

Multibeam Mapping of the Exclusive Economic Zone of India

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ABSTRACT

The seabed in the Exclusive Economic Zone (EEZ) of India is covered with a variety of minerals of economic interest. High resolution bathymetric maps are needed for effective utilisation and management of these resources. To assess the general character of the seabed, detailed mapping has been carried out on a part of the central western continental margin of India with multibeam swath bathymetric system. The multibeam maps indicate the presence of several small scale topographic features which were not observed in the echosounding data. Though larger features like the Gaveshani Bank were recorded on the echograms, their exact morphology and areal extension could be obtained only from the multibeam mapping. The results suggest that multibeam maps reflect both macro- and micro-topography of the seabed and would provide insights into sedimentary and tectonic processes and seafloor mineralisation. This study indicates that application of multibeam technology in exploration and exploitation of mineral resources is essential. A scheme for mapping the EEZ of India with multibeam system is presented.

INTRODUCTION

The Exclusive Economic Zone (EEZ) extends to 200 nautical miles offshore from the coastline where the coastal state has the rights for exploration and exploitation of the resources and protection of the environment. India, with a coastline of about 6000 km, has an area of about 2×10^6 km² under its EEZ, equal to 2/3rd the size of the country. The seabed in the EEZ forms part of the continental margin and displays tremendous diversity in its morphology. The important mineral commodities present in the Indian EEZ and possibly within reach of exploitation include petroleum hydrocarbons, placers, calcium carbonate, and phosphorites on the continental shelf. In addition, the tectonic situation is conducive for hydrothermal minerals in the Andaman back-arc basin. As the need for raw materials increases with the expanding economy and population growth, the oceans are seen

as a potential source for the future in which case the EEZ is most likely the first to be exploited. Therefore, a study of the seafloor morphology is essential and would not only provide information for academic purposes but also for navigation, engineering, living and non-living resources evaluation and exploitation, seismic risk assessment and environmental monitoring.

STATE-OF-THE-ART

Our present knowledge of seafloor bathymetry has been evolved from the single beam echosounders which provide depth data at a point along the trackline. This resulted in sparse sampling of oceanic depths and the maps often underestimated the nonuniformity of the seabed. The last two decades have witnessed tremendous advancement in bathymetric survey. Single beam echosounders have given way to a variety of high resolution swath bathymetric mapping systems, thus enhancing accuracy and reliability of bathymetric maps. Multibeam system revolutionizes our understanding of the ocean bottom and its major structural features by providing highly detailed bottom maps. Depth resolution is much greater than what can be achieved employing single beam conventional echosounders. The cost effectiveness of the multibeam system is very high. Various surveys with deep towed echosounders, side looking sonar and swath bathymetric systems have shown the morphological diversity of the seafloor. Conventional techniques of hydrographic survey are inadequate to meet the increasing demand of high resolution maps. Multibeam bathymetric systems which have a swath of 200% of water depth can provide spatially correct and continuous data utilising far less ship time. While some of the existing multibeam systems have been developed for use in medium to deep waters, some others have a coverage of 400% of depth and can be used only in shallower waters — up to 1000 m. India acquired a multibeam system (Hydrosweep) in 1990 (installed on *ORV Sagarkanya*) and over 300,000 km² of area has been surveyed in the Central Indian Ocean Basin as part of the polymetallic nodule exploration programme.

The system Hydrosweep, which is proposed to be utilised for mapping EEZ, is described briefly. Basically, the multibeam echosounders measure depths simultaneously from a series of beams pointing at discrete angles of incidence in the athwartship direction. Hydrosweep system covers 45° on either side of the ship by a fan of 59 preformed beams, thus providing the capability to achieve a total swath width equal to twice the water depth. By spacing the survey lines at twice the water depth, a complete coverage of the seabed from this system can be obtained with no need of interpolation in between. The system is capable of measuring depths from 10 m to 10000 m [further technical details are in refs. 1,2]. This system has two sets of identical acoustic transducers mounted in 'T' shape on the hull of the ship. One set is installed along the longitudinal fore-aft axis and is used for transmission during the normal survey and the other set is installed perpendicular to the first one for reception.

Conventional echosounders use a constant value for sound velocity to calculate the depth. Hydrosweep uses a unique patented calibration process. Calibration provides an average sound velocity value for the entire water column. This value is used till the next calculation from calibration process is obtained.

DATA COLLECTION AND PROCESSING

Data collection in Hydrosweep is monitored through operator's console. Either a graduated color-coded depth contour map or cross-section profile can be displayed on color display unit. On-line contour map is also printed on the ink-jet printer. Data (position, depths and distances from the centre) are stored on magnetic tape for further processing. For depths of about 1000 m, data for about 20 hours can be stored on one magnetic tape.

The data thus stored on the magnetic tape are used for post-processing on Hydromap — the dedicated post-processing system for Hydrosweep data. Hydromap consists of a EPR 1300 computer with a color video display unit, a four color printer and an eight pen plotter. Individual Hydrosweep survey lines can be processed on Hydromap to produce track-coverage maps, isoline maps, etc. By combining Hydrosweep data from different lines, a depth grid is created which can be used to generate depth contour maps, cross-section profiles and three-dimensional figures.

A prerequisite for accurate bathymetric survey is a good navigation system. On *ORV Sagarkanya*, Hydrosweep gets navigation data from the Integrated Navigation System (INS) with Global Positioning System (GPS). GPS is the most accurate positioning system with accuracy up to 30 m. About 24 satellites have been sent in the space by US Navy and a minimum of three of these satellites will be available to the receivers on the earth and accurate position of the receiver on ground is calculated using the data sent from these satellites, which are within the range of the receiver. GPS satellite transmissions are now available for 24 hours/day in the Central Indian Ocean Basin and hence there is no need of carrying out position post-processing.

A CASE STUDY

Detailed morphological mapping has been carried out on a part of the central western continental margin of India with the multibeam bathymetric system (Fig. 1). The morphology of the continental shelf is influenced to a great extent by the Quaternary glacio-eustatic sea level fluctuations. The continental shelf in the study area is nearly flat with extremely low angle of slopes from shoreline to the break in slope. The topography on the outer shelf reveals the presence of 2-3 m undulations that are produced by the reef exposures. Although the presence of the algal and oolitic ridges of 2-6 m high is known earlier [3,4], their continuation could be mapped in the present study. These ridges built as long structures parallel

to the shelf occur as groups spaced at less than 1 km to a few kilometres and more than 2 km in length (Fig.2).

The multibeam mapping also revealed that dimensions of the Gaveshani Bank reported earlier need to be revised [5]. The shape of the bank observed in both the studies varies considerably (Fig.3). The area occupied by the bank as per the calculations from the single beam survey ($\sim 0.23 \text{ km}^2$) is much less than the area from the multibeam data ($\sim 3 \text{ km}^2$). The length of the bank (2 km) is nearly 3-fold more than the earlier reported one (0.77 km) whereas the width in the middle of the bank (1.66 km) is 5-fold more than the previously known one (0.33 km). The

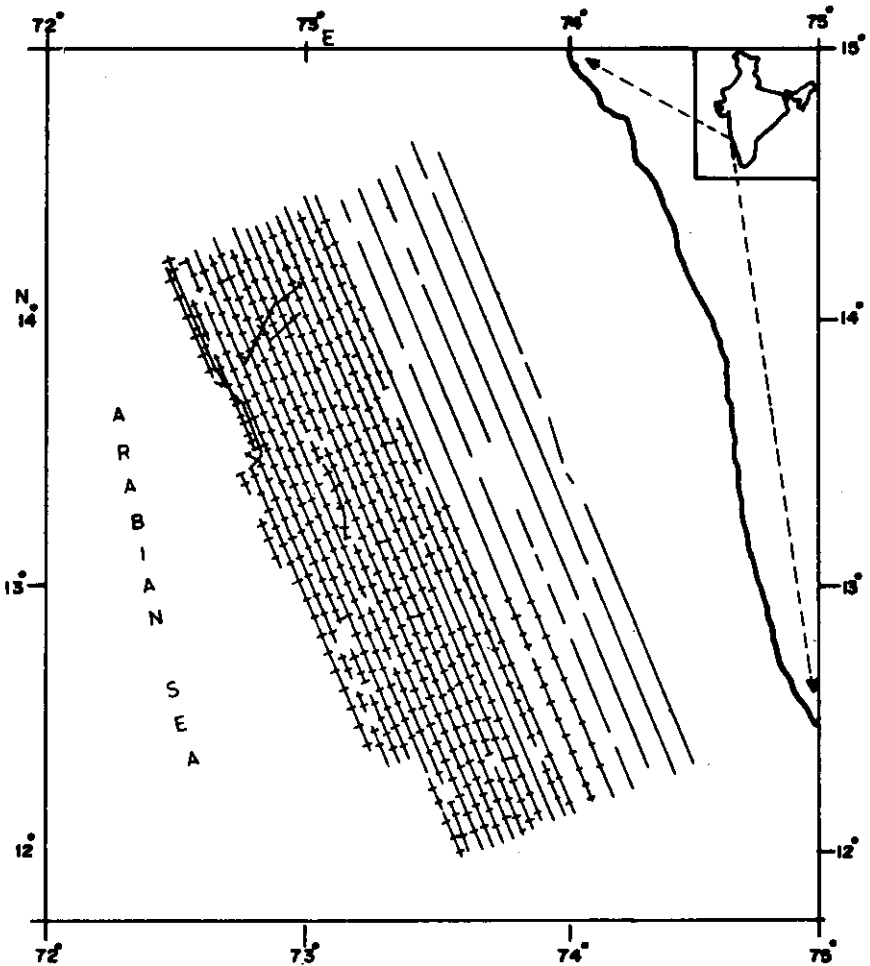


Fig. 1 — Cruise tracks and the area covered with multibeam system on the western continental margin of India

shallowest point of 32 m on the apex reported to be present on the periphery of the bank is not confirmed in this study.

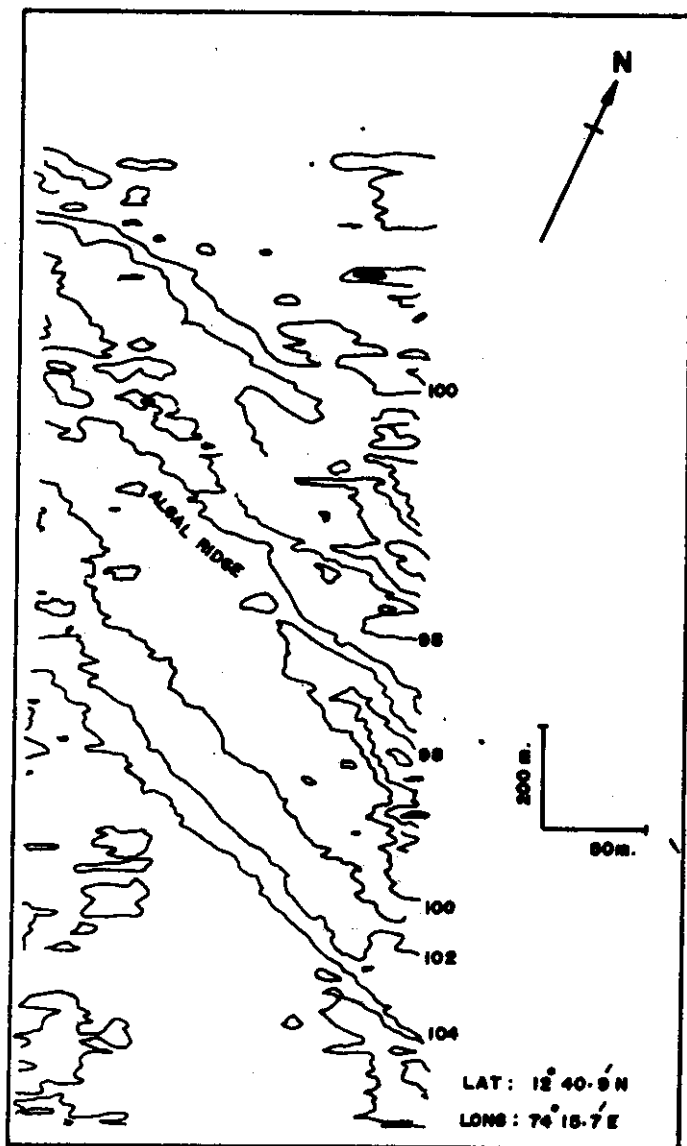


Fig.2 — Contour map showing an algal ridge (Ridges in general are parallel to sub-parallel to the coast. Contour interval 2 m)

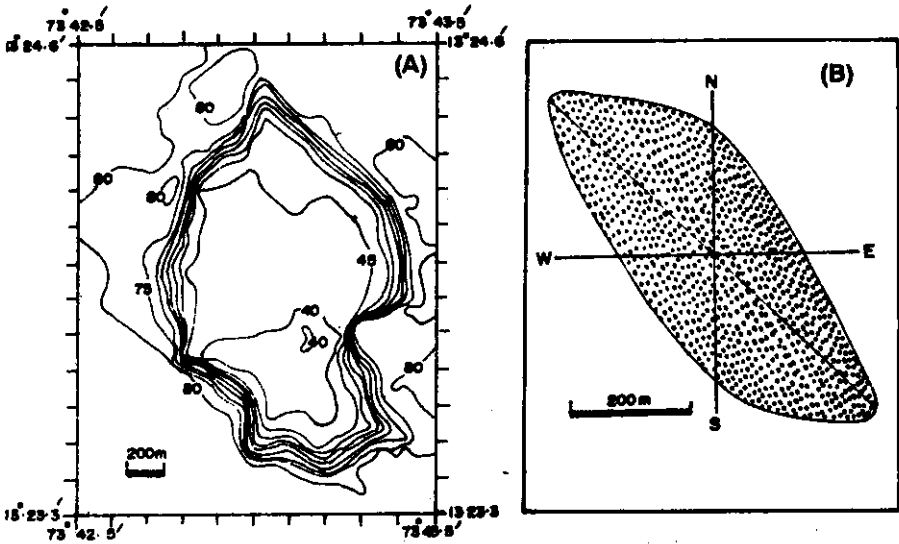


Fig.3 — (A) Depth contour map of the Gaveshani Bank (contour interval 5 m) obtained from multibeam system showing the shape of the bank (B) Shape of the Gaveshani Bank as outlined from the single beam echosounding data [5] (Note the differences in size and shape of the bank)

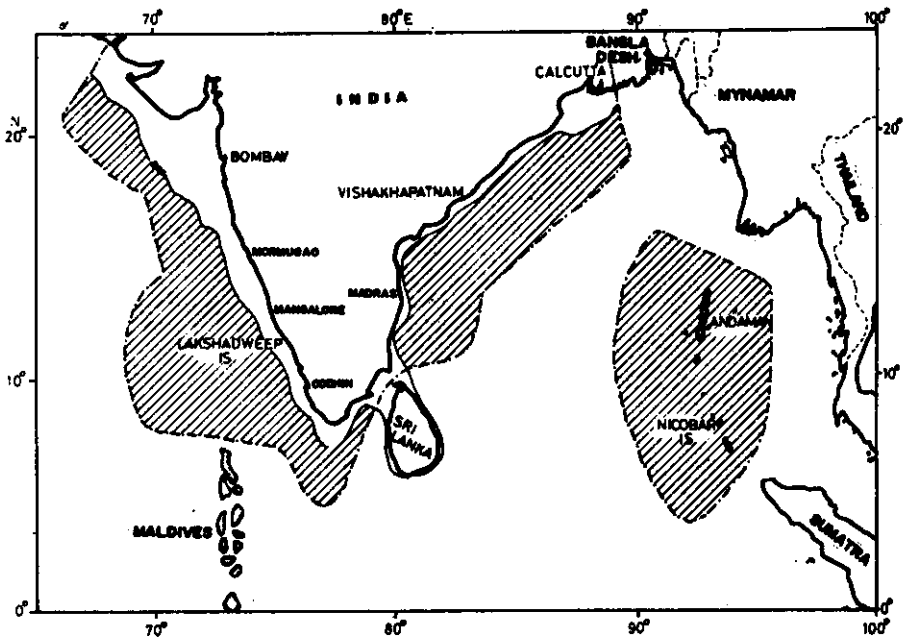


Fig.4 — Map showing the area proposed to be covered with the multibeam system in the EEZ of India (Areas shallower than 200 m water depth are not included in the present scheme)

The present study shows that topographic highs, such as banks and seamounts, can be recorded with a single beam echosounder, when the trackline is placed over the feature of interest, but the exact extension and detailed morphology can be obtained only from the multibeam data. Therefore, multibeam mapping of the EEZ is essential to map hitherto unreported features and to know the true morphology of the previously reported ones. The maps from the multibeam reflect both macro- and micro-topography of the seabed and would provide insights into the sedimentary processes and seafloor mineralisation.

SCHEME FOR MULTIBEAM MAPPING OF THE EEZ OF INDIA

The multibeam system, though capable of operating at depths from 10 m to 10000 m requires very close cruise tracks to obtain 100% coverage of the seafloor in shallower depths, resulting in exponential increase in the ship time. Therefore, it is optimum to cover the area with depths higher than 200 m during the first phase of the mapping (Fig.4). However, a few known interesting features and area at depths less than 200 m also will be mapped (For example, the area off the Kerala coast is proposed to be covered under the project 'Studies on placer deposits'). Uniformly, a survey line spacing of 3 nautical miles is proposed, which will ensure total coverage of over 80% of the EEZ. The idea is to obtain complete information on the EEZ by the turn of the century. This optimum track spacing is arrived at from the experience gained from the cruise conducted on the western continental margin of India. Along with multibeam mapping, gravity and magnetic data are also proposed to be collected simultaneously, which will further our knowledge on tectonic history of the Arabian Sea and the Bay of Bengal.

Table 1 gives the projections of area to be covered, the ship days required, etc. It is seen that over 1000 days are required to complete the mapping work. It is assumed that about 192 nautical miles will be covered in a day (at 8 kn speed for 24 hours). Along the multibeam survey, gravity and magnetometer survey will also be carried out which will not need additional ship time. If 3-4 cruises per year

Table 1 — Area with Water Depth More than 200 m within the EEZ And Ship Time Required for Completion of Mapping
[Cruise duration, 35 days each; average line spacing, 3 nautical miles]

Region	Area (km ²)	Ship time (days)	No. of cruises required
West coast (includes Lakshadweep)	850250	430	13
East coast	431235	220	6.5
Andaman islands	492840	250	7.5
Total	1774325	1000	27

are conducted, about 10 years will be required to complete the EEZ mapping with site specified sampling and photography.

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