

MAGNETIC ANOMALIES OFF BOMBAY COAST, WEST OF INDIA

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ABSTRACT

Bathymetric and total magnetic intensity anomaly maps of the continental shelf off Bombay coast, west of India are prepared. Very sharp gradient positive and negative anomalies in the south east, low frequency negative anomalies in the south and southwest, high amplitude low frequency positive anomalies in the offshore basin and smooth gradient anomalies in the west of the continental shelf are noticed. The anomalies trend E-W, ENE-WSW, N-S and NW-SE. Correlation of the anomalies with the results of the drill wells logs of the Oil and Natural Gas Commission of India revealed that positive and negative magnetic anomalies occur in areas of late Cretaceous/early Tertiary basaltic lavas, Deccan traps and Archean/Precambrian granitic gneisses etc. respectively. Two-dimensional model study of the anomalies revealed depth to top of the magnetic basement at 1.4 km to 5.0 km. sediment thickness of about 1.4km to 5.0km is interpreted on the shelf.

INTRODUCTION

Magnetic anomalies of the world oceans are studied to decipher the crustal structure, tectonics of the rifted and the drifted continents. The anomalies arise due to heterogeneities in composition of rocks or structures or both within the earth's interior. Identification of the anomalies vis-a-vis known geology and crustal structure yield the best results and limit the uncertainties in deciphering the geology of the earth's crust with its complicated structure. The correlations are essentially utilized in syntheses of the anomalies and model studies for quantitative estimation of the complex submarine geology of the earth's crust. The studies of magnetic anomalies afford great promise for investigating the submarine basement structure enabling the assessment of mineral prospects of the areas and development of the offshore oil fields.

Such studies on the magnetic anomalies on the continental shelves and margins off Bombay coast (India) have also been done¹⁻⁶. With this background, regional and detailed magnetic

investigations in the offshore regions off Bombay coast and on the Bombay high respectively were carried out (Fig.1). A brief description of the plan and procedure of the present surveys, equipment employed, the analyses of the data and the presentation of the results are summarised.

PLAN AND PROCEDURE OF SURVEYS

In the present surveys bottom topography was recorded with a 30KHz frequency echosounder. Total magnetic intensity of the earth's magnetic field was measured by employing a Barringer oceanographic proton precession magnetometer, OM101. The sensor of the magnetometer was towed 150m astern of the 68.8 m long Research Vessel *Gaveshani*. Console of the magnetometer was mounted on a non-magnetic stand inside the onboard laboratory. Analog recording of the magnetic data in nanotesla (nT) was made at 12 sec. interval, which corresponds to a distance at sea of 30m and 60m at 5 and 10 knots speed of the vessel respectively. The recorder is a Hewlet Packard recorder model no.3272 which has a 10 inch wide pressure sensitive recording paper for a full scale range of 100 nt. Digital magnetic values at an interval of 25 readings were also noted on the recording paper from the digital display provided on the console of the magnetometer.

During the surveys Shoran (model XR) and Decca (Mark 80309A) receivers and Decca Radars (Type X & Y band) were utilised to obtain accurate positions continuously along the survey lines. The positional accuracies are ± 15 to ± 20 m with the shoran and ± 100 to ± 300 m with the other systems. The magnetic surveys were undertaken in the three fine weather field seasons during 1976-78. The magnetic measurements on the Bombay High were made on E-W profiles of 280 line kms and N-S profiles of 400 line kms. While a regular spacing of profiles in the E-W direction could not be achieved, the N-S profiles are laid at an interval of 2 kms. In the regional surveys on the continental shelf off Bombay the magnetic measurements were made on profiles of 1720 line km. These regional profiles are closely spaced enabling preparation of reliable anomaly maps. From the magnetograms of the Colaba magnetic Observatory of the Indian Institute of Geomagnetism, Bombay it was ascertained that the days of the field work of the surveys were magnetically quiet.

PROCESSING OF DATA

A bathymetric contour map at 5m interval was prepared (Fig.2). The magnetic data of the total magnetic intensity

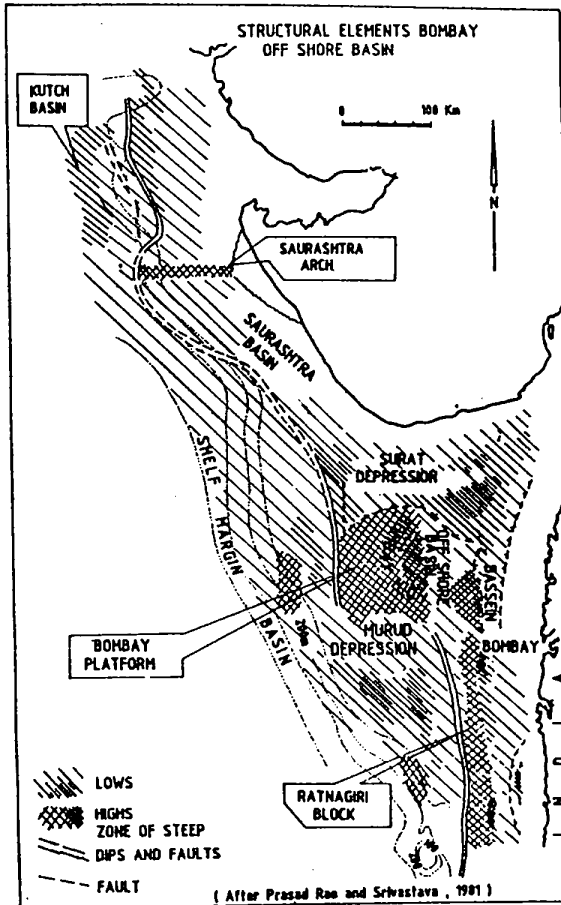


Fig.1. Regional structural elements of the northwestern continental shelf of India.

values collected in analog form in the field surveys are digitized in the laboratory at an interval of half a kilometer. World magnetic Data Centre at Copenhagen, Denmark and Indian Institute of Geomagnetism at Bombay, India, provided the magnetograms of daily variations of vertical, horizontal intensities and declinations in analog form observed at the Geomagnetism Observatory at Colaba ($18^{\circ} 30' N$ latitude and $72^{\circ} 52' E$ longitudes), India for the periods of the surveys. The time variation in the total magnetic intensity values were estimated from the measured horizontal and vertical components from the magnetograms. Earth's dipole field is considered to be based on the

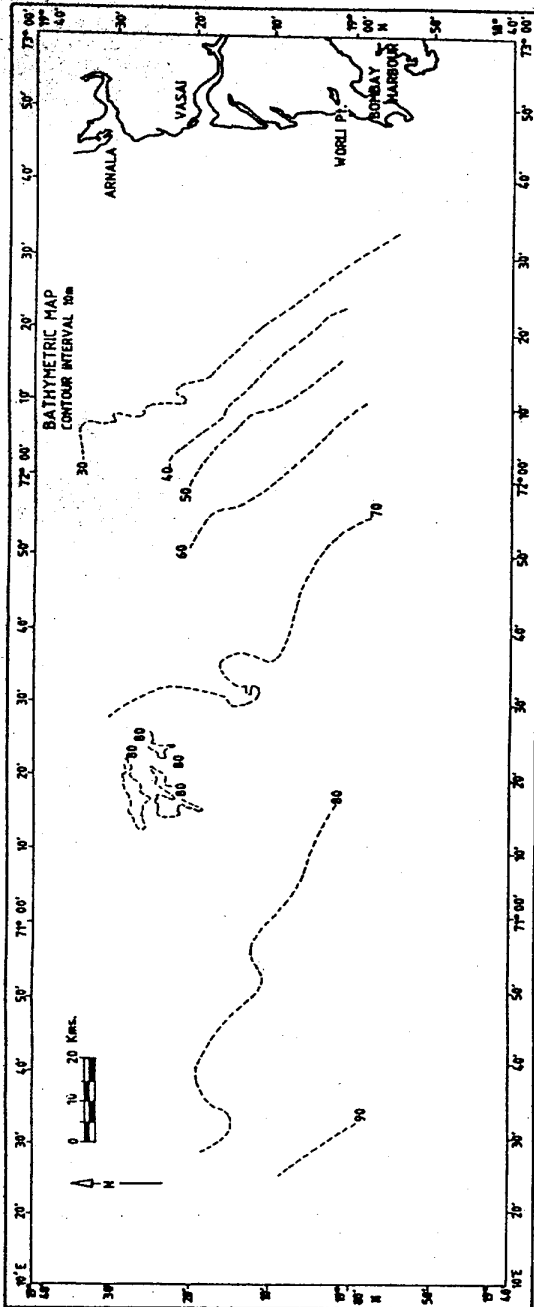


Fig.2. Bathymetric map of the continental shelf of Bombay coast (Contour interval 10m).

coefficients suggested for the International Geomagnetic Reference field (IGRF) for 1975 epoch⁶ (IAGA Working Group, 1975). Anomalous field/time invariant field of every digitized data was obtained after subtracting the time variant field and the regional magnetic field which arises due to inhomogeneities within the magnetised crustal layers above the cruise isotherm, normally at about 18 to 25 km depth.

In spite of the procedure adopted in these surveys of towing the sensor at a distance of about 150m astern (slightly more than twice the length of 68.8 m long Research Vessel Gaveshani), it has been observed that there is heading effect in the observations. The effect is seen to be more on N-S profiles than on E-W profiles. The observations were corrected for the heading effect with the help of Bullard and Mason's formula in its first approximation.

$$F_{\text{Head}} = a \cdot \cos Q$$

Where Q is the course of the ship relative to the magnetic north. The coefficient 'a' was determined by the observed changes in the magnetic field during sharp changes of course and was found to vary between 5 to 30 nT depending on the length of the towing cable and the speed of the vessel. Even after the application of the corrections mentioned above, it was observed that at cross over points of intersecting profiles the corrected total magnetic intensity values were usually found to differ by variable amounts but not greater than 20 nT in any case. These discrepancies were suitably adjusted by altering the baseline values of the profiles so that consistent magnetic anomalies are derived from the observations. The stacked anomaly maps are prepared on to two scales: one is on horizontal scale of 1 cm = 5 km and vertical scale 1 cm = 200 nT (Fig.3), the other is on horizontal scale of 1 cm = 3 km and vertical scale 1 cm = 100 nT (Fig.4). While the magnetic anomalies were plotted and profiles and iso-anomaly maps prepared. The anomaly maps were prepared on to 1 cm = 5 km and 3 km scale with variable contour interval from 20 to 50 nT.

These are found convenient to illustrate the anomalies without loss of detail and correlations could be made either on stacked anomaly illustrations or on anomaly contour maps. Discussions of the observed anomalies are presented.

QUALITATIVE AND QUANTITATIVE INTERPRETATION OF MAGNETIC ANOMALIES:

Identification of anomalies vis-a-vis known geology and crustal structure is the first approach of interpretation of the

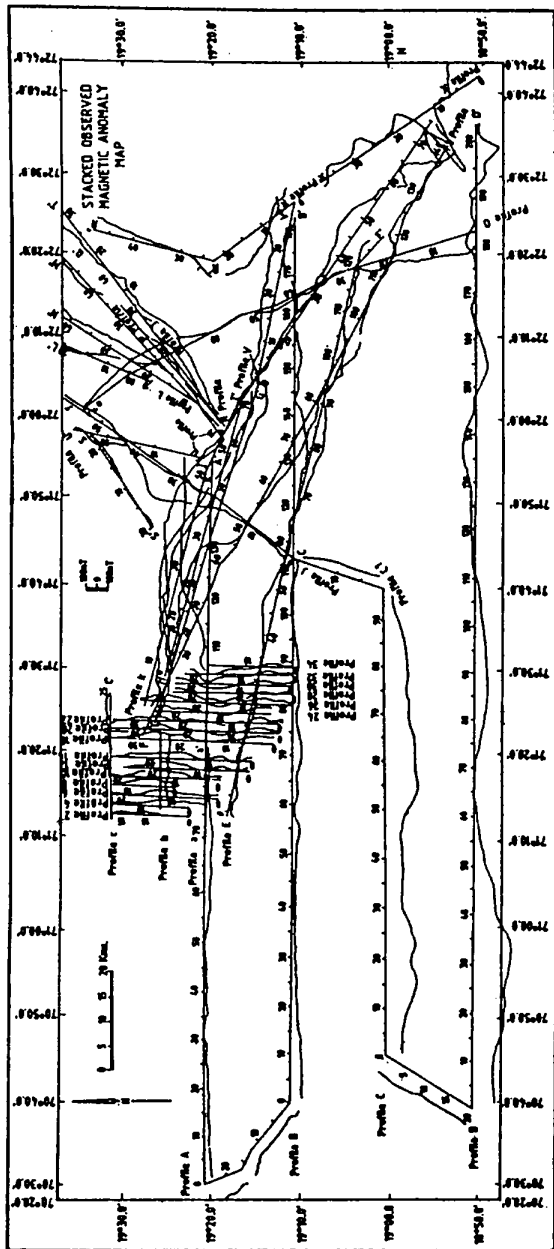


Fig. 3. Stacked observed magnetic anomaly map of Bombay coast (Anomalies plotted perpendicular to the profile direction).

anomalies. The correlation are essentially utilized in further synthesis of the anomalies and identification of model causative bodies. The model calculations are done considering the natural remanent magnetisation either intensity 3.0 Am^{-1} , inclination $+50^\circ$ and declination $+150^\circ$ in case of reverse magnetisation of it or intensity 3.0 Am^{-1} , inclination -50° and declination $+320^\circ$ in case of normal magnetisation. Induced magnetic intensity of 1.1 Am^{-1} is also considered. They are vectorially added and projected onto the present earth's magnetic field. The palaeomagnetic studies of basalts from the western continental shelf of India by Gopala Rao³ confirmed them.

The anomalies on a stacked total magnetic intensity anomaly map (Fig.3) of forty five profiles covering about 2400 line km of area of investigation have been discussed on regional and detailed basis. The regional studies cover the area between $18^\circ 48' \text{ N}$ to $19^\circ 38' \text{ N}$ latitudes and $70^\circ 28' \text{ E}$ to $72^\circ 44' \text{ E}$ longitudes. Detailed studies cover the area between $19^\circ 80' \text{ N}$ and $19^\circ 32' \text{ N}$ latitudes and $71^\circ 10' \text{ E}$ to $71^\circ 35' \text{ E}$ longitudes.

A. Regional studies in offshore areas of Bombay coast

The area of regional studies is covered by twenty six profiles (Fig.3) across the western continental shelf off the Bombay coast in water depths of 30m to 90m. The profiles run almost E-W, NW-SE and cover around 1720 line km. They are referred to as profiles A-A', B-B', C-C', D-D', E-E', F-F', G-G', H-H', I-I', J-J', K-K', L-L', M-M', N-N', O-O', P-P', Q-Q', R-R', S-S', T-T', U-U', V-V', X-X'. A-B, C-D, and C'-C''. The magnetic anomaly signatures, wave lengths and amplitudes along each profile with reference to geology of the areas and the interpreted model parameters (Table I) of the causative sources of the anomalies from two dimensional model calculations following Talwani and Heirtzler⁸ are discussed below

Profile A-A'

Magnetic anomalies in the west (0-80 km) of the profiles are very smooth. Very small amplitude (25 to 30 nT), high frequency anomalies are observed. A notable high frequency (5-6 km wave length) anomaly of 30 nT amplitude exactly occurs to the east of the Bombay high (105-110 km). Further east the pattern of the anomalies abruptly changes to high amplitude and low frequency. A very broad high amplitude of about 20 nT anomaly is recorded in the offshore basin area (110-148 km) on this profile.

The anomalies are interpreted with four reversely magnetised model bodies whose dimensions are noted in Table I. The anomalies in the east of the profile are distant part

Table I - Quantitative interpretation of magnetic anomalies - body parameters

Profile	Model Body	Distance from origin of profile		Length in km	Thickness		Depth to top surface		Depth to bottom surface		Normal or Reverse (N or R)
		(3) Nearer edge in km	(4) Farther edge in km		(6) Maximum km	(7) Minimum km	(8) Maximum km	(9) Minimum km	(10) Maximum km	(11) Minimum km	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A-A'	1	22	30	8	0.4	0.2	2.0	1.8	2.2	2.0	R
	2	31	40	9	0.4	0.2	1.8	1.8	2.2	2.0	R
	3	41	51	10	0.4	0.2	1.8	1.7	2.1	2.0	R
	4	52	61	11	0.4	0.2	2.0	1.8	2.2	2.0	R
B-B'	1	49	56	6	0.4	0.4	1.8	1.8	2.2	2.2	R
	2	56	61	5	0.4	0.4	1.6	1.6	2.0	2.0	R
	3	61	73	12	0.4	0.4	1.8	1.6	2.4	2.0	R
	4	73	91	18	0.4	0.2	1.8	1.4	2.2	1.6	R
	5	91	128	37	0.4	0.2	1.8	1.6	2.2	2.0	R
	6	128	141	13	1.8	1.6	2.4	2.4	4.2	4.0	N
	7	141	179	38	0.8	0.4	1.2	1.2	2.0	1.6	R
C-C'	1	16	29	13	1.6	1.6	3.0	3.0	4.6	4.6	N
	2	55	71	16	1.2	1.2	2.8	2.8	4.0	4.0	N
D-D'	1	87	111	24	2.2	2.0	4.4	4.4	6.4	6.2	N
	2	136	152	16	1.6	1.6	3.2	3.2	4.8	4.8	N
	3	166	196	30	1.6	0.4	2.0	1.6	3.2	2.4	R
	4	200	203	3	0.8	0.8	1.8	1.8	2.6	2.6	N
E-E'	1	11	71	60	1.2	0.2	1.6	1.4	2.6	1.8	R
	2	75	88	10	1.6	1.6	3.2	3.2	4.8	4.8	N
	3	98	103	5	1.8	1.8	3.0	3.0	4.8	4.8	N
F'-f''	1	11	66	55	0.6	0.4	1.6	1.6	2.2	2.0	R
X-X'	1	12	13	1	1.0	1.0	2.0	2.0	3.0	3.0	R
	2	18	28	10	0.4	0.1	2.0	1.8	2.2	2.1	N
a-a'	1	15	27	12	1.8	0.8	5.0	3.8	5.8	5.6	R

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
14	1	7	→	→(?)	0.1	0.2	2.4	2.0	2.6	2.1	R
	1	2	4	2	0.1	0.1	3.5	3.5	3.6	3.6	R
18	2	9	11	3	0.0	0.2	2.4	2.4	2.6	2.4	R
	3	12	35	23	0.1	0.4	2.4	2.2	2.6	2.5	R
	1	2	9	7	0.1	0.2	3.7	3.5	3.8	3.8	R
20	2	14	30	16	0.0	0.4	2.6	2.0	2.6	2.2	R
	1	1	3	→(?)	0.2	0.2	3.0	2.8	3.2	3.0	R
22	2	11	→	→(?)	0.2	0.8	2.8	2.2	3.0	2.4	R
	1	8	→	→(?)	0.3	0.6	2.3	2.0	2.6	2.6	R
24	1	1	6	5	0.1	0.0	3.1	3.2	3.2	3.2	R
	2	9	11	2	0.2	0.2	2.4	2.4	2.6	2.6	R
26	3	12	32	20	0.6	0.3	2.3	1.9	2.6	2.6	R
	1	4	5	1	0.5	0.4	3.2	3.2	3.7	3.7	R
28	2	10	25	15	0.6	0.2	2.4	1.8	2.6	2.4	R
	1	2	5	3	0.4	0.0	3.8	3.4	3.8	3.6	R
30	2	14	25	11	0.6	0.2	2.4	2.0	2.6	2.4	R
	1	3	6	3	0.2	0.1	2.2	2.2	2.5	2.3	R
32	2	9	26	17	0.8	0.2	2.8	1.8	3.0	2.2	R
	1	1	3	2	0.2	0.1	2.6	2.4	2.6	2.6	R
34	2	8	25	17	0.8	0.2	2.6	2.2	3.0	2.4	R

of the prominent high amplitude anomaly centered in the offshore basin area which are interpreted separately.

Profile B-B'

Four distinct provinces of the anomaly signatures based on amplitudes and frequencies are identified. A very smooth magnetic anomaly province prevails in the west (0-50 km). A series of low amplitude of 20-64 nT and high frequency 4 to 7 km wave length anomalies are noted in the Bombay high area (50-90 km). Both the amplitudes and wave lengths increase to 80 to 100 nT and 12 to 16 km respectively in the offshore basin area (90-120 km). At the eastern end of the profile (120 to 180 km) except in between 150 to 165 km distance high amplitude (140 to 160 nT) and broad wave length (20 to 25 km) anomalies are noticed. A U-shaped anomaly trough is observed to the west of the Bassein structure (120-145 km).

The anomalies are interpreted with seven reversely magnetised model bodies except one (Table I). Maximum thickness occurs in south of the Bassein high (128 to 141 km) on the body that is normally magnetised.

Profile C-C'

It is seen that anomalies on this profile are of generally much high amplitudes (120-140 nT) and low frequency (25 to 30 km) than on the two previous profiles. In the west, high frequency anomaly of 30 to 40 nT amplitude superposes on the centre of the anomaly trough. The anomalies are interpreted with normally magnetised rectangular model bodies (Table I). Deeper depths and larger thicknesses are found in the west.

Profile D-D'

The profile anomalies can be grouped into eight categories based on distinct anomaly signatures and represent the magnetic anomaly pattern of the continental shelf in its entire length of the region under study. A prominent high amplitude (around 300 nT), low frequency (45 to 60 wave length) anomaly trough centered around 32 km on the profile (between 0 to 66 km) is one of them. Another anomaly trough of around 100 nT maximum amplitude and low frequency (45 to 46 km wave length) centered around 88 km on the profile is seen (between 66 to 115 km). In the east, the anomaly amplitudes and wave lengths are reduced considerably and a series of positive and negative anomalies are seen. One of them is low frequency (18 to 26 km wave length) and around 80 nT amplitude positive anomaly (between 115 to 148 km) with the maximum amplitude centered

around 137 km. Next to it in the east (between 148 to 162 km) an anomaly low of 80 nT amplitude and 14 to 16 km length is seen centered at 154 km. A small peak of 50 nT amplitude positive anomaly between 162 to 170 km and smooth gradient with an almost zero amplitude anomaly is seen between 170 to 176 m. Further east (between 176 to 186 km) a small 50 nT amplitude and high frequency (8 to 10 km wave length) positive anomaly is seen centered around 181 km. At the eastern end (185 to 204 km) the anomalies are of high frequency (5 to 6 km wave length) and low amplitude of around 50 nT positive except around 195 to 200 km or so where a sharp gradient negative anomaly of more than 200 nT centered at 198 km is observed. The sharp negative anomaly in the east is 'V' shaped and distinct compared to the anomalies in the west of the profile where the anomalies are broad and 'U' shaped. The anomalies are interpreted with four bodies three of which are rectangular and normally magnetised and one lenticular and reversely magnetised (Table I). The reversely magnetised lenticular body occurs at shallow depth of 1.6 km. Larger thicknesses and depths occur in the south of the Bombay high on the west of the profile.

Profile E-E

Magnetic anomalies of the profile are identified in three categories; High frequency (8 to 10 km wave length) and low amplitude (40 to 60 nT) band of anomalies in the west (0 to 25 km) over the Bombay high, next to them on the east (30 to 66 km) a sequence of long wave length (6 to 25 km) and high amplitude (60 to 160 nT) positive anomalies in the offshore basin and two U-shaped anomalies in the east (66 to 110 km) with pronounced negative troughs centered around 80 km to 100 km. Close to the end of the profile in the east (105 to 118 km), a band of very high frequency and low amplitude (20 to 30 nT) anomalies persist in the southeast of the Bassein structure. High frequency anomalies of 1 to 2 km width superposed on anomaly flanks and troughs of the Bombay high anomalies in the west.

The anomalies are interpreted by three bodies two of them normally magnetised and third reversely magnetised (Table I). The reversely magnetised body (between 11 and 60 km) occurs at shallow depth of 1.4 km over the Bombay High. Larger thicknesses of the bodies at deeper depths in areas of the offshore basin area are noticed.

Profile F-F'

Three magnetic anomaly provinces; a most prominent low frequency (28 to 30 km wave length) high amplitude around 240 to 250 nT anomaly over the offshore basin in the east, a sequence of low frequency (25 to 30 km wave length) high

amplitude (90 to 110 nT) negative anomalies inverted compared to its adjacent regions with negative troughs centered around 70 km and 90 km in the middle (50 to 110 km) and a sequence of high frequency and 80 to 100 nT amplitude anomalies in the east (110 to 142 km) are noticed.

Profile C-C', H-H' and K-K'

The characteristic anomaly feature of these three profiles is a broad (45 to 50 km wave length low frequency and high amplitude (260 to 280 nT) positive anomaly, which becomes negative on either side with low amplitude.

Profile I-I'-I''

In the northwest (0 to 38 km) of the profile a sequence of low frequency and low amplitude anomalies is noticed. The anomalies are superposed by very high frequency low amplitude anomalies. In the middle of the profile (30 to 58 km) a high amplitude (140 to 160 nT) low frequency (14 to 15 km wave length) positive anomaly is noticed. Further east (60 to 70 km), sharp gradient, high amplitude (220 to 260 nT) and high frequency (5 to 8 km wave length) negative anomalies are recorded. The anomalies on the profile I'-I'' are interpreted with only one reversely magnetised model body of sheet like in shape (Table I). The very sharp gradients of the high amplitude anomalies in the east are not interpreted because the full extent of the anomalies is not known.

Profile L-L', M-M', N-N', P-P', Q-Q', S-S', T-T' and V-V'

The nine short length (30 to 40 km) parallel and oblique profiles run from the Bassein structure in a NE-SW direction except the profile V-V'. The profiles registered negative anomalies of around 80 to 100 nT amplitude centered in the north of the Bassein structure (10 to 30 km). Towards the northeast, positive anomalies are recorded. Due to the limited length of the profiles full extent of these anomalies could not be recorded. However, on profiles U-U' and V-V', positive anomalies of 100 to 150 nT amplitude are observed.

Profile O-O'

Positive anomalies of around 50 to 80 nT is noticed in the southeast (0 to 25 km). Towards the northeast a low frequency negative anomaly trough centered at 70 km is registered.

Profile R-R'-R''

Negative anomaly peak of about 200 nT flanked on either

sides by positive anomalies of the order of 100 nT is noticed.

Profile X-X'

A very sharp gradient, high frequency and high amplitude negative anomaly of about 580 nT in the southeast (10 to 20 km) is noticed. Adjacent to this peak in the northwest a series of high frequency (5 to 6 km wave length), low amplitude (20 to 30 nT) positive anomalies are registered. The anomalies are interpreted with one reversely magnetised body in the northwest and another normally magnetised body in the southeast. The model body in the west is sheet like in appearance, the one in the east is square type body (Table I).

Profile A-B, C-D and C'-C''

These three are also short profiles of 20 to 25 km. Two of them, A-B and C-D in the west, recorded smooth gradient negative anomalies. The profile C-C'' (around 18 to 20 km) in the east records smooth gradient positive anomaly.

Profile a-a'

The anomalies of the profile are interpreted in terms of a reversely magnetised body, 12 km long with a steeply sloping upper surface. Depths to top and bottom surfaces of the body are 3.8, 5.0, 5.6 and 5.8 km (Table I). Thus its thickness varies from 0.8 to 1.8 kms. Deeper depths of the model body occurs in the NNW of the offshore basin area.

Based on the above observations the region of investigations is divided into four distinct magnetic anomaly provinces, the very sharp gradient negative anomalies in the southeast, the low frequency remarkable negative anomalies in the southern and southwestern parts, the prominent low frequency high amplitude positive anomalies occurring in the offshore basin area and the smooth gradient anomalies in the west.

B. Detailed studies over the Bombay High.

The detailed studies include sixteen N-S and three E-W total magnetic intensity anomaly profiles. They are referred with profile numbers 2,4,6,8,10,12,14,18,20,22,24,28,30,32,34, a-a', b-b', c-c' and parts of the regional profiles A-A', B-B', E-E', C-C', H-H', and K-K' are also included and are shown in Fig.4 as the stacked magnetic anomaly profiles, plotted on scales, distances on horizontal scale of 1 cm = 3 km and anomaly on vertical scale of 1 cm = 100 nT. The N-S profiles are equispaced, 2 km apart and their lengths range from 20 to 35 km. The E-W and WNW-ESE profiles lengths range from 18 to 48 km.

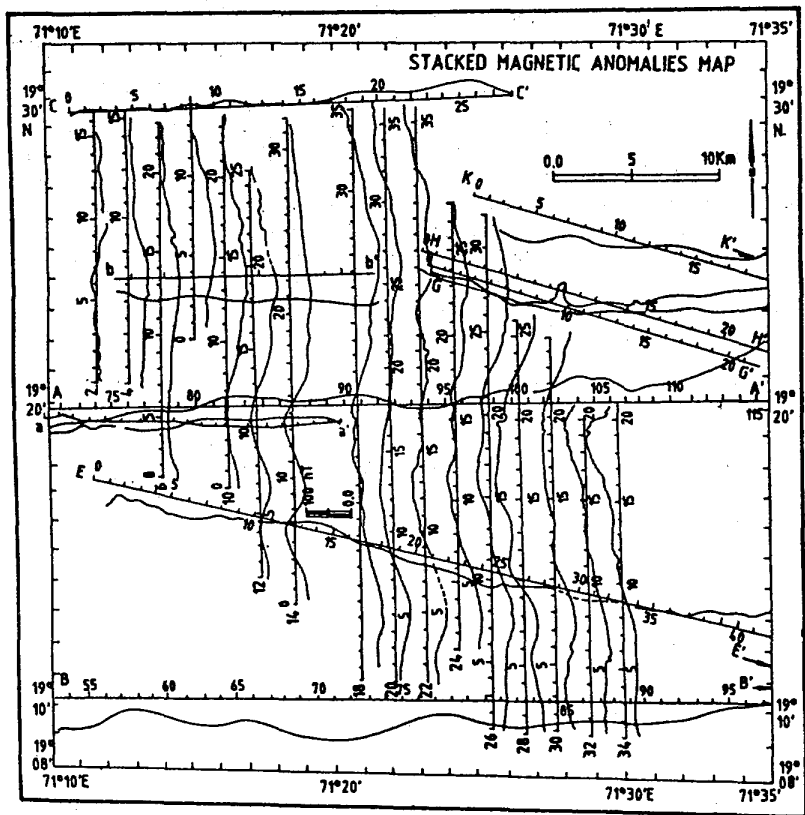


Fig.4. Stacked observed magnetic anomaly map of the Bombay High (Anomalies plotted perpendicular to the profile direction).

A close examination of the map of stacked magnetic profiles in Fig.4 shows the following features. It would be more convenient to discuss the anomalies on maps instead of individual profiles because of close similarities among the limited anomalies. The anomalies mainly fall into two groups, long wave length and short wave length anomalies. The long wave length positive and negative anomalies are symmetrical and are correlatable among profiles. It is seen that on the profiles 20 to 30, the anomalies show central positive peaks with amplitudes ranging from 50 to 120 nT and wave lengths of about 10 to 15 km flanked on either side by negative anomalies sometimes appearing as fairly well defined troughs. On the profiles 32 and 34, however, this feature is not prominent due to their limited length. On the western profiles the amplitudes and

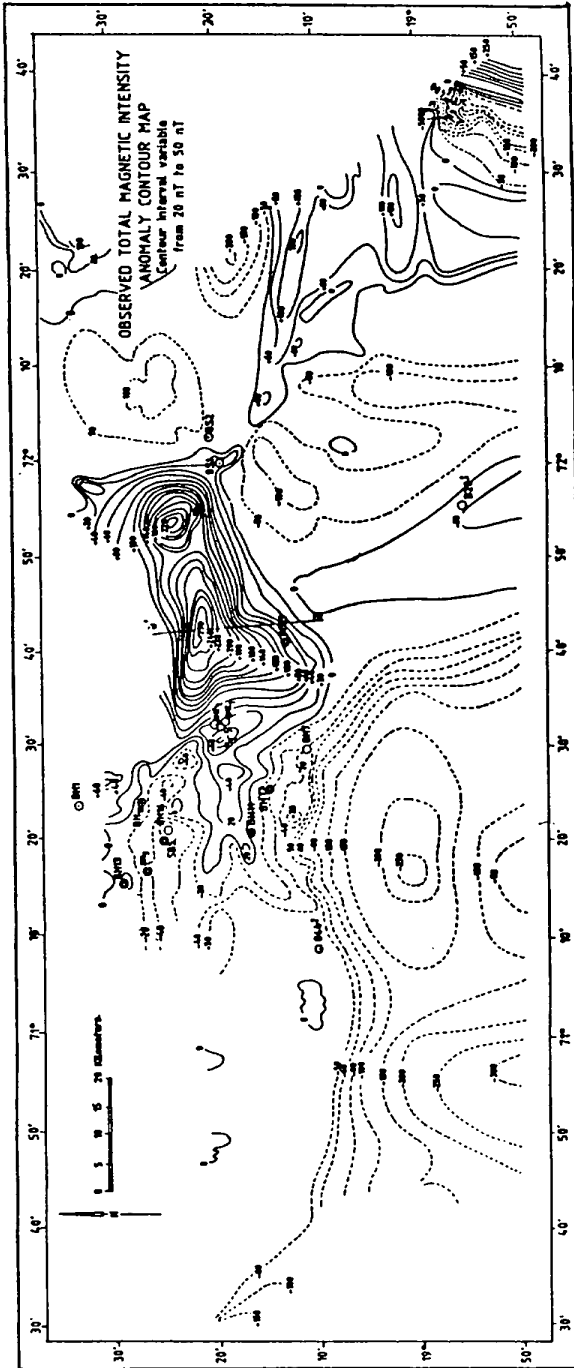


Fig. 5. Observed total magnetic intensity anomaly contour map. Contour interval variable from 20nT to 50nT. Continuous lines are +ve anomalies and discontinuous lines -ve anomalies. Double circles, single circle with dot at the centre and the circle with inside plus indicate exploratory drill wells ended in Archaean/Precambrian rocks, basaltic lava spreads and Tertiary sediments respectively.

the widths of the anomalies, which are mostly negative only, are considerably reduced.

The short wave length (5 to 9 km) and low amplitude (20 to 54 nT) positive anomalies, occur in the beginning of the profiles e.g., on anomaly profile 14 between 0 and 8 km. They are also seen on profiles 12 and 14. Very high frequency anomalies (wave length less than 2 km) normally are superposed on peaks of highs and flanks of the anomalies. Maximum concentrations of these high frequency anomalies are confined to the central part of the region as shown in Fig.4. Also, symmetric short wave length (4 to 5 km) and low amplitude (30 to 35 nT) anomalies are limited to the northern end of the profiles 32 and 34 (15 to 20 km) and on profile A-A' between 102 to 107 km. Anomaly troughs of variable sizes are also noticed in the south and north of the profiles.

RESULTS AND DISCUSSION

The anomalies are contoured at different intervals, 20 to 50 nT. The anomaly maps are presented in Figs. 5 & 6. Fig.5 shows the observed total magnetic intensity anomaly of the region of investigation and depicts regional trends and signature of magnetic anomalies. These anomalies occur in the southeast (between 18° 50' N, 19° 16' N latitudes and 72° 05' E, 72° 40' E longitudes) with trends of E-W and N-S respectively in the inner shelf. The anomalies over the Bombay High and the offshore (between 19° 05' N, 19° 30' N latitudes and 71° 15' E and 72° E longitudes) trend E-W and ENE-WSW respectively.

Rest of the area is covered by negative anomalies except for a few isolated limited anomalies in the northeast, northwest, south and southeast. The negative anomalies mostly trend E-W except in the southeast and the northeast of the innershell where NE-SW and N-S trends are observed. In the northeast a circular negative anomaly closure is noted between zones of positive anomalies.

The isonantesla map of detailed surveys of the Bombay High is presented in Fig.6. The anomaly map shows very simple distribution of positive and negative anomalies. The axes of the anomaly lows and highs are marked. The negative anomalies are on either side of the positive anomalies. A gradual decrease in amplitude of positive anomalies towards the west is noticed. Some positive anomalies in the north and a series of oval shaped or asymmetric NW-SE trending anomaly closures in the east of the Bombay high are recorded. The map also registered the ENE-WSW trend of the strong positive anomalies of the offshore basin in the east. In the east, a zone of magnetic discontinuity

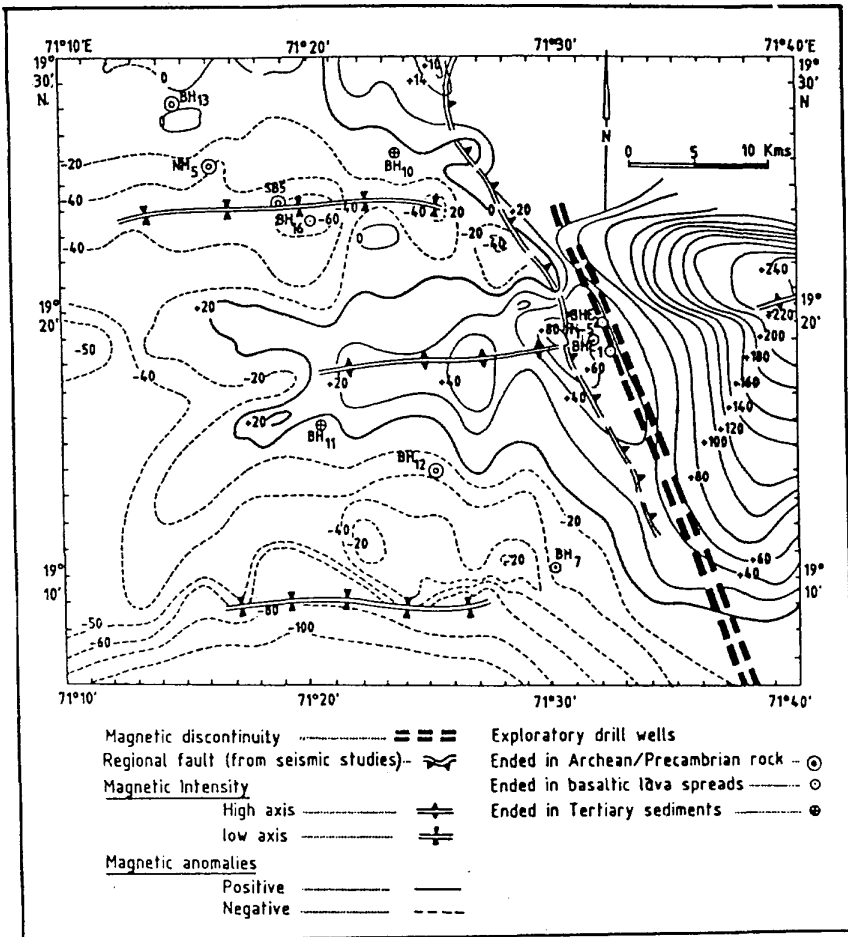


Fig.6. Observed total magnetic intensity anomaly map of the Bombay High. (Contour interval 20nT).

parallel to the regional boundary fault in the east of the Bombay high separates the E-W trending anomalies of the Bombay High and the ENE-WSW trending anomalies of the offshore basin.

The anomalies on almost all the profiles are interpreted with reversely magnetised model bodies excepting the negative anomalies observed along the innershelf. Most of the bodies occur between depths of 1.4 and 5.0 km and their thickness vary between 0 to 2.2 km. The anomalies over the Bombay high and the offshore basin are only interpreted with reversely magnetised models. The bodies over the Bombay High occur

at depths of 1.8 to 3.8 km and in the offshore basin they occur at greater depths of 3.8 to 5.0 km. While the thicknesses of the model bodies over the Bombay High vary between 0.0 and 0.8 km, those in the offshore basin are between 0.8 and 1.8 km.

Geology of the area mostly known from bore hole logs and seismic reflection studies revealed that the nature of the basement varies (Fig.7). The basement underlying the Tertiary sediments is either Archaean/Precambrian granitic gneisses/Argillites or late Cretaceous/early. Tertiary basalts/Deccan traps (Fig.8). Correlation of the bore hole geology with the anomalies showed that by and large, the positive magnetic anomalies occur in the areas of basaltic basement as seen for example, in drill well B28-1 BS-1 and BH-1 logs (Fig.7) and results of drill wells of BHE1, BHE2, and H1-5. The negative anomalies correspond to areas of Archaean/Precambrian granitic basement, e.g., drill well BH-12 log (Fig.7) and results of drill wells of SB-5, NM-5 and BH-13.

The elongated anomalies observed and correlated with the geology of the area suggests the two dimensionality of the casuative sources of the observed anomalies.

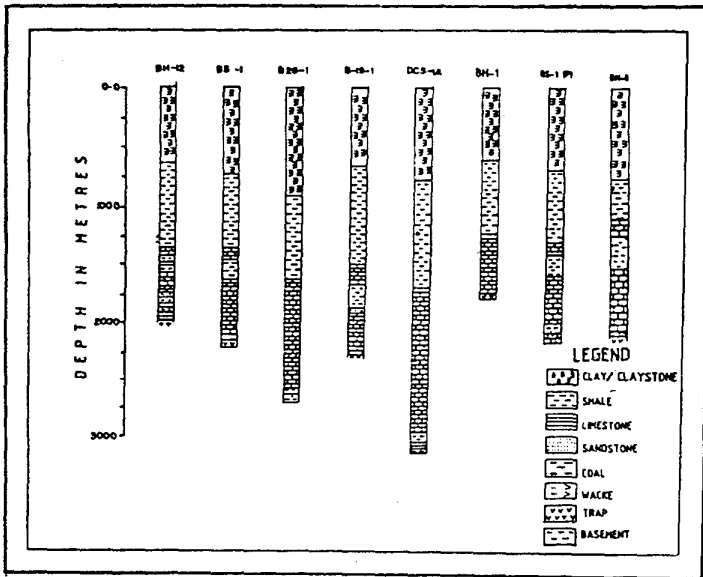


Fig.7. Drill well logs of the continental shelf of Bombay coast. (Published by ONGC, India).

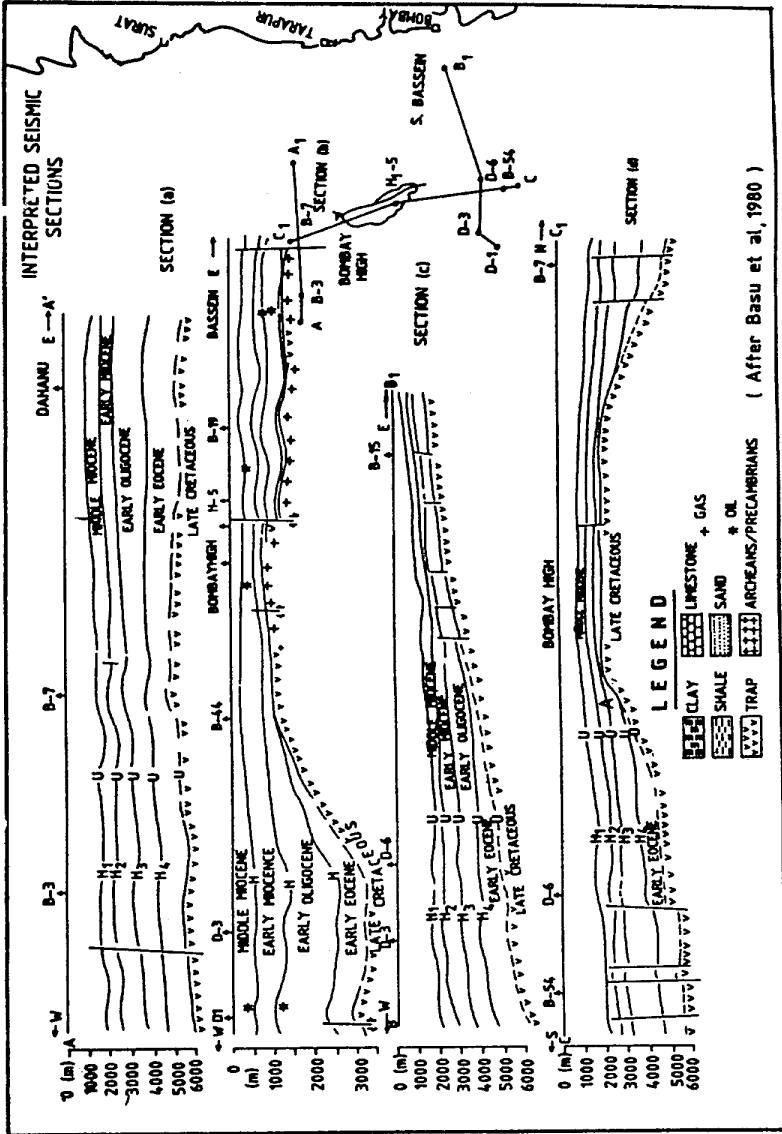


Fig.8. Interpreted seismic reflection sections across the Bombay High and the continental shelf of Bombay coast.

Negative magnetic anomalies are also observed sometimes in areas of basaltic basement as is evidenced from boreholes BH-7 and BH-16(Fig.6). Thus, it would appear that while the occurrence of positive anomalies could be directly attributed to the magnetisation characteristics and relatively shallow depths of the basalt basement, the negative anomalies have to be viewed in terms of changes in the magnetic parameters of basalts, the relatively deeper depths and lesser magnetisations of the Archaean/Precambrian granitic basement.

It may also be pointed out that, in quantitative analyses made on the entire region of investigation, the intervening areas between the basaltic bodies employed as magnetic sources for the observed anomalies are left blank. Due to paucity of borehole information in the region, it was not possible to determine the nature of geological formation in these intervening areas. However, in the quantitative analyses of the negative anomalies over the Bombay High, it was possible to delineate and distinguish between the basaltic and the Archaean/Precambrian basements in the light of the borehole data. The area of thin basalts at shallow depth below the Tertiary sediments e.g. the Bombay high is suggested for further investigations to find out the geological formations of the period from the Archaean/Precambrian to late cretaceous/early Tertiary times.

CONCLUSIONS

1. The magnetic anomalies of the continental shelf off Bombay coast, west of India trend E-W, ENE-WSW, N-S and NW-SE.

2. Positive and negative anomalies are identified in areas of basaltic and granitic basements respectively. The correlations can be used in identifying the nature of basement in the areas of the western continental margin of India.

3. The Tertiary sediment thickness varies from 1.4 to 5.0 km and the presence of granitic basement below the sediments revealed extensions of the continental type crust into the offshore area.

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