Deep-Marine Clastic Systems

- References:
  - Walker & James – Chapter 13
  - Emery & Myers – Chapter 9

Processes

- Submarine fan systems maintained by density currents
- Density currents transport clastic detritus (sand, gravel, mud) to deep water
- Four end-member types of density currents

Processes

- Turbidity Currents
  - Grains held in suspension by fluid turbulence
  - Generated by submarine failures, rivers entering lakes, etc.
  - Can transport sediment long distances (100s of km)
  - Slow/stop through mixing with ambient water or change of slope
Processes

- Turbidites
  - Sedimentary structures record waning currents
  - Commonly normally graded
  - Thickness variable – cm to 10s of cm; tabular beds
  - Complete Bouma Sequences not always developed
    - Use shorthand notation
    - E.g., ABC, BC, A, ACE

An Ideal Turbidite – “Bouma Sequence”

- E – Pelagic
- D – Planar laminated
- C – Ripple cross-laminated
- B – Planar laminated
- A - Massive
**Processes**

- **Fluidized/liquefied flows**
  - Grains held in suspension by intergranular flow (loss of grain contacts)
  - Pore fluids escaping upward
  - Loosely packed sands subjected to a shock
  - Flow “freezes” from bottom up as it slows and sediment is redeposited

- **Grain Flows**
  - Grains held in suspension by grain-to-grain collisions (dispersive pressure)
  - Relatively steep slopes
  - Flow “freezes” from bottom up as it slows and sediment is redeposited

- **Debris Flows**
  - Grains held in suspension by matrix strength (suspended fines)
  - "Traditionally" thought that clays were needed, now known not to be true
  - Wide range of grain sizes transported if available
Processes

- Four end-member types – gradation from one type to another
  - "Hybrid" flows
  - Changes with time, location
  - Other classification schemes possible
- Most experimental work done in 60s and 70s – new work changing some ideas
- Relatively low submarine slopes needed, & trigger mechanism
- Cohesive mass movements – slides, slumps, etc.

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Submarine Fans – Facies Models

- Knowledge of deep-marine clastic systems based on outcrop, logs and especially imaging/sampling of modern fan systems in 1980s, 1990s
  - Gloria/Seabeam/side-scan sonar
  - 2-D and 3-D seismic images
  - Deep-sea drilling (DSDP, ODP)
Submarine Fans – Facies Models

- Much more elongate, complex than previously thought
- Main components: incised channels (submarine canyons, slope channels), leveed channel systems, mass transport complexes, frontal splays, distal lobes
Offshore Nigeria – Pleistocene Leved Channel

Cross Line 5454

Overbank Wedge
Channel Fill

100 msec | 2 km Buried Leved Channel

Offshore Nigeria - Shallow Buried Leved Channel

Leved channel feeding frontal splay (lobe)

Condensed section

Posamentier, 2005

Sand-prone channelized deposits

Decreasing sand content within levee

Levee (Mixed sand and mud)
Levee deposits

Amalgamated Channel Fill – Massive sandstones

Channel cut

Levee deposits

Submarine Fans – Facies Models

- Channel fills – amalgamated sandstone
- High-amplitude facies
- May show meandering
- Levees – interbedded turbidites and shale
- “Gull-wing” geometry
Submarine Fans – Facies Models

- Mass transport complexes
  - Chaotic facies
- Frontal splay – turbidites, “debrites”
  - “HARP” – high-amplitude reflection packages
- Distal lobes – channel sandstones, turbidites and shale
  - Parallel reflections, some channels

Controls on Submarine Fan Development

- Line source vs point source
- Texture (mud, sand, gravel)
- Seafloor relief (bathymetry)
- Sea level change
Controls on Submarine Fan Development

- Form when sediment can be supplied to shelf margin
- Generally when sea level is low
- Also if rivers can build deltas across shelf during high sea level, because of high sediment influx (e.g., Mississippi) or narrow shelf (e.g., Congo)
Sequence boundary is typically placed below the submarine fan

Subaerial Unconformity
Correlative Conformity

Basin-floor fan

Summary

- Erosion, sediment transport, deposition via density currents in submarine fan systems
  - Slumps and other mass movements possible (mass transport complexes)
- 3-D seismic data, swath bathymetry data useful for studying entire systems
  - Don’t show details of sedimentology

Summary

- Principal components:
  - Incised channels (includes submarine canyons, slope channels)
  - Leved channel systems – amalgamated sands (channels), turbidites (levees)
  - Mass transport complexes – chaotic, convolute bedding
  - Frontal splays – debrites (sandy), turbidites
  - Distal lobes - turbidites

Summary

- Controls on submarine fan development/morphology:
  - Line source vs point source (apron vs fan)
  - Sediment texture (sand, mud, gravel, mix)
  - Seafloor relief (channel systems usually follow bathymetric lows)
  - Sea level