International Symposium on Precambrian Accretionary Orogens at University of Delhi and Field Workshop in the Dharwar Craton, Southern India – T.R.K. Chetty, NGRI, Hyderabad - 500 007

There have been significant advances in recent years in understanding and extending the concept of Plate tectonics to the Archaean period addressing the issues such as plate interactions, lithospheric deformation and continental growth. In recent years, geological and tectonic history of the continents was explained by the concept of orogens. Realizing the strong need to bring these interesting results of Dharwar craton, it is befitting that Prof. M. Jayananda and his colleagues thought of organizing an international symposium by inviting many scientists of national and international repute to review the current status and to explore new lines of research for the future. The major focus was on the current understanding of the Precambrian accretionary orogens and to identify important scientific issues to be addressed in future research.

In the last two decades, there have been significant publications characterizing the Dharwar craton in terms of structure, petrology, geochemistry and geochronology by several workers, particularly from the group of Indo-French international collaborative program. The results culminated in a successful event of 2-day (2-3 Feb 2011) symposium at Delhi University and 8-day field excursion (4-11 Feb 2011) in the Dharwar craton, jointly organized by the University of Delhi and the Geological Society of India.

The symposium was excellently organized with inaugural function on 2nd February 2011, and the Chief Guests included Prof. Harsh Gupta, President, Geological Society of India, Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Government of India, Prof. S.K. Tandon, Former Pro-Vice-Chancellor, University of Delhi. The inaugural ceremony was presided by Prof. Vivek Suneja, Pro-Vice-Chancellor, University of Delhi. Prof. Harsh Gupta emphasized the importance of understanding the deep structure of the continents in view of recent seismicity in stable continental regions.

Both the events were very successful and the field workshop was very impressive and exciting with fruitful discussions and debates. The field workshop generated new stimulus and provided insights on the scientific issues that require urgent attention from the global Earth Science community.

There were eight thematic scientific sessions during the symposium: (i) Origin of continents: Early Earth Evolution (4.0 to 2.5 Ga); (ii) Tectonics of Precambrian accretionary orogens; (iii) Metamorphic evolution of Precambrian accretionary orogens; (iv) Geophysical constraints on the structure of Precambrian accretionary orogens; (v) Archaean TTG, potassic granites and mafic dykes: Insights into juvenile magmatism, continental growth and reworking; (vi) Precambrian sedimentary basins; (vii) Precambrian greenstone belts: Insights into mantle dynamics, metamorphism and lithosphere evolution and (viii) Mineralization, Mining and Industry.

The symposium culminated with Concluding Session and Recommendations. There were about 18 foreign participants and a total of 120 Indian participants including research scholars. There were totally 12 invited keynote talks covering the sessions.

Bor-ming Jahn described the crustal evolution of Shandong province of North China craton with the help of SHRIMP U-Pb zircon age data ranging between 3.2 to 2.5 Ga. His review suggested that an early Neoarchaean (2.75 to 2.7 Ga) tectono-thermal event is widespread in the western and eastern Shandong provinces. In contrast, the craton is better known for a strong tectono-thermal event in the terminal Archaean (2.55 to 2.5 Ga) resulting in both crustal growth and intra-crustal recycling.

M. Ramakrishnan explained the advances in understanding the orogenic processes, while presenting a review on the crustal evolution of Dharwar craton. According to him, the Sargur Group (3 to 3.3 Ga) deposited on a putative sialic basement (>3.4 Ga) was involved in the subduction of oceanic plateau to produce TTG batholith (2.9 to 3.0 Ga) of Peninsular gneiss covering the entire Dharwar craton. He also advocated that the evolution of Dharwar craton is comparable to modern accretionary orogens (Pacific or Miyashiro type) that did not culminate in continent-continent collision.

Michael Brown addressed an important topic of one-sided subduction that generates lower thermal gradients in the subduction channel and higher thermal gradients in the arc-back-arc or orogenic hinterland of the over-riding plate. This kind of duality of...
thermal regimes is the hallmark of one-sided subduction and paired metamorphic belts are the characteristic imprints of this thermal structure in the geological record. He also opined that the change to one-sided subduction must have commenced locally in the Mesoarchaean–Neoarchaean Eras and became global in the Paleo-Proterozoic, which was a landmark event in the Earth’s history. Somnath Dasgupta reviewed the significant advances in the last two decades that took place in understanding the nature of Proterozoic tectonothermal events in India. The thermal history of Peninsular India was described in the order of geochronological sequence from the Early to Paleo-Proterozoic tectonothermal event (~ 2500 to 1800 Ma) recorded in Southern Granulite Terrain (SGT), Paleo-Proterozoic to Early Meso-Proterozoic UHT event (Ca. 1800 to 1500 Ma) from the Central Indian Tectonic Zone (CITZ) (~ 1.6 Ga) and other parts of Aravalli-Delhi Mobile belt and the Eastern Ghats Mobile Belt (EGMB); Late Meso-Proterozoic and Grenvillian event (Ca. 1300 to 900 Ma) from the high grade rocks in NE India and some parts of CITZ and the EGMB; and Neo-Proterozoic Pan-African event (Ca. 650-500 Ma) in SGT. These are correlated with the successive stages in the evolution of Columbia, Rodinia and Gondwana supercontinents.

J.F. Moyen considered the range of existing Archaean granitoids, first from a global perspective as well as within the context of the Indian Dharwar craton and concluded that the existence of different granitoid types represent markers of distinct tectonic environments during the Archaean. He also described various characteristics of granitoids in the western and the eastern Dharwar craton, as small plutons of crustal potassic granites and a range of granitic types respectively which are largely described as mantle originated granitoids. Jaana Halla described the existence and timing of Archaean felsic crust suggesting that the modern tectonic processes must have operated in the same way to transform mafic crust into felsic during the Earth early history. She suggested that the geochemistry of Archaean granitoids would indicate how and when the modern style subduction processes began. She also pointed out that the slab-break off was responsible for the formation of Sanukitoids, which are volumetrically minor but geodynamically important series of potassic granitoids, enriched in incompatible elements (Ba, Sn and LREE), but also having relatively high content of compatible elements (Mg, Ni and Cr).

Abhijit Basu emphasized the importance of robust geochronology, while reviewing the traditional and modern constructs of the geology of Purana basins of India. The ages, on a regional scale, indicate: (i) the Purana basins are older by about 500 Ma than in the 20th Century view; (ii) the extant C-isotope stratigraphy of Purana basins is not time-marked; (iii) the real fossils identified in Purana are much older and may have had longer age – ranges; (iv) it remains to be tested if the putative interbasinal correlation can be achieved by stromatolite stratigraphy and (v) selected carbonate rocks from these basins are yet to be raided giant store house for information on the ocean-atmospheric interaction and tracking of global oceanic oxygeneration or sulphidization during Meso-Proterozoic. Robert Dall’Agnol described the evolution of granitoids from the Mesoarchaean Rio Maria granite.
greenstone terrane, eastern Amazonian craton, Brazil. He has envisaged a tectonic model involving hot subduction underneath a thick oceanic plateau for the origin of different granitoid suites.

Bhaskar Rao presented recent result comprising zircon in-situ analysis aided by electron microprobe BSE/CL imaging, LAM-ICPMS U-Pb ages and estimation of U, Th, Zr, Hf, Y, Yb abundances for understanding the crust formation in western Dharwar craton. He concluded that younger zircons with ages between 3.1 and 2.5 Ga from the Dharwar craton indicate increasingly recycled crust that manifest in younger granites and granitic gneisses. Significant addition of juvenile magmas into the Dharwar crust between Ca. 3.36 to 3.2 Ga is also emphasized. Zorano Sergio de Souza, described five episodes of magma generation from 3.41 to 3.03 Ga, cycled each at 100 Ma, from the Sao Jose de Compestre Massif NE Brazil. Another episode was at 2.66 Ga after an apparent quiescence. He proposed a model of convergent tectonics and considered the generation of magmas by partial melting of hybridized lithospheric mantle, generating Mg-andesite that subsequently evolved by hybridization to form the mantle and crustal pressure to form the differentiated series.

Ewa Slaby explained the early evolution of the whole Earth system from the rock records of Archaean craton. She addressed the issue of volatile elements in the petrogenesis of both mantle and crust derived magmatic rocks during the Archaean and suggested that some additional mechanisms like mixing, admixing and interaction could lead to large compositional diversity in terms of trace elements. Balaram emphasized on the importance of ground and surface waters in geochemical exploration and in search of minerals. He emphasized the lack of interest in the exploration of Platinum Group of Elements. He provided the list of mineralized areas of interest such as Baula-Nuasahi ultramafic complex in Orissa, Madawara Igneous Complex in Uttar Pradesh and the Sittampudi-Bhavani layered mafic-ultramafic complexes in Tamil Nadu.

In addition to the above keynote talks, there were several interesting presentations (both oral and poster) dealing with different aspects of geology and geophysics related to the thematic sessions.

Regionally and globally several areas were covered, apart from cratons of Indian shield, North China craton, Kyrgyzstan, Southern Canadian shield, Australia, Brazil Finnoscandinavia and Antarctica. The main focus was on the crustal evolution of several terranes in India, the important being Dharwar craton, Bastar craton, Eastern Ghats Mobile Belt, Southern Granulite Terrain, Aravalli-Delhi Collisional orogen, Central Indian Tectonic Zone, etc. The geodynamic evolution of these terranes were mostly compared and correlated with the processes of modern orogenic belts. Further, Precambrian cratons and the adjoining mobile belts are increasingly addressed in the light of accretionary orogenic processes culminating in collision tectonic regimes.

An excellent abstract volume extending to 168 pages was published by the Geological Society of India covering the technical program of the symposium. There were 45 oral and 40 poster presentations. The symposium finally concluded with a panel discussion moderated by Prof. Borming Jahn, Prof. Michael Brown and Dr. M. Ramakrishnan. Several issues were covered including the global issues on the origin and tectonic evolution of Archaean cratons, regional issues pertaining to Indian cratons and international scientific cooperation involving Indian scientific groups specifically in the areas of geochronology. The specific issues recommended for future research including secular changes in the tectonic styles and accretionary processes through Archaean, Proterozoic and Phanerozoic, what can we learn from Dharwar craton in terms of magmatism, metamorphism and tectonics, sedimentary basins and shifting from anoxic to oxygenated environments, cratons and supercratons, coupling of exogenic envelopes and endogenic reservoirs and mineral endowment. The organizers did a very commendable job in making the symposium a successful and memorable one.

Field Workshop

This field workshop is the culmination of a long-lived (1988-2010) collaborative and multi-disciplinary research program between Indian and French scientific groups on the geological evolution of Dharwar craton. There were 14 foreign participants and 26 Indian participants including 10 research scholars from different Indian universities. An excellent field guide book was prepared jointly by Prof. M. Jayananda and Prof. D. Chardon incorporating colourfull field geological and structural maps, integrated cross sections, 3-D schematic tectonic models, field photographs etc., and a range of details dealing with petrology, geochemistry and geochronology. The field workshop covered large section of exposed Archaean continental crust passing through boundary shear zone in the Dharwar craton including different age provinces, metamorphic grade and crustal thickness. It was a great opportunity for the field participants, particularly younger scientists, to have the guidance and the information from Prof. M. Jayananda, who guided the entire field excursion. He provided many details of the geological history of every outcrop covering integrated aspects of field geology, structural setup, petrology, geochemistry including isotopic and geochronological data. There were lively discussions at each outcrop debating on various alternate interpretations and tectonic models covering the fundamental aspects of the accretionary processes, geodynamic settings and cratonization of lithosphere during the Precambrian with special reference to Dharwar craton. On the first day, a visit was organized to internationally well known Kabbaldurga quarry exposure where participants had a lively interaction on spatial link between magmatism, fabric development and metamorphism. Second day, a crustal section from Bangalore to Hassan covering processes of mafic-felsic magma interaction in the Closepet granite, 3.55 Ga spinifex textured komatites at Banasaandra belt and 3.0 Ga high potassic Bellur-Togamangala plutons. The whole of third day was dedicated to the Holenarsipur greenstone belt and surrounding TTG gneisses where spectacular dome-keel structures, vertical tectonics, metasediments and oldest dated Gorur gneisses have been visited (Fig.3).

On the fourth day, a traverse across the
crustal section from Hassan-Kudremukh was undertaken visiting the basement-cover relationship at Sigegudda belt (Fig.4) and the abandoned Kudremukh iron ore mines. The Kudremukh Iron Ore Company (KIOCL) had arranged the visit to mines with good reception. There was also an interactive session on the issues of mining and environment at KIOCL. The whole of fifth day was dedicated to the Bababudan basin, starting from the polyphase basement through the basement–cover contact to the highest stratigraphic level about 1900 m altitude (Fig.5) discussing various aspects of greenstone development including the kinematics, radial convergent flow of high density mafic crust into low density basement and deposition of thick Banded Iron Formations as markers of the shifting of environments. On the sixth day, ENE traverse from Chikmagalur to Sira across the craton crossing the boundary shear zone visiting interesting exposures of chromitite layered Banavara fuchsite quartzite, 2.62 Ga Arsikere granite, 3.3 Ga TTG basement at the western margin of Chitradurga belt, mylonitic 3.0 Ga Bukkapatna granite marking the boundary shear zone, 2.74 Ga Javanagondanahalli volcanic and 2.5 Ga Maddakkanahalli pluton. On the seventh day, the group made a traverse from Bangalore to Madanapalli to see the late Archaean (2.55-2.53 Ga) juvenile gneisses (Fig.6) and plutons and mafic dyke swarms. Numerous lively discussions and debates among the participants on the juvenile magmatic accretion processes, reworking and also tectonic context of accretion culminated the day. An interaction cum concluding session of field workshop was held in the A.P. Tourism hotel on the Horsley hills top on the night where many participants, particularly young Indian participants, spoke about their experience and how they were benefitted from the interactions with globally known experts. Great appreciation about the organization, wonderful crustal section chosen and quality of exposures with all data base has been expressed by the participants.

Finally, it is hoped that the field work provided new stimulus and insights to address current scientific issues of global relevance and interest and a new international scientific cooperation will be launched in understanding the geodynamic processes of primitive Earth keeping the Dharwar craton as a central theme.