**Primary sedimentary structures**.

The text divides primary sedimentary structures into two main categories: **I. Inorganic Sedimentary Structures** and **II. Organic or Biogenic Sedimentary Structures**.

---

**I. Inorganic Sedimentary Structures**

These structures form during or shortly after sediment deposition due to physical processes like water or wind movement.

**A. Bed Forms and Surface Markings**

These are features found on the surface of a sediment bed (or on bedding planes in sedimentary rock).

1. **Ripples:** Undulations of the sediment surface produced by wind or water moving across sand.
    - **Asymmetrical Ripples:** Form in **unidirectional currents** (like streams or rivers). They have a **gentle slope on the upstream side** and a **steep slope on the downstream side**. Their geometry allows them to be used to determine **paleocurrent directions**.
        - Examples of crest types: straight, sinuous, or **lingoid ripples** (lobe-like).
    - **Symmetrical Ripples:** Form in **waves or oscillating water**. Crests tend to be relatively straight, but may bifurcate.
    - **Interference Ripples:** Complex patterns produced by the interaction between **waves and currents**.
2. **Mudcracks:** A **polygonal pattern of cracks** produced on the surface of mud as it **dries**. The resulting polygons may be redeposited as **intraclasts**.
3. **Raindrop Prints: Circular pits** on the sediment surface produced by the impact of raindrops on soft mud.

<hr>

The document provides detailed descriptions of **Internal Bedding Structures**, **Sole Marks**, and **Organic/Biogenic Sedimentary Structures** (Trace Fossils).

---

**Internal Bedding Structures (Best seen in side view)**

These structures provide information about depositional conditions and relative 'up' direction.

1. **Stratification (or Layering):**
    - **Beds:** Layers thicker than 1 cm.
    - **Laminations (Laminae):** Thinner layers.
    - **Bedding Planes:** The upper and lower surfaces of these layers.

    - **Varves:** A special type of lamination found in **glacial lakes**. They represent one year of deposition, showing a **graded sequence** with coarser material (silt/sand) from spring/summer meltwater runoff at the bottom, and finer material (clays/organic matter) from winter settling at the top. They are used to **measure ages**.
2. **Graded Bedding:**
    - Forms as a sediment-laden current (like a **turbidity current**) slows down.
    - Grain size changes from **coarser at the bottom to finer at the top**.
    - Can be used as **"up indicators"** for strata orientation.
3. **Cross-stratification:**
    - A general term for inclined internal layering in sand produced by moving wind or water (beneath ripples and dunes).
    - **Cross-bedding:** Inclined layers thicker than 1 cm.
    - **Cross-lamination:** Inclined layers thinner than 1 cm.
    - The layering is **inclined**, dipping downward in the **down-current direction**.
    - Can be used as **paleocurrent indicators** (ancient current flow directions).
    - Used as **"up indicators"** because the layers become **tangent to the lower bed surface** but are truncated at a steep angle by the overlying bedding plane.

---

**Sole Marks (Preserved on the bottom surfaces of beds)**

These result from filling in impressions made on soft mud, usually preserved in relief on the bottom of an overlying sandstone bed.

1. **Tool Marks:**
    - Produced by **"tools"** (objects like sticks, shells, or pebbles) carried by a current that **bounce, skip, roll, or drag** on the sediment surface.
    - Preserved as **thin ridges** on the lower surfaces of beds, generally **aligned parallel to the current direction**.
2. **Flute Marks (Flute Casts):**
    - Produced by **erosion or scouring** of muddy sediment, forming "scoop-shaped" depressions.
    - Preserved as **bulbous or mammillary natural casts** on the bottoms of sandstone beds.
    - Used to determine **paleocurrent directions** due to their geometry.

---

**Organic or Biogenic Sedimentary Structures (Trace Fossils/Ichnofossils)**

These are formed by the interaction of living organisms with the sediment (**bioturbation**). Organism activity can destroy primary structures, leading to homogenized sediment.

1. **Tracks or Footprints:**
    - Impressions on the surface of a bed produced by the feet of animals (e.g., dinosaur or bird tracks).
    - A **trackway** is a line of tracks showing the animal's path.

- Can be preserved as **sole marks** (casts) on the bottom of the overlying bed.

2. **Trails:**
   - **Groove-like impressions** on the sediment surface produced by an organism that **crawls or drags** part of its body.
3. **Burrows:**
   - **Excavations** made by animals into soft sediment for dwellings or searching for food.
   - Often filled by sediment of a different color/texture, and fillings may become cemented and weather out in **rope-like patterns**.
4. **Borings:**
   - **Holes made by animals into hard material**, such as wood, shells, rock, or hard sediment.

1. **Borings** are holes made by animals into hard material, such as wood, shells, rock, or hard sediment. Borings are usually circular in cross-section. Some snails are predators and produce borings or "drill holes" into other molluscs, such as clams, to eat them. Another mollusc, known as the "shipworm", drills holes into wood. Sponges also produce borings, commonly riddling shells with numerous small holes.

*Boring in **Arca** bivalve shell, produced by carnivorous moon snail, **Lunatia** or **Polynices**. Note the conical, tapering shape of the hole, like a countersunk hole for a screw.*

*Photo by Pamela Gore.*


*Borings in bivalve shells, St. Augustine, FL*


*Borings in fossil giant oyster produced by Clionid sponge*

2. **Root marks** are the traces left by the roots of plants in ancient soil zones (called paleosols). Rootmarks typically branch downward in a pattern resembling an upside-down tree. Root marks are sometimes gray or greenish, penetrating reddish-brown paleosols. This contrast in color can make them easy to see and identify.


*Rootmarks in the Triassic Deep River Basin,North Carolina*

## B. *Biostratification structures*

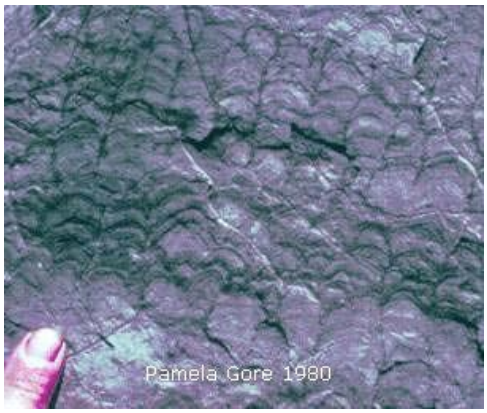
Biostratification structures are sedimentary layers produced through the activities of organisms. Stromatolites are the only type of biostratification structure we will study.

1. **Stromatolites** are mound-like structures formed by colonies of sediment-trapping cyanobacteria (commonly called blue-green algae). These organisms inhabit some carbonate tidal flats, and produce dome-like laminations in lime mud (fine-grained limestone or micrite).

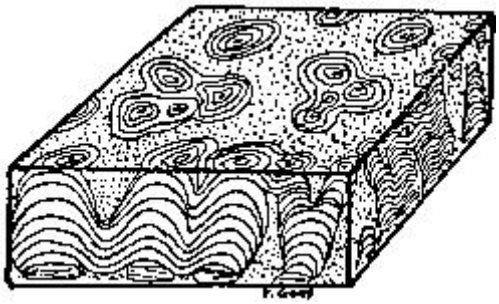
   Stromatolites are "organo-sedimentary structures", and not fossils because they contain no recognizable anatomical features.

   Stromatolites form today in only a few places in the world, primarily in hypersaline environments (such as Shark Bay, Australia), and a few freshwater carbonate- precipitating lakes. In the geologic record, most stromatolites are found in Precambrian and lower Paleozoic limestones. The cyanobacteria which formed these stromatolites were photosynthetic, and they are therefore responsible for changing the character of the Earth's atmosphere from one dominated by carbon dioxide to one with significant quantities of free oxygen.


*Stromatolites,*
*Ordovician, western Maryland*




*Digitate (finger-like) stromatolites,*
*Ordovician, western Maryland*



*Stromatolites*

## DETERMINING "UP DIRECTION"

When you examine a sequence of beds which has been tectonically deformed and possibly overturned, it is necessary to determine the "*up direction*". This is done by studying the sedimentary structures for clues.

Sedimentary structures such as graded beds, cross beds, mudcracks, flute marks, symmetrical (but not asymmetrical) ripples, stromatolites, burrows, tracks, and other structures can be used to establish the original orientation of the beds. (Fossils can also be used to establish up direction, if they are present in the rock in "life position".)

Carefully examine the sedimentary structures in any dipping sedimentary sequence, because the rocks can be *overturned* by tectonic forces, and what initially appears to be younger because it is on top, may in fact turn out to be at the bottom of the section!

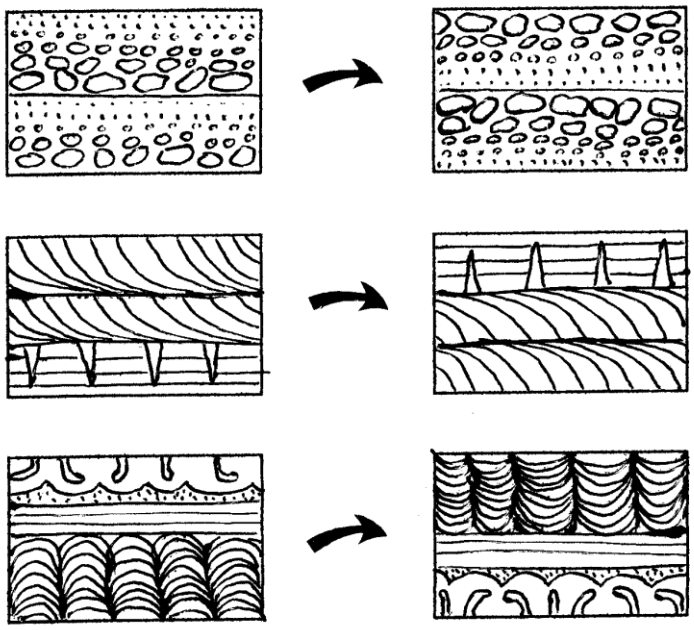


*Illustration of overturned beds.* Left column = right-side-up Right column = upside-down

# Summary

The following list is a summary of the sedimentary structures mentioned in this lab:

## I. *Inorganic sedimentary structures*

A. Bedforms and surface markings
    1. Ripples
        - Asymmetrical ripples (including lingoid and rhomboid ripples)
        - Symmetrical ripples
        - Interference ripples
        -
    2. Mudcracks
    3. Raindrop prints

B. Internal bedding structures
    1. Stratification (strata)
        - Beds
        - Laminations or laminae
        - Varves
    2. Graded bedding
    3. Cross-stratification
        - Cross-bedding (cross-beds)
        - Cross-lamination

C. Sole marks
    1. Tool marks
    2. Flute marks

## II. *Organic or biogenic sedimentary structures*

A. Trace fossils or ichnofossils
    1. Tracks
    2. Trackways
    3. Trails
    4. Burrows
    5. Bioturbation
    6. Borings
    7. Rootmarks

B. Biostratification structures
    1. Stromatolites

Pamela J. W. Gore
Department of Geology, Georgia Perimeter College
Clarkston, GA 30021



# Pre-Lab Exercises

Do these exercises before you come into lab, and have them ready to turn in.

1. Matching. Match the sedimentary structure with the environment in which it is most likely to be found. Put the letter in the blank.

| | **Sedimentary structure** | **Possible Environment** |
|---|---|---|
| 1. _____ | Mudcracks | a. turbidity currents |
| 2. _____ | Stromatolites | b. dried up lake |
| 3. _____ | Symmetrical ripples | c. glacial lake |
| 4. _____ | Asymmetrical ripples | d. tidal flat |
| 5. _____ | Graded bedding | e. river |
| 6. ____ | Varves | f. wave-washed shoreline |

2. Which of the **sedimentary structures** in this lab may be useful in determining paleocurrent directions? (List 4 different structures.)

_____ _____

_____ _____

3. Which of the **sedimentary structures** in this lab may be useful in helping determine the top from the bottom of a bed ("up indicators")? (List 4 different structures.)

_____ _____

_____ _____

4. Place an X in the table for the environments in which the sedimentary structure may form.

| Sedimentary structure | River | Shallow sea | Beach | Tidal flat | Dry lake bottom | Sand dunes (wind) | Deep Sea |
|---|---|---|---|---|---|---|---|
| Laminations | | | | | | | |
| Asymmetrical ripples | | | | | | | |
| Symmetrical ripples | | | | | | | |
| Mudcracks | | | | | | | |
| Raindrop prints | | | | | | | |
| Cross-stratification | | | | | | | |
| Graded bedding | | | | | | | |
| Tracks | | | | | | | |
| Burrows | | | | | | | |
| Stromatolites | | | | | | | |

# Lab Exercise

Using the sedimentary structures provided in the lab, fill in the chart below.

| Sample | Inorganic or Biogenic? | Rock Type | Describe the environment of deposition | Name of Sedimentary Structure |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |

| | | | | |
|---|---|---|---|---|
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |

Online students see additional Sedimentary Structures exercises here:
http://facstaff.gpc.edu/~pgore/geology/historical_lab/sedstr.htm

This is a reformulation and completion of the pre-lab exercises based on the provided text, as requested.

# Pre-Lab Exercises (Completed)

## 1. Matching: Sedimentary Structure and Environment

Match the sedimentary structure with the environment in which it is most likely to be found.

| Sedimentary Structure | Possible Environment | Match |
|---|---|---|
| 1. **Mudcracks** | a. turbidity currents | **b** |
| 2. **Stromatolites** | b. dried up lake | **d** |
| 3. **Symmetrical ripples** | c. glacial lake | **f** |
| 4. **Asymmetrical ripples** | d. tidal flat | **e** |
| 5. **Graded bedding** | e. river | **a** |
| 6. **Varves** | f. wave-washed shoreline | **c** |