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Mid-oceanic ridges

Several geoscientific discoveries in the last century have appreciably added to our knowledge of the creation of the Earth and the morphotectonic features that constitute a large part of the terrestrial and marine environments. One of the most important geological discoveries is the Mid-Oceanic Ridges (MOR) that was first reported by M. F. Maury (1855) in the North Atlantic Ocean. The MOR are ~70,000 km long linear ridges having an average width of 300 km and rise to ~2000 m above the sea bottom. MOR produce juvenile oceanic crusts and are typified by high heat flow and shallow focus earthquakes.

Concurrent to the discovery of the MOR, the theory of 'Continental Drift' was forwarded but the driving mechanism to carry the continents was unknown. In 1960s, Hess and Dietz independently proposed the concepts of 'Plate Tectonics' and 'Sea-floor Spreading'. Depending on the direction and rate of the plate motion, amongst others, the continental and oceanic plates diverge, converge or subduct. The oceanic plates move at variable rates: very slow (< 50 mm/yr; Atlantic, Indian) to intermediate (50–90 mm/yr; North Pacific), fast (> 90 mm/yr; South Pacific) and ultrafast (> 120 mm/yr; Galapagos).

Marine geologists were keen to know more about the various geophysical and geochemical characteristics of the oceanic crusts and thus, in the sixties the Deep Sea Drilling Project (DSDP) was created, wherein the services of the drilling vessel, *DV Glomar Challenger*, was utilized. In 1985, the Ocean Drilling Project (ODP) employed the more state-of-art Joides Resolution. The deepest drill hole measures over 2100 m and has penetrated under 200 m of sediment cover and sampled 1900 m of oceanic crust near the East Pacific Rise (EPR). So far, kilometres of core samples have been recovered from the world oceans.

A sequel to investigations of the MOR is seafloor hydrothermal activity. When seawater seeps through

the cracks and fissures in the oceanic crust, it encounters the hot rocks of the MOR, leaches the elements and concentrates them. This mineral-laden water ascends to the seafloor at temperatures of < 30°C to > 350°C. During this process, chimneys and vents are formed in the vicinity of which several oxide and sulphide minerals are deposited (e.g. chalcopyrite, pyrite, silica, baryte, etc.).

Besides the mineral deposits, vent localities host unique ecosystems such as chemosynthetic bacteria that thrive at elevated temperatures and obtain their energy by oxidizing sulphides from the vents. The megafauna such as crabs, seaworms, clams, tubeworms and mussels reproduce quickly due to the increased metabolic activities. This trait helps the animals since hydrothermal activities could either stop or be reduced at a locality. A detailed study of water column adjacent to and at a vent site is critical to understand the role of the latter on the physico-chemical, thermal and ecological balances in the world oceans. Interestingly, vent sites provide valuable clues to comprehend the origin of life on Earth.

Exploration of the MOR is a huge ordeal in terms of finance, manpower and infrastructural facilities (both onboard and onshore) and is highly risk prone. To partly overcome these difficulties, the RIDGE (Ridge Inter-Disciplinary Global Experiments) programme was conceived in 1987 and formalized under the auspices of the Ocean Studies Board of the National Academy of Sciences, USA. The RIDGE programme was basically an initiative of the USA and involved NASA, USGS and NSF. Four years after its formation, RIDGE explored the Cleft Segment on Juan de Fuca, near Iceland.

Since few other countries were simultaneously carrying out ridge studies, it was felt necessary to bring them together under a single umbrella to avoid duplication of the work, help process the data faster and, most importantly, conserve the various types of resources. Thus, the Inter-Ridge (IR) was born. The IR consists of four principal members (France,

Japan, UK, USA), seven Associate members (Canada, Germany, India, Italy, Korea, Norway, Portugal) and seventeen corresponding members (Australia, Austria, Brazil, China, Denmark, Iceland, Mauritius, Mexico, Morocco, New Zealand, Philippines, Russia, SOPAC, S. Africa, Spain, Sweden and Switzerland). A Steering Committee (STCOM), which comprises about 20 national representatives, looks into the development and implementation of various programmes. The IR's office, presently in Japan but shortly to be moved to Germany, is concerned with formulating science plans, holds special conferences and workshops, publishes information and sponsors post-doctoral candidates.

The Indian Ocean Ridge Systems (IORS) is constituted by the Central Indian Ridge (CIR) that meets the SouthEast Indian Ridge (SEIR) and SouthWest Indian Ridge (SWIR) in the form of an inverted 'Y' at the Rodriguez Triple Junction (RTJ, 25°S/70°E). In the north, the Carlsberg Ridge (CR) truncates against the Owen fracture zone near the Red Sea. Other than these ridge systems, there are two more important features: the Andaman Back-Arc Basin (ABAB) lying in the Bay of Bengal and the longest unbroken underwater feature, the NinetyEast Ridge that runs approximately from 5°N to 35°S latitude. This ridge has been noted to be seismic in the north and aseismic in the south.

In the 1970s, the petrological findings of the CR–CIR by K. V. Subbarao and his group acted as an impetus for subsequent studies by the National Institute of Oceanography (NIO), Goa. Towards this end, the InRidge was formed in 1997 and India became a corresponding member and an associate member of the IR in 2000. At the June 2001 STCOM and at the Next Decade Working Group in December 2001, India's proposal for a CR–CIR working group was favourably received. InRidge aims to amalgamate the several ridge researches in India to make optimum use of the available expertise and resources of the country and to facilitate cooperation between

Indian and the other global ridge research programme.

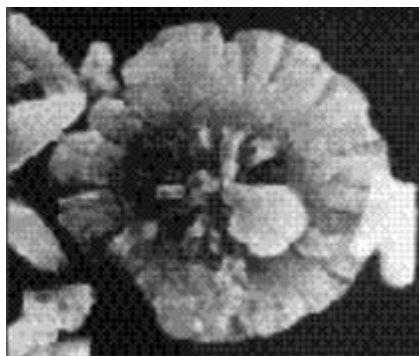
The activities carried out so far under the InRidge programme have been variously funded: inhouse (NIO/CSIR); the Department of Ocean Development, New Delhi; Office of Naval Research, USA and the Department of Science & Technology, New Delhi. At the time of going to the press, an expedition is underway along the CR that would be immediately followed by another along the CIR.

The special section on 'Mid-Oceanic Ridges' incorporates the articles encompassing a few important topics on different ongoing research initiatives on the IORS by Indian and international research groups, while the history and future of ridge-related researches are also discussed.

Since 1997, the salient observations made so far on the IORS by the InRidge are as follows:

- Evolutionary history of CIR up to about past 10 Ma is traced.
- Identification of the morphotectonic features in the Sealark, Vityaz and Vema areas.
- Ferromanganese nodules and crusts show both hydrogenous and hydrothermal contributions both at CR and CIR.
- Palaeoceanographic aspect of Vityaz area is inferred from calcareous substrate of ferromanganese crust.
- Magmatic sulphide-oxide minerals are reported in CR basalts and overall sedimentary environment indicated dominant hydrogenous precipitation.
- Fossil chimney with disseminated and vein-type sulphide mineralization was reported for the first time from ABAB.

In recognition of the tremendous response towards the InRidge's initiative, a special section was organized during the 38th Annual Convention of Indian Geophysical Union (IGU) in 18–20 December 2001 at Waltair. During just more than one decade the ridge research by NIO scientists



has resulted in 25 scientific papers in Indian and international journals. This is in addition to a number of presentations at national and international fora including a best poster award at the 87th Session of the Indian Science Congress in January 2000 at Pune University and in *InterRidge Newsletter*.

The special section in this issue elaborates on the structure and evolution of the CR, formation of CR basalts, tectonic and structural control on the petrology of ridge basalts, detailed bathymetric investigations of ridge profiles using swath-bathymetry from a recent cruise, importance of neural networks and their application to understand the seafloor topography, deep-sea benthic community and their relation to ridge system, a review on oxide and sulphide mineralization at hydrothermally active/fossil sites of the IORS, isotopic signatures of sea water at ridge area and age modelling of the India–Capricorn–Somalia plate motion using magnetic anomalies.

There are several key topics that the InRidge need to address, a few of which are: tectonic architecture, ridge–transform interaction, incipient triple junction formation and relation of spreading kinematics of CR–CIR with the seismicity of the Indian subcontinent. The location of active hydrothermal sites and their characteristics, ridge-crest biological communities, palaeoceanography of the ridge sediments, aspects related to back arc basin and backscatter signal-related studies using high resolution swath-bathymetry data are also In-

Ridge's priority. These efforts would certainly help to develop a model for ridge–crest processes and hydrothermal events along the IORS.

The response to InRidge has been tremendous as visible from a list of more than fifty scientists, working in varied fields of geology, geophysics, water chemistry and biology, affiliated to several universities, Indian Institutes of Technology and national laboratories. A few International researchers, notably from the USA, Portugal, France and Japan too have shown interest in the InRidge and are keen to collaborate with India. It is foreseen that InRidge would lay down goals, provide guidelines, coordinate and monitor high quality multidisciplinary integrated scientific researches. The first decade of IR has been completed and at the STCOM meet in September 2002 at Italy, the science plans (especially for the Indian Ocean) for the next decade were discussed. In 2004, it is proposed to have an international meet of ridge scientists at NIO that would be preceded by a brain-storming session. It is noteworthy that at this moment, the Council of Scientific & Industrial Research, New Delhi, has earmarked ridge studies as a thrust and network programme for the 10th year plan. This is an opportune moment for the InRidge community to gather, interpret and build a large database that would cater to researchers in various fields, since the IORS lie in the 'backyard' of India.

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