**Sedimentary Facies and Structures** **10-13-06**

**Maturity revisited:**
**Textural maturity**: refers to degree of sorting and rounding both increasing from immature to mature rocks

**Compositional maturity**: refers to abundance of unstable grains (rock frags and feldspar) to stable grains (quartz);; stable grains increase as compositional maturity increases

**Sedimentary Structures**

**Sediments occur in 'strata' or layers**

Layers have internal structure:

1. **Massive bedding**—no internal structure
2. **Graded bedding**--coarser material at bottom of bed (normally graded) or at top (inversely graded)
3. **Cross-stratification**—formed by migrating ripples, dunes, or sediment waves—curved surfaces that are concave in the direction of sediment transport and ripple movement
    a. Cross-stratification can be a variety of scales form small ripple sets to 3-5 m high dune foresets
4. **Climbing ripples**—indicator of rapid sedimentation since sediment supply overcomes erosion
5. **Sole marks**—scratches or 'prod-marks' on the base of rapidly deposited beds caused by pieces or rock or wood being dragged along by a rapidly flowing current
6. **Mud cracks**—polygonal cracks often filled with mud or sand indicating wetting-drying cycles
7. **raindrop prints**—just what they sound like….
8. **Tracks and trails—underprints** caused by compaction of sediment beneath a foot, or can have horizontal or vertical burrows—often filled with different type of sediment—appear ***circular or oval*** in cross-section

**Facies**

Strata characteristic of particular environments

**Walther's law**: Facies that represent adjacent environments will tend to occur adjacent to each other; e.g. stream channel sandstones and floodplain deposits; beach sands, marsh mud and back-beach dune deposits

**Large scale depositional pattern**:

1. **Fining-upward sequences**—sedimentary layers become progressively finer-grained up section
2. **Coarsening upward sequences**—become coarser upwards

    a. These sequence types indicate increasing or decreasing distance form the sediment source
3. **Onlap**—strata that pinch-out up onto a surface
4. **Offlap**—strata pinching out down on a surface
5. **Channels**—erosion surfaces that are half-moon shaped with erosional bases
6. **Reefs**—organic build-ups that interfinger with fine-grained sediments; these can be wave-resistant structures or can form below the depth of storms (deep-water reefs)

## Characteristics of Sedimentary Facies

### Alluvial fans

1. coarsening-upward with few small-scale sedimentary structures
2. boulders  often not well rounded (short transport distance)
3. poorly sorted with abundant rock debris (also short transport)
4. little soil and few fossils
5. red sediment owing to oxidation of iron by the air (typical for non-marine sediments)
6. lap up against mountain bedrock

### Stream deposits

1. sandstones with conglomerate in channels
2. cross bedding common
3. sands often pink with Fe-oxides, can be well sorted
4. interbedded with siltstone and claystone representing overbank deposits or pond-fillings
5. soils may be present, particularly in fine-grained overbank or marsh deposits
6. fossils in overbank deposits or at the bases of channels
7. may have coal
8. both fining-upward and coarsening-upward sequences due to stream channel migration

### Sand dunes

1. well sorted sandstones
2. large scale cross bedding (1 m or more high)
3. discontinuous soils in blowouts,
4. tracks and trails in low areas between dunes

### Shoreline deposits

1. *fine-grained* clay and mud rich in *organic matter* and *root* marks (back beach marsh)
2. marsh sediments also have *abundant fossils* of brackish-water oysters and snails (low diversity), *wood* common, sometimes *mud cracks*

3. channels filled with sand or silt,--red or pink if in freshwater, yellow or green in salt water
4. beach is *well sorted* sand, *few fossils*, *planar lamination*
5. Foreshore (Plunge zone in breakers): gravelly to coarse sand, cross-bedding and few burrows, yellow sand
7. offshore sands—sandstone and siltstone, burrowed, high fossil diversity, cross-bedded or massive beds depending upon water depth,

**Reef systems**

1. nearshore settings may be sandy (like the beaches above) or may consist of "lime mud"
2. lagoonal lime mud with few types of fossils, lamninated beds, mud cracks, stromatolites, often gray or black with Fe-pyrite., sometimes chert
3. reef composed of massive limestone with diverse fossils, no stratification commonly with lots of pore space, even caverns where carbonates have been dissolved away
4. fore reef—blocks of reef limestone in lime mud, massive layers, contorted bedding associated with slides or slumps
5. Offshore—fine grained lime mud with abundant fossils, massive bedding (often highly burrowed), sometimes chert

**Deep Marine—Submarine Canyon fills**

1. well stratified with beds of regular thickness and laterally extensive
2. Channels filled with cobbles and pebbles, often poorly sorted with abundant fine grained sediment
3. abundant sole marks
4. fining-upward and coarsening upward cycles
5. few fossils (other than microfossils), but trace fossils common on bedding surfaces
6. beds frequently show graded-bedding ("Bouma Sequences") from **Turbidity currents**
7. *The "greywacke' paradox*: How can a sandstone be full of clay?—*Answer*: it started off as a lithic sandstone, but the lithics broke down to clays during compaction.

**Deep Sea**

1. fine grained carbonate/siliceous limestone or red clay
2. massive bedding with abundant burrows
3. few large fossils, but microfossils may be abundant
4. chert nodules common
5. gradual upward gradation from biogenic sediments to red clay

**Tectonic Settings**

Putting it all together

**Mid Ocean Ridges**

Typical sequence:

1. pillow basalts (perhaps mixed with some calcareous sediment)
2. umbers (metal-rich sediments blown out of black smokers and hydrothermal vents)
3. deep sea carbonates
4. siliceous sediment or chert
5. red clay with mn-nodules

Reflects the gradual subsidence of the originally hot, buoyant ocean crust into deeper water where carbonates are dissolved

**Ocean-Continent**

1. Volcanoclastics, lithic sandstone and greywacke in trench, accretionary wedge and fore-arc basins
2. accretionary wedge may have other sediments scraped off the subducting plate—deep sea limestone, chert
3. have reef limestones interbedded with volcaniclastics

**Continent-Continent**

1. upward transition from deep marine sedimentary rocks (turbidites) to volcanic arc sediments to granitic/metamorphic-derived sediments as the collision zone is uplifted and successively deeper rocks are eroded
2. thick continental sediments—alluvial fans, stream deposits
3. Continental interiors can have limestone, shale and coal reflecting flooding and re-emergence from "epicontinental seas"

**Passive margins**

1. sequence from continental sediments and salt (initial rifting)
2. to reef carbonates and shallow marine clastics (early rift phase)
3. to deep marine clastics and hemipelagic sediments (late stage of rift and passive margins