Geo 302D: Age of Dinosaurs

LAB 1: Introduction to Rocks and Sedimentary Processes

The purpose of this lab is to introduce you to the three major types of rocks, and the type in which you would expect to find fossils – sedimentary rocks. You should come away from this lab with an understanding of the major rock types and the processes that form them.

All rocks are composed of **minerals**. Minerals are naturally occurring, solid, inorganic substances with specific chemical compositions. Some common examples are: quartz, calcite, feldspar, and mica, just to name a few.

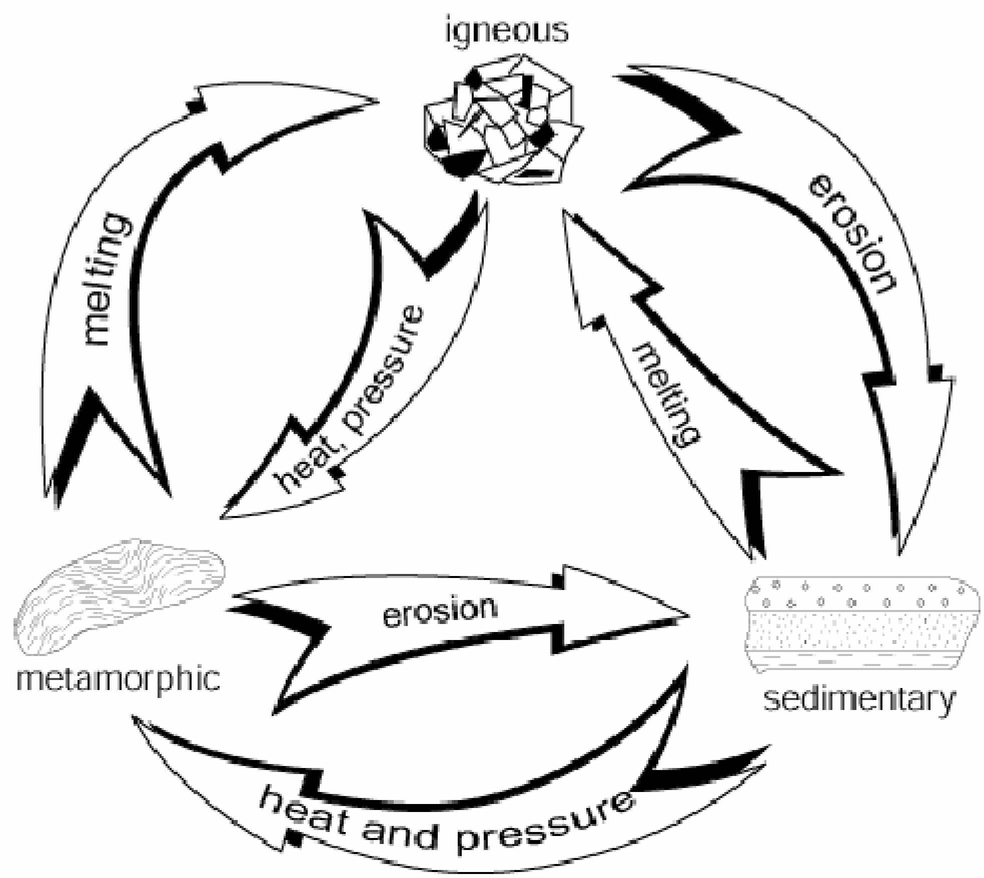
As mentioned above, there are three major categories of rocks. They are:

1. **Igneous rocks**. These are formed by crystallization directly from molten material. This molten material is called **magma** when it is below the surface, and **lava** once it reaches the surface. As the molten rock cools, the atoms within it begin to combine with one another, forming mineral crystals. As cooling continues, the crystals butt up against one another, eventually interlocking and forming a rock made up of many mineral crystals. Igneous rocks can be further categorized by their composition and texture. No fossils are found in igneous rocks.

2. **Sedimentary rocks.** These are formed in one of two ways. One way is from the erosion, subsequent deposition, and lithification of pre-existing rocks. Sedimentary rocks formed by this process are called "clastic" sedimentary rocks. They are composed of grains ranging in size from very coarse-grained cobbles and pebbles to extremely fine-grained clay particles. Common clastic sedimentary rocks are sandstone, mudstone, breccia, and siltstone. The other way to form sedimentary rocks is by precipitation of minerals from seawater. This may be accomplished by evaporation (often yielding halite [=rock salt]) or through the action of organisms in the water (limestone). We will study sedimentary rocks and the processes associated with them more closely later in this lab.

3. **Metamorphic rocks**. Under conditions of intense heat and pressure, pre-existing rock can be physically and chemically altered, transforming ("metamorphosing") into an entirely new type of rock. These are called metamorphic rocks. They have not been re-melted, but the conditions get harsh enough to break down the bonds of many of the minerals making up the rock. When heat and pressure finally subside, entirely new minerals are often left behind, such as garnet. Common metamorphic rocks include gneiss (from granite), marble (from limestone), schist (from muddy sediments), and slate (from shale). Fossils are less commonly found in metamorphic rocks, but are often distorted.

An interesting feature about these three rock types is that any one of them can undergo processes that turn them into either of the others, or new versions of the same type. This inter-relationship is called the **rock cycle**, first proposed by James Hutton almost 200 years ago. For example, suppose a particle of quartz forms deep in the earth as part of a large underground mass of granite. Over millions of years, the Earth's crust is uplifted, the overlying layers of rock erode away, and our little quartz crystal is exposed to the air. A pounding rainstorm knocks the quartz particle off the rock, it rolls down a small stream, and is buried with millions of other rock fragments. After years of burial, dissolved minerals carried in groundwater cements the rock fragments together. Our quartz crystal is now part of a sedimentary rock. Later, the sedimentary rock with the quartz crystal is shoved deep under the surface by tectonic activity. As the rock is shoved deeper, heat and pressure increase greatly. Eventually the sedimentary rock is altered, with the minerals within it being physically and chemically changed, resulting in a metamorphic rock. If the metamorphic rock continues to be heated, the rock may melt entirely and the atoms making up our one-time quartz crystal are released and the process may start all over again. This is just one example of the many different combinations and inter-relationships found in the rock cycle.



Sedimentary rocks have special importance to the field of paleontology because they are the only rock type that regularly preserves the remains of organisms. By the time you finish this lab, you should be able to identify basic sedimentary rock types and their environments of deposition.

Sedimentary rock types

All sedimentary rocks are originally deposited in horizontal layers, or beds. You can usually see the lines of contact (bedding planes) distinguishing different beds. However, sedimentary rocks are formed in several ways. **Evaporites** are formed by the evaporation of sea water. As the water disappears, the minerals in solution begin to precipitate out and form layers on the bottom. Rock salt and gypsum are relatively common evaporites. **Carbonates** include all limestones and dolostones and are generally formed in warm water environments. They are called carbonates because they contain carbonate ions (CO_3). Limestones are made of calcium carbonate ($CaCO_3$: calcite) and are usually biogenic. This means they were created through the activities of organisms. Many life forms, particularly marine organisms, secrete calcium carbonate in the form of shells or skeletons. Their remains build up large layers of carbonate sediment, which eventually lithifies (turns to rock) into limestone. Nearly all of the bedrock in the Austin area is some form of carbonate.

Clastic sedimentary rocks are formed by the erosion, transport, deposition, and lithification of pre-exisiting rocks. They are categorized on the basis of their grain size (a grain being any particle or clast (fragment) within the rock) and to a lesser extent, the degree of rounding of the grains. For example, very large, well-rounded grains (e.g. cobbles, gravel) cemented together make a conglomerate. Very large, angular clasts cemented together form a rock called a breccia. Most other clastic rocks are named on the basis of the grain size of which they are composed (e.g. sandstone, siltstone, mudstone). Shale is a very fine mud that is highly fissile, meaning it splits very easily along its thin bedding planes.

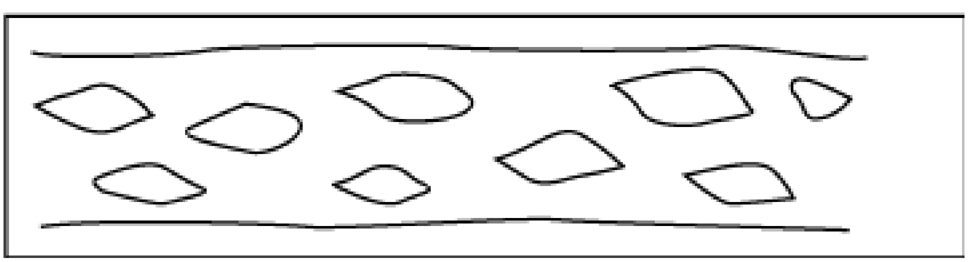
Clastic sedimentary environments of deposition

Clastic depositional environments leave behind recognizable deposits. The higher the relative energy of an environment, the larger the grain size of the material transported by the environment and deposited within it. It simply takes more energy to transport large particles than it does to transport smaller ones. High energy environments usually have a relatively steep gradient (change in elevation over a distance). The steeper the slope, the more force will be generated as the material moves downhill due to gravity. In addition to transporting coarser sediment, higher energy environments also build larger sedimentary structures. Sedimentary structures include bedforms such as ripples, dunes, sand waves, and bars.

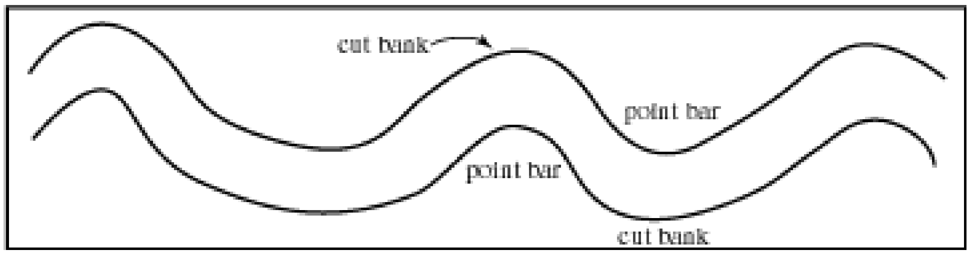
The degree of rounding of a grain can tell you how far a particular clast has traveled from its parent rock. The more rounded the grain, the further it has traveled. A jagged, sharp-edged clast probably has not traveled far from its source. Sorting and size can also give some idea about how far clasts have traveled from their parent rock. If you have a poorly sorted mixture of various sized sediments, it probably has not traveled far from the parent rock, whereas well sorted, fine grained sediments have probably traveled further away from their parent rock.

Because most commonly preserved terrestrial sediments were deposited in river systems, we often find Mesozoic dinosaur remains in fluvial deposits. The term “fluvial” refers to rivers and streams. There are a couple basic stream types you need to recognize.

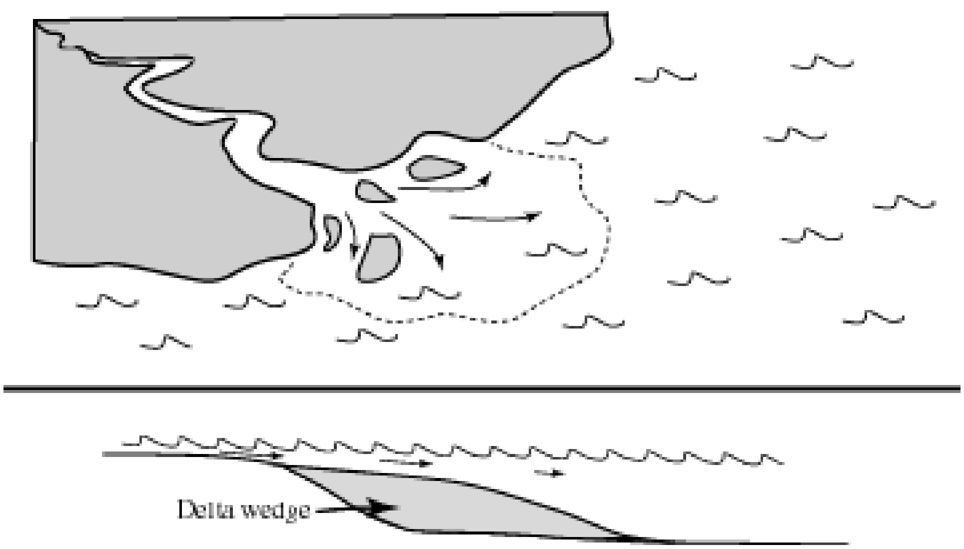
Braided streams are relatively high energy systems. They are usually wide, shallow, fast-moving streams with a large percentage of coarse-grained sediment in their beds. Between the rather straight-sided banks of the stream channel are numerous coarse grained sand and gravel bars, and gravelly islands. This gives the stream its “braided” appearance. The figure below shows a braided stream in aerial view.



Meandering streams are moderate to low energy streams with sinuous channels. Because of their sinuosity, the velocity of water is different in different parts of the channel. Along the inner banks of a bend in the stream water slows down, loses energy and deposits sediment and any other suspended material, building large sandy bars called **point bars**. The water along the outer bank of a bend moves relatively faster, possesses more energy, and is an area of erosion where previously deposited layers of rock are uncovered. This bank is called the **cut bank**. Outside the banks of the actual channel, meandering streams often have large floodplains. As the name implies, during floods these areas are covered with sluggish water filled with fine grained sediment. They are sites of episodic deposition of fine grained sediments such as silts and muds. The figure below shows a meandering stream in aerial view.



Lakes leave behind **lacustrine** deposits. The relatively still, low energy waters of most lakes allow the deposition of some of the finest grained sediments, such as fine silt, mud and clay. **Deltas** form wherever running water meets standing water, such as a lake or sea. When running water in a channel suddenly slows down and spreads out upon meeting standing water, it loses energy. Because the water no longer has the energy to transport its sediment, the material falls out and forms a large, fan-shaped pile of sediment that grows out into the body of water. Over years, a deep wedge of deltaic sediment can form.



Exercises

1. Quickly draw a map-view sketch of the creek from the edge of the bridge, downstream to just around the bend. Label all cutbanks, point bars, areas you can see erosion occurring, and any areas you see the potential for deposition to occur.

2. Based upon the shape of the stream and its channel, what category of stream system is this?

3. If Nutter the squirrel were to die and fall into the creek today, where is the most likely place for Nutter to be buried and hopefully preserved to one day become a fossil? Why?

4. If you're walking along the banks of the creek today, where is the best place to look for a fossil? Why?

5. Identify these three rocks and briefly describe how each of these formed.

a)

b)

c)

6. Which of the rocks from question 5 is most likely to contain a fossil?

7. a) Compare rocks “A” and “B”. Which of these was deposited further from its source rock (e.g. the rock that supplied the clasts within it)? Why do you say so?

b) Compare rocks “B” and “C”. Which rock was deposited in a higher energy environment? Why do you say so?