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GEOLOGICAL AND GEOPHYSICAL SURVEYS OF VISAKHAPATNAM COAST

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ABSTRACT

Continuous records of the total earth's magnetic field and the surface sediment samples from the ocean bottom have been collected off Ramakrishna Beach and Lawsons Bay along the Visakhapatnam coast. The magnetic data has recorded significant anomalies upto 15 m water depth. The bulk percentage of the heavy mineral concentration varies between 20 and 40% upto 15 m water depth. In Lawsons Bay area, a large amplitude magnetic anomaly with its peak to peak value of more than 700 nT extending beyond 30 m water depth has also been recorded. Two dimensional modelling of this anomaly has revealed a shallow intrusive body with its upper surface faulted on either side.

Key-words: Magnetic anomaly, Visakhapatnam coast, Geophysical studies. Black sands.

INTRODUCTION

The Visakhapatnam coast runs roughly NE-SW between the harbour and the Lawsons Bay and takes a turn towards north near Lawsons Bay. The width of the Visakhapatnam beach which is locally called as Ramakrishna beach (R.K. Beach) varies between 50 and 300′ and its general gradient is fairly steep. Throughout the year the wave action is quite heavy and it is more intense during the cyclones. Several patches of black sand deposits are generally noticed all along the beach and they are very distinct after monsoon and cyclonic periods. They are more concentrated at the mouths of the streams. Many of these streams are not seen now a days because some of them have got buried and others are diverted into drainage channels due to the rapid development of the city. The exposed cut face of the beach reveals alternating horizontal and inclined layers of black and white sands.

Department of Geology at Andhra University, Waltair, has been actively engaged for several years in the investigations of black sand deposits over the Visakhapatnam beach and the adjacent coastal regions. The samples collected were analysed and interpreted to derive the mode of transportation, deposition and concentration and to estimate the amount of available reserves. Sriramadas (1951) from the Petrographic studies of the beach sands concluded that the sediments brought by the empherical streams during the monsoon months are further sorted by the wave action and got accumulated over the beach. Mahadevan and Sriramadas (1954) reported nearly 5″ thick black sand patches over the Visakhapatnam beach and estimated that more than 10,000 tons of black sands were available from the patch formed over the beach immediately after the severe cyclonic storm, centered about 650 miles south-

east of Visakhapatnam, that occurred on December 5, 1951. They estimated the percentage composition of the magnetite and ilumenite together as more than 90% and the zircon, monazite and garnet as 4 and 2%, respectively and concluded that the greater the wave height, greater is the retrogradation of the beach, due to which the white sands are removed and the concentration of the black sands increased.

To the knowledge of the present authors, no work has been carried out in the offshore regions of the Visakhapatnam coast to study the occurrence and extent of these black sand deposits. Much evidence has been accumulated to show that the Visakhapatnam beach which was fairly wide, a few decades ago, has been retreading steadily. Prasada Rao and Mahadevan (1957) reported that some years before the construction of the harbour, bullock carts used to pass by the sandy beach which is now totally submerged. The beach was considerably narrowed down with the result that a road constructed parallel to the beach was completely damaged and washed away.

DATA COLLECTION

Preliminary magnetic surveys carried out by Rao and Murthy (1980) have shown the magnetic anomalies of the amplitude of about 600 nT off Visakhapatnam. Subsequently, detailed topographic and magnetic data were collected off Visakhapatnam covering the areas off R.K. Beach and Lawsons Bay. The profiles were placed at about 200 to 300 m intervals and were run parallel to the coast. These cover the area between 6 and 30 m water depths. The sea-bed topography was recorded continuously using the Simrad EY Echosounder with an outboard ceramic transducer. Total magnetic field intensity was recorded using the Proton Precision Magnetometer. The Magnetometer Sensor was towed about 30 m behind the boat and the readings were noted at 20 sec interval. The surveys were carried out on a mechanised fishing boat of about 12 m long which is fitted with a navigational compass and the speedometer. During the surveys the speed of the boat and its course were kept constant. Three theodolite stations were set up on the coast and the position of the boat was fixed at 5 minutes interval. About 50 surface sediment samples, using the grab, were also collected. The profiles along which the continuous topographic and magnetic data were recorded and the locations at which the sediment samples were collected are shown in Fig. 1.

DATA ANALYSIS AND DISCUSSIONS

The contours drawn for the distribution of the intensity of the earth's total magnetic field in the R.K. Beach and Lawsons Bay areas are shown in Fig. 2. The magnetic data presents two significant anomalies marked 'A' off R.K. Beach. The peak to peak amplitudes of these two anomalies are of about 400 nT. The anomalies get weakened towards the deep waters as shown by the closer of the contours at about 15 m water depth. Both these anoma-

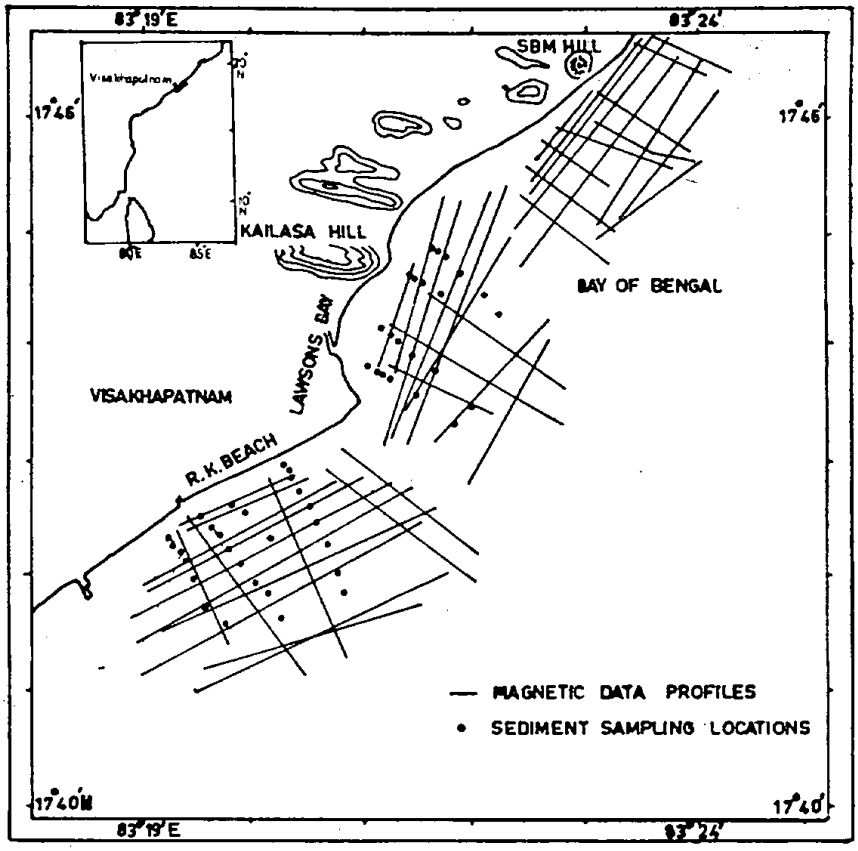

Fig. 1. Location map of the magnetic profiles and sediment samples.

lies occurred off the mouth of a stream. Off Lawsons Bay also two anomalies, marked 'A' which are getting closed at about 18 m water depth, were recorded. These anomalies also occurred opposite to the stream and the peak to amplitude of the anomalies varies between 200 and 400 nT. In addition to these two near shore anomalies, another anomaly, marked 'B' of more than 700 nT was also recorded off Lawsons Bay. This anomaly runs into the deeper parts of the sea and the contours do not get closed even upto 30 m water depth upto which the data were collected.

The anomalies were computed from the total magnetic field values recorded in Lawsons Bay area using the IGRF subroutine. The anomalies thus computed are interpolated for equal intervals of distance and are plotted along the profiles. The anomalies recorded on some of the profiles are stacked and presented in Fig. 3. These profiles cover the area between 8 and 28 m water depth. The average depth recorded at the middle of each profile is noted in parenthesis on each anomaly (Fig. 3). From this stacked profiles (Fig. 3), it could be clearly seen that the anomaly recorded at the northern end marked 'A' is quite predominent at shallow depths and gradually gets weakened and almost disappears at about 20 m water depth. The other anomaly marked 'B'

progressively becomes stronger towards deep waters and it does not get closed even at 30 m water depth. The anomaly also gets broadened as it advances to the deep waters and it is about 3 km wide at about 24 m water depth.

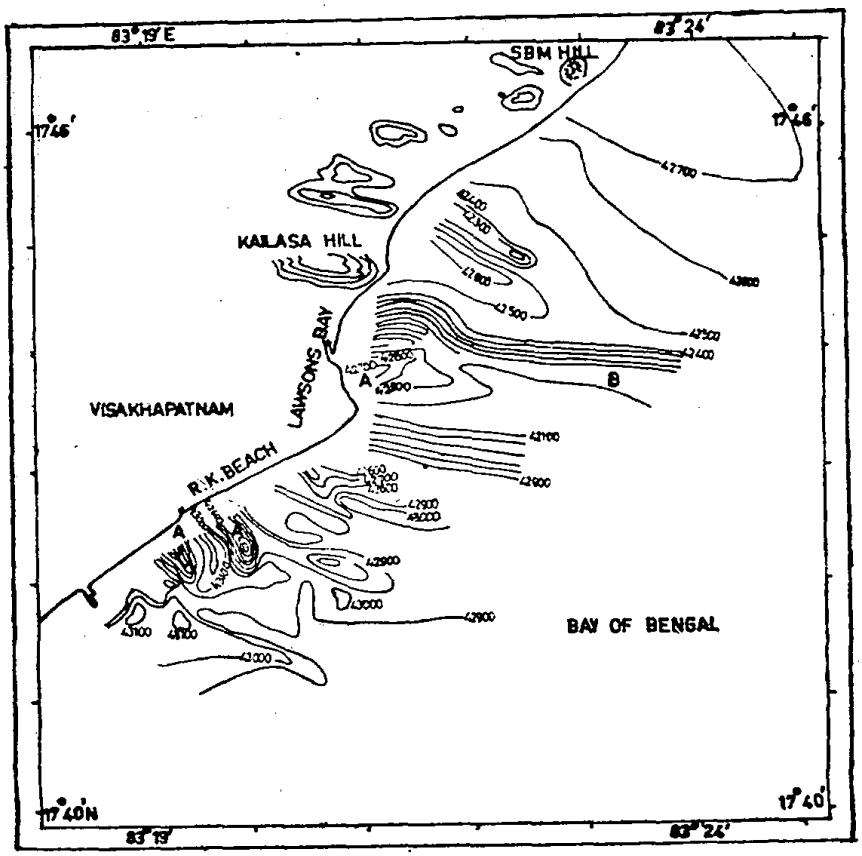

Fig. 2. Map showing the total magnetic field intensity contours.

The sediment samples collected off R.K. Beach and Lawsons Bay areas are analysed for the grain size distribution and the separation of heavy mineral fractions, following Folk (1974) and Milner (1962), respectively. After the samples are thoroughly washed and dried, the sieve analysis was carried out at 0.5 ϕ ' interval with the sieves starting from 18 mesh to 230 mesh size using the rotar sieve shaker. As the sand fractions, whose sizes are greater than 250 microns are found to be almost devoid of heavy minerals, only those fractions that are less than 250 microns are subjected to heavy mineral analysis. These were further divided into two groups called as coarse fractions whose sizes are more than 125 microns and finer fractions whose sizes are less than 125 microns. The heavy mineral separations are carried out for each group separately using the Bromoform, having specific gravity of 2.89 g/cc. The weight of each group thus obtained are added together to get the bulk total heavy mineral percentage of the respective samples. Among the heavy

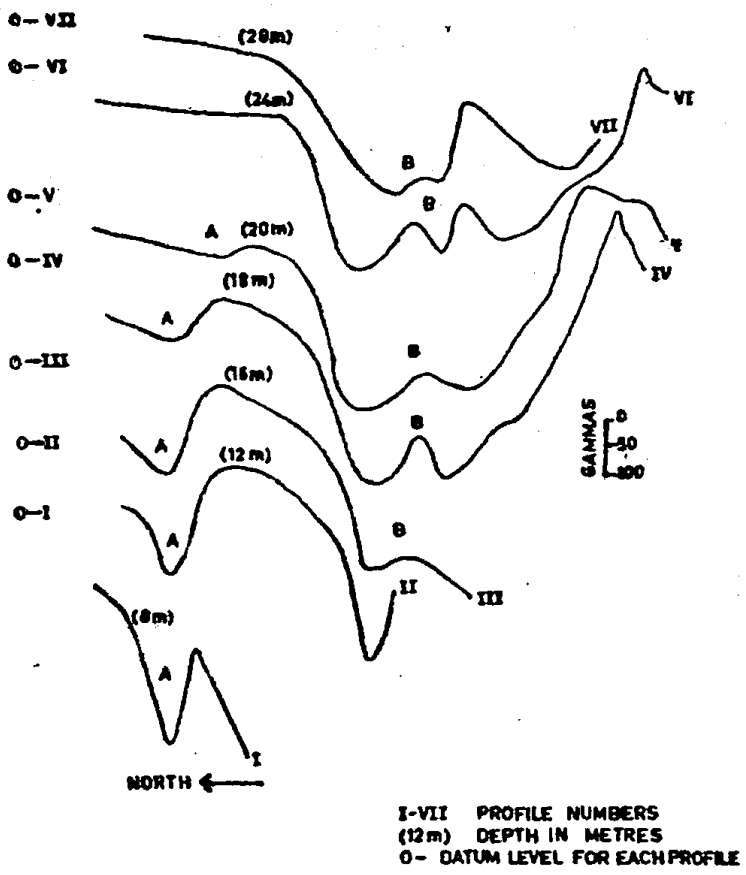

Fig. 3. Total magnetic field anomalies stacked along some profiles in Lawsons Bay area.

minerals noticed magnetite is found to be prolific and dominating. The bulk percentage of heavy mineral concentrations varied from 5 to 45% off R.K. Beach and from 5 to 33% in the Lawsons Bay. The higher concentrations of the heavy minerals ranging between 20 and 40% normally occur upto about 15 m water depth beyond which they progressively decrease. The percentage distribution of the total heavy mineral concentrations in the R.K. Beach and Lawsons Bay areas is shown in Fig. 4.

Heavy minerals are found to be more concentrated at the places where the small streams and drainage channels enter into the sea. This suggests that the streams drain large quantities of sediments from the land into the sea during the monsoon periods where these were further subjected to winnowing by the waves and currents. Due to this winnowing, the heavier finer particles are settled near to the mouths of the streams and the lighter particles are carried to the deeper parts. The laboratory analysis of the sediments also indicates that the heavy mineral concentrations are predominant in the finer fractions of the sediments that are present near to the coast. The concentra-

tion of the total heavy minerals in the size fractions less than 88 microns is found to be more than 90%. It also supplemented the earlier investigations by Mahadevan and Sriramadas (1954) for the black sand deposits on the Visakhapatnam beach.

The total magnetic field intensity values contoured in Fig. 2 and the distribution of the heavy mineral concentration drawn in Fig. 4, suggest that the magnetic anomalies, marked 'A' off the R.K. Beach and Lawsons Bay correlate well with the high concentrations of the heavy minerals. This further confirms the occurrence and the extension of black sand deposits into the offshore regions. Two dimensional modelling of these anomalies is being

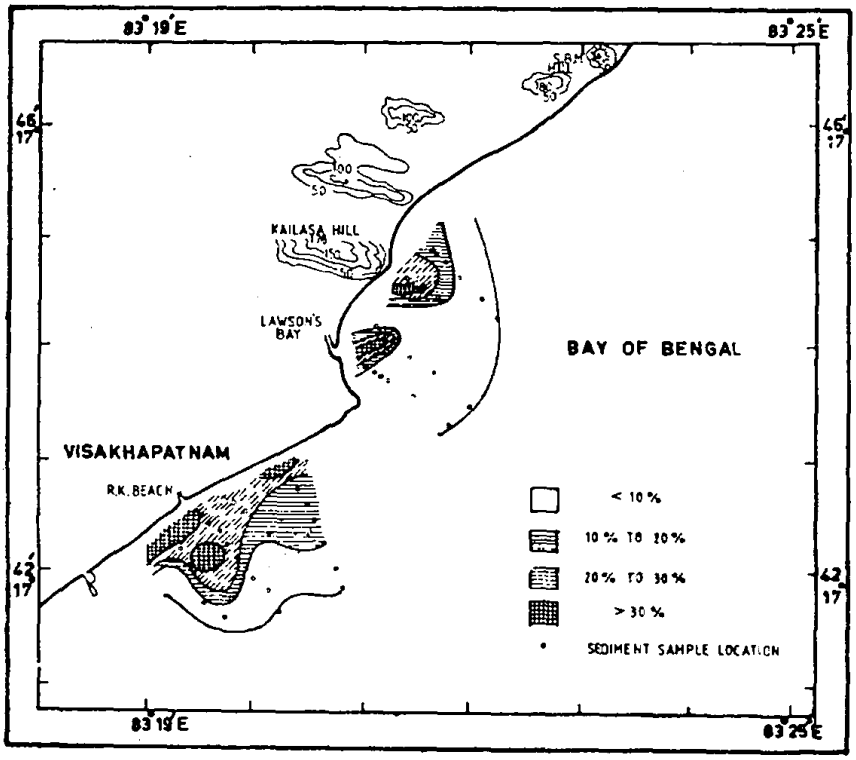

Fig. 4. Map showing the distribution of bulk percentages of heavy minerals.

carried out separately to determine the extent and thickness of these black sand deposits. The analysis and interpretation of the large amplitude anomaly, marked 'B' (Fig. 3) in the Lawsons Bay area is presented in this paper.

Among the seven profiles stacked in Fig. 3, the anomaly on profile 5 recorded at about 20 m water depth is choosen as a representative anomaly for the Lawsons Bay area. The theoretical anomaly has been computed for the two dimensional body by trial and error, following Talwani (1965) till a reasonably good fit is obtained between the anomaly recorded and the theoretical anomaly computed. The observed anomaly, the theoretical anomaly and

the two dimensional body are shown in Fig. 5. The model that gives the reasonably good fit for the central portion of the observed anomaly represents an isolated intrusive body extending infinitely downwards. It is about 2.5 km in width and its upper surface is irregular associated with local shallow faults on either side. The central portion of the body is less than 200 m deep from the sea surface and the two edges on either side are at a depth of about 600 m. At the southern end of the profile the anomaly presents a positive peak but the complete trend of the anomaly could not be recorded since the profile did not extend further south. This puts the constraints for obtaining a better fit at the southern end of the profile. Similarly, at the northern end also the theoretical curve does not fit well with the observed anomaly. It may

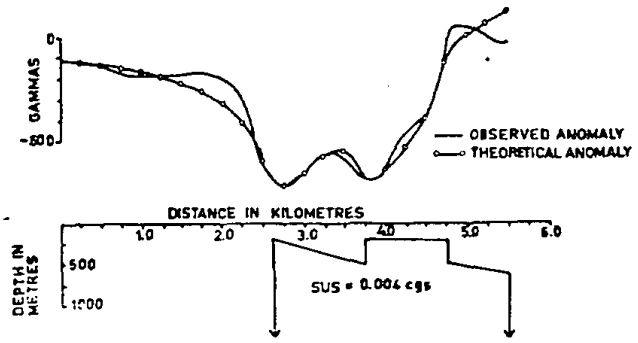

Fig. 5. Two dimensional model body along with the theoretical and recorded anomalies.

be due to the fact that the effect of the anomaly 'A' which is predominant at the shallower depths and gradually becomes weaker towards the deep waters is not taken into account in the present computations. Comprehensive modelling of the anomalies in this area after taking into account the shallow water anomalies that are believed to be associated with the black sand deposits in the offshore region will give a better idea about the causative sources for the magnetic anomalies. However, the present studies clearly indicate that the anomaly 'B' in Lawsons Bay area is caused by the shallow intrusive body that has undergone faulting.

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REFERENCES

Folk, R.L., 1974. Petrology of Sedimentary Rocks. Hemphill, Austin, Texas, 182 pp.

Mahadevan, C. and A., Sriramadas, 1954. Effects of high waves on the formation of coastal black sand deposits. *Andhra University Memoirs*, **1**: 57–62.

Milner, H.B., 1962. Sedimentary Petrography. George Allen and Unwin Ltd., London, **1** and **2**: 643 pp and 715 pp.

Prasada Rao, R. and C. Mahadevan, 1957. Evolution of Visakhapatnam beach. *Andhra University Memoirs*, **2**: 33–47.

Rao, T.C.S. and K.S.R. Murthy, 1980. Magnetic Surveys of the continental shelf off Visakhapatnam. *Mahasagar–Bulletin of the National Institute of Oceanography*. **13**: 83–89.

Sriramadas, A., 1951. The Black sand concentrates of the Visakhapatnam Beach. *The Quarterly Journal of the Geological, Mining and Metallurgica· Society of India*. **XXIII**: 169–180.

Talwani, M., 1965. Computation with the help of a digital computer of magnetic anomalies caused by bodies of arbitrary shape. *Geophysics*, **30**: 797–817.