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Exploration of Nearshore Placers Off Konkan Coast, West Coast of India

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ABSTRACT

A detailed geological and geophysical survey comprising sediment sampling, short cores, shallow seismic profiling and magnetics covering about 90 sq. km. was carried out in the nearshore area (upto 20 m water depth) of 2 bays, Pawas and Purangad, Konkan Coast, Maharashtra to explore the offshore extension of promising onshore placers. The onshore beach placer sands extend to offshore to a water depth of 10 - 11 meters beyond which it is covered by clays. The surficial sands in these bays contain upto 93.69% of heavy minerals with appreciable amount of ilmenite and magnetite. Seismic profiles and short cores confirm the presence of heavy mineral rich sands below clays after 11 meters of water depth. The thickness of heavy mineral rich sand is 2-3 meters. The basement in the area is undulatory and has a N-S trending depression (about 200-300 m wide) in Pawas bay which probably acts as trap for accumulation of sediments. The magnetic picture in the area shows positive correlation with heavy mineral placers and basement configuration. The offshore reserves of ilmenite and magnetite are inferred to be about 1 and 3 million tonnes respectively. The extensive onshore and offshore deposits offer encouraging possibilities for future integrated development.

INTRODUCTION

The occurrence of heavy mineral beach placers are known from many localities along the Indian Coast. The major deposits are along Kerala and Maharashtra on the west coast and along Tamil Nadu, Orissa and Andhra Pradesh on the east coast. The placer sands with varying proportion of ilmenite and magnetite have been reported from the areas of Ratnagiri and Sindhudurg district of Konkan Coast Maharashtra. The continuity of these coastal beach deposits is interrupted by morphological features such as cliffs, promontories and drainage features like creeks and tidal inlets. These deposits in general, occur as beach deposit which is immediately in contact with the sea, as a dune deposit further inland, as bars in river and creek mouths and also in the lowlying interior area behind the bars in the marshy lands. Patel¹ (1936) and Roy² (1958) surveyed these coastal deposits at many places. Their survey indicated 54.4% of magnetite and titanomagnetite, 29.4% ilmenite, 7.2% rutile with other constituents like tourmaline pyroxene, quartz, and feldspar along Purangad, but during their survey the Pawas beach was not covered. The average thickness of Purangad beach sands is about 1 to 2 meters. The reserve of ilmenite is estimated to be about 0.025 million tonnes and along with this titanomagnetite is also present Roy² (1958). These beach placers and adjacent Pawas beach placers are expected to extend in the offshore regions. To check its

References and illustrations at end of paper.

offshore extension, the survey was carried out in 13 days along the Konkan Coast, Maharashtra by National Institute of Oceanography (Fig. 1). In the present paper the data from 2 adjacent bays-- Pawas and Purangad-- have been included. The survey covered an area of 90 km² and comprised of 264 line km echosounding, 213 surface sediment samples, 10 short cores, 108 line km of shallow seismic profiling and about 105 line km of magnetics. The sand samples were studied for its heavy mineral content, shallow seismic profiles data was used to know vertical thickness of subsurface strata, whereas magnetic data was used for checking correlation between magnetic anomalies and heavy mineral concentration.

The main objective of this survey was to check the possible offshore extension of these promising placers and to study its feasibility for economic exploitation. Besides these, the other objectives were to study the geology, the environment of deposition and structural and tectonic settings of the area.

METHODS

The surveys were carried out by installing the equipment on fishing boat (about 15 m long, 2 m draft).

Position Fixing

Before commencing the offshore surveys, the shore stations were fixed by establishing triangulation chain by taking positions from established geodetic stations. Initially, for fixing positions in the offshore, Kelvin Hughes hydrographic sextant was used. These positions were plotted by using micrometer station pointer on 1 : 10,000 scale. Subsequently, Motorola Miniranger MRS III system was used. The range console, Data processor (MRDP 500), Receiver Transmitter, Track plotter, Tape recorder and Omni directional antenna were installed on the boat. The accuracy of fixes obtained is of the order of ± 3 to 5 meters within the range of system. The tracks were spaced at about 200-300 m interval normal to the coast in order to get the best possible coverage of variation in topography and sediments.

Echosounding

The echosounding during the surveys was carried out by using a dual frequency Atlas Deso 10 echosounder. The low frequency of 30 KHz provided the subbottom penetration, whereas the high frequency 210 KHz provided good resolution. The bar check was carried out usually before the commencement of the survey daily and necessary corrections were made on record. The soundings were reduced to datum from the predicted tide values of Purangad

Port, supplied by the Captain of Ports of Maharashtra State. These tide values were fed to computer and necessary tidal deductions were made in the soundings at suitable positions.

Shallow Seismic Profiling

For Shallow Seismic profiling, EG & G Sparkarray (200-300 joules) was used. The system consisted 3 electrode Sparkarray (Model 268-A), power supply (Model 232-A), Control bank (Model 231-A) hydrophone (model 262 J) and receivers. The latter being a combination of EPC 3200 recorders and Key gate programmer. The seismic data was processed in the laboratory and profiles were prepared (Fig. 2). For identification of strata/reflector bore-hole logs of the adjacent areas were used along with cores.

Magnetics

Barringer Proton Precision Oceanographic Research Magnetometer was used. It was operated on 24 volts DC supply. The sensor was towed at a distance of about 1.5 times the length of boat to avoid disturbances caused to the sensor due to the hull. The data was recorded at 4-12 seconds and later corrected to IGRG 1980, 0.1 spoch and diurnal variations. The magnetic profiles were plotted along the tracks and isogonal maps at a contour interval of 100 nT were prepared (Fig. 3).

Seabed Samples

The surface sediment samples were collected with Van Veer Grab (area 0.04 m²) on a grid of approximately 200-300 m. The cores were collected with Piston Gravity Corer. The locations for cores were selected after an examination of underway records and nature of sediment samples. The main purpose for coring was to confirm the extension of heavy mineral rich sand below the seabed and the over-laying clays. In the laboratory, the sediment samples were washed, coned and quartered and were subjected to heavy mineral separation by using bromoform (sp. gr. 2.89). From the heavies magnetite was separated by hand-magnet and ilmenite by using isodynamic separator. The weight percentage of heavy minerals, magnetite and ilmenite were calculated to the total sediment and distribution maps were prepared (Fig. 4).

RESULTS AND DISCUSSION

Configuration and Bathymetry

Both the bays under study are open bays and have more or less similar configuration, but differs in the nature of

sediment source. Purangad bay has one river (Machkandi river) which flows westerly with seasonal intensity through well cut channels and meets the sea forming point bars. Pawas bay has a tidal creek which indent the coast. The tidal range in the area varies from 1 to 2 meters. The area receives precipitation of the order of 2500 to 3000 mm which is confined to the season of the southwest monsoon during June to September. This season is also the period of maximum turbulence. The area is affected by four predominant wave directions SW, WSW, W and WNW with periods ranging from 5 to 14 seconds. The convergence and divergence of littoral currents are observed at many places. These zones of convergence and divergence are related to the sediment motions in this area. Reddy³ (1976) and later Rajamanickam et al⁴ (1986) have attributed wave refraction, physical barrier and presence of sand bars and shoals responsible for the nature of heavy mineral distribution and concentration. The area is bordered by crenulated coastline with projecting promontories and cliffs of Deccan trap basalt (Late Mesozoic to Early Tertiary) and capped by laterite of Pleistocene age. The hinterland geology mainly consists of different flows of variable thickness of Deccan Trap basalts and its weathered derivatives i.e. laterite. The ilmenite and magnetite are the common accessories of this trap.

In the present survey seismic and magnetic profiling is extended to a water depth of 18-22 m, whereas sampling is restricted to a sandy zone which is upto 12 m water depth. At this zone the echogram shows the continuation of surficial sand layer below clays. The gradients in the nearshore area is slightly steep to gentle off river mouth and in the bay, whereas off promontories it is steep which changes to very gentle in the offshore. Presence of point bar at the Machkandi river mouth (Purangad bay) is the only noteworthy feature.

Sediment Distribution and Mineralogy

The seabed in the area surveyed is largely covered by sand, silty sand, silty clay and clay. The sand is widely distributed in the bay. Sand covers the seabed in the bays to a water depth of 11-12 m, beyond which and off promontories, clay overlies sand or rocks. The core collected in this area (maximum penetration 1.26 m) clearly shows clay and sand contact. The top 50 cm comprises reddish-brown clay which overlies olive grey clay which in turn overlies heavy mineral rich sand. Nair⁵ (1985) has reported from studies of grain size distribution that sediments are mostly well sorted and unimodal except sediments from river mouth which are poorly sorted and polymodal. The sediments represent mixed depositional environment i.e.

dune/beach/river to barrier/lagoon and palimpsest type. Similar types of environment are indicated by Rajamanickam and Gujar⁶ (1984) and Rajamanickam⁷ et al. (1986) from their studies of sediments from adjacent areas.

The heavy mineral concentrations range upto 60 per cent in Pawas bay and 80 per cent in Purangad bay (Fig. 4). The heavy mineral assemblage mainly consists of ilmenite, (upto 22 per cent in Pawas and upto 17 per cent in Purangad) and magnetite upto 47 per cent in Pawas and upto 43 per cent in Purangad (Fig. 4). The remaining mineral suite consists of minor quantities of augite, epidote, tourmaline, hornblende, rutile zircon and kyanite. The magnetite in the sediments are titanomagnetite and its alteration products such as hematite. The lighter minerals are quartz and feldspar. Chemically these placers contain on an average of 34.65 per cent of Fe₂O₃ and about 10 per cent of TiO₂ in Purangad sand Nair⁵ (1985). The distribution of heavy minerals is more localised in the nearshore than further offshore. The patches of high concentration are noted off Tellitek and off Light House in Purangad bay and in the southern portion of Pawas bay. The magnetite distribution is fairly uniform throughout the bays. However, within the bays, patches of higher concentration are noticed. Such patches are localised off Machkandi river mouth in Purangad bay suggesting probably, its transportation through the river. Similar trends are also observed by Siddiquie⁸ et al (1982) off Ratnagiri bay. The ilmenite distribution is more uniform in Pawas compared to Purangad bay where it is patchy.

Seismics and Magnetics

A representative seismic profile shows 4 major reflectors, viz. clay, sand, sand + Murram (Murram - chemically weathered product of basalt) altered trap and last one is acoustic basement (Fig. 2), beyond which no penetration is observed. The first two reflectors are confirmed after collecting grab and core sample whereas the rest of reflectors were confirmed after correlating with bore holes drilled in the nearby area by taking traverses adjacent to the bore-hole Rajamanickam⁹ et al (1988). The last reflector is in general, irregular. This irregular nature is probably due to erosion and structural disturbances such as faulting and intrusion. Beyond this reflector no clear reflectors are seen and therefore, it is interpreted as acoustic basement. This is identified as the basalt or its weathered derivatives. The depth of this undulatory or eroded nature of basement varies from 5 m to more than 30 meters in Pawas bay. In the northern portion of this bay the depth of basement rock is over 20 m. However, towards south, even though the undulatory basement is noticed the depth of basement decreases

gradually forming N-S trending depression over a length of 2 km with an average width of 200-300 m, and this depression gradually shallows towards offshore. Further south in Purangad bay the basement depth varies from 5 to 25 m, and its undulatory or uneven nature slowly changes to gentle towards south (Fig. 5). In Pawas and Purangad the sand is confined in the near-shore area with a minimum thickness of about 2 m which even extends to offshore below clay layer (Fig. 5). The configuration of the Konkan coastline has been controlled by a system of sinistral enclon faults Baby¹⁰ (1977). Based on geomorphological analysis, he has suggested that sedimentation around Ratnagiri (which is about 5-8km north of Pawas) has taken place in a basin bound by N-S faulted blocks which presumably extend to offshore and obviously affect the sedimentation in adjacent area.

The magnetic surveys were primarily carried out to check the possibility of correlating the magnetic anomalies with heavy mineral concentration, basement configuration and structural trends. The magnetic anomaly maps (Fig. 3) depict a general N-S trending magnetic anomalies. Besides low-amplitude circular to elongated and dipole anomalies, some ill defined anomalies were also noticed, and this type of anomalies were attributed to the eroded basement surfaces or disturbed basement without any extent. The low amplitude magnetic anomaly closers were more concentrated in Purangad bay. The low amplitude anomaly closers were attributed to the concentrations of heavy minerals in the offshore. Similar magnetic anomaly closers observed in Mirya bay (Ramana¹¹ 1988a) and Jaigad, Varvade and Ambwah bays (Ramana¹² 1988b) were interpreted partly due to the heavy mineral placer concentrations. In the light of magnetite distribution in the above area, magnetic model studies using Talwani and Heirtzlers¹³ 1964 method further confirmed that placer deposit possesses susceptibilities ranging from 1×10^{-3} to 3×10^{-3} exceptionally with few higher values ($4-5 \times 10^{-3}$). In Purangad the low amplitude magnetic anomalies were seen to concentrate nearer to the coast suggesting the distribution of heavy mineral sands not too far off the shore with 10-20% of magnetite. In Pawas bay the low amplitude magnetic anomaly closers were also seen. The distribution is not so dense. This may be due to variation in the general distribution of magnetite (Fig. 4).

The magnetic anomaly maps were also characterised by dipole type of magnetic signatures with considerable magnitudes. These anomalies were interpreted due to the structural elements like intrusives within the Deccan Traps. Since the occurrences of dykes are not uncommon as reported by Auden¹⁴ 1949 and (Ramana¹⁵, 11, 12 1986, 1988a, 1988b). Thus, these magnetic

anomaly maps were used to delineate the various prospectus zone.

The surveys so far carried out indicate presence of different concentration patches of placers (about 15 sq. km) on a very conservative way the reserves of ilmenite and magnetite to the 1 meter sand thickness can be inferred to be about 1 and 3.2 million tonnes in the study area respectively. The continuity of the sands in the offshore even below the clays and its average thickness of 2-3 meters would undoubtedly boost up the reserves. Thus, the extensive onshore and offshore deposits offer possibilities of an integrated development.

CONCLUSIONS

1. Beach placer sand extends offshore to the water depth of 11-12 meters beyond which it is covered by clays.
2. The heavy mineral concentration ranges upto 93.69% containing ilmenite (upto 22% in Pawas and upto 17% in Purangad) and magnetite (upto 47% in Pawas and upto 43% in Purangad) respectively.
3. The seismic profiles and sand isopach shows average sand thickness of 2-3 meters. The basement isopach of Pawas shows undulatory basement and north to south trending depression which probably acts as a trap for the accumulation of heavy minerals.
4. The correlation has been established between the magnetic anomalies and distribution of heavy minerals, specially magnetite.

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REFERENCES

1. Patel, M. S. : "Magnetite sands at Ratnagiri", Proc. Ind. Sci. Congr. (1936), 249.
2. Roy, B. C.: "Ilmenite sand along Ratnagiri Coast, Bombay", Rec. Geol. Surv. India, (1958), Vol. 87, 438-452.
3. Reddy, M. P. M.: "Wave refraction in relation to sediment transport tendency along the west coast of India", Indian J. Mar. Sci. (1976), Vol. 15, 152-162.

4. Rajamanickam, G. V., Vethamony, P. and Gujar, A. R.: "Effect of waves in the redistribution of sediments along Konkan coast", Proc. Indian Acad. Sci. (Earth Planet Sci) 95, (1986), 237-244.
5. Nair, B.: "Nature of nearshore heavy mineral placer sands off Purangad bay, Konkan Coast, Maharashtra", M. Sc. Dissertation, Delhi University (1986), 85.
6. Rajamanickam, G. V. and Gujar, A.R.: "Sediment depositional environment in some bays in Central West Coast of India", Indian. J. Mar. Sci. (1984), Vol. 13, 53-59.
7. Rajamanickam, G. V., Gujar, A. R. and Varma, O. P.: "Grain size studies from nearshore sediments off Jaigad, Maharashtra", Proc. Sedi. and Tectonics in Indian Subcontinent. (Oct. 1986).
8. Siddiquie, H. N., Rajamanickam, G. V., Gujar, A. R. and Ramana, M. V.: "Geological and Geophysical exploration for offshore ilmenite placers off the Konkan, Maharashtra", Offshore Technology Conference Proc. OTC 4296 (1982), 749-762.
9. Rajamanickam, G. V., Ramana, M. V., and Gujar, A. R.: "Use of shallow seismic surveys in the exploration of nearshore placers off Maharashtra coast, India", Offshore Technology Conference Proc. OTC. 5864, (1988), 475-487.
10. Babu, P. V. L. P.: "Geomorphological analysis of a sedimentary basin around Ratnagiri, Maharashtra" (W. India), Bull. Oil and Natural Gas Comm. (1977), 14, 81-85.
11. Ramana, M. V.: "Ramana, M. V.: "The relationship of magnetic anomalies with heavy mineral placers and basement configuration, Mirya bay, Central west coast of India", Mar. Mining (1988a), 7(1).
12. Ramana, M. V.: "Marine geophysical investigations off Konkan Coast with special reference to Jaigad, Ambwah and Varvada bays, Maharashtra, India". Ph. D. Thesis, Andhra University, Waltair (1988b), 202.
13. Talwani, M. and Heirtzler, J. R.: "Computation of magnetic anomalies caused by two dimensional structures of arbitrary shape", Computer in mineral industry (ed. G. A. Parks), Stamford University, (1964), 464-480.
14. Auden, J. B.: "Dykes in Western India", Trans. Nat. Sci. India. (1949), 3, 123-157.
15. Ramana, M. V.: "Regional tectonics trends on the inner continental shelf off Konkan and Central West Coast of India", Geo. Mar. Letters (1986), 1-5.

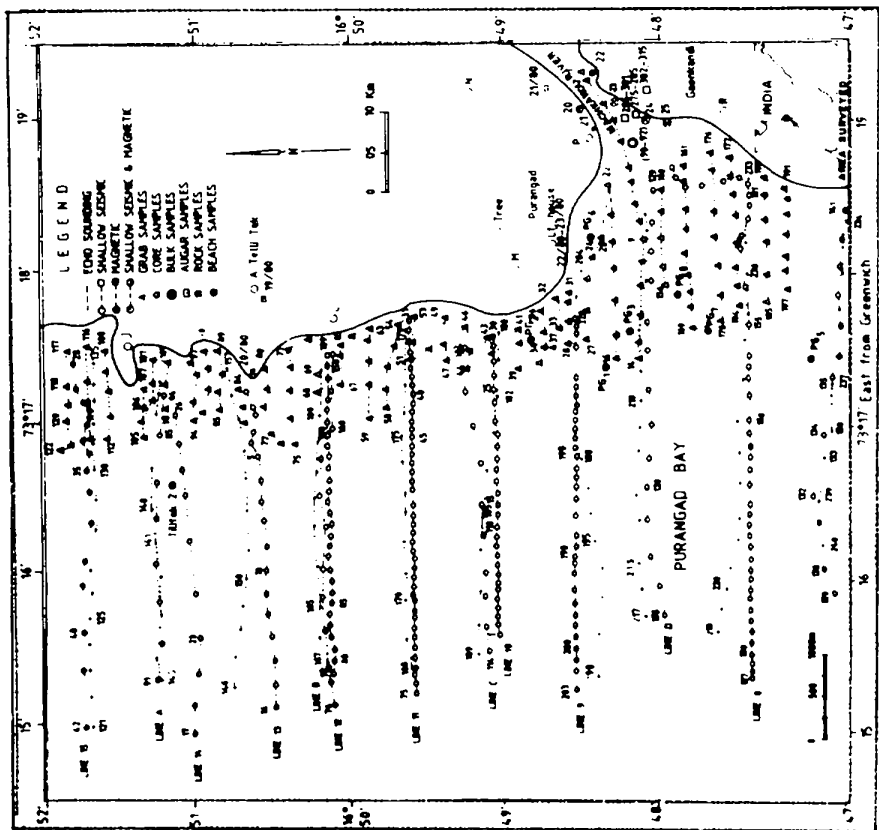
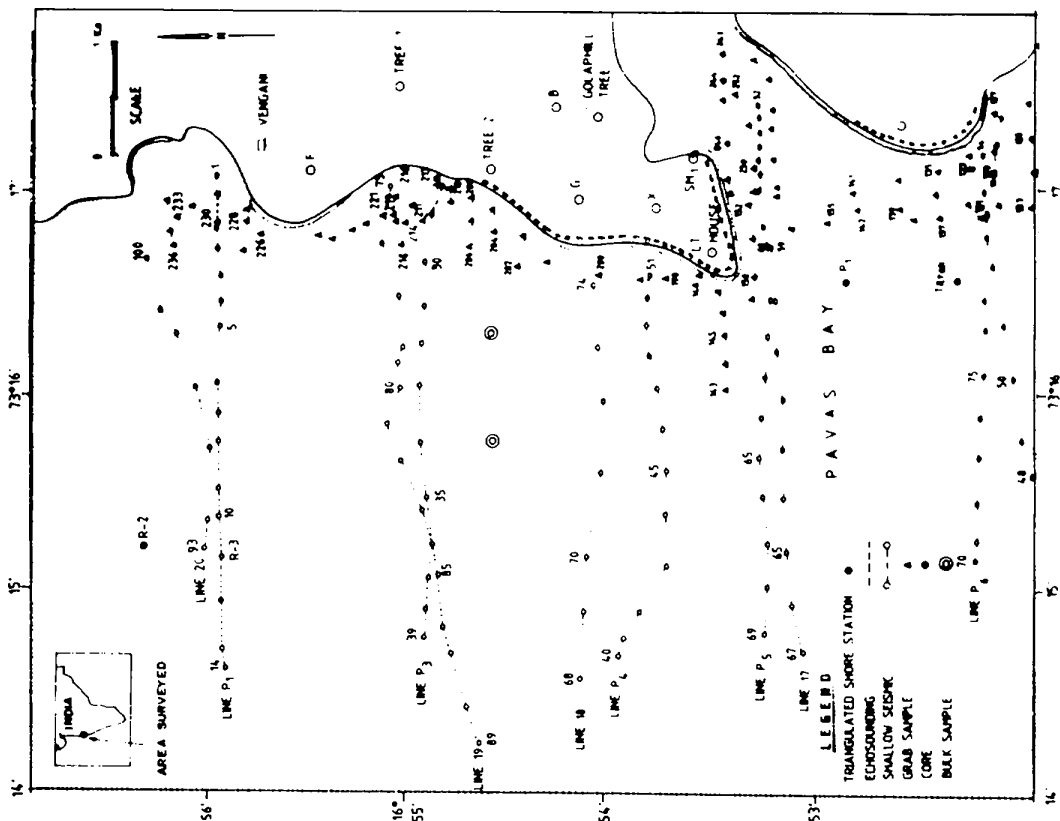


Fig. 1 MAP OF SURVEY TRACKS AND SAMPLING STATIONS OFF PAWAS AND PURANGAD BAYS KONKAN COAST, MAHARASHTRA

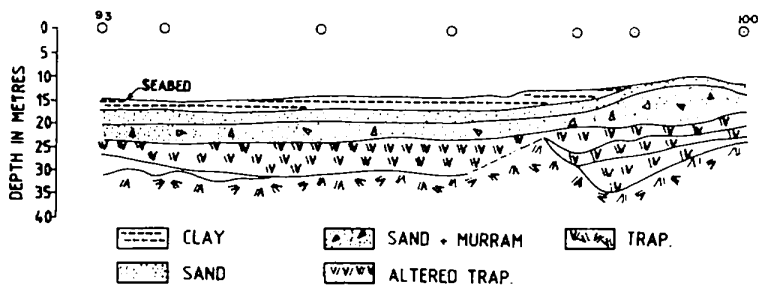


Fig. 2 INTERPRETED SELECTED SEISMIC PROFILE

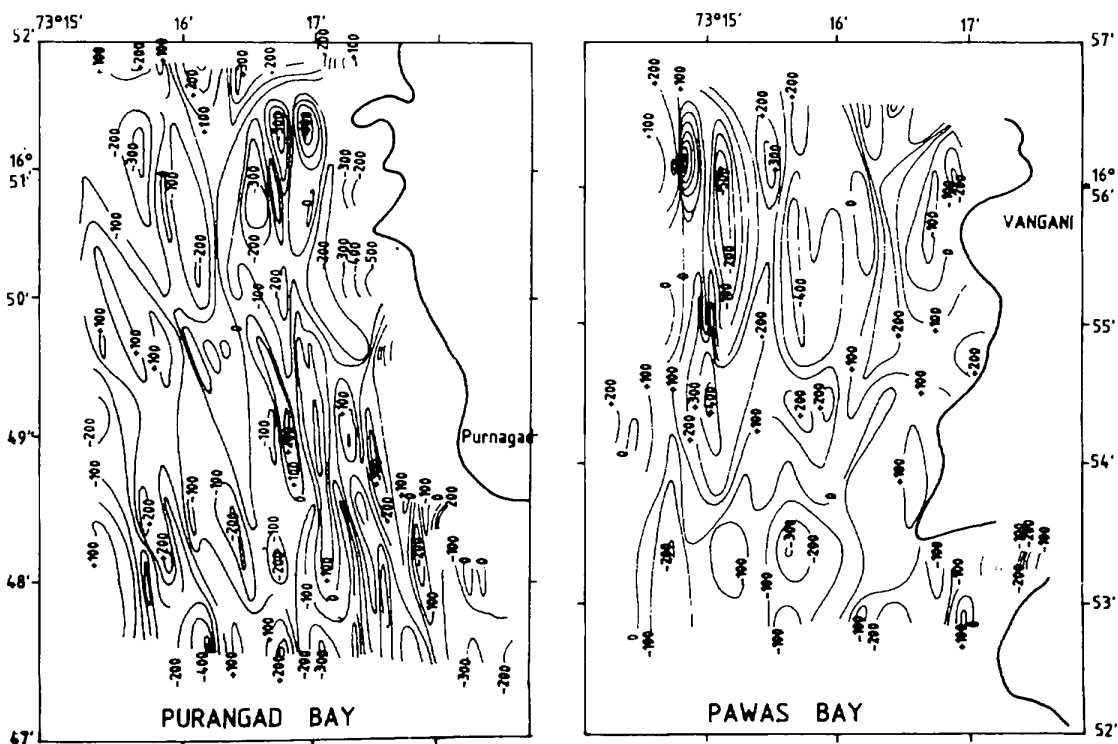


Fig. 3 TOTAL INTENSITY MAGNETIC ANOMALY MAPS OFF PAWAS AND PURANGAD BAYS KONKAN COAST, MAHARASHTRA (Contour interval 100 nT)

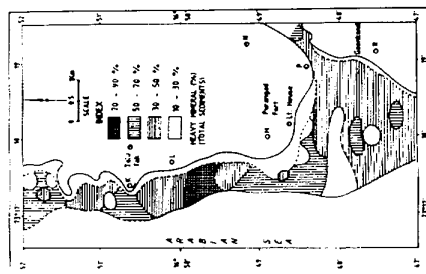
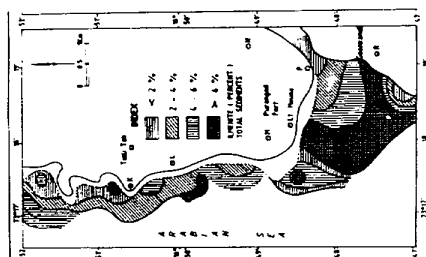
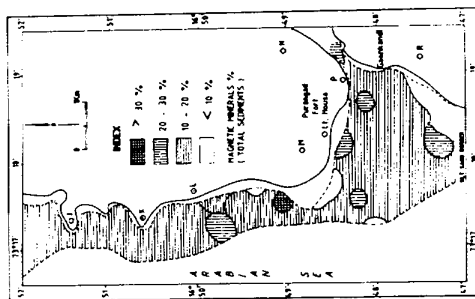
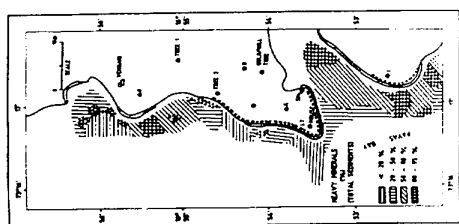
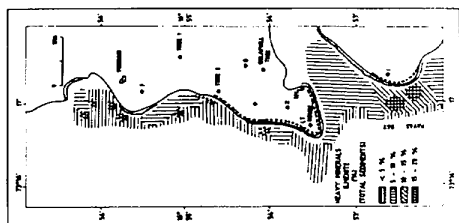
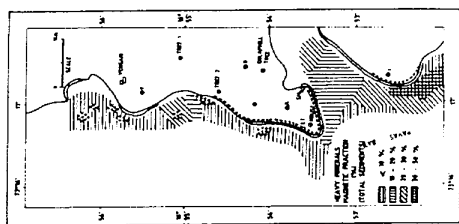


Fig. 4 : DISTRIBUTION OF HEAVY MINERALS. ILMENITE AND MAGNETITE IN THE SEDIMENTS OF PAWAS, AND PURANGAD BAYS KONKAN COAST, MAHARASHTRA.

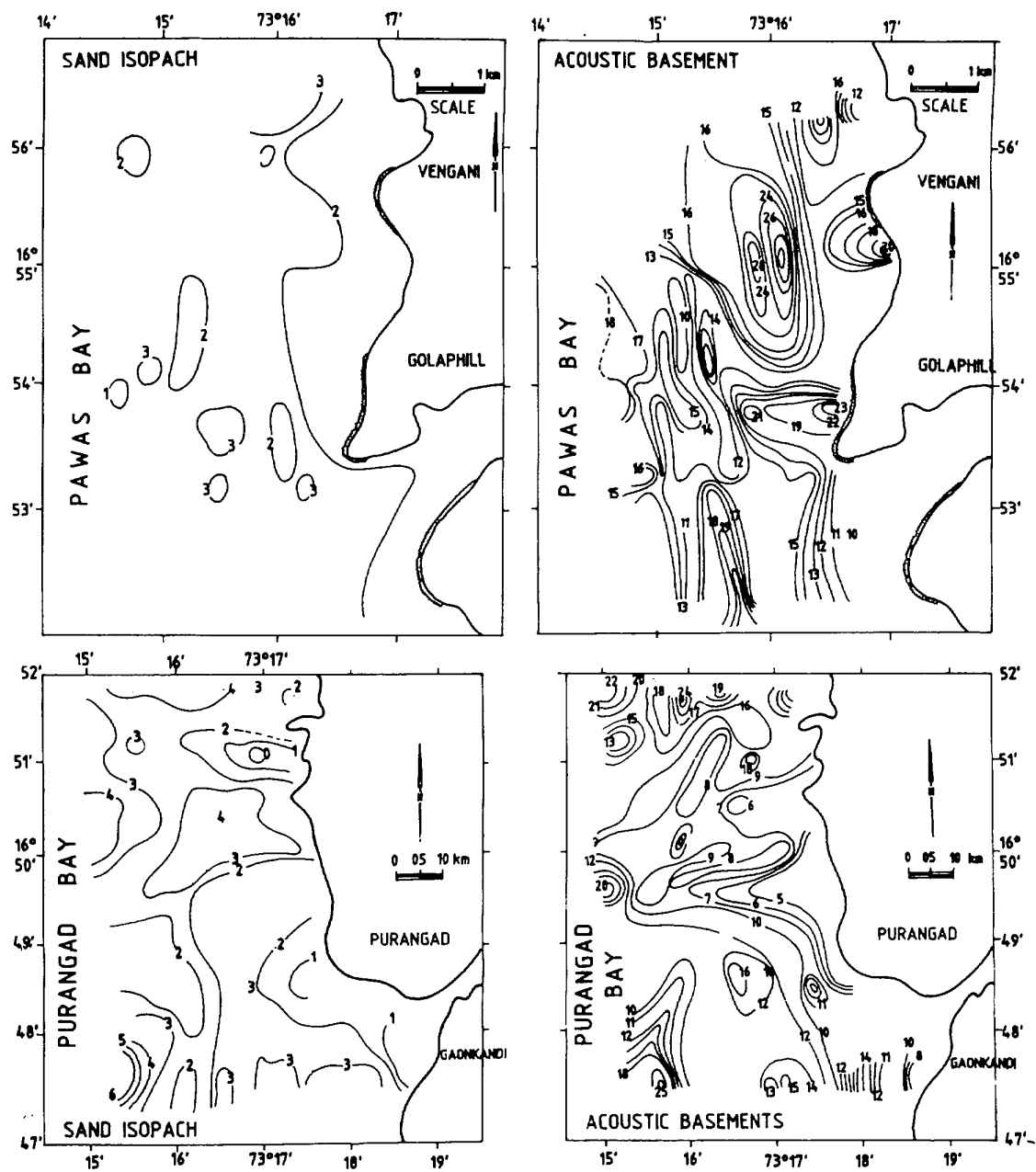


Fig.5 ISOPACH MAP OF PLACER RICH SAND AND ACOUSTIC BASEMENT OF PAWAS AND PURANGAD BAYS KONKAN COAST, MAHARASHTRA.