# Geologic Time

**Introduction**

An important aspect of geology is our effort to understand the history of the earth. We want to know when the earth was formed, when plate tectonics started working, when the first life forms began to show up, how the environment at the earth’s surface has changed through time, what causes all the change, and many other things. Sedimentary rocks and sequences of sedimentary rocks go a long way toward helping us answer many of these questions, because they form completely at the earth’ surface and record many things about the earth’s surface environment at the time they formed.

**Depositional environments**

We have already spent some time learning about depositional environments. Things to consider when interpreting depositional environments include lithology, fossils, color of the rocks, grain size and sorting of the rocks, and sedimentary structures. Please refer to the previous lab for more information on these characteristics.

One other feature that can be helpful in determining depositional environments is **trace fossils**. Trace fossils are things like burrows, tracks, footprints, etc. Features that were made by animals, but do not include any part of that animal’s body. These trace fossils can help us to determine the depositional environment because we can sometimes specifically identify the type of animal that left the feature, and so learn about the depositional environment because of the type of environment in which that animal lived. Also, just the fact that a particular type of trace fossil was preserved can tell you something about the depositional environment. The conditions needed to be of a specific nature for the actual trace fossil to exist in the rock record.

**Geologic History**

**Sequences of Rock**

Although it is very important to be able to interpret a rock’s depositional environment, if you want to construct a history of the area where it occurs that is not enough. To establish a geologic history of an area, you need a chronology of events (depositional and otherwise) as well. And to establish a chronology you need a sequence of rocks. We will consider vertical sequences of rock (stratigraphic sections or stratigraphic columns), like the example below. When a series of sedimentary layers is studied, we can see successive changes in the environmental conditions that occurred at a particular place with the passage of time.

A

B

C

D

E

 Figure 1.

Figure 1 represents four sedimentary rock layers (A-D) some of which are cut by an igneous intrusion (E). In order to list the formation of each of these rock units in chronological order you need to accept a couple of geologic principles:

**The principle of superposition** - The principle of superposition states that the oldest rock in a sequence lies on the bottom and the youngest rock lies on the top.

**The** **principle of cross-cutting** **relationships** - The principle of cross-cutting relationships states that a rock layer which cuts another layer is younger than the layer it cuts.

Using these two principles you can say that in the sequence below the first event in its history was the deposition of layer D, the second event was the deposition of rock layer C, the third event was the deposition of rock layer B, the fourth event was the deposition of rock layer A, and the fifth event was the intrusion of rock E. This is a very simple example.

In constructing a geologic history for an area we need to do a few things.

1. We need to discuss the depositional environment at every possible stage in the chronology using the indicators previously discussed,
2. We need to come up with a sequence of events as indicated by the arrangement of the different rock layers, and
3. We then need to attribute the change in depositional environment from rock layer to rock layer to some larger phenomenon-- (when possible, anyway).

One phenomenon that leads to a change in depositional environment is sea level change. Geologists talk about rises in sea-level as **transgressions** and drops in sea-level as **regressions**.

Fluctuations in sea level are caused by things such as:

1. **Changes in the size of the polar ice caps**, due to climatic changes. Melting of ice caps leads to sea level rise (transgression) and growth of ice caps leads to drop in sea level (regression).
2. **Rate of sea floor spreading** - during times of rapid sea floor spreading and submarine volcanism, the ocean ridge system is enlarged by the addition of lava, displacing water onto the edges of the continents (transgression).
3. **Localized subsidence or uplift of the land** – Uplift would cause a regression and subsidence would bring about a transgression.

You can recognize a transgression in the rock record by noticing as you look at the rock layers in a vertical sequence that, for example, the depositional environment changes from a land environment to a shallow marine environment to a deep marine environment as you go from the bottom to the top (past toward present). The environmental change shown for a regression would be the opposite.

If you think about the profile that we worked with in lab last week which ran from terrestrial environments through some transitional environments out over the marine shelf to a deep marine environment, the depositional environments changed laterally. These different depositional environments could exist at one time, but not in the exact same physical space. To simplify what we found, sand was in the beach environment, muds were deposited in the inner shelf (or shallow marine) environment, and farther offshore on the outer shelf to deep marine environments, the dominant sediment was carbonate. We use the term **facies** to describe these related sediments.

As transgressions and regressions occur throughout geologic history, these facies will move laterally as well. This will affect the changes that we see in a vertical sequence such as the one described in Figure 1 above. Understanding how to identify these changes and what might cause them will help you to piece together a more complete geologic history of a given area.

In order to construct a larger-scale picture of how the environment in an area has changed with time we need to be able to correlate information from several different sequences of rock. These could be sequences that are separated by tens of miles or even hundreds of miles. In correlating rock layers between two different rock sequences, we want to match the rock layers of the same age and often similar rock type to one another.

The best way of establishing age-equivalency between rock layers from different sequences is to use the fossil assemblages in them. The basis for this is that we know particular animals lived during particular time intervals in the past. At any one time period you could find a group of animals that lived in a similar environment and might end up fossilized together in the same rock layer. So for each time period we can assume that there is a distinctive group of fossils that, when found together in a rock layer, indicate the age of that rock layer. This idea is formalized as the **principle of faunal succession**.

Establishing the ages of rock layers is not the only way to correlate them. You might also try to correlate layers by rock type (lithology).

More often than not, you will correlate using both fossil assemblages and lithologies.

During this week’s lab we will be interpreting a geologic history for a large area and will need to be able to interpret environments of deposition, changing environments through time, and to correlate stratigraphic sequences of rock over fairly large distances.