Strati-Structural and Stratigraphic Prospect identification in East Godavari Sub Basin in Krishna Godavari-Basin: A case study

D.N. Murthy, S. Nawaz, B.P. Sarma

Oil India Limited

Abstract

Identification of traps is the first and foremost step in any hydrocarbon exploration programme and thereafter the traps can be classified into Structural, Stratigraphic & Combination. By analyzing the individual trap and its characteristics, origin of the trap and the depositional environment can be evaluated. Knowledge of the petroleum systems and source rocks and reservoir rocks in the area helps in attributing the identified traps to corresponding petroleum system and thereby to define source and reservoir rocks of the traps. Also integrating the other geo scientific data i.e. Gravity and magnetic data, Geo chemical and well log data with seismic helps in determining the prospectivity of the identified traps. This paper briefly describes strati structural and stratigraphic plays available and their characteristic features in the study area.

Introduction

The study area lies in the East Godavari sub basin in K-G Basin (Fig.1) and surrounded by hydrocarbon discoveries in the formations ranging from Miocene to Gondwana Age. Major Fields in vicinity are Pasarlapudi (Eocene-gas and condensate) towards southwest, Mandapeta (Gondwana age) and Endamuru (Cretaceous) Fields in the Northwest and the Deen Dayal Field, shallow offshore gas field in the north east, and the Miocene Ravva and Dhirubhai offshore fields in the southeast of the study area. The area was covered by 3D seismic and Gravity-Magnetic survey. Identifying structural and/or stratigraphic traps in the area for exploring hydrocarbons being the prime objective, the first step carried out was basement mapping which helped in understanding the tectonic setup and basin configuration. Further Early Cretaceous, Intra Cretaceous top, Late Cretaceous, Paleocene, Eocene and Oligocene tops were mapped (Fig. 2) to understand the prevailing structural trends, depositional pattern and for understanding various play types available in the study area.

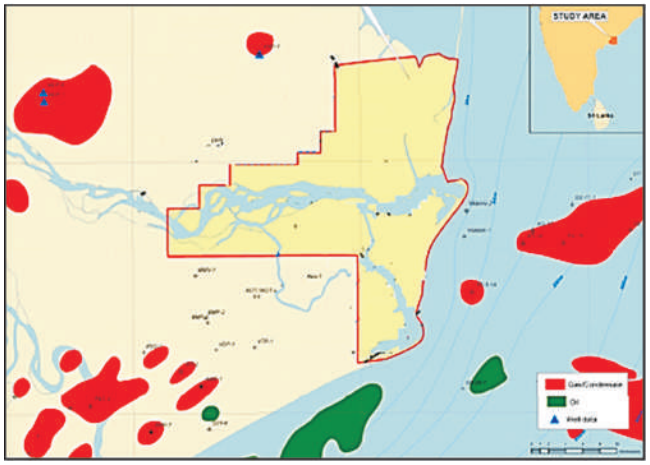

Fig. 1: Map showing the study area

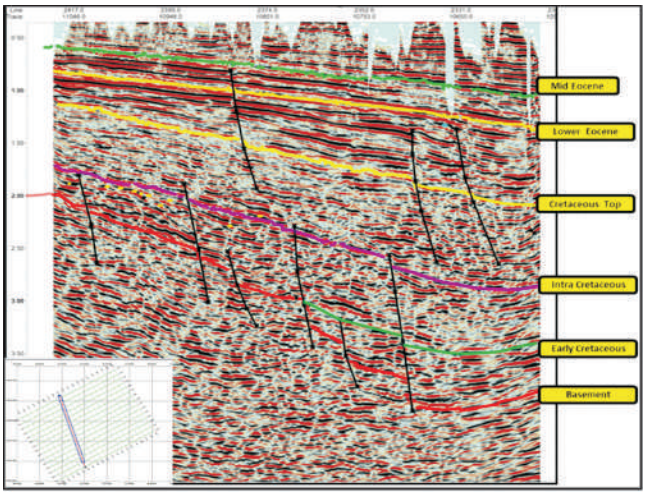

Fig. 2: Seismo-geological section with mapped formation tops

General Geology of the Basin

Krishna Godavari basin is a pericratonic passive margin basin comprising of number of NE-SW trending horst and graben features. Tectonically, the basin can be divided in to three sub basins viz. Krishna, West Godavari and East Godavari sub basins (The study area is located in the East Godavari sub basin) which are separated by Bapatla and Tanuku horsts respectively. The West Godavari sub basin is further, subdivided in to Gudivada and Bantumilli graben by Kaza Kaikalur horst. Further the basin is characterized by NW-SE cross trends (Ongole, Avanigadda, Krishna, Chintalapudi and Pithapuram from South west to North east). These are transform faults which originated parallel to the extensional direction. The margin of KG Basin is formed during the Late Jurassic and Early Cretaceous along the line of older lineaments, the Precambrian Eastern Ghats trend.

The Basin characterized by tensional tectonic regimes with three distinct successive events- Early rift, Main rift and Drift. The Early rift (Gondwana rift) commenced in Late

Paleozoic through block faulting. The NW-SE trending early rift trend of Pranhita-Godavari graben extends to coastal KG basin as cross trend. The Main rift commenced in Late Jurassic with the development of horst-graben feature and rotation of pre-existing fault blocks of early rift system. The Drift phase is marked by basin scale breakup unconformity and ocean-ward aided by major basement faults through which volcanic lava flow could have occurred at the end of Cretaceous period. Marine sediments comprising clastic and carbonates were deposited over the fill sediments. As a result of continued eastward tilting of the continental block, a Tertiary deltaic system developed on the south eastward prograding shelf edge. Figure: 3 shows the tectonic frame work of the basin along with the cross trends and the study area.

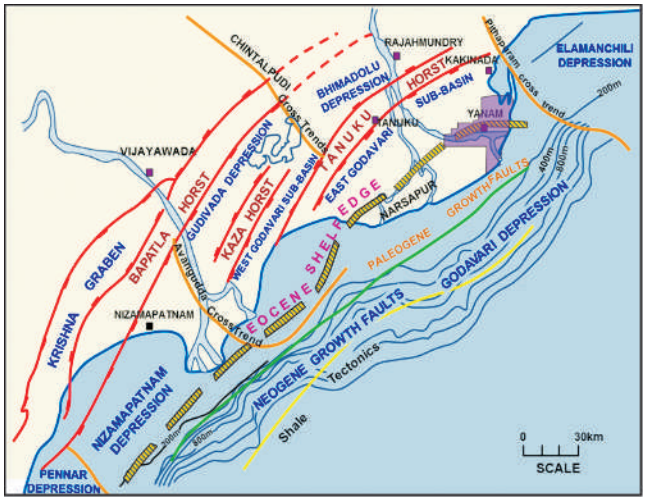

Fig. 3: Regional Tectonic Map of KG Basin showing the study area

Stratigraphy

Study area lies in the Gouthami- Godavari Delta and falling between Chintalapudi and Pithapuram cross trends. Tectonically, majority of the study area is within the rift/drift tectonics and NE-SW trending basin margin fault area. Expected stratigraphy of the area is shown in Figure -4.

AGE	Ma	Formation	Lithology	Expected Fm. Thickness (m)	Lithologic Description
Recent	0.01	Rajamundry Sst / Godavari Clay		500-700	-Brick colored ferruginous s.st -Clay stone expected
Miocene	23	Narsapur Clay St.			
Oligocene	34	Matsyapuri Sst.		0-250	-Sst. with Shale/clay interbeds
Eocene/ Paleocene	121	BMP Lst.		400-750	-Mainly L st.
		Pasarlapudi Fm.			-Shale with lenticular sand bodies
		Palakollu Shale		400-750	-Mostly shale, possible channel sand in the area
		Razole Fm.			-Sporadic Basaltic flow
Cretaceous	145	Raghavapuram Shale/ Chintalapalli Shale		2400-3400	-Dominantly shale, channel sand bodies expected
		Gollapalli S.st.		30-1200	-Dominantly syn -rift sandstone with shale interbeds -Absent in the northern part or very thin cover of sediment in parts of the area
Archean	3800				Metamorphic Charnokite Basement

Fig. 4: Generalized stratigraphy of the study area

The stratigraphy in study area is expected to encounter starting from Archean basement, Early Cretaceous (Gollapalli sandstone) to recent. Yanam High trend lies in the North of the Godavari River where possibility of having less thickness of Tertiary sequence with Cretaceous sediments.

Gravity &Magnetic

Basement configuration has been interpreted from gravity and magnetic data indicating deepening of the basement towards South-East of the study area (i.e. showing more sedimentary thickness in SE). Features like Yanam High (Basement High) can be observed clearly and the fault patterns are aligned in NE-SW trend along the cross trends. The Basement depth map from Gravity interpretation is shown in Figure -5.The basement configuration from Gravity is depicting similar trend to that of the seismic data (Figure -6).

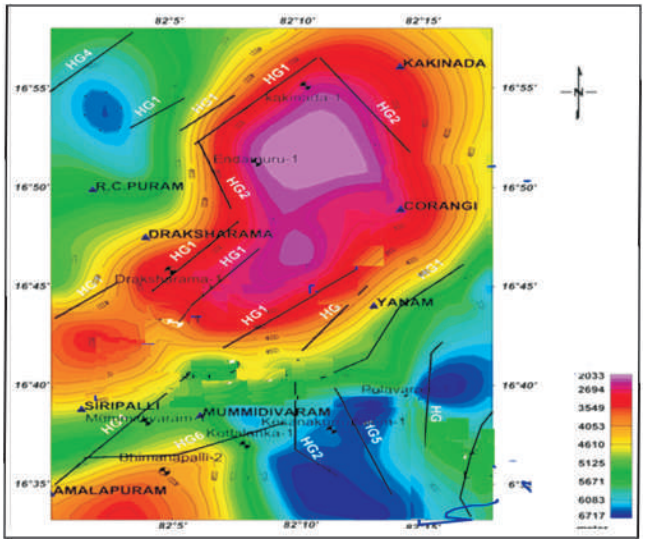

Fig. 5: Basement depth map from Gravity

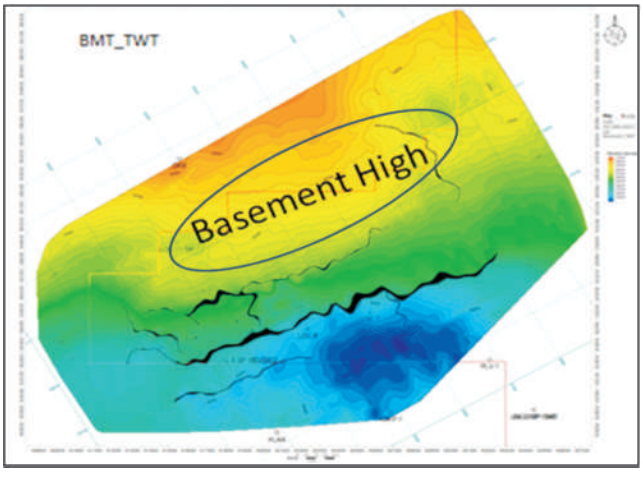

Fig. 6: TWT Contour for basement reflector

Structural Plays

Synrift Prospects

Synrift prospects associated with basement faults were identified in the area is shown in Figure-7 which are

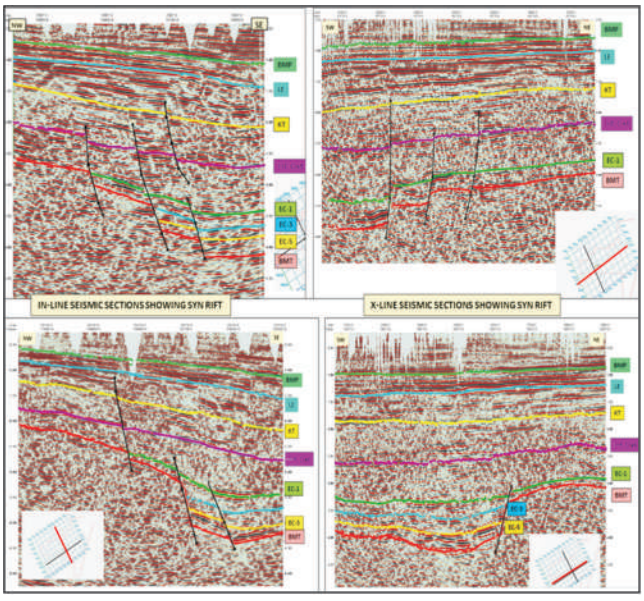

Fig. 7: Synrift prospects identified in the area

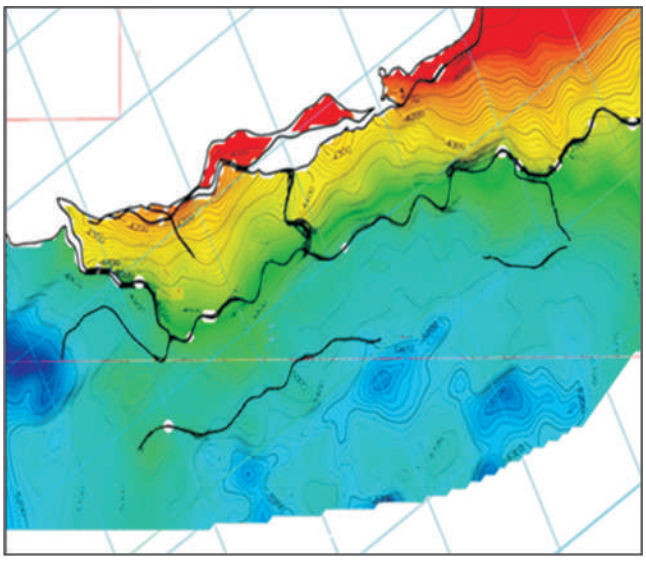

Fig. 9: Depth Contour map of basement reflector

structurally down thrown in fault blocks. The normal faulting associated with the basement was due to rifting during Jurassic to early Cretaceous and the deposition of sediments had taken place in the same geological period. The bright seismic packages at the early Cretaceous level in the Raghavapuram-Gollapalli petroleum system are expected to be prospective at favorable entrapment conditions. The depositional environments are of non-marine, lacustrine, marginal marine and shallow marine. (S.K.Gupta etal).The expected source rocks are shale's of Gollapalli formation and Raghavapuram shales and Gollapalli sand stones are reservoir rock. The locations are likely to fall under high pressure and high temperature zone (around 350° F Temperature and around 13000 PSI pressure).

The stuctural disposition of syn-rift sediments is shown in depth contour map (Figure 9) indicating the up-dip terimination of syn-rift sediments against the basement.These are forming fault closures which are good targets of hydrocarbon exploration.Similar features were proved to be hydrocabon bearing else where in the basin.The post stack inversion studies carried out at these locations reveal that the locations seems to be more favorable and may be considered for exploratory drilling. The inverted seismic sections showing (Fig-8) low impedance features at deeper levels probably indicating the Gollapalli sand stones of early Cretaceous age charged with gas.

Drape Structure

Another structural feature was also identified as a Multi level drape fold shown in Figure.10.The drape was bounded by faluts creating suitable entrapement conditions through out the stratigraphic sequences.The structural high associated with the identified prospect is at various levels i.e. Lower

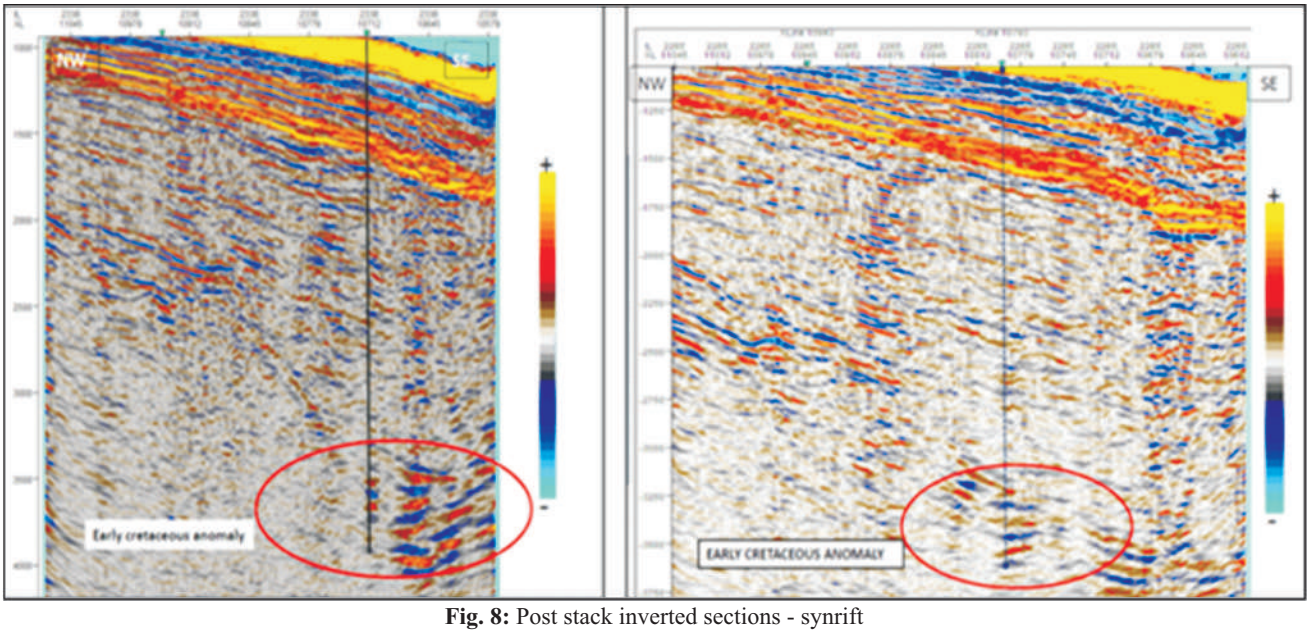

Fig. 8: Post stack inverted sections - synrift

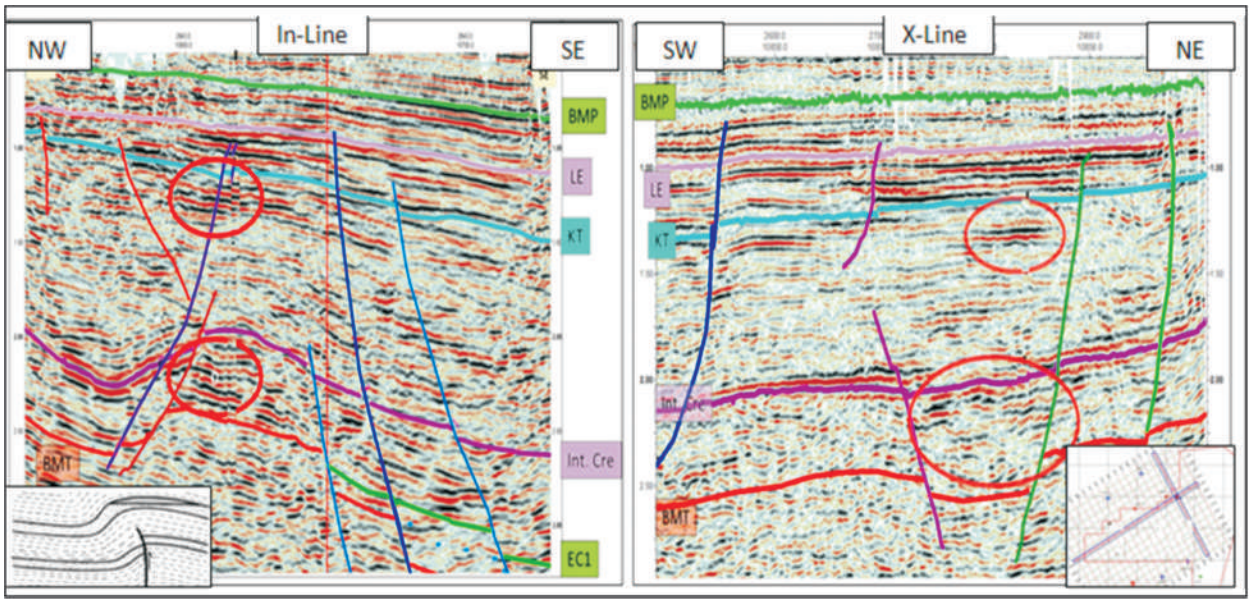

Fig. 10: Drape

Eocene/Paleocene,upper Cretaceous and intracretaceous.The formation of drape in the present case is probably due to the deposition of various sequences on the undulations of the South- Easterly dipping basement.

The expected source rocks being shales with in Palakollu and Raghavapuram formations and the resorvoir rocks being sandstones of Tirupati/Pasarlapudi formations and sandstones with in the Raghavapuram shales.

Stratigraphic plays

Channel sand

Channel sand of intra Cretaceous age with sufficient areal extension has been identified which is clearly visible from the seismic sections (Fig. 11). The orientation of the prospect is nearly across the basement in a localized area. The possibility of the prospect is combination of stacked sand bodies charged with gas. The depositional environment is likely to be shallow marine and belongs to Raghavapuram-Gollapalli petroleum system. The expected source rock being Raghavapuram shale's with Channel sand of Rahavapuram formation being reservoir rock. Figure 12 showing inverted seismic profiles at the location from which the stratigraphic feature of intra cretaceous age "Channel sand" is very clear. The post stack inversion studies carried out reveal favorable conditions for exploratory drilling.

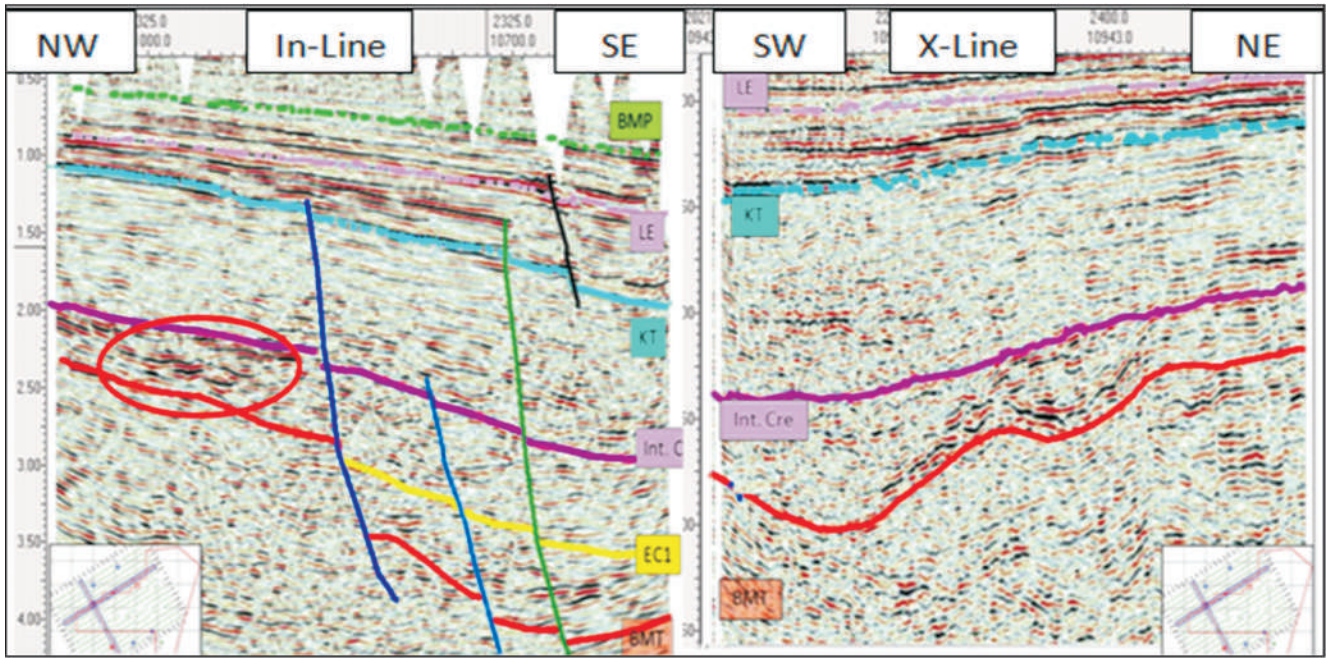

Fig. 11: Channel sand of intra cretaceous age

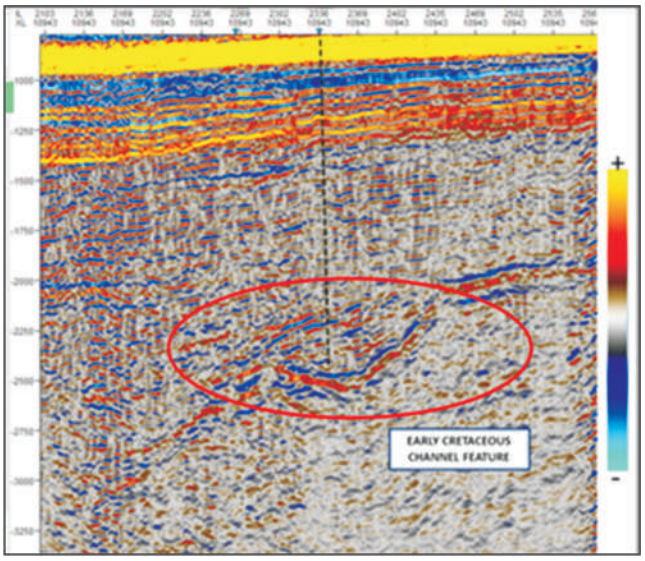

Fig. 12:

Coastal Belt Sands

Coastal belt sands (Fig-13) deposited in lower Eocene Formation have been identified as another stratigraphic prospect. These sands probably deposited during the transgression during Eocene period (G.N.Rao) and are over lined by Bhimanapalli limestone of Eocene age and juxtaposed (on lapping) with Palakollu shale forming a seal. The depositional environment being outer neritic for these sands (S.K.Gupta), i.e. pertaining to the ocean environment, having depth zone between low tide level and 100 fathoms.

The seismic reflection pattern derived from the seismic section (Fig: 14) for sequence stratigraphic analysis infers that these coastal belt sands formed during transgressive phase as they are on lapping on to the palakollu shales, which could be good reservoir rocks. The expected reservoir rocks are Pasarlapudi sand stones. Sweetness attribute at this level is showing bright amplitudes, probably due to presence of hydrocarbons (Fig: 15).

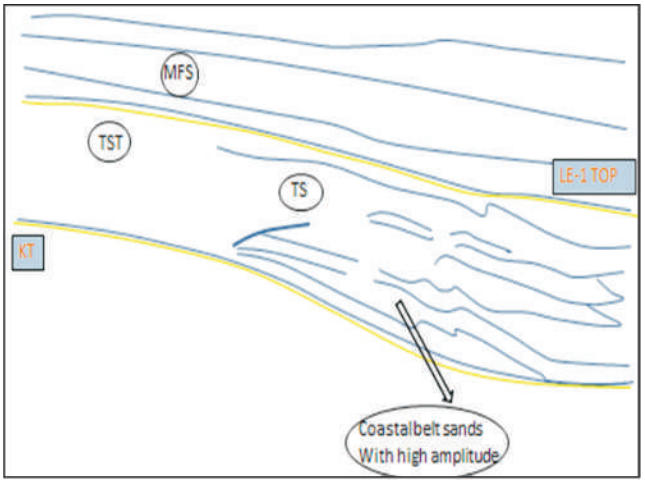

Fig. 14: Seismic reflection pattern

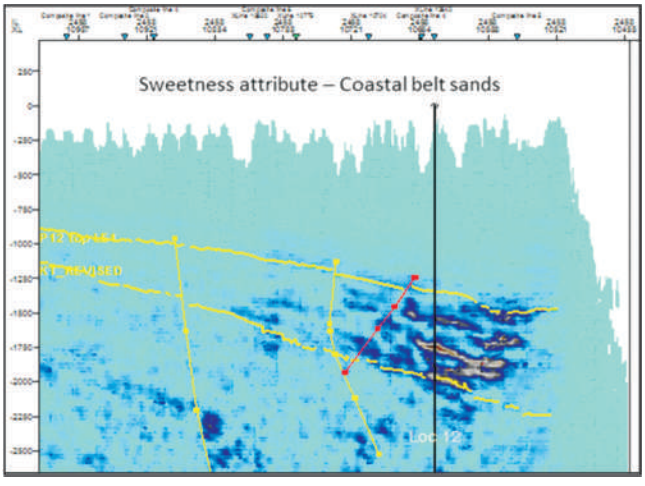

Fig. 15: Sweetness attributes - Coastal belt sands

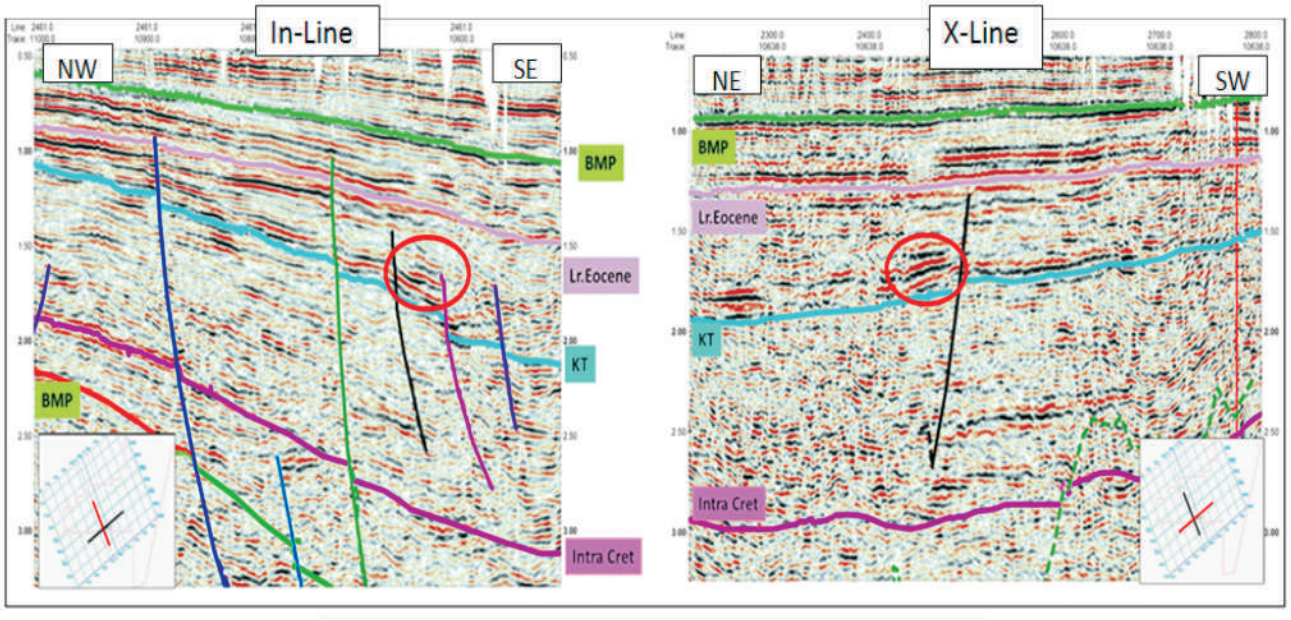

Fig. 13: Coastal belt sands - A stratigraphic Play

Conclusion

The study area is exhibiting varied geological settings and different environments of deposition. It is interesting to mention that basement is shallow in the northern side of the study area and deepens up to /or above 6000 meters towards southern and S-E side of the area. Different prospects identified in the study area are classified in to structural and stratigraphic traps. From the analysis it is clear that the identified prospects belongs to Raghavapuram-Gollapalli petroleum system {(Lower cretaceous -Synrift sediments of Gollapalli formation, Intra cretaceous (channel sand), upper cretaceous (drape structure)} and Palakollu-Pasarlapudi petroleum system (Coastal belt sands). The prime objective of identifying the prospects was successful.

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Author's Profile

D.N. Murthy

Mr.D.N.Murthy currently working in Oil India Limited. He did his MSc (Tech) Geophysics degree from Andhra University in 1998.

He has worked in various geological environments at India & Abroad such as Thrust belt areas of Assam-Arakan and Gnaga valley and Desert environment of Barmer basin, vindyan basin of Madhya Pradesh and passive marginal basin of Krishna-Godavari Basin, Gabon (west Africa) and Libya for Acquisition, Processing and Interpretation.