

Facies Analysis Of The Reservoir Rocks In The Sylhet Trough, Bangladesh

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Abstract

This study examined the sedimentary facies and stratigraphic architecture of the Miocene aged Boka Bil formation of the Surma Basin, exposed along the Sari River section, Sylhet, Bangladesh. Three hundred meter thick succession was logged for lithology, sedimentary structures, bed geometry, grain size and trace fossils. In the lower part of Boka Bil, nodular shale with calcite cemented sandstone is interpreted as a periodic storm influenced Inner Shelf deposit. Flaser-, lenticular- bedding, Bioturbated mudstone, ripple/trough laminated sandstone, herringbone/bidirectional laminated sandstone, wave rippled parallel laminated sandstone are interpreted as wave influenced Tidal Flat deposit. Above this association, the wave influenced Mouth Bar and Abandon Channel facies is reported. These regressive facies association are comprised of massive sandstone, parallel laminated sandstone with wave ripples, trough bedded sandstone, conglomerate and shale. As the basin ward progradation continued, Shoreface Sandstone was deposited. The Upper Marine Shale above this sandstone facies remarks, the last transgressive phase in the Boka Bil Formation. The overall facies association gets shallower in the stratigraphically up direction and the whole section is interpreted as Wave-Tide Dominated Prograding Deltaic system.

Three types of reservoir sand bodies are interpreted from the exposed outcrops. The Shoreface sand and the Mouth Bar sands have good reservoir characteristics. They have poorly cemented, moderate to well sorted- medium to coarse grain sand. The Tidal Flat sand can act as secondary reservoir, but the porosity-permeability distribution and the sand body geometry will not be as good as the mouth bar and shoreface sand bodies.

Keywords : Boka Bil, Tidal Flat, Mouth Bar, Shoreface

1. Introduction

In Bangladesh the main reservoir rock is the Miocene aged clastic sediments of the Surma Group which comprises the

Bhuban and Boka Bil Formation (Uddin and Lundberg, 1999). The outcrop exposed along the Sari River, Sylhet has been an analogue for the Boka Bil deposits. The observations made in this study will contribute better

predictions to the subsurface reservoir potential of the Boka Bil Formation in the Surma Basin.

2. Methodology

Sedimentary facies analysis was conducted for the Late Miocene Boka Bil Formation in Sari River Cut section by using outcrop sections to establish depositional systems. Boka Bil formation has a thickness of about 1.5 km in this section but only at few places exposed rocks can be studied. For this work the outcrops are divided into four sections, Station 1 to Station 4 (Fig.1).



Figure 1. Satellite Image of the area (yellow line is the international border).

3. Facies of Station 1 (Tetul Ghat, Sari River Cut Section, Sylhet)

3.1 Nodular shale with Sandstone interbeds:

Thick sequence of Nodular shale is present at the starting point of station-1. Calcite cemented sandstone beds occur occasionally in the shale sequence. In these calcareous beds the grains are well sorted and parallel laminations present with load structure. It is interpreted that, the sand deposits may be carried from the nearby

beach during episodic storm event into the inner shelf environment

3.2 Mudstone

In the mudstones thin sands form parallel and very small angle cross lamination with lenticular bedding. Bioturbations are found on the surface of the mudstone bed. Sand in the mudstones is carried from the landward side during high tides or storm. Parallel and low angle cross laminations in the mud indicates the influence of wave energy. The sedimentary structures in thin sand and silt layers with Bioturbation indicate an inner shelf environment.

3.3 Alternating sequence of sand and shale

The alternating sequence of sand and shale is deposited under low to moderate energy condition. The sedimentary structures like thin sand and silt layers, with flasers indicate a tidal environment. But parallel lamination and symmetric ripples are also present simultaneously, which indicate wave influence. It is interpreted as mixed flat deposit with wave influence in the intertidal zone.

3.4 Trough/Ripple laminated sandstone

This unit is composed of trough-shaped ripple, very fine- to fine grained, light brown colored silty sandstone. These beds show small scale herringbone cross lamination.

This facies succession is characterized by-(a) High frequency of abrupt facies change and erosional contact (b) Presence of abundant flaser bedding (c) Wave influenced structures like wavy ripples, parallel lamination (d) Bimodal direction of current formed cross lamination (e) Repeated occurrences of facies after small scale interval. These all indicates that this logged

facies association are deposited in a wave influenced tidal flat environment.

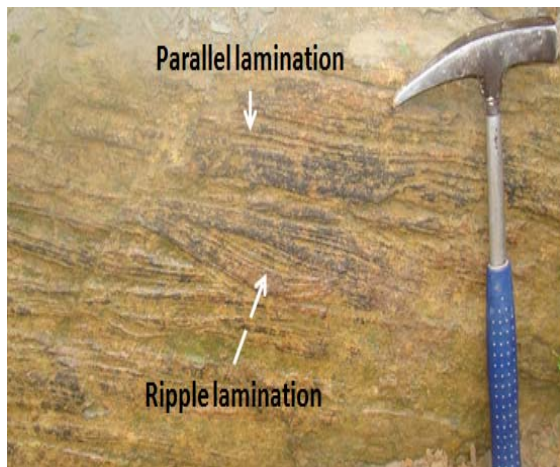


Figure 2: Ripple lamination occurring with parallel lamination in sandstone bed (hammer- 25 cm long as scale).

from the source area and became parallel laminated by swash and backwash flow. Consequently, this facies unit is interpreted as a mouth bar deposit.

4. Facies of Station 2 (Afifanagar Tea Garden, Sari River Cut Section, Sylhet)

4.1 Massive sandstone

Massive sandstone bed is composed of medium to coarse grain, sub- rounded to round and moderate to well sorted sand. The abundance of *Ophiomorpha* in this unit suggests that, the deposition occurred in a shallow marine environment. The occurrence of symmetrical ripples, coarsening upward trend in grain size, carbonaceous material and rip up clasts with mud lenses suggests high energy of sediment transport. This massive sandstone unit is interpreted as a Distal bar deposit.

4.2 Parallel laminated sandstone

This facies unit is characterized by parallel laminations in the sand and bounded by symmetrical ripples. Parallel lamination, mud clasts and size of the sands indicate a high energy condition. This sand may be carried

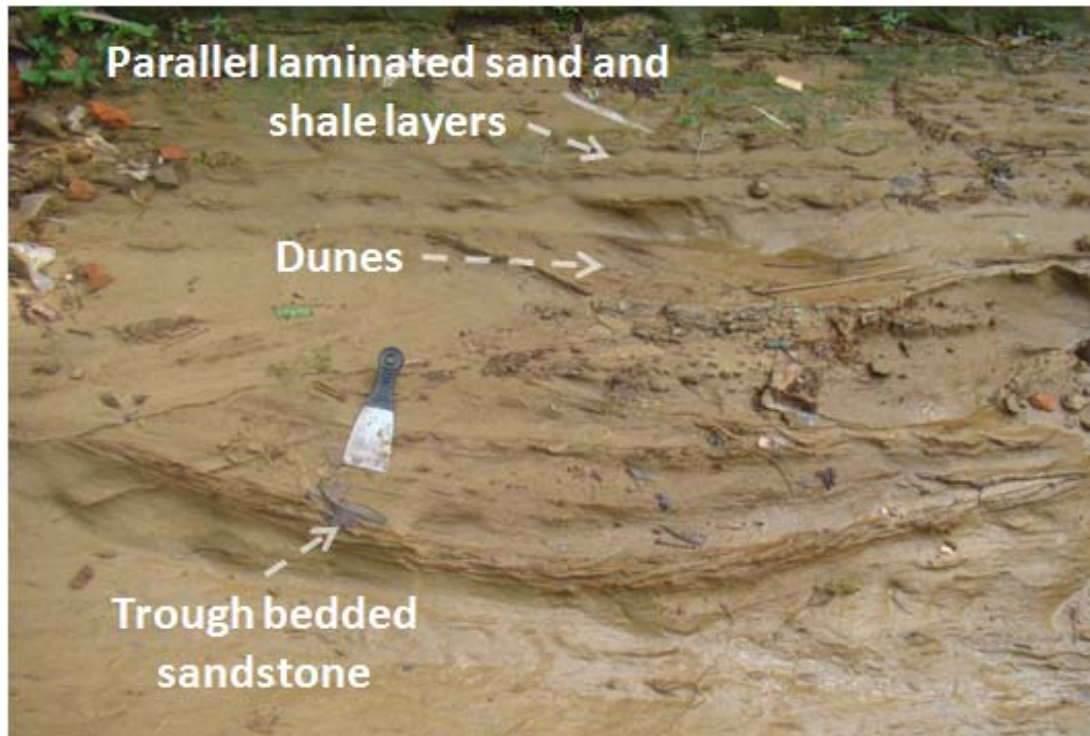


Figure 3: Trough cross bedding occurring between parallel laminated sandstone bed (shovel- 15 cm long as scale).

4.3 Trough bedded sandstone

Sets of curved shaped sand beds forms trough bedded structure. Small dunes are also present. The abundant trough cross beds, mud drapes on the troughs, dunes and overall position of this bed between the parallel laminated sandstone facies suggest that, this particular unit is a longshore current deposit at the bar crest with little tidal influence.

4.4 Conglomerate

The clast supported conglomeratic bed is highly weathered, dark brown to reddish brown in color, hard and highly compacted and has erosional contact with the underlying sandstone facies unit. The clasts are mainly cobbles and pebbles which are sub-angular to sub- rounded. The parallel

orientation to the bedding plane and presence of dried out mud and shale fragments indicate a strong current in channel. The sharp contact on the sand facies indicates channel erosion. Consequently, this particular facies unit is interpreted as a channel lag deposit.

4.5 Shale

Thickly bedded shale is present above the conglomerate. Fine sands are present as thin laminations in this bed. This fine grain facies association is deposited in quite water environment during slack period. Considering the facies association, this shale facies unit is interpreted as abandon channel deposit.

5. Facies of Station 3 (West bank of Sari River Cut Section, Sylhet)

5.1 Massive sandstone

Considering the stratigraphic succession of Surma basin, the sandstone unit of station-3 is inferred as the upper most Boka Bil sand, because after this- only thick sequence of shale is present. This shale is reported as the Upper Marine Shale which is underlain by Tipam Sandstone of Pliocene age (Reinmann, 1993).

Two different color sand beds are present due to different amount of weathering or because of different sediment source area. Massive structure, well sorted coarse grain sand, sub angular to sub rounded grains, abundance of rip up clasts indicates a high energy of deposition. The presence of symmetric ripples on top with rip up clasts suggests a wave influenced deposit. Consequently this unit is interpreted as a shoreface sandstone deposit.

5.2 Thick shale sequence

This shaly sequence continues to the Tipam formation with the monotonous alteration of fine sand lamination in the shale. These beds also contain flasers and forms wavy bedding. The occurrence of *Skolithos* ichnofacies in thin sandstone beds indicates a shallow marine environment. Thick mudstones are inferred as near offshore deposits. Therefore, this particular facies association is interpreted as a shelf deposit.

6. Facies of Station 4 (West bank of Sari River Cut Section, Sylhet)

6.1 Conglomerate

The conglomeratic bed is present at the top of thick shale sequence. This sandy-matrix supported conglomerate facies composed of angular to sub-angular shale

fragments indicates that the sediments have been transported into channel under high energy conditions. This type of strong current indicates a fluvial channel activity and consequently this unit is interpreted as lag conglomerate of a fluvial channel.

6.2 Cross bedded sandstone

Cross bedded sandstone facies comprises planar as well as curved foresets. Tabular cross bedding in the sandstone bed is formed mainly by the migration of large-scale ripples and dunes in the lower-flow regime conditions (Boggs, 1995). These indicate a fluvial environment of sediment deposition. This facies unit is interpreted as lateral accretion deposit of a point bar in a meandering river.

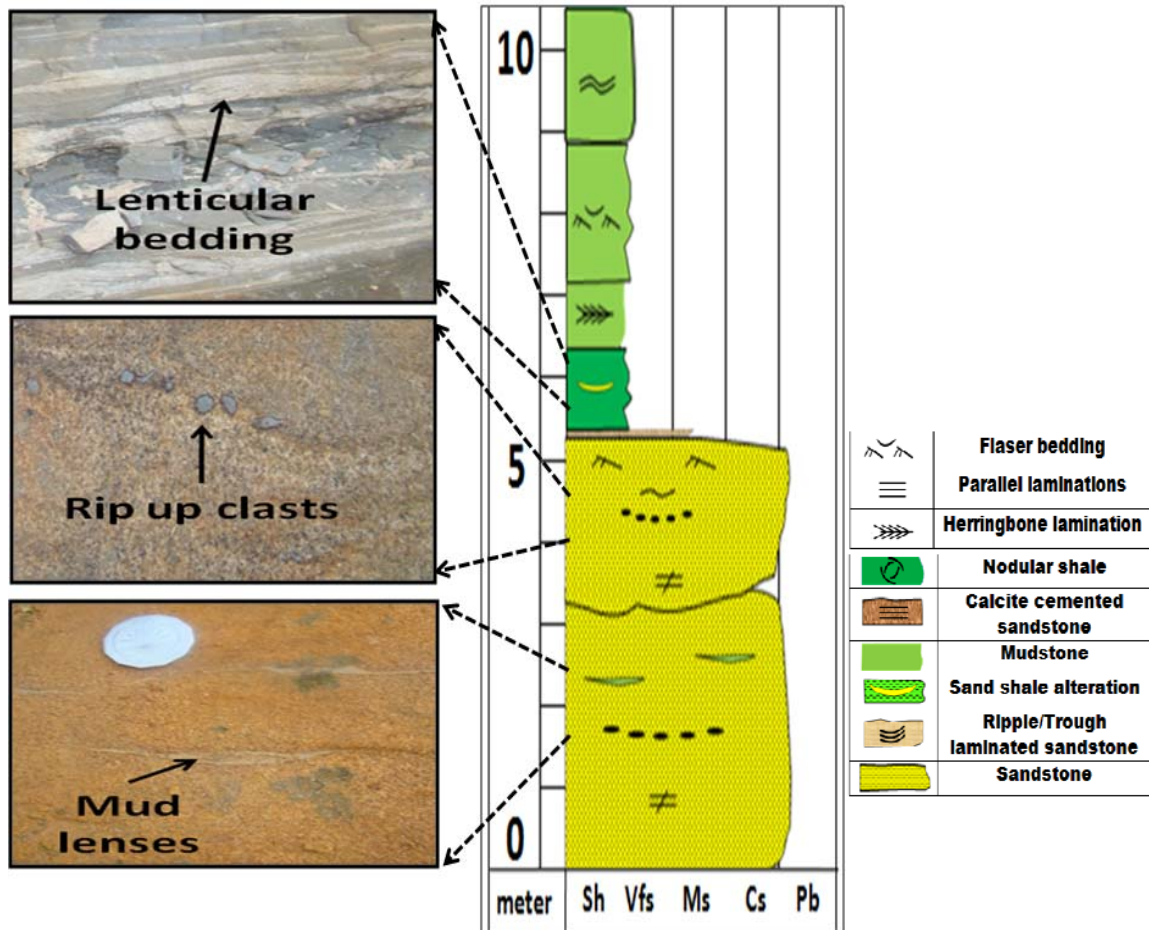


Figure 4: Sedimentary log at the contact between Shoreface sand and Shelf shales.

6.3 Massive sandstone with lag deposits

This facies unit is characterized by thick lag deposit at the bottom part, followed by preferentially oriented rip up clasts with fining upward trend. These features indicate sediment transport by strong traction current. Considering all these nature of deposition setting and grain size distribution, it is interpreted as a channel lag deposit.

6.4 Parallel laminated sandstone

This facies is distinguished by flat parallel-lamination with parting lamination occurring in the bedded plane. Considering the internal sedimentary structure, fining upward trend and overall facies association, this unit is also interpreted as a fluvialite deposit in a point bar.

6.5 Ripple laminated sandstone

Asymmetric ripples are the characteristic sedimentary structure of this bed indicating current activity. Low angle cross laminations are present in the fine sands

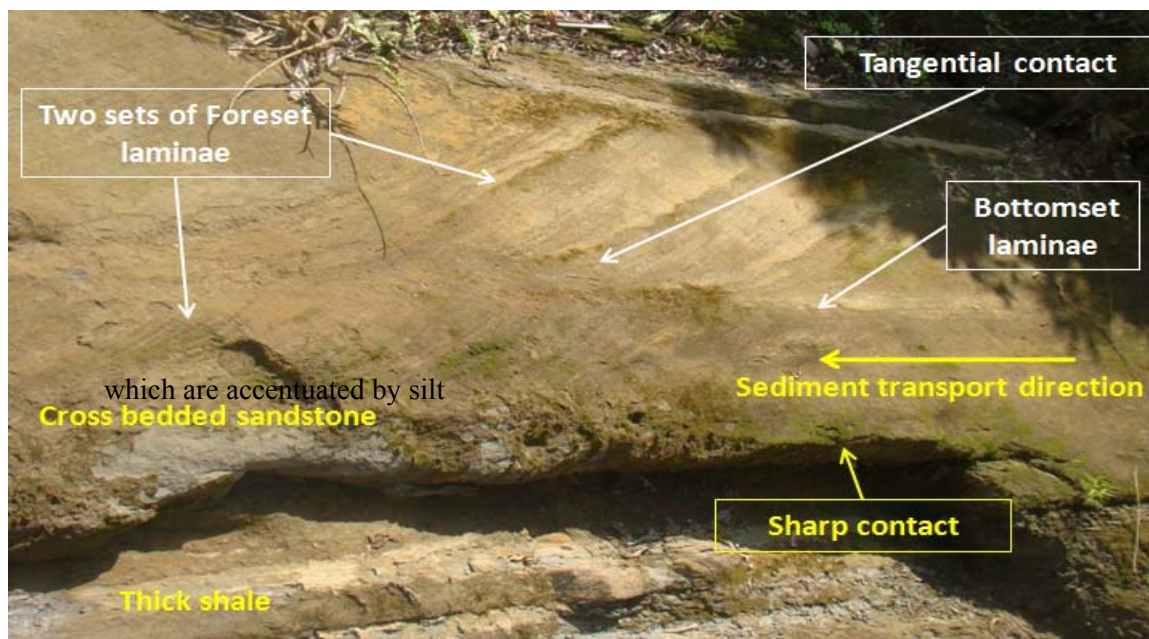


Figure 5: Tabular cross bedding with foreset and bottom set laminae overlying on shale.

deposition on the trough. Considering the ripple association with fining upward trend of grain size, this facies unit is interpreted as the upper part of point bar.

7. Synthesis of Sedimentology and Stratigraphy

Lower part of Boka Bil began to develop in a shelf environment which was effected by periodic storms. But gradually the relative sea level was dropping. The prograding coast line then became a tidal flat, which was influenced by wave action.

From station-1 to station-2 about 354m section is not exposed. In the most probable case, the relative sea level had increased after the deposition of station-1 facies associations and may have deposited outer shelf shales that are unexposed because of weathering and subsequent vegetation, followed by the prodelta deposits of renewed progradation recorded by the Station-2.

Station-2 at the Afifanagar Tea Garden is comprised of stacked succession of thick sandstone facies units. Parallel laminated sand units occur repeatedly in this section. Theses indicate that the deposition of this section was rapid and the influx of sediments from the river was relatively high. After the logged section of station-1, sea level shallowing facies sequence continues to this part also. Log sequence here represents facies association from distal bar to mouth bar. As the delta moves further to the basin, the abandon channel deposited the shale facies.

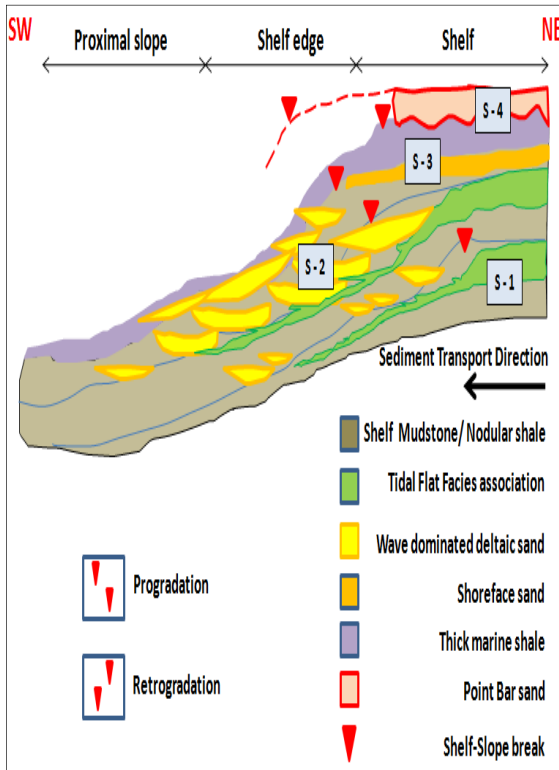
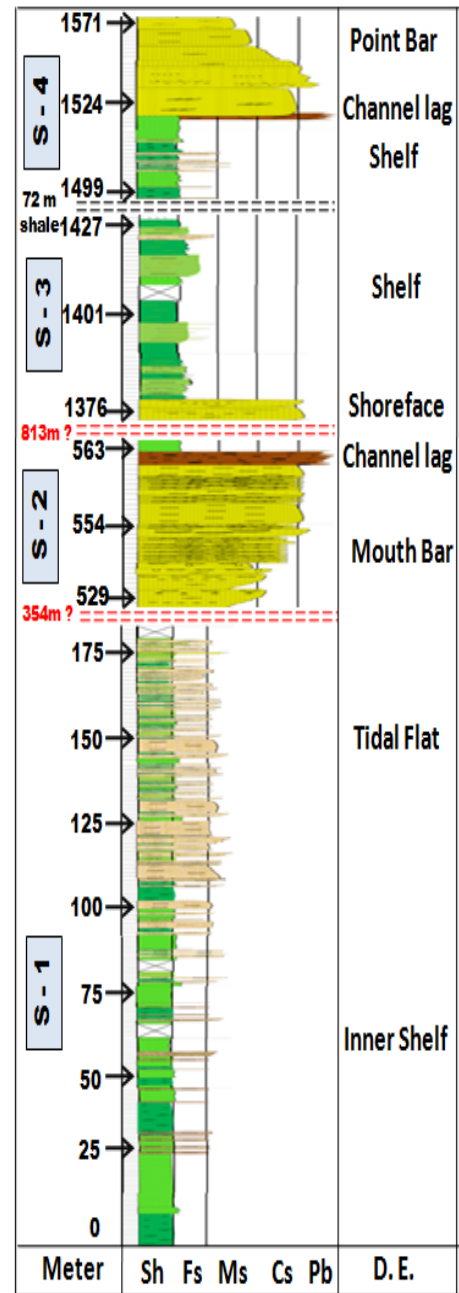


Figure 6: Stratigraphic column and schematic diagram showing the depositional setting of Boka Bil Formation exposed along the Sari River Section,

From station-2 to station-3 about 813m section is not exposed. In the most likely case, again the relative sea level had raised and deposited shelf shales which are unexposed because of weathering and subsequent vegetation. In least probable case of deltaic progradation, the principal depositional environments above the mouth bar are abandon channel, lacustrine delta fill, backswamps and flood-plain environments. The deposits of these environments consist of locally derived sands, muds and organic debris (Boggs, 1995). This also makes senses why a long section is not preserved in the outcrop, as the fine grain sediments erodes easily than coarser sediments.

The sandy facies unit at Station-3 is deposited in a shoreface environment. After this particular facies, fine grain deposition took place, which remarks the last transgression phase in the Boka Bil Formation. Station-4 is dominantly sandy

facies. It begins with the marine



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shale, which has erosional contact with the conglomerate and sharp contact with the sand facies. After the marine transgression the sea level again decreased, and the coastline moved to the basin creating a continental environment.

The meandering river cut through the shale, depositing the sandy facies unit as a point bar.

The individual parasequences in the exposed part of the Boka Bil Formation get sandier in the upward direction. These facies associations are deposited during regressive phases. In the unexposed part the most likely deposits are shales, which are may be the deposit of transgressive and prodelta phases. But the overall facies association gets shallower in the stratigraphically up direction and the whole section is interpreted as wave-tide dominated prograding deltaic system.

At least three types of reservoir sand bodies are interpreted from the exposed outcrops. They are Tidal flat sands, Mouth Bar sands and Shoreface sands. Tidal flat sands are intercalated with silts and clays. So, the porosity and permeability will not be high and the sand body geometries may be irregular in the subsurface. The mouth bar association is composed of medium to coarse grain, poorly cemented, well to moderately sorted sand. From the field observation it can be assumed that, porosity and permeability will be high as the sand is influenced by regressive phase and wave action. This will act as a good reservoir in the subsurface. Last but not least is the shoreface sand. The sands are coarse grained, poorly cemented and well sorted. Porosity and permeability will be also high and can act as a good reservoir in the subsurface.

8. Conclusion

- The Boka Bil Formation began to develop in a periodic storm influenced inner shelf regime.
- The relative sea level decreased and the coast line became a wave influenced tidal flat environment of sediment deposition.
- The relative sea level kept lowering and delta progradation occurred as the mouth bars.
- The basin ward progradation deposited shoreface sandstone at the upper part of Boka Bil.
- Upper Marine Shale above this sandstone facies remarks, the last transgressive phase in the Boka Bil Formation.
- Pont bar fluvial deposits belong to the Pliocene aged Tipam Formation.
- The individual parasequences in the exposed part of the Boka Bil Formation gets sandier in the stratigraphically up direction and the whole succession is interpreted as a wave-tide dominated prograding deltaic system.
- Three types of reservoir sand bodies are interpreted from the exposed outcrops. They are Tidal flat sands, Mouth Bar sands and Shoreface sands.

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