Gravity and Magnetic fields - Integrated Interpretation of Mandapeta area, KG Basin

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Summary

This study describes the results of detailed Gravity-Magnetic studies carried out to delineate the structural fabric of the basin, its basement configuration and nature of the basement.

Introduction

The Krishna-Godavari basin, a pericratonic basin, is located in the central part of the eastern passive continental margin of India. The basin area includes the deltaic plains of the Krishna and Godavari rivers and inter deltaic regions. Geographically, the basin lies between Kakinada in the northeast and Ongole in the Southwest. Archaean crystalline (Eastern Ghats) rocks acting as the basement on which number of sedimentary rock outcrops ranging from age Triassic to recent are exposed on different parts of the basin. A significant part of the onshore basinal area is covered by Quaternary alluvium. The basin extends southeast into the deep waters of the Bay of Bengal. The study area is situated in the East and West Godavari District, in Andhra Pradesh (Fig.1).

The northeast-southwest (NE-SW) trending KG basin situated on the east coast of India is one of the most promising petroliferous basins of India and is orthogonally juxtaposed to NW-SE trending Pranhita-Godavari Gondwana graben (Fig.1). The KG basin evolved as a consequence of breakup of India and East Antarctica during Early Cretaceous time (Sastri et al., 1973). The NE-SW rifted graben and horst system created during this event got dislocated along older Permo-Triassic Pranhita-Godavari rift by the end of the Early Cretaceous which resulted in a series of smaller en-echelon horst and graben systems (Gupta, 2006). The Late Cretaceous witnessed widespread marine transgression when the entire basin area was under deposition. Towards the end of Cretaceous the region witnessed igneous activity which accumulated subaqueous lava flow over most part of KG basin.

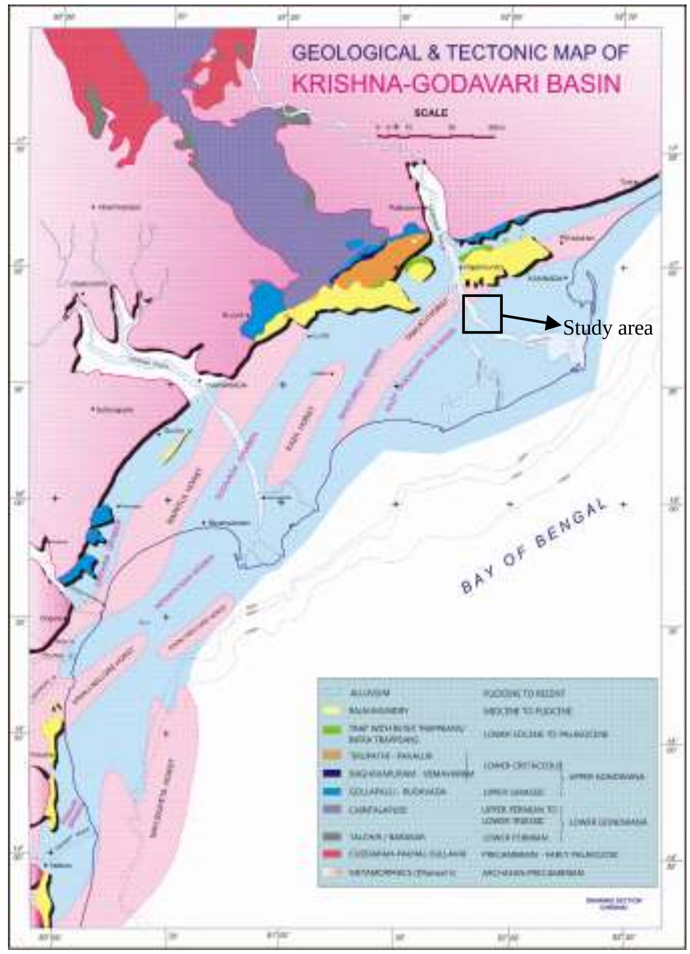

Fig (1) Geological and Tectonic Map of Krishna Godavari Basin (Source Kg Basin Chennai, ONGC)

The post volcanic period witnessed active Tertiary sedimentation. Subsurface geology and structure of the KG Basin is mostly derived from geophysical studies and drill holes as alluvium sands cover most of the region. Geophysical studies indicate NE-SW trending ridges and depressions (Rao, 1993) which forms the major tectonic elements (Fig. 1). The basin is subdivided in to west Godavari and East Godavari sub-basins separated by northeast-southwest trending

Tanuku horst. The Matsyapuri-Palakollu fault (MPF) and Mori fault control the Tertiary sediments as a result of continuous subsidence and growth fault related tectonics (Rao, 2001). Thickness of the sediments varies from 3-6 km in the onshore depressions and up to 7-10 km thick deltaic sediments in the offshore (Rao, 1993; Bastia and Nayak, 2006).

The oil and gas prospects have been established within the subsurface formations ranging in age from Cretaceous to Eocene and the entrapment is due to fault closures and anticlinal structures (Gupta, 2006). Although pre-existing regional gravity map (Singh and Diljit, 2009) and borehole provide useful geological information but the geophysical exploration work is very scanty in the study area. This study describes the results of detailed G-M studies carried out to delineate the structural fabric of the basin, its basement configuration and nature of the basement.

Analysis of Gravity and Magnetic anomaly maps

Gravity and Magnetic was acquired at 1200 stations with a grid spacing of about 1.0 km. Elevation of each station was measured through Differential Satellite Positioning Systems. After applying the necessary corrections to the G-M observations, Bouguer anomaly (BA) and Total Magnetic Intensity (TMI) anomaly maps were prepared.

The BA map (Fig. 2) indicates a major gravity low and a high in the area of operation nearly 1200 sq. km, and these anomalies are likely to be caused due to basement relief. The gravity highs reflect the basement uplift referred as Draksharama horst whereas, the low represents Mandapeta depressions. The TMI anomaly map of the study area (Fig.3) shows a NE-SW trending prominent low and associated feeble high towards the north as an anomaly pair. In general, it is observed that long wavelength gravity high coincides with magnetic low and vice versa suggesting basement undulations as the causative source. Presence of magnetic high to the north of a dominant low at this magnetic inclination (19^{o} N) suggests presence of remanent magnetization in the basement rocks.

The Precambrian metamorphic basement may consist of gneisses, quartzite, charnockite and

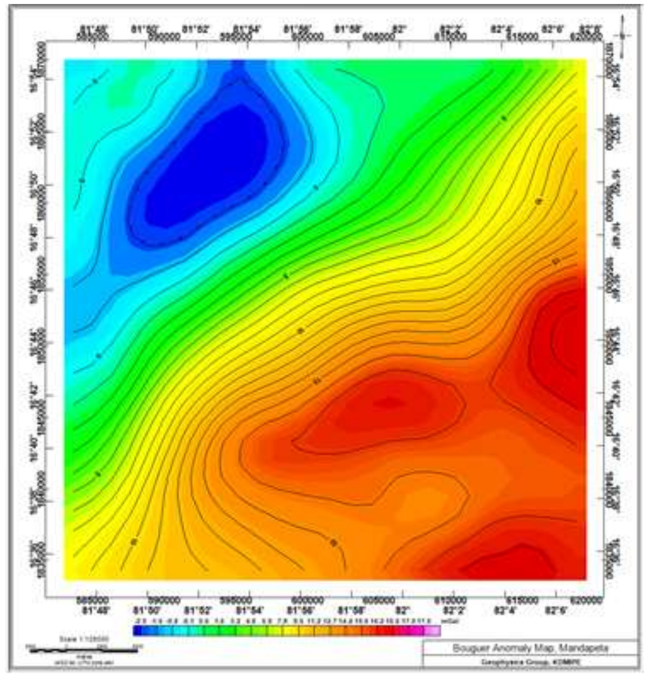

Fig (2) Bouguer Anomaly Map of Mandapeta Area, KG Basin

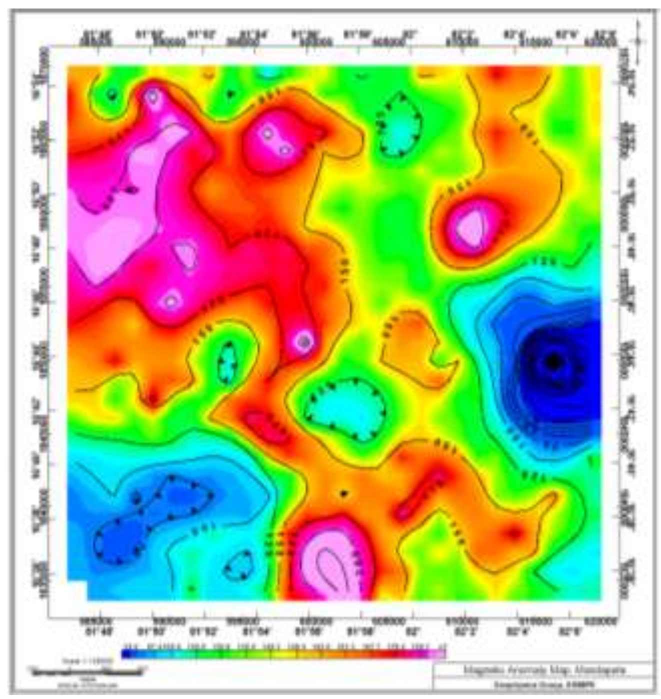

Fig (3) Magnetic Anomaly Map of Mandapeta Area, KG Basin khondalite in this region. Since, gneiss, quartzite and khondalite have low magnetic susceptibility as compared to charnockites and the presence of remanent magnetization in Charnockites of Eastern Ghat terrain (Bhimasankaram, 1964; Radhakrishna Murthy and Rama Rao, 2001) suggests that charnockites constitute the basement rock in this region. The average depth of the causative sources at 3.1 km and 5.3 km obtained from the power spectra analysis of the gravity data (Fig.4a) relate to uplifts and depressions in the basement which are the major sources for the long wavelength G-M anomalies. The Residual gravity anomaly of (Fig.4) reflects the gravity effects of the basement undulations. Presence of short wavelength magnetic anomalies (Fig.3) indicates variation in the thickness of the mafic volcanic (Deccan Trap) spread over the area at shallow depth which is well reflected by causative source at 0.94 km depth and basement reflected at depth of 2.86 km in the power spectrum of magnetic data (Fig. 4b).

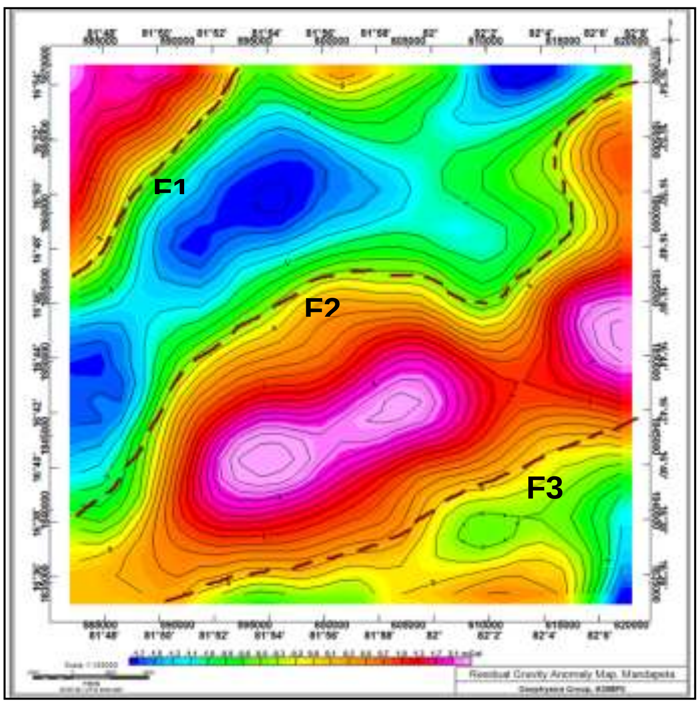

Fig (4) Residual Anomaly Map

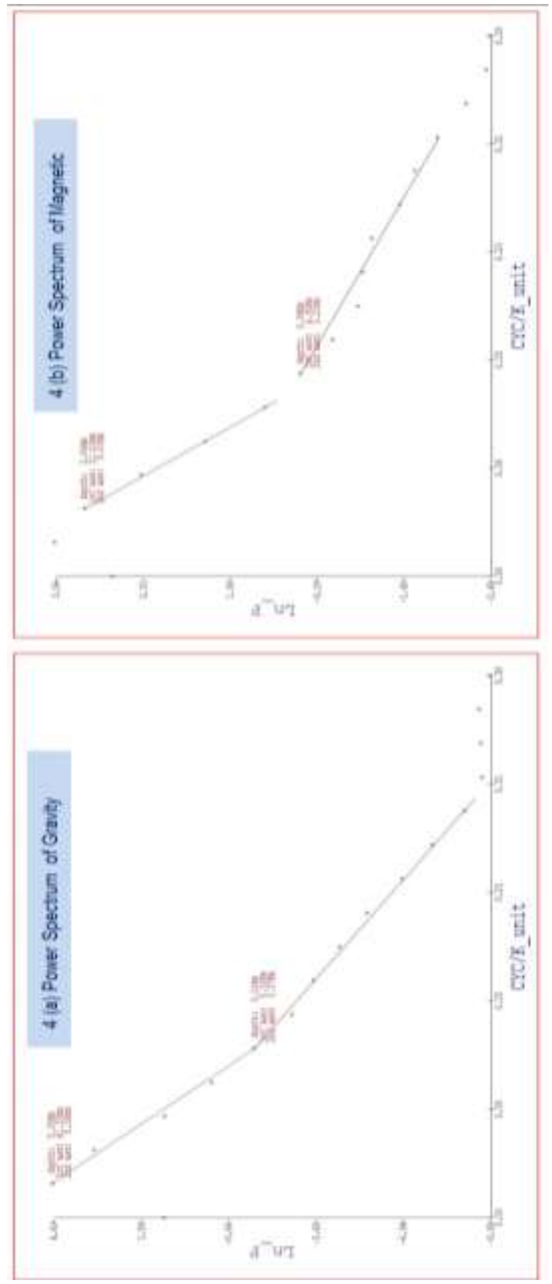

Fig (4a & 4b) Power Spectrum of Gravity and Magnetic

Structural interpretation of G-M fields

To delineate and define the source boundaries, total horizontal derivative map is effectively used in recent years (Yuan, et al., 2012). Fig.5 depicts total horizontal gradient map of BA, which clearly brought out the major fault that are seeing on residual fig.4 as well as minor faults which are consistent with the regional fault patterns of the area. In the basement, faults control the boundaries of the structure, the NE-SW trending faults may represent the major rifting events associated with India-Antarctica separation, whereas slightly NW-SE trend reflects the early rift stage associated with lower Gondwana Permo-Triassic sedimentation in Pranhita-Godavari graben.\

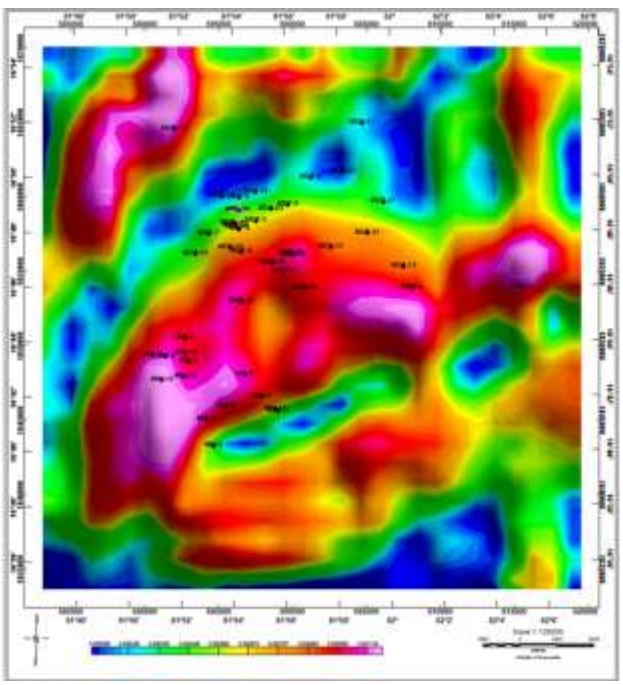

Fig (5) Horizontal Gravity Gradient Map of Mandapeta Area, KG Basin

Integrated G-M modeling

The subsurface models derived from gravity and magnetic are not unique. Hence, care is taken to incorporate the results from borehole to constrain the models to arrive at plausible geological section. In order to compute depth of the main strata 2.5D interactive forward software is applied. Gravity and Magnetic anomalies along a SE-NW trending profile is jointly interpreted (Fig.6) and is 34 km long passing mainly through Yanam-Draksharama high and Mandapeta depression. The initial geometry of sedimentary layers is adopted from the borehole data at MDP-1 and DRK-1. The density values of different sedimentary layers and basement are shown against each layer (Fig. 6). The basement up warps is associated with gravity high and magnetic low can be attributed to low latitude. In order to match the magnetic anomalies due to the basement, it requires remanent magnetization direction (inclination (MI) ≈ -48º and declination (MD) ≈ 45º) similar to that of Charnockites of Eastern Ghat terrain (Bhimasankaram, 1964; Radhakrishna Murthy and Rama Rao, 2001, Bijendra Singh etal .. 2012). Thus, it is inferred that the charnockite constitutes the basement rock in this region.

The short wavelength magnetic anomalies are interpreted due to variation in the thickness of Razole traps (Deccan volcanic) with the direction of the remanent magnetization (inclination (MI)≈-50º and declination (MD)≈ 330º) which corresponds to Deccan stratigraphy (Bhimasankaram, 1965). This inference is in agreement with the findings of the presence of Deccan volcanics in the deep wells of K-G basin in the onshore and offshore area. Deccan volcanic province is the world's largest and longest lava flows (Keller, et al., 2011). The interpreted section reveals maximum depth of basement to be 4.9 km near NW and attains a depth of 2.9 km over Yanam-Draksharama high. From the interpreted section it can be seen that in the study area, the faults are controlling the graben and horst.

Conclusions

Joint interpretation of G-M fields has not only brought out the structural features of the basement but also revealed the nature of the Precambrian basement. Based on integrated modeling, it is suggested that the basement primarily consists of Charnockites of Eastern Ghat terrain. Topography of the basement reflect horst and graben structures having large thickness of syn rift and drift related in the study area. Basement depth varies from 2.9 km to 4.9 km. The structural faults derived from total horizontal gradient of gravity fields coincides with the major discontinuities in the basement and are aligned in the northeast and northwest directions which coincides with the major tectonic trends of the region.

Acknowledgments

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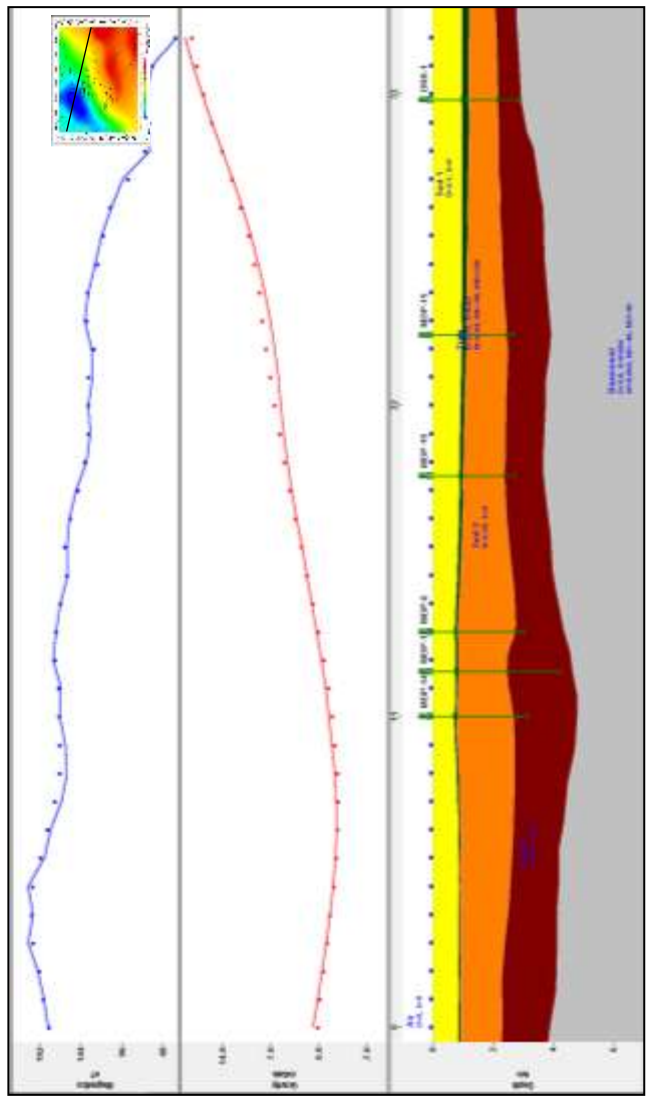

Fig. 6 Gravity Modeling along a profile passing through the low