GEOS 302 Lab 3: Sedimentary Structures
(Reference – Boggs, Chap.4)

Objectives:
1. Become familiar with the different sedimentary structures
2. Understand the origin of these different structures and be able to interpret them

Intro

A. Sedimentary structures are textures in sedimentary rocks - physical forms resulting from the interaction of sediment and some force or organism

B. Why are they important? Sedimentary structures provide clues about the conditions under which the sediments were deposited, such as:
   a) flow conditions
   b) depositional environment
   c) paleoclimate
   d) which way is stratigraphic up

DEPOSITIONAL SEDIMENTARY STRUCTURES

I. Depositional: Ripples

Asymmetric ripple terminology (from Boggs, 2006, fig 4.12)

A. Bedforms
   1. The migration/deposition associated with bedforms produces sedimentary structures

B. Symmetrical ripples a.k.a. vortex ripples, wave ripples, orbital ripples
   1. Bidirectional current
   2. Swashing in and out
   3. Symmetrical ripples

C. Asymmetric ripples a.k.a. current ripples
   1. Unidirectional current
   2. Develops a stoss and lee side (up and down flow; see Boggs, Fig 4.12)
   3. 2-D and 3-D ripples
   4. Results in CROSS STRATIFICATION
D. Cross-stratification (from ripples)
   1. What/how
      a) Build up of sediments to the crest, then avalanche down
      b) Produces lamina or beds that are oriented at an angle to general bedding
      c) Bedding is erosional - LAMINATIONS ARE DEPOSITIONAL
   2. Planar- 2-D ripples
      a) Bedding planes or erosional surfaces are planar
   3. Trough - 3-D ripples
      a) Bedding planes are concave upward (troughy)
   4. Current and X-strata (cross-strata)
      a) Dip in the downstream direction
   5. Nomenclature
      a) Ripple Cross-stratification
      b) Set of cross-lamination
      c) Set or bed of cross-stratification
      d) Cross-bedded
   6. Important: ripple cross stratification can be a “way up” indicator because they are asymmetrical: concave (scoop) up, upper parts are truncated, the lower parts toe-out

E. Climbing Ripples
   1. bedding surfaces (erosional surfaces) 'climb' - go up at an angle
   2. large portion of the ripple is preserved
   3. high sedimentation rates

II. Depositional: Dunes/Megaripples
   A. Subaqueous = Large Ripples
      1. Behave and form pretty much like ripples
      2. in subaqueous settings – usually refers to bedforms > 10 cm high
   B. Eolian = Windblown sand
      1. Very large ripples – usually measured in meters
      2. Developed through air flow- sand dunes

III. Depositional: Planar beds
   A. Flow conditions
      1. High, fast - Ripples/dunes washed out
      2. Lower plane beds - low flow + grain size > 0.6mm
   B. Deposits
      1. plane parallel lamina
      2. plane parallel beds
      3. primary current lineations (heavy mineral grains)

IV. Depositional: Antidunes
   A. Upper flow regime – Froude # > 1
   B. Poor preservation potential
   C. Foresets dip in opposite direction of flow
V. Depositional: Hummocky Cross Stratification

1. See Boggs Fig 4.24
2. Thought to be the result of chaotic storm flows

VI. Depositional: graded bedding, the grain size trend within one bed.

1. “normal”: coarse at bottom to fine at top
2. “reverse”: fine at bottom, coarse at top

EROSIONAL SEDIMENTARY STRUCTURES

A. Tool Marks
1. rock, twig, etc dragged along

B. Flutes (most seen as casts)
1. turbidity flow
2. deep in up-current end, shallows out

C. Precipitation impact marks
1. little craters

POST-DEPOSITIONAL STRUCTURES
(GENERALLY RELATED TO FLUID FLOW)

A. Convoluted bedding
1. wavy, irregular
2. semi-consolidated
3. common with slumps

B. Fluid escape
1. dish/pillar structure: fluid escaping up through a bedding layer
2. load/flame structure: fluid escaping from semi-consolidated sediments

OTHER SEDIMENTARY STRUCTURES

B. Styolites
1. pressure solution
2. carbonate dissolution along a surface
3. look like little EKGs

C. Fluid Flow Structures
1. Concretions
2. Leisegang banding

D. Mud Cracks
1. Clays with a lot of H2O, dry out, reducing volume
2. Polygonal cracks
3. Often preserved as casts.
**BIOGENIC STRUCTURES**

A. What?
   1. tracks, trails, homes, etc., of little organisms

B. Vertical Burrows
   1. if marine, often indicates a higher energy environment

C. Trails/Tracks, Horizontal burrows
   1. horizontal
   2. if marine, often lower energy
   3. if non-marine, could be anywhere

D. Stromatolites
   1. microbial mats that catch sediment and form wavy laminations in the rock record

**BEDDING TERMINOLOGY**

A. Beds
   Very thick >1m
   Thick 30cm-1m
   Medium 10cm-30cm
   Thinly 3-10cm
   V. thin 1-3cm

B. Lamina, laminations
   Thick 0.3-1cm
   Thin <0.3cm
Physical, biological and chemical conditions in a depositional environment will dictate the types of sedimentary structures formed in a sedimentary rock. Therefore, the ability to identify different sedimentary structures can be a powerful tool for sedimentologists as they try to reconstruct the depositional environments responsible for different stratigraphic units.

A primary sedimentary structure is any organized distribution of sediment (a structure) formed on upper or lower surfaces of a sedimentary layer (e.g. bedforms, casts), or within the layer itself (e.g. sorting, grading, etc.). Secondary sedimentary structures form after sediment deposition, before or sometimes during the processes of burial, compaction and diagenesis that transform unconsolidated sediment to rock.

There are four categories of sedimentary structures:

a.) **erosional**: flutes, grooves, tool and scour marks, and the casts (infillings) thereof.

b.) **depositional**: bedding; lamination; bedforms (including ripples, dunes, sand waves, antidunes, etc.); cross-stratification; lenticular, wavy and flaser bedding; graded bedding.

c.) **post-depositional**: soft-sediment deformation (slumps, convoluted bedding, load casts, ball-and-pillow structures, dish structures, flame structures); nodules; concretions; dessication cracks and the casts thereof; pressure dissolution features.

d.) **biogenic**: bioturbation, trace fossils, root and rootlet traces.

1. Sample **302-IV-la and/or 302-III-1a** The laminations are interpreted to be seasonal layers called varves.

   A. What are the compositions of the layers?

   B. Describe the bedding (e.g. thick beds, thin beds, very thin laminations, etc.)

   C. Did deformation of these varves occur during or after deposition? Cite evidence.

2. Sample **302-II-2G** Lower Cretaceous Amole Formation, Tucson Mts., Arizona. What is the lithology of this rock? What is the name of the structure contained within? How do these laminations form?
DIRECTIONS: Sketch each of the following sedimentary structure samples. With each sketch, be sure to include a scale, the lithology of the rock in which the structure resides, the bedding type (thin laminations, thick beds, etc.) and a name for the sedimentary structure(s) present. In the case of ripple marks, be sure to describe the symmetry of ripples (in cross-section) and the linearity of ripple crests (in plan view – e.g. 2D vs. 3D). Where applicable, indicate “stratigraphic up,” and/or the direction of fluid flow. Indicate whether each sedimentary structure is depositional, erosional, biogenic, or post-depositional.

1. Sample 302-IV-2A

2. Sample Q-5
3. Sample 302-IV-2C

4. Sample 302-IV-6K
5. Sample 302-IV-2E

6. Sample 302-IV-2F
7. Sample **302-IV-2H**

8. Sample **302-IV-5D**

9. Sample **Goodwin 91-1**
10. Sample 14

11. Sample 302-IV-6H

12. Sample 302-IV-2D
THOUGHT QUESTIONS

1. Do thick beds require more time to accumulate than thin beds or laminations? Explain why or why not and provide an example to support your claim.

2. How are sedimentary structures useful for reconstructing depositional and diagenetic environments? Provide three reasons and/or examples.
3. On the bottom of this page, **sketch** a graph of velocity versus grain size (this well-known graph is called the “bedform” or “flow regime” diagram) and label the various fields in which different bedforms develop. Next, **plot where each of today’s samples would lie on the diagram**. (See Boggs, figure 4.10).