

Seabed Surveys of Mormugao Harbour, Central West Coast of India

B G WAGLE, A R GUJAR, V SUBRAHMANYAM & P G MISLANKAR

National Institute of Oceanography, Dona Paula, Goa 403 004, India

Received 18 November 1986; revised received 2 November 1987

Detailed echosounding, side scan sonar and shallow seismics (125 line km) covering an area of 6.2 km² in the Mormugao harbour provided information on seabed topography, surficial distribution of sediments, their thickness and rock outcrops along with natural and man-made features. The depth in the area ranged from 2-16 m and in the navigational channel from 7-15 m. The seabed in the inner harbour and towards the offshore end was marked by even topography, whereas in the northern and northwestern part of the bay the topography was uneven. The seabed in the southern and southeastern area was covered by clays, thus masking the uneven topography. The northeastern area was largely covered with sand. Towards the offshore end the sediments were dense and compact. Rock outcrops were prominent towards the northern and northwestern side of the breakwater. The differences in the geomorphology and the distribution of sediments are attributed to the earlier topography and the influx of sediments.

Detailed echosounding, side scan and shallow seismic surveys were carried out in the Mormugao harbour area to collect information on the seabed topography and sediment characteristics and the results of these surveys are presented in this paper.

The Mormugao Harbour lies along the central west coast of India, about 400 km south of Bombay in the Mormugao Bay (Fig. 1). The funnel shaped bay (14 km length, 6.5 km maximum width) extends almost in an east-west direction and opens into the Arabian Sea in the southwest. The bay is marked on the northern and southern sides by a flat topped rocky (laterite capped) promontories of about 60-80 m high. The rocky shoals and reefs extending north south across the entrance of the bay separate the bay from the Arabian Sea. The river Zuari (32 km long) flowing NNW-SSE enters the bay through a constricted passage at its eastern end at Cortalim-Agaciam junction (Fig. 2) and the bay further west widens considerably.

Methods

The surveys (125 line km and 300 m grids) were carried out employing a fishing trawler in an area of 6.2 km². Position fixing was done using microwave position fixing system (Motorola Mini Ranger MRS III) and the accuracy was ± 3 m. The echosounding was carried out by an Atlas Deso 10 echosounder (30 and 210 kHz) with basic scale of 0-20 m and maximum range of 280

m. A bar check was usually carried out daily before the commencement of the surveys and necessary corrections were made on the records. Side scan sonar surveys were made using EG&G mark 1 B side scan sonar (10° beam depression, 20° beam width). Shallow seismic profiling was carried out by ORE mud penetrator (frequency 3.5-7 kHz, pulse length 1-4 m.sce⁻¹, band width 0.5-4 and power 2-10 kW).

Results and Discussion

Depths obtained from the echosounding were corrected for the tides. The low frequency (30 kHz) gave the sub-bottom penetration whereas high frequency (210 kHz) provided a good resolution.

The water depths in the survey area range from 2-16 m and 7-15 m in the navigational channel. The area shows a gradual slope due west without any major irregularities. The echograms indicate that the seabed is marked by even topography in the south, southeast and offshore end of the bay and uneven topography in the north and northwest part of the bay. The even surface in the inner harbour is principally due to the clayey sediments (Fig. 2) covering the underlying uneven topography. Along lines 34-21 (in the channel; Fig. 1), the surface is carpeted by acoustically transparent clays masking the underlying irregular topography. At the offshore end (lines 61-98), the echograms show an even surface with relative variations (up to 0.5m). This surface is typical of

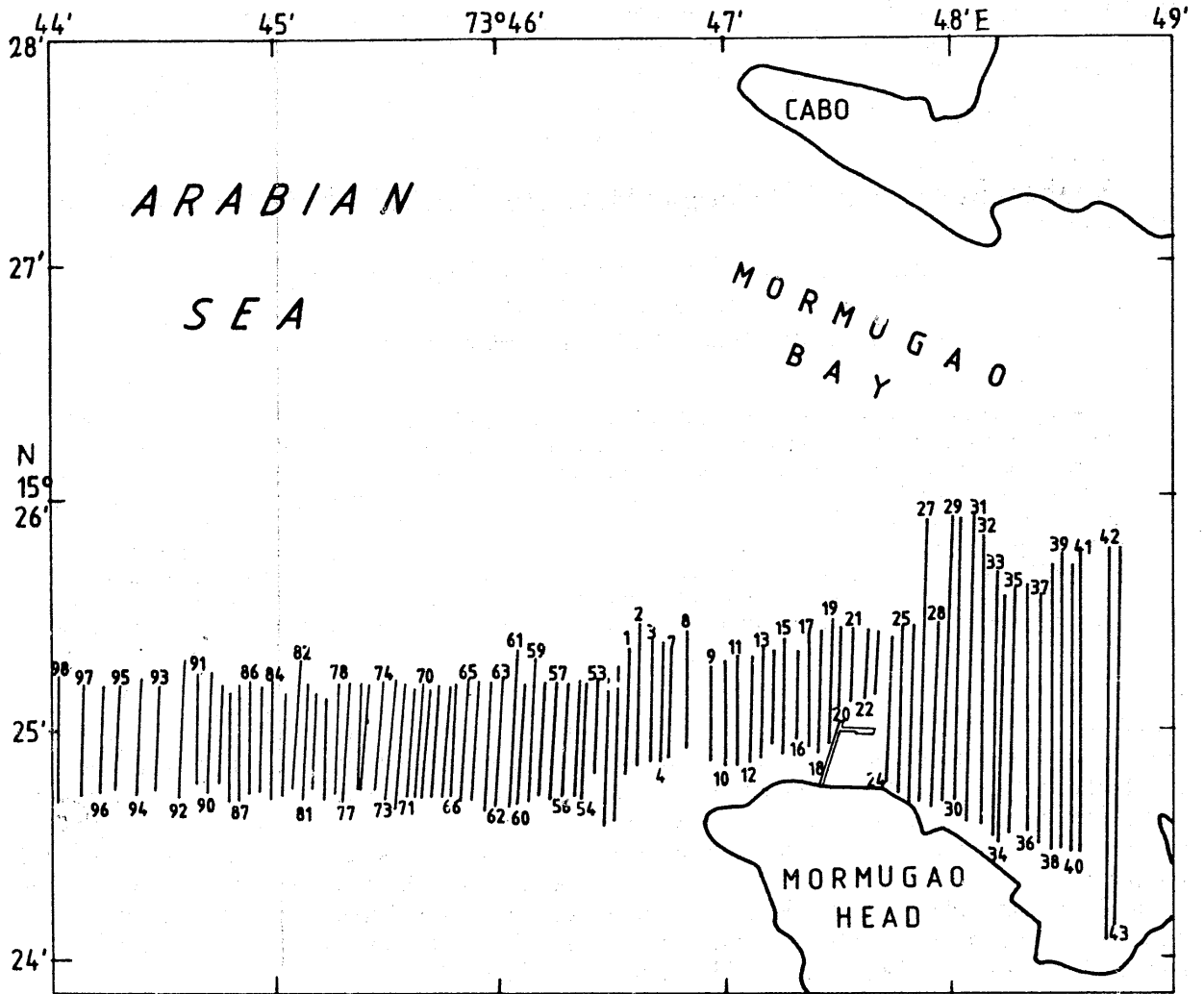


Fig. 1—Area surveyed

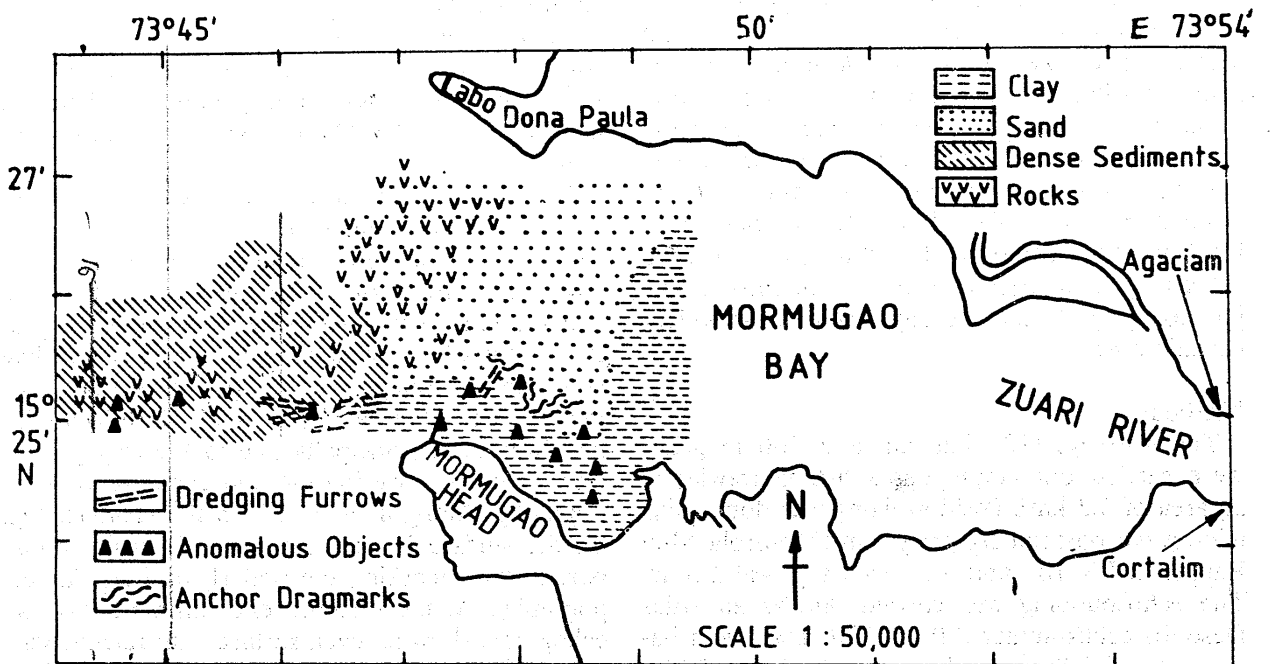


Fig. 2—Sediment/rock distribution in the study area

shelly sand, lithified sediments or a rocky seabed thinly covered by sediment. The region of uneven topography is marked by sharp pinnacles and ridges with relative variations (up to 2-3 m). This may represent the offshore extension of coastal rocks. The northeastern part of the inner harbour (lines 32-43) shows an uneven topography probably due to exposure of hard compact sand on the seabed.

The sonographs of the area show tonal and textural differences due to variations in the seabed topography, sediments and rocks. In addition, the records also show various natural and man-made features.

The sonographs (Fig. 2) of the southern, and southeastern area (lines 36-43) and up to the break-water (lines 20-35) show dark tone of typical clay covered seabed without any irregularities. In this area at places because of thin clay cover the underlying uneven strata when exposed pro-

vide a contrast with clay. The uniform light tone of the records from the inner harbour, (northeast of break-water) indicate that the area is largely covered with sand. Whereas at the offshore end the sonographs are well marked by a light tone smooth featureless surface characteristic of hard strata. Sonographs of northern and northwestern area also depict the rock outcrops which are well demarcated from the surrounding sand covered area. The navigational channel as expected is also well marked in the sonographs. Southern end of the bay shows some man-made features such as dredging furrows in the navigational channel anchor drag marks and anomalous unidentified objects of different size and shape (Fig. 2).

Based on the interpretation of seismic records obtained using ORE mud penetrator system the line drawings of the profiles were prepared (Fig. 3). The shallow seismic records show an average penetration of 4-5 m. The limited penetration

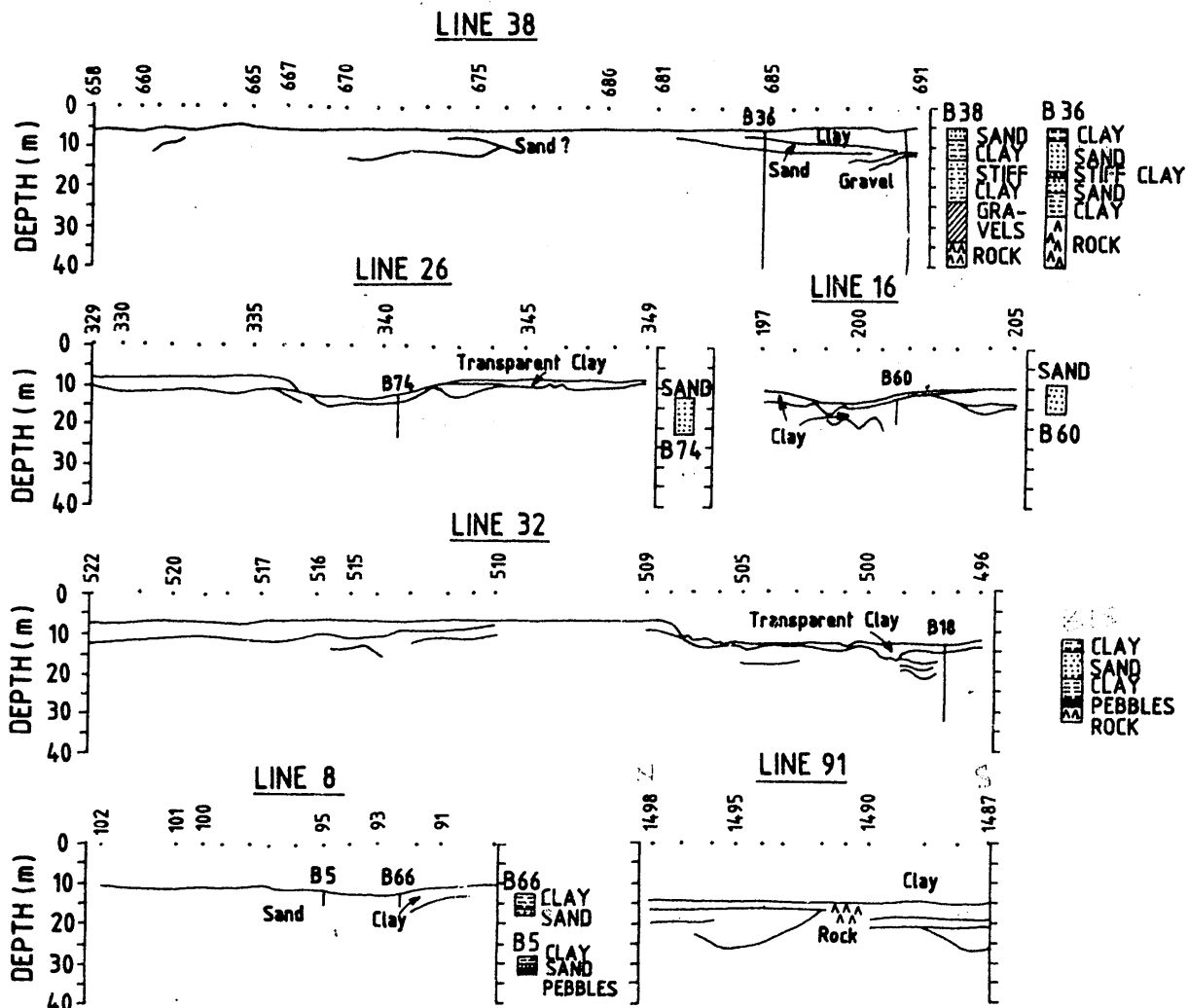


Fig. 3—Line drawings of selected shallow seismic profiles

may be due to the occurrence of hard formation at shallow depth or hard strata (rock/lithified sediments) in the seabed. The records of the inner harbour (lines 25-40) show that the area is largely covered by clay ranging from 4 to 8 m thick. These show 3-4 reflectors which may indicate variations within the clay or thin layers of dense material (Fig. 3). The southern part of the area (inner harbour) is covered with acoustically transparent clay (3-4 m) masking the underlying uneven topography (Fig. 3) and the clay cover thins towards the west and finally disappears. At places in the inner harbour, the underlying hard formations crop out on the seabed. The northeastern part of the inner harbour is covered with unconsolidated sand in which some hard sandy patches (where there is no penetration) are also recorded. In the offshore end the seismic sections show a penetration of about 0.5-1 m, which diminishes towards west, this is perhaps due to the dense sediments in the area. The seismic profiles in the northern and northwestern area show unconsolidated sand and some dense sandy patches where less or no penetration is observed (Fig. 3). In the same area at some places the underlying hard formations outcrop in the sediments giving rise to uneven topography with sharp pinnacles.

The survey area can be demarcated broadly into 3 distinct zones with different geomorphology and lithological facies. The clay cover is mainly due to finer material (silt and clay) brought into the bay by river Zuari, and this is supplemented by the ebb currents (3 knots) which are stronger than flood currents (1.5 knots) during the spring tide. The northern and northwestern area where

the coarser material (mainly sand) predominates owes its origin to the transportation of coarser material from Cabo and Dona Paula region, where wave heights are maximum, and the area is defined as high energy zone¹. The rock outcrops in this area represent (lithologically and structurally) the extension of coastal rocks². At the offshore end the presence of dense sedimentary strata with occasional rocky patches can be attributed to the combined effects of current and topography. The currents in this area indicate that the flood and ebb currents are of the same magnitude which do not favour sediment accumulation. The topography also suggests that the transport and supply of sediments into the bay by the littoral currents³ is considerably less and further the rock shoals weaken the currents.

This information regarding the surficial distribution of the different types of sediments and rock outcrops as well as the thickness of the sediments overlying the hard strata will be of great use for the planned development of the ports and harbours.

Acknowledgement

The authors are thankful to late Dr H N Siddiquie, former Director for helpful comments on the manuscript. Surveys were carried out at the request of Mormugao Port Trust.

References

- 1 Gopalarao D & Rao T C S, *Indian J Mar Sci*, **3** (1974) 93.
- 2 Wagle B G, *Proc Indian Acad Sci, (Earth Planet Sci)*, **91** (1982) 105.
- 3 Reddy M P M, *Mahasagar-Bull Natn Inst Oceangr*, **1** (1970) 28.