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Seismic Mapping of Decollement Surfaces, Thrusts, and Related Structures in Assam-Arakan Fold Belt, India, for Hydrocarbon Exploration

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Abstract

The structurally complex fold belt of Assam – Arakan Basin, India, bestowed with two petroleum systems, vast sedimentary thickness, series of narrow, plunging folds and thrusts holds great potential for hydrocarbon generation and entrapment. Bulk of oil generation is estimated to be within the schuppen zone. Structurization is generally ascribed to thin skinned tectonics with major detachment planes at Oligo-Eocene that remains unmapped due to absence of well data and limitations of seismic imaging.

The present work attempts to identify the decollement planes on regional 2-D seismic lines through identification of certain features like selective deformation of post-Oligocene horizons above relatively undisturbed pre-Oligocenes. Besides thin skinned, an inclusive thick-skinned tectonics is also indicated by differential deformation in both Pre and Post Oligocene horizons. Transition from thin to thick skinned tectonics appears influenced by pre-existing basement highs. Additionally, thick argillaceous facies within Miocene sequences seemingly influence local fold, fault generation.

This study will contribute to the understanding of fold belt tectonics and associated structures and will be helpful in identifying favourable sites/structures for exploration.

Introduction

With the end of easy oil era, search for oil takes us to structurally and logistically complex areas, generally with limited subsurface data. The structurally complex fold belt of Assam – Arakan Basin, India, bestowed with vast sedimentary thickness and incorporating two petroleum systems within its three main paleoenvironments -forelands, foredeep and the fold and thrust belt with sedimentary thickness estimated upto 14 km (Fig 1) - holds great potential for hydrocarbon generation and entrapment. Regarding the origin of the Schuppen belt there are divergent views. The earlier workers in this field such as Mathur and Evans (1964), Murthy (1983) opined that the imbricate thrust sheets are actually basement involved reverse/inversion faults while others such as Ranga Rao and Samanta MK(1987) Ranga Rao (1983,1984),Bally (1997) favoured thin skinned tectonics. While the former envisaged decollement planes within Barails, the latter favoured Sylhet limestone. Prof Bally

(1997) identified three major structural styles-early extensional, Miocene reactivated early faults, and thirdly the “late compressional structures”. Current views on the subject consider the Oligo-Eocene as the major surface for detachment. Some authors also consider the thick argillaceous sediments of middle Bhuban (Miocene) to be also favourable for generating detachment surfaces (IFP/ONGC Report, 1997).

The present work attempts to examine the seismic evidences that may suggest the role of thin skinned or deep rooted (basement related) tectonics in present day Structurization. Of particular interest is the identification of thrust sheets that can provide regional seals for hydrocarbon entrapment.

Methodology and Observations

As part of the study, numerous 2-D lines and seismic volumes of the Assam-Arakan Basin, covering both the shelf and the fold belt parts were studied in both time and depth domain, with particular emphasis given to identify likely decollement planes that are indicated by significant local change in formation thickness in incompetent beds that can promote shearing and slippage. The sequence of narrow, elongated, plunging fold sand numerous thrusts in the area of considerable sediment thickness implies a rather shallow decollement plane for Structurization. However, severe limitations to the quality and quantity of seismic data have left this hypothesis undocumented.

The present work is an attempt to identify the dislocation planes (decollement) by

a. Generation of intra-formational thrust planes in incompetent beds

b. Indications of generation of reverse faults in deeper beds (Oligocene)

c. Indications of differential deformation of Pre-Oligo and Post –Oligocene

As part of study it was observed that in the shallow Shelf part of the basin, the basement is commonly faulted and occasionally the smaller blocks are tilted, with accretionary sediment prisms along them holding hydrocarbon prospects (Fig 2).

However, in the fold belt area, the sediment thickness is estimated to be upto 10000m, due to which (as well as limitations in seismic data acquisition in inhospitable terrain), the data is generally of poor quality and not resolvable below Oligocene (Renji Formation). Hence interpretation and inferences have been made based on available data.

The detailed discussion of the main concepts is as follows

a. Generation of intra-formational thrust planes in incompetent beds

Thick argillaceous facies within Miocene sequences seemingly influence local fold/fault generation. This feature has been observed in several sections in fold belt area. Localized thickening and thinning of shaly/clayey beds sandwiched between more competent beds (Fig

3) is indicated in the seismic section. Further deformation along these beds can result in generation of slippage planes, intra-formational thrusts etc.(Fig 4,5 and 6) that may develop into major dislocation planes by propagation with development of associated folds (fault propagation folds). Such features are quite common in Mid Miocene formation like Mid Bhuban.

b. Indications of generation of reverse faults in deeper beds (Oligocene)

As mentioned earlier, the Oligo-Eocene surface (Renji) is believed to be one of the major decollement surfaces. Accordingly, effort was made to locate evidences for slippage/shearing at this level. Fig 7 brings out slippage/shear planes generated in Post Oligocene layers during late stages of slippage while Fig 8 shows a much flatter, undeformed Oligocene surface overlain by more deformed Post –Oligocene layers. These sections have been extracted from a prominent structure of Tripura fold belt.

c. Indications of differential deformation of Pre-Oligo and Post –Oligocene

Decollement planes can also be interpreted by differently by less deformed layer underlying the more deformed layer. This feature was recorded in a number of lines. Flattening was done at Oligocene to bring out differential deformation. Some illustrations are given in Fig 9 and 10, extracted from a part of fold belt.

Summary

The Schuppen belt is considered as the most likely site for generation of hydrocarbons that are currently being tapped in the Assam shelf. The concept of thin skinned tectonics, that is likely to have given rise to a series of narrow, plunging folds and shears has been examined through relevant seismic sections, which are admittedly, not conclusive but do give a fair indication of localized thinning, thickening of beds leading to slippage, intra-formational thrusts and faults. Miocene and Oligocene sequences – comprising dominantly of interbedded sands and incompetent argillaceous units- appear to be most affected by this deformation, and likely to generate decollement surfaces. These nappes hold potential for draping the charged reservoir beds as well as generation of fault propagation folds that can be explored for hydrocarbons.

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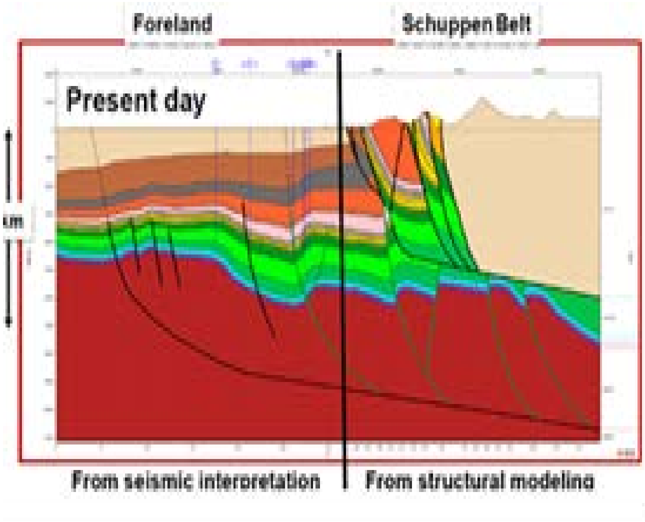

Fig 1 Schematic Geological Section across the Assam Shelf to the Schuppen Zone

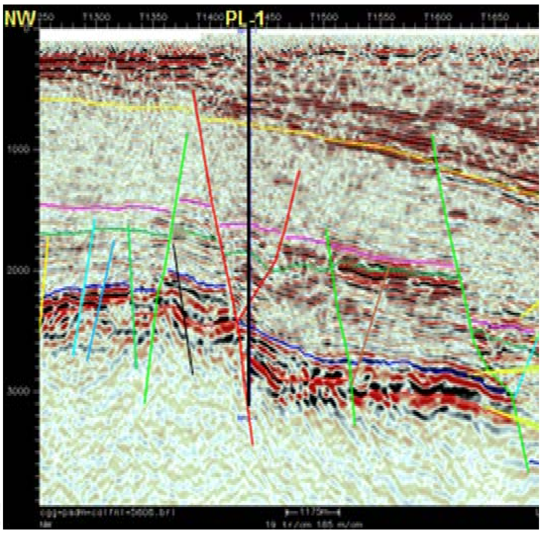

Fig 2 Down to Basement Faults seen in a part of South Assam Shelf

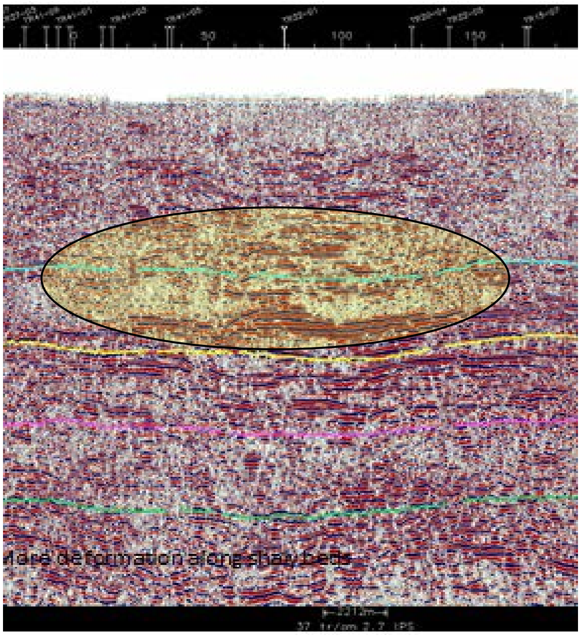

Fig 3 Showing development of localized thinning/thickening along Clayey beds (Miocene) in a part of Fold Belt

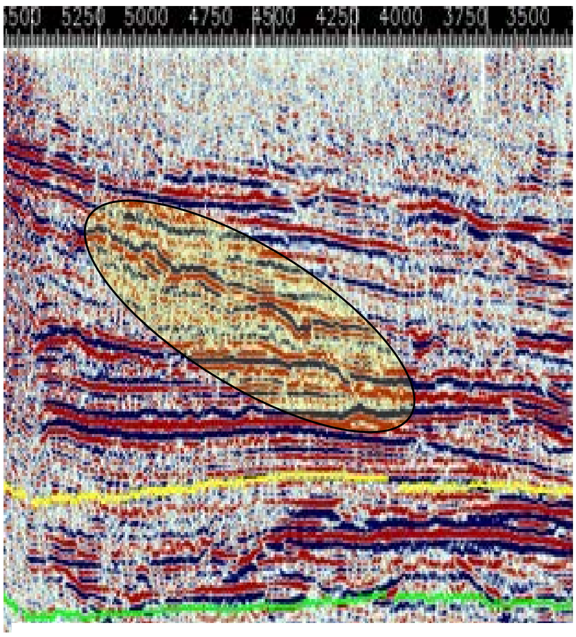

Fig 4 Development of intra-formational thrusts along incompetent beds (Miocene) in a part of Fold Belt

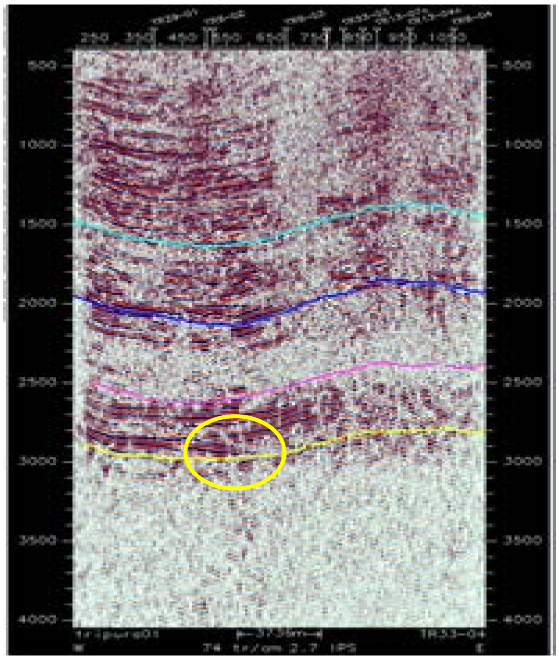

Fig 5 Shearing (Reverse Faulting) observed at Oligocene level

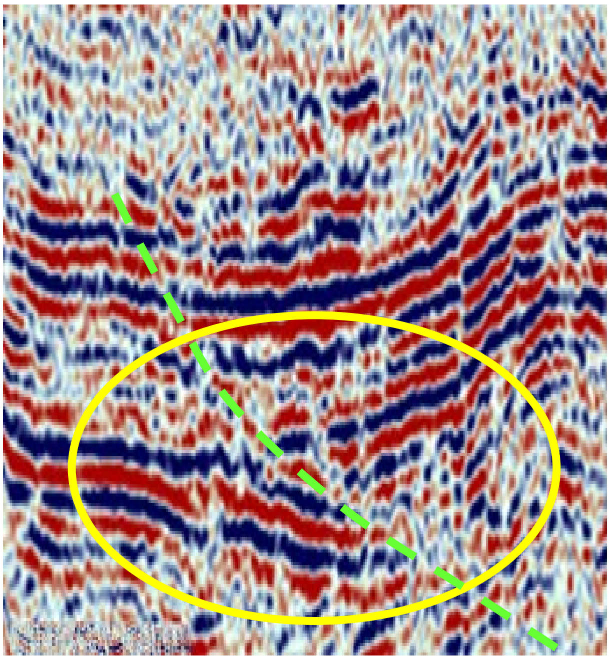

Fig 6 Close- ups of Sheared layer of Fig 5

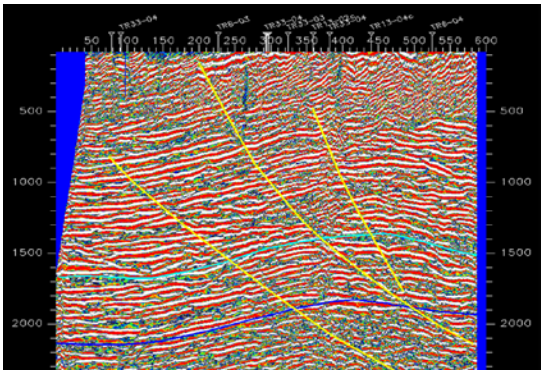

Fig 7 Section across a structure in Tripura indicating the probable detachment surface (Oligocene Renji Fm) along with generation of shears

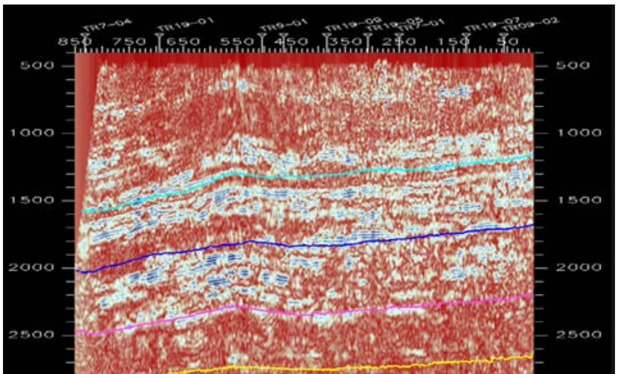

Fig 8 Probable decollement surface below Renji fm (less deformed of Oligo-Eocene)

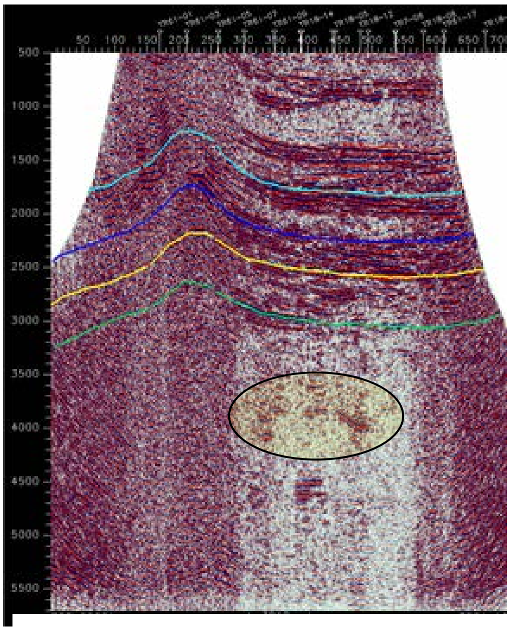

Fig 9 Showing Pre Oligocene layers more deformed than Post Oligocene layers extracted from a part of Fold Belt (Pre-Oligo highlighted)

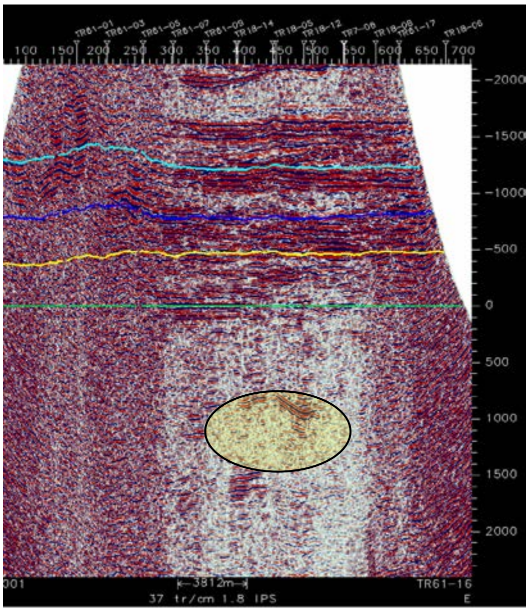

Fig 10 Pre Oligocene layers more deformed than Post Oligocene (After flattening at Oligocene level)