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Delineation of western margin fault of West Godavari sub-basin and Bapatla Horst of K-G basin using 3D Seismic and Gravity data – A case study of KG-Onland block area falling in Krishna and West Godavari districts, Andhra Pradesh

Narsaiah Rapolu*, Rituraj Dubey, Maninee P. Barik and J.V. Ramana, *GSPC Ltd.*

Summary

Seismic survey is the direct tool to image the subsurface and a good tool in identifying structure towards finding of hydrocarbons. Gravity and Magnetic studies are also important to understand and determine the sediment thickness. Present study is a combined work of Seismic and Gravity data to identify the basin margin fault (western margin fault of West Godavari sub-basin and Bapatla Horst of K-G basin) and corroboration of the same with reference to earlier published data with more support from present study. Bouguer Gravity anomaly maps are available for entire KG area and at present Gravity and Magnetic survey was conducted over 1000 stations with 1km X 1km grid interval in the present study area. 3D seismic data was also acquired in the area and the present study is done using both Gravity and Seismic data.

Introduction

The present study area is geographically located in Krishna and West Godavari districts of Andhra Pradesh State and in the West Godavari sub basin of the Krishna Godavari Basin.

Gravity and Magnetic methods are well established in locating structures such as faults, fractures and intrusives and in helping to detect variations in lithological units (B. Madhusudan Rao et al. 2006) in the detailed survey and interpretation work. Whereas, if the survey is reconnaissance, Gravity and Magnetic data reveals about the depth to basement, regional structural pattern, fault orientation, sediment thickness, which are very important tool in oil and gas exploration.

General Geological Setting

The position of area with respect to generalized topography and general geological setting is shown in Figures 1 & 2. The Krishna-Godavari Basin is a peri-cratonic passive margin basin (Jurassic - Recent basin) on the east coast of India. The basin's characteristic feature is its en-echelon horst and graben system. The Proterozoic Eastern Ghats Belt of igneous and metasedimentary rock comprises most of the western margin of the Krishna-Godavari Basin (KGB). The NW-SE trending Permo-Triassic (Lower Gondwana) Pranhita-Godavari Basin cuts the Eastern Ghats basement and extends to the coast, where it un-conformably underlies the Late Jurassic - Early Cretaceous Krishna-Godavari Rift between two prominent NW-SE trending faults, the Chintalapudi and Pithapuram cross trends. The Mahanadi and Cauvery Basins lie to the northeast and south respectively. These three coastal basins developed along a NE trending extensional system during the separation of India from Antarctica-Australia. The pseudo en-echelon basin distribution suggests that rifting of India from Antarctica-Australia may have occurred along transform faults operating parallel to the NNW-SSE direction of extension. To the east, the KGB extends towards the 85°E Ridge.

DIC, GSPC Bhavan, Ground Floor, Sector-11, Gandhinagar-382010 Gujarat, India. Phone: +91-79-66701011
E-mail: narsaiah@gspc.in

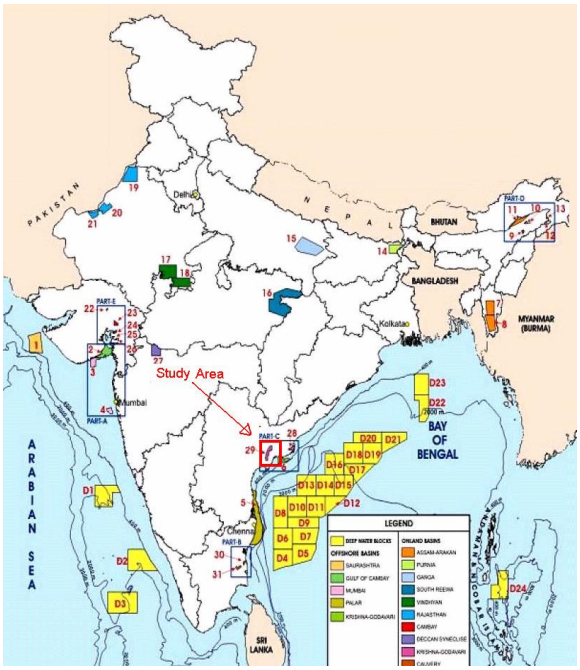

Figure-1: Map showing the study area marked in RED colored square (Map taken from DGH website).

The Gondwanas crop out near the basin margin near around Eluru and Vijayawada area. The basin comprises of sediments ranging in age from Lower Permian to Recent. The Lower Gondwanas occur in subsurface in Kommugudem and Mandapeta areas indicating the extension of "Lower Gondwana Pranahita Godavari Graben" in NW-SE to WNW-ESE trend underneath the KG basin having NE-SW strike. The NE-SW trending KG basin comprises sediments of Late Jurassic to Early Cretaceous in the area between the basin margin fault and Matsyapuri-Palakollu (MTP-PLK) Fault.

West Godavari sub basin mainly comprises of alluvium in south and south eastern parts as outcrop and also Raghavapuram shale in central parts and basement exposures in the northern parts of the basin.

Present study area is covered with alluvium in south, central parts and basement/ hard rock is exposed in north and northeastern parts of the block.

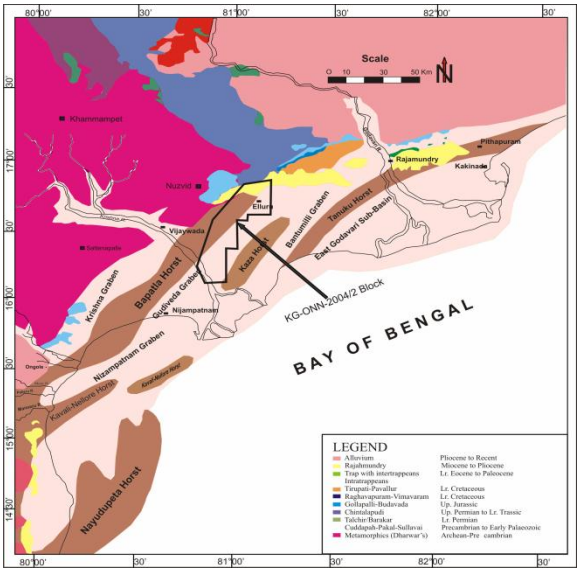

Figure-2: Regional Geological map of Krishna Godavari Basin, Andhra Pradesh.

Tectonic Evolution of Krishna Godavari Basin

KG basin appears to have gone through three stages of rifting process. The Proterozoic Proto-rift (NW-SE) accommodated Purana group sediments. This was superimposed by Gondwana rift that held the sediments of Lower Gondwana (Talchir to Chintalpudi Sst.). The final rifting (NE-SW) took place during the break-up of Gondwana land (Late Jurassic – Early Cretaceous) and was followed by drifting of the separated part. The drifting was accompanied by SE tilting of the basin that heralded the open sea conditions and deposition of transitional, deltaic, inter-deltaic and deep water sediments.

The KG basin has three lows (grabens) viz., Krishna, West Godavari (WG) and East Godavari (EG) sub-basins separated by two basement highs viz., Bapatla High and Bhimavaram-Tanuku High situated in the direction of west to east respectively. The West Godavari sub-basin is further subdivided into Gudivada and Bantumilli grabens by Kaza-Kaikalur high.

ENE-WSW to NE-SW trending grabens and half-grabens developed during Late Jurassic–Early Cretaceous (Upper Gondwana) rifting. Late Jurassic block rotation and uplift resulted in a highly erosive, angular unconformity between the Lower and Upper Gondwana sediments. The Upper

Gondwana syn-rift sediments are dominated by fluvial fine- and coarse-grained clastics (Gollapalli Group). The Gollapalli Sandstone with its lateral equivalents, the Nellore Sandstone, Bapatla Sandstone and Krishna Formation, is a proven reservoir. Intra-formational shales act as seal.

Post-rift thermal sag of eastern India, with associated isostatic uplift and northward drift of the Indian Plate resulted in a tilt of the Indian Plate to the southeast and marine transgression over the rifted margin. The syn-rift topography influenced facies distribution, with development of restricted marine basins atop the half- grabens. Deposition of the post-rift Raghavapuram Formation was dominated by shale, with sandstone to the west (near the palaeo-shoreline) and minor limestones. With continuing thermal subsidence, drainage networks diverted to the southeast, resulting in progradation of the palaeo-Godavari and Krishna deltas over the now passive margin.

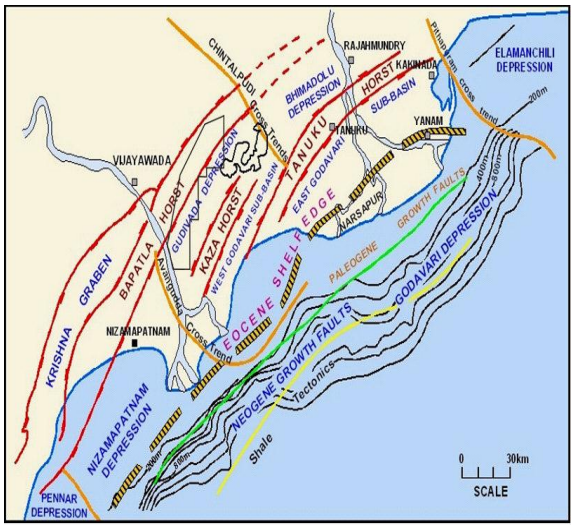

Figure-3: Tectonic Map of Krishna Godavari Basin, Andhra Pradesh.

Eruption of the Deccan Traps in western India resulted in further eastward tilting of the Indian Plate and volcanism within the Krishna-Godavari Basin (Basaltic Trap marker). The Tertiary– Recent sedimentary sequence is dominated by siltstone and sandstone with volumetrically minor limestones. For all Tertiary formations, the proportion of fine-grained clastics (shale) increases basin wards. Unconformity surfaces with possible relationship to major eustatic sea level changes, orogenic events in the hinterland or internal basinal re-adjustments are developed within the sequence, most notably at the Upper Eocene and Upper Miocene levels.

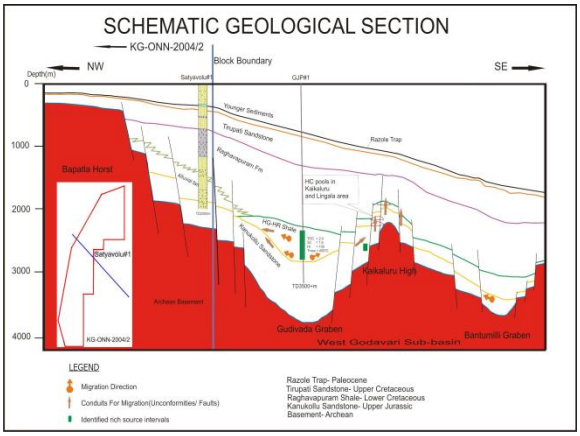

Figure-4: Schematic Geological cross-section of the study area in Northwest-Southeast direction.

Present Study

To evaluate the hydrocarbon potential of the study area, Seismic, Gravity and Magnetic surveys were conducted over an area of 1000 sq. km. along with geochemical-geological studies. NW-SE directional seismic sections are interpreted to mark the basin margin fault which is prominently visible and made a fault polygon to corroborate with different type of Gravity anomaly maps. The area, where the fault is observed on seismic sections is persistently in comparable with the trends observed in various Gravity anomaly maps (Figure.5b).

We have also generated a schematic geological cross-section (Figure-4) passing through Satyavolu#1 exploratory well which is also revealing the high angle basin margin fault against the Bapatla Horst which was reflected in different type of Gravity Anomaly maps as well as in the 3D seismic data. (Fig: 5 & 6). To generate the geological cross section, we used the Satyavolu#1 well stratigraphy and matched with the seismic section crossing the well.

Western margin fault of West Godavari sub-basin of K-G basin is dominantly visible in all the maps prepared from Seismic, Gravity and Geological cross-section.

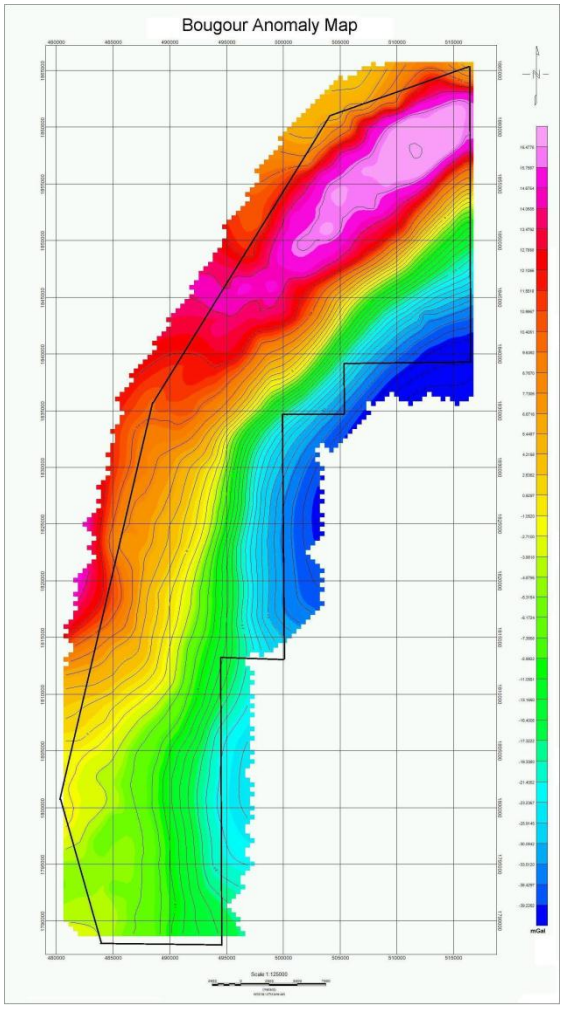

Figure-5a: Bouguer Anomaly Map of the study area

Conclusions

Seismic and Gravity data interpretation brought out very good results in defining the high angle basin margin fault of West Godavari sub-basin against the Bapatla Horst. Bapatla ridge indicated by highest Complete Bouguer Anomaly (CBA) (19mGal) in the North West corner of the block (Figure-5b). Lowest CBA of 9mGal observed along the eastern boundary of block. Different NW-SE fault trends are also observed both in Gravity and Seismic data. Complete Bouguer Anomaly and its different derivate maps have brought out 2-D disposition of hidden Bapatla ridge (Figure-5)

The regional gravity field is in the direction of NE-SW parallel to the coast line. The Minimum depth to the ridge top at North West corner interpreted to be around 0.5km.

Three distinctive depth horizons are calculated as 1.66 to 1.99km, 3.3km and 6km represents the thickness of different sediment packages. Deepest basement depth estimated to be about 6km. Intersections of cross-faults (NW-SE and NE-SW0 cutting across the regional NNE-SSW faults could be good locales of hydrocarbons in the area. Finally, the study reveals the delineation of Western margin fault of West Godavari Sub-basin of K-G basin.

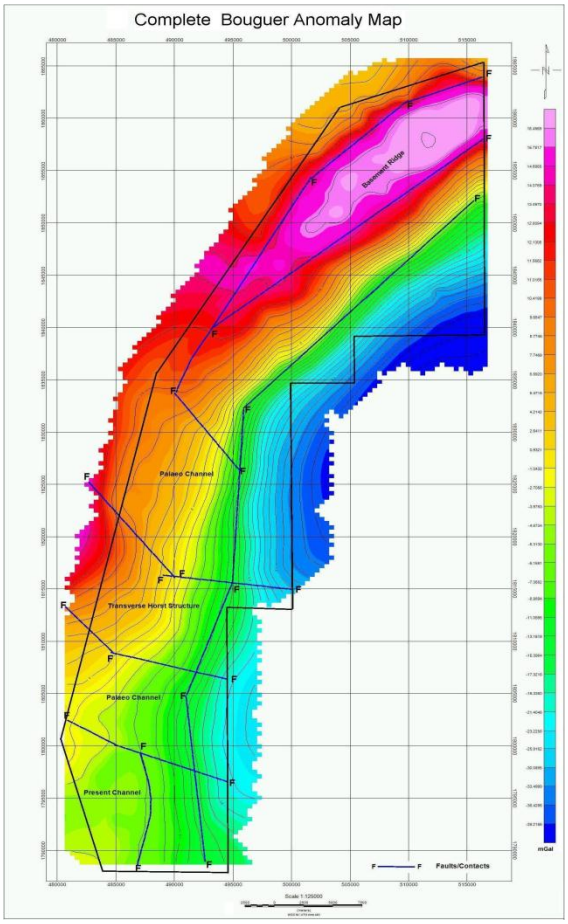

Figure-5b: Complete Bouguer Anomaly Map of the study area with major fault markings.

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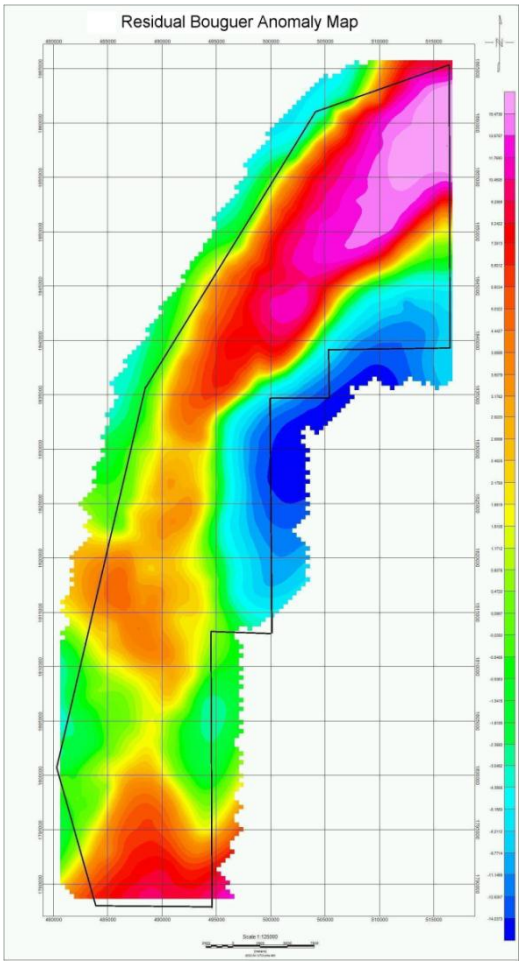

Figure-5c: Residual Bouguer Anomaly Map

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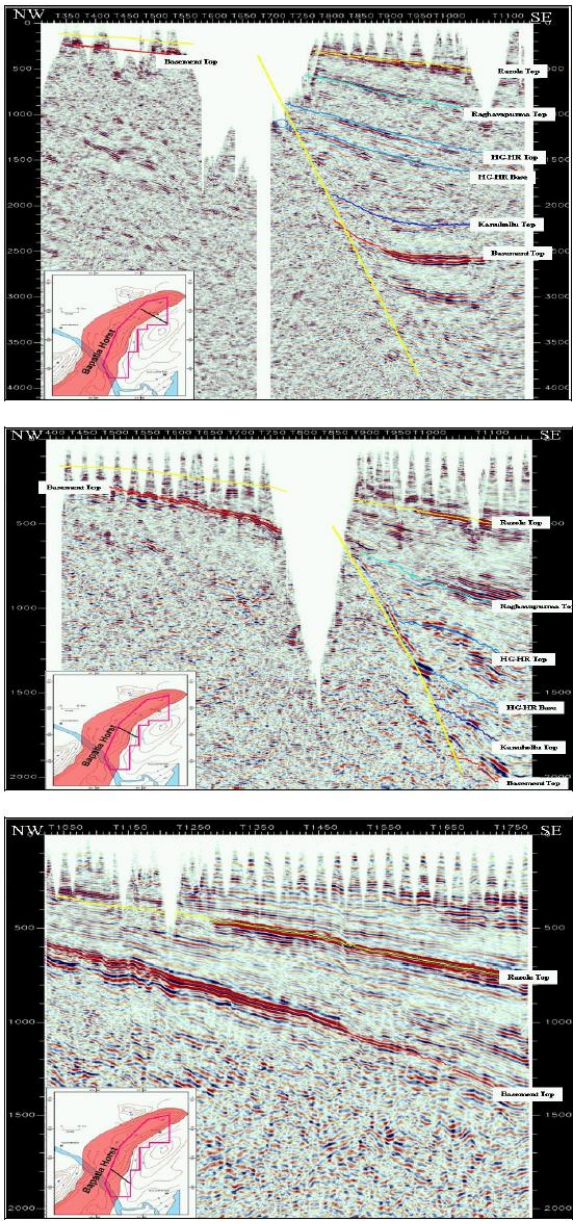

Figure-6: Three Seismic Sections in NW-SE direction delineating the Bapatla Horst and basin margin fault. Bapatla Horst is marked in red colored shading in the map.

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