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Facies Analysis of Early Miocene Bombay Formation in Panna-Bassein-Heera area, Mumbai Offshore Basin

INTRODUCTION

The Early Miocene carbonates are known to be the one of the important reservoirs in Mumbai Offshore Basin particularly in the Mumbai-High platform area. However, in the Heera-Panna-Bassein area to the east of Mumbai High, there is a significant facies variation within the Miocene sequences observed in the drilled wells. The Early Miocene Bombay Formation, in particular, shows facies variation from carbonates to alternations of clastics-carbonates to clastic facies in this area, which has created velocity anomalies resulting in pseudo-structures at lower levels of Middle-Late Eocene.

The present analysis attempts to bring out the facies distribution and the depositional setting of the Early Miocene Bombay Formation in the Heera-Panna-Bassein area to the east of Mumbai High. Integrated analysis of well data, electrologs, laboratory data including sedimentological and biostratigraphic inputs and 3D seismic data has been carried out to understand the facies variation and depositional framework.

GEOLOGICAL SETTING AND STRATIGRAPHY

The Mumbai Offshore Basin is a pericratonic rift basin and is the largest among the west coast sedimentary basins of India (Biswas et al, 1987). The basin is located on the Western continental margin of India Hydrocarbon accumulations occur in carbonate reservoirs ranging in age from Middle Eocene to Middle Miocene. These are mostly structurally controlled, with a few exceptions of stratigraphic/combination plays in Paleocene-Lower Eocene clastic reservoirs.

The study area (Fig.1) in Panna-Bassein-Heera block is located to the east of Mumbai High comprising of a broad platform, central graben and a westerly dipping homocline. The area is divided into two distinct sub-elements i.e. the western elevated Panna-Bassein-Heera-Ridge and the eastern depression called the Central Graben.

The Bombay offshore region experienced thick Paleogene and Neogene sedimentation over a predominantly Trappean floor. Locally, the Tertiary sediments directly overlie Precambrian metamorphic basement. The generalized stratigraphy (Zutshi et al, 1993) of Mumbai Offshore Basin is depicted in figure 2. The Early Miocene sequence comprises of two formations viz. Bombay Formation and Mahim Formation. Bombay Formation consisting of limestone with thin beds of shale is overlain by Mahim Formation with a gradational contact. Mahim Formation consisting of shales with thin limestone bands is unconformably overlain by Bandra Formation. The Middle Miocene Bandra Formation consisting of limestone facies with thin shale bands is unconformably overlain by Chinchini Formation of Post- Middle Miocene age.

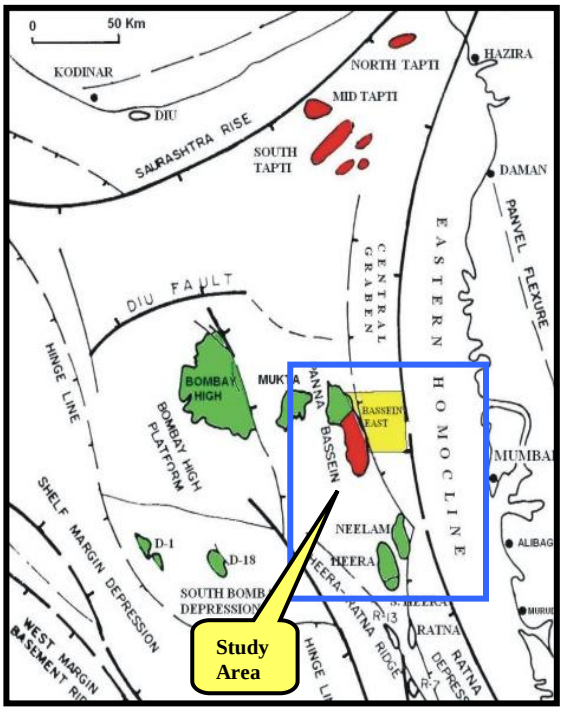


Fig.1. Map showing tectonic elements of Mumbai Offshore Basin

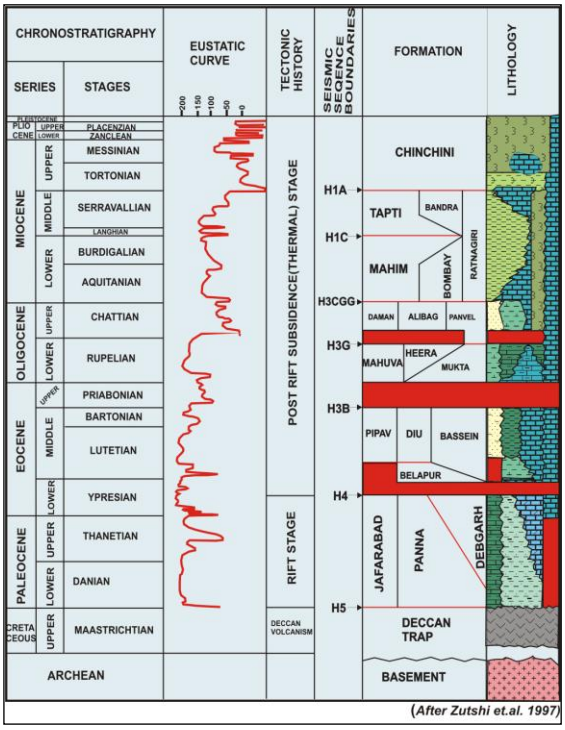
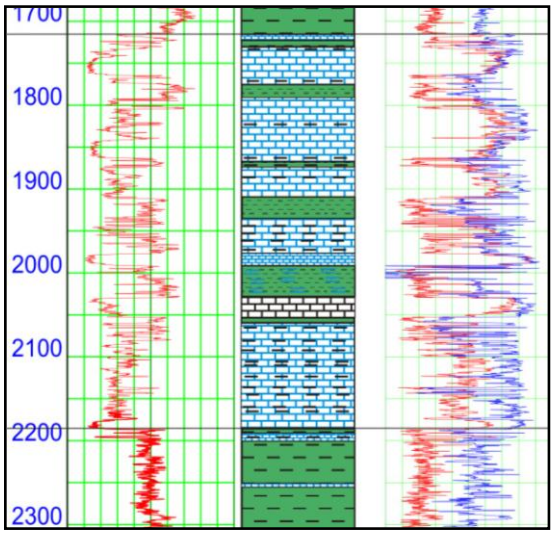


Fig.2. Generalized stratigraphy of Mumbai Offshore Basin

FACIES ANALYSIS

Facies analysis has been carried out with integration of inputs from Sedimentology, Electrologs and Seismic Attributes. The Early Miocene Bombay Formation is dominantly represented by limestone with intercalations of shale streaks (Fig.3). The sedimentological analysis shows that limestone is milky white, moderately hard with foram wackestone /packstone facies which are sparitized at places (Sharma et al, 2006).



Limestone:
Mostly Milky white to dirty white, Highly fossiliferous, fossils are mainly larger, as well as smaller forams, corals and shell fragments. Macroscopically appears to be foram-coral wackestone/ packstone.

Shale:
Greenish to brownish grey, moderately hard and compact, fissile with some carbonaceous specks and few pyrite nuggets at places.

Fig.3 Lithofacies of Early Miocene sequence in one of the well

Electrolog correlation along east-west direction indicates a prominent reduction of sedimentary thickness of Early Miocene sequence from west to east. It also brings out lateral litho-facies variation in the Early Miocene sequence, which is carbonate dominated in the in the west and becomes shale-carbonate alternations towards east and mainly shales at some places in the east

The seismic section (Fig.4) oriented in east-west direction brings out the facies variation within Bombay Formation showing development high amplitude over structural highs and low amplitude in lows indicating development of carbonate facies in structurally higher area and shaly and alternations of carbonate/shale in the lows and graben area.

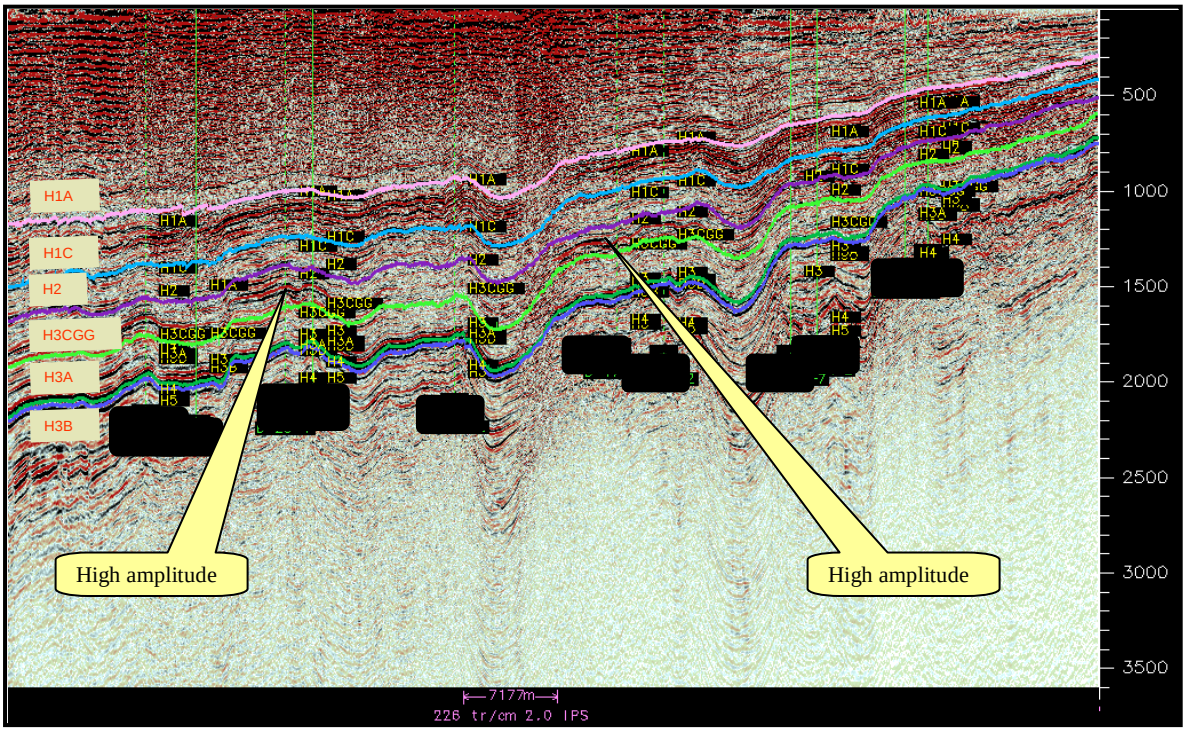


Fig.4. High amplitude facies development within Bombay Formation over structural Highs

Lithofacies Distribution

The carbonate percentage map of Bombay Formation indicates development of mainly carbonate facies in the northwestern part of Panna-Mukta-Bassein platform area with high carbonate percentage (Fig.5). There is a distinct change of facies from carbonate to shale to the north across the Diu Fault to the north with carbonate percentage reducing to 15-20%. To the further south, the carbonate percentage decreases to 50-60% in the Mukta area. Carbonate percentage gradually reduces to with 50-55% in the east-central part and to the further east in the Central graben area; the Early Miocene Bombay Formation is represented mainly by argillaceous facies with 15-20% carbonate.

The south-central part shows good patchy development of carbonates with 60-70% carbonate with carbonate percentage increasing to further south-western part. Panna/Bassein and Bassein West area in the central part shows patchy development of carbonates. Good development of carbonate facies is observed in the south and south-eastern part with high carbonate percentage of the order of 80-90% around Neelam, Heera and south Heera area.

Attribute Analysis

RMS amplitude of Early Miocene Bombay Formation has been extracted between H2 and H3 CGG to bring out the litho-facies variation of Early Miocene Bombay Formation across the 3D area, which covers the central and southern part of the study area. The map indicates moderate to high amplitude in the northern part of 3D area (Fig.6). The map brings out development of NE-SW trending high amplitude facies intervened by low amplitude facies in the central and north-eastern part indicating development of carbonates and shaly facies respectively. High amplitude facies are developed in the north-western, southern and south-eastern part showing good development of carbonates. It also brings out the development of low amplitude facies in the north-eastern part covering Central graben and Bassein east area.

The amplitude development matches with the litho-facies development brought out by carbonate percentage map. It broadly corroborates with the structural picture showing higher amplitudes over the structural highs and lower amplitudes in the lows and graben part, indicating development of carbonate facies in structurally higher area and shaly and alternations of carbonate/shale in the lows and graben area.

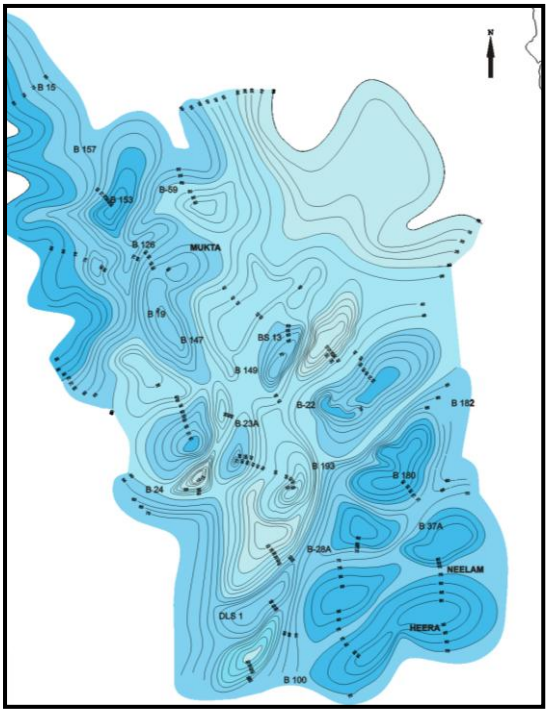


Fig.5. Carbonate percentage map of Bombay Formation in Panna- Bassein area

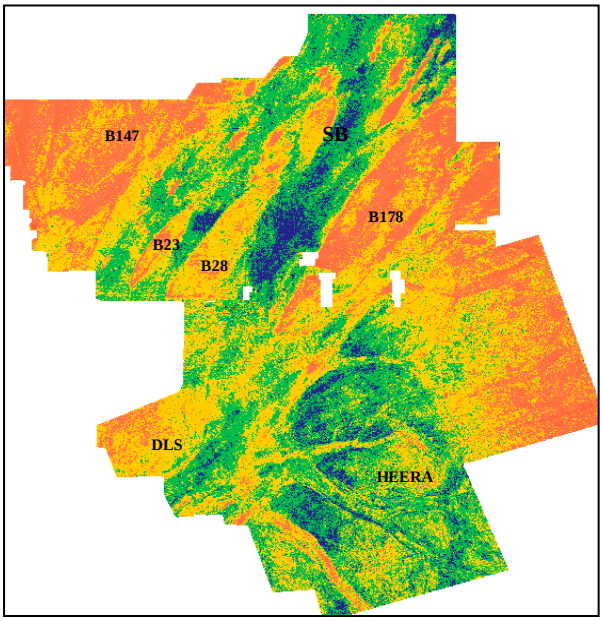


Fig. 6. RMS attribute map of Bombay Formation in Panna- Bassein area

DEPOSITIONAL SETTING

Depositional setting of Early Miocene Bombay Formation has been conceptualized from biostratigraphic inputs and litho-facies distribution. The micro-paleontological inputs i.e. dominance of mainly larger and smaller forams along with coral fragments and few gastropod shells suggest low to moderate energy of deposition under open marine conditions for these sediments.

The northeastern part covering Central Graben is represented by is shaly facies with minor carbonates. The northern part to the north of Diu fault is also represented by shaly facies. In eastern side of Eastern Homocline, carbonate facies are mainly developed. In central part there is development of some clastic/shaly facies. In southeastern part of the area, thick carbonate facies has developed with patchy argillaceous facies. The clastic input direction is from the northeast, as seen in the wells of Central graben and Mahim arch area in the northeast.

On the basis of biostratigraphic inputs, litho-facies distribution and RMS amplitude map, it is envisaged that Bombay Formation was deposited under open marine conditions with deposition of carbonates over the structural highs and shales in the lows and graben area under relatively deeper bathymetry. An increasing argillaceous content in the Bassein east area suggests increase in clastic supply in this area under relatively deeper bathymetry.

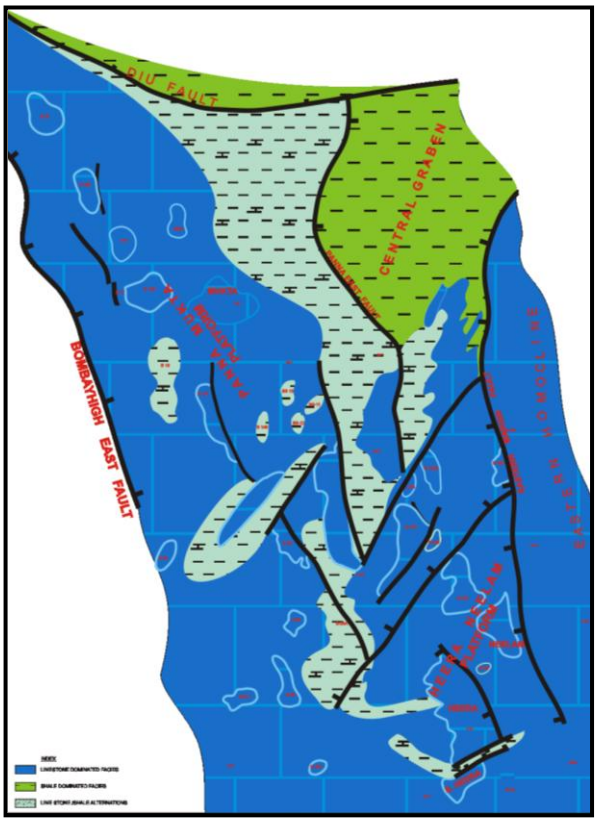


Fig. 7. Conceptual Depositional Setting of Bombay Formation

CONCLUSIONS

Integrated picture of litho-facies variation and development of carbonates facies of the Early Miocene Bombay Formation has been brought out for the Heera- Panna- Bassein area. The facies maps including carbonate percentage map and RMS amplitude maps suggest that carbonate facies are developed over the structural highs and shaly and alternations of carbonate/shale are observed in lows.

The shaly facies, in general, are present to the north and northeastern part, while the western and the southeastern part shows good development of carbonate facies. Central Graben is represented mainly by argillaceous facies with minor development of carbonate facies. It is envisaged that Bombay Formation was deposited under open marine conditions with deposition of carbonates over the structural highs and shales in the lows and graben area under relatively deeper bathymetry with clastic input direction from the northeast.

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