Diagenetic Events, Reservoir Compartmentalization and its Relationship with Lower Order Relative Sea-Level Fluctuation in Early-Middle Eocene Sylhet Formation, South Assam Shelf (SAS), Assam and Assam-Arakan Basin*

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Abstract

Our work focuses on diagenetic events, reservoir quality and its relationship with sea-level fluctuation for the reservoir sands restricted in upper part of Early-Middle Eocene Sylhet Formation within South Assam Shelf. Synergy between sequence stratigraphy and diagenesis, however, enables prediction of spatial and temporal distribution of diagenetic alterations and post-depositional evolution of reservoir quality. It also provides information on diagenetic baffles and barriers for fluid flow, thus potential diagenetic reservoir compartments and seals. Sylhet Formation consists of mixed siliciclastic-carbonate sequence deposited in tide affected marginal marine to inner shelf carbonate ramp environment with episodic siliciclastic supply during regressive pulses within an overall fining-up transgressive unit. Twenty-one cores along with electrologs have been investigated to infer lithofacies, mineralogy and diagenetic facies controlling reservoir quality using petrography, XRD and SEM analysis. The dominant microfacies are calcareous quartz arenite/quartz wacke and arenaceous foraminiferal wackestone with minor dolostone. Twelve diagenetic facies have been identified within Sylhet Formation. The salient diagenetic features responsible for reservoir deterioration are intense early calcite cementation, authigenic pore filling kaolinite and chlorite. However, during lower order sea-level fluctuations, diagenetic alterations owing to percolation of meteoric water below subaerially exposed sequence boundaries causes extensive dissolution of calcite cement enhancing secondary porosity (~30%). Based on textural relationship among different diagenetic facies, a paragenetic sequence depicting two major diagenetic events, has been identified and mapped to bring out the diagenetic history. Paragenetic sequence includes early calcite cementation and its immediate dissolution in eodiagenetic stage, subsequent dissolution of feldspar and precipitation of kaolinite and quartz cements, followed
by patchy calcite cementation in mesodiagenetic stage. Porosity distribution map depicts good porosity in NE-SW corridor with isolated poor porosity pods. However, in some areas, primary porosity is preserved where localized acidic environment inhibits precipitation of early calcite cement. Integration of diagenesis and sequence stratigraphy thus constitutes a powerful tool for prediction of the evolution of reservoir quality and of diagenetic baffles for fluid flow and seals.
Diagenetic events, reservoir compartmentalisation and its relationship with lower order relative sea-level fluctuation in Early-Middle Eocene Sylhet Formation, South Assam Shelf (SAS), Assam and Assam-Arakan Basin

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5th November, 2018
Presentation Outline

- Introduction
- Case Study Area
- Results
- Conclusion
In most parts of the Assam shelf, Passive margin sequence starts from Paleocene.

Sedimentary column of Paleocene to Oligocene age is demarcated as younger 2\textsuperscript{nd} order passive margin sequence.

2\textsuperscript{nd} order TST is divided into three major lithostratigraphic units:
- Lower-Coarser Clastics (Tura Fm.)
- Middle-Carbonate (Sylhet Fm.)
- Upper-Finer Clastics (Kopili Fm.)
Work Flow

**Sedimentological Studies**
- Microfacies analysis and Reservoir characteristics
  - Paragenetic Sequence and Fence Diagram
  - Diagenetic Map
- Facies architecture and association
- Paleo-depositional environment

**Electrolog**
- Vertical and Lateral Facies Distribution and lower order genetic correlation
- Facies maps
- Depositional Model
Diagenetic Facies
Glauconitisation

Well M-7, CC-1, 2836.8m glauconite pellets as framework grains

Well C-8, CC-2, 2700.60m

Well C-8, CC-2, 2700.60m

Well C-8, CC-2, 2700.60m

Well C-8, CC-2, 2700.60m

Well M-7, CC-1, 2836.8m

Well M-7, CC-1, 2836.8m

Well B-57, CC-3, 2479.6
Alteration of Glauconite

Well C-8, CC-1, 2702.5m

Well B-25, CC-1, 2734.4m

Well F-1, CC-1, 1587.8m

Well B-1, 1300-1305m

Well M-7, CC-1, 2840m

Well M-7, CC-1, 2836.8m
Anhydrite cementation (Early)

Well B-57, CC-3, 2479.6m
Well B-57, CC-3, 2479.9m
Well B-57, CC-3, 2480m
Well B-57, CC-3, 2475.2m
Well H-3, 1585-90m
Well H-3, 1585-90m

Quantitative results

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<th>Weight%</th>
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<tr>
<td>0</td>
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<tr>
<td>20</td>
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<tr>
<td>40</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>80</td>
</tr>
</tbody>
</table>
Calcite cementation (Early)

Well M-7, CC-1, 2840m

Well C-8, CC-2, 2700.60m

Well E-4, 2055-60m

Well C-8, CC-2, 2700.60m

Well B-57, CC-3, 2479.9m

Well S-1, 2945-50m
Chloritisation

Well C-8, CC-2, 2703.8m
Well B-57, CC-3, 2475.2m
Well C-8, CC-2, 2705.6m
Well C-8, CC-2, 2705.6m
Well B-25, 2734.9m
Well B-25, 2734.9m
Pyritisation and Iron-oxide cement

Well C-8, CC-2, 2700.60m

Well C-8, CC-2, 2700.60m

Well N-1, 1406.3m

Well C-8, CC-2, 2702.50m

Well E-4, 2030-35m

Well B-25, 2729.2m
Calcite cementation (Late)
Kaoliniteisation
Mechanical compaction
Constructive Porosity

Well C-8, CC-2, 2705.6m

Well B-25, 2734.9m

Well K-2, 23305-10m

Well K-2, 23305-10m

Well C-8, CC-2, 2703.8m

Well C-8, CC-2, 2700.6m
Constructive Porosity

Well N-1, 1406.8m

Well N-1, 1406.8m

Well N-1, 1406.3m

Well K-31, CC-3, 2333.30m

Well K-31, CC-3, 2333.30m

Well K-31, CC-3, 2333.30m
Constructive Porosity

Dissolution of feldspar

Clay coating

Well C-8, 2703.8m

Well M-7, 2836.3m
Destructive Porosity

Well C-8, 2705.6M: Quartz overgrowth and chlorite clay

Well B-57, 2479.6m

Well K-31, 2333.3m: quartz overgrowth and chlorite clay

Well G-1, 2155-60m

Well K-31, CC-3, 233.3m

Well M-7, 2836.8m: quartz overgrowth and chlorite clay
## Sedimentological Attributes

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter/Observation</th>
<th>Diagenetic Process</th>
<th>Inference</th>
<th>Diagenetic stage</th>
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<tr>
<td>1</td>
<td>Floating contact with calcite cement</td>
<td>Precipitation</td>
<td>Early diagenetic cementation</td>
<td>Eogenesis</td>
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<tr>
<td>2</td>
<td>Corroded quartz</td>
<td>Dissolution</td>
<td>Etching of quartz grains</td>
<td>Eogenesis</td>
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<tr>
<td>3</td>
<td>Good porosity along with etched quartz</td>
<td>Dissolution</td>
<td>Dissolution of early calcite cement</td>
<td>Eogenesis</td>
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<tr>
<td>4</td>
<td>Bent mica/deformed glauconitic pellets</td>
<td>Compaction</td>
<td>Mechanical compaction due to overburden pressure</td>
<td>Mesogenesis</td>
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<tr>
<td>5</td>
<td>Suture contacts</td>
<td>Compaction and recrystallization</td>
<td>Pressure solution due to mechanical compaction</td>
<td>Mesogenesis</td>
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<tr>
<td>6</td>
<td>Feldspar dissolution/kaolinite precipitation</td>
<td>Dissolution</td>
<td>Burial diagenesis</td>
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<tr>
<td>7</td>
<td>Silica cemenattion</td>
<td>Precipitation</td>
<td>Late diagenetic cementation</td>
<td></td>
</tr>
</tbody>
</table>
Paragenetic sequence and diagenetic stages

**Eogenesis**
- Iron cement (Eg. K-31)
- Authigenic coating (M-7)
- Detrital coating (mostly ferruginous clays)
- Intense corrosion of quartz by replacement (floating contact) (Eg. B-57, C-8 etc.)
- Dissolution of calcite cement, creation of secondary porosity (K-2, M-7)

**Mesogenesis**
- Feldspar dissolution
- Mechanical compaction (Eg. N-1, B-57)
- Kaolinite precipitation (Eg. K-31, B-57)
- Extensive Quartz overgrowth (Eg. C-8, B-25)
- Authigenesis of chlorite (Eg B-25)
<table>
<thead>
<tr>
<th>Age</th>
<th>FIRST ORDER</th>
<th>2ND ORDER</th>
<th>3RD ORDER</th>
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<td>Boundary</td>
<td>Sequence</td>
<td>System</td>
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<td>3.8 Ma</td>
<td>CB-126</td>
<td>Q3-1H3</td>
<td>HAST</td>
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<td>3.2 Ma</td>
<td>CB-116</td>
<td>Q3-1H3</td>
<td>LAST</td>
</tr>
<tr>
<td>6.3 Ma</td>
<td>CB-108</td>
<td>Q3-1H3</td>
<td>HAST</td>
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<td>CF-1 mfs</td>
<td>Q3-1</td>
<td>HST</td>
</tr>
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<td>21.6 Ma</td>
<td>Cl 44</td>
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<td>25.5 Ma</td>
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<td>37.2 Ma</td>
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<td>46.3 Ma</td>
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<td>58.5</td>
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</tbody>
</table>

**EME-1**

- TST
- MFS-3
- FS-3
- FS-2

- HST
- MRS-3
- MRS-2
NW-SE profile showing the distribution of different systems tracts in dip direction
M-7 CC#1 (2846-2856m) Recovery 33%

Top

Sandstone with rip-up mud clast at base

Whole core

Intermixed sandstone shale as a result of burrowing activity

Depth 2850.8m: Photomicrograph depicting flood-Ebb cyclicity

Depth 2850.8m: SEM image showing good intergranular porosity

Depth 2854m: Photomicrograph depicting calcareous quartz arenite microfacies

Depth 2850.8m: General view showing moderate intergranular porosity
C-8 CC#2 (2700-2708m) Recovery 96.25%

**Depth 2700.6m:** SEM image showing secondary porosity created by dissolution.

**Depth 2705.6m:** Enlarged view showing pore spaces.

**Depth 2700.6m:** Etched quartz grains floating in calcite cement.

**Depth 2700.6m:** Enlarged view depicting etching of quartz grains by patchy calcite cement.

**Depth 2700.6m:** Massive Sandstone

**Argillaceous Sandstone**
Fence diagram depicting sedimentological attributes and porosity distribution in between MFS_3rd-3 (bottom) and FS_4th-3 (top) within South Assam Shelf

Fence diagram depicting sedimentological attributes and porosity distribution in between FS_4th-3 (bottom) and MRS_3rd-3 (top) within South Assam Shelf
Paragenetic sequence 1) Eogenesis a) Early calcite cement b) Dissolution of early calcite cement,  
II) Mesogenesis a) Kaolinite cement (southern part) and silica cement (northern part) b) Patchy calcite cement;
Porosity distribution map showing zones of good primary and secondary porosities and poor porosity
Conclusion

◆ Carbonate cementation is more extensive in TST sandstones that creates reservoir compartments between amalgamated sandstone

◆ A fall in relative sea-level and exposure of the sand in Sylhet Formation is accompanied by infiltration of meteoric waters, which results in dissolution of pre-existing calcite cement, leads to creation of secondary porosity.

◆ Two paragenetic sequences identified viz. early diagenetic stage (eogenesis) and late diagenetic stage (mesogenesis). In Eogenesis, intense calcite cementation has created a mappable corridor and during regressive phase, dissolution of early calcite cement has created good secondary porosity zones. In Mesogenesis, kaolinitisation is the salient diagenetic event which has reduced the porosity.

◆ The porosity distribution map shows an overall good porosity corridor along NE-SW direction with patchy zones of poor porosity. The map also depicts better porosity zones in eastern and western part. In the eastern part (basinal), good porosity zones may be interesting from the hydrocarbon point of view because of its close proximity to kitchen area. In contrast, in the western margin part, is more prone to sub-aerial exposure resulting in development of secondary porosity and consequent structurally favourable entrapment condition.
Thank You