

STRATIGRAPHY

Teacher Guide

including

Lesson Plans, Student Readers, and More Information

Lesson 1 - What is stratigraphy?

Lesson 2 - Correlation Activity

Lesson 3 -Geologic Time

Lesson 4 - Earth's History - Lab

Lesson 5 - Environments through Time



*designed to be used as an Electronic Textbook
in class or at home*

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES - STRATIGRAPHY

Lesson 1 - What is stratigraphy?

MATERIALS:

reader

Objective: Students learn the how stratigraphy developed.

Teacher note

Stratigraphy is usually overlooked in beginning Earth Science classes. However, it is an important tool to the petroleum and mining industries. Stratigraphy is the analysis of different rock formation through time and changing environments. Usually it is associated with sedimentary rocks because they follow predictable rules as they are deposited. Igneous and metamorphic rocks are more random on how they are deposited.

Rocks repeat themselves through geologic time and are difficult to determine the age when they were deposited. A granitic sandstone that was formed millions of years ago, can resemble a granitic sandstone of today. However, if you look at the fossils within these sedimentary rocks, they can provide clues on timing of deposition. For example, rocks with trilobites in them will not be forming today because there are no trilobites. The evolution of organisms helps us to compare the different rock strata and determine which one is older or younger. Fossils give us clues for which strata is younger or older.

It was the layers of rocks that made early geologist think about what could have created these layers. After careful analysis, many geologists became convinced that it took a lot of time to create these layers. Serious debates over the age of the Earth were started by geologists stating that the Earth was older than one thousand years.

Stratigraphy is built on the concept that the present is the key to understanding the past. The same processes that create the rocks today were in operation in the past. This helps us reconstruct how the strata was deposited in the past.

The following website has more information on stratigraphy and the scientists involved in changing how we think:

<http://turnpike.net/~mscott/index.htm>

Walking along cliffs that were cut by ocean waves or rivers have always made humans wonder how they were formed. The time required to create such majestic towers has created serious debate, both scientific and religious.

Geologic time was very difficult for scientists to "discover." It was not until the mid 18th century that James Hutton, a Scottish geologist, realized that the Earth was many millions of years old. This was an unimaginable idea because people in

his day believed the Earth was only a few thousand years old. Hutton tried to develop scientific methods to determine

the time required for every day geologic processes and compare with the past. For example he tried to calculate mud accumulating in the ocean today, to figure out how much time had passed since the formation of the Earth. He used the term "**uniformitarianism**" to compare the present day rock cycle with the past rock cycle. From these comparisons you can interpret how rock layers or **strata** were formed

but not the length of time. You can determine which stratum is younger or older, just by the position of the strata.



James Hutton



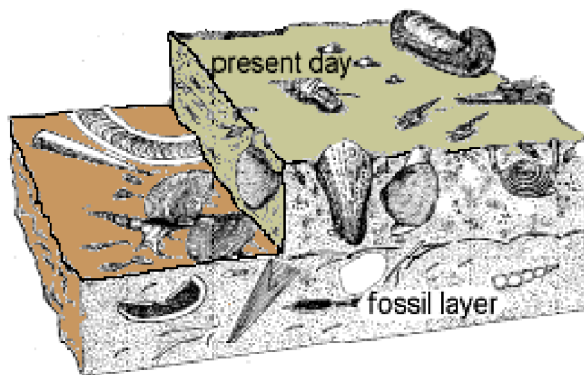
James Hutton wondered about the rocks from the Dorset, United Kingdom coastline



Sedimentary layers with fossils

Since most rocks on the surface of the Earth are sedimentary, early geologists used them to look for answers to the age of the Earth. The birth of **stratigraphy** has its roots in scientists trying to determine the age of the Earth. They made simple predictions by looking at sedimentary processes going on today.

Geologists started to realize that you can trace certain strata by comparing the fossils that it contains. The use of fossils became an important tool to unravel the history of the Earth.



Deposition of fossils and sediment

Nicholas Steno, a Danish physician living in Italy in 1669 proposed that the Earth's strata accumulated with three basic principles. Steno pointed out obvious, but overlooked principles of sediment accumulation. They included the **Principle of Original Horizontality**, **Principle of Superposition**, and **Principle of Original Continuity**.

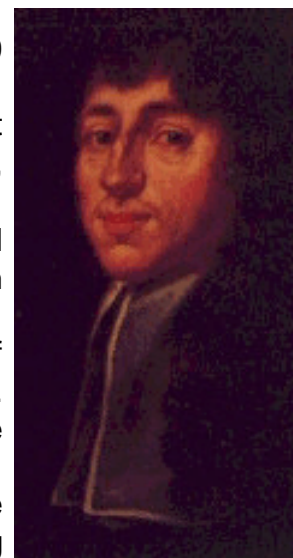
If sediments accumulate in a large basin, the laws of gravity will deposit the beds, horizontal to the surface of the Earth. Beds can "pinch out" along the sides of the basin as in the figure below.

The Principle of Superposition states that in a sequence of sedimentary rock layers, the bottom layers are older than the top layers. The bottom layers were deposited first. In the figure below A is the oldest bed and G is the youngest.

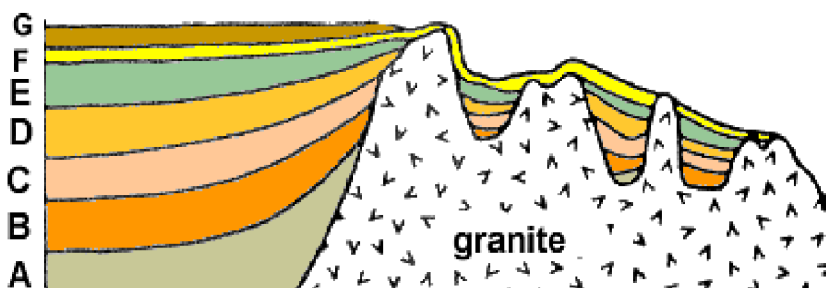
The Principle of Original Continuity states that the beds can be

traced over a long interval if the basins were open.

For instance, Bed F can be traced continuously to the smaller basin in the figure below. The other beds below F can then be correlated to Beds A-E.



Nicholas Steno



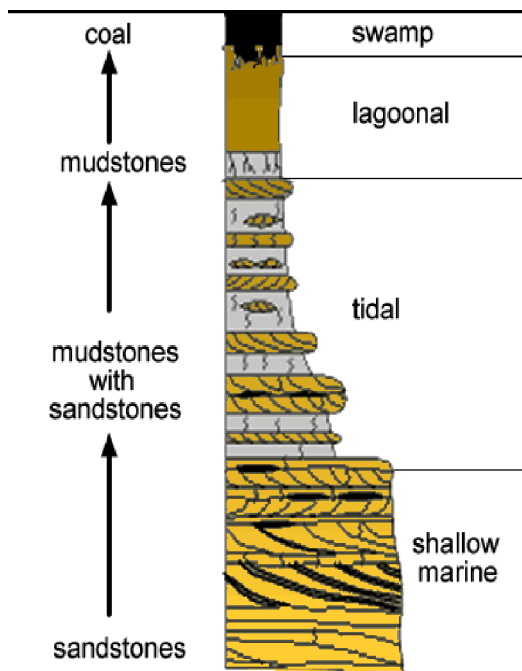
Sedimentary layers

The **Principle of Faunal Succession** was later added by William Smith in the late 1700's who observed and studied fossils embedded in rock layers. This principle states that the oldest fossils in a series of sedimentary rock layers will be found in the lowest layer (layer A). Progressively younger fossils occur in higher layers (layer B). This is the same concept as superposition, but it helped geologists realize that you can look at the age of these layers and assign relative dates. This parallels evolution. Younger organisms replace older organisms as the older ones become extinct.

Since organisms change through time, it allows **correlation** of beds far apart. If the layers have similar fossils, one can deduce that the layers are the same age.



William Smith

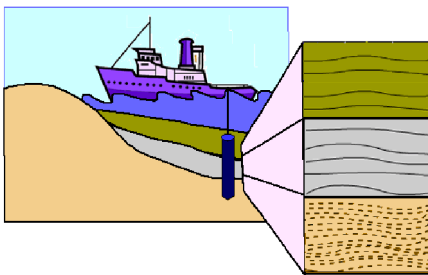


The principles of stratigraphy help to develop a **sequence** of rock layers. In the figure to the left, the oldest rocks are on the bottom (sandstones). The sandstones represent rocks deposited in a shallow marine environment. The younger rocks reveal an environment change into a tidal area. Through time the **tidal** area evolves into a **lagoon** and then a swamp.

The sequence provides information on changing environments through time. Then you can determine the sequences in other places and then correlate one rock type with another. For instance, along the beach in Darwin, Australia you can trace rock layers easily. They look like they match!



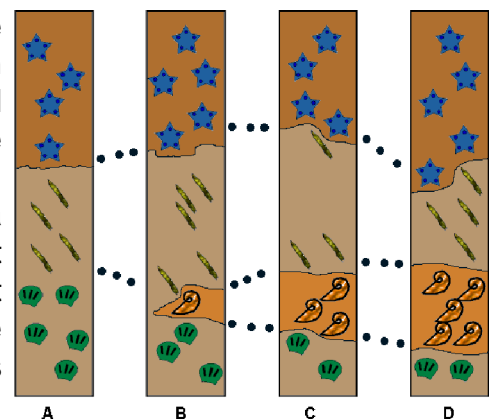
Darwin, Australia



Ship taking a core

Stratigraphy is important to understand events that happened over time and over a large area. However, to interpret these events you require slices of rocks through time commonly referred to as or **cores**. Ships can core rock layers from the ocean bottom. Cores would be taken at intervals that can help us correlate and interpret how the rocks were laid down.

In the figure of cores, each core represents a slice of the Earth. In "A," the green shells are the oldest and the blue seastars are the youngest. You can see that as you go from cores A to D the fauna adds snails to the region. A **stratigrapher** would determine what caused this sequence of events. Stratigraphers also look at the rocks, the fossils, and other evidence to make these conclusions.



Cores

Interpreting how the Earth's sedimentary layers have formed, is difficult. Cores taken on land and from the ocean are not only expensive to retrieve, but represent a small percentage of the Earth's surface. Methods using **seismic waves** developed in the 1960's help to observe the crust's layers in detail. **Seismic stratigraphy** is when energy waves are used to bounce off the different layers of the Earth. These layers provide us with data that a seismic stratigrapher can then interpret. For example, in the seismic profile below we show the results of waves bouncing off the different layers and then recorded on the surface of the Earth. These "wavy" images can then be used to reconstruct the area in



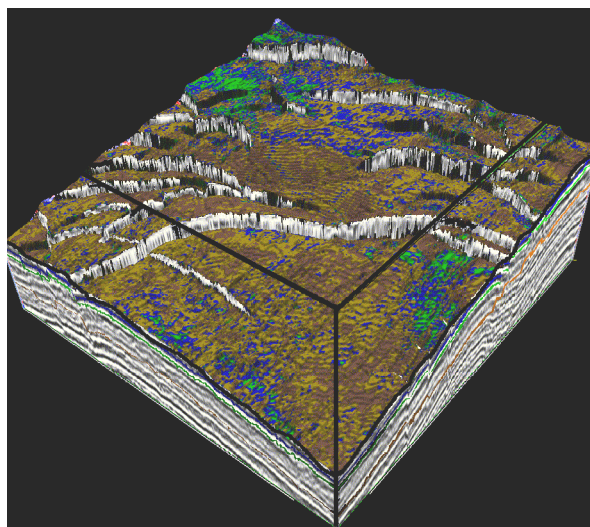
Seismic profile of an idealized area



Interpretation of the ideal seismic profile

rock units, as shown in the interpretation of the **seismic profile**.

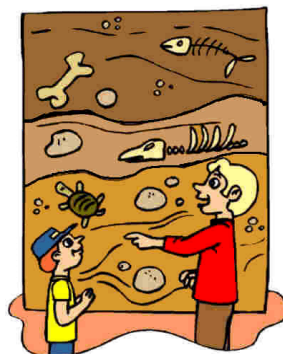
These advances have allowed geologists to map more area than ever before. Prior to these advances, only **outcrops** and geologists walking and recording on their maps could be used.



Three dimensional seismic model

Seismic profiles can be used to help calculate and create three-dimensional models of the Earth's layers that are hidden from view. New advances in other methods such as **infrared** profiles and other **electromagnetic wave** technologies, will allow us one day to see what the crust looks like.

Stratigraphy has evolved from an observational science into a high tech search for tools to help us explore what our world looks like. All these new techniques that we are developing will help us find resources like oil and metals. This technology can also be used to learn about the surface of other planets.



EARTH SCIENCES - STRATIGRAPHY

Lesson 2 - Correlation Activity

MATERIALS:

reader
colored pencils
worksheets

Objective: Students practice correlation of rock units.

Teacher note

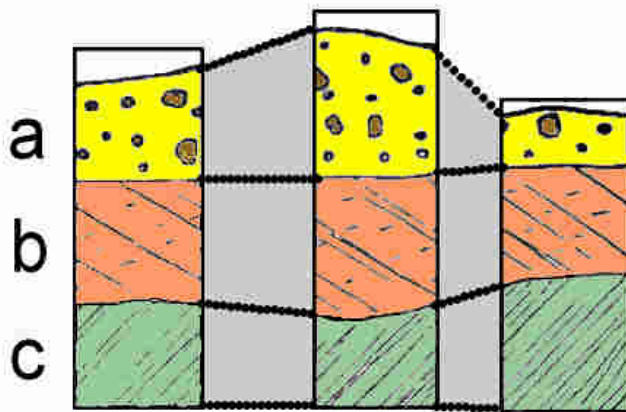
Rock units without fossils are hard to correlate over large areas that are not visually continuous. Visual correlation of rock units are difficult because many outcrops may be covered. Erosion after the rocks were deposited may also prevent correlation.

Lithologic units (rocks) without fossils can look the same. Sandstones created on the beach could look similar to sands that were deposited offshore in storm conditions or even sand created in deserts.

In this activity we want the students to train their eyes to see these correlation in cores. If you have access to cores, you might want students to see the real thing. You may want to do an internet search to see cores on line.

Correlation of cores from the Earth can be easy if you match them up unit by unit. Geologists would map an area and collect samples to confirm the units connected. For example, in the cores to the right, "a" has brown pebbles so you can correlate across the three cores.

In the following exercises you are looking at cores or outcrops and trying to see similarities. You look at similar rock types in one section and then connect it with the appropriate area. Coloring the units, one color helps to visually see the units easily. In the next exercise, follow the instructions for each activity.



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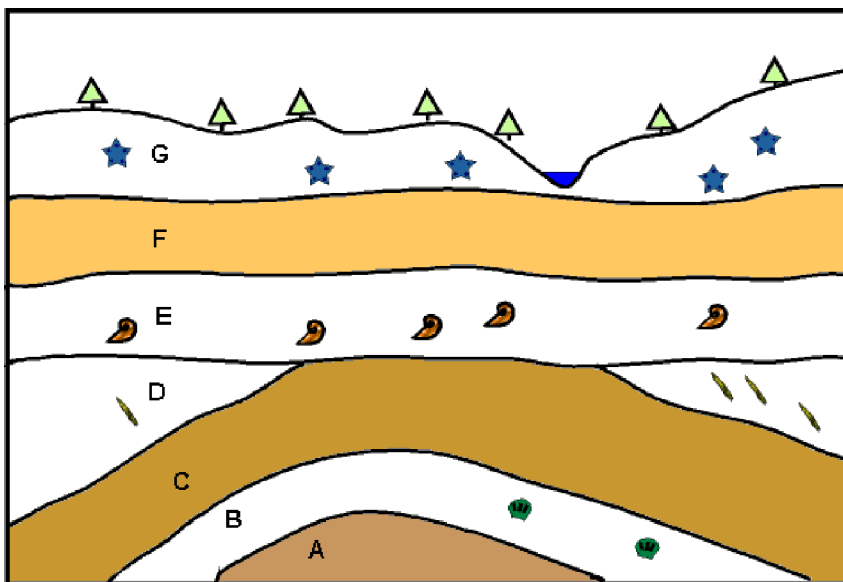
CORRELATION ACTIVITY

PROBLEM: How can the principles of stratigraphy be used to do relative age dating?

HYPOTHESIS:

PROCEDURE:

Exercise I. This drawing shows a cross-section, or a side view, of the rock layers below the Earth's surface. The trees and water show where the surface is. Each rock layer is identified by a letter. Some of the rock layers contain fossils. Using the principles of stratigraphy, answer the following questions about the cross section.



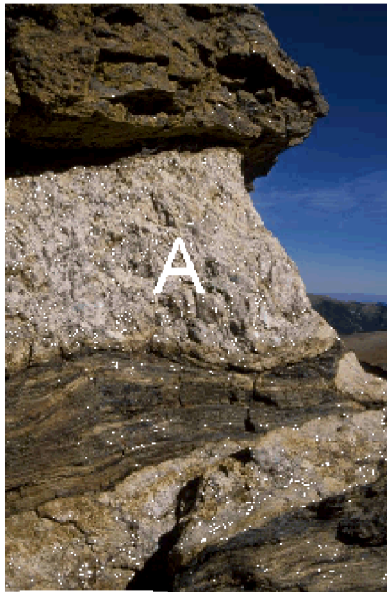
1. Which rock layer is the oldest? Which rock is the youngest? Which principles helped you determine your answer?
2. Between what two layers has erosion occurred? How can you tell?
3. Which rock units have been affected by mountain building? How can you tell?
4. Which type of fossil is the oldest? Which stratigraphic principles helped you answer this question?

Exercise II.

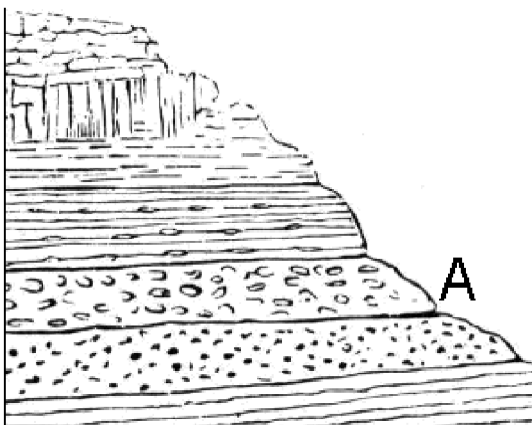
Correlate the appropriate rock units by drawing a line between the cores. You are given one clue in defining bed "A." Color the appropriate units and name them logically. Make a legend so your teacher can easily see the results.

1. Describe what units are missing in section 3.

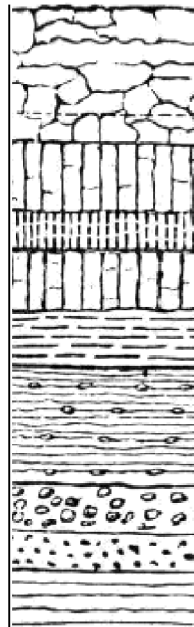
LEGEND



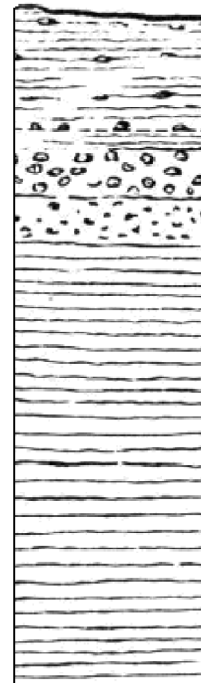
photograph of unit "A"



section 1

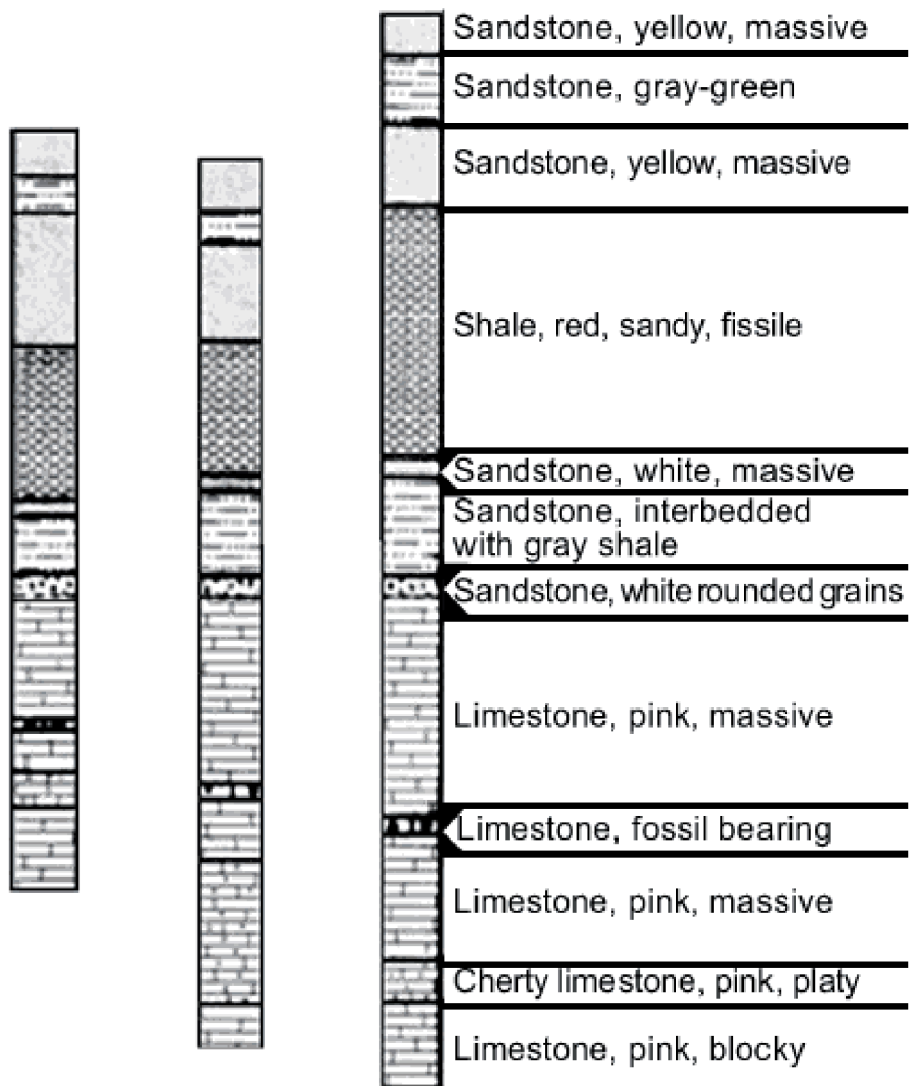


section 2



section 3

Exercise III. Correlate the appropriate units. Label the cores. Draw a line between units that match and color them appropriately. Create a legend using one of the cores. Can you interpret under what environmental conditions these units were deposited (i.e., deep or shallow)?



EARTH SCIENCES - STRATIGRAPHY

Lesson 3 - Geologic Time

MATERIALS:

reader

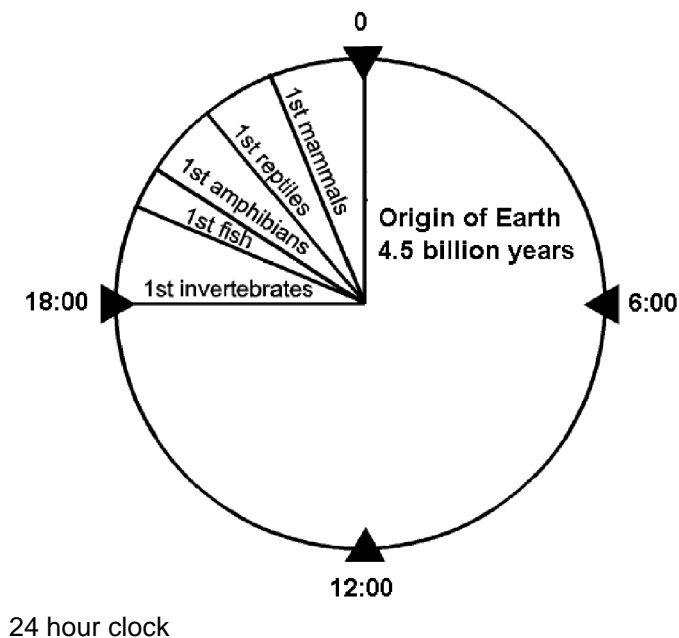
Objective: Students learn different ways to visualize geologic time.

Teacher note

The age of the Earth has been estimated to be about 4.5 billion years, with an error of plus or minus 1 billion years. It is difficult to date rocks and has always been a problem for geologists. Two scales are used to date rocks and to measure the age of the Earth, relative and absolute. Relative time scale is based on the sequence of layering of the rocks and the evolution of life. Absolute time is based on radiometric time scale which is the natural radioactivity of chemical elements in some of the rocks.

The U.S. Geological Survey has an online booklet on geologic time which gives more detailed information on absolute and relative time.

<http://pubs.usgs.gov/gip/geotime/>



The Earth is more than 4.5 billion years old. This is a very large number. One way to understand this amount of time, is to use seconds instead of years. If you looked at a watch, it would take a little more than 11.5 days for a million seconds to go by. Now remember that a billion is one thousand times one million. This means that it takes almost 32 years for a billion seconds to go by! Even if you can't visualize the time, just remember the Earth has existed for a long time.

This picture shows the history of the Earth as if it took place in 24 hours. The creation of the major types of animals was not until 20:00. Humans have only been on the Earth for a very short period, only 30 seconds before 24:00!

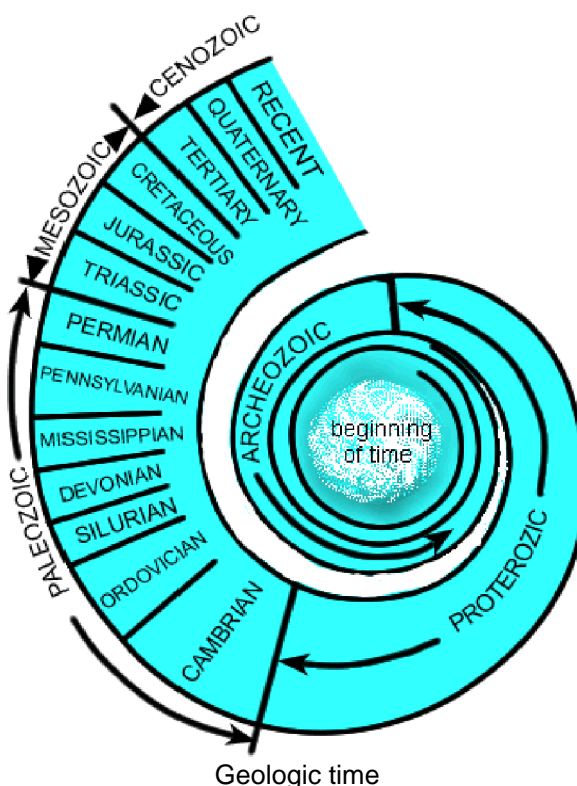
The age of the Earth was determined by using **absolute dating** of meteorites and moon rocks, which gives a date of 4.5 billion years old. The oldest known Earth rocks are younger, at just more than 4 billion years in age. Older Earth rocks have been destroyed by **meteorite** impacts, weathering, or metamorphism.

The oldest known fossils are almost 3.8 billion years old. The oldest fossils, however, are from very simple, single-celled forms of life. They are far removed from the complex life forms of the present. Multi-celled organisms (our likely ancestors) did not appear until approximately 650 million years ago.



Fossils from Bitter Springs Formation in Australia, oldest fossils known.

These creatures likely gave rise to animals with hard body parts (skeletons) about 560 million years ago. Evolution of organisms has taken place in the last quarter of Earth's history, which includes the **Paleozoic, Mesozoic, and Cenozoic**.



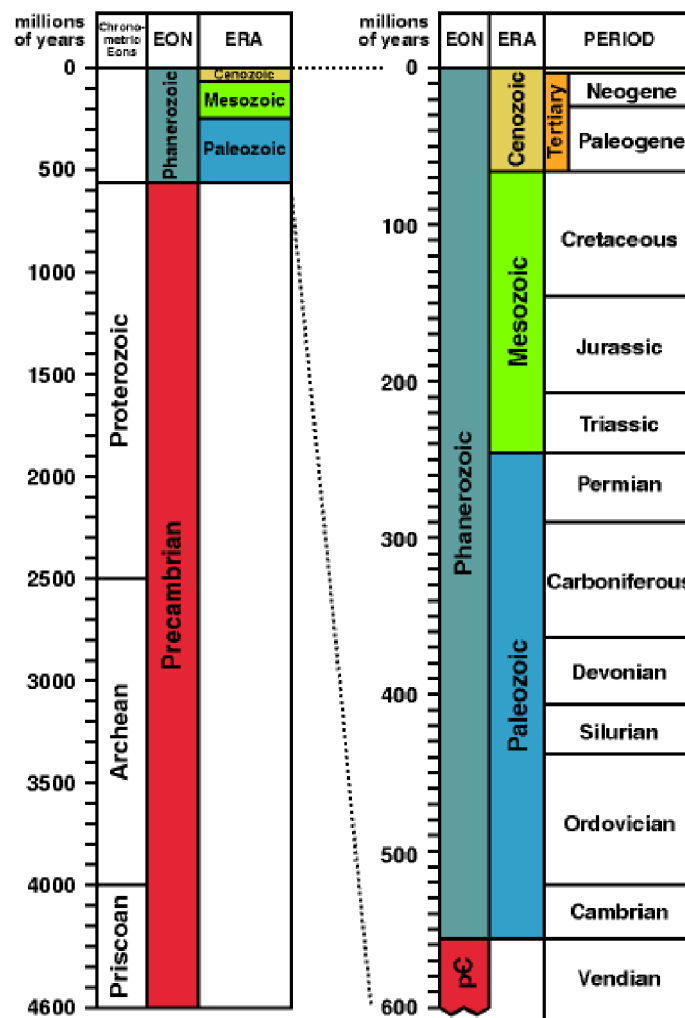
Geologic time is so different from the time that influences our lives. Geologic time refers to long periods of time measured in millions to billions or years in the rock record. However, geologic time can also record events that might be only a few hours or minutes in duration, like a catastrophe. Throughout geologic time, volcanic eruptions have caused ash to mix with snow causing an avalanche of mud. This wall of mud can cascade over towns and bury all forms of life. This event would be recorded in the rock. The bodies of organisms might not be there when uncovered by future generations, but the mud that accumulated will turn into mudstone. You can sometimes accumulate tens of meters of material in less than a day's work. Time is odd, and it is the job of a geologist to unearth the truth.



Avalanche

Paleontologists have made a detailed record of the evolution of life through Earth's history. This record is the basis for the geologic time scale and is referred to as **relative time**. The geologic time scale subdivides the 4.5 billion year history of the Earth into shorter time periods, based on changes in fossils.

The broadest division of geologic time is the **Eon**. There are two Eons, the PrePhanerozoic (or Precambrian) and **Phanerozoic**. The **Precambrian** stretches from the formation of the Earth 4.5 billion years ago until the start of the Phanerozoic Eon, about 560 million years ago. There are many fossils in PrePhanerozoic rocks, but they are almost all microscopic. Phanerozoic means "visible life." The rocks of the Phanerozoic Eon, which covers about the last 560 million years of Earth history, are characterized by abundant visible fossils.

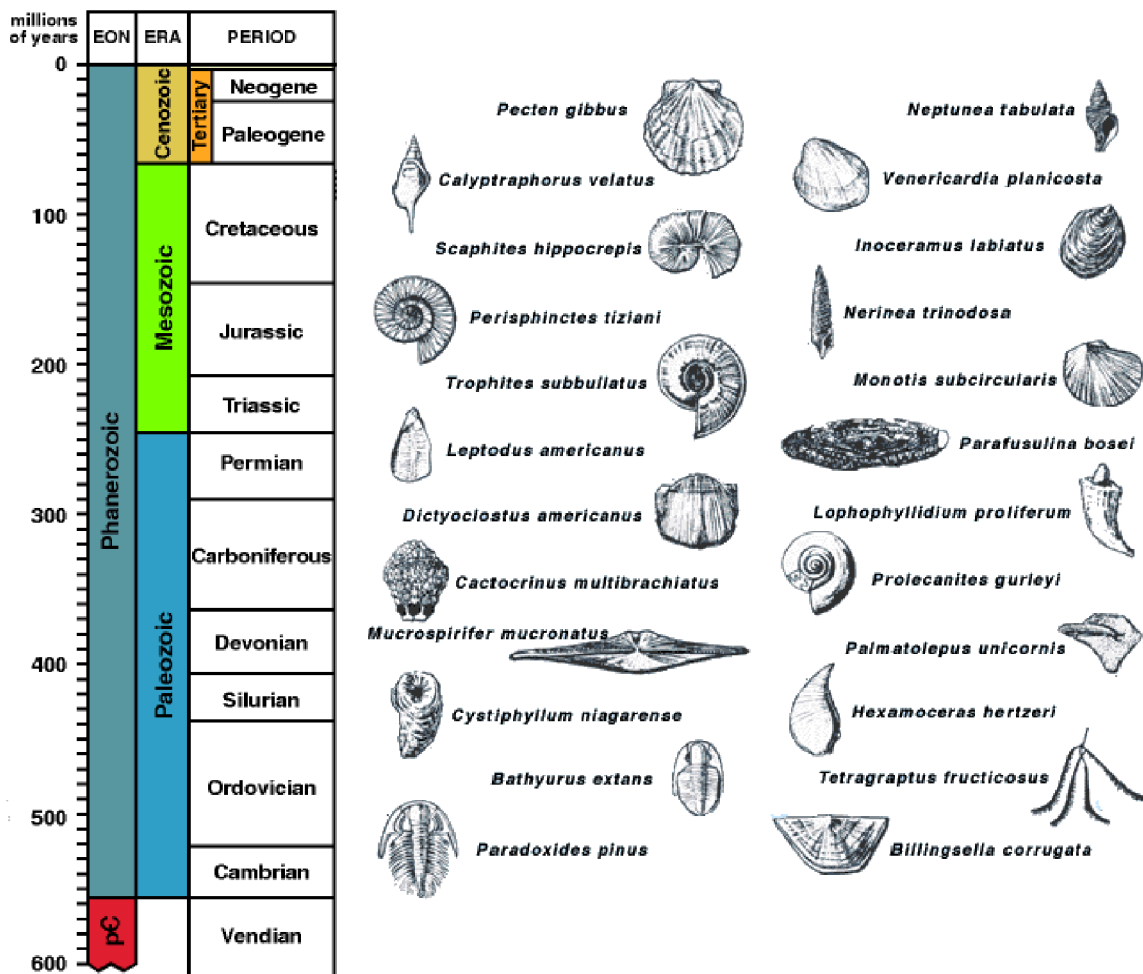


Geologic Time Scale

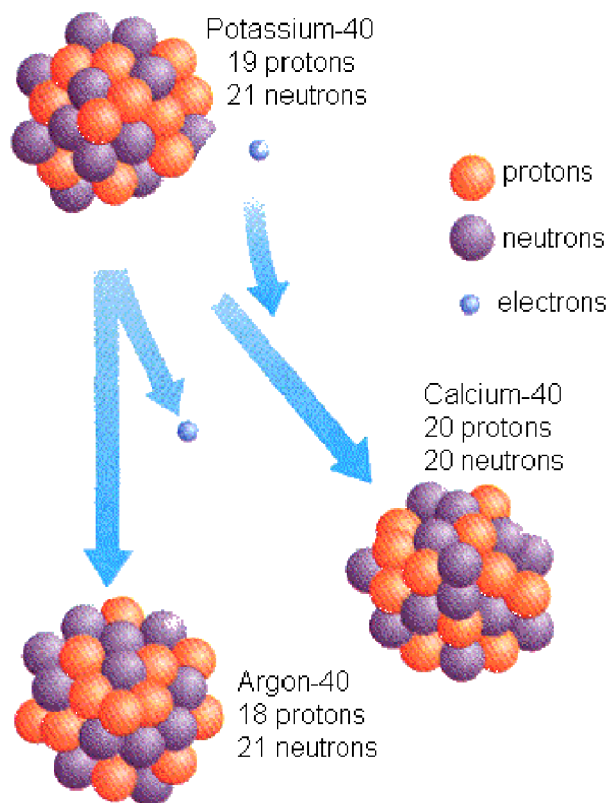
The use of fossils in stratigraphy is referred to as **biostratigraphy**. It is more accurate than absolute dating which has large margins of error. Biostratigraphers are still refining how the fossils can be used, but its use in relative dating is powerful.

It has been noted that species have a life span. If the species is short lived and abundant over a large area, it is called an index fossil. So if you find these fossils you can correlate time events. Marine organisms are the best because they can be found in large geographic environments and are deposited in many rock units.

Below are some examples of index fossils. Their time range is graphically displayed in a general manner. Biostratigraphers use much more detailed information.



Index fossils



Radioactive decay of Potassium-40

begins. It is this process that gives us the ability to date rocks that formed at different times in earth history.

Absolute age dating determines how many years before the present a rock formed. It gives the age of the rock in years. Geologists use **radioactive elements** to do absolute age dating. Radioactive elements are unstable. Over time, they decay or change into stable elements or will decay to become either some nearby element in the periodic table or some isotope of the same element. For example, radioactive potassium-40 decays into calcium-40 (11%) and Argon-40 (89%). We know how long it takes for such a transformation, by calculating the amount of **daughter material** (calcium and argon) that is produced from potassium. The time it takes is called its "**half-life**" and represents the average time an atom will survive in its original state.

Radiometric clocks are "set" when each rock is created. So the moment an igneous rock solidifies from magma or a sedimentary rock layer is deposited or a rock changed by metamorphism, the clock

EARTH SCIENCES - STRATIGRAPHY

Lesson 4 - Earth History Lab

MATERIALS:

reader

Objective: Students describe fossils that have biostratigraphic significance.

Teacher note

Students have learned to identify fossils in previous units. This lab has students look at similar fossils from specific locations and determine what age they represent. Students should use the charts and information in the reader to help interpret what age and environment the fossils represent.

This is a good time to use local fossils to add to this lab. If you are unfamiliar with fossils in your area, you may want to contact a local college or rock shop to help find localities and materials.

The materials should be displayed as a unit. For example, the crinoid, brachiopod, trilobite, and orthoceras are from the Paleozoic of Morocco. They should represent one area and time slice. The ammonites represent the Mesozoic of Morocco. The fossil shark teeth, although from Morocco, represent the Eocene which is in the Cenozoic.

The Capitola, California fossils represent just the Miocene, which is part of the Cenozoic.

This lab requires that they have completed all other fossil units. You may also want to see if students can connect the type of rocks that the fossils are in for more clues. Observation and making the connection that fossils can provide us clues on geologic time are the important skills.

Collecting Fossils in California

<http://www.gtisys.com>

Fossils tell a story about an area. They provide the stories of rocks that would otherwise be in many cases, just rocks. In this lab we will highlight two areas that are on two different continents. There are many other fossil localities in the world that have similar stories. In your travels, you should always ask what does this fossil represent and what clue does it provide to understand the geologic history?

Morocco is on the African continent in the northeastern portion facing the Mediterranean and Atlantic



Red marks Capitola, California

Oceans. This area has been known for centuries as a fossil hunter's paradise. The Atlas Mountains contain some of the most beautifully preserved fauna in the world. The fossils represent two similar environments (marine) but with different time spans.

Capitola is a small beach community on the central California coast. Many swimmers and surfers look at

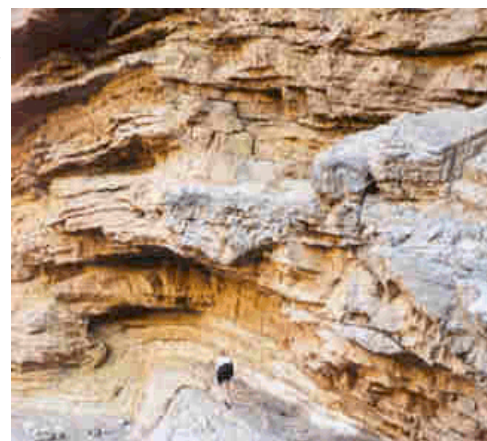
the cliffs while they are in the water, but most never look at the secrets of the cliffs. Layers of layers of invertebrate fossils embedded in the sandstones and mudstone, tell a story of death on the high seas.

Morocco is, geologically, a very complicated area. It records the marine environment of north Africa over 500 million years. This area is noted for its shops and export of fossils to many parts of the world.

In some areas you have typical marine Paleozoic fauna including **brachiopod**, **trilobites**, **ammonites**, **crinoids**, and **sea urchins**. The Mesozoic is noted for its

extremely large ammonites that are found in fossil shops throughout the world. The

Cenozoic is full of fossil shark teeth, which reflects a biologically happy area for a long time. Now the area is part of the Sahara Desert, with little sign of its glorious past, except in the fossils.



Morocco Mesozoic deposits



Fossil shop

The California coast has been subject to movement because of **transform** motion of two major plates. Mudflats that were once home to millions of organisms slowly were uplifted exposing their remains along the cliffs. Layers of fossils represent millions of years of accumulation. You can find mollusk including **bivalves** and **gastropods**, bones from

marine mammals, sand dollars, and even crab claws.



Mollusk fossils in mudstone

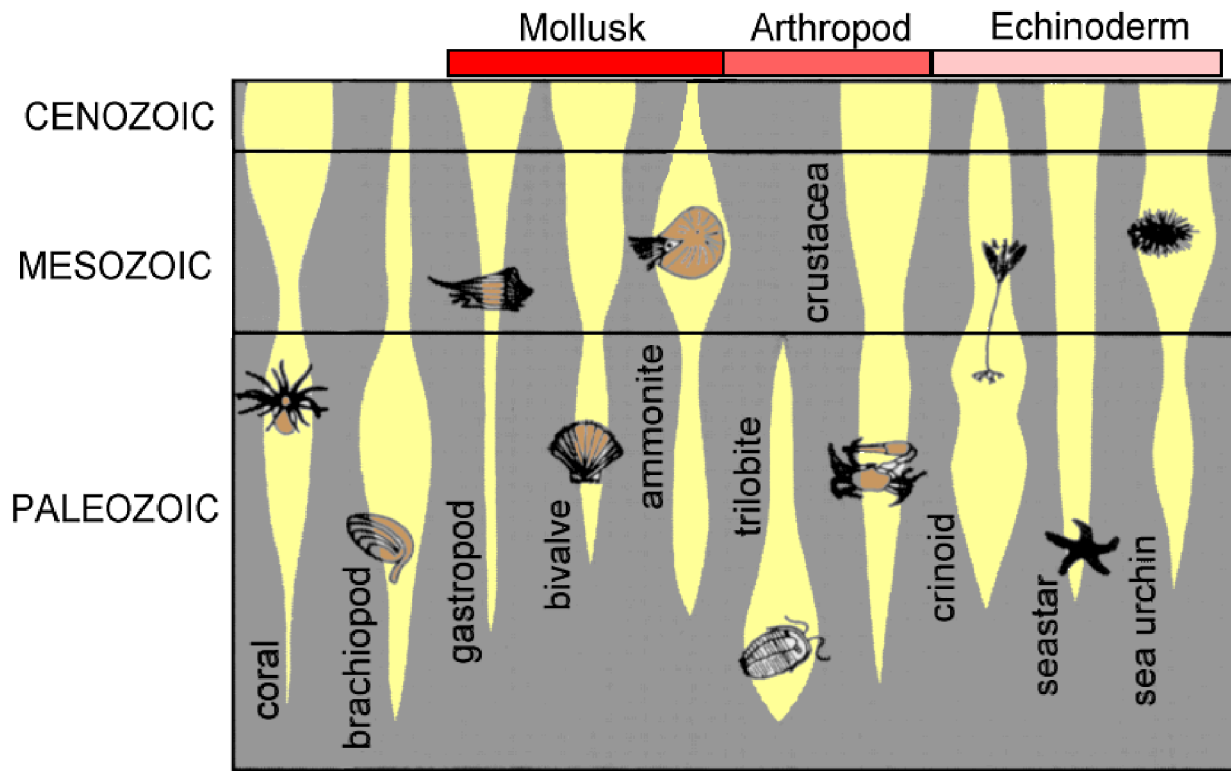


Marine mammals

Many times the shells are in distinct layers, with few still having two shells. Paleontologists have deduced that this represents storm layers. A storm would come in with violent waves and rip up the mollusk community. After the storm the shells would create a "burial" layer. In between the storm layers, you can find bivalves that whose shells are still intact, so they lived to a ripe old age.

Evolution seems to be in one direction. Once a species becomes **extinct**, the likelihood of that organism coming back to life is remote. It is this belief that allows us to date rocks. For instance, we will not have dinosaurs again. If you find dinosaur bones in rocks, those rocks are in the Mesozoic. Rocks without dinosaurs are younger (Cenozoic) or older (Paleozoic).

Relative time is very important and based on fossil occurrence. The ordering of the Principle of Faunal Succession will remain the same. Look at your fossils and try to familiarize yourself with the organisms and when they lived in geologic time.



EARTH SCIENCES - STRATIGRAPHY

GEOLOGIC TIME LAB

PROBLEM: How can you use fossils to date and determine the paleoenvironment of an area?

HYPOTHESIS:

MATERIALS: fossils

PROCEDURE:

1. Describe the fossil specimens from Capitola? Draw two different species that you see on the space provided below. Look at the range chart from the reader and determine the age of this specimen. Explain your answer.

2. Morocco is noted for its hills of fossils. However, many of their fossils come from different times. Draw all the fossil specimens on a the space provided below. Draw the specimens in the geologic time grouping they are from.

EARTH SCIENCES - STRATIGRAPHY

Lesson 5 - Environments through Time

MATERIALS:

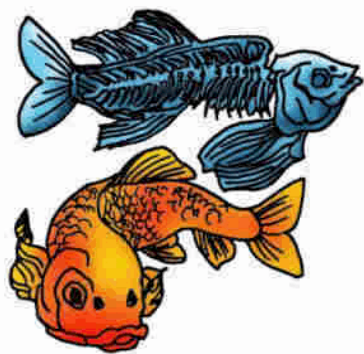
reader

Objective: Students reflect on why environments change through time.

Teacher note

The fossil record charts how organisms in a certain area have changed through time. This evolution of organisms provides clues to interpret past environmental conditions.

This reader tries to get students to look at the entire environment that is represented by rocks and fossils. In the next units on petroleum and mining, we will investigate specific examples of how interpretation of past environments is important to find and extract resources.



We all live in environments that are comfortable. Fish live in water because their body only works in that habitat. The chemistry of the water makes a perfect place for fish to thrive. In a healthy environment the fish will live, produce young, and die. In the present day environments, we can see that if you change the chemistry or water availability, you can have a drastic effect on organisms. Even in the ocean, a change of temperature of just 2-5 degrees centigrade can wipe out certain species, but also make conditions better for other species.

If you remove one species, it can cause a chain reaction through the food chain and cause the entire environment to change.

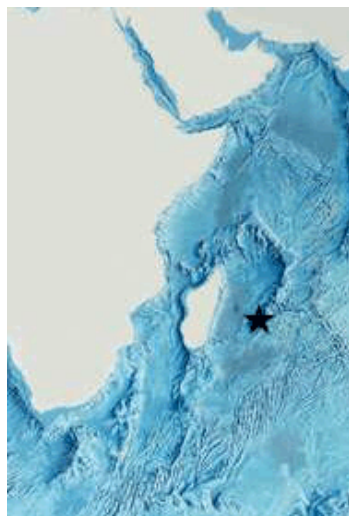
In the fossil record we can witness mass death and chart when a species becomes extinct. We can see if the events were at a local level or a larger regional area. These events help us interpret how the environment evolved through time.



Fossil fish kill

A “species” in a biological sense refers to male and female organisms that can produce young. If organisms are living, this is easy to observe. However, if the organisms are extinct we only have their skeletal remains. In paleontology we compare similar fossil **morphology** and refer to them as a single species. We record when a new skeleton is observed and chart the range of that species.

Sometimes we can see slight changes that branch off into another species.



Mauritius Island

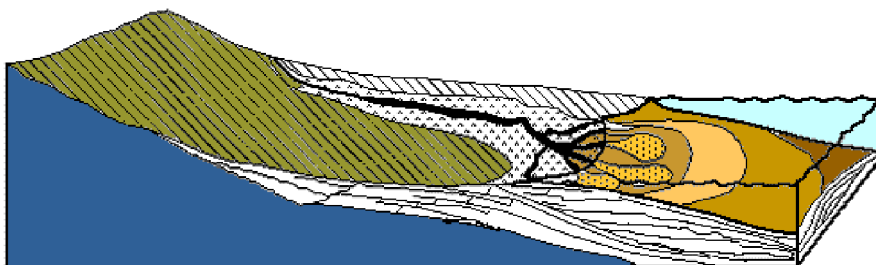
In the present we can see the evidence of why organisms became extinct. The dodo bird is an example of a modern day extinction on Mauritius Island in the Indian Ocean. This 50 lb. bird was flightless with no enemies on the island. When humans came to the shores in the early 1500's they ate the bird for meat. Humans also brought pigs, rats, and monkeys that ate the dodo bird's eggs. Within 180 years after man came to its shores, the dodo was extinct by 1681. So why is one species important in the fossil record. Unfortunately when you take away one species another species will soon follow.

In the case of the fruit-eating dodo, it was recently noted that certain trees were no longer producing seedlings. There were 300 year old trees with no younger trees. It was concluded that the dodo ate the fruit and as the seeds passed through the gut, it prepared the seed for germination. Without the dodo naturally eating the fruit the tree would become extinct. To save the tree, turkeys are now being used to eat the fruit to produce seedlings.



Dodo bird

Change is part of Earth's history. Stratigraphy records and saves these changes in rocks. Fossils reveal many extinctions through time. Geologists first felt these represented catastrophes which wiped out entire groups of organisms. Some felt this was evidence of biblical floods that caused all these extinctions. However, an extinction is more severe than just a one time disaster. For example, in the figure you can see that the river enters into an ocean. Organisms live there. A large **monsoon** rips up the bottom where the organisms live and kills them. The river then adds new sediment from the land and buries the creatures, preserving them as fossils. With time, the organisms can reestablish their habitat and live until the next storm event. This is not an extinction.



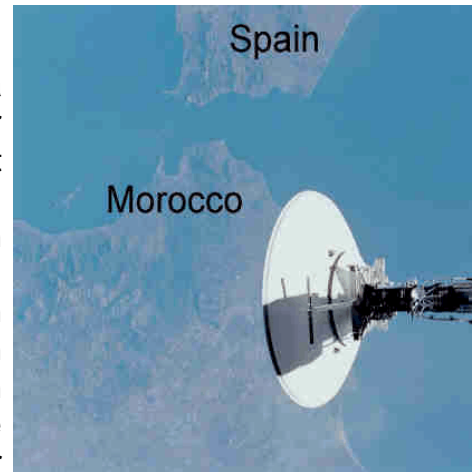
A permanent change in the physical conditions of a habitat, may only cause organisms to move to another location. However, if an ocean slowly evaporates or is cut off from another main body of water, and all representatives of a species live in that area, then extinction can occur.



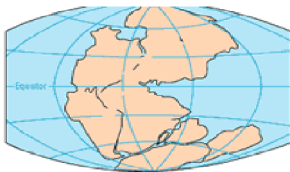
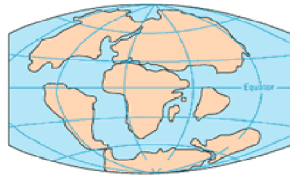
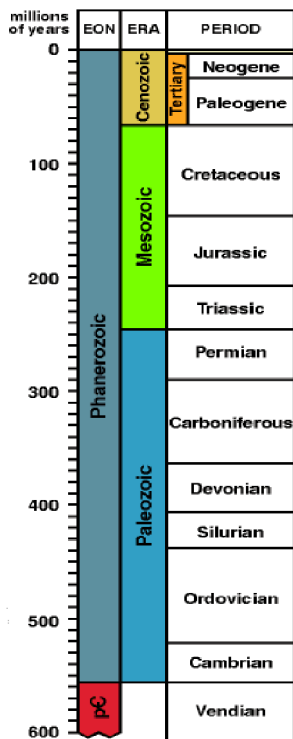
A meteorite

A disaster could change an environment that would cause an extinction. For example if an earthquake caused a narrow area like the Straits of Gibraltar to close, water would be trapped in the Mediterranean Sea. Circulation would become limited and cause layering of zones of stagnant water. The environment would change. It might take thousands or millions of years for the water to evaporate, but species that are endemic to the Mediterranean could not leave. They would slowly die to extinction.

So an event could trigger an entire habitat to change which would cause organisms to die off. Some scientists feel that even large meteorites could change a long term habitat and cause extinction over a rapid period of time, other scientists feel that organisms are not all like the dodo bird, and can find other areas to live.



Straits of Gibraltar



It has been long realized that the fossil record showed extinctions that had something to do with plate movements. As plates move the positions of land and ocean, there seems to be drastic shifts of environments. Marine conditions become land, and this would cause extinctions of any marine organisms.

The timing of plate tectonics and extinctions that are recorded in the fossil record are similar. When plate movement brings continents together, the environment of the organisms will slowly change, but in the fossil record it could look "rapid."

Plate tectonics can cause mountains to emerge through converging or transform boundaries which become barriers for organisms. Unlike humans, most organisms do not have the ability to just "move." An elephant cannot just find a new habitat that will sustain a healthy population. They just can't get into a car and drive to a new place.

TODAY

nitrogen 78%
oxygen 21%
CO₂ .036 %
CH₄ 1.6 ppm

ARCHEAN

carbon dioxide 30-90%
nitrogen 10-80%
CH₄ 10³-10⁴ ppm
carbon monoxide
no free oxygen

Although the present is the key to the past, not all the keys fit to unravel our geologic past. Some conditions in the past will never be the same. For example, the atmosphere is always changing. When life was first noted in the fossil record, the atmosphere was not like it was today. It wasn't until the beginning of the

Cambrian that methane, hydrogen, and ammonia were not the common gases in our atmosphere. Organisms, like plants, have changed the chemical composition of the atmosphere. Humans could not have survived in the atmosphere when trilobites were king of the oceans.

The level of the water has also evolved. Only about a billion years after the Earth was formed, was there evidence of water. Erosion of the rocks and the addition of gases from the atmosphere, have all changed the composition of the oceans.

Environments through time have changed. There are lessons in the present, but all geologists realize the past is a difficult subject to interpret.



Atmosphere of today

Earth Science - Stratigraphy and Correlation - Unit Test

Part I. Definitions: Match the number of the term or concepts in Column 1 with the letter of the correct definition in Column 2.

Column 1	Column 2
1. Precambrian	a. Principle of original horizontality
2. extinction	b. study of layers that correlate using fossils
3. absolute date	c. oldest fossil
4. index fossils	d. dinosaurs and ammonites
5. relative dating	e. last occurrence of a species
6. 3.8 billion years	f. older than 560 million years
7. biostratigraphy	g. species with a short life span and abundant
8. beds that are layered	h. origin of Earth
9. Mesozoic	i. based on half lives of radioactive decay
10. 4.5 billion years	j. using fossils to determine age

Part II. Multiple Choice Choose the best answer to complete each statement.

- Stratigraphy is not based on
 - Principle of Superposition
 - Principle of Faunal Succession
 - Principle of Horizontality
 - Principle of Verticality
- Uniformitarianism was first described by
 - James Hutton
 - William Smith
 - Nicholas Steno
 - Robert Jones
- Which principle states that beds can be traced over a long interval
 - Principle of Superposition
 - Principle of Original Continuity
 - Principle of Faunal Succession
 - Principle of Horizontality

4. Younger organisms replace older organisms refers to
 - a. Principle of Superposition
 - b. Principle of Original Continuity
 - c. Principle of Faunal Succession
 - d. Principle of Horizontality
5. Geologists use _____ to help correlate rock units.
 - a. rocks
 - b. cores
 - c. sequences
 - d. sandstone
6. Seismic profiles help to
 - a. interpret stratigraphy that is not exposed
 - b. find fossils
 - c. record rocks
 - d. find earthquakes
7. The age of the Earth is determined by
 - a. relative dating
 - b. a clock
 - c. absolute dating
 - d. fossils
8. The oldest known fossils are almost ____ years old.
 - a. 3.8 million years
 - b. 4.5 million years
 - c. 3.8 billion years
 - d. 4.5 billion years
9. Which combination represents the Phanerozoic
 - a. Cenozoic, Precambrian, Paleozoic
 - b. Eocene, Cretaceous, Jurassic
 - c. Precambrian, Cenozoic, Eocene
 - d. Cenozoic, Mesozoic, Paleozoic
10. Which of the following is responsible for changing environments through time?
 - a. Plate Tectonic movements
 - b. amount of rain
 - c. amount of sun
 - d. fire

ANSWERS:

Part I.

1. F
2. E
3. I
4. G
5. J
6. C
7. B
8. A
9. D
10. H

Part II.

1. D.
2. A
3. B
4. C
5. B
6. A
7. C
8. C
9. D
10. A