Abstract

The Tripura-Cachar-Mizoram areas in NE India and in adjoining areas of Bangladesh and Myanmar show a series of approximately N-S trending anticlines. Many of the anticlines are hundreds of km long and are spectacularly seen in regional satellite imagery-based DEM of NE India. Hydrocarbon systems in the NE India are mostly controlled by structural geometry formed during collision between the Indian and West Burmese plates in the late Mesozoic. Following Elliot's bow-and-arrow rule, the arcuate map pattern of the anticlines suggests an east-west collision and tectonic transport from east towards west. Although there are many producing oil/gas fields the NE Indian tectonic province, exploration efforts in the state of Mizoram have started recently. Recent geological/structural mapping and reflection seismic surveys in the remote and heavily forested hilly areas of Mizoram still do not permit definitive structural interpretations. In order devise an exploration strategy, including locations of first set of drilling, with minimum risk, the techniques of cross-section balancing have been applied. Balanced structural cross sections are essentially inverse structural modeling based on kinematics of fault-fold relations.

Out of sixteen anticlines present within the Mizoram exploration block, four anticlines and intervening synclines have been taken up for this study. The anticlines are named as Tuahzawl, Aibwak, Seling and Keifang anticlines. The dip domain data suggest that the anticlines are fairly tight, sub-horizontal, upright, and sharp-crested, except for Keifang anticline, which is flat-crested. Six different kinematically valid balanced cross sections could be constructed using the same data set. Structural models used include parallel and similar folding above a decollement surface, forward-breaking detachment folding and ramp anticlines, such as fault-bend/fault-propagation folding, with breakthrough structures and with or without simple shear. Multiple valid balanced cross sections with the same data set do not render the technique untenable; rather it helps in better risk assessment of hydrocarbon exploration. Multiple valid structural models suggest that the strategy of drilling at the crest of anticlines except for Keifang anticline is not a sound proposition and deviated drilling from eastern limbs of the anticlines offers minimum risk. Detailed structural modeling of each of the anticlines helps in determining drilling trajectory.
Mizoram Fold Thrust Belt, NE India: Initial Hydrocarbon Exploration Strategy Based on Balanced Structural Cross Sections

Ajoya N. Borthakur
Diganta Changmai
Oil India Ltd
Duliajan, India

Dilip K. Mukhopadhyay
Indian Institute of Technology
Roorkee, India
Content

• Geographical & Geological Setting of the study area
• Seismic data quality
• Stratigraphy and Surface Geological Data
• Structural Models adopted
• Conclusion
Where is Mizoram, NE India?

Why is it important?
Location of the Study Area

Mizoram Block MZ-ONN-2004/1
Regional Hydrocarbon Producing Areas

Discovery of commercially viable oil/gas reserve will open up new opportunities for further exploration.
Oil & Gas shows in Mizoram suggest potential hydrocarbon plays.
Geologic map of NE India, Bangladesh, and Burma showing the Mizoram Exploration Block MZ-ONN-2004/1.
DEM shows NS trending long anticlines
Structural control of hydrocarbon accumulation can be easily anticipated

Elliot’s bow-and-arrow rule gives tectonic transport direction
One would imagine seismics should give us a handle on the hydrocarbon exploration.
Seismics are of poor quality and definitive structural interpretation is difficult, if not impossible.
Even where seismic data are somewhat better, structural interpretation is model dependent.
Lack of quality seismic data is in part due to crooked survey lines in this logistically very difficult terrain and rugged topography.
Rugged topography
Road cuttings provide some geological clue
Structural modelling based on

• Geological map
• Surface structural data
• Stratigraphy from adjacent areas
• Kinematically valid structures
Geological Map of Central Mizoram

Anticlines:
T: Tuahzawl
A: Aibawk
S: Seling
K: Keifang

Block boundary
## Stratigraphy

<table>
<thead>
<tr>
<th>Age</th>
<th>Group</th>
<th>Formation</th>
<th>Lithology</th>
<th>Formation</th>
<th>Thickness, M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOWER</td>
<td>UPPER Bhuban</td>
<td>Sandstones</td>
<td>Shallow Marine</td>
<td>1200-1800</td>
</tr>
<tr>
<td>MIocene</td>
<td>SURMA</td>
<td>MIDDLE Bhuban</td>
<td>Shales</td>
<td>Marine</td>
<td>2000-2400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LOWER Bhuban</td>
<td>Sandstones and Shales</td>
<td>Shallow Marine</td>
<td>1000-1200</td>
</tr>
<tr>
<td></td>
<td>Oligocene</td>
<td>Renji</td>
<td>Sandstones</td>
<td>Shallow to Fresh Water</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>Barail</td>
<td>JENAM</td>
<td>Carbonaceous Shales</td>
<td>Lagoonal</td>
<td>1200-1500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LAISONG</td>
<td>Sandstones and Shales</td>
<td>Deltaic</td>
<td>1500-1750</td>
</tr>
<tr>
<td></td>
<td>Upper</td>
<td>DISANG</td>
<td>Dark Grey Shales with Thin Sandstones</td>
<td>Deep Marine</td>
<td>&gt; 3000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schelling report</th>
<th>Evans &amp; Mathur</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 - 1800</td>
<td>1100</td>
<td>1800</td>
<td>1200</td>
</tr>
<tr>
<td>2000 - 2400</td>
<td>600</td>
<td>2400</td>
<td>2000</td>
</tr>
<tr>
<td>1000 - 1200</td>
<td>1400</td>
<td>1200</td>
<td>1000</td>
</tr>
<tr>
<td>800</td>
<td>1000</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>1200 - 1500</td>
<td>1200</td>
<td>1500</td>
<td>1200</td>
</tr>
<tr>
<td>1500-1750</td>
<td>2400</td>
<td>1750</td>
<td>1500</td>
</tr>
<tr>
<td>&gt; 3000</td>
<td>&gt; 1500</td>
<td>&gt; 3000</td>
<td>&gt; 3000</td>
</tr>
</tbody>
</table>
Geological map of the northern part of the block
Structural data suggest horizontal, upright and fairly tight folds.
Outcrop-scale structures

Thrust fault

Upright, nearly chevron fold
Line of section, Dip domain data

Tuahzawl anticline
Aibawk anticline
Seleng anticline
Keifang anticline

Approximate topography

Up Bhuban
Mid Bhuban

Keifang section line
Regional section line

10 km
Folding models used

- **Fault-Bend Folding**
- **Fault-Propagation Folding**
- **Detachment Folding**
Structural model - I

Section line: UTM N2614000; No vertical exageration
Fold model: Fault-propagation folding, Fault-bend folding, flexural flow with or without shear

Shortening 26%
Structural model - II

Detachment folding
Structural model - III

Block MZ-ONN-2004/1

Approximate topography

Restored section

Section line: UTM N2614000
No vertical exaggeration
Fold model: Parallel
Maximum thickness

10 km
Structural model - IV

Block MZ-ONN-2004/1

W

Tuazvoc anticline
Albark anticline
Seling anticline
Keijang anticline

E

Loose line

Approximate topography

U Bhuban, 1200 m
M Bhuban, 2000 m
L Bhuban, 1000 m
Renji Fm, 800 m
Jenam Fm, 1200 m
Laisong Fm, 1500 m
Disang Gr > 3000 m

Restored section

Section line: UTM N2614000
No vertical exaggeration
Fold model: Parallel
Minimum thickness

10 km
Structural model - V

Block MZ-ONN-2004/1

Approximate topography

W Pin line

Thalazow anticline

Athawk anticline

Seling anticline

Keifang anticline

E Loose line

U Bhuban, 1800 m
M Bhuban, 2400 m
L Bhuban, 1200 m
Renji Fm, 800 m
Jenam Fm, 1500 m
Laisong Fm, 1750 m
Disang Gr > 3000 m

Restored section

Section line: UTM N2614000
No vertical exaggeration
Fold model: Similar
Maximum thickness

10 km
Structural model - VI

Block MZ-ONN-2004/1

West

- Tiahažawl anticline
- Albawik anticline
- Seling anticline
- Keifang anticline

East

- Loose line

Approximate topography

- U Bhuban, 1200 m
- M Bhuban, 2000 m
- L Bhuban, 1000 m
- Renji Fm, 800 m
- Jena Fm, 1200 m
- Laisong Fm, 1500 m
- Disang Gr > 3000 m

Restored section

Section line: UTM N2614000
No vertical exaggeration
Fold model: Similar
Minimum thickness

10 km
Tapering outcrop pattern for syncline between Tuahzawl-Aibawk anticlines
Tapering outcrop patterns for synclines is due to variable slip/shortening along the axial traces.
Exploratory drilling locations need to take into account all the structural models. Given the paucity of data, lack of definitive geological understanding and difficult logistics, Keifang anticline seems to be the “best” structure for initial exploration.
Thank you