2D PETROLEUM SYSTEM MODELING TRANQUEBAR SUB-BASIN, CAUVERY BASIN

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Summary

ABSTRACT

Cauvery Basin is a Pericratonic rift basin, on the East Coast of India. The basic architecture consists of en-echelon asymmetric half-grabens, separated by basement horsts. It has 7-8 km thick syn-rift and post rift stratigraphic succession deposited as a consequence of basin evolution since Late Jurassic (145Ma). An understanding of basin evolution and the related petroleum system is an essential step in hydrocarbon exploration and exploitation. In Tranquebar sub-basin, the flanks are HC rich locales but other prospects drilled within the sub-basin are dry, in spite of having good TOC and porosity retention even on deep burial. 2D- Petroleum System Modeling study along a geological cross section was the basis for paleohistory reconstruction and to assess hydrocarbon prospectivity. It traces the GME cycle through geologic time and leads to better understanding of hydrocarbon proclivity of the area.

Introduction

The journey of exploration for hydrocarbon in Cauvery basin began in 1958. The first wildcat well was drilled on Karaikal high in 1964. Presence of hydrocarbon (though non-commercial) in this well had given an impetus to intensify exploration. However commercial success was not met until 1984. Several oil & gas fields were discovered on the onland & offshore parts of Cauvery basin. PY-3 structure towards east in the offshore extension of Tranquebar sub-basin was discovered 1988, whereas Kali and Kuthalam oil and gas fields (onshore) within Nannilam and Andimadam Formations in the NW were discovered in 1998. Mayavaram-1 gave definitive gas shows. All other prospects are barren. Tranquebar is supposed to have one of the best TOC content in Cauvery Basin. Reservoir properties are preserved even at 300m depths (TKD-3 produced water @ 108m3/d) from Nannilam Fm.

In view of these set of present geological conditions, it is an enigma why HC exploration results in Tranquebar sub-basin are not fruitful.

Petroleum system modeling was carried out to answer questions with regard to generation, timing of hydrocarbon expulsion and accumulation along a 2D seismic transect in Tranquebar sub basin. The model also helps to understand whether the source rock in this area is within the oil or gas generation window. Due to the paucity of calibration data in the deepest part of the modeled 2D transect, geochemical information from offset wells has been included in the model. The calibration wells were selected based on their proximity to the modeled 2D transect, abundance and reliability of data.

Regional geology and Tectonic setting

Cauvery basin is a pericratonic rift basin, on the East Coast of India. The entire sedimentary column deposited as a consequence of the basin evolution since Late Jurassic- Early Cretaceous period (145 to 112 Ma), has been termed as “East Coast Super group”. The basin has 7-8 km thick syn-rift and post rift sediments resting over the basement. The basic architecture of the basin consists of en-echelon asymmetric half-grabens arranged in three trends, separated by basement horsts. The half grabens/subbasins from south to north are: Gulf of Mannar, Ramnad-Palk-Bay, Tanjore, Nagapattinam, Tranquebar and Artiyalur-Pondicherry. The basement horsts/ridges are: Mandapam-Delft, Pattukottai-Mannargudi, Karaikal, Kumbakonam-Madanam-Portonovo (Fig. 1). The dominant basement trend in the basin is NE-SW and is parallel to the regional Eastern Ghat trend.

The Tranquebar sub-basin trending NE-SW, encompasses present day onland and offshore parts of Cauvery basin. It is bounded by Karaikal horst to southeast and Kumbakonam-Madanam-Portonovo high to the northwest. The sub-basin forms a part of the tri-junction towards southwest, where the Tanjore and Nagapattinam sub-basins meet Tranquebar sub-basin. The onland part of the Tranquebar sub-basin is a type area for the entire litho-stratigraphic succession in the subsurface that portrays the sedimentation history of the entire Cauvery basin.
Petroleum System Modeling

The petroleum system modeling study gives a better understanding of the potential petroleum systems within the basin. It illustrates the maturation of a source rock and the migration into potential traps. For the present study, 2D Module of PetroMod software Version 2013.1 has been utilized.

Methodology

Standard Workflow for PSM study as provided in PetroMod software is as follows:

To carry out PSM study, along 2D seismic transect in the Tranquebar sub-basin (Fig. 2), Horizons / Faults were digitized and gridded to make the basic model geometry (Fig. 3).
Each formation/layer having lateral variation of facies across the modeled 2D transect (Fig 4) is assigned with its relevant lithological facies and geochemical properties pertaining to Petroleum system elements is given in Table-1. The classification of the different source rocks were derived by laboratory data basis and the interpretation of the geological history and depositional environment of the area. The Albian and Cenomanian age source rocks are assumed to be a Type III, generally gas-prone with organic matter being mainly woody and coaly.

Table-1: Facies definition with geochemical parameters across the modeled 2D transect

Geological age of deposition of different formation/layer as well as erosion and hiatus events observed in geological past of Tranquebar sub-basin are assigned in the modelled 2D transect is given in Table-2.

Table-2: Geological age of deposition and erosion/hiatus assigned in modeled 2D transect

**Boundary Conditions**

Heat Flow Trends used are different for shelfal area and basinal part. Paleo Water Depth information was derived from analysis of sediment composition related to their depositional environment (e.g. carbonates in water depth less than 50m) and structural evolution (e.g. age of rise of ridges). Sediment Water Interface Temperature for study area through geologic time generated inside PetroMod software. Boundary conditions (HF, PWD, SWIT) are calibrated along the modeled section (Fig 4).
2D Petroleum System Modeling across Tranquebar sub-basin, Cauvery Basin

Fig. 4: Boundary Conditions for Modeling (HF, PWD, SWIT) and Temperature & VRo Calibration

Depending on seal thickness and their absolute depth breakthroughs could be seen within different migration scenarios. In ‘closed’ (sealing) fault scenarios, faults may act as parts of a structural trap. In ‘open’ (non-sealing) faults scenarios hydrocarbon migration could be shown along faults. The fault definition was assigned based on tectonic history and interpretation of seismic data.

**Modeling Results**

The modeling results shows that the Upper and Lower Albian source rocks are in late oil to wet gas generation window and have attained Critical Moment approximately from 114 to 99 Ma and 85 to 76Ma respectively, with present day transformation ratio for Upper and Lower Albian source rock of approximately from 96-85% and 75-69% respectively in basinal part of sub-basin. Cenomanian source rock falls within main oil generation window and has attained CM around 16-13Ma with present day transformation ratio (TR%) in range of 55-38 % in basinal part of sub-basin (Fig. 5A, 5B, 5C). Most of the generated hydrocarbon is expelled from the sub-basin via upward and sideways migration and the accumulations observed along the modeled section in reservoirs of Cretaceous and Paleocene age are mainly structurally entrapped (Fig. 6).
Conclusions

In the Tranquebar sub-basin, the Lower and Upper Albian and Cenomanian source rocks are mature and have expelled significant quantity of Hydrocarbon. Significant part of the expelled hydrocarbon is lost during migration while some hydrocarbon accumulation are observed due to structural entrapment in the modeled 2D transect.

The Albian lower and upper source rocks shows significant transformation upto 96 % and 85 % respectively while The Cenomanian source rocks shows transformation upto 55 %. The main expulsion peak for Albain lower and upper source rocks in the Tranquebar sub-basin could be evaluated around 114 Ma to 76 Ma respectively whereas for Cenomanian source rock around 16-13 Ma.

Miocene tilting might have affected established accumulations and effected some large-scale distribution of hydrocarbons.

References


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