

S. Uppal and H. Upadhyay  
KDMIPE, ONGC, Dehradun, India  
E-mail: [uppal\\_s@rediffmail.com](mailto:uppal_s@rediffmail.com)

## Diagenetic imprints and their effect on porosity modifications in Bassein Limestone- A case study in the area East of Neelam Field, Mumbai Offshore Basin.

### Summary

Hydrocarbon occurrence has already been proved in the Middle-Late Eocene Limestone of Bassein Formation in different structures of Heera- Panna- Bassein block of Mumbai Offshore Basin. Present work is outcome of sedimentological study of the five wells namely A, B, C, D and E covering microfacies analysis, diagenesis and porosity modifications in Bassein Formation. Foram wackestone to foram-bioclastic packstone characterizes the Bassein Formation. Stylolaminations along with selective dolomitisation, partial sparitization of matrix with development of microspar and dissolution process are dominant diagenetic imprints observed in these microfacies. Good secondary porosity is observed in the form of solution vugs observed at certain levels in wells A, B and C due to karstification, leaching / dissolution of grains. The porosity in other structures of the area under study has been occluded by sparitization as well as filling of solution channels by blocky spary calcite. Subsequent dissolution of the spary calcite has generated minor secondary porosity in some intervals at later stage.

In general, reservoir characteristics in terms of development of porosity in Bassein Formation is poor to moderate except in the paleohighs where Bassein formation is subjected to prolonged subaerial exposures resulting in karstification and localized development of porosity.

### Introduction

Mumbai Offshore is surrounded by the Deccan Trap outcrops to the east, Bombay High East Fault to the west, Ratna North Fault to the south and Diu Fault to the north (Fig. 1). The study area lies east and north east of Neelam structure in the Heera-Panna-Bassein tectonic block of Mumbai Offshore basin and has been explored extensively in recent years for Panna, Bassein and Mukta Pays. In this block, commercial production has been established from Bassein, Neelam, Bassein East and Bassein west fields. In the studied area hydrocarbons indications are known from few wells. The present study is taken up to understand the microfacies, porosity development and reservoir characters of the sediments in the area east of Neelam field.

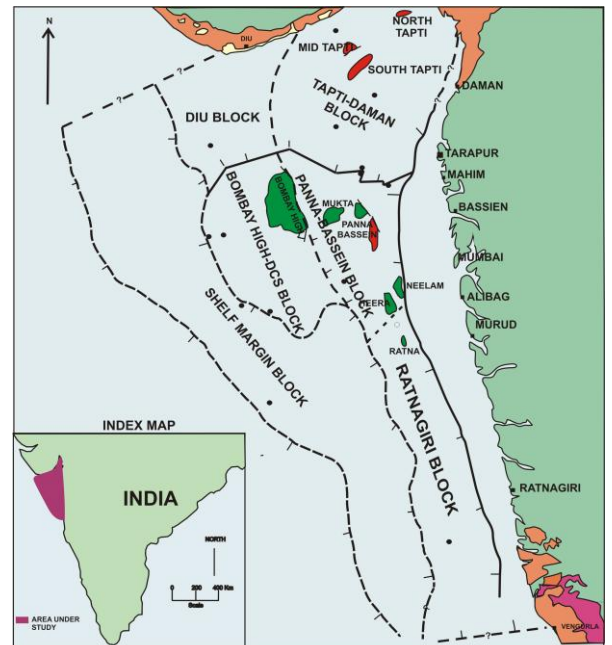


Fig.1: Tectonic Map of Western offshore Basin  
(After Pandey et al. 1998)

## Methodology

Six conventional cores comprising 32 meters of core length from 5 wells i.e. A, B, C, D and E (Fig.2) have been studied for detailed lithology, microfacies and porosity assessment. Besides a correlation profile at top of Mukta Formation was also prepared covering all the five wells. Megascopic and thin section studies were carried out to understand the different facies developed in this area and effect of diagenesis on reservoir quality. SEM studies of selected samples were carried out to decipher the reservoir characteristics and XRD analyses have also been carried out to know the type of carbonate minerals.

## Geological Setup and Stratigraphy of the area

The Western Continental Margin of India is described as a “passive margin” (Biswas 1982, 1987) and its evolution related to the breaking of Gondwanaland in Late Triassic to Early Jurassic time and the subsequent rift drift history. Faulting along the Precambrian basement trend developed the major West Coast Fault (Dessai & Bertrand 1995) and also developed the structural mosaics of Bombay Platform.

Widespread Deccan volcanism in the Western Continental Shelf is considered to be a late synrift event (Whiting et al, 1994). The post rift stage between Late Paleocene / Early Eocene to Recent witnessed deposition of very thick sedimentary succession on the faulted floor of Deccan basalts and isolated inliers of metamorphic basement. The Deccan basalt constitutes the technical basement for the sediments of this area and the sediments range in age from Late Paleocene / Early Eocene to Recent (Fig.3).

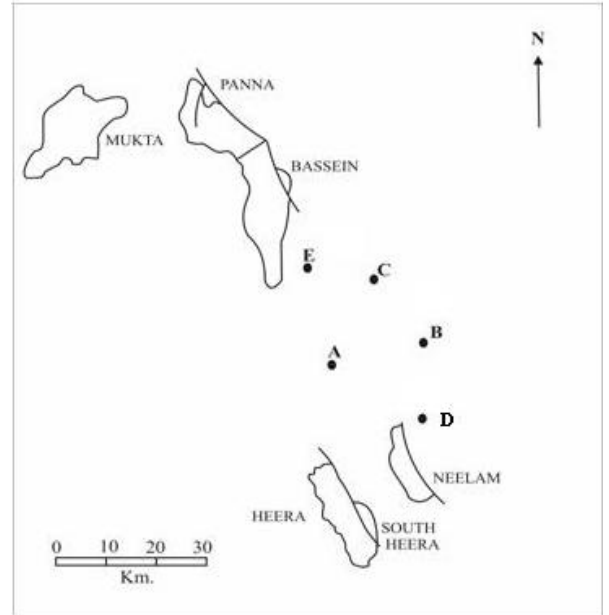


Fig. 2: Location Map of Studied wells

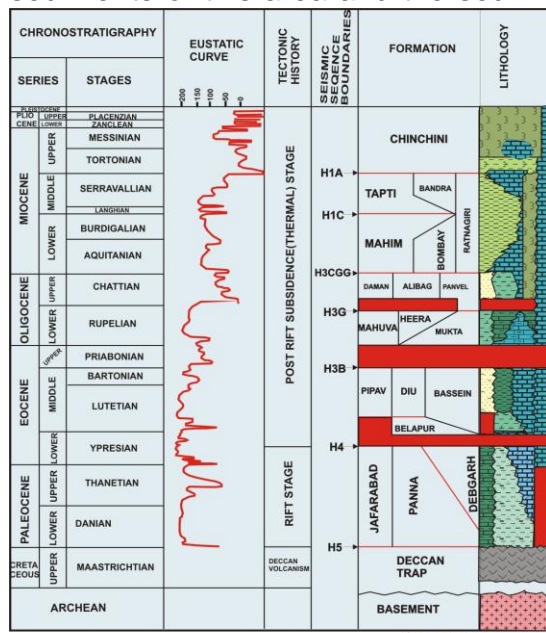


Fig.3: Stratigraphy of Mumbai offshore Basin

The Late Paleocene / Early Eocene sediments are represented by Panna Formation comprising of claystone, shale, siltstone and at places very fine grained sandstone which is absent in the studied wells. The overlying Bassein Formation is characterized by thick foraminiferal and algal wackestone, packstone and occasional grainstone facies. In few wells, Bassein Formation directly overlies the basaltic basement.

The Mukta Formation, which unconformably overlies the Bassein Formation, is characterized by presence fossiliferous limestone with shale intercalations. The Alibagh Formation (Upper Oligocene – Basal Miocene) overlying the Mukta Formation is separated by an unconformity and

consists of greenish gray splintery shale interspersed with thin limestone bands. Bombay Formation (Lower Miocene) consists of thick limestone interspersed with thin shale and unconformably overlies the Alibagh Formation.

### **Facies analysis and diagenetic imprints**

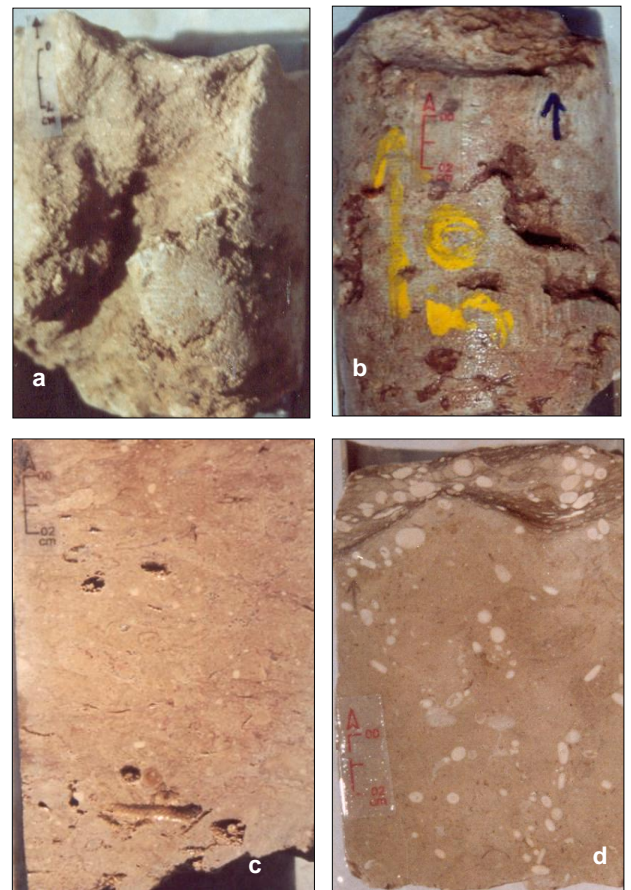
Bassein Formation (Middle- Late Eocene) constitutes a thick (225->500m) massive limestone with occasional thin streaks of shale. Six conventional cores from five wells namely A, B, C, D and E have been studied for understanding the reservoir vis a vis the diagenetic aspects. Most of the cores were taken in the upper part of the Bassein Formation except in well-C where the cores belong to the lower part of this formation.

The megascopic study reveals that upper part of Bassein Formation in the well- A is karstified limestone giving chalky appearance and foram-coral packstone to wackestone with some argillaceous matter in the other wells ( B,C,D&E)

The visual porosity is moderate to good in these wells except in well E where it is poor due to sparitization. Wackestone facies shows extensive karstification and generation of good secondary porosity in wells-A & B (Figs.4a&b).

The main microfacies in these wells are foram bioclastic wackestone, foram-algal packstone, and algal coral packstone facies, argillaceous and dolomitic at places except in well E where the microfacies is represented by foram packstone with very poor porosity (Fig.5-F). Pyritic encrustation of fossil chamber is common.

These facies are characterized by partial sparitization of matrix and skeletal grains with development of microspar. Porosities are moderate to good and mostly present in form of vugs and molds. Patches of ferruginous matter and presence of large vugs and cavities indicate sub aerial exposure common in the upper part of Bassein Formation. At places good vuggy porosity is generated due to dissolution of grains and spary calcite in the lower part along stylotitic seams. Porosity in Bassein Formation is heterogeneous and is destroyed at places, due to blocky calcite spar filled in fossil chambers, earlier generated Vugs/cavities and neomorphic development of microspar with in the matrix (Figs.5B-C). Compactional features are abundant and include irregular solution seams, grain breakage etc. Dolomitization is associated with higher matrix content. Two stages of cementation are observed, first stage displayed by isopachus rim



**Fig.4 Well A:** a) Highly porous chalky wackestone facies showing karstification. b) Well B: Coral-foram wackestone/ packstone facies, ferruginous, highly leached with generation large vugs and cavities, c) Well D: Coral-foram packstone facies having good moldic and organic porosity and d) Well C: Foram (larger) packstone facies with argillaceous matter at the top.

cement followed by large equant spary calcite cement. The facies represent low to medium energy set up for the sediments with rare high energy conditions.

### Reservoir Characterization:

X-ray diffraction (XRD) and SEM studies are carried out to understand the mineralogy of the carbonates and their reservoir characteristics. The limestone of Bassein Formation shows calcite as the dominant carbonate mineral with subordinate dolomite (Fig.6). Samples studied under SEM show presence of smaller solution vugs, organic porosity and micro porosity enhanced by solution activity. In well-C isolated vugs, channels and intergranular pores are filled with equant spary calcite has occluded the secondary porosity. The sparitization of grain is accompanied by presence of clay floccules (kaolinite - Fig.5-H)

### Microfacies and Reservoir characteristics of Bassien Formation

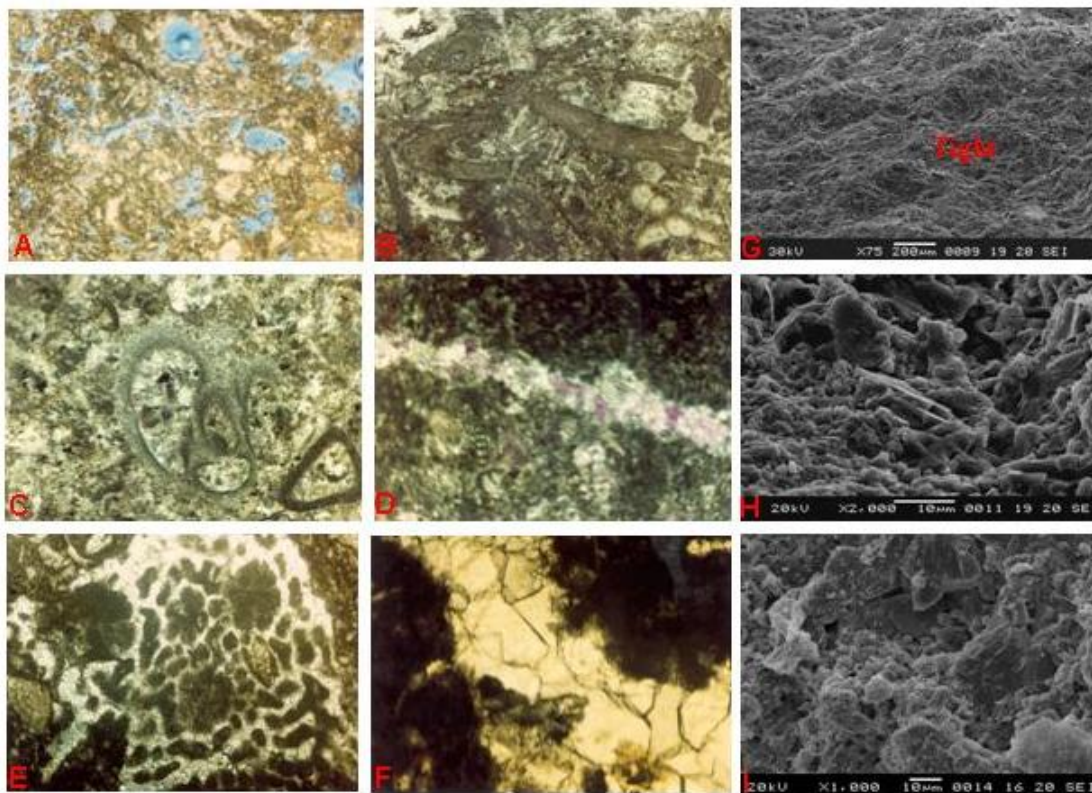


Figure No. 5: A) Well no. B, CC-3, Coral- bioclasic wackestone facies with good vuggy porosity. B) Well no. C, CC-2, Algal coral wackestone facies with sparitized grains. C) Well no. C, CC-1, Coram wackestone facies showing sparitization with smaller spar inside the chamber. D) Well

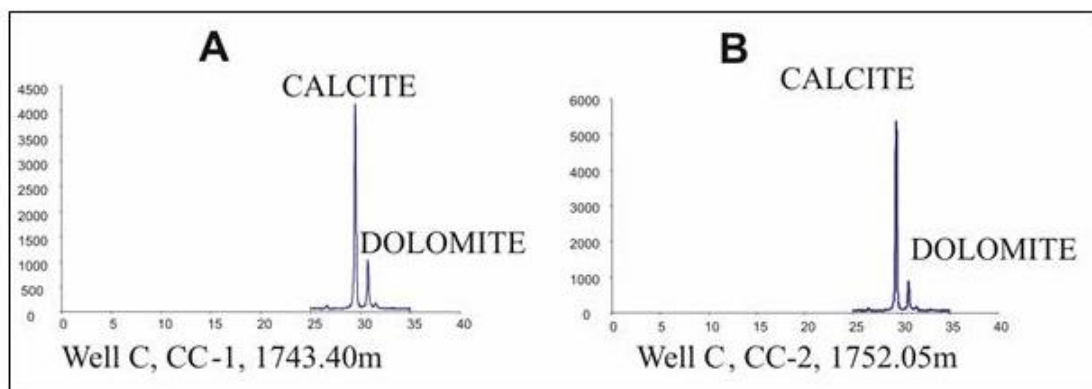
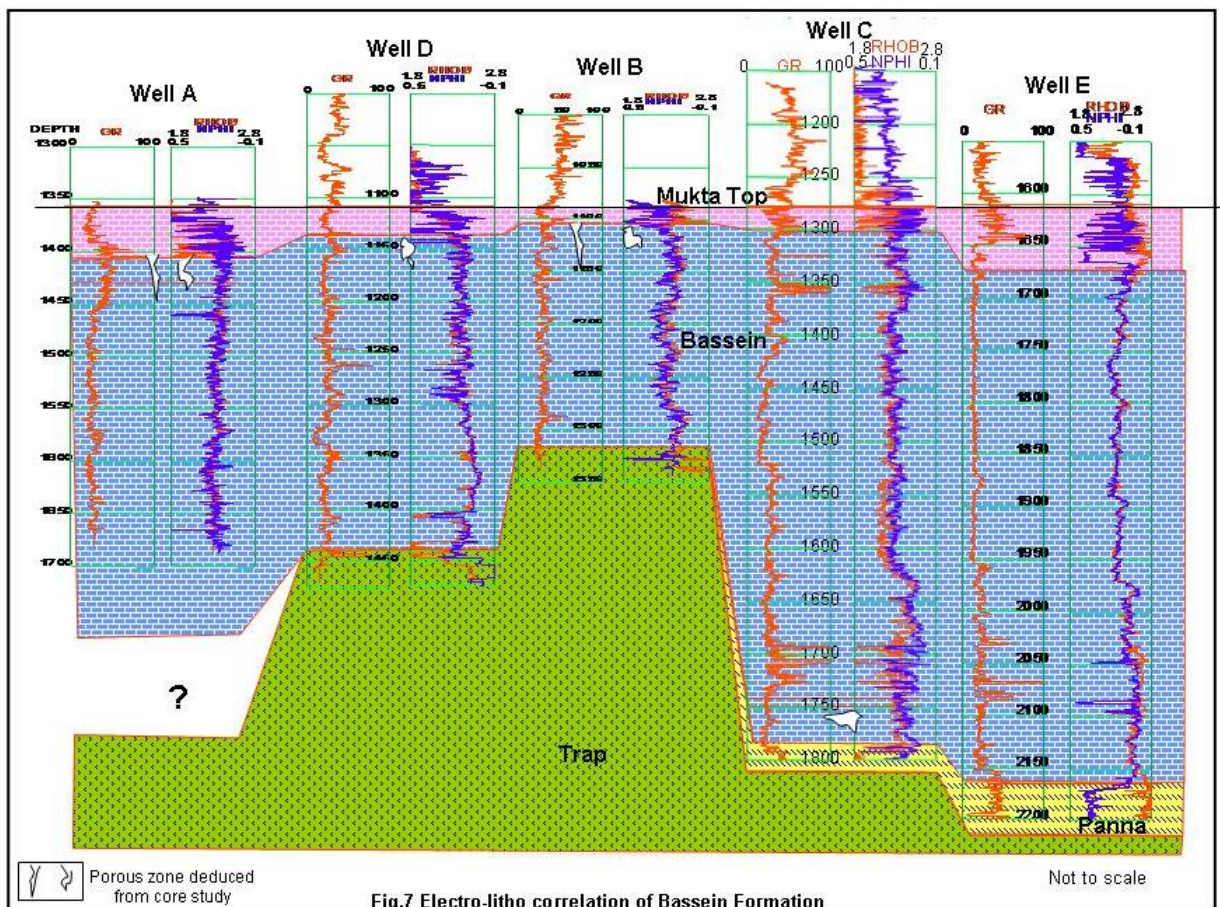


Figure.6: XRD analysis of Bassien Formation

**Diagenetic effects on Porosity Developments** During diagenesis, carbonate sediments may gain or lose porosity. With increasing depth of burial there is generally a decrease in porosity but there are late processes of dissolution and fracturing, which can create higher porosity. The understanding of porosity creation and deterioration is major aim of diagenetic studies. Textural criteria indicating a burial origin of spar include broken and collapsed micritic envelopes present within calcite spar, fracture grains and sutured or concavo-convex contacts between grains.



The Bassein Formation is represented by bioclastic wackestone, foram-algal packstone, and algal coral packstone facies with extensive karstification in wells A and B, along with moderate to good vuggy porosity in well B formed due to dissolution of grains and spary calcite. Partial sparitization of matrix and skeletal grains are common diagenetic process responsible for deterioration of porosity. Dolomitization is observed in the argillaceous limestone in the lower part of Bassein Formation as well as along stylolites. A correlation profile (Fig.7) at top of Mukta Formation shows the variation of thickness of Bassein Formation which varies from 225 m in well-B to 506m in well-E.

Subaerial exposure at top of Bassein Formation resulted in the development of karstified zone creating better porosity pods in the upper part. Additional porous layers are

observed in the lower part of this formation wherever it lies over the paleohighs or locales with lesser thickness of Panna clastics as observed in wells A, D, B and C. The porosities in the lower Bassein are generated during late burial diagenesis due to the movement of corrosive fluids along the faults. This is evident from the log motives of well B, as well as from the core data of well-C where only 2 meters core was recovered against the 18 meter cored section suggesting that major part of the core is washed out in the porous zone. This type of localized porosities is developed in the areas where ever this formation either lies over the paleohighs or with locales with lesser thickness of Panna clastics

### **Conclusions:**

- Occurrence of foram bioclastic wackestone, foram-algal packstone, and algal coral packstone in Bassein Formation are suggestive of shallow water platform carbonate origin in the studied area.
- Porosity in Bassein Formation is generated mainly due to karstification in the upper part represented by solution vugs/ channels and molds.
- Additional porous layers are observed in the lower part wherever it lies over the paleohighs or locales with lesser thickness of Panna clastics. The porosities in the lower Bassein are generated during late burial diagenesis due to the movement of corrosive fluids along the faults.
- Diagenetic imprints like sparitization, presence of blocky calcite in earlier generated vugs/cavities and neomorphic development of microspar within the matrix are responsible for deterioration of porosities.

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**The views expressed in the present paper are solely by the authors and not necessarily of the organization they belong.**

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