Gross depositional environment (GDE) maps of Ariyalur-Pondicherry and part of Tranquebar sub basin from Oxfordian to Albian of Cauvery Basin, India

Harswaroop Singh Aswal
Palynology Division, Geology Group, KDMIPE, ONGC, Dehradun
Email: aswalhs@gmail.com

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Gross depositional environment, stratigraphic architecture, Maximum flooding surface

Summary
The Cauvery Basin is a pericratonic rift basin situated along the south eastern part of Indian peninsula. Gross deposition mapping is focused specifically on the environments in which the rocks were deposited at the time period being considered. This vertical succession of facies in each well is has been used to predict the lateral facies variation. The result is a Gross Depositional Environment map for each sequence incorporating all the basic observations and tied precisely to known well data. With exploration focus shifting to synrift sediments, there is a greater need to understand the reservoir depocentres and source facies distribution with respect to gross depositional setup. The present study was taken up with the objective to provide stage wise Gross depositional environmental maps from Oxfordian (Late Jurassic) to Albian (Early Cretaceous) using forwards stratigraphic modeling approach (stratigraphic forward modelling (SFM) is a technique to provide process-based predictions. SFM links sedimentary processes to geological products in a more direct way helps understand the evolution of stratigraphic successions) in order to provide a probable distribution of expected reservoir facies within the sequence stratigraphic framework.

During the Late Jurassic-Early Cretaceous, a regionally extensive cover of dominantly siliciclastic sediments was deposited across the Ariyalur-Pondicherry sub basin. These sediments are considered a relatively heterogeneous lithofacies known as the Andimadam Formation, described as coarse-fine grained sandstone and shale of fluvial to marine origin. The study focuses upon biostratigraphic details, lithofacies variability and paleogeographic evolution of the study area. Building upon previous work and new insights from the Andimadam Formation, a synthesis and re-interpretation of the spatial and temporal heterogeneity of sediments and depositional environments throughout the Late Jurassic - Early Cretaceous is presented. During the Oxfordian time the sub basin was dominated by fluvial and lacustrine regime with minor influence of marine transgression. During Kimmerdigan-Tithonian the sub basin experienced more marine influence resulting in the lacustrine setup encroached by marine water turning them into brackish water lakes and the coast line started moving inland. Since, Tithonian-Albian continuous rise in sea level resulted in the prevalence of open marine environment and the sediments deposited in overall transgressive mode and finally the deposition of Sattapadi Shale Formation considered as maximum flooding surface.

Introduction
The Late Jurassic-Early Cretaceous succession in Ariyalur-Pondicherry Sub Basin and adjoining parts of Tranquebar sub basin comprised of fluvio-deltaic and marine sediments are represented by Andimadam Formation. In order to achieve the objective of the study, detailed biostratigraphic and
sedimentological analysis of the Andimadam Formation is presented and discussed in terms of paleo-environmental evolution and controls on lithofacies distributions and stratigraphic architecture.

Objectives
To provide stage wise Gross depositional environmental maps from Oxfordian (Late Jurassic) to Albian (Early Cretaceous) using forwards stratigraphic modeling approach in order to provide a probable distribution of expected reservoir facies.

Methodology

Stratigraphy
Detailed lithostratigraphy of Cauvery basin was worked out by Venkatrengan et al., (1993). The Cauvery basin has a sediment pile of over 8 km in the subsurface (Gulf of Mannar sub basin). In the western fringe of the basin, discontinuous exposures of Cretaceous and Paleocene age are seen at four places, viz., Sivaganga, Trichinopoly, Vriddhachalam and Pondicherry. The stratigraphic succession is presented in Table-1.

Gross depositional environments (GDE)
GDE maps have been drawn for each stage from Oxfordian to Albian and have been presented within sequence stratigraphic framework.

Oxfordian
There are very few wells which have penetrated in these sediments. Along with the available well data, to come to the conclusion about the GDE during the Oxfordian time, relief map at the top of the basement has been taken in to account for extension of the lows as well as to understand the limit of marine influence. The sediments of the Oxfordian age correspond to the basal part of synrift sediment. The depositional environment prevailed during the period is mainly the fluvial setup while the sediments from the alluvial fan axis are transported to the initial lows formed with the rift tectonics where dominantly a lacustrine setup was prevailing. The marginal marine setup appears only in the north-eastern part of the basin.
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**Kimmerdigian**

During the Kimmerdigian, sediments begin to infill the inherited mini basins. The thickness map shows thick accumulations of reservoir facies towards the proximal part (PN wells viz. F, G, AA) and in the axis (BV-I, VL- A) of alluvial fan systems. The lacustrine environment prevailed during the Oxfordian time turned in to brackish set up during the Kimmerdigian due to rise in sea level. The sediment distribution and transportation is controlled by distributary channels of alluvial fan system.

**Tithonian**

Tithonian witnessed further filling of the inherited mini rift basins. In Bhuvanagiri and Pandanallur-Andimadam area the shift in the fan axis is clearly evident as well PN#G and BV#I shows maximum sand thickness. During Tithonian the marine realm extended further in the basin encompassing all the lows which were acting as inland lakes. This is for the first time the alluvial fan systems further extended and started debouching in the marine realm in shore face to inner shelf environment.

**Berriasian**

During the Berriasian time the coast line further moved inland engulfing more areas in A- P sub basin. Due to the continuous rise in sea level the alluvial fan facies paved the way for foreshore to shore face environmental set up especially in Pandanallur area. In Bhuvanagiri area the alluvial fan system continued to prograde in the fore shore- shore face environment due to unabated sediment supply. Bhuvanagiri fan prograded near to the well CD#EA. For this fan system two models have been proposed as the location represented by CD#E well was getting the sediment supply from the adjoining Madnam high from Oxfordian - Tithonian. The sand models of Berriasian suggests, due to the high sediment supply in Bhuvanagiri fan the proximal fan facies extended to the CD location, however, the same location, sediment supply from Madnam high cannot be ruled out as the seismic line passing through this area suggest bimodal sediment supply.
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Valanginian

The Valanginian period corresponds to global sea level fall due to opening of northern Atlantic with the separation between Europe and Newfoundland characterized by major regressive sequence due to which the fan system started receiving the more sediment input while the deeper part of the basin has low sediment accumulation suggested by the presence of low sand percentage in the proximal part of the fan while the mid fan complex accumulated more sand. The fan architecture suggest more widening then the progradation in comparison to the Berriasian fan architecture in Bhuvanagiri and Pandanallur area while in Komarakshi area the fan progradation is observed. In the basin dominantly foreshore to shore face environment prevailed.

Hauterivian

During the Hauterivian period, the sediment input increases drastically as reflected by the increase in sand percentage in all the alluvial fan system since Oxfordian. Another evidence of the increase in sand percentage is from north where another fan develops in Chattaram area with approximately 87 percent sand deposited during the period. The change is sediment supply may be attributed to the basin entering in sag phase of rift tectonics. The rapidly increasing sediment load and development of additional alluvial fan system. With the rising sea level and coast line moving landward the Bhuvanagiri fan system instead of prograding started increasing laterally as the ever rising sea level hinders the sediment supply to the deeper part.

Barremian

During this time, the sedimentary system has started to evolve with a continuous increase in shale content in the shore face to fore shore areas of the period. The widening of the alluvial fan system continues during Barremian also. The depositional environment is more open to marine influences. In order to better understand sands distribution from distal part of the fan system to the basinal part during this time frame, a sand depositional model has been constructed. Results show a broad distribution of sandstone across the basin. A major transgressive event occurs during the Barremian period leading to the increase of shale content in overall lithofacies. This event is related to global Barremian transgression and with the basin entering in the sag phase of rifting due to the heavy sediment supply during Hauterivian period resulting in overall mechanical compaction of early cretaceous –Late Jurassic sediments and overall subsidence of the basin.

Fig. 6. Gross depositional environment during Valanginian.

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Fig. 7. Gross depositional environment during Hauterivian.

Aptian

The period witnessed the global regression which commenced in Barremian and continued till Aptian, but in A-P sub basin due to the
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Fig. 8. Gross depositional environment during Barremian.

Sagging of the basin resulting in differential subsidence the sea level continued to rise. Due to this rise due to subsidence the area in and around the CD#E, KMR#A, the high shale percentage i.e. 100% in CD#E suggest this area continued to subside more and may represent inner to middle shelf conditions where dominantly the finer clastics are deposited. There is overall increase in shale percentage throughout the basin since Barremian.

Fig. 9. Gross depositional environment during Aptian.

Albian

This period in the sub basin experienced the widespread marine transgression throughout the basin which has brought most highs or positive areas in the basin under marine realm. This transgression in the basin is in conformity to the eustatic sea level rise. The extent of this transgression was so wide spread that the coastline crossed the basinal boundaries and deposited a continuous sequence of calcareous and siliciclastic sediments in the outcrop area of Trichinapalli. The dominant lithology deposited during this period in the basin is mainly shales and siltstone/claystone represented by Sattapadi Shale Formation, considered as MFS.

Conclusions

1. The sediments of the Oxfordian age corresponds to the basal part of synrift sediment is deposited in fluvial- fluvio lacustrine setup. The sediments are transported to the initial lows formed with the rift tectonics where dominantly a lacustrine setup was prevailing through alluvial fan system. During Kimmeridgian sediments begin to infill the mini basins. Sediment distribution and transportation is controlled by distributary channels of alluvial fan system. Tithonian witnessed the shift in the fan axis and marine realm extended further in the basin encompassing all the lows which were acting as inland lakes. The alluvial fan systems further extended and started debouching in the marine realm.

Fig. 10. Gross depositional environment during Albian.

2. During Berriasian the coastline further moved inland. With continuous rise in sea level the alluvial fan facies paved the way for foreshore to shore face environmental setup. The sand models suggest that due to the high sediment supply in Bhuvanagiri fan the proximal
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Fan facies reached up to the CD location along with the supply from the Madnam high cannot be ruled out as the seismic line suggests bimodal sediment supply.

3. The Valanginian period corresponds to global relative sea level fall suggested by presence of low sand % in proximal fan, the mid fan complex accumulated more sand. The fan architecture suggest more widening in comparison to the Berriasian fan architecture in Bhuvanagiri and Pandanallur area while in Komarakshi area fan progradation is observed in foreshore to shore face environmental setup.

4. During the Hauterivian period, the sediment input increases drastically as reflected by the increase in sand percentage. In Barremian, sedimentary system started to evolve with continuous increase in shale content in the shore face to fore shore areas of the period. The widening of the alluvial fan system continues during Barremian also.

5. The Aptian period witnessed the regressive phase which commenced in Barremian and continued till Aptian, but due to differential subsidence the sea level continued to rise reflected by overall increase in shale percentage throughout the basin.

6. The Albian period experienced the widespread marine transgression throughout the basin which has brought most highs or positive areas in the basin under marine realm. The dominant lithology deposited during this period in the basin is mainly shales and siltstone/claystone represented by Sattapadi Shale Formation, which is considered as MFS.

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Bibliography


