MEETING REPORT

Palaeomagnetism and rock magnetic research in India*

The main purpose of the workshop was to bring various active groups working on 'palaeomagnetism and rock magnetism' on a common platform to review the approaches of the on-going programmes with an objective of enlarging the scope and visible impact of these studies.

T. M. Mahadevan (Atomic Minerals Division) delivered the inaugural address, tracing the history of palaeomagnetic research in India. He focused his attention on the current research activities encompassing new vistas of applications for continental reconstructions, magnetostratigraphy, environmental magnetism and structural fabric studies, etc. in the Indian scenario. He suggested that solving problems of the evolution of complex terrains in India could be achieved by careful integration of several methods, of which palaeomagnetic and rock magnetic data constitute an important component. His lecture, with examples of unique stratigraphic features of the Indian peninsular shield and the Himalaya, steered the presentations of the workshop and the interactive discussions to devise some future programmes.

The second day of the workshop focused on the principal objectives and status of the on-going programmes. The presentations commenced with a talk by T. Radhakrishna (CESS, Thiruvananthapuram), wherein available Indian palaeomagnetic data of the Proterozoic have been evaluated with some suggestions for future study. Following this, Basu Mallik (Jadavpur University, Kolkata) highlighted the problems in establishing the Phanerozoic APW path of India, particularly with reference to the Gondwana Supergroup. S. K. Patil (IIG, Mumbai) emphasized the significance of new palaeomagnetic data from selected mafic dykes of the Dharwar craton to extend the Proterozoic APW path for the period of 2000 to 2500 Ma. N. R. Krishnendu (CESS, Thiruvananthapuram) brought out new evidence for 1650 Ma thermal/tectonic event from the dykes in the Dharwar craton, bordering the Cuddapah Basin in the west. D. R. K. Rao (Hyderabad) spoke about developments in instrumentation and explained the ideal configuration of a palaeomagnetic laboratory. K. Venkata Rao (GSI, Nagpur) stressed upon the importance of incorporating geological and geophysical inputs in establishing polarity sequence in Quarternary sediments of the Narmada valley. A. K. Mullick (ONGC, Dehradun) traced the importance of on-going magnetostratigraphy work in Siwalik with special reference to K/T problems and hydrocarbon prospecting. B. R. Arora (IIG, Mumbai) explained, using the interpreted magnetization age of 1000 Ma for the Oddanchatram anorthosite pluton, that the role and extent of thermal imprints of the Pan-African have been overestimated in the South Indian Granulitic Terrain and the scope for similar studies on other anorthosite bodies. M. A. Mamtani (IIT, Kharagpur) and P. K. Verma (Vikram University, Ujjain), in two separate presentations, highlighted the emerging scenario of integrating petrofabric with AMS studies to gain insights into regional structural studies. They illustrated the applications of the AMS studies in structural geology with special reference to Aravalli craton in Rajasthan. Mathew Joseph (GSI, Thiruvananthapuram) outlined the nature of palaeointensity variation in relation to Mesozoic low to Neogene high field transition. R. Venkatachalapathy (Annamalai University, Annamalainagar) showed that archaeomagnetic intensity studies on recently excavated artifacts from Maligaimedu, Tamil Nadu compared well with secular variation curve for the interval of 100 BC to 800 AD.

Three talks were presented from interrelated disciplines of isotopic dating, sedimentation and stratigraphy and granulites. Emphasizing the importance of isotopic dating of the palaeomagnetic poles for drawing APW paths, S. Balakrishna (University of Pondicherry, Pondicherry) deliberated upon the need-based isotope mineral dating techniques, such as U–Pb isotope dating of zircon, baddeleyite, titanite or monazite. Vibhuti Rai (University of Lucknow, Lucknow) illustrated Rodinia reconstructions primarily based on the biostratigraphic correlations and emphasized the importance of integrated biostratigraphic and magnetostratigraphic investigations in Purana basins. G. R. Ravindra Kumar (CESS, Thiruvananthapuram) enumerated petrological and geochemical results emerging from the South India Granulitic Terrain that can be vital inputs to understand the processes controlling the magnetic properties of lower crustal rocks. The discussion on his presentation re-emphasized the need of extending palaeomagnetic work to basement rocks. A concluding session chaired by K. R. Gupta (Department of Science and Technology, New Delhi) was devoted to discuss the future studies.

The presentations and the following discussions drew a few recommendations to guide future research in India: a refinement of the Proterozoic APW path by establishing palaeopole data from the dyke swarms (and other igneous suites) of the Dharwar, Singbhum and Aravalli cratons and extending the studies to the Purana basins is vital for assessing pre-Gondwana supercontinental assemblies and the kinematics of the Indian Shield through time. Investigations on the sedimentary basins should also aim, in spite of complexities due to their great age, to derive magnetostratigraphy from these oldest records of sedimentation on the Indian craton. For meaningful interpretations, these investigations should be coupled with those of petrology and geochemistry, and accompanied by isotopic dating on the igneous rocks. Studies on the sedimentary basins should be accompanied by chemostratigraphy and biostratigraphy. Efforts to refine the Phanerozoic palaeomagnetic record appear to be frustrated by the serious Deccan/Rajmahal overprint problems and paucity of suitable rock facies, but continuing efforts in Phanerozoic palaeomagnetism should help to evaluate the effects of the thermal impact and may succeed in obtaining a few pole positions in favourable circumstances. AMS study is shown to be a

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potential tool for working out deformational fabrics in rocks where mesoscopic signatures are obscure and use of this technique needs to be more fully explored to trace the strain variations across the cratons, to work out basement cover relations and to deduce direction of magmatic flow, especially in the light of recent investigations in the Mackenzie swarm of the Lawrentian Shield. The preliminary palaeointensity results on Cretaceous dykes have shown that there is scope for further work, particularly for understanding the secular variations of the magnetic field and polarity transitions. Studies on the Himalayan foreland basins are regarded as crucial for establishing stratigraphic correlations, evaluating the neotectonic movements and uplift history, resolving rates of sedimentation and determining palaeoclimatic changes during the latter part of Cenozoic–Recent times. The workshop recommended upgrading and enhancement of facilities with introduction of SQUID and JR-5 spinner magnetometers, AF demagnetizers with ranges up to 200 mT, thermal demagnetizers, KLY-3S Kappabridge, Curie balance, IRM, VSM and thermomagnetic experimental facility for VFTB and AFGM and to hold two contact programmes/summer schools on advanced palaeomagnetic techniques and on application of AMS techniques. The vital link of palaeomagnetism with isotope dating is well recognized and it is imperative that additional isotope dating facilities are established. Other aspects that came up for discussion included applications to archaeomagnetism, laterites, soils, suspended particles in oceans and atmosphere for understanding monsoon climatic changes. A more detailed report has appeared in the *DST Newsletter* (2002, **12**, 13–14).

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RESEARCH NEWS

The controversy over early-Archaean microfossils

A. V. Sankaran

Few events in early earth history – whether they were concerned with the chemical, physical or biological aspects of the planet's evolution – have remained undebated, emerging views uncontested and which did not polarize the debating scientists into differing groups. The latest example is about discoveries of ancient fossils[1–6] from the Archaean (2.5–3.8 b.y. period) which have generated much controversy about their authenticity and antiquity. Palaeontologists were undoubtedly excited when these discoveries were first reported, since these helped to modify the view that the Archaean era represented an 'azoic' or lifeless geological time. Besides bringing about this change in their perspective, the finds also infused fresh 'life' to fossil studies and shifted the emphasis from conventional approaches based on geology or morphology to sophisticated analytical techniques to solve not only problems about biogenecity or antiquity, but also enhance our understanding of organic metamorphism and biochemical evolution of the organisms. Though plenty of new data emerged from these innovative approaches, they also triggered a fresh volley of debates.

The life forms that existed during the Archaean and pre-Archaean were bacteria and single-celled archaea lacking nucleus (prokaryotes), and they thrived in aquatic environments. Hence sediments deposited in water were the obvious choice of palaeontologists to look for early life. Unfortunately, the first half-billion years of the earth's history were marked by high flux of harmful UV radiation and impacting meteorites leading to development of extreme temperature, all disastrous for preservation of sedimentary rock-records of bacterial life. Hence the hunt for the fossils necessarily had to be limited to the few surviving sedimentary domains (cherts, greywackes, metapelites, banded iron formations) and to sites of structures known to be influenced by bacterial colonies[7]. Thin sections of such sedimentary rocks and structures (stromatolites and oncolites) from several countries have, in fact, shown fossilized cells of filamentous organisms, replaced by pyrite (Fe-sulphide), hematite (Fe-oxide) or silica. Some of them are from Warawoona Group, Pilbara Block, NW Australia[2,8–12], Onverwacht Group, Barberton Mountain land, South Africa[4,13], Gunflint Formations, Canada[3] and a few more sites in USA[14] and India (schists and iron formations in Karnataka, Orissa and Madhya Pradesh)[15–17]. While these are direct fossil-finds, indirect clues like isotopic, spectral or other signatures typical of biologic origin preserved in the rocks and minerals have indicated existence of life during Archaean and even earlier times. For example, forms of life even prior to 3.8 b.y. have been inferred from apatites hosting distinctly biogenic carbonaceous inclusions occurring in banded iron formations (BIFs), Isua Supracrustals, Greenland[1,6].

Initial excitement over the discoveries of Archaean fossils waned soon as questions were raised about their biogenecity, antiquity and contemporaneity with host rock formation. Some of the finds were rejected as they did not meet these criteria for acceptance as genuine fossils. Especially, two well-cited early Archaean-period occurrences have been challenged in recent years. One of them is about the biogenecity of the reported 'oldest microfossils' (3.3–3.5 b.y.) from western Australia[2,5,10]. These were first observed in 1986 by Schopf and Packer[2], University