GEOL-201
Marginal to Deep Marine Depositional Environments
Ocean bathymetry
Sand-rich sub-marine fan
Gravel-rich sub-marine fan

Boggs, 2006
Modern Submarine Fans

http://www.nature.com/scitable/knowledge/library/submarine-fans-and-canyon-channel-systems-a-24178428
La Jolla Canyon
(southern California)
Himalayas - Indus and Bengal Fans
Modern fan model (Normark 1970)

- Canyon
- Leved channel
- Distributary channels
- Lobe

Ancient fan model (Mutti and Ricci Lucchi 1972)

- Canyons
- Slope
- Channels
- Lobe

Generalized grain-size profile

- Thinning- and fining-up channel fill
- Thickening- and coarsening-up lobes

Shelf edge

La Jolla Canyon-channel system
a) Slide

b) Slump

c) Flow

d) Shelf-edge failure → transition from slump to turbidity current

shelf

slope

Turbidity current

basin floor
Christian Hiibscher, Volkhard Spiel, Monika Breitzke, Michael E. Weber

The youngest channel-levee system of the Bengal Fan: results from digital sediment echosounder data

Marine Geology 141 (1997) 125-145
Fig. 2. PARASOUND section of the Swatch of No Ground. For location, refer to Fig. 1. The data gap at the eastern flank of the canyon is caused by the steep slope angle. Channels are incised into the bottom of the canyon. $VE =$ vertical exaggeration.
Fig. 3. (A) Parasound section of the youngest channel-levee system in the middle fan at 16°30N with Hydrosweep data. (B) Interpreted section. For location, refer to Fig. 1. Italic number refers to swath width. Piston cores 117–120 KL are marked with arrows. The locations of 119–120 KL are projected onto the levees, which have been collected outside the profile. See text for discussion. aCLS = abandoned channel-levee system. dl = di use layer. ich = intra-channel highs. VE = vertical exaggeration.
Fig. 4. PARASOUND section and HYDROSWEEP data of the youngest channel–levee system in the lower fan at 13°30'N. For location, refer to Fig. 1. Italic number refers to swath width. The westernmost of the two observed channels represents the recent channel: cl = chaotic layer, sl = slump. VE = vertical exaggeration.
Fig. 6. **PARASOUND** section with **HYDROSWEEP** data of the youngest channel-levee system in the lower fan at 5°30′N. For location, refer to Fig. 1. Italic number refers to swath width. The interpreted base of the levees is marked by arrows. The channel has been constricted by the deposition of sediment at the inner levee flank; *lar* = low amplitude reflections, *il* = inner levees, *VE* = vertical exaggeration.
Fig. 7. (A) PARASOUND section of the youngest channel-levee system in the lower fan at 4°30'N. (B) Line drawing. For location, refer to Fig. 1. The entire system is separated into two vertical units. The lower unit generally exhibits a diffuse reflection pattern with some divergent reflections onlapping at the convex shaped base. Distinct dipping reflections of the outer side of the upper unit terminate as a downlap on to the surface which separates the two units. The maximum reflection amplitudes are plotted at the top. VE = vertical exaggeration.
Fig. 10. Allocyclic model of the evolution of a channel–levee system in the lower fan. (A) Phase I: erosion of an elongated valley (Clark and Pickering, 1996). (B) Phase II: relatively coarse-grained sediments (CGS) are deposited within the valley and a narrow channel emerges near the centre. (C) Phase III: depositional process changes from valley-filling to overbanking. (D) Phase IV: decrease in sediment input leads to channel constriction, when inner levees develop. CGS = coarse-grained sediments.
Submarine Fan Facies

**Facies A**
Thick to massive, channeled and amalgamated, poorly sorted coarse Ss and Cgl, with thin or no mud intervals; all gradations to facies E

**Facies B**
Thick to massive, lenticular sorted Ss with parallel to undulating laminae, common mud clasts, and erosional bases; thin mud intervals

**Facies C**
Couplets of even, parallel-bedded M-F Ss and minor homogeneous muds; Ss may show complete Bouma succession, some broad, shallow channels; common sole marks

**Facies D**
Couplets of parallel-bedded, laterally continuous F-VF Ss/Siltst. and thicker muds. Ss with regular to convolute to ripple-drift laminations. Bouma base cutout sequences common

**Facies E**
Thinner, irregular and discontinuous beds of slightly coarser Ss and Siltst. than D; also thinner muds. Ss with basal graded and structureless intervals; sharp upper contacts with mud

**Facies F**
Thick intervals of mildly deformed chaotic deposits derived from sliding or mass flow

**Facies G**
Thick muds with often obscure continuous parallel bedding

Massive or stratified mudstone (facies G); discordant surfaces and facies F deposits from mass movements; lag deposits of sediment gravity flow; facies A in channels, locally succeeded by facies E

Facies G mudstones enclosing thick, broad channel-filling facies A, B, and F; facies E may be present

Essentially facies D and E; subordinate facies C; local intercalations of lenticular facies A, B, and F; typically showing thinning-and fining-upward sandy cycles; paleocurrents show dispersion of about 90°

Facies D sediments with lenticular facies C; typically showing thickening- and coarsening-upward sandy cycles; coarser deposits usually not channelized; paleocurrents spread over 90°, transverse or longitudinal to basin axis

Facies D, with thin intervals of facies G mudstone sometimes detectable; paleocurrents parallel to basin axis

Prothero and Schwab, 2004
Prothero and Schwab, 2004

Environment

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Depositional processes
- Debris flows, liquified flows
- Debris flows, liquified flows, turbidity currents (high energy)
- Turbidity currents
- Turbidity currents (low energy)
- Liquified flows, turbidity currents, traction currents (?)
- Slumps, debris flows
- Pelagic and hemipelagic sedimentation

Prothero and Schwab, 2004
Bouma Sequences

Bouma units

- Laminated mud
  - Pelagic sedimentation or fine-grained, low-density turbidity current deposition
- Laminated silt and mud
  - Ripples, wavy lamination, or convoluted laminae
  - Lowest-flow-velocity plane beds
- Sand
  - Plane-parallel laminae
  - Lower-flow-velocity ripples
  - High-flow-velocity plane bed
- Silt
  - Massive and graded
  - High flow velocity and rapid deposition
- Mud

Commonly scours into previous layer

Prothero and Schwab, 2004
Not all Bouma layers are likely to be visible in any one place. The notation for turbidite layers is as follows:

\( T_{\text{abcde}} \): all present
\( T_{\text{acd}} \): only a, c and d present
\( T_{\text{e}} \): only e present
etc.
Deep Ocean Sediments

Prothero and Schwab, 2004
Prothero and Schwab, 2004

Calcite saturation (%)

Rate of dissolution
Rate of supply × 100

Calculated \( \text{CaCO}_3 \) content

Observed \{ of sediment \}
The diagram illustrates the depth of sedimentation for Radiolarians and Formaminifers.

- **Radiolarians**
  - Silica corrosion zone
  - Minor dissolution in transit

- **Formaminifers**
  - Virtually no dissolution in transit
  - Calcite corrosion zone

The x-axis represents increasing dissolution, and the y-axis represents depth in kilometers.