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Analysis of Gravity-Magnetic signature of Ramnad sub-basin for estimation of basement depth

D. Saha^{1*}, Sudhir Kumar², Vedpal³, J.N Prabhakardu⁴, Kuldeep Prakash⁵

Summary

Ramnad sub-basin is formed due to rifting like other East Coast basins. During last two decades about sixty five wells have been drilled in the land part. Only Mandapam-1, Ramanavalasai-4, Nainarkoil-1 and Uchipuli-1 wells met with basement. Gas is being produced from five areas within the Ramnad sub basin viz. Pariyapattinam (PP), Perungulam (PE), Ramanavalasai (RV), Kanjirangudi (KJ) and Palk Bay Shallow (PBS). Nannilam formation is main hydrocarbon producer in the Ramnad sub-basin.

KJ8 located towards Western side, dolerite was encountered in the interval 3762-3803 m. This is the only well in Ramnad sub basin where considerable thickness of source sequence was encountered in the interval 3880-4200m and probably this intrusion may have a bearing for the peak maturation phase of these sediments.

Further in (UP-1), located towards Eastern margin, intrusive rocks are also reported. It is worth mentioning that in the adjacent Gulf of Mannar area, apart from deep basinal area, dolerites are encountered in wells located in shallower part viz. Mannar-1-1A, GM-4-1, GM-5-1 GM-6-1. Knowledge of location of these dolerites and its lateral extension in Ramnad area is very much essential to assess HC potential for further exploration activities.

In view of the above, the present study was undertaken to delineate the Basement configuration and lateral extension of dolerite in the Ramnad area from GM Modeling. Magnetic study indicates that causatives (dolerite) exist in a curvilinear fashion extending from NK-1 to Mandapam-1 and farther. Causative depth of these magnetic bodies is almost matching with well data Mandapam-1, NK-1, RV-4 and it is varying between 2km to 4km in the study area. The study brought out Basement depth is about six kilometers at the deepest part of Ramnad low and raising to one and half kilometers towards the Eastern flank (Mandapam –Delft horst) and about 3 km in the Western flank (Pattukottai-Mannargudi ridge).

Keywords: Ramnad sub-basin, GM Data Interpolation

Introduction

Ramnad and Palk bay offshore areas constitute the Southern part of Cauvery basin. Ramnad sub-basin is flanked by the Pattukottai-Manargudi ridge in the West and Northwest, Mandapam delft ridge to the East and Southeast, and Gulf of Mannar to the South Fig-1 & 2. Ramnad sub-basin has an area of about 2500 km² with thick sedimentary cover from lower Cretaceous to recent. The deepest sedimentary pile in the Ramnad sub-basin is six kilometres. The source rock facies are encountered in Andimadam formation of Albian and pre Albian sediments. Hydrocarbons are discovered in several reservoirs viz Bhuvanagiri and Nannilam (Main producer) formations. ONGC in 2006 acquired nearly six hundred and fifty stations of GM data in Ramnad sub-basin. The

present study deals with processing and analysis of above data.

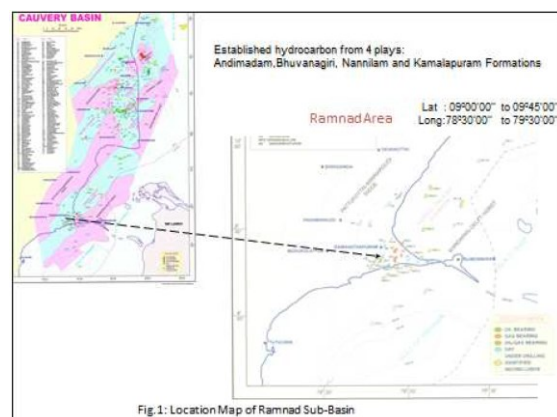


Fig. 1: Location Map of Ramnad Sub-Basin



Notwithstanding emerging technologies and new methods developed, post stack seismic inversion still remains a powerful tool in defining reservoir if integrated judiciously with geological, petrophysical and production data.

Geology

Cauvery basin forms the South-western attenuated margin of Jurassic rift of east coast of India. Taphrogenetic fragmentation of Archean basement as a result of rift-drift phenomena of Indian plate took place during late Jurassic-Early Cretaceous which resulted in formation of horst and graben aligned in NE – SW direction. The Bay of Bengal opened up around 125 Ma as India drifted apart. The Cauvery basin configuration was initiated in the NE-SW direction during rifting and different tectonic elements took their shape by subsequent drifting.

The grabens and horsts of the Cauvery basin are aligned in NE-SW direction and the designated grabens and horsts from North to South are Ariyalur-Pondichery sub-basin, Tranquebar sub-basin, Tanjore sub-basin, Nagapattinam sub-basin and Ramnad sub-basin Palk-Bay Offshore and Gulf of Mannar. Similarly horsts are KumbakonamMandapam ridge Karaikal ridge, Pattukottai-Mannarargudi ridge, Vedaraniyam high and Mandapam delft ridge.

Gravity anomaly map

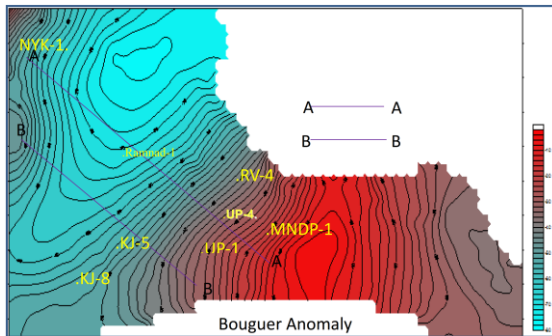


Fig2: Bouguer anomaly map (mgal) of Ramnad sub-basin and adjoining area

The major features in the map are as follows

- There is a low axis running SW-NE direction towards west of Ramnad town. The NE side Gravity low is of very high amplitude compared to SW low.

- The most striking feature of the map is a smooth rise of anomaly (-26 mgal) from SW near KJ-8 to PY-1 (Koluvur-2) indicating the direction of basinal low.
- The gravity low corresponds to the basinal low. The gravity high trend in the eastern part, corresponds to Mandapam-delft horst

Free air anomaly map

Satellite altimeter derived gravity data was merged with the acquired land data and free Air anomaly map with 2 mgal contour interval was generated to study regional tectonic elements.

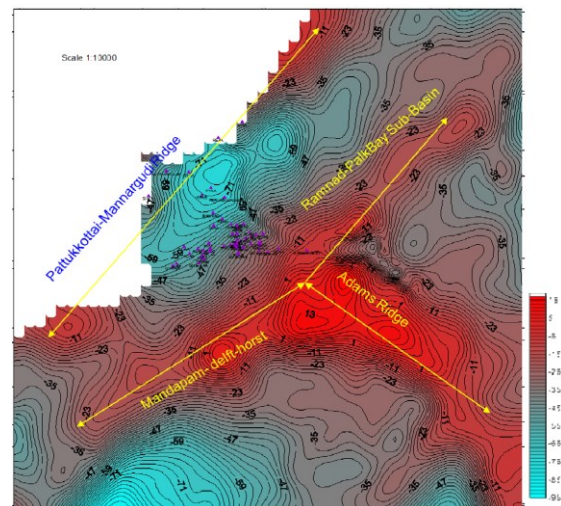


Fig3: Free Air anomaly map (mgal) of Ramnad sub-basin and adjoining area

The map brought out the Mandapam-delft ridge, and Pattukottai-Manargudi ridge, and Adams ridge (Fig-3). It is observed that Ramnad low is sandwiched between two ridges.

Magnetic anomaly map

Magnetic anomaly map with contour interval of 25 gamma is prepared with low pass filter of 5km wavelength as the original anomaly map was showing high frequency features. The major features in the magnetic anomaly data are discussed below.

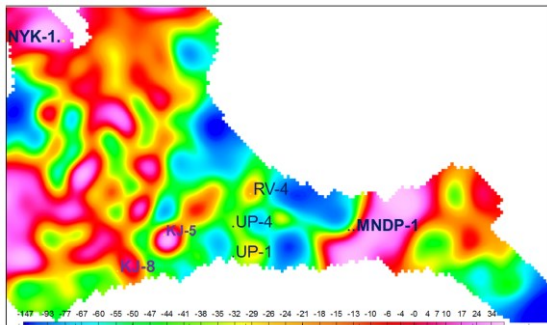


Fig.4: Magnetic anomaly map (units in Gamma)

- The Western and Eastern margin of Ramnad low is characterised by Magnetic low and The magnetic high in the Eastern part of basin can be attributed to the presence of igneous rocks in the Mandapam-delft horst . The Mandapam high corresponds to gravity high.
- It also indicates shallow basement in comparison to basement at Ramnad low. The dispersal of the basaltics flow during volcanic eruption and their subsequent deposition in the rift period can be attributed to the orientation of many large and small magnetic highs.
- Many bipolar magnetic features in North-South linear fashion are observed which may be due to the presence of sharp magnetic bodies. The wave length and frequency of magnetic field shows that the causatives are probably shallower which is supported by and their East-West aerial extent is less than North-South extent. (Volcanic?)

Basement encountered wells

Well Name	Drilled Depth
RV#4	3052
NK#1	3633
UP#1	2985
MNDP#1	1679

Dolerite encountered well

Well Name	Drilled Depth
UP#4	3035
KJ#8	2812
UP#3	3010

The above mentioned wells are plotted on gravity and magnetic map where it is observed that shallower

basement wells show gravity and magnetic high. Moreover Dolerite encountered wells are also falling on Magnetic high.

Gravity modelling

Gravity modelling has been done with following input data.

1. Interpreted Seismic profiles along AA , and BB for delineating total sedimentary pack. Fig-5 and 6.

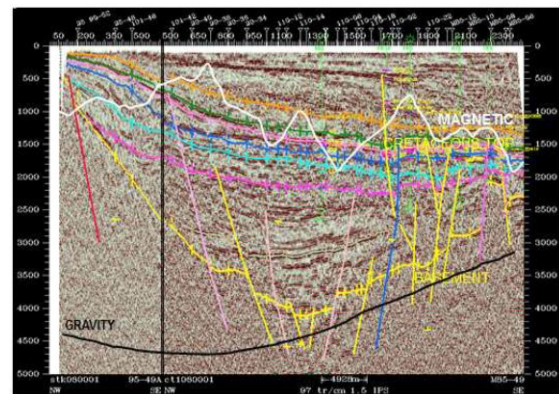


Fig.5 : Composite Seismic Section of Line no AA

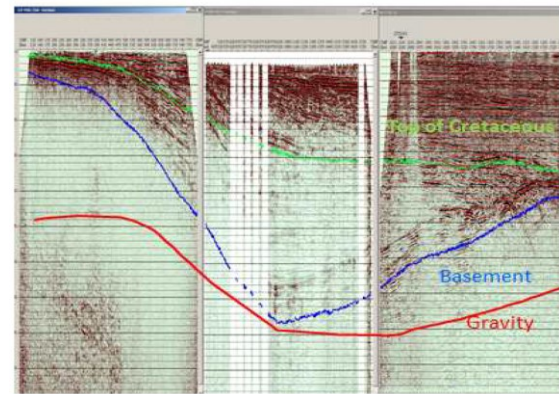


Fig.6 : Composite Seismic Section of Line no BB

2. Well data of 67 wells viz. drilled depth, density, age of the rocks etc.

Well	Age	Formation	Depth Range	Density	Well	Age	Formation	Depth Range	Density
Ramnad 1	Paleocene Cretaceous		855-1615	2.11-2.14	RV-5		Karikal	1200-1915	2.2
			1615-3550	2.40-2.49			Portonovo	1915-2154	2.32
PE-7		Kamilapuram	1402-1815	2.16			Nanilam	2154-2265	2.47
		Portorovo	1815-2039	2.39			Kudavasal	2265-2318	2.48
		Nanilam	2039-2104	2.39			Bhuvangiri	2318-2431	2.5
		Kudavasal	2104-2208	2.4		RV-1		Portonovo	1868-2024
	Bhuvangiri	2208-2605	2.41				Nanilam	2024-2157	2.45
							Kudavasal	2157-2181	2.47
							Bhuvangiri	2181-2685	2.51
PE-6		Kamilapuram	1174-1926	2.0-2.25			Satapadi	2685-3044	2.55
		Portorovo	1926-2127	2.29		Andimadam	3044-		
		Nanilam	2127-2241	2.3	RV-2		Karikal	1200-1852	2.2
		Kudavasal	2241-2281	2.32			Portonovo	1852-2053	
	Bhuvangiri	2281-2351	2.35-2.41			Nanilam	2053-2139	2.39	
						Kudavasal	2139-2202	2.45	
PE-5		Karikal	900-1163	2.15		Bhuvangiri	2202-2505	2.47	
		Kamilapuram	1163-1866	2.2	UP-1		Campanian	1950-2025	2.4
		Portorovo	1866-2085	2.38			Coniacian-Santonian	2025-2350	2.42
		Nanilam	2085-2190	2.44			Turonian	2350-2605	2.44
		Kudavasal	2190-2256	2.46			Cenomanian	2605-2655	2.40
	Bhuvangiri	2256-2400	2.47			Albian&older	2655-2905	2.49	
PE-2						Basement	2905-2985	2.75-2.95	
		Karikal	1370-1770	2.11-2.29	UP-2		Paleocene	1800-1905	2.39-2.42
		Portorovo	1770-2045	2.3			Cretaceous	1905-2700	2.48-2.58
		Nanilam	2045-2112	2.32					
		Kudavasal	2112-2242	2.45					
		Bhuvangiri	2242-2840	2.6					
	Satapadi	2840-3210	2.52						
	Andimadam	3210-3303	2.55						

Gravity response has been simulated for two profiles AA and BB passing through the wells Ramnad-1, PE-2, PE-5, PE-6, PE-7, RV-1, RV-2 and RV-5; UP-1 UP2, KJ-3, KJ-5 and Mellur-1 with density of 2.80 gm/cc for Basement, 2.25 to 2.57 for sediments, results of models are shown in Fig.15 and 16.

Modelling results

The depth model has fairly reproduced the main observed gravity anomaly features. Gravity modelling shows that the total sedimentary pack in the center of Ramnad low is about 6 km and it is 1.6 km approximately towards Eastern flank Mandapam –Delft horst.

Conclusion

Gravity modelling has reproduced fairly the rift and drift related tectonic elements in the area with quantitative agreement between observed and computed gravity values. The basement is much deeper than what it appears to be from seismic data, particularly in the epicentre of Ramnad low which is in the central part of the study area

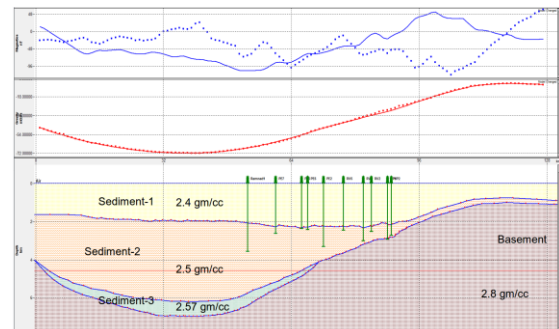


Fig.14: Gravity Modeling along profile AA

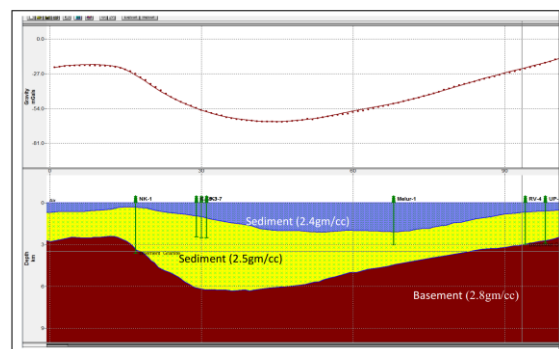


Fig.15: Gravity Modeling along profile BB



- Basement depth is about 3 km in the Western flank of basinal low (Pattukottai-Mannar Gudi ridge) and in the center of the low it is 6 km and raising to 1.6 km approximately towards the Eastern flank (Mandapam– Delft horst)
- Magnetic study indicates that causatives dolerite exist in a curvilinear fashion extending from NK-1 to Mandapam-1 and farther.
- The causative depth of these magnetic bodies is almost matching with well data of Mandapam-1, NK-1, and RV-4 and it is varying between 2 to 4km in the study area.

The crust is thinning considerably towards Eastern margin but it is not possible to infer about the nature of crust because of presence of intrusive and volcanic bodies. Structurally favourable lows with thick sedimentary columns devoid of intrusive bodies in the Western margin are likely to be good source areas for hydrocarbon potential.

Acknowledgement

The authors express profound gratitude to Dr D. K Dasgupta , GGM -HOI KDMIPE, ONGC, for his critical suggestions and inspiration for writing this paper.

References

Lowell, J.D. Mechanics of basin inversion from worldwide examples. P-39-57 Geol. Society special publication no-88 edited by James.G. Buchman and Peter.G.Buchman. 1995

Sibson, R.H., Selective fault reactivation during basin inversion: potential for fluid redistribution through fault-valve action. P-3-19, Geol. Society special publication no-88 edited by James. G. Buchman and Peter.G.Buchman.1995

Macgregor, D.S., Hydrocarbon habitat and classification of inverted rift basin. P-83 -93, Geol. Society special publication 6th International Conference & Exposition on Petroleum Geophysics “Kolkata 2006”

Mahesh Chandra, Pateria,M.L. , Jaya Kumar, I., Srinivas.D.,Awasthi,A.K., 1989, Integrated Geological

and Geophysical studies for reassessment of prospects of Palk Bay area in Cauvery Basin. - An unpublished ONGC report.

S.G.K.Mohan., Gita Singh., S.P. Sharma, S.K.R. Moulick & J. Baral: Tectonic evolution & sequence stratigraphy of Cretaceous sediments in Ramnad sub basin, Cauvery basin. 1999. An unpublished ONGC report.

B.M.Juyal, C.Chakrobarty, M.S.Rana & Sushil Chandra : Re-Evaluation of Palk Bay, Gulf of Mannar and adjoining areas to assess the hydrocarbon potential of KMP, NLM, BVG & AND. formations in light of recent drilled wells, 2005. An unpublished ONGC report.

D. Saha*, C.S. Bahuguna, etal: Integrated interpretation of Gravity & Magnetic data for delineation of sedimentary thickness in deepwater block of Andaman Basin. 9th International Conference & Exposition on Petroleum Geophysics “Hyderabad 2012”.