediments of the Archaean successions in SC have been interpreted as comparable to Phanerozoic convergent tectonics[4]. Compared to the vast geological data generated so far, there are only a few geophysical studies from this craton that mainly deal with lithospheric thickness. Estimates of lithospheric thickness of 65 km from surface heat flow data[5], 70–100 km by receiver function analysis[6], and 58–96 km by magnetotellurics[7,8] suggest that it is significantly thinner than the typical global average of >200 km for Archaean shields. Such observations raise a major question as to how and when the cratonic keel of SC vanished, the answer to which would have implications for the geodynamics of this region. A two-day workshop on SC was organized to review the present status of our understanding of this craton and discuss new data and results.

Ch. Mohan Rao (Director (Additional Charge), CSIR-NGRI, Hyderabad) welcomed the delegates and briefed about the R&D programmes of the institute under various plan projects. The first talk delivered by R. S. Sharma (Jaipur), presented an overview of the Indian cratons through a comparative study of the cratonic blocks. He pointed out that all cratons, except SC, have granite intrusion at 2.5 Ga, at which time they were stabilized concomitant with the maximum growth of the continents. He also highlighted that the earliest sedimentation in SC occurred at 3.5 Ga with the deposition of the OMG, but much later in the Dharwar craton (DC) with the deposition of Sargur (3.3–3.1 Ga). According to Sharma, the correlation among cratons of the Indian shield is difficult because of unequal erosion, differing metamorphic grades, vertical tectonics, dissimilar igneous activities and varying proportions of greenstone and tonalitic gneisses. Y. J. Bhaskar Rao (CSIR-NGRI, Hyderabad) reviewed the emerging views on Mesoarchaean crustal evolution. He mentioned that about 72% of the earth's continental crust was extracted by the end of the Archaean Eon, with major peaks in the rate of juvenile crust formation during the Neoarchaean around 2.7 and 3.0 Ga. However, controversy persists on the dominant mechanism of juvenile crust accretion, where the central theme of discussion concerns the relevance of the plate tectonics paradigm in explaining Archaean geodynamics.

The next five talks were devoted to the status of geological, geochemical and geochronological studies from SC. Joydip Mukhopadhyay (Presidency University, Kolkata) covered the aspect of the Archaean stratigraphy of SC and provided an overview of the ages of various geological formations of SC and the tonalite – trondhjemite – granodiorite (TTG)-D core with three phases of emplacement at 3.44, 3.29 and 3.1 Ga. He also highlighted the significance of the Iron Ore Group (IOG) as one of the oldest global records of ocean basin development, bimodal volcanism, deep-water sedimentation, and modern day-like geodynamics. B. Sreenivas (CSIR-NGRI, Hyderabad), in his talk on Palaeo- to Mesoarchaean redox conditions and biogeochemical evolution, also emphasized the potential of the Banded Iron Formation (BIF) in the IOG to unravel the oceanic oxygenation during the Palaeoarchaean. Pulak Sengupta (Jadavpur University, Kolkata) presented an overview on the metamorphic evolution of the North Singhbhum Fold Belt (NSFB) sandwiched between SC to the south and Chhotanagpur Granite Gneiss Complex (CGGC) to the north. NSFB records geological evolution from ~1.6 to 1.0 Ga. He synthesized the existing information on: (a) boundary relations of NSFB with SG and CGGC, and (b) the intensity of metamorphism, metamorphic *P–T* path and regional variation of the grade of metamorphism in the NSFB and their tectonic significance. Gautam Ghosh (Presidency University, Kolkata) described the crustal remobilization along the craton margin through tectonostratigraphic analysis of the supracrustal sequences from the northern and southern margins of SC and concluded that the region has undergone repeated tectonic pulses after early stabilization. He reported a Pan-Africa (~0.5 Ga) transpressional event from the southern margin. C. Manikyamba (CSIR-NGRI, Hyderabad) presented the results of the high field strength elements (HFSE), rare earth elements (REE) and platinum group elements (PGE) compositions of metavolcanics of OMG, western IOG, and Malangtoli lava. She inferred that the IOG volcanic rocks correspond to intra-oceanic arc setting with polygenetic crustal signatures and the basalts of Malangtoli are affiliated to transitional arc to rift-controlled back arc tectonic setting.

In the geophysical studies session, six talks were presented covering a general overview of the Indian lithosphere as well as new results from SC and adjoining regions. M. Ravi Kumar (ISR, Gandhinagar) elucidated the paradox of seismic lithosphere beneath the Indian cratons. He reviewed the work done on Indian cratons to map the seismic lithosphere – asthenosphere boundary (LAB) and the discrepancies in the results obtained by seismic tomographic studies, receiver functions and other observations like magnetotelluric, heat flow and xenoliths. He attributed the discrepancies between the results to uneven sampling or anisotropic effects. Prantik Mandal (CSIR-NGRI, Hyderabad) presented seismological results on the nature of crust–mantle structure and mantle anisotropy underlying the region. He obtained

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the thinnest crust of 37 km overlying a thin lithosphere of 58 km below the region near South Singhbhum Shear Zone and attributed this to the 1.6 Ga plume activity associated with Dalma volcanics. The thickest crust of 47 km overlying a thin lithosphere of 85 km in his model is noticed below the region near the Singhbhum granite and he attributed this to lithospheric delamination. He reported that the LAB beneath SC is thinner than the LAB beneath CGGC. A. P. Singh (CSIR-NGRI, Hyderabad) presented a model of the 3D lithospheric density structure of SC based on the integrated analysis of satellite gravity and geoid anomaly and topography data. His results reveal a relatively flat Moho at 35–40 km depth and LAB at 130–140 km depth beneath SC and adjoining CGGC. Labani Ray (CSIR-NGRI, Hyderabad) reported preliminary results on the radioelemental studies being carried out for the northern part of SC covering the OMTG and three phases of the Singhbhum granite (SG Phase I, II and III). Preliminary results reveal that the radiogenic heat production of SG phase III is marginally higher than other formations. O. P. Pandey (CSIR-NGRI, Hyderabad), in his talk, mentioned that Indian cratons have been repeatedly rejuvenated since at least 1.5 Ga, and SC appears most unusual. This craton, marked with circular mor-pho-structures of large dimension, is rejuvenated, eroded and uplifted to the tune of more than half a kilometre and the underlying lithosphere is anomalously thin (65–75 km). There is no deep seismic profile across the SC. Laxmidhar Behera presented the wide-angle seismic results from the adjoining Mahanadi basin.

The presentations on both days were followed by interactive discussion sessions on the work presented as well as the gaps and future directions. Salient points that emerged from the discussion are listed below.

- Is the lithosphere of SC thin? If so, when did the delamination take place, assuming initially craton-type thick lithosphere for this region? The lithospheric thicknesses obtained by different geophysical methods have a fairly wide range of variations, though the new results presented in the workshop have an upper limit of 140 km, implying that it is probably thin compared to the global estimates of >200 km. There is a need to adopt an integrated geophysical approach to arrive at a unified model of the lithospheric thickness of SC.
- Are the signatures of the Hadean crust present in SC? The elusive Hadean crustal signatures might be present in this region as SC potentially comprises the oldest crustal remnants in the Indian shield. We need to tap detrital zircon populations from supracrustals and OMG to substantiate this.
- Longevity of the magma chamber that sourced the Singhbhum granites – Singhbhum granite has three phases of emplacement, which span in time from 3.4 to 3.1 Ga. It is puzzling that the magma chamber existed for such a long duration. Geochemical and field data might provide insight into the depth of the magma chamber at different times within this time-span.
- Oldest rocks from the CGGC – As of now, no rock older than ~1.6 Ga has been reported from the CGGC, suggesting that has not played any role in the formation of NSFB. However, the tectonic trend of the NSFB along with late Palaeoproterozoic to early Mesoproterozoic metamorphic age requires that the northern cratonic block (presumably CGGC) should be older than ~1.6 Ga. To solve this dichotomy, a concerted effort is needed to date the rocks of CGGC.
- Assemblage of cratonic blocks of the Indian shield – Differing properties of the cratonic blocks of the Indian shield raise a question as to whether these blocks were together or they came from somewhere else. To test this, it was suggested to apply 2–3 different geochronological techniques.
- Unexplored western part of SC and NSFB – This region is largely unexplored. Rigorous geological/geochemical work is needed to build the stratigraphy of this region.
- Focused short-duration geophysical programmes in IOG, Singhbhum Shear Zone (SSZ) and supracrustals – These may be taken up to map the buried ore bodies in and around the present mining areas. A joint workshop with mining companies may be hosted to understand their requirements and plan surveys accordingly.
- Integrated geophysical, geological studies in corridors – (i) About 3 to 4 profiles across the southern part of the NSFB and CGGC to improve the existing tectonic models that rely on observed structural elements in rock formations. (ii) One profile across the southern margin of SC passing through Talchier and Rangali regions to find whether the Eastern Ghats Mobile Belt is crossing Rangali.

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