TEACHER BACKGROUND KNOWLEDGE

Interpreting the History of the Earth

Core Concepts

- The Earth's History can be read by observing and interpreting the features of the Earth's surface and the layers of rock buried underground.
    - Principle of Uniformitarianism
    - Principle of Superposition
    - Principle of Cross-Cutting Relationships
    - Fossils
    - Relative and Absolute Dating
    - The Geologic Timeline

Earth's History

Geologists constantly refer to events that happened long ago in the Earth's history – well before the time humans have been on the Earth to record history. The question is, how can they interpret what they can see on and under the Earth's surface today in order to explain what happened so long ago in the past? There are several

simple geologic principles and processes that allow geologists to put together the puzzle of our planet's 4.5 billion year history.

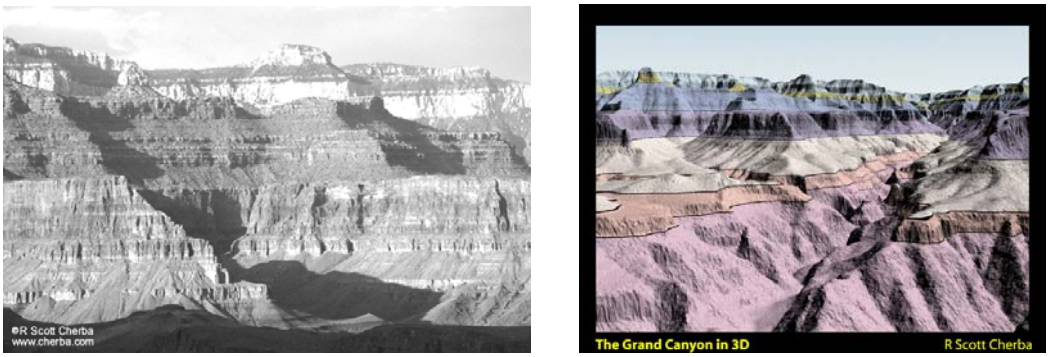
Interpreting the Crust's Layers

Geologists operate under the basic assumption that the processes which change the surface of the Earth today are the same as they have been throughout its history. Volcanism, earthquakes, weathering, mountain building, and the rock cycle have all worked the same way with the same effects since the time that the Earth's crust was formed. This is a plausible assumption because the changes we see today all follow the accepted laws of physics and chemistry that work in every other situation.

This idea was first presented by James Hutton in 1795 when he wrote "the present is the key to the past." We now refer to this idea as the **principle of uniformitarianism**. The rates of change may have changed over time, especially due do catastrophic events such as the collision of a large meteorite or comet with Earth, but the processes themselves have remained the same.

Armed with the idea of Uniformitarianism, geologists began to determine the **relative ages** of rock layers. The layering of

sedimentary rock – referred to as **stratification**, always results in older rock getting buried under newer rock. When these layers are initially deposited, gravity causes them to be formed horizontal to the surface of the Earth. The **principle of original horizontality** states that sedimentary layers always start out horizontal. This principle is supported by present observations of current sedimentation. It gives geologists a starting point for looking at rocks. Based on this principle, any time we find layers that have been tilted, bent, or otherwise deformed we know that they have undergone additional processes or changes since they were initially formed. From this knowledge, geologists can begin to determine the nature and causes of these changes.



Layers in the Grand Canyon, Source: R. ScottCherba

The **principle of superposition** states that older layers will always be under newer layers. This follows the common sense idea that a layer of rock could not be deposited under another layer that

has already been deposited. Using superposition, geologists can determine the relative ages of rock, creating a timeline of when different layers were laid down. Sometimes this timeline is broken by the uplifting or eroding away of layers, resulting in a "missing" layer, or layers that have been tilted up or bended, with a horizontal layer deposited on top. This is called an **unconformity**. Also, some features can cut through and change multiple layers, such as a line of magma squeezing through to the surface. This feature must be younger than any layer it cut through or else it could not have cut through the layer – you can only cut through something that is already there. This is called the **principal of cross cutting relationships**.

Fossils

Fossils are the remains of ancient living things. They can be shells, bones, teeth, tracks of animals, or impressions of tracks. Shells of ocean invertebrates are the most common fossils of the last half-billion years. Fossils of vertebrates such as dinosaurs or mammals are much less common. Plant fossils are often found in sedimentary rock from when they were initially buried in sediment or

in metamorphic rock. Individual leaves and branches can often be identified in fossils. The study of ancient life through fossils is called **paleontology**.

Geologists use fossils to help relate the age of rocks from one area to another, whether across a canyon or across the world. Because it is believed that living things arrived, evolved, and went extinct at approximately the same time around the world, specific species of fossils can be used as markers to connect layers of rock that were laid down at approximately the same time. Thus, if the absolute or relative age of a rock layer discovered in Africa is determined and a specific species of mollusk is identified in that layer, then any other layer found anywhere else in the world with that same species would have been laid down at about the same time.

Relative and Absolute Time

Several methods for determining the relative age of a rock or a group of rocks have been mentioned. Using the principles of uniformitarianism, superposition, original horizontality, and cross cutting relationships, along with the knowledge contained in the fossil record, geologists figure out which rocks are relatively older and

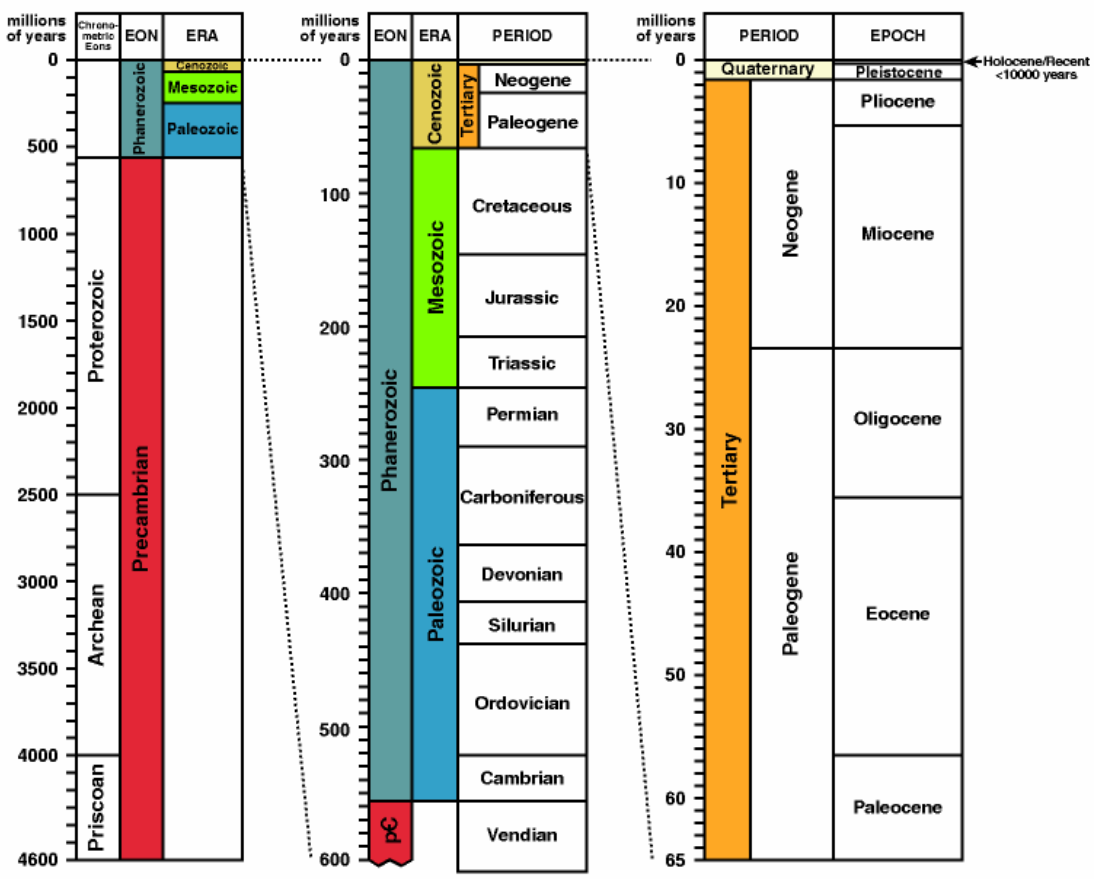
relatively younger than other rocks. This creates a geologic timeline with no dates... just an order of when different rocks were formed.

Adding dates to the timeline is much harder and relies on a combination of various techniques to provide dates to specific rocks. These dates are added to the relative timeline as they are discovered and confirmed. It is still a work in progress, as is much of geology. These specific dates are referred to as **absolute**.

Many of the dates that geologists have established are determined by studying unstable atoms that slowly decay within rocks. These atoms are referred to as radioactive. Because physicists have determined how long it takes for different types of atoms to decay, they can determine approximately how long a particular rock has existed. Carbon atoms in rocks and fossils can be used to determine age but this process only works for rocks and fossils dating back no more than 70,000 years, a very short part of the Earth's history. For older rocks, scientists use much larger and more complex atoms, such as uranium, rubidium, and strontium.

The result of decades of dating rocks from different layers and from different parts of the Earth is the current **Geologic Time Scale**. The time scale is divided into eons, which are then subdivided

into eras, periods, and epochs. These divisions are determined by major changes to the Earth, either geologic (such as the solidification of the Earth's crust which causes the division between the Hadean and Archean eons) or living (such as the mass extinction of the dinosaurs and other animals which causes the division between the Mesozoic and Cenozoic eras.)



Geologic Time Scale. Source: University of Calgary