Impact of Geologial interpretation on reservoir modelling- A case study Jotana field Cambay Basin

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Reservoir modelling, parasequence, reservoir heterogeneity

Summary

Petroleum industry has lots of uncertainty and risk in each element of its different domains. Different tools are being used to optimize the uncertainties especially in characterizing the reservoirs thus defining optimum development strategy for a field. In recent years with development of advance mathematical principals and algorithms, constructing geological models has become a significant step in reservoir characterization as reservoir modeling and provides a spot to integrate and compile all available data.

The attempts to create 3D geological model with present understanding needed revisit of reservoir modelling process to capture all structural and stratigraphic features. The study was taken up to update geological model of the Mandhali pays. Major challenges had been encountered in the area like the cross cutting of pay units and to explain HC distribution within the pay sands that was unable to explain with present structural setup. Thus ambiguity remains in understanding the spatial distribution and in building depositional model of Mandhali sands in Jotana field. To resolve the issue a methodology was adopted to correlate different parasequence units based on log characteristic, biostratigraphy data and matching the regional log profiles with seismic profiles and integration with depositional environment. The 23 pays were redistributed based on the method adopted and this resulted in preparation of more realistic static model resolving all the known structural uncertainties.

Thus, the successful synergistic integration of geological model based on sequence stratigraphy and its consistency with seismic data resulting in preparation of good structural model.

Objective

The objective of this paper is twofold:

1. To provide a simple, consistent, technique that can support sequence stratigraphic interpretation in clastic lower delta plain system. Resolve the issue of cross cutting of pays.
2. This will provide input for static reservoir modelling for preparation of structural model for Mandhali pays.

Finally it aims to prepare a better static model which will provide better results during simulation for further field planning.

Introduction

The Mandhali member of Kadi formation encompasses the major oil producing pay sands in Mehsana block, particularly in Jotana field (Fig: -1). The Mandhali pay sands have wide range of petrophysical properties and reservoir facies variation indicating complex depositional set up. The presence of Mehshana host as paleo high on the west of the Jotana field and Shobhasan low in the east with main Jotana fault (NNE-SSW trend) along the Mehsana host make the area structurally complex. Further sands of

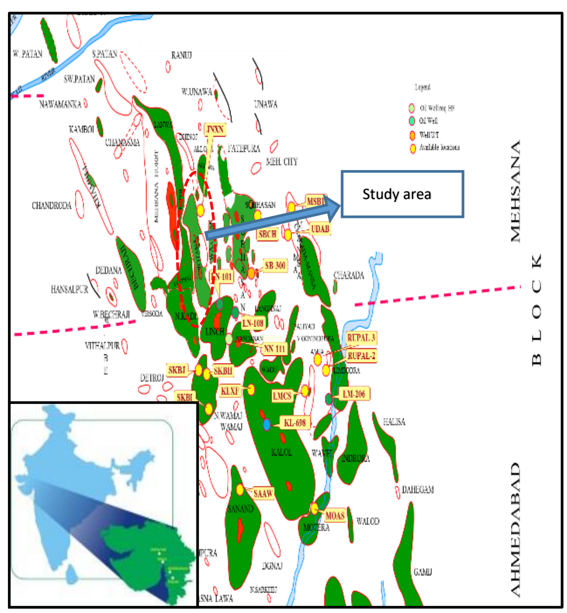

Fig: 1- Location Map

Mandhali and Linch are pinching out as we move towards the main Jotana fault. This has resulted in ambiguity in understanding the spatial distribution of the sands and building the depositional model. This study brought out the depositional model, sand dispersal pattern as well as hydrocarbon distribution pattern within Mandhali member.

Based on basin formative tectionic events and therir impact on sedimentation processes three first order sequences (Parakh et. Al, 2007) viz Late Cretaceous passive margine sequence followed to Kutch rifting, Paleocene rift related to separation of Sychelles from India and Early Eocene to recent rift fill /passive margin sequence. The present study covers the synrift phase of Paleocene. Mandhali represents Paleocene HST top (Parakh et. Al, 2007). In the present study additional two higher order sequence / parasequence has been identified.

Tectonics

The Cambay basin came into existence due to rifting along N-S to NNW-SSE Dharwarian trend in the Early Cretaceous (Biswas, 1987). This basin is bounded by step-faults in the Eastern & Western margins. The major cross-trends have divided this basin into five tectonic blocks from south to north viz. i) Narmada-Tapti Block, ii) Jambusar-Broach Block, iii) Cambay-Tarapur Block, iv) Ahmedabad-Mehsana Block, v) Patan-Tharad-Sanchor Block. The study area falls in Ahmedabad-Mehsana Block in Northern part of Cambay Basin (Fig:2).

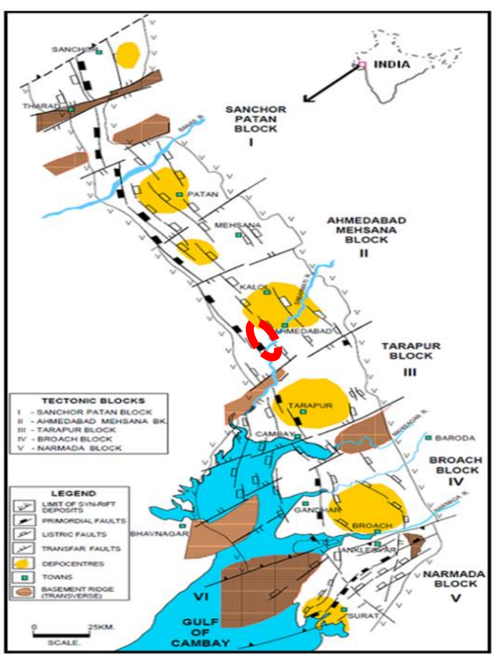

Fig-2: Tectonic map of Cambay field

Methodology

The methodology adopted for study:

- Identification of Mandhali (Paleocene HST) and OCS Mandhali boundary on log signature.
- Identification of three parasequence units within Mandhali and OCS boundary on log and validating the same across the field with regional arbitrary seismic lines.
- Classification of Mandhali into 3 sub-units based on well log to understand the depositional history.
- Generation of isopach, sand/shale ratio maps , coal thickness map and integrated with seismic and of biostratigraphic study plus sedimentological study resulted in better understanding of sand dispersal pattern.
- Integration of parasequence units and depositional model resulting in fixing the structural configuration.
- Input for structural frame work and facies model during preparation of geo cellular model.

Sequence stratigraphy

Identification of two significant surfaces (flooding surface or sequence boundary) to predict the strata that would occur below and above that surface. Mandhali member is a part of Paleocene 1st order rift sequence. This sequence relates to the breaking of Seychells from India starting at the K/T boundary and represents synrift phase of the basin evolution and comprises rift sediments i.e Olpad , OCS & Mandhali (Parakh et. Al, 2007). Major regression represented as Paleocene HST corresponding to Mandhali top is a mapped on logs and seismic (Fig:4).

Mandhali member is the lower most member of Kadi formation. It lies between two shale unit, Lower tongue (LT) and Older Cambay shale (OCS) beneath. The bottom of Mandhali unit is marked by shale unit (neck marker). In absence of neck marker, the member rests unconformably above OCS. The top of this is marked by low resistivity high GR shale, corresponding to flooding surface. Mandhali top is easily correlate able on logs as well as seismic.

The study area consists of 23 pay sands within Mandhali member. The heterogeneity in lithology and complex structural position resulted in cross cutting of

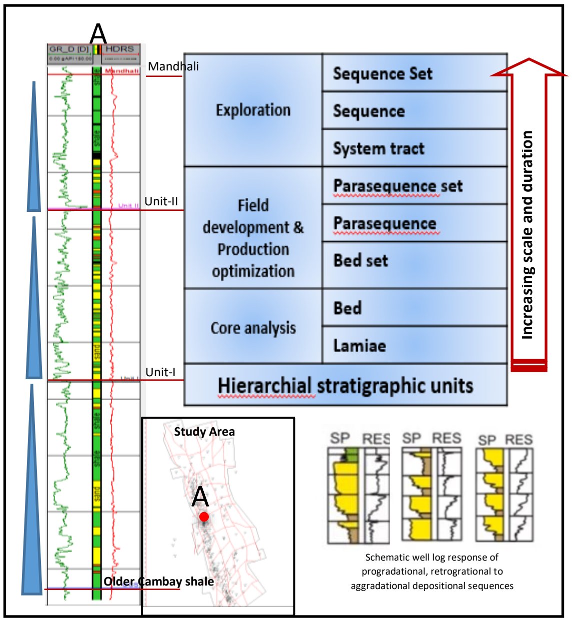

Fig-3: Sub-units identified on logs within Mandhali and Older Cambay shale

the pays. To resolve this stratal packages were identified so that the pays are confined within these packages (i.e. the parasequences). Parasequences are relatively conformal succession of genetically related beds bounded by flooding surface (Fig:3).

Based on well data and electrolog the Mandhali member was divided into three parasequences. On log they are identified by resistivity, SP, neutron-density and gamma ray logs. Each para sequence were correlated across the field. Isopach, sand isolith maps for each unit was prepared to understand structural and

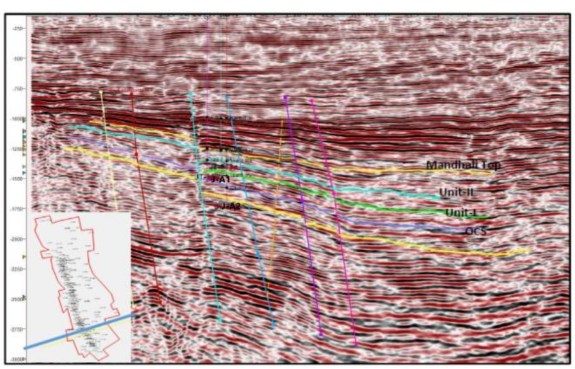

Fig-4: Seismic mapping of Unit-I and Unit-II within Mandhali & OCS

depositional model as well as the dispersal pattern. The 23 pays were confined within the three-para sequence. The three parasequence which include 5 pays in unit-I, nine pays in unit-II and nine pays in unit-III from bottom to top units.

Depositional Environment

The distribution pattern of the reservoir units, its thickness and litho association in the area have been used to prepare unit-wise deposition model for the Mandhali Member in the proposed study area and also beyond it. A facies distribution map and resultant process response model of Mandhali Member has been deciphered in the study area in Jotana field. The three units viz. Unit –I to Unit-III within Mandhali has been studied with focus on their lithofacies, thickness variations of sandstone (sand)/ siltstone/ shale and coal; sand : shale ratio and overall distribution pattern of these facies.

Unit-I: This is the lowermost unit and has prolific development of sandstone in the northern part of Jotana field, suggestive of a tide influenced estuary associated sand flat along the western part of the field. The rest of the area in the central and south Jotana and Warosan low having less sand and form mud flats and mixed flats. The Unit-I, thereby transforming the estuary into a typical tide influenced delta. There is better distribution of prograding sands from north in to the Warosan low by the retreating ebb current and

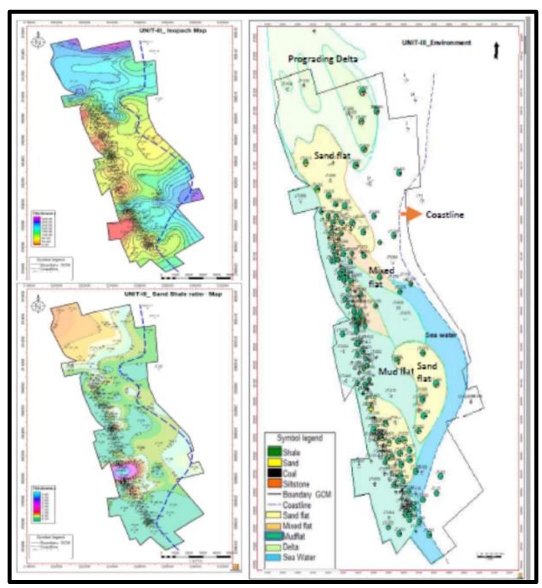

Fig-5: Isopach, sand/shale ratio maps and depositional environment of Unit-I

often are deposited orthogonal to the bay as longshore bars/sand flats in the southern part. (Fig:5).

Unit-II: The progradation of Unit–I was arrested during deposition of Unit-II, with withdrawal of sea from north and the entire area became rich in argillaceous matter and thin coal are formed in dominant shale. The area towards south however, forms new prominent sand flat along the western coast with a few tidal channels oblique to the coast dissipating thin sands in the central and the southern part of the Jotana field (Fig:6).

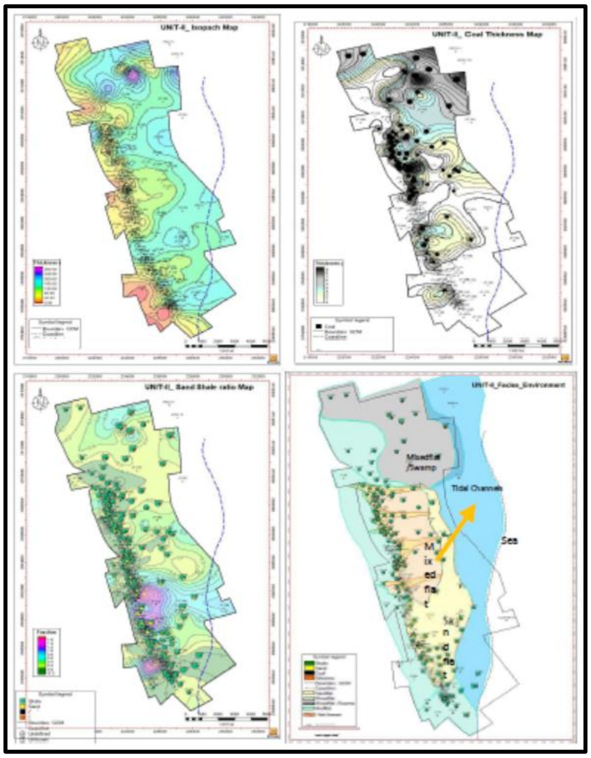

Fig-6: Isopach, coal thickness, sand/shale ratio maps and depositional environment of Unit-II

Unit-III: After the deposition of Unit-II, there is a gradual onset of transgression towards north, starting from minor modification of sand flat of Unit-II and followed by total reduction of sand in the entire area and onset of deposition of shale coal alternations and forming mud flats. The dominance of coal in Unit-III is an expression of the transgressive cycle covering the topmost Mandhali and the overlying Lower Tongue. Very thick sand flats especially during Unit-III and Unit-II in central and south Jotana field could have been developed by longshore currents moving sands originating from further southwest of Jotana field (Fig: 7).

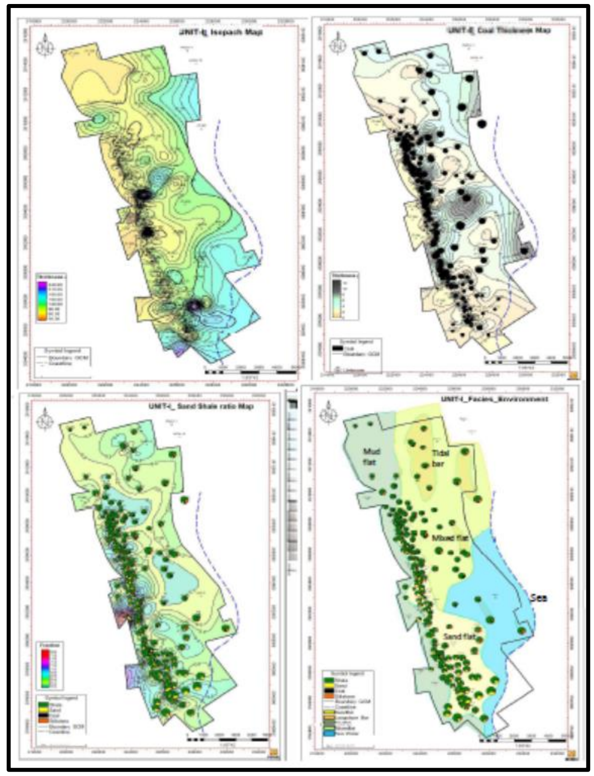

Fig-7: Isopach , coal thickness ,sand/shale ratio maps and depositional environment of Unit-III

On the basis of this study, the intertidal environment has been predicted in the northern blocks of Jotana field with sand flat area and in central eastern part of the AOI and in south west intertidal to sub tidal environment with mixed and sand flat area in the southern block. Sand Isolith maps of all the 23 pays of MU-I to MU-III were prepared giving the trend from depositional model.

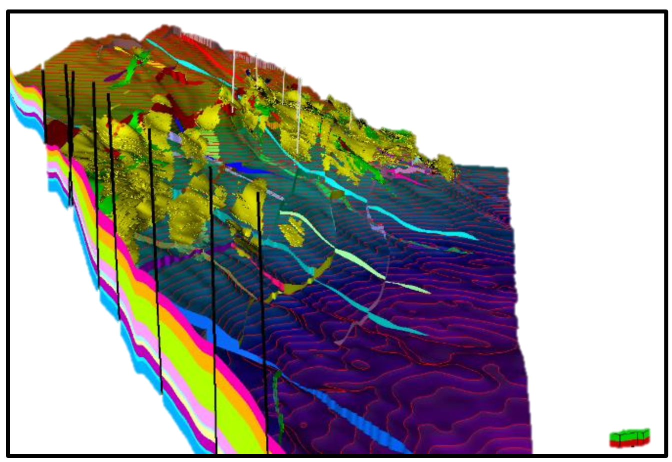

Fig-8: The 3D Geological Model of Mandhali Unit for the study area

This approach rendered a realistic image of the reservoir heterogeneity and capturing structural configuration (Fig:8).

Conclusion

The study was taken up to update geological model of the Mandhali pays and prepare 3D model. Mandhali unit was deposited in prograding deltaic environment for lower unit with substantial influence of tides with major sediment input direction from NNW.

Initially the arenaceous units were deposited in the northern part of the study area which shifted towards south during deposition of second and third unit.

Major challenges encountered in the area like the cross cutting of pay units in structural setup. The parasequence correlation with 5 pay sand in Unit-I and 9 pay sands in Unit-II and Unit-III respectively has resolved the ambiguity in understanding the spatial distribution resulting in building depositional model of Mandhali sands in Jotana field.

The work has brought out regional depositional model and resolved the understanding of sand dispersal pattern as well as hydrocarbon distribution pattern within Mandhali member and it was used for populating the facies in the reservoir model.

The results of the study are in line with expectations and the model is anticipated to contribute to more effective and efficient reservoir management.

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