Fluvial-Tidal Sandbody Relationships in the “Nonmarine” Iles Formation near Rangely, Colorado*

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Abstract

Tidal influence has been rarely reported in the geologic literature in the nonmarine portions of the Upper Mesaverde Group in the Piceance and Uinta basins. However, a detailed field study of the nonmarine Iles Formation north of Rangely, CO, finds a number of tidal indicators, including paleocurrents in the landward direction, mud drapes and double mud drapes, and sigmodial cross-stratification. Tidal influence is strong within the field area despite its location 60 to 70 km to the closest transgression of the Iles shoreline. Tidal units in the field area occur in six sandbody types: tidal bars, tidally influenced channel fills, fill-and-spill channels, tidally influenced splays, tidal constructional bars, and tidally influenced braided complexes. Fluvially dominated sandbody units are also present within the field area, including point bars, fluvial channel fills, fluvial constructional bars, and minor crevasse sprints and channels.

A cyclical pattern of tidal influence is observed in the field area. The lower portion of the field area is strongly tidally dominated. Tidal influence decreases upwards with the middle portion of the field area exhibiting fluvial dominance. The upper portion of the field area shows evidence of increasing tidal influence. This cycle is linked to the migration of relative sea level. Multiple cycles of mudstone to sandstone dominance are also observed within the field area. These cycles occurred on a shorter time scale and represent the migration of the main channel belt in and out of the area. Strata in the field area are correlated into the Cozzette and Rollins members based on the cycles of tidal influence, amalgamation of sandstone units, and evidence of lengthy subaerial exposure.

Selected References


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Jeffrey A. Thompson & Donna S. Anderson
Rocky Mt Section AAPG
June 29, 2011
Objectives

- What types of sandbodies are present within the field area?
- How do they vary in geometry and facies architecture?
- How did the depositional environment change over time?
  - Signs of tidal influence?
- What are sequence stratigraphic implications?
  - Correlation with marine members of the Iles Formation?
Iles Formation

- Late Campanian (76-70 Ma)
- Mesaverde Group
  - Above Sego Sandstone
  - Below Williams Fork Formation
- Three members (marine shoreface units)
  - Corcoran (lower)
  - Cozzette (middle)
  - Rollins (upper)
- Near Rangely (this study)
  - Lower Unit
  - Coal Unit
    - Main Coal Zone (middle)
  - Upper Unit
  - Described as “nonmarine”

From Hettinger and Kirschbaum (2002)
Iles Formation Shorelines

Study Area is 60 to 130 km NNW of Projected Max Transgressive and Max Regressive Iles Shorelines, Respectively

Modified from Gomez-Veroiza and Steel (2010)
Regional Location of Field Area

- Northwest Colorado
  - 13 km north of Rangely
- North of Douglas Creek Arch
- North flank of Rangely Anticline, south flank of Red Wash Syncline

Modified from Green (1992), Sprinkel (1999) and Wray et al. (2005)
Field Area Detail

- ~1 sq. km
- ~97 m stratigraphic thickness
- Above area studied by Anderson (2005)
- Lower ~50 m
  - 8 major sandbodies
    - 23 subbodies
  - 11 thin sandstone units
- Structural dips of 3° NNE
Methods

- GPS Mapping
  - 1:500 scale in 1 km²
  - >900 waypoints on contacts, marker beds, fossil localities
  - ArcGIS on DEM
- 48 measured sections
  - 1:20 scale
  - 16 Lithofacies (emphasized sandstone)
- 10x V.E. Cross-sections
  - Maps of facies architecture for 8 major and 11 minor sandbodies
  - Calculated facies proportions for each body
Stratigraphic Intervals

3 Sandstone-rich Intervals containing major sandbodies, Separated BY:
4 Mudstone-rich Intervals:
Lower 3 lack Coal, Upper (M4) is coal-rich
Capped at top by “coal marker sandstones” correlated to base of Williams Fork by Brownfield et al., 2000
### Facies

<table>
<thead>
<tr>
<th>Color</th>
<th>Facies Name</th>
<th>Characteristics</th>
<th>Interpretation</th>
<th>Facies Association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>organic material from terrestrial plants</td>
<td></td>
<td>floodplain lake/marsh</td>
<td>Floodplain</td>
</tr>
<tr>
<td></td>
<td>organic-rich mud, plant fragments and root traces</td>
<td></td>
<td>shallow floodplain lake/marsh</td>
<td>Floodplain</td>
</tr>
<tr>
<td></td>
<td>mud and silt sized grains, plant and vertebrate fossils common</td>
<td></td>
<td>overbank and abandonment deposits</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>abundant root traces, lower very fine to lower fine sand</td>
<td></td>
<td>highly rooted, bioturbation index 5</td>
<td>Floodplain</td>
</tr>
<tr>
<td></td>
<td>vertical and horizontal burrows, upper very fine sand</td>
<td></td>
<td>highly burrowed, bioturbation index 3-4</td>
<td>Floodplain</td>
</tr>
<tr>
<td></td>
<td>symmetrical ripples, vertical burrows, medium very fine sand</td>
<td></td>
<td>wave ripples in floodplain lake</td>
<td>Floodplain</td>
</tr>
<tr>
<td></td>
<td>mud-draped, sigmoid shape ripples, upper fine to lower medium sand</td>
<td></td>
<td>tidally modified low velocity traction flow</td>
<td>Channelbelt</td>
</tr>
<tr>
<td></td>
<td>current ripples, lower very fine to lower medium sand</td>
<td></td>
<td>low energy traction flow</td>
<td>Channelbelt</td>
</tr>
<tr>
<td></td>
<td>climbing ripples, upper very fine to upper fine sand</td>
<td></td>
<td>low energy traction flow with high deposition rate</td>
<td>Channelbelt</td>
</tr>
<tr>
<td></td>
<td>mud-draped, planar tabular cross-stratified sandstone</td>
<td></td>
<td>moderately high velocity traction flow with periodic hiatuses</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>35 cm thick sigmoidal cross-sets, lower fine sand</td>
<td></td>
<td>moderately high velocity traction flow with subordinate current direction</td>
<td>Channelbelt</td>
</tr>
<tr>
<td></td>
<td>convolute laminations, upper very fine to lower medium sand</td>
<td></td>
<td>post-depositional liquefaction</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>no sedimentary structures, lower very fine to lower medium sand</td>
<td></td>
<td>post-depositional liquefaction</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>10 to 90 cm thick planar tabular cross-sets, lower very fine to lower medium sand</td>
<td></td>
<td>moderately high velocity traction flow</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>5 to 35 cm thick trough cross-sets, upper very fine to lower medium sand</td>
<td></td>
<td>high velocity traction flow</td>
<td>Floodplain, Channelbelt</td>
</tr>
<tr>
<td></td>
<td>pebble to lower boulder mud clasts in very fine to fine sand matrix</td>
<td></td>
<td>very high energy traction flow (units with boulder sized clasts - bank collapse)</td>
<td>Channelbelt</td>
</tr>
</tbody>
</table>

**Low energy**

**High energy**
Sandbodies: Tidal & Fluvial Recognized
Tidally Influenced Sandbody Types

- **Tidal Bars**
  - 3 (Subbodies I1, I2, and J2)
- **Tidal Constructional Bar**
  - 1 (Subbody A2)
- **Tidally Influenced Channels**
  - 2 (Subbodies I3 and D/E1)
- **Fill-and-Spill Channels**
  - 2 (Subbodies J1 and J3)
- **Tidally Influenced Braided Complex**
  - 1 (Subbody D/E2)
- **Tidally Influenced Splay**
  - 1 (Subbody A1)
Sandbody I [S1 Interval] (Tidal bars/Tidally Influenced Channel Fill)

- **I1- Tidally dominated**
  - Westerly paleocurrents
  - Sigmodial cross-stratification
  - Tidal bundling
  - Mud drapes and double mud drapes

- **I3- Tidally influenced**
  - Decreasing tidal influence

Lower Red-Brown Marker

Legend: Measured sections, Sandbody I Deposits

Decending tidal influence

Subbody I3
n=10
mean=127°

Subbody I1
n=31
mean=300°
Sandbody I [S1 Interval] (Tidal bars/Tidally Influenced Channel Fill)
Sandbody I [S1 Interval] (Tidal bars/Tidally Influenced Channel Fill)
Sandbody A [S1 Interval] (Tidally Influenced Splay/Tidal Constructional Bar/Fluvial Channel Fills)

- Westerly paleocurrents
- Mud drapes

Subbody A2
- n=5
- mean=177°

Subbody A4
- n=5
- mean=149°

Subbody A3
- n=5
- mean=89°

Upper Subbody A1
- n=10
- mean=76°

Lower Subbody A1
- n=11
- mean=258°

Decreasing tidal influence
Sandbody A [S1 Interval] (Tidally Influenced Splay/Tidal Constructional Bar/Fluvial Channel Fills)
Fluvially Dominated Sandbody Types

- Fluvial Constructional Bars
  - 4 (Subbodies G2, G3, G4, and B)

- Point Bars
  - 1 (Subbody C)

- Fluvial Channel Fills
  - 8 (Subbodies A3, A4, H1, H2, G1, F1, F2, and F3)

- Minor Crevasse Splays and Channels
  - 11 (Minor Sandbodies)
Sandbody B/C [S2 Interval] (Fluvial Constructional Bar/ Point Bar)
Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced Braided Complex)

- Westerly paleocurrents
- Herring bone cross-stratification
- Tidal bundling
- Mud drapes
- Marine fossils

Increasing tidal influence
Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced Braided Complex)

Landward Increasing thickness
Sandbody D/E [S3 Interval] (Tidally Influenced Channel Fill/Tidally Influenced Braided Complex)
Subbody D/E2 (major body in Zone S3)

Isopach: 12m (39ft) thick, 900 m (2900 ft) wide

High barform preservation within a thick succession of high net:gross sandstone
Maximum Flooding Surfaces

- Tidal indicators
  - Decreasing in S1
  - Increasing in S3

- Regional coal
  - Above Sandbody D/E (M4 interval)

- Two maximum flooding surfaces
  - Base of S1 interval
  - Top of S3 interval or coal bed in M4 interval
Sequence Boundaries

- Sandstone amalgamation
  - Up to 22m of continuous sandstone in S3
- Lengthy subaerial exposure
  - Concentration of terrestrial fossils at base of S1 and S3
  - Possible paleosols in S3
- Two sequence boundaries
  - Base S1 interval (merged with MFS)
  - Lower S3 interval

Location of permineralized wood fossils
Sequence Boundaries

- Sandstone amalgamation
  - Up to 22m of continuous sandstone in S3
- Lengthy subaerial exposure
  - Concentration of terrestrial fossils at base of S1 and S3
  - Possible paleosols in S3
- Two sequence boundaries
  - Base S1 interval (merged with MFS)
  - Lower S3 interval
Conclusions

10 Sandbody Types
- 6 tidal
- 4 fluvial

Low gradient coastal plain
- Tidal Influence > 60 km inland

Strong tidal influence in alternating, cyclical pattern
- Decreasing then increasing
- Linked to 4th-order relative sea-level changes?

Likely Correlates to Cozzette to Rollins members of Iles Fm.
- Based on tidal indicators, sandstone amalgamation, and evidence of lengthy subaerial exposure
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Questions?