

Letter Section

MARINE MAGNETIC ANOMALIES OFF RATNAGIRI, WESTERN CONTINENTAL SHELF OF INDIA

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ABSTRACT

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Total magnetic intensity and bathymetric surveys were carried out in the offshore area of Ratnagiri on the western continental shelf of India and an isomagnetic anomalies map at a contour interval of 50 nT was prepared which reveals N–S trends of magnetic anomalies. Two-dimensional model and spectral studies of these anomalies were carried out, and subsurface models of the geology in the area have been derived from anomalies at a number of places. The results suggest that the anomalies occur over a magnetic crystalline basement at a depth of 1–1.2 km which is similar (in magnetization) to onshore basalts of northwest India. These anomalies are believed to be an expression of a considerable thickness (around 1.7 km) of basalt, underlain by sediments. Identification of these basalts in offshore areas along the northwestern continental shelf of India would support (1) the idea that the onshore Deccan basalts of western India and the rhyolitic tuffs at the Laccadive ridge system (DSDP Site 210) are related to the same volcanic events, and (2) subsequent downfaulting of onshore Deccan basalts into the Arabian Sea and submergence below the Tertiary sediments.

INTRODUCTION

Geological and geophysical investigations carried out by Naini and Kolla (1981), Babenko et al. (1981) and Ramaswamy and Rao (1980) have contributed to the understanding of the sub-surface geology of the western continental margins of India. Such investigations were further intensified after the discovery of the giant Bombay High Oil field on the mid-shelf (70–90 m water depth) off Bombay. Recent deep seismic surveys and bore holes drilled by the Oil and Natural Gas Commission of India on the western continental shelf revealed Paleocene to Eocene sediments overlying either late Cretaceous/early Tertiary basalts or Archean/Precambrian granitic gneisses (Sahay, 1978; Basu et al., 1980). As the nature and structure of the basement are not known at many places on the western continental shelf of India detailed geophysical studies were needed.

As a part of the Institute's project to study the offshore extension of

ilmenite placers, a total magnetic intensity survey in offshore areas of Ratnagiri was carried out on board RV "Varsha" during April 1975. Two-dimensional model and spectral studies of the magnetic anomalies found under constraints from seismic reflection and paleomagnetic studies were carried out. Subsurface models of the geology in the area led to the identification of the nature and structure of the basement.

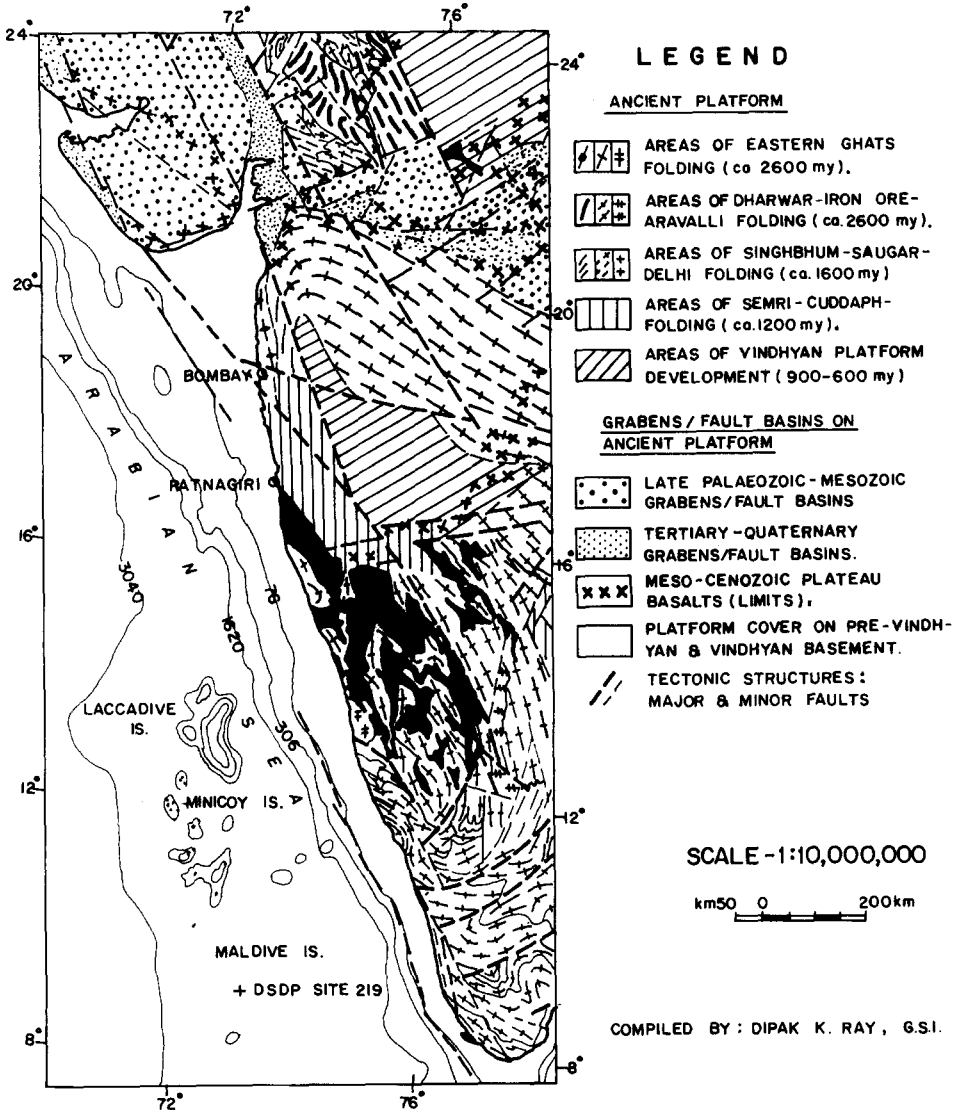


Fig. 1. The regional geology and tectonic setting along the western Indian peninsula and continental margins.

GEOLOGY OF ONSHORE AREA

The Deccan traps are exposed all along the Konkan Coast, between 16° – 25° N (Fig. 1). Auden (1969) reported a large thickness (around 2 km) of basalts near the Bombay Coast, while Kaila et al. (1981) reported more than 600–700 m of thick basalts near the Koyna region. The thickness of the basalts increases towards the west and they end abruptly near the coast. Krishnan (1960) suggested offshore extensions of basalts along the continental shelf of the Kathiawar and Bombay coasts, western India.

Wensink et al. (1981) reviewed the results of paleomagnetic studies of basalts from the central and western India peninsula. The studies revealed that: (1) 6–20 m thick lava flows extend over large distances and sequences of such flows or piles lie one on top of the other; (2) thick continental Permian or Mesozoic sediments (Gondwana formations) underlie the lava flows in the north and northwest of India (Kaila et al., 1981); and (3) the paleomagnetic stratigraphy of basalts in central and northwestern India reveals that at least 800 m thick lava flows at the bottom show a reversed magnetic polarity with a remanent magnetic intensity inclination of around $+50^{\circ}$ and declination of $+130^{\circ}$. Basu et al. (1980) noted the presence of basalts overlain by around 2 km of Paleocene/Eocene to Recent sediments in the offshore areas of the Bombay coast. Paleomagnetic studies on drill cores of basement rocks and two-dimensional modelling of magnetic anomalies in areas offshore of Bombay revealed reversed magnetic polarity (positive remanent magnetic intensity inclination around $+50^{\circ}$; (Gopala Rao, 1983), similar to onshore basalts of northwestern India. Rhyolitic tuffs on the Laccadive ridge system (DSDP samples at Site 219) below Eocene sediments were derived from the same volcanic activity as the onshore basalts (Siddiquie et al., 1976).

FIELD AND LABORATORY METHODS

The area studied lies in the offshore area of Ratnagiri, western continental shelf of India (Fig. 2). Total magnetic intensity measurements were carried out with an ELSEC magnetometer along five profiles covering near-shore and mid-shelf areas. The magnetometer sensor was towed at more than twice the length of the vessel to avoid interference by extraneous magnetic effects. The data were recorded at 8 s intervals, resulting in sampling at about 30 m intervals. Diurnal variations of 5–10 nT were noticed for the survey period from magnetograms from Colaba Observatory ($18^{\circ}38'N$, $72^{\circ}52'E$) and are negligible compared to the observed anomalies. The Earth's dipole field, IGRF (International Geomagnetic Reference Field) for the 1975 epoch suggested by the IAGA working group, was considered for the regional magnetic field. An isomagnetic anomaly map (Fig. 2) at 50 nT intervals was prepared after duly correcting the observed magnetic intensity values.

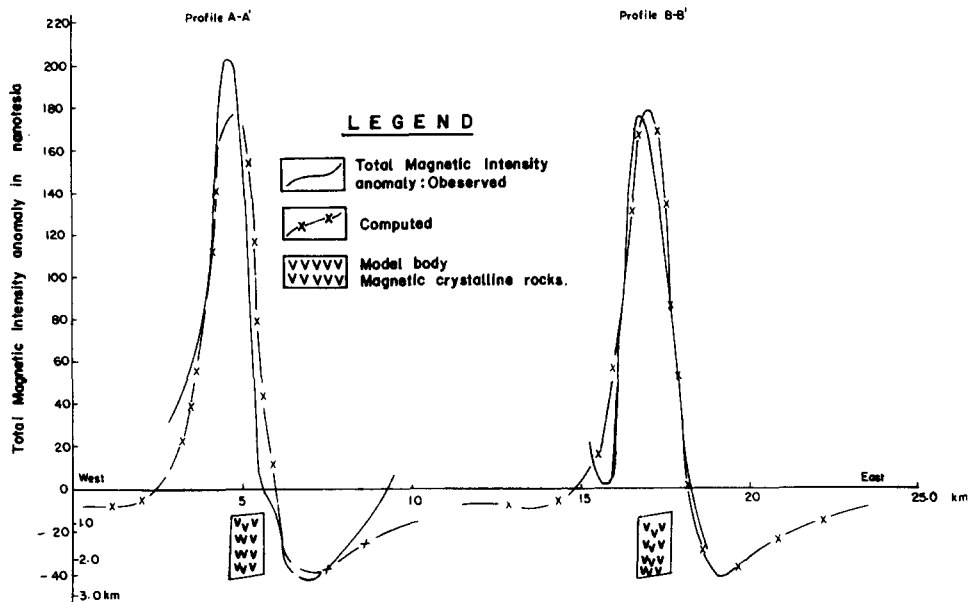


Fig. 3. Two-dimensional magnetic block model contributing to observed total magnetic intensity anomalies. Effective magnetization = 3.1 A/m parallel to present field. (Strike of body = north-south; profile direction = west-east; induced magnetic intensity = 1.1 A/m; inclination of induced magnetic intensity = $+23^\circ$; declination of induced magnetic intensity = -2° ; intensity remanent magnetization = 3.0 A/m; inclination of remanent magnetization = $+50^\circ$ and declination of remanent magnetization = $+130^\circ$.)

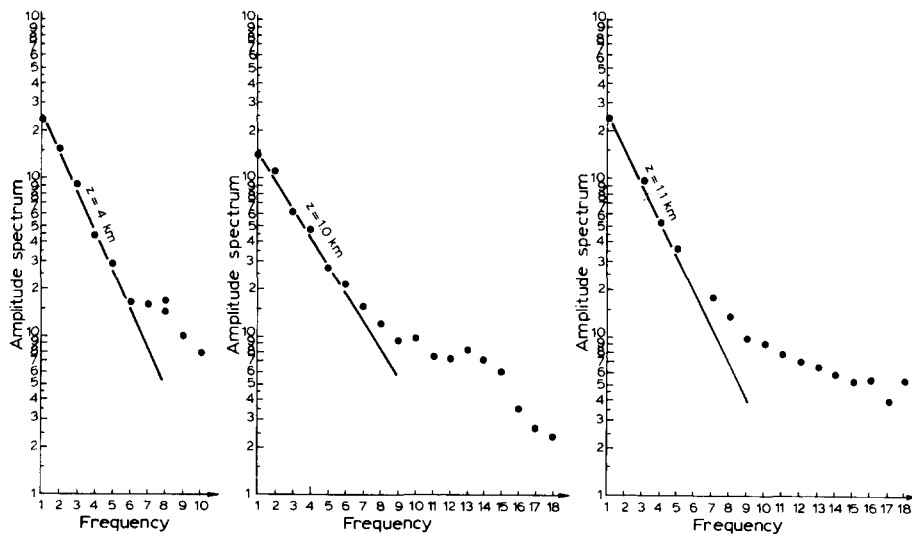
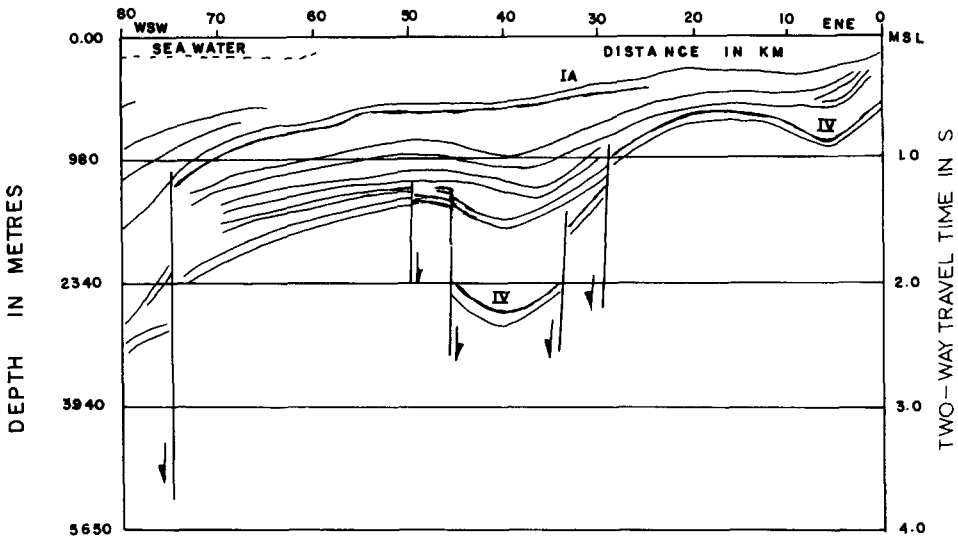


Fig. 4. Amplitude spectrum of magnetic anomalies of the continental shelf off Ratnagiri, western India. *a* and *b* are amplitude spectra of western and eastern halves of the anomaly map (Fig. 1; at 0.5 km distance interval). *c* is the amplitude spectrum of the magnetic anomaly map (Fig. 1; at 1.0 km distance interval).

TABLE I

Estimated depths and thicknesses from two-dimensional spectral analysis and two-dimensional mode studies

Area block of anomalies/ anomaly profiles	Peak to peak amplitudes (in nT)	Wave- lengths (km)	Depth (km)	Thick- ness (km)
<i>Spectral analysis</i>				
Block A			1.4	—
Block B			1.0	—
Block C			1.1	—
Average			1.2	—
<i>Model studies</i>				
Anomaly (A-A')	200-210	3-4	1.0	1.7
Anomaly (B-B')	170-180	2-3	0.8	1.8
Average			0.9	1.7



Seismic Section along line D-D'

Fig. 5. Interpreted seismic section of the seabed across the continental shelf off Ratnagiri, western India (after Agarwal and Singh, 1981). IA and IV are the base of middle Miocene and Paleocene sediments, respectively, influenced by deep faults.

offshore basalts off the Bombay coast (Gopala Rao, 1983). A two-dimensional spectral analysis of the magnetic anomalies (Fig. 4) in a data matrix of 52×52 spaced at 0.5 km intervals was also performed following Hahn (1965), considering the area under two data matrices. Table I presents the model parameters obtained from the present studies. The anomalies

were found to be due to bodies with a top at around 1.0 km and with a thickness of 1.7 km, close to the depths of the acoustic basement on the seismic section, D—D' in Fig. 5 from the areas offshore Ratnagiri, west of India (Agarwal and Singh, 1981).

CONCLUDING REMARKS

(1) The N—S lineations of magnetic anomalies reveal structural trends contributing to the anomalies.

(2) A close conformity between the depths estimated of about 1 km from magnetics and the acoustic basement from seismic reflections indicates that the basement depth in both the cases is almost the same. Considering the onshore and offshore geology and the tectonics of adjacent onshore regions, it is believed that the source contributing to the anomalies is the downfaulted basalts in the Arabian Sea along northwest India.

(3) These anomalies could be attributed to either magnetic intensity contrast due to differential mineralisation within the basalts at shallow depth, or increased thickness of basalt flows. The latter explanation is supported by the geology of the onshore basalts of northwest India and is therefore preferred.

(4) Similar crustal magnetic anomaly studies in other areas of the western continental shelf of India are suggested.

(5) Identification of basalts in areas offshore of Ratnagiri, northwest of India will bridge the existing gap in the geology and also support the idea of Siddiquie et al. (1976) that rhyolitic tuffs on the Laccadive Ridge below Eocene sediments (DSDP Site 219) and the further extension of basalts along the west coast of India are connected events.

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