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EDITORIAL

Marine geophysical research in India – new challenges

The solid surface of planet Earth, in general, consists of rocks of two distinctive age groups, viz. oldest and youngest. The rocks beneath the continents are the oldest, about four billion years, while those beneath the oceans are significantly younger, no more than 280 million years. The process of continental break-up was envisaged way back in 1912 by a German scientist, Alfred Wegner based on some key scientific evidences and near-perfect match of coastlines. However, the hypothesis was not accepted by the scientific community as the premise failed to explain the physical mechanism involved in moving outweighed continents. In 1960s, the ocean floor data, particularly the Earth's ancient magnetic fields frozen in the rocks on either side of the mid-ocean ridge (Hess, H., *Geol. Soc. Am.*, 1962; Vine and Matthews, *Nature*, 1963; Tuzo-Wilson, *Nature*, 1965; Dan McKenzie, *J. Geophys. Res.*, 1966) opened a new vista on continental fragmentation and expansion of the ocean floor. Almost a decade later, Morgan (*Nature*, 1971 and *Geol. Soc. Am. Mem.*, 1972) proposed a classical hotspot model explaining the mechanism of upwelling of buoyant lower-mantle material to the surface of the Earth. These two hypotheses together have changed the perspective of the global Earth science community in understanding its dynamics.

In late 1950s, the Scientific Committee on Oceanic Research along with the Intergovernmental Oceanographic Commission of UNESCO commissioned the International Indian Ocean Expedition (IIOE) programme for mapping and understanding the basic features of the Indian Ocean. When the IIOE was reaching the concluding phase, a strong need was felt by India to setup an oceanographic institution for practising the learned skills and to discover more about the Indian Ocean; this led to the establishment of the National Institute of Oceanography (NIO) in Goa as a CSIR National Laboratory in 1966. In 1973 a few researchers from Geological Oceanography at NIO initiated marine geophysical activities. Around the same time, Andhra University as an academic institution recognized the importance of marine geophysics education in India; thus it took the responsibility of introducing the subject for the first time in India in its Master's curriculum. In 1974, the first indigenous geophysical (magnetic field) observation was made on-board INS *Darshak* in the Arabian Sea by researchers from the National Geophysical Research Institute (NGRI), Hyderabad. In the subsequent year, the Oil and Natural Gas Corporation Ltd (ONGC) commissioned the first fully equipped geophysical vessel *MV Anveshak* and carried seismic regional surveys in the Arabian Sea.

H. N. Siddique, who then headed the Division of Geological Oceanography at NIO envisioned the importance of marine geophysical research in India for developing evolutionary models of the Indian Ocean lithosphere and for inputting critical constraints to various branches of geology to unravel the physical processes. With the commissioning of *RV Gaveshani* in 1975, more systematic geophysical experiments begin on the western margin of India. Keeping the subject of marine geophysics at the forefront, Siddique set up a team of researchers to pursue different aspects of Indian Ocean lithosphere. They acquired further technical expertise with assistance from Norway under the NORAD programme and scientific expertise from Russia under the ILTP and TIOG bilateral programmes. The developed capabilities were utilized for carrying out experiments on-board the research vessels *RV Gaveshani*, *ORV Sagar Kanya* and a few chartered vessels in important regions of the Indian Ocean. Further, these researchers collaborated with institutions in France, UK, USA, etc. to establish a clear lead in certain aspects of the Indian Ocean.

During the last four decades, marine geophysicists have researched some of the complex features of the Indian Ocean and resolved many enigmatic science questions for a better understanding of the dynamics of the Indian Ocean lithosphere. Some of the noteworthy studies are mapping and genesis of unusual plate tectonics features like palaeo-propagators in the Arabian and Eastern Somali basins (Chaubey *et al.*, *Geol. Soc. London*, 2002), determining the nature of the crust in the Laxmi Basin of the Eastern Arabian Sea (Krishna *et al.*, *Tectonics*, 2006), establishing the two-phase continental break-up process initially at 132 million years ago (Ma) from the eastern margin of India and later at 120 Ma from Rajmahal–Sylhet Line for explaining the splits between Greater India and East Antarctica (Talwani *et al.*, *J. Geophys. Res.*, 2016), unravelling the onset timing of Bengal Fan sedimentation in the Bay of Bengal (Krishna *et al.*, *Curr. Sci.*, 2016, **110**(3), 363–372), understanding the Indian plate break-up process into three sub-plates and also resolving the major discrepancy in the timing of intraplate

deformation between plate reconstructions and seismic stratigraphy (Krishna *et al.*, *Geology*, 2001; *Geology*, 2009), composing new insights on interactions between the once active Wharton Ridge segments and Kerguelen mantle plume during the formation of long, linear, aseismic, Ninetyeast Ridge (Krishna *et al.*, *J. Geophys. Res.*, 2012), determining the onset timing for opening of the deep Andaman back arc basin and its tectonic evolution (Kamesh Raju *et al.*, *Earth Planet. Sci. Lett.*, 2004). These tectonic models and proposed hypotheses are being extensively used by researchers from national and international institutions for advancing their understanding to new levels and also for resolving interspersed geological aspects. Thus, the new science generated from marine geophysical research in India has brought value and pride to the nation.

The expertise in marine geophysics developed at institutions, like NIO and NGRI has become useful and self-reliant for the execution of a nationally important project – Commission on the Limits of the Continental Shelf (CLCS) – for claiming additional seabed territory, thereby extending the present exclusive economic zone on both the eastern and western continental margins of India. On a future source of energy front, NGRI and NIO have together implemented an ambitious programme using various geophysical parameters and long sediment cores for understanding the gas hydrates system in the Krishna–Godavari Basin. Researchers from ONGC, NIO, NGRI and Oil India Ltd jointly contributed to another project, the National Gas Hydrate Programme under the Directorate General of Hydrocarbon, for drilling thick sedimentary strata in the eastern and western offshore basins of India for exploration of gas hydrates.

Although a few universities and institutions from India are involved in marine geophysical research, NIO remains in the forefront, for focusing on many intriguing geological problems of the Indian Ocean. This has led the Institute to become not only a Centre of Excellence in this field in India, but also one of the well-recognized institutions among the marine geophysical organizations of the world working on the Indian Ocean. With the passage of time, the first generation of marine geophysicists in India had superannuated, but did not pass on the expertise developed during the last four decades to the next generation for various reasons, resulting in the creation of some hiatus in the sustenance of learned expertise. This has happened largely because of less manpower recruitment and lack of wisdom in strengthening and/or sustaining marine geophysical research. On the whole, marine geophysical research in India had witnessed continuous growth during its first phase. Now it is a great challenge to the present generation to sustain all the developed skills and expertise, and learn new developments/technologies in order to scale new peaks in the field of marine geophysics. This can be achieved with a good number of exciting and fascinating students in the subject. Further, the new generation scientists must focus on resolving exciting science problems such as genesis of the 85°E Ridge, break-away location of the Elan Bank from the eastern margin of India, and nature of the crust beneath the Laxmi and Laccadive basins, etc. The new understandings are expected to provide more certainty of continuity of continental rocks into the offshore regions, continental assemblages and role of sediments in transforming the gravity fields.

During the last two decades, a few more institutions, particularly Geological Survey of India and National Centre for Polar and Ocean Research have initiated organized experimentation and research in the field of marine geophysics. Thus, a couple of institutions in India at present are pursuing marine geophysical research in addition to the generation of new datasets in waters around the Indian mainland and deep-water regions. Unfortunately, no organized coordination seems to be present among these institutions regarding experimental plans and their main purposes. The meagre communications between the institutions led to either duplicate or outsized overlap datasets in many parts of the Bay of Bengal and Arabian Sea. Further, there is no viable mechanism currently in place for exchanging and sharing data between institutions and making data available to individual researchers working in various academic institutions of the country. This is indeed a serious concern for the geoscience community. It may possibly be overcome by setting up a national-level monitoring body involving senior members from all concerned institutions in the field of marine geophysics, or with the help of advisory boards of these institutions.

Another equally important issue is the archival of marine geophysical data at the national level. A few institutions do maintain their own data centres for certain parameters; these holdings are known and available only to the researchers working in those institutions. Many of the advanced countries store all parameters of decades-old marine geophysical data acquired under international and national programmes, and make them available to researchers working in any part of the world. World Data Centers for Marine Geology and Geophysics established in USA, Russia and China are such examples for holding global data, while NOAA's National Centers for Environmental Information (formerly the National Geophysical Data Center) provides public access to the scientific community. Likewise, India should maintain a national-level data centre to make data available to researchers, working on a variety of important scientific problems. These are some of the challenges that marine geophysical research is currently facing in the country. Once we address these issues, the country will again become a leader in the Indian Ocean geophysical studies.

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