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Basin structure from gravity and magnetic anomalies in the southern part of K-G Basin, India.

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Abstract: The gravity and magnetic data along the profile across the southern part of the Krishna Godavari-Basin have been collected and the data is interpreted for basement depths. The profile II[1]is taken from Kotturu to Biyyapuppa covering a distance of 70 km .The gravity lows and highs have clearly indicated various sub basins and ridges. The density logs from ONGC, Chennai, show that the density contrast decreases with depth in the sedimentary basin, and hence, the gravity profile is interpreted using variable density contrast with depth. From the Bouguer gravity anomaly, the residual anomaly is constructed by graphical method correlating with well data, subsurface geology and seismic information. The anomaly profile is interpreted using polygon model. The maximum depths to the khondalitic basement are obtained as 2.0km, 1.60 km and 2.50 km at Krishna sub-basin,Bapatla ridge and Nizampatanam sub-basin respectively. The regional anomaly is interpreted as Moho rise towards coast. The aeromagnetic anomaly profile is also interpreted for charnockite basement below the khondalitic group of rocks using prismatic models.

Keywords: Gravity anomaly, Variable density contrast, Khondalite basement, Magnetic anomaly, Charnockite basement, Moho depth. K-G basin.

I.INTRODUCTION

The Krishna-Godavari basin is located between 15°30'N and 17°N latitudes and 80°00'E and 82°30'E longitudes and covers 15,000 sq.km on land and about 25,000 sq. km on adjoining offshore regions on the East coast of India. It is an important and promising petroliferous basin of India. Tectonically, it is a pericratonic basin and it occurs on the margin of the Indian craton which is of highly metamorphosed pre-Cambrian rocks consisting of mainly khondalites. The sedimentary strata consists of clay,sandstone, limestone, and shale etc., deposited in marine as well as continental environment ranging in age from the Permian to Pliocene (Rao, 2001 and Sastri et al,1981). Ramamohan Rao et al (1994) have studied the tectonic features of the basin and presented a basement configuration map of K-G basins.

O.N.G.C has carried out gravity and magnetic surveys in the K-G basin in 1960s (Kumar[3], 1993) and presented the Bouguer gravity anomaly map .Venkateswarulu (1971) has carried out gravity surveys over a part of the K-G basin and presented the Bouguer anomaly map. Radhakrishna Murthy and Bangaru Babu (2006) have carried out regional magnetic surveys over a part of the K.G basin.Verma[6] (1991) has analyzed few gravity profiles in the K-G basin. The geological and geophysical work clearly delineated the presence of a number of ridges and sub-basins trending in NE-SW directions (Prabhakar and Zutshi1993 and Hardas [8], 1991), viz; Gudivada sub-basin, Mandapeta sub-basin, Narasapur sub-basin, Krishna sub-basin, Nizampatanam sub-basin and Baptla ridge, Yanam ridge, Tanuku ridge and Kaza ridge. The gravity and magnetic surveys are carried out in the entire K-G basin along nine profiles, at closely spaced interval, and placing the profiles at approximately 30 km interval and perpendicular to various tectonic features. In this paper gravity and magnetic anomaly profile II’ is presented along the line shown in the tectonic map of Prabhakar and Zutshi (1993)(Fig.1).The gravity anomaly is interpreted with variable density contrast for khondalitic basement depth and the aeromagnetic profile is interpreted for the chornockite basement below the khondalite group of rocks.

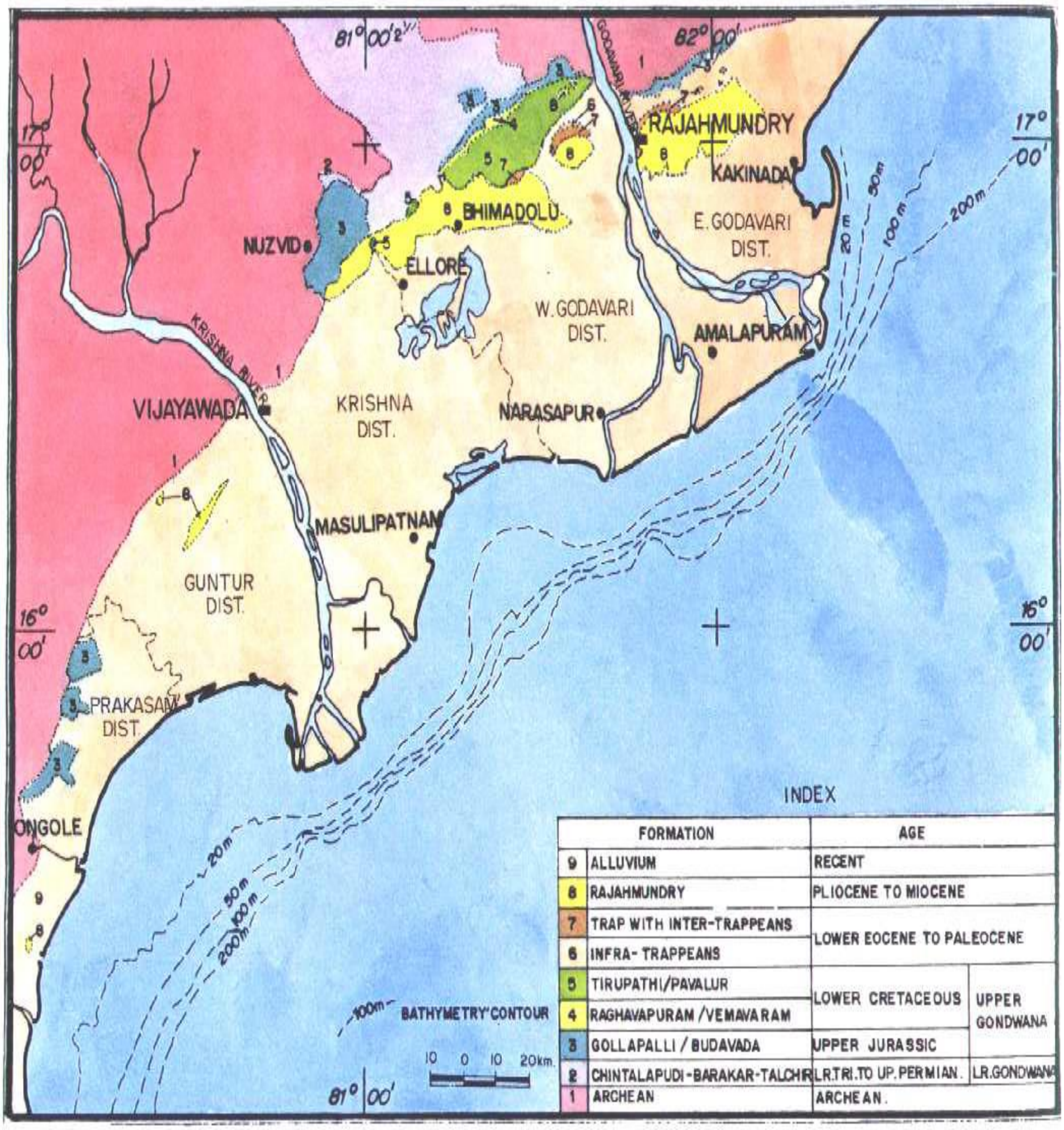

Fig.1. Geology map of the K-G basin

GRAVITY AND MAGNETIC SURVEYS

The gravity, magnetic and DGPS(Differential Global Position System) observations are made along profile II[1] across the various tectonic features (Prabhakar and Zutshi, 1993) in the Southern part of the K-G basin as shown in Fig.2.Gravity measurements have been made at approximately 1.5 to 2km station interval. Gravity readings are taken with Lacoste-Romberg gravimeter and Position locations and elevations are determined by DGPS(Trimble).The HIG (Haiwaii Institute of Geophysics) gravity base station located in the Ist class waiting hall of Rajahmundry railway station is taken as the base station. The latitude and longitude of this base are 16°59'08.11818"N and 81°46'59.3941"E respectively. The gravity value at this base station is 978475.90 mgals. With reference to the above station, auxiliary bases are established for the day to day surveys. The Bouguer anomaly for this profile is obtained after proper corrections viz (i) drift (ii) free air (iii) Bouguer and (iv) normal. The Bouguer density is taken a value of 2.0gm/cc after carrying out density measurements of the surface rocks. The gravity observations are made along available roads falling nearly on straight lines as shown in Fig.2.The maximum deviations from the straight lines at some places are around 5 km.

Total field magnetic anomalies are also observed at the same stations using Proton Precession Magnetometer (Geometrics) but the data is later found to be erroneous. This might be due to faulty instrument and hence discarded. In order to get magnetic picture, aeromagnetic anomaly maps in toposheets 65G, 65H, 65L, 56P, 65D, 66A, 66 and 66B covering the entire K-G basin on land from GSI are procured and anomaly data is taken along II[1]profile. The total field magnetic anomalies are observed at an elevation of 1.5 km above msl. IGRF corrections are made for this data using standard computer programs and the reduced data is used for interpreting magnetic basement.

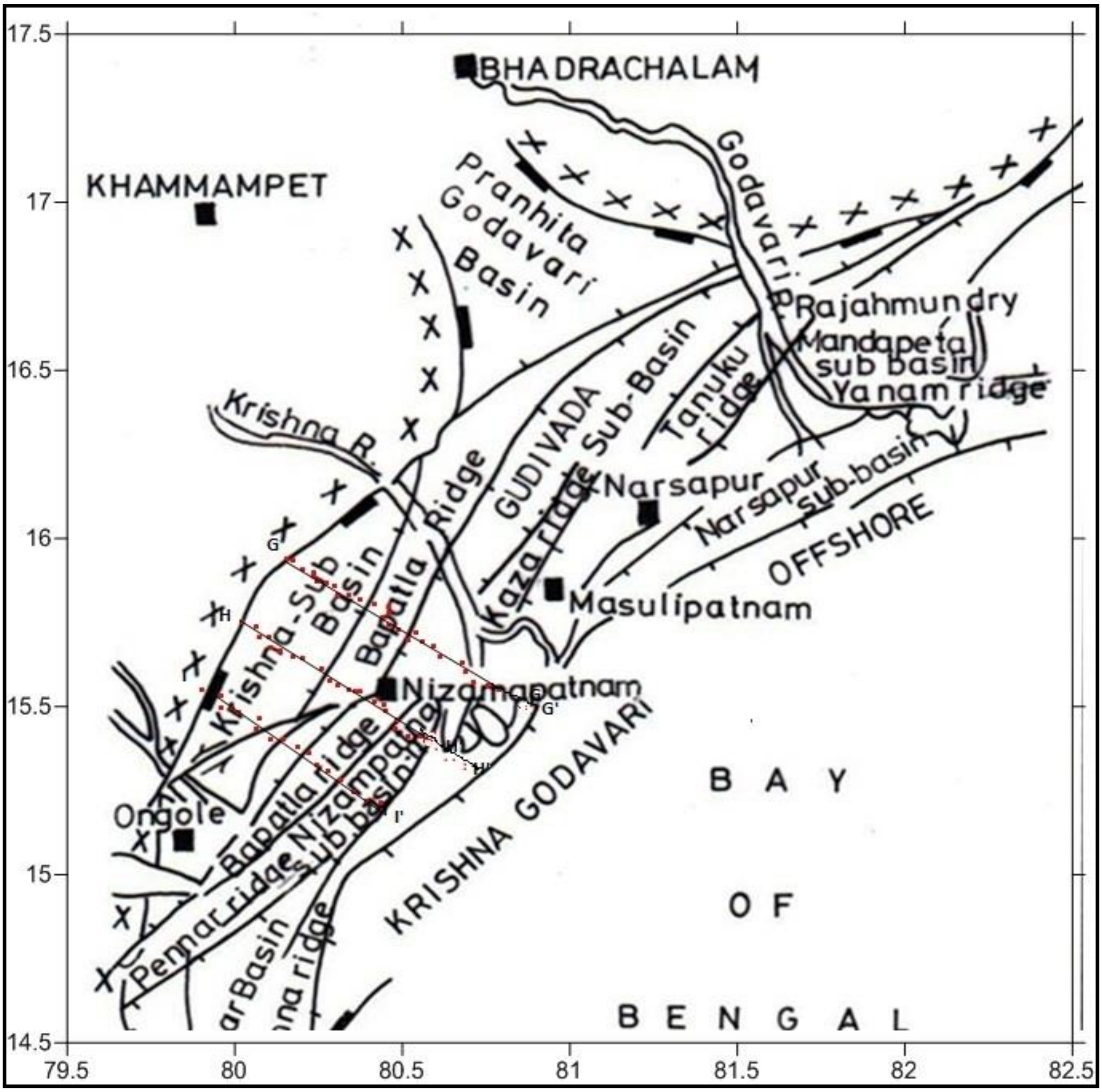

Fig.2.Tectonic elements of Krishna-Godavari basin (after Prabhakar and Zutshi,1993).

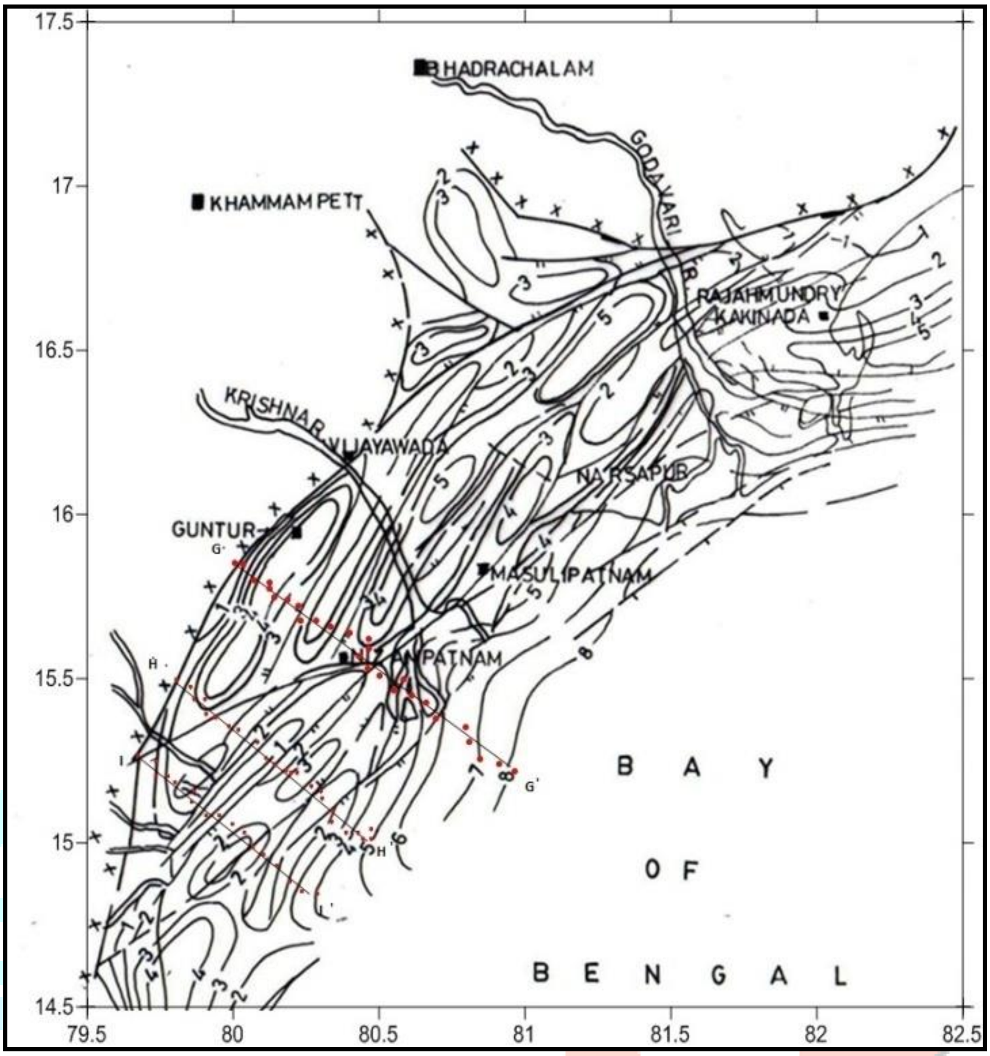

Fig.3.Basement configuration map of Krishna-Godavari basin (after Prabhakar and Zutshi,1993).

VARIATION OF DENSITY CONTRAST WITH DEPTH

The density data with depth from 16 wells in the K-G basin drilled by ONGC have been collected. The kondalite basement is assumed to be having an average density of 2.7gm/cc. This value is subtracted from the well densities to obtain the density contrast with depth in the basin. The curve representing the variation of density contrast with depth has been plotted and shown in Fig.4.The well log density is available up to a depth of 4.5km. However, the curve is extended up to a depth of 6.5km as the maximum depths deduced from the gravity anomalies are around this value. The density contrast is about –0.67gm/cc at the surface and falls to –0.21gm/cc at 4.5 km depth. The decrease of density contrast is due to compaction, age etc. of the sedimentary strata. Hence, the interpretation of the gravity anomalies cannot be carried out with the assumption of a constant density contrast. The variation of density contrast with depth is approximated to a quadratic function (Bhaskara Rao[9], 1986) such as $\Delta\rho (z) = a_0+a_1z+a_2z^2$, where a_0, a_1, a_2 are the constants to be found. Accordingly, the variation of density contrast is fitted to a quadratic function and the coefficients are solved by the least squares method. The values of the coefficients so obtained for a_0, a_1, a_2 are -0.67374, 0.18321 and -0.0166 respectively

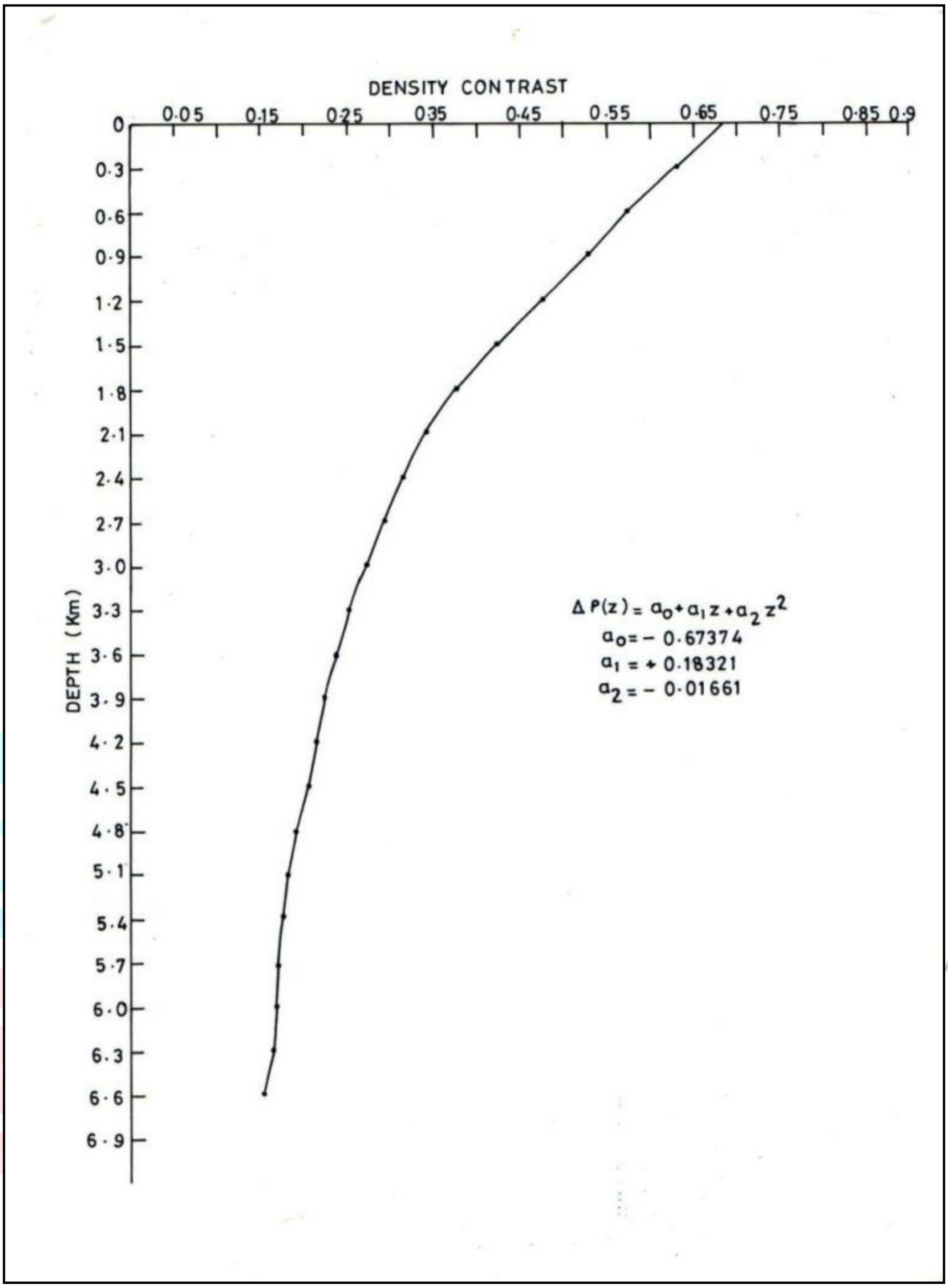

Fig.4. Variation of density contrast with depth

GRAVITY PROFILE ALONG II'

The southern part of the profile II' is taken from Kotturu (Latitude 15°48'10.10361"N and Longitude 80°00'25.1145"E) to Biyyapuppa (Latitude 15°36'14.3023"N and Longitude 80°13'01.1113"E) covering a distance of 70 km and 32 stations are established along this profile (Fig.5). This profile passes across the Krishna sub- basin, Bapatla ridge and Nizamapatnam sub-basin (Fig.5) and these tectonic elements are visible on the Bouguer and residual gravity anomaly profiles (Fig.5.).An auxiliary base station is established at Uppugunduru (land mark is Railway station) for this profile on 12-04-2008 and gravity value is 978522.3524 mGals. The elevation above msl, latitude and longitude at this base are 2.490 m, 15°50'01.00121"N and 80°21'00.12414"E respectively. 20 gravity stations are established along this profile on 12-04-2008 using this auxiliary base. For the next day survey on 13-04-2008, another auxiliary base at Uppugunduru (land mark is Railway station) is used, and the gravity value here is 978522.352404 m Gals. The elevation, latitude and longitude at this base are 2.490 m, 15°50'01.00121"N and 80°21'00.12414"E respectively.17 gravity stations are established along II' profile on 13-04-2008 using this auxiliary base. The minimum and maximum Bouguer gravity anomalies over the basins and ridges are given in Table1.The basement depths, based on sub-surface geology (Prabhakar and Zutshi, 1993), are plotted as dotted curve.

Based on this data, and using gravity modeling, the regional is assumed as a smooth curve as shown in the figure. The regional is -20 mGals at the origin and continuously increases reaching a maximum of 60 mGals towards SE near the coast. The minimum and maximum residual anomalies on the basins and ridges are given in Table 1. The residual anomaly is interpreted with quadratic density function using polygon and prismatic models. The depths are obtained by iterative method using Bott's method and the results at 10^{th} iteration are plotted as polygon and prisms (Fig.5).The maximum and minimum depths over the basins and ridges are given in Table 1.The interpreted depths are nearly coinciding with subsurface geological depths. The regional anomaly is interpreted for Moho depths. For this, the regional anomaly is obtained by removing a constant value of -20 mgals from the regional. The Moho depths are plotted at the bottom of the Fig.5. It is observed that the Moho depths are decreasing towards the coast.

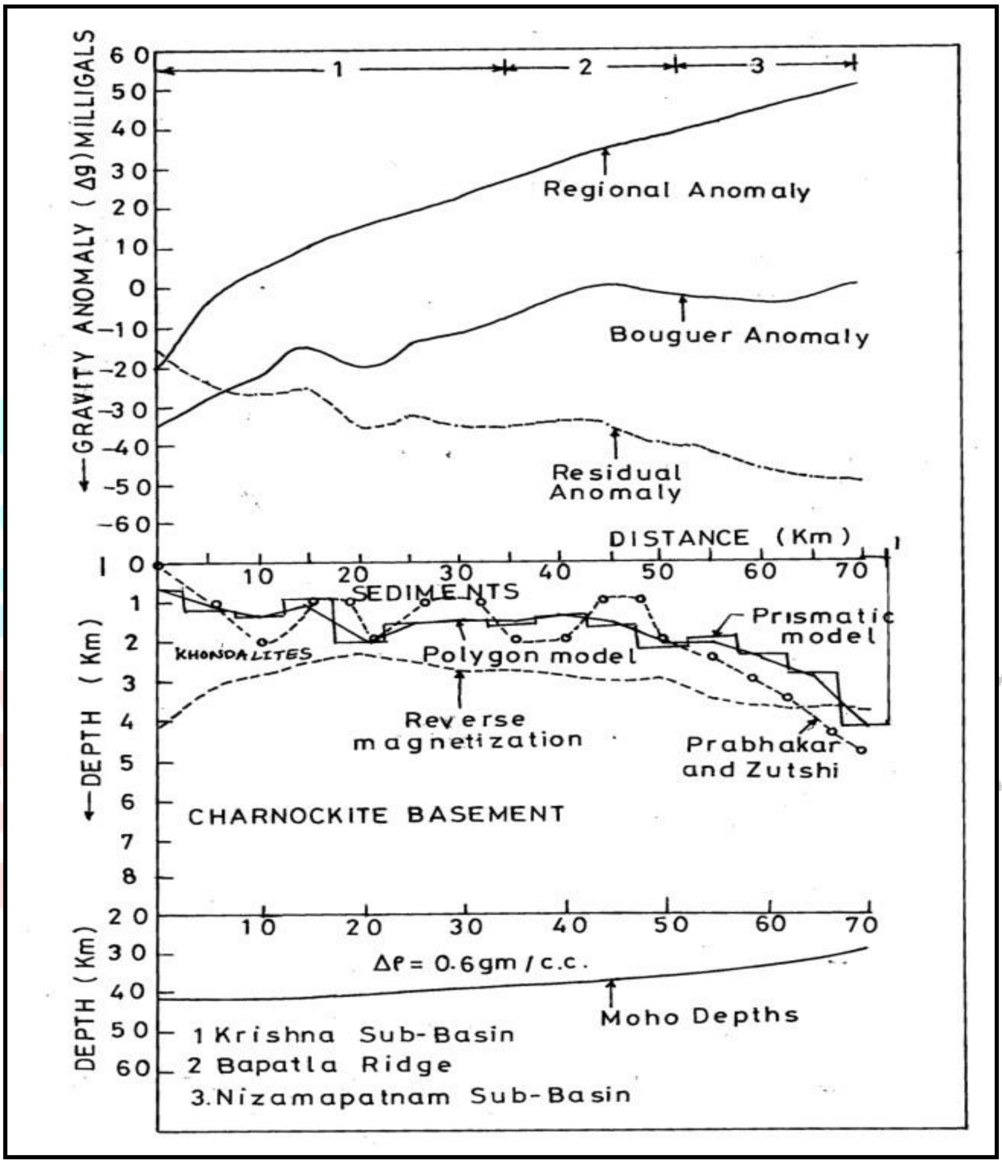

Fig.5. Interpretation of gravity anomaly profile along II'

MAGNETIC PROFILE ALONG II'

The magnetic data for the profile II' is taken from the topo sheet (66A), for which the survey was conducted in 1985-1987. IGRF corrections are made to this data using 1990 coefficients and the magnetic anomaly profile is constructed. The length of the magnetic anomaly profile is 70 km and is sampled at 5 km interval. The magnetic anomalies vary from 112ηT to 312 ηT. The anomalies are interpreted for magnetic basement structure below the Khondalites using prism models. The profile is interpreted by taking the mean depth of the basement at 4.0 km and constraining the depths to upper and lower limits of the basement as 2.0 km and 6.0 km respectively. A linear order regional is assumed along this profile. The profile is interpreted for different magnetization angles (Φ) and intensity of magnetizations (J).The results of interpretation of the magnetic profile II' for normal and reverse magnetizations are given in Table 2.The interpretations of the depths for these magnetizations are shown in Fig.6 .These two interpretations are nearly the same. The magnetic basement for reverse magnetization is presented in Fig.6.There is not much correlation between the Khondalitic and charnockite basements. Here the objective function for normal magnetization is 0.08 and that of reverse magnetization is 0.07.The observed and the best fitting anomalies for reverse magnetization are also shown in Fig.6.For the reverse magnetization, the linear order regional is as shown in the figure 6. The residual anomaly after removing the regional from the observed anomaly is plotted in the figure 6. The differences between the residual and the calculated anomalies are negligible as shown in the figure 6. The charnockite basement depths for the reverse magnetizations are from 0.7 to 4 km below the Khondalitic basement along this profile.

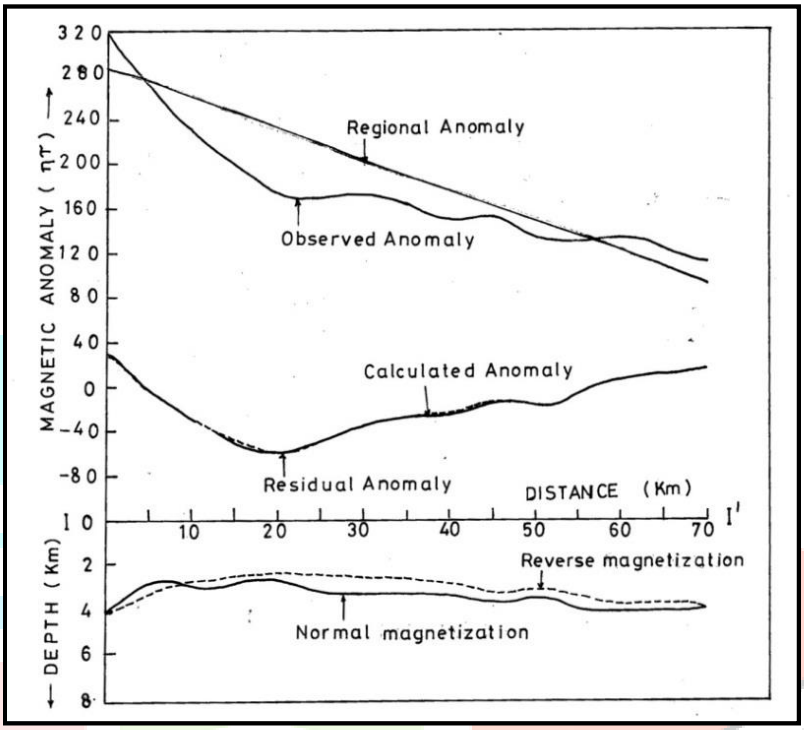

Fig.6. Interpretation of total field magnetic anomaly profile along II'

Table 1. Anomalies in mGals/Depths in km on various tectonic features

Profile	Type of anomaly /Depths	Krishna sub-basin	Bapatla ridge	Nizamapatnam sub-basin
II'	Bouguer(mGl)	-20.0	0.0	-5.0
II'	Residual(mGl)	-35.0	-35.0	- 47.0
II'	Depths(km)	2.00	1.60	2.50

Table.2.Results of magnetic interpretation

Profile	Magnetization	Average Value of total field (F)	Average value of inclination (i)	Angle between strike and magnetic north(α)	Calculated magnetization angle (Φ)	Assumed magnetization angle for best fit (Φ)	Assumed value of intensity of magnetization for best fit (J) in gammas	Regional at the origin (A)	Regional gradient (B)	Damping factor (ℷ)	Iterations carried out	Objective function
II'	Normal	41560	16.88	40	25.26	+28.0	270	258.2	-2.1	0.00	2nd	0.08
II'	Reverse	41560	16.88	40	25.26	-28.0	270	291.1	-2.8	0.00	2nd	0.70

RESULTS AND DISCUSSIONS

The profile II' is taken in to southern part of the K-G basin from Kotturu to Biyyapuppa covering a distance of 70 km. This profile passes across the Krishna sub- basin, Bapatla ridge and Nizamapatnam sub-basin. The residual anomaly is interpreted with quadratic density function using polygon and prismatic models. The depths obtained by gravity methods on the Krishna sub-basin, Bapatla ridge and Nizamapatnam sub-basin are 2.00 km, 1.60 km and 2.50 km respectively and these are nearly the same as those given by the sub-surface geological studies. The regional gravity anomalies are interpreted for Moho depths. It is observed that the Moho depths are decreasing towards the coast.

The magnetic anomaly profile is interpreted with different intensity of magnetizations (J) and dips (Φ) for charnockite basement. There is no correlation between the gravity and magnetic basements. The observed magnetic anomalies can be best explained with the intensity of magnetization of 270 gammas and dips of ±28.0 degrees. The objective functions for normal and reverse magnetizations are 0.08 and 0.70 respectively.

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