Seismic Sequence Stratigraphy Analysis in the Gulf of Moattama, Offshore Myanmar.

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Abstract

The Gulf of Moattama is the shallow embayment at the northern-most end of the Andaman Sea and is mainly composed of Miocene to Plio-Pleistocene deltaic offlap and slope sediments derived from the interior basins of Myanmar which may have potential prospectivity for hydrocarbons. To assess this potential, sequence stratigraphic analysis using 2D seismic data, well data and biostratigraphic data was carried out to determine the evolution and distribution of depositional environments taking into account the affects of significant changes in sediment supply, relative sea level change, and subsidence rates through time. Understanding the relationships between sediment depositional processes and the controlling factors on these processes is very useful in exploration within the oil and gas industry. Based on all data, depositional sequences were interpreted by analyzing the character of well logs, biostratigraphic information and 2D seismic data. As a result, eight sequence boundaries were mapped from the base deltaic complex to the seafloor. From this analysis, the best possible reservoir distributions in this area should be found in the lowstand deposits within the turbidite zones associated with sequences 3, 4 and 5 that were deposited during the Late Pliocene to Early Pleistocene. These potential reservoirs may be trapped as ponded turbidites or draping over older structures. Another area that may have good potential reservoirs is in the incised valleys fills which occur prominent when the sea level falls.

Keywords: Gulf of Moattama, Seismic sequence stratigraphy, Turbidite

1. Introduction

To understand the relationship between sediment depositional processes and the controlling factors on these processes is very useful in exploration within the oil and gas industry. To achieve this, sequence stratigraphic analysis can be used to determine the evolution of depositional environments. Integration of observations from seismic and well data can be used to identify the reservoir distribution and the inter-relationship of sediments, which are significant factors in defining prospects in the area of investigation.

As an example of this type of analysis, a seismic sequence stratigraphic study of the Gulf of Moattama, offshore Myanmar was carried out (Figure 1). The primary objective was to define reservoir distribution within the Plio - Pleistocene prograding deltaic sediments which overlay the main reservoir in the area, the Miocene carbonates.

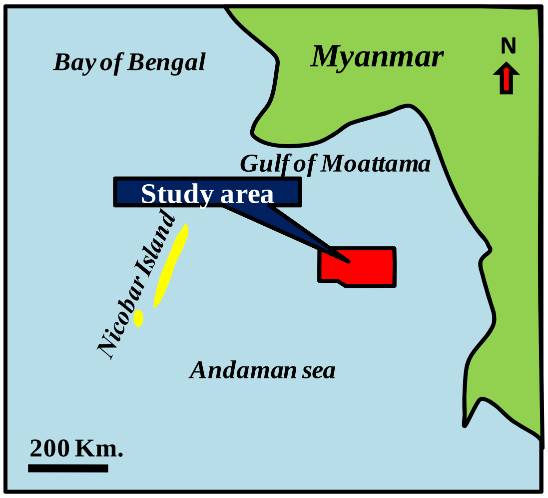

Figure 1. The study area in the Gulf of Moattama, offshore Myanmar.

2. Methods

The study area included two wells and a grid of 2D seismic data. There are 41 east-west and 25 north-south seismic lines. The two wells have a full set of log data and biostratigraphic control.

This research focused on the interpretation of 2D seismic data using Kingdom software and Interactive Petrophysics program. The first step was to interpret the wireline log data and seismic data character.From the correlation of well to seismic eight depositional sequences were defined and mapped. Next, time structural maps and isochron maps were generated for each sequence to analyze and interpret the depositional model and reservoir distribution. Finally, integration of all data interpreted such as well log data, seismic data and biostratigraphic data was carried out.

3. Results

3.1. Well log analysis

Based on the well data, five sequences were separated by log characteristics (Figure 2). The gamma ray log is high in the first sequence and gradually lower toward the upper sequence suggesting an overall coarsening upward succession. Sequence 1 is characterized by very high gamma ray, which suggests hemipelagic sediments. The next sequence is similar but with thin inter-bedded sands suggesting a prodelta environment. Sequence 3 shows silts and fine sands deposited suggesting the approach of deltaic sediments. Sequence 4 is characterized by more sand development and inter-bedded silt and fine sand which shows a coarsening upward sequence succession. Outer shelf to deltaic environment is interpreted. Sequence 5 shows coarsening upward character and more sand than sequence 4. Inner neritic to deltaic environments are interpreted. The upper three sequences, 6, 7 and 8 are interpreted as shelfal deposits based on seismic character.

3.2 Biostratigraphic control and well sequence stratigraphy.

Biostratigraphy reports (reference) from the wells were used to identify the age of each sequence (Figure 2).Well A was considered the key well for sequence stratigraphic correlation.

Using this information the sequences were correlated with a relative sea level curve for this time interval (Wornardt *et al.* ,2001). The boundaries BD and H1 were correlated with lowstand events at 8.6 and 6.98 Ma based on the regional observation that post-rift strata started deposition in late Miocene. H2 and H3 can be correlated with relative sea level lowstands at 4.37 and 2.0 Ma respectively. The upper horizons are hard to define because of the limitation of the biostratigraphic data. Based on the high frequency changes of relative sea level at this time data, H4 to H7 may correlate to 1.4 to 0.10 Ma.

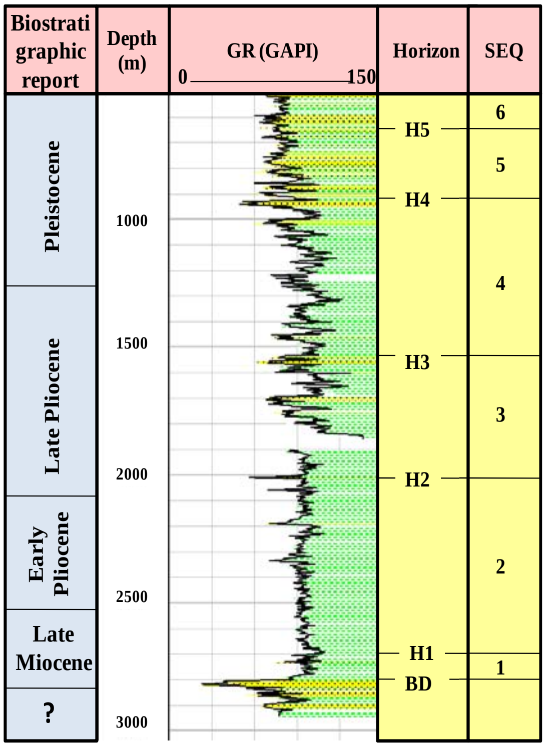

Figure 2. The well log data related to the ages, horizons and sequences incorporating the biostratigraphic data.

3.3 Seismic Sequence Stratigraphic Analysis

The study area received sediment from the Irrawaddy River from upper Miocene to the present. Figure 3 shows the general progradation from north to south of the sediment package and of the shelf edge.

Eight sequence boundaries were mapped. These sequence boundaries were picked on the difference in character of the wireline logs and seismic character above and below. The interpretation of the seismic data in each sequence is as follows: Sequence 1 is bound by BD and H1 and was deposited onlapping the basal highs and in-filling the lows. The amplitude of seismic is quite variable high and low, chaotic and discontinuous in places.

Sequence 2 has high amplitude sub-parallel reflectors within it and the log character shows high gamma ray that can be interpreted as shale or hemipelagic sediment deposits.

Sequence 3 is bound at the top by an erosion surface (H3) with associated incised valleys and at its base by H2 horizon. Sequence 3 shows parallel to sub-parallel continuous reflectors from the north to the south. Towards the south this sequence become thinner and is characterized by low amplitude reflections with poor continuity.

Sequence 4 is bound at bottom by erosion surface (H3) and at the top by H4 horizon which also shows miner erosion. Internal seismic character of this sequence shows significant prograding clinoforms that is seen by the prograded shelf break and some associated chaotic sediments in slope zone.

Sequence 5 is defined by erosion surface H4 at its base and H5 at the top. The characteristic of seismic shows parallel reflections on the shelf and some chaotic patterns on the slope zone. Downlap patterns and high amplitude are also present.

Sequence 6 is defined by erosional surface H5 at its base and erosional surface H6 at the top. H6 is characterized by apparent top lap on the shelf. The sequence shows channel or incised valley cuts on the shelf and some sigmoid clinoform packages on the slope zone.

Sequence 7 is recognized by the package of toplap within the upper part of the sequence. Moreover, the shelf breaks show more aggradational transport process following N-S direction.

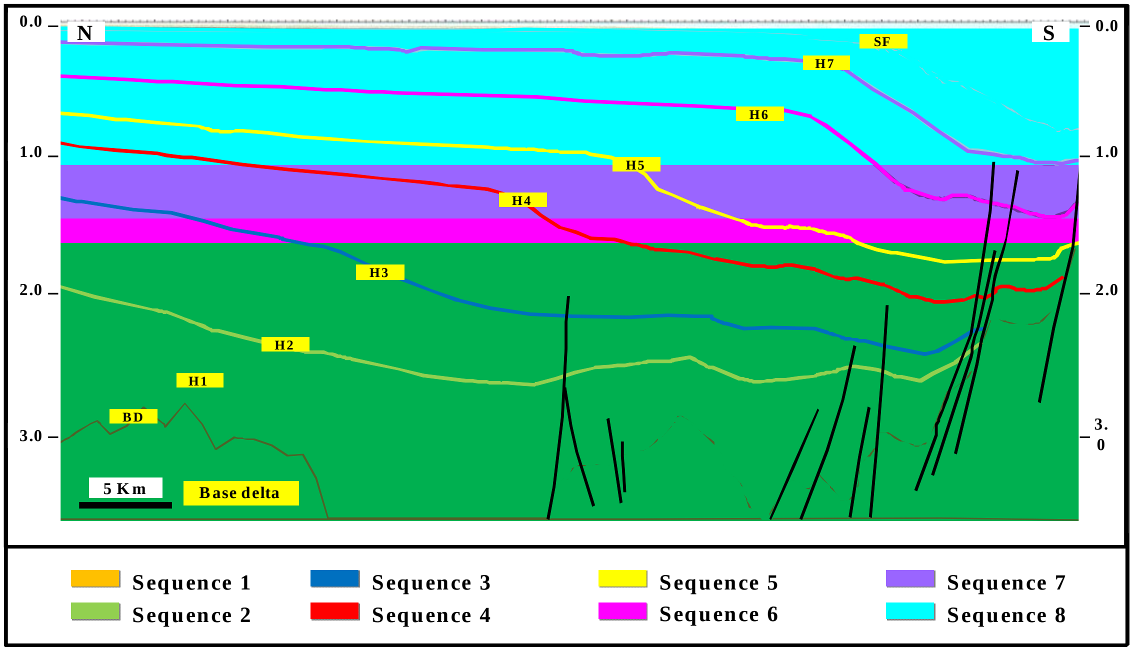

Figure 3. Each sequence boundary was picked across whole area.

Sequence 8 is bound at its base by horizon 7 and at the top by the seafloor (SF). The internal seismic character shows shingled and oblique clinoforms that can indicate that sediment prograded very quickly to the shelf edge.

4. Discussion

4.1 Evolution of depositional systems

In order to understand the depositional environment evolution, paleogeographic maps were constructed based on correlation of 2D seismic data. The section below the deltaic deposits (BD) has a NE-SW structural trend in the study area related to syn-rift and consists of volcanics and some carbonate rocks as confirmed by well A.

The depositional model of sequence 1 (Late Miocene) shows basal highs and some slope zone. The main sediment is hemipelagic that can be identified by onlap and infill of basinal topography. During this time the sediment supply is low and post-rift subsidence caused carbonate platform extinction due to transgression which was calibrated at Well A. The carbonates environment was replaced by basinal deposits.

During sequence 2 (Late Miocene to Early Pliocene) there was continued post-rift subsidence and active tectonic activity along the Sagaing fault. Some isolated ponded turbidite facies are evident which suggests pro-deltaic sediments coming into the area from the northeast. These are possibly derived from the volcanic margin and may be diagenetically inhibited by high clay content.

Sequence 3 correlates to the early Pliocene to late Pliocene. This correlates to collision between the Myanmar micro-plate and NE India and a southwest shift in delta system at this time. As a result sediment rate is increased substantially and improved sand qualities are predicted in the basin within axial turbidite sands. Slope fans and basinal sand systems are well developed as the shelf progrades from the north.

Sequence 4 correlates to late Pliocene to early Pleistocene and shows well developed incisions along the shelf. There is significant erosion surface with onlap of shelf edge which can be indicative of relative sea level falls below shelf break. Moreover, there are slumps and turbidite fans on the slope and basin within the lowstand system tracts associated with these sequence boundaries.

Sequence 5 correlates to the Early Pleistocene to Middle Pleistocene and is similar to sequence 3 and 4 and shows continuity of incised valleys. Progradation is followed by aggradation indicating that sediment supply is decreasing and equal to accommodation space generation. Sediment reaching the shelf edge and beyond would be expected to be finer grained.

The depositional model of sequence 6 to sequence 8 which correlates to the Middle Pleistocene to Recent suggests that during this time there is also more shelf zone and high sediment supply combined with low subsidence rate. These sequences also have more slump sediment deposits because of high slope angle and instability.

4.2 Reservoir evaluation and prospectivity

The analysis of seismic interpretation data, paleogeographic maps, well data and biostratigraphy information suggests that the possible sequences and areas to have good reservoir distribution and prospectivity are as follows:

Late Miocene to Early Pliocene (Sequence 2): This sequence is the deepest interpretable seismic package that indicates presence of turbidite sands. The seismic interpretation shows strong amplitudes in this sequence which are possible turbidite sands in the southern part of this study area and have a good trap by stratigraphic pinch-out onto the basal high.

Early Pliocene to Late Pliocene (Sequence 3): This sequence is associated with ponded turbidite sands in the southwestern part. These turbidites should be good reservoir and have good trap potential as a pinch-out against the basal high. This sequence also has interpreted sand distribution in the slope and base of slope zones. To the south, these deposits pinch-out onto the basal high. This sequence also shows a progradational package associated with more sediment supply to the basin and should have potentially higher net to gross during lowstands. Strong amplitude reflections in the middle zone indicate sand prone facies (Figure 4).

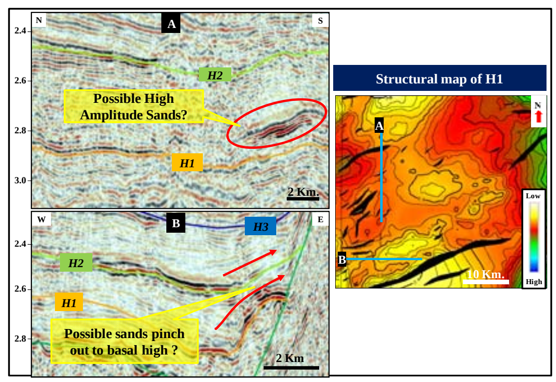

Figure 4. The seismic sections show A: possible strong amplitude sand area, and B: possible sand pinch-out onto basal high. structural map of H1

Late Pliocene to Early Pleistocene (Sequence 4): This sequence is one of the shallowest intervals that shows possible turbidite sands that pinch-out onto the basal high in the south. The seismic amplitudes in this area are quite strong and can be interpreted as good sand or reservoir in turbidite deposits. Incised valleys at the base of this sequence indicate a period of relative sea level fall when the sediment can more likely be supplied to incised valley fill and continue to the basin and deposit as basin floor fans. Also, drape structures over basinal highs are good structures for traps and may represent good reservoir traps in this interval (Figure 5).

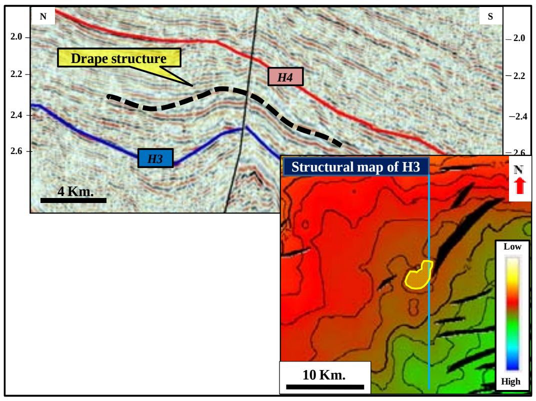

Figure 5. The seismic section shows the drape structure which represent a good trap for potential turbidite reservoirs in sequence 4.

Sequence 5 shows similar prospects but has less high amplitude packages and possibly less sand. Above sequence 5, the sediment deposition shows aggradational packages that can be identified with finer and thinner sands compared to sequences below. These sequences are in the Pleistocene to Recent. Sediment is reduced coming into the basin and these sequences show many slump deposits in the slope zone to the basin.

Some zones close to faults have gas chimneys and shallow gas indicators suggesting that the gas has migrated along the faults to the shallower sequences. This implies that an active petroleum system exists in this basin and locating reservoir and trap is the key to evaluating this areas potential.

5. Conclusions

This study incorporates a regional seismic interpretation of 2D seismic data from the Gulf of Moattama, Myanmar with seismic sequence stratigraphy analysis to understand the depositional controls and reservoir distribution in this area. Eight major depositional sequences were recognized on the seismic section. These sequences can be separated by analyzing the character of well logs, biostratigraphic information and 2D seismic data. Based on the depositional mapping, sequences 3 to 5 show an increase in sediment supply into the basin at this time and significant progradation of shelf break. These sequences also have recognized incised valleys which suggests that during sea level falls sediment could by-pass the shelf into the basin. Sequence 6 to sequence 8 shows slower sediment supply but has a lot of sediment slumps on the slope into the basin. Subsidence rate is very low as recognized by shingled and oblique clinoform patterns across shelf.

Based on these observations the best possible reservoir distributions in this area should be in the lowstand deposits within the turbidite zones of sequence 3, 4 and 5 that represent the age during Late Pliocene to Early Pleistocene. This zone has potential sands deposited and possible high net to gross sand values. Another area that may have good reservoir distribution is in the incised valley fills which occur when the sea level falls and subsequent sediment supply infills the valleys. These can be recognized by seismic character at several sequence boundaries.

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7. References

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