Common Depositional Sequences

Sequences that represent geologically instantaneous events, lasting a few hours to a few days

Point Bar (Meandering River)

<table>
<thead>
<tr>
<th>C</th>
<th>S</th>
<th>Sand</th>
<th>Gr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Flood Plain</td>
<td>Crevasse splay/levee sands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Point Bar</td>
<td>Climbing ripples</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Channel</td>
<td>Large trough cross laminations (sometimes HVL at base)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mud pebble conglomerate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Channel scour</td>
</tr>
</tbody>
</table>

Hummocky (Sirm Shelf)

<table>
<thead>
<tr>
<th>C</th>
<th>S</th>
<th>Sand</th>
<th>Gr</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M - mud</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X - cross laminations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F - flat bed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>H - hummocky unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- lag gravel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gutter</td>
<td>flute</td>
</tr>
</tbody>
</table>

L-Bar/T-Bar (Braided River)

<table>
<thead>
<tr>
<th>C</th>
<th>S</th>
<th>Sand</th>
<th>Gr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T Bar</td>
<td>L Bar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T Bar</td>
<td>L Bar = gravel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T Bar = large planar cross beds</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>T Bar</td>
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</tbody>
</table>

Bouma (Turbidity Current: Submarine Fan)

<table>
<thead>
<tr>
<th>C</th>
<th>S</th>
<th>Sand</th>
<th>Gr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T_E - shales</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_D - laminated silts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_C - small trough cross laminations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_B - high velocity laminations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_A - graded sands</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>flutes and tool marks</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>thickness in centimeters</th>
<th>thickness DM to M</th>
</tr>
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<tbody>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>thickness in centimeters</th>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Regime Divisions and Resulting Sedimentary Structures</td>
<td>High Energy</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Upper Flow Regime</strong></td>
<td>Plane Bed (HVL)</td>
</tr>
<tr>
<td><strong>No Deposition, Erosion</strong></td>
<td>(All particles in motion)</td>
</tr>
<tr>
<td><strong>Flute Marks</strong></td>
<td>Antidunes</td>
</tr>
<tr>
<td><strong>Scours</strong></td>
<td>Chute and Pool</td>
</tr>
<tr>
<td><strong>Channels</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sediment Channel Fill</strong></td>
<td></td>
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</tbody>
</table>

*Increasing water velocity*
Submarine Fan Depositional Models

Fig. 12.45. Carboniferous-Permian Sweetwater Slope Group of the Midland Basin Texas (after Galloway and Brown, 1973).
History of Divergent Plate Boundaries

Hot Spot / Thermal Doming

Foundering of Rift Valley / Marine Invasion

Early Divergent Margin Sediment Wedge

Newly Opening Ocean Basin

Mid Oceanic Rift (Generating Ophiolite Suite)

Early Divergent Margin

Full Divergent Margin
Depositional Systems in Two Stages
In the Development of a Terrestrial Rift System

(a) Early Fault Stage: Initiation stage: numerous isolated fluvo-lacustrine sub-basins.

(b) Interaction and Linkage Stage; abandonment of smaller grabens.
Wave Translation Across a Shallowing Shelf and Typical Structures

Lower-Lower Structures

Unidirectional

Combined

Oscillatory

Unidirectional

Wave washup

Plunging

Spilling

Asymmetric

Stokes

Sinusoidal

Upper-Lower Structures
Text book hummocky sequence

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**Shallow, proximal, near shore**

- Thick, amalgamated sand beds with large planar and/or trough cross beds; small ripples common.

- Very thick amalgamated sandstone beds with reactivation surfaces; thickening and thinning, intersecting lamination bundles, or undulating lamination bundles, sometimes with "" (hummocky) upper surface, and/or small ripples.

- Thicker beds that may swell and pinch laterally, sometimes disappearing altogether; laminations may truncate at top or bottom of bed; some beds with more than one lamination bundle; overlying bundles scour into underlying bundles; may have rippled upper surfaces.

- Thin, flat-laminated beds of uniform thickness, or that begin to undulate - over meters horizontally - laminations follow top and bottom of bed; coarse silt to very fine sand.

**Deep, dark, distal shelf**

- Top of underlying parasequence

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**Flooding Surface**
Upper Martinsburg (Cub Sandstone), Catherine Furnace. 
Measured by Rick Diecchio and Lynn Fichter, August, 2012

Parasequence Boundary 1
- thin fine wackes
- (not to scale)
- thins 1.6-2.3; laminations

Parasequence Boundary 2
- thin amalgamated sands w/ clay drapes
- laminated, clean
- convolute bedding (erosional weathering?)
- pinches to zero

Parasequence Boundary 3
- thinning; dipping laminations (hummocky)
- thinning; dipping laminations (hummocky); abndr brachiopods
- laminations

cm scale; fine, wacke sand beds may be present

lower outcrop too deteriorated to measure accurately
Upper Martinsburg (Cub Sandstone), Catherine Furnace.
Measured by Rick Diecchio and Lynn Fichter, August, 2012
Upper Martinsburg (Cub Sandstone), Catherine Furnace. 
Measured by Rick Diecchio and Lynn Fichter, August, 2012

Amalgamated, laminated sand beds, 0.5 to couple dm thick; thinning and pinching (hummocky)

Wacke with lenticular bedding (not to scale)
Hummocky (laminations in thinning bundles)
Thin, flaky bedding
Graded bedding?
Reactivation surface
Reactivation surface
Reactivation surface
Reactivation surface

Amalgamated, showing little distinct internal structures

Undulating top

Probably amalgamated showing little distinct internal structures

Scour

Wacke (thin, flaky bedding)
Large trough cross bedding
Wacke (thin, flaky bedding)
Graded bedding?
Large planar cross bedded

Interbedded sandstones/shales; generally thickening upward (not to scale)

Amalgamated, laminated sand beds, 0.5 to couple dm thick; thinning and pinching (hummocky)

Covered

Silty; perhaps lenticular

Laminations

Scour (clay filled)

No clear internal structures; probably amalgamated

meters & decimals

80

81

82

83

84

85

86

87

88

90

91

92

93

94

95

96

80

79

78

77

76

75

74

73

72

meters & decimals

90

89

88

87

86

85

84

83

82

81

80
**State of the Outcrop and Measured Section**

The Catherine's Furnace section of the "Cub sandstone" or upper Martinsburg is badly deteriorated by weathering, masking many of the sedimentologic and stratigraphic signatures. Some relatively clean arenite beds do stand out, but wacke beds are more common and often have diffuse boundaries, especially at the top where they may grade or fine upward into flaky weathered units looking superficially like weathered silt or shale but on close examination are sand rich. Many parts of the outcrop that look to be dominated by weathered shale/silt have sand rich zones that may be lenticular, wavy, or flaser-type bedding, but without distinct bed contacts to identify them. Sand rich zones were not mapped as beds unless distinct contacts were visible. We frequently used the cleavage to distinguish shale layers because the shale cleavage differs by a few degrees from the bedding fissility of weathered wacke or silt beds.

Many of the sand beds change thickness laterally, thickening and/or thinning, or pinching to zero, but it is easy to miss these changes. The thickening/thinning may occur on both the top and bottom of the bed; or one or the other; often it is not possible to tell. Some sandstones show internal layering (laminations or cross bedding), and were indicated as such, but many do not, or have only a faint hint of internal layering. We assume that all the sandstone beds were deposited by flow regime conditions that would result in laminations, beds, or bedsets (as opposed to mass transport mechanisms), consistent with the beds for which we do have flow regime structures.

Many of the thicker sandstone beds are almost certainly amalgamated (composed of more than one deposition event separated by reactivation surfaces, such as scours, clay drapes, or pebble lags). In some cases the reactivation surfaces were visible, but often they were not. Flow regime and environmental interpretations are based on a composite of all the information in the section and extrapolated to parts of the section where evidence was sketchy or missing. Our interpretation is most consistent with storm shelf parasequence models.

It is difficult to be entirely objective when measure a section like this. We strove to be consistent in the accuracy and precision of the data collected, especially across the coarsening/thickening upward changes in the section, but someone else might make different judgements about what is significant or not, and therefore what patterns are present. We welcome discussion and debate on these differences of observation and opinion.
Composite Sea Level Curves and Sequences

- 2nd order curve
- 3rd going up
- 4th going down; muted rise
- 3rd and 4th both going down; exaggerated fall
- 3rd and 4th both going up; exaggerated rise
- 4th going up when 3rd going down; para-sequence thinner than average
- Fall = shallower
- Rise = deeper
The QFL Distribution Of Sedimentary Rocks In Various Tectonic Regimes

Stable Continental Craton

Block Faulted Continental Basement (including continental rift systems)

Quartz

Feldspar

Recycled Orogen
Continent-continent collision, or Continent-volcanic arc collision

Volcanic Island Arc

Lithics
Interpretive Cross Sections From Eastern West Virginia Across Northern Virginia
Showing Deep and Shallow Taconic Facies Relative to Present Geology

Divergent Continental Margin (DCM) carbonate shelf

CO (Cambrian to Middle Ordovician strata)

Grenville basement and rift graben with clastic fill

PRE-TACONIAN (CHAZYAN)

western Taconic facies (clastic shelf)

CO (Cambrian to Middle Ordovician strata)

Grenville basement and rift graben with clastic fill

TACONIAN (CINCINNATIAN)

MASSANUTTEN SYNCLINORIUM

BLUE RIDGE FRONT

western Taconic facies

Sil/Dev eastern Taconic facies

present-day surface

Blue Ridge Overthrust
(complex of overthrust basement and terranes; volcanic arc/microcontinents)

Cambro-Ordovician DCM sediments

Precambrian basement

Alleghenian (Late Paleozoic)

R.J. Dieckho, 1993 Tectonics v 12, no 6, redrawn by L.S. Fichter, 1999
Predictive Model for Development of the Chilhowee Group in the Blue Ridge From Elkton to Luray, Virginia

F - Early Cambrian (700 - 570 Ma)
- Swift Run Cataclinal Fold
- Early proto-Atlantic Ocean Basin

E - Late Proterozoic-Early Cambrian (760 - 700 Ma)
- Ocoee/Grandfather Mt./Mt. Rogers graben
- Crassmore-Mt. Rogers volcano

D - Late Proterozoic (~0.8 Ga)
- Grenville Mountains reduced to peneplain

- Erosion of Grenville mountains exposing metamorphosed batholiths; initiation of the largest unconformity in the region’s history, now exposed in the Blue Ridge mountains.
Composite Reconstruction Across the Blue Ridge During the Lower Cambrian

Northwest

Transgressing Sea

Antietam

Harpers

Weyers

Mechum River

Robertson River

Feeder Dike

Feeder Dike

Grenville Basement

Attenuated Continental Crust

Transition Crust

Oceanic Crust

Lynchburg

Evington

Microcontinent (present only in places)

Continental Slope and Rise

Southeast

Shady

Marble

Loudoun Group

Swift Run

Fauquier

(E = Alligator Back in N.C. and Tenn)

S. Run

L. S. Fischer 1993
Braided River Spectrum

S. Saskatchewan Model

Proximal

DONJEK TYPE

PLATTE TYPE

superimposed linguoid bars

longitudinal bar

S. SASKATCHEWAN TYPE

Distal

major channel

compound bar
Stratigraphy and Interpretation of the Tumbling Run Section, Strausburg, Virginia

Route 601, Fisher's Hill Road, North Side Outcrop Profile

- New Market
- Lincolnshire
- Edinburg

Interpretive Cross Section

- Intertidal
- Beach
- Lagoon
- Reef
- Shelf
- Slope
- Foreland basin

With time sea level rises and basin subsides as Taconic orogeny begins. The trick is determining when subsidence becomes more important than sea level at creating accommodation.

Shales begin entering from Taconic terrane to east (eventually Martinsburg Fm.)

Beekmantown Fm.

Outcrop Profile - north side of road

- Drainage
- Cobbly weathering
- Nudities (Mastopora) calcareous algae string along some bedding planes

Carbonate beach packed carbonate sand (bio-mic-spar)

Lagoon uniform bedded, cm thick black micrites

Reef packed coarse biospar w/ lrg fossil frags (best exposed on south side of road)

Shelf decimeter interbedded dark micrites and packed biosparite

Condensed section (black, smudgy, organic rich)
K bentonites (volcanic ash beds)
Interbedded shale/micrite; micrite loaded into shales

Cobbly weathering

Tetradium coral

- Black chert nodules (scattered through outcrop above condensed section)
- Beds of spherical calcareous algae (best exposed on south side of road end of outcrop near driveway)
**Carbonate beach** packed carbonate sand (bio-mic-spar)

**Lagoon** uniform bedded, cm thick black micrites

**Reef** packed coarse biospar w/ lrg fossil frags (best exposed on south side of road)

**Shelf** decimeter interbedded dark micrites and packed biosparite

- bridge over Tumbling Run
- Tumbling Run

Knox Unconformity

- birdseye limestone

- solution surface (unconformity)

- black chert nodules (scattered through outcrop above condensed section)

- beds of spherical calcareous algae (best exposed on south side of road end of outcrop near driveway)

- condensed section (black, smudgy, organic rich)

- K bentonites (volcanic ash beds)

- interbedded shale/micrite; micrite loaded into shales

- cobbly weathering

- drainage