

# **Facies Analysis of Early Miocene Bombay Formation in Panna-Bassein-Heera Area, Mumbai Offshore Basin\***

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## **Abstract**

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 ([Figure 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. The 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.

### **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 ([Figure 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).

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

The seismic section ([Figure 4](#)) oriented in an east-west direction brings out the facies variation within Bombay Formation showing 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.

### **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 (Figure 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%. Further south, the carbonate percentage decreases to 50-60% in the Mukta area. Carbonate percentage gradually reduces to 50-55% in the east-central part and 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 in the 60-70% range with carbonate percentage increasing further to the southwest. 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 southeastern 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 lithofacies 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 (Figure 6). The map brings out the development of NE-SW trending high amplitude facies intervened by low amplitude facies in the central and northeastern part indicating development of carbonates and shaly facies respectively. High amplitude facies are developed in the northwestern, southern and southeastern part showing good development of carbonates. It also brings out the development of low amplitude facies in the northeastern part covering the Central graben and Bassein east area.

The amplitude development matches with the lithofacies development brought out by the 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.

Depositional setting of Early Miocene Bombay Formation has been conceptualized from biostratigraphic inputs and lithofacies distribution (Figure 7). 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 the Central Graben is represented by shaly facies with minor carbonates. The northern part to the north of the Diu fault is also represented by shaly facies. In eastern side of Eastern Homocline, carbonate facies are mainly developed. In the central part, there is development of some clastic/shaly facies. In the 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 the Central graben and Mahim arch area in the northeast.

On the basis of biostratigraphic inputs, lithofacies distribution and RMS amplitude map, it is envisaged that the 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.

### **Conclusions**

An Integrated picture of lithofacies 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. The Central Graben is represented mainly by argillaceous facies with minor development of carbonate facies. It is envisaged that the 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.

### **References**

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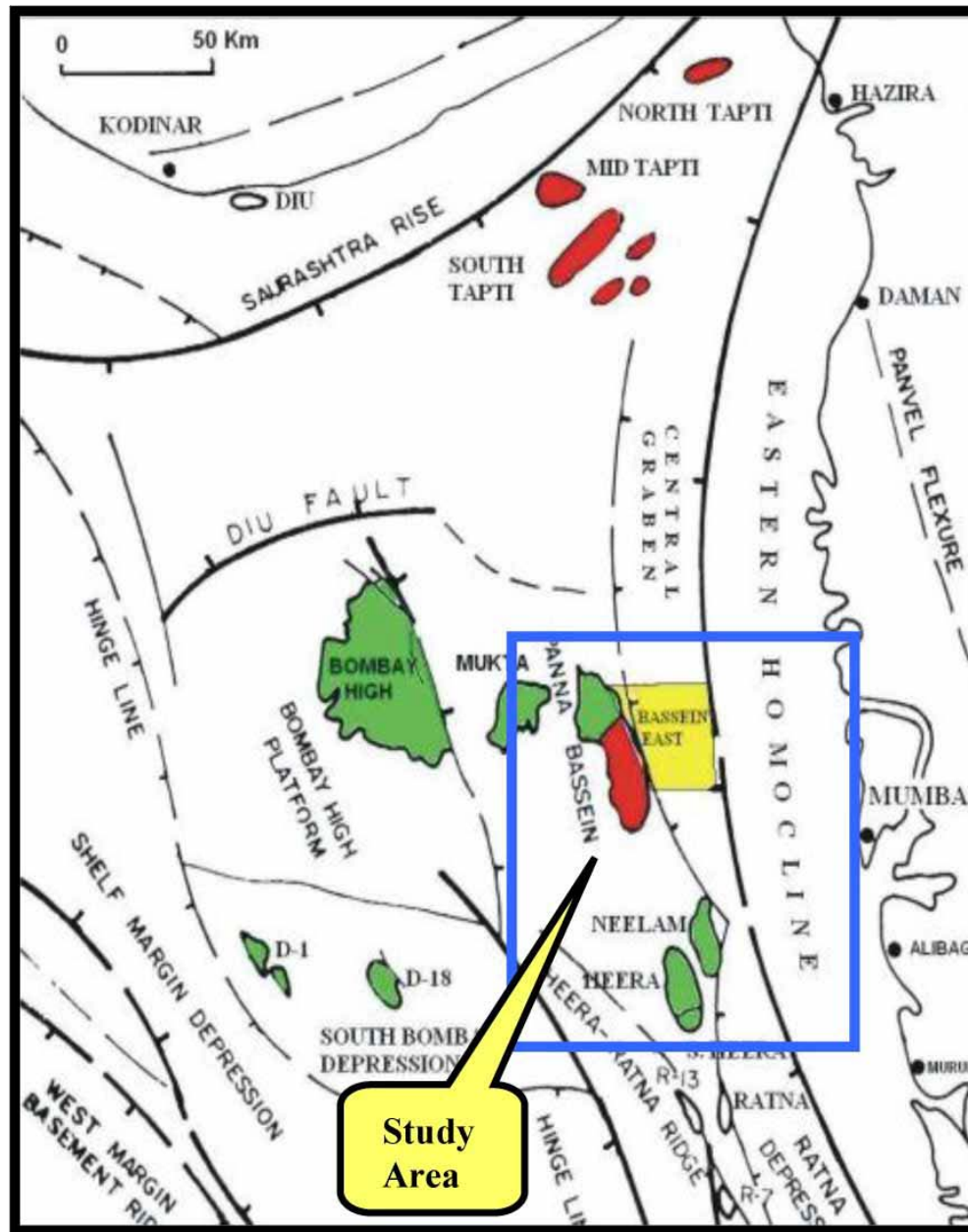


Figure 1. Map showing tectonic elements of Mumbai Offshore Basin.

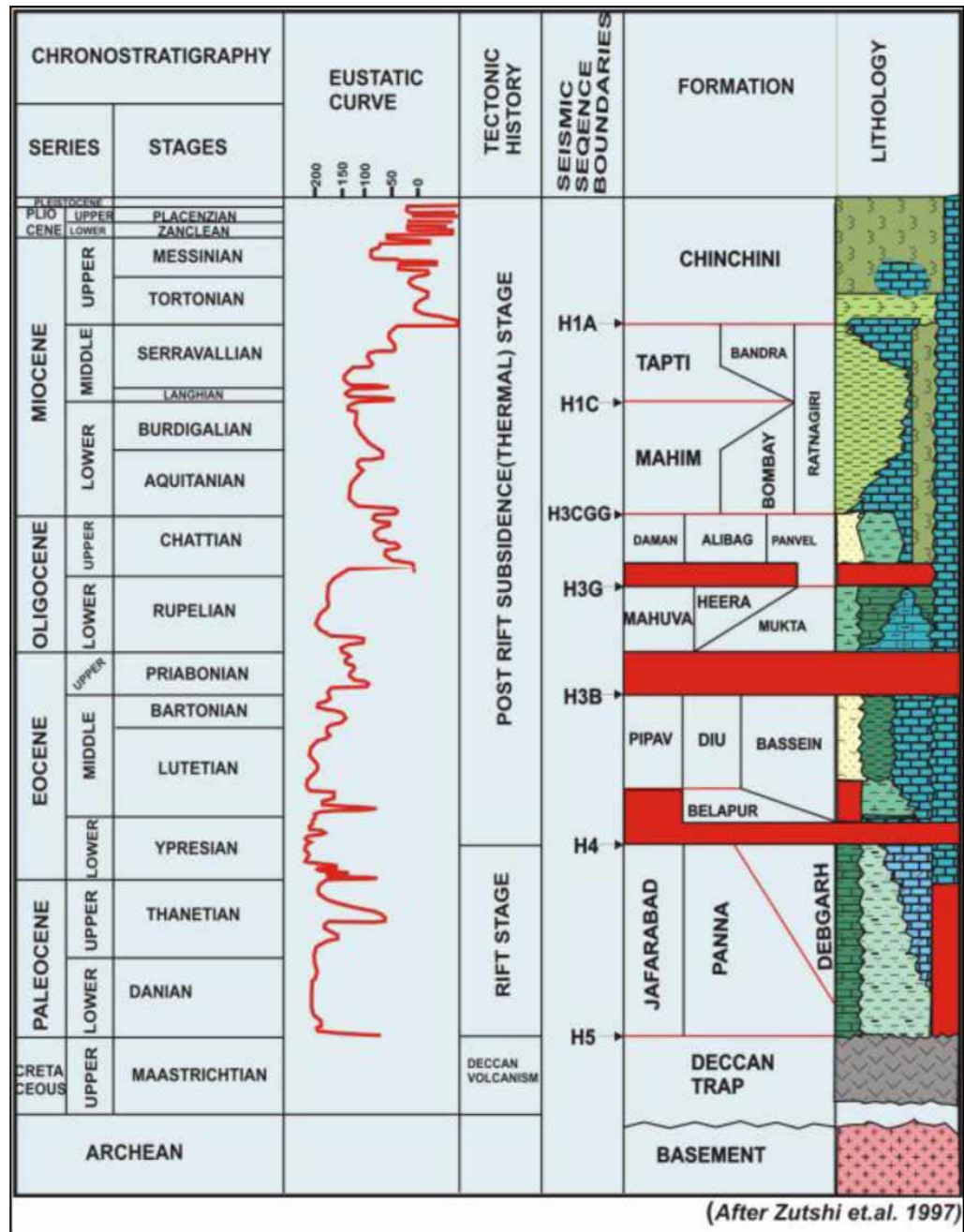
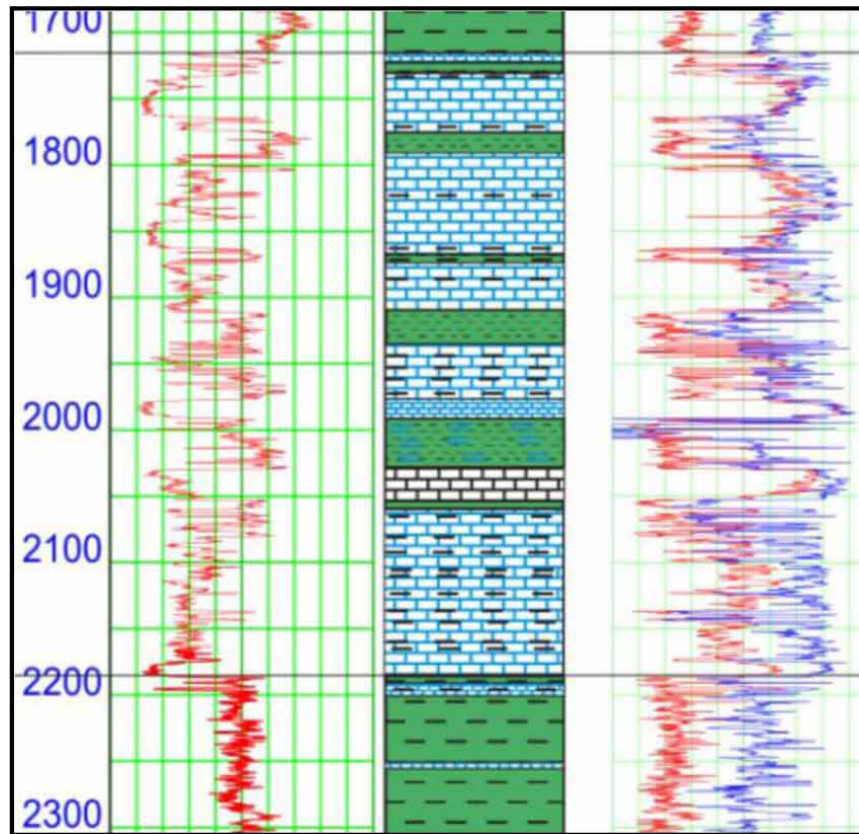


Figure 2. Generalized stratigraphy of Mumbai Offshore Basin.



**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.

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



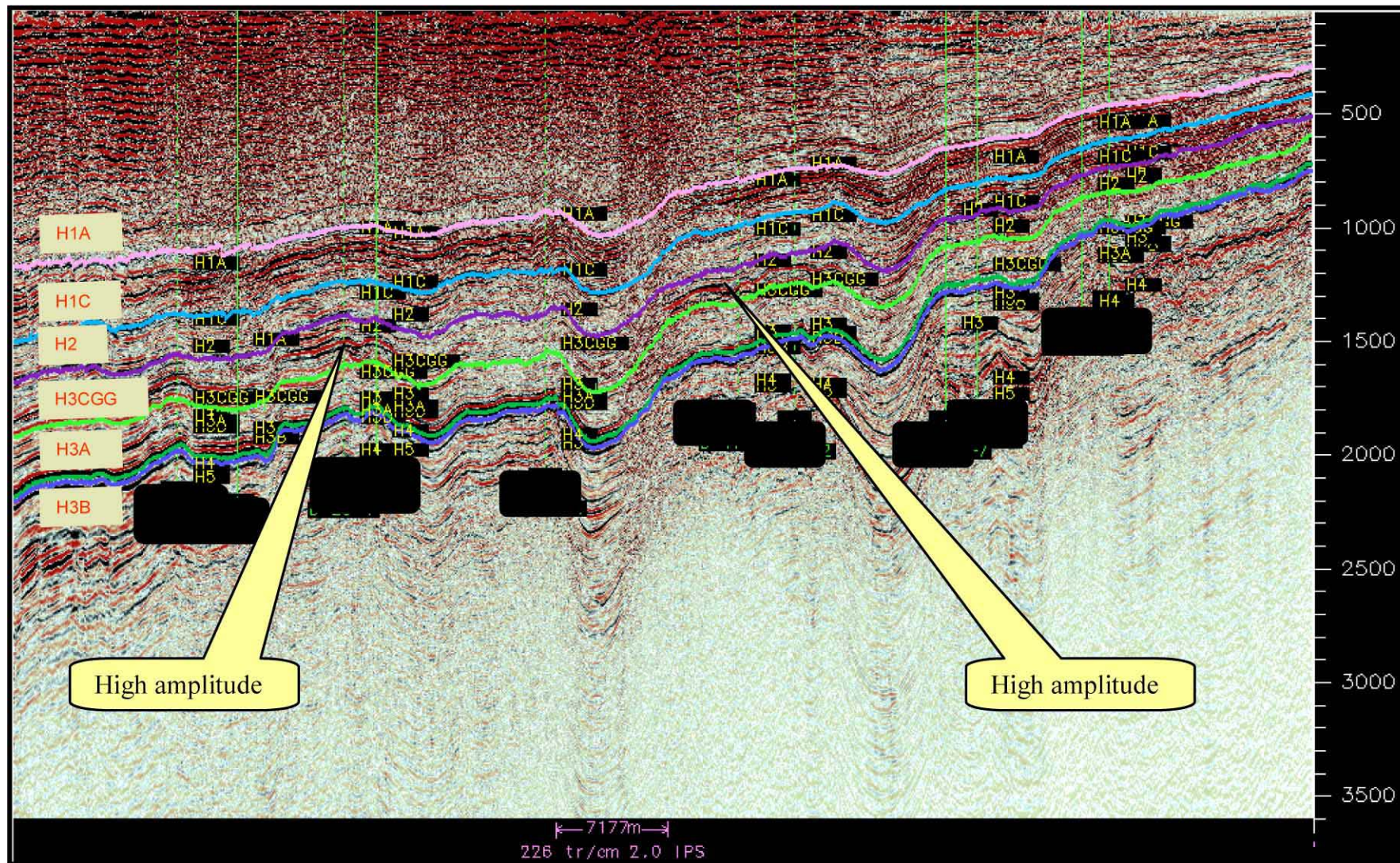


Figure 4. High-amplitude facies development within Bombay Formation over structural highs.



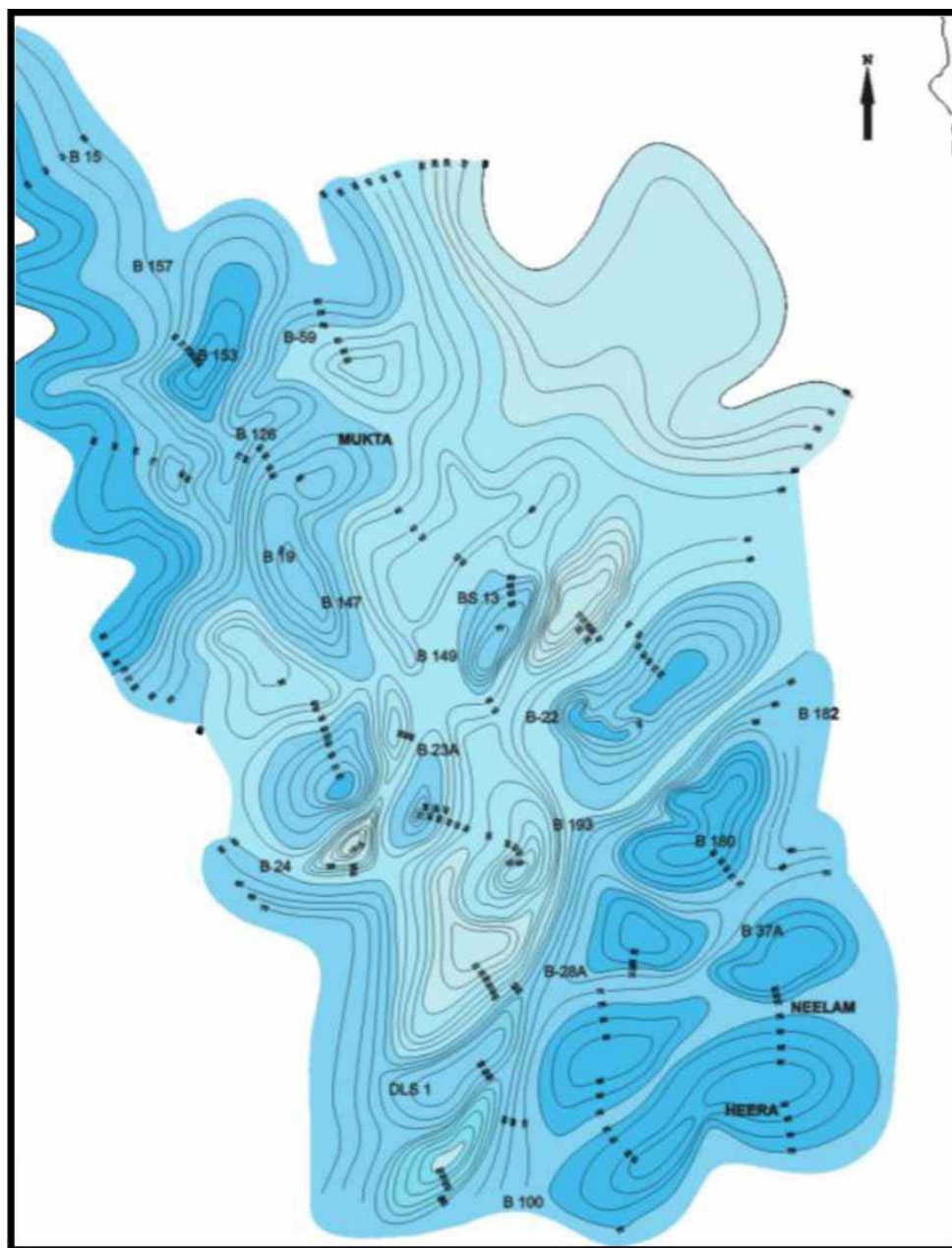


Figure 5. Carbonate percentage map of Bombay Formation in Panna-Bassein area.

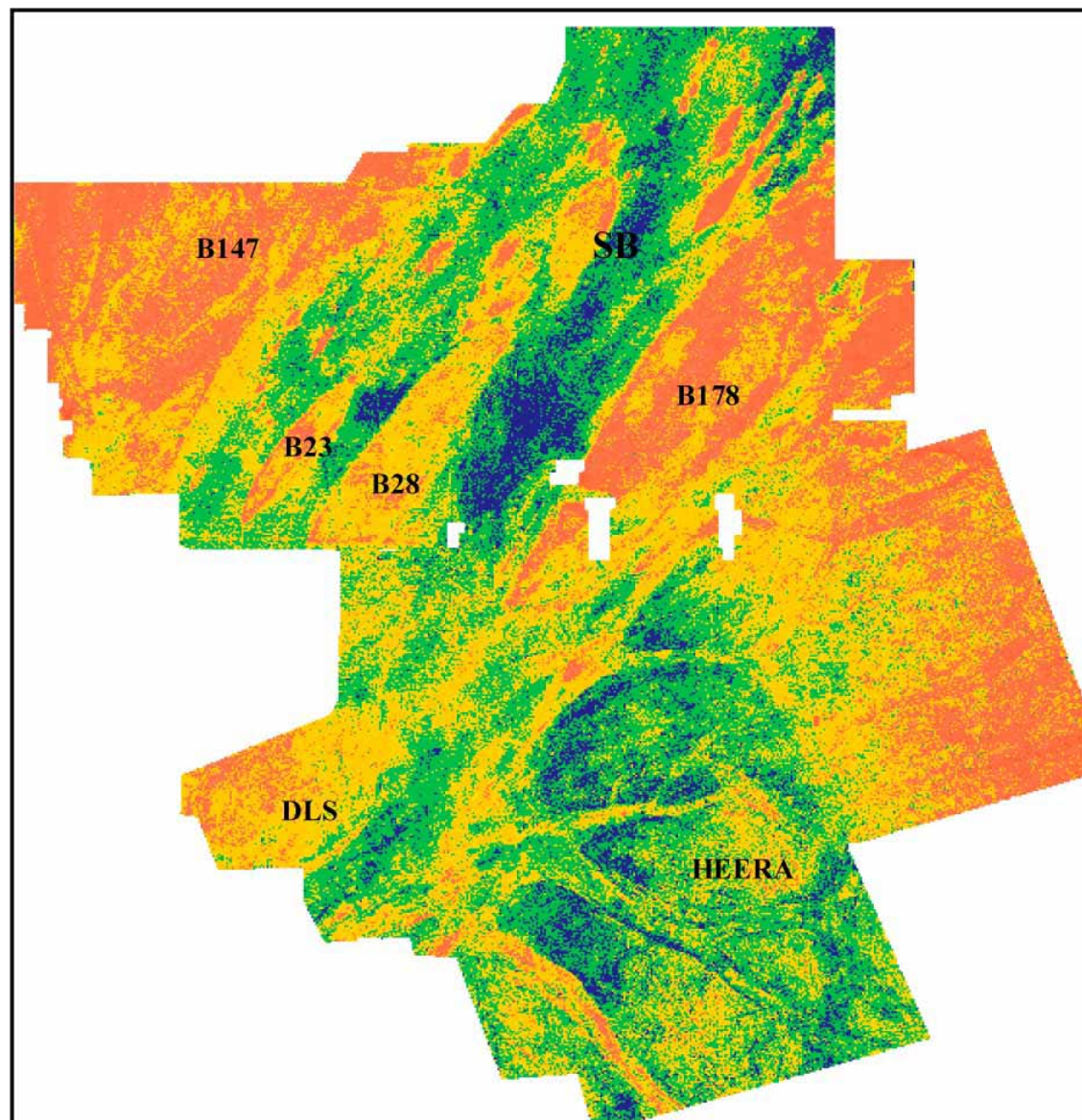


Figure 6. RMS attribute map of Bombay Formation in Panna-Bassein area.

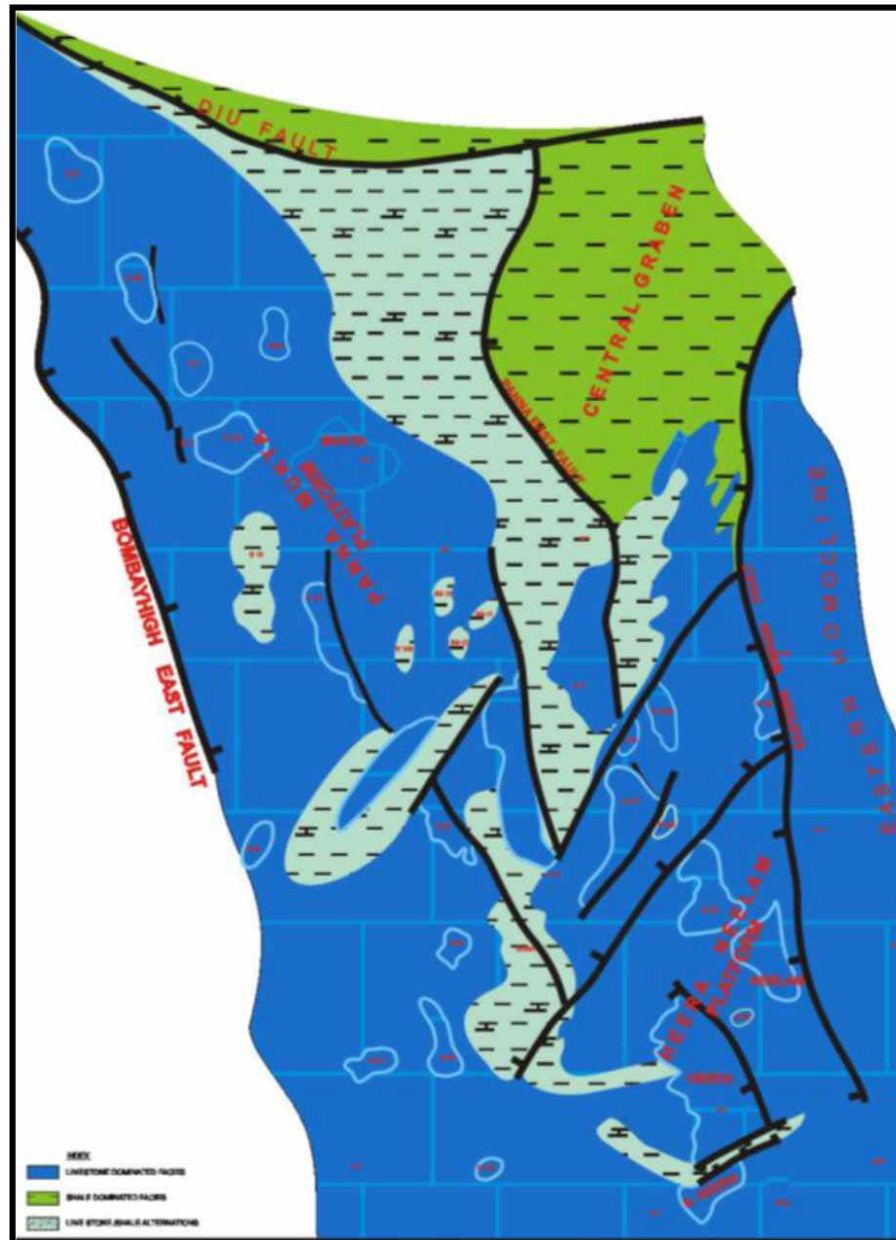


Figure 7. Conceptual depositional setting of Bombay Formation.