

SHALLOW STRATIGRAPHY AND GAS-CHARGED SEDIMENTS IN THE INNER SHELF OFF REDI, WEST COAST OF INDIA

L.V. Subba Raju
National Institute of Oceanography
Dona Paula, Goa - 403 004, India
Fax: 0832-223340; e-mail: lvsubba@csnio.ren.nic.in

ABSTRACT

Bathymetric, side scan sonar and seismic studies were conducted in shallow waters of 11-18 m off Redi along central west coast of India to understand the stratigraphy and structural features. Bathymetric contours suggest the existence of a palaeochannel running across the region in ENE-WSW direction. Shallow seismic surveys indicate a pseudo escarpment of more than 7 m deep between 12-14 m water depths. Eastern part (11-14 m) of the escarpment indicate the existence of gas-charged sediments (silty clays) within 3 m of sea floor. In the west (14-18 m), the subsurface layer (silty sand?) observed at 10-12 m from sea floor is breached and pushed upwards into the surface layer indicating inverted U-like and cylindrical features. These features reaching within 4-5 m of sea floor suggest the continuation of gas-charged sediments in the west. Isopach and gas-charged sediment maps of the region lead to the demarcation of the areas that should be avoided by any offshore engineering activities.

INTRODUCTION

The central region of west coast of India (Fig.1) between Bombay and Devgarh contains basaltic formations (Deccan Traps) and the region towards south of it upto Karwar is covered by laterites of late Pleistocene times with occasional presence of basaltic formations (Sahasrabudhe and Deshmukh, 1981). The topography near coastal region with cliffs and promontories (Wagle, 1989), rises to a maximum height of 100 m. The trend of the coast is NNW-SSE with rivers flowing westward into the Arabian Sea and coring the sediments to the shelf.

The sea level curves of Nair (1974), Berger (1983) and Kale and Rajaguru (1985) indicate that the sea level was near the present shelf break during the late Pleistocene and reached its current position at 5000-6000 yr. BP. Since then, sea level has oscillated maintaining the present level on an average. The present shallow water regions with their basement near the surface, were exposed till pre-Holocene times having effected by weathering, erosion, sea level changes, sediment deposition, bio-degradation and neo-tectonic activity etc.

Anomalous features like gas-charged sediments were reported off Bombay (Siddiquie et al., 1980) and Goa (Karisiddaiah et al., 1993) in outer and mid shelves respectively. In this context, the shallow water regions of west coast were studied for such anomalous features and sedimentary structures (Subba Raju et al., 1989). The present study was conducted to identify

similar structural features and anomalous signatures in surface and sub-surface formations in the shallow water regions off the west coast.

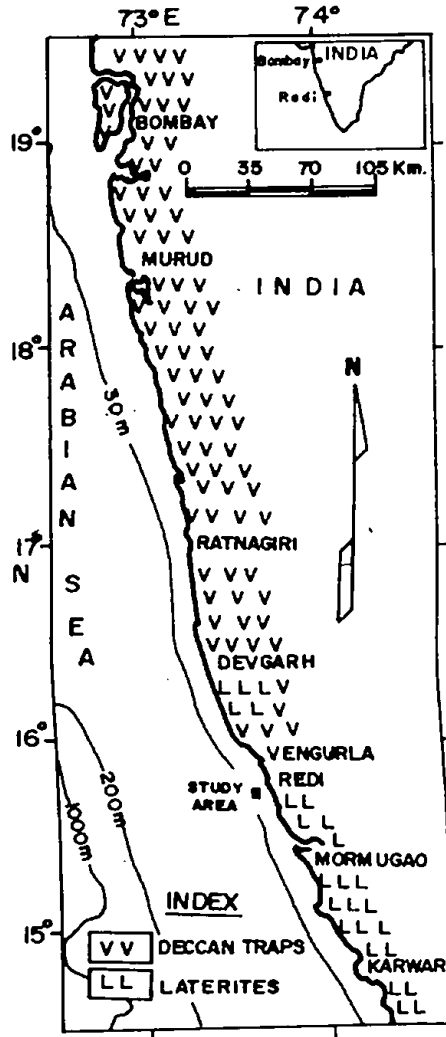


Fig. 1 Map showing the central west coast with geological formations from Bombay to Karwar

GEOLOGY

The geology of the adjacent coastal region of Redi consists of laterite outcrops of late Pleistocene times resting directly over Dharwarian quartzites, enriched with iron ore deposits

(Sahasrabudhe, 1985) and it is observed that the lateritic formations extend into the sea from the coastal region..

METHODOLOGY

The survey area is located off Redi within the water depths of 11 to 18 m between the mouths of rivers Talavda in the north and Terekhol in the south covering an area of nearly 12 sqkm (Fig.2).

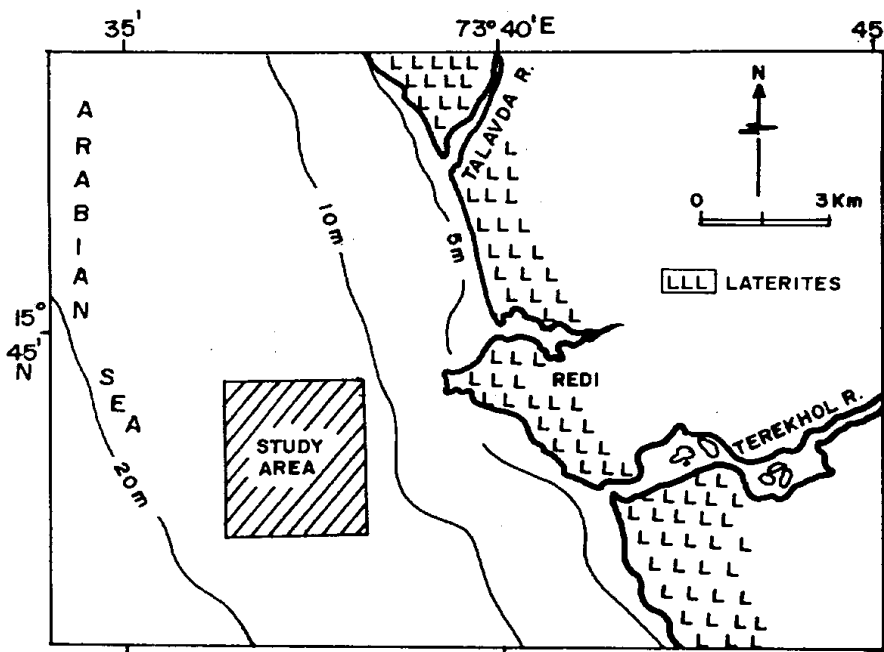


Fig. 2 Location of the study area showing the bathymetry

The data base consists of 26 profiles (L1-26) in east-west and 33 profiles (L27-59) in north-south directions intersecting in a nearly orthogonal grid pattern (Fig. 3). More than 500 line km of echosounding (ES), side scan sonar (SSS) and shallow seismic profiling (SSP) data were collected using an Atlas Deso-10 echosounder of dual frequencies (210 and 30 kHz), a side scan sonar (105 kHz) and a high resolution Uniboom profiler (300 Joules and 400-5000 Hz bandwidth) respectively. Sea floor samples were collected with the help of a Van-Veen grab sampler. Continuous position fixing was achieved by Mini Ranger MRS III system (+3 m accuracy).

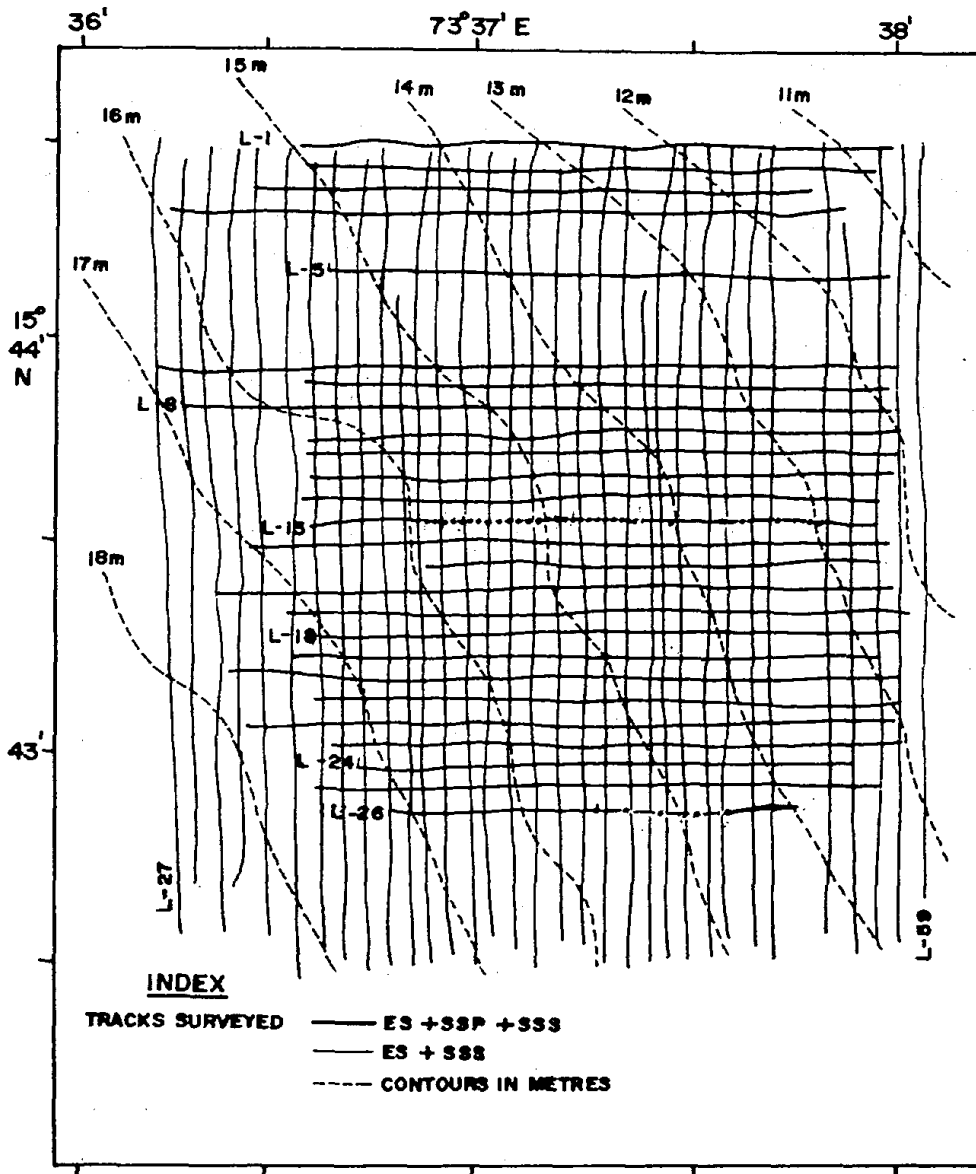


Fig. 3 Map showing the area covered and various methods used in the survey (ES: Echosounding; SSP: Shallow seismic profiling; SSS: Side scan sonar)

RESULTS

Bathymetry and Sonography

Bathymetry of the area between 11 and 18 m is characterised by a gently sloping sea floor. The bathymetric contours in the area run sub-parallel to the coast and display a 'kink' in the central region of the area exhibiting a palaeochannel running from 12 to 18 m in ENE-WSW direction (Fig.3). The sea floor is carpeted by unconsolidated sediments. No features due to the rock formations on the sea floor are observed either in the bathymetry or sonography.

Shallow Seismic Features

A pseudo escarpment (PE) of about 7 m deep is observed in the subsurface between 12-14 m isobaths. Strong reflections within the sediments which are acoustically transparent, mark the gas-charged sediments in the east of the escarpment. A prominent horizon with gas-charged sediments appears intermittently in the upper sediment layer to the west of the escarpment. It is observed that the underlying acoustic basement is breached in the shape of inverted U-like and cylindrical features and reach within 5 m of sea floor representing the acoustic turbidity (Subba Raju and Wagle,1996). Fig. 4 represents some typical profiles of the region showing the pseudo

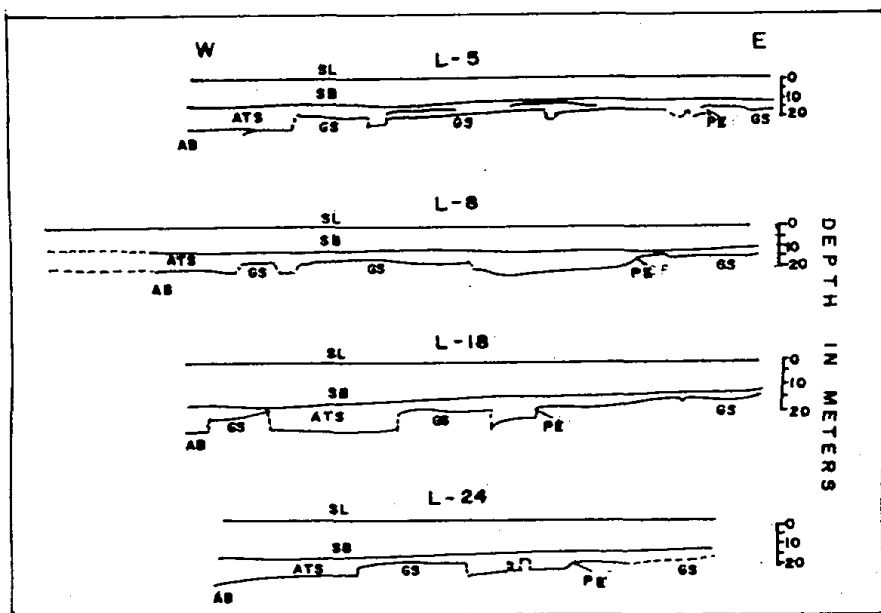


Fig. 4 Typical profiles showing the shallow stratigraphy and associated sediments
 SL: Sea level; SB: sea bed; ATS: Acoustically transparent sediments;
 AB: Acoustic basement; GS: Gas-charged sediments; PE: Pseudo escarpment

escarpment and the gas-charged sediments towards east and west. Thickness of the transparent-layer towards east of the escarpment is around 3 m and around 11 m in the west.

DISCUSSION

The rate of sedimentation in the region is high during southwest monsoon due to 1) the heavy rainfall (average 2700 mm/yr), and 2) weathering and erosion that occur in the surroundings and en-route by the adjacent rivers and rivulets flowing towards the coast. The sediments supplied are deposited on to the shelf by Talavda and Terekhol rivers. Surficial samples collected by Van-Veen grab sampler are identified as silty clays by smearing test and visual appearance. Varied thickness of the surface layer from 3 m in the east to 11m in the west is observed due to the escarpment Fig. 5 shows the isopach map of these sediments depicting the same. East of the escarpment, the gas-charging signatures are observed in the surficial layer of

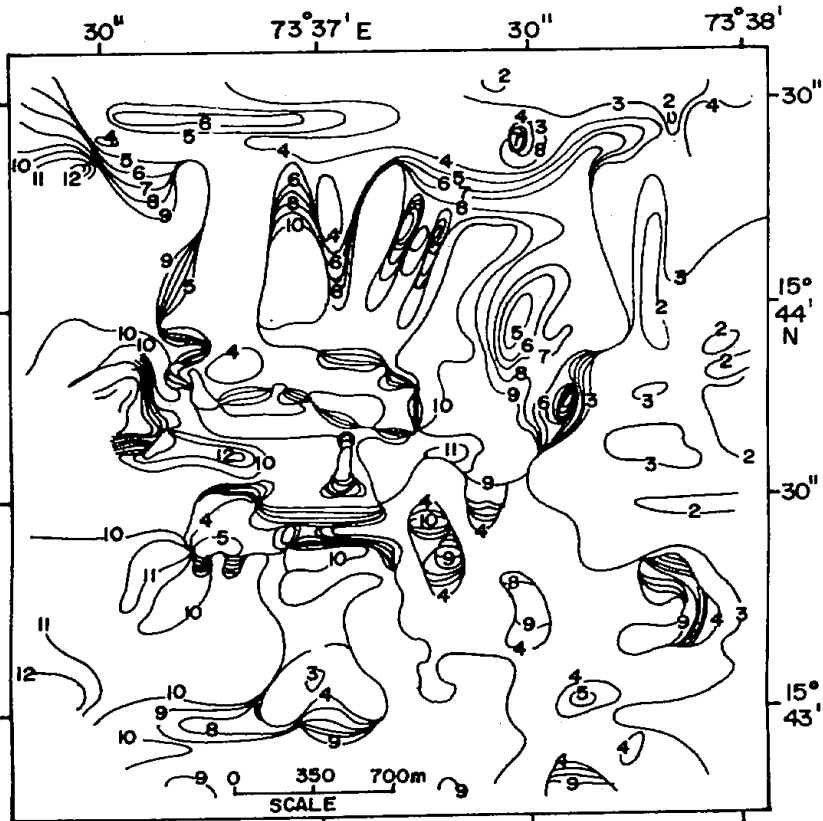


Fig. 5 Isopach map of the sediments in the survey region. Thickness of the sediments is given in metres.

silty clays while the silty clays are marked in the west by the strange appearance of several patches of gas-charging intermittently with typical features in the form of acoustic turbidity disturbing the top of the subsurface layer indicating the inverted U-like and cylindrical features. These strange formations have risen in the surface layer by their abrupt contact with gas-free sediments. Gas-charging masks the surficial sediments beyond 3 m of sea floor in the east and beyond 4-5 m intermittently in the west. The zones of gas-charged and gas-free sediments are represented in Fig. 6. An extension of the subsurface layer of the west is of late Pleistocene-early Holocene times (Siddiquie et al., 1977) and 1 mm/yr rate of sedimentation in the surrounding region (Subba Raju et al., 1991) probably suggest the silty sand nature of the subsurface layer in the west.

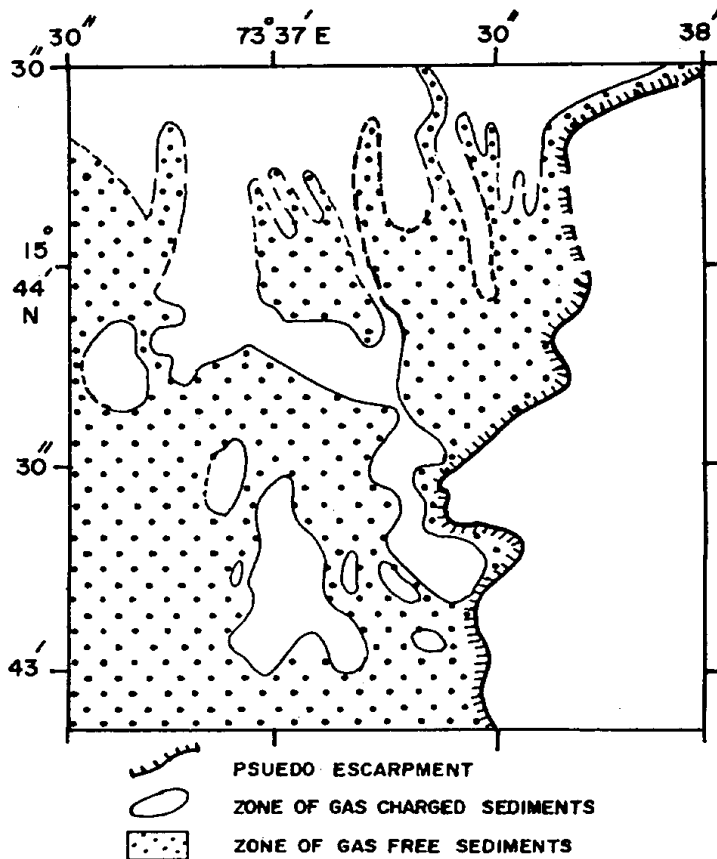


Fig. 6 Zones of gas-charged and gas-free sediments.
A pseudo-escarpment is observed in water depths of 12-14 m.

If the zones of gas-charged sediments are not identified in time, it can prove harmful as the heavy and huge structures become imbalanced accumulating differential stress in one direction or the other. Knowing this, Butenko et al. (1985) have stressed the need for detecting such zones

by conducting marine geophysical surveys before commencing any marine construction activities since the geological hazards such as gas turbidites etc. can constrain the drilling activity and further erection of offshore structures.

By using the seismic systems with proper energy and resolution, a detailed exploration in grid pattern in the continental shelf will detect the gas-charged sediment zones that prove greatly useful to the nation as a future energy resource.

CONCLUSIONS

1. Bathymetric contours suggest a palaeo-channel running in the region in ENE-WSW direction. and the sea floor is carpeted by silty clays of middle-late Holocene times;
2. A pseudo escarpment of 7 m deep lies between 12-14 m water depths and the thickness of upper layer (silty clays) varies from 3 m in the east to 12 m in the west;
3. Gas-charging in silty clay layer reaches to 2-3 m of sea floor in the east and in the west, it appears as strange features of intermittent patches reaching to 4-5 m of sea floor breaching the subsurface (sandy silt ?) layer;
4. To assimilate knowledge about the gas-charged sediments, a planned approach is suggested for exploring the shelves and to exploit the future energy resources; and
5. By making use of the gas-charged sediment maps, effected regions can be recognised to constrain the offshore engineering activities or a suitable methodology can be found out for their smooth operations .

Acknowledgements

The author is grateful to the Director, Dr. Ehrlich Desa for permitting to publish this paper and to Dr. Ch. Madhusudana Rao, Head, Geological Oceanography Division for his useful suggestions.

References

- Berger, R., 1983. Sea levels and tree-ring calibrated dating. In: Masters, P.M. and Fleming, N.C. (eds.), *Quaternary Coastlines and Marine Archaeology*, Academic Press, London, pp 51-62.
- Butenko, J., Milliman, J.D. and Yinkan Ye, 1985. Geomorphology, shallow structure and geological hazards in the East China Sea. *Continental Shelf Research*, 4, pp.121-141.
- Kale, V.S. and Rajaguru, S.N., 1985. Neogene and Quaternary transgressional and regressional history of the west coast of India - An overview. *Bulletin of Deccan College Research Institute, Pune, India*, 44, pp.153-165.
- Karisiddaiah, S.M., Veerayya, M., Vora, K.H. and Wagle, B.G., 1993. Gas-charged sediments on the inner continental shelf off western India. *Marine Geology*, 110, pp.143-152.
- Nair, R.R., 1974. Holocene sealevels on the western continental shelf. *Proceedings of Indian Academy of Sciences (New Delhi)*, 79, Section B, pp.197-203.
- Sahasrabudhe, Y.S., 1985. Northern extension of the iron and manganese deposits of Goa into the Sindhudurg district, Southern Maharashtra - their prospects and potential. In:

- Director General (pub.), Earth Resources for Goa's development, Geological Survey of India Special Publication, Calcutta, pp. 209-223.
- Sahasrabudhe, Y.S. and Deshmukh, S.S., 1981. The laterites of Maharashtra state. *Proceedings of International Seminar on Lateritisation Processes*, Trivandrum, pp. 209-220.
- Siddiquie, H.N., Gopala Rao, D., Veerayya, M. and Wagle, B.G., 1980. Acoustic masking due to gases in shallow seismic profiling on the shelf off Bombay. *Indian Journal of Marine Sciences*, 9, pp.51-54.
- Siddiquie, H.N., Rao, D.G., Veerayya, M., Wagle, B.G., Almeida, F. and Bhattacharya, G.C., 1977. Surficial geology of Bombay High region and its implication in offshore engineering problems. *Proceedings of the Seminar on Coastal Engineering*, Goa, pp. 5.
- Subba Raju, L.V., Divakar Naidu, P. and Almeida, F., 1989. Marine geoscientific surveys in port and nearshore regions of the Arabian Sea off central west coast of India. Recent geoscientific studies in Arabian Sea, *Geological Survey of India Special Publication 24*, pp. 291-297.
- Subba Raju, L.V., Krishna, K.S. and Chaubey, A.K., 1991. Buried late Pleistocene fluvial channels on the inner continental shelf off Vengurla, west coast of India. *Journal of Coastal Research*, 7, pp.509-516.
- Subba Raju, L.V. and Wagle, B.G., 1996. Gas-charged sediments in shallow waters off Redi along the central west coast of India, *Current Science*, 71, pp.416-419.
- Wagle, B.G., 1989. Morphology and evolution of the central west coast of India, *Mahasagar*, 22, pp.13-21.