

Sedimentological attributes displaying reservoir extent, characteristics and depositional environment of the reef units in Early Miocene, Bombay Formation: A case study from the northern part of Heera- Panna- Bassein Area, Mumbai Offshore Basin

Rachana Singh* ONGC, Almas Rajguru ONGC, Vikrant Patel ONGC

singh_rachna@ongc.co.in

Keywords

Coral reef exploration, Patch reef, Depositional environment, pay zones, Early Miocene, Bombay Formation, Mumbai Offshore

Abstract

Sedimentological and biostratigraphic analysis of more than 700m of well cutting samples and side wall core sample of three key wells (A, B and C) are carried out to understand the coral reef reservoir in terms of microfacies, porosity trends, diagenesis and depositional setup of coral reef unit of Early Miocene age (Bombay Formation) in the northern part of Heera- Panna-Bassein Area, Mumbai Offshore Basin (Figure-1). The microfacies analysis of the carbonates of the studied interval are represented mainly by high energy packstone and boundstone unit along with low energy wackestone in study area. The presence of coralline boundstone in wells A, B and C shows the development of coralline patch reef. Coralline patch reef is slightly dolomitized in pay-I and is best developed in well C that is towards western part of study area as compared to wells A and B. The porosity in general is moderate to fair with presence of occasional vugs, intercrystalline, intracrystalline and framework pores. Potential reservoir facies are better developed towards the Eastern side of the studied area.

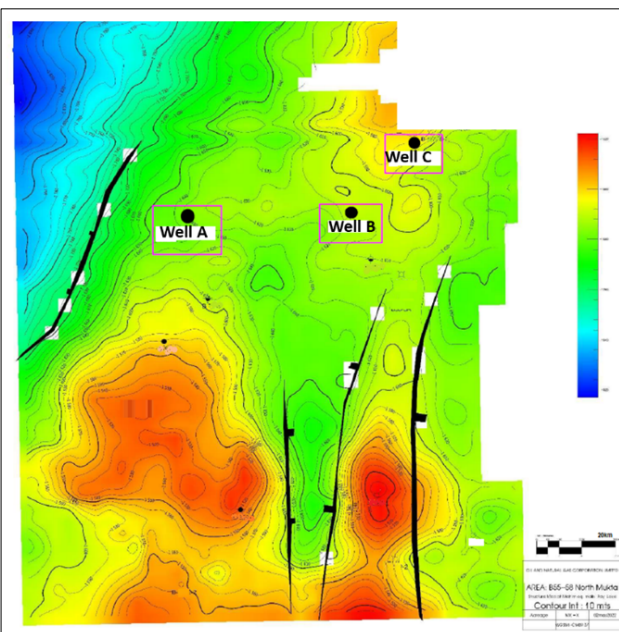


Figure 1, Location map of Study area

Introduction

The structure is located in the North of the Panna field. It is adjacent to B-58 and Tarapur structure. Sedimentological studies were attempted to understand paleo-bathymetry, micro-facies, depositional environment and porosity in different patch reefs developed at different intervals. An

attempt has been made to evaluate the pay zones, which is of coral reefs in the studied wells.

Methodology

Biostratigraphic studies are carried out on all the side wall cores and cutting samples in the studied interval to determine the environment of deposition and paleo bathymetry. Sedimentological studies include detailed megascopic and microfacies and XRD analyses to bring out lithological variations, mineralogical composition, environmental interpretation and reservoir characterization of the studied succession.

Well A: The lithology of Early Miocene in well A is limestone represented by foraminiferal wackestone, foraminiferal-algal wackestone, Foraminiferal coralline packstone, Foraminiferal coralline boundstone and shale (figure-3). The biostratigraphic study of the cutting samples illustrates foraminiferal assemblage includes *Ammonia* sp., *Ammonia papillosa*, *Lepidocyclina*, *Miogypsina* sp., *Sphaerogypsina*, *Operculina* sp., *Austrotrillina howchini*, *Quinqueloculina* sp., *Amphistegina* sp., *Spiroloculina* sp., *Biloculina* sp., *Elphidium* sp., bryozoa, micro-cephalopoda, miliolids, rotaliid, ostracodes (smooth and pitted). On the basis of fossil assemblage, and their characteristic test features (thick central zone and well developed pillars of *Lepidocyclina*; thicker test of *Operculina*; strong undulated test of *Miogypsina* sp. etc.); the interval (1540m -1795m) suggests an Early Miocene age with a prevailing paleo-bathymetry setup between 10-30m [1540m-1700m] & 10-20m [1700m-1795m]. An Inner shelf with low to high energy environmental conditions is interpreted for the studied sequence.

Pay 1: Pay-1 of well-1 is 6 m thick (1668m-1674m) comprises of limestone represented by Foraminiferal -algal wackestone and Coralline foraminiferal packstone/ boundstone and shale. The bathymetry is ~20-30m. Major diagenetic features are sparitization, pyritization, with minor dolomitization. The porosity developed is moderate to fair.

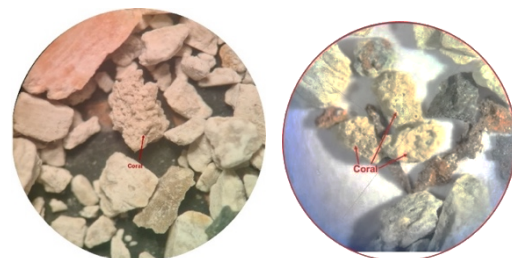
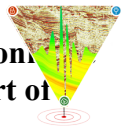


Figure 2, Well A, Depth 1705-1710m, Cutting samples shows good porosity is coral fragment, Depth 1760-1765m, Cutting samples shows good porosity is coral fragment

Pay 2: Pay-2 is 45m thick (1698m-1743m) comprises of limestone (figure 2) (Foraminiferal bioclastic wackestone) with minor shale. Foraminiferal bioclastic wackestone is the dominant microfacies. Deposition occurred in lower shoreface in a bathymetry set-up of 10- 20m as defined by the foraminiferal assemblage. Sparitization with minor



dolomitization is major diagenetic feature. The development of porosity is fair (vugs, molds, channels). Oxidization signatures are observed at 1680m. The Coralline boundstone is recorded at depth 1765m and 1776m representing patch reef which is slightly dolomitized.

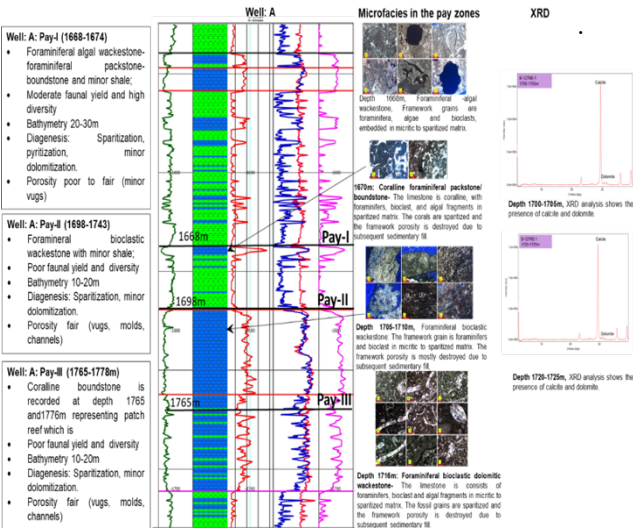


Figure 3, Sedimentological attributes of different pays in well-A

Pay 3: Pay-3 is 11m thick (1765m-1776m), consist of Limestone (figure 2 -3), microfacies is coralline boundstone, recorded at depth 1765m and 1776m representing patch reef. Poor faunal yield and diversity is observed in this zone. Bathymetry 10-20m. Diagenesis is observed in the form of sparitization and minor dolomitization. Porosity fair (vugs, molds, channels).

Well B: Dominant lithology of the well in Early Miocene interval is limestone represented by foraminiferal bioclastic wackestone and coralline boundstone with shale (figure-4). Limestone is dirty white, moderately hard, fossiliferous, coralline, sparitized and occasionally chalky. The detail biostratigraphic studies of interval 1540m to 1735m of Early Miocene section have been carried out to infer paleobathymetry and depositional conditions of the sediments. The interval has recorded a diverse foraminiferal assemblage including *Ammonia* sp., *Lepidocyclus* sp., *Miogyopsina* sp., *Sphaerogypsina* sp., *Operculina* sp., *Quinqueloculina* sp., *Triloculina* sp., *Elphidium*, rotaliids, bryozoa, miliolids, coral fragments, micro-gastropoda, micro-cephalopoda, ostracodes (smooth and pitted) and Globular bodies. At places, presence of pyrite suggesting a reducing (anaerobic) conditions and faunal leaching indicates a subaerial exposure. Depositional environment is suggested to be a paleobathymetric setup ranging from 10-20m.

Pay-1: Pay-1 in this well is 9m thick, (1643m-1652m), the lithology is limestone represented by foraminiferal wackestone-packstone with minor shale. Few coral fragments are recorded at depth 1640-1645m. Based on the associated foraminiferal assemblage the depositional environment is inferred to be in lower shoreface to proximal offshore regime

within a bathymetric setup of 10-30m. Sparitization is the major diagenetic feature, however dolomitization is occasionally recorded. Porosity is poor to fair due to minor framework pores, vugs and intracrystalline pores).

Pay-2: Development of Pay-2 is observed in the interval 1676m-1684m, which is dominantly coralline boundstone-foraminiferal packstone. Based on the associated foraminiferal assemblage the depositional environment is inferred to be in lower shoreface regime with a bathymetry of 10-20m. Sparitization is the major diagenetic feature, however dolomitization is occasionally recorded. Porosity is poor (occasional framework pores, vugs and intracrystalline pores).

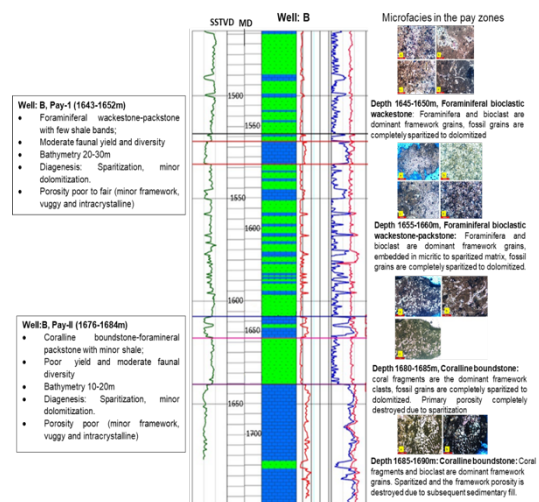
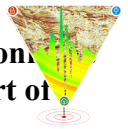


Figure 4, Sedimentological attributes of different pays in well-B

Well C: This well was drilled down to a depth of 3030m and has flowed condensate and gas from Early Oligocene & Early Miocene carbonates. The lithology of the interval is shale and limestone (figure 6), represented by foraminiferal packstone-wackestone, glauconitic packstone, foraminiferal packstone and Coralline boundstone. Bryozoa, ostracodes (both pitted and smooth) and coral fragments. The recorded fossil assemblage, their characteristic test features (thick, ornamented and strong undulated tests) and at places highly leached, ferruginous, pyritized and glauconitic suggests a shallow marine environment with moderate-high energy conditions for this Early Miocene sequence having occasional exposure of the shelf regime. The interval above and below 1620m-1625m is marked by the paleo-bathymetric setup between 5-15m whereas it is around 10-20m. The entire section shows the presence of coral growth in abundance representing reefal depositional environments in warm-shallow water with high energy conditions. The interval from 1500m-1600m and 1640m-1725m is marked by the exposed shelfal conditions. Pay-2 and pay -3 is not developed in this area.



At places lithology is silty, glauconitic, calcareous and occasionally fossiliferous. The interval between 1500m to 1725m is highly fossiliferous with diverse foraminiferal assemblage comprising *Ammonia* sp., *Lepidocyclina* sp., *Miogypsina* sp., *Sphaerogypsina* sp., *Operculina* sp., *Quinqueloculina* sp., *Amphistegina* sp., *Elphidium* sp., echinoid fragments, shell fragments, microcephalopods, microgastropods, microfossils, miliolids, rotaliids.

shallow water with high energy conditions. The interval from 1500m-1600m and 1640m-1725m is marked by the exposed shelfal conditions and better development of porosity.

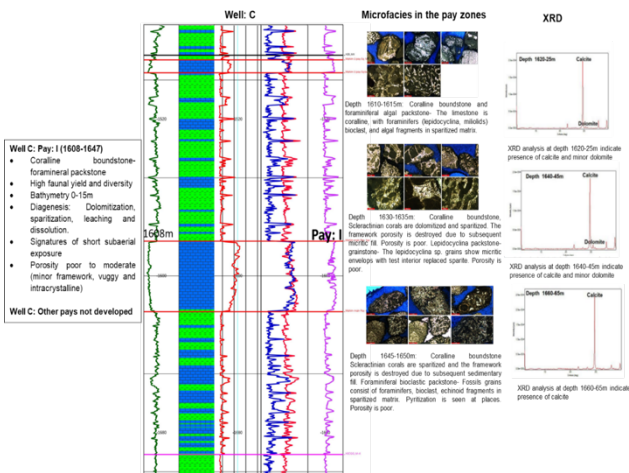


Figure 5, Sedimentological attributes of pay-1 in well C

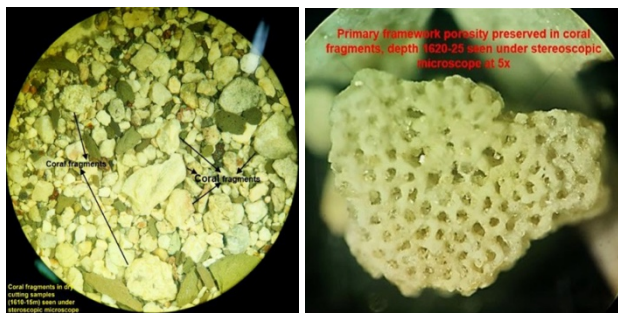


Figure 6, Cutting samples shows coral fragments at 1600m-1605m, good organic porosity preserved in coral fragment at 1620m-1625m.

Pay-1: Pay-1 is 37m in thickness (1608-1647m) and represented by thick coralline boundstone unit encountered at 1610-1645m. The associated foraminiferal assemblage (micro gastropods, echinoid fragments, micro bivalves) indicate deposition in upper shoreface to lower shoreface environment with paleobathymetry of 5-15m. The frequently oxidized intervals along with leached fossils suggest intermittent sub-aerial exposure conditions. The major diagenetic features include dolomitization, sparitization, glauconitic pellets, oxidation, leaching and dissolution. Minor intraparticle, intercrystalline pores and vugs resulted in fair porosity.

One geological profile have been generated across the various pay zones demarcated in the study area (Figure 7). The correlation of sedimentary data, diagenetic imprints in the demarcated layers were mapped to understand the pattern of deposition and the subsequent diagenetic history. Profile (W-E) is passing through wells A, B and C representing abundance reefal depositional environments in warm-

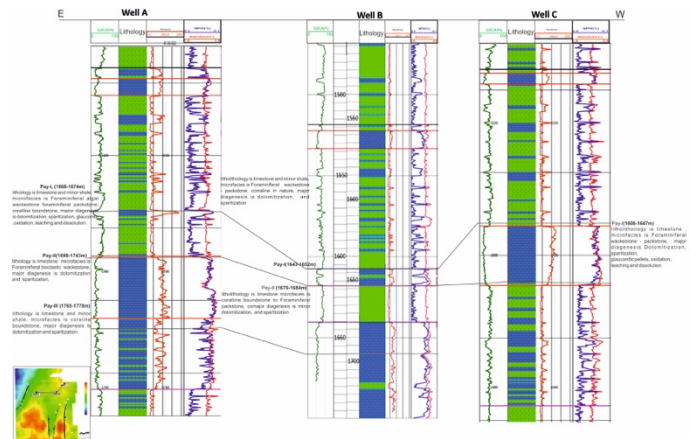


Figure 7, Correlation profile of different pay zone in E-W passing through wells A, B and C

Conclusion

The presence of coralline boundstone in wells A, B and C indicates development of patch reef. Coralline patch reef in pay-1 is best developed in well C. However in wells A and B, the patch reef of pay -1 thins out. Pay-2 of Well B shows good development of coralline patch reef. Whereas in pay 2 of well A foraminiferal bioclastic wackestone is the major lithomicrofacies with poor occurrences of coralline limestone. This pay is not developed in well C. In well A, porosity is better developed than well B because of occasional vugs, molds and channel result in fair porosity. Coralline boundstone is recorded in Pay-3 of well A towards western side of study area representing another patch reef and is not developed in well b and well C. Potential reservoir facies are better developed in pay-1 of well C and pay 3 of well A.

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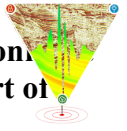
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