

Senior High School

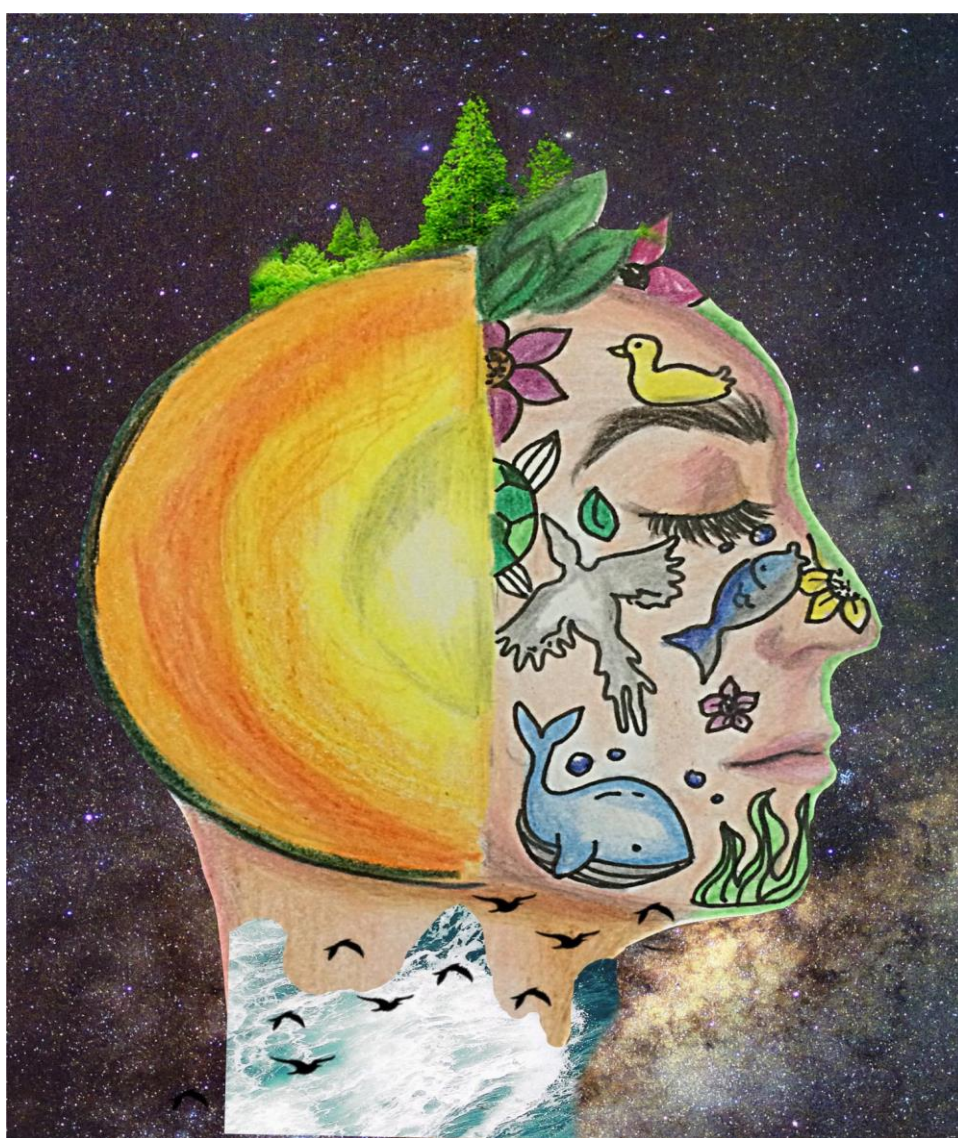
Department of Education
National Capital Region

**SCHOOLS DIVISION OFFICE
MARIKINA CITY**

Earth and Life Science

First Quarter-Module 8

Earth Materials and Processes

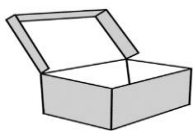


Catherine T. Balita



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What I Need to Know

This module was designed and written with you in mind. It is here to help you master the nature of Earth and Life Science. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course.

The module is divided into three lessons, namely:

- Lesson 1 – Stratification of Rocks
- Lesson 2 – Methods of Dating
- Lesson 3 – How Geological time is subdivided

After going through this module, you are expected to

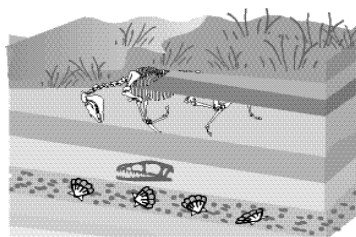
1. describe how layers of rocks are formed;
2. describe the different methods used in determining the age of rocks;
3. explain how relative and absolute dating were used to establish the subdivision of geologic time; and
- 4. describe how marker fossils are used to define and identify the subdivision of geologic time (S11/12ES-Ia-e- 25-29).**



What I Know

Read the question carefully and encircle the letter of the correct answer.

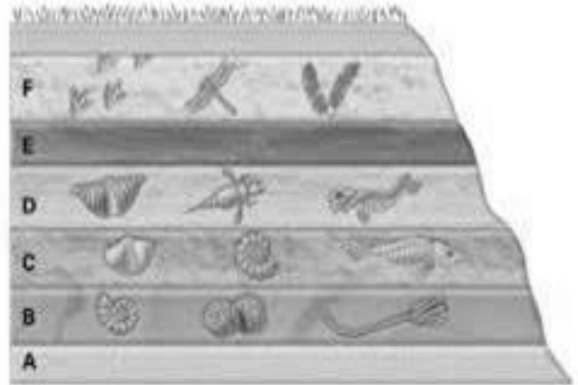
1. How old do Paleontologists believe the Earth is?
A. 10 billion years old
B. 4.6 billion years old
C. 5.6 billion years old
D. 3.6 billion years old
2. Which of the following best explains the content of Law of Superposition?
A. The age of fossils.
B. The super powers of rocks.
C. The relative age of rock layers.
D. The absolute age of rock layers.
3. According to the Law of Superposition, which is the oldest fossil in the illustration below?



4. How can scientists learn from the sequence of rock layers?
- Based on recorded geological events.
 - Based on the geological history of that area
 - Based on the impact that hikers had on an area
 - Based on the number of organisms that live in the area.

5. Which rock layer in the diagram seems to be the oldest?

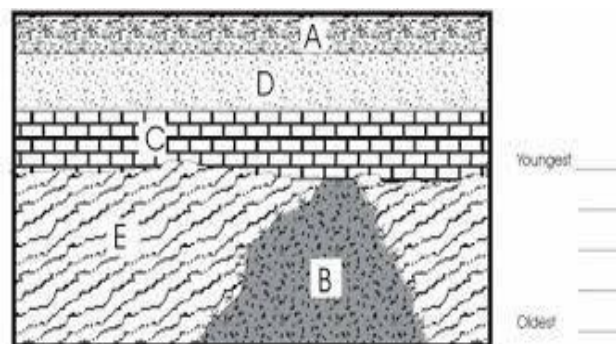
- A
- D
- B
- F



6. Which type of dating method can be used on rock layers by applying the Law of Superposition?
- Absolute dating
 - Radiometric dating
 - Radioactive dating
 - Relative dating
7. Which radioactive element is usually used to date rocks?
- Carbon-14
 - Nitrogen-12
 - Oxygen-18
 - Uranium-238
8. Why is radioactive decay important?
- It is used to measure absolute time.
 - It is used to measure relative time.
 - It is used to measure half lives.
 - It is used to measure time of day.

9. Which of the following correctly shows the layers of rocks from oldest to youngest?

- A,B,C,D,E
- C,D,A,E,B
- E,D,C,B,A
- E,B,C,D,A



10. What is the length of time required for half of the radioactive atoms in a sample to decay?
 A. Age B. Era C. Eon D. Half-life
11. A rock formed with 1000 atoms of radioactive parent element but only contains 250 radioactive parent atoms today. If the half-life of the parent is one million years, how old is the rock?
 A. 250,000 years old C. 500,000 years old
 B. 1,000,000 years old D. 2,000,000 years old
12. Which of the following does a geologist use to determine the relative ages in rock sequence?
 A. Cross-cutting relationship C. Stratigraphy
 B. Fossils D. All of these
13. Which of the following best describes geometric age?
 A. It is absolute. C. It is historic.
 B. It is geologic. D. It is the totality.
14. How is the under formed sedimentary layer organized?
 A. older—older C. older- young
 B. younger—older D. younger – younger
15. When does a disconformity occur?
 A. When a rock unit that does not contain fossils.
 B. When an erosional surface between different rock types.
 C. When an erosional surface between horizontal sedimentary rocks.
 D. When an erosional surface between igneous and metamorphic rocks.

Lesson 1

Stratification of Rocks

In the previous discussion, you learned about the habitable planet- Earth. In addition, you have discovered how the internal structures and Earth's subsystems interact together to enable life to exist. Our planet existed for about 4.5 billion years ago and throughout these long years various integral changes occurred. Internal and external processes happen causing great shifts in the appearance of the surface of our planet today. The question of interest though is, how come that some of the geologic structures come in layers and convolutions.

In this lesson, you will explore how rock layers are formed, the different stages in the formation of rock layers, and the forces responsible for their deformation.





What's In

In the last module, you studied the different geological processes and plate tectonics. Before you proceed to the lessons of this module, take time to read the following major concepts about stratification of rocks:

- **Stratification** refers to layers of rock formation.
- **Stratum** plural Strata) a layer of sedimentary rock or soil with internally consistent characteristics which distinguish it from other layers.
- **Weathering** is a geological process which means breaking of rocks into pieces which may be caused by physical and chemical factors.
- **Protolith** means parent rock or main rock.
- **Lithification** similarly means compaction of particles in which the weight of the body of water on top packs the sediments tightly together, as a result expelling water between the grains.
- **Compaction** putting sediments together by a great pressure.
- **Deposition** is a geological process of transporting materials by water from one place to another.



What's New

Stratification of Rocks

You have learned Earth's history by studying the record of past events that is preserved in the rocks. The layers of rocks are like pages in our history books. Most of the time what we see around us are pieces of rocks. But when we go around to a school tour, we pass by the side of mountains, hills, sides of rivers and we see huge formations which face contains layers of rocks. Generally, most of the sedimentary rocks are found on the surface of the earth that comes from particles of older rocks that have been transported by wind, water, or biological factors. Rock layers are also called strata (plural form of the Latin word stratum). Moreover, stratigraphy is the science of strata. The layering of rocks shown in the picture is what we call **stratification**.



Figure 1.1. Stratification of Rocks

Source: Stratification of Rocks. Imageo. Accessed September 4, 2020.
<https://imageo.edu/view/4117/>



Stratification of rocks

During or immediately after the accumulation of biological, physical sediments, and chemical processes, sedimentary structures are produced. This is also what happens to almost all sedimentary rocks which display some type of bedding. A rock that contains bed is stratified or displays Stratification. Strata or stratification is a geologic term which applies only to sedimentary rocks. Since stratification pertains exclusively to sedimentary rocks, the process behind the formation of rock stratification is the same process that produces sedimentary rocks.

Geologists match rock layers by studying index fossils. These are useful because they tell the relative ages of the rock layers in which they occur and the organisms that exist during that time. The process of matching up rock layers in separate areas is called **correlation**. This includes comparing rock type, index fossils, volcanic ash fall.

Activity 1.1. Correlating rock layers using index fossils.

In order to find out the relationship between rock layers and the time they were formed, geologists tried to match similar rock layers in different locations. This is to see if the rocks formed at the same time and conditions. Sometimes the rock type will match but not always. This is because erosion can remove layers that used to be there and then more layers can be deposited on top of the eroded layer.

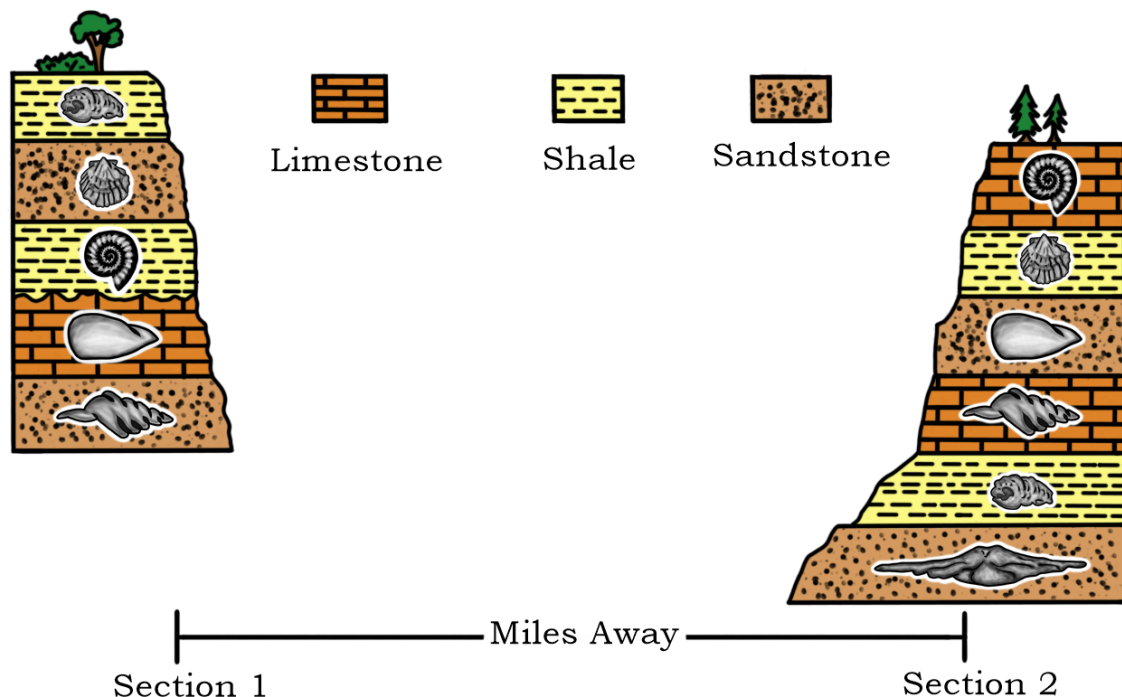


Figure 1.2. Correlating Rocks Layers

1. Using the illustration above, draw arrows to connect the rock layers with their fossils.

Note: (Not all layers will have a match)

2. Which section is older?

3. The fossil that is a wing-shaped clam (on the bottom layer of the first section) is found in sandstone in the first layer and limestone in the second layer.

Give one reason why they are not found in the same type of rock.



What Is It



Figure 1.3. An eroded limestone. Kapurpurawan Rock Formation Burgos, Ilocos Norte.

Source: Kapurpurawan Rock Formation 2017. Wikimedia Commons. Accessed September 4, 2020.
https://commons.wikimedia.org/wiki/File:Kapurpurawan_Rock_Formation_2017.jpg

During a school tour, you probably saw formation of rocks on mountains, hills, or riverbanks. Some of the common thoughts were, how come it is composed of many layers and why those layers sometimes are convoluted. To answer these questions, we have to trace the formation of sedimentary rocks.

Stages in the formation of rock strata

Table 1.1. Stages in the formation of rocks

Weathering	Weathering of rocks Physical, Biological or Chemical Weathering -breaks down rocks into tiny fragments. The protolith (parent rock) can be an igneous rock, sedimentary or metamorphic.
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Erosion and deposition	Erosion moves weathered rock and soil from one place to another. Deposition occurs when wind and water lay down sediment into a sedimentary basin.
Lithification	Through the action of compaction by pressure and cementation, they form a layer of sedimentary rocks.
Folding, faulting, uplift, subsidence, etc.	The movement in the earth's crust causes deformation in the sedimentary rocks, giving the rock stratification its varied arrangement.
Erosion and Deposition	New sediments are carried into the sedimentary basin, forming a new layer of sedimentary rocks on top of the old ones.

Weathering is the process where a rock is dissolved, worn away or broken down into smaller and smaller pieces. There are mechanical, chemical, and organic weathering processes. Erosion happens when rocks start to weaken and broken down into pieces due to weathering. On the other hand, erosion occur when rocks and sediments are picked up and move from one place to another by gravity, ice, water, or wind. Wind and water carry them in sedimentary basins, usually a body of water, such as lakes and seas where they settle at the bottom. Different types of sediments are deposited in the basin per specific time period. This reflects the condition of the environment at that time period.

Accumulated sediments harden into rock by **lithification**. There are two important steps needed for sediments to lithify.

1. Due to compaction, sediments are squeezed together by the weight of overlying sediments. Clastic rocks are formed from nonorganic sediments while bioclastic rocks are formed from organic.
2. Cementation starts to happen when fluids fill in the spaces between loose particles of sediments and then crystallize.

Deformation of rock strata

Recall your experiences during your school field trip. You probably noticed that as you pass by the different formation of rocks. You would see that the rock formations are not neatly parallel layering. This is because their layering had been deformed. Deformation of rock involves changes in the shape and volume of material. There will be changes in the shape and volume of material when stress and strain and stress are inflicted. This causes rock to fracture or crumple into folds. A fold happens when the rock bends as a response to compressional forces. Compressional stresses on rocks over long periods of time causing them to fold. Intrusion of new rock forms, such as intrusive igneous rocks, breaks its uniform layering. The movement of plates beneath causes a column of sedimentary rocks to rise up, descend, or tilt to its original position.



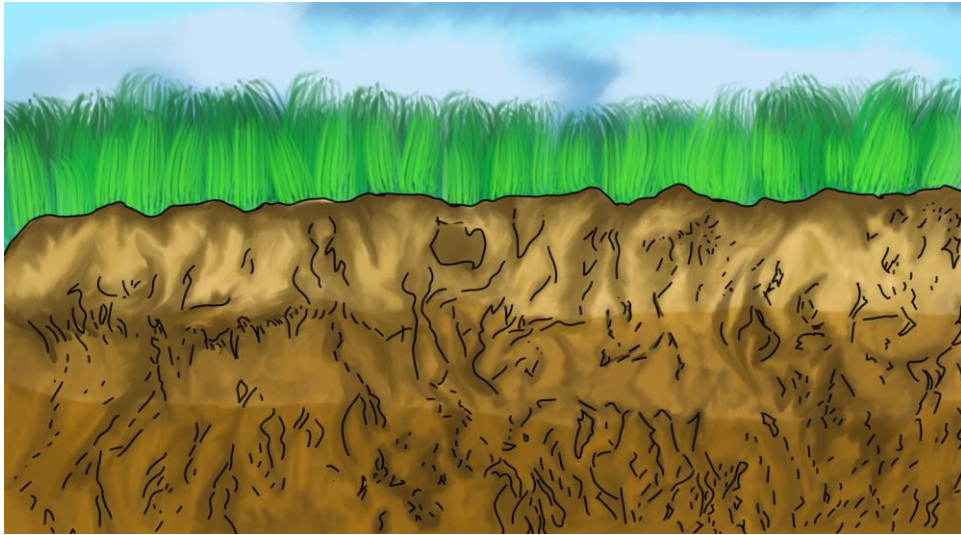
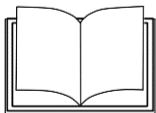


Figure 1.4. Deformation of columns.

Forces that cause deformation in a column

When strain and stress are applied to a rock it may cause deformation. The following are the forces that may cause deformation:

- Compressional stress
- Intrusion of new rock forms
- Movement of plates beneath the earth crust.



What's More

Why study old rocks?

"The past is a key to the future" as one may say. By studying the age of rocks, we can gain an understanding about landslides, mass wasting, and future earthquakes. Doing fieldwork, interpreting seismic reflection data, and studying drill-hole samples are the ones involved in this.

The branch of geology that deals with the study of rock layers and layering is known as Stratigraphy. It primarily studies sedimentary and layers of volcanic rocks.

Activity 1.2. Studying the stratigraphic cross section of rocks.

Study the stratigraphic cross section of rocks and answer the questions below. Write the letter of the correct answer in a separate sheet.

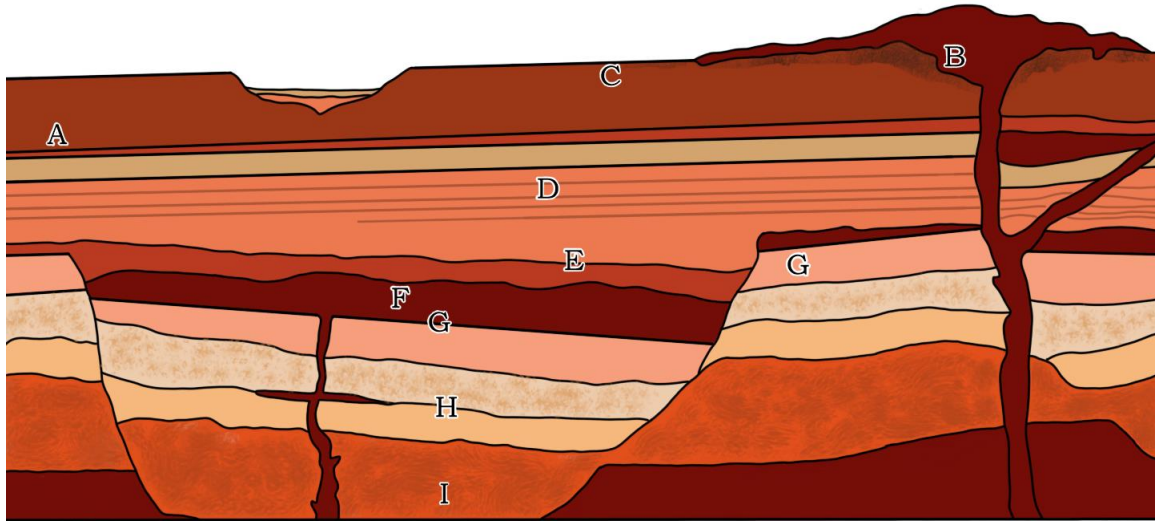


Figure 1.5. Stratigraphic cross section

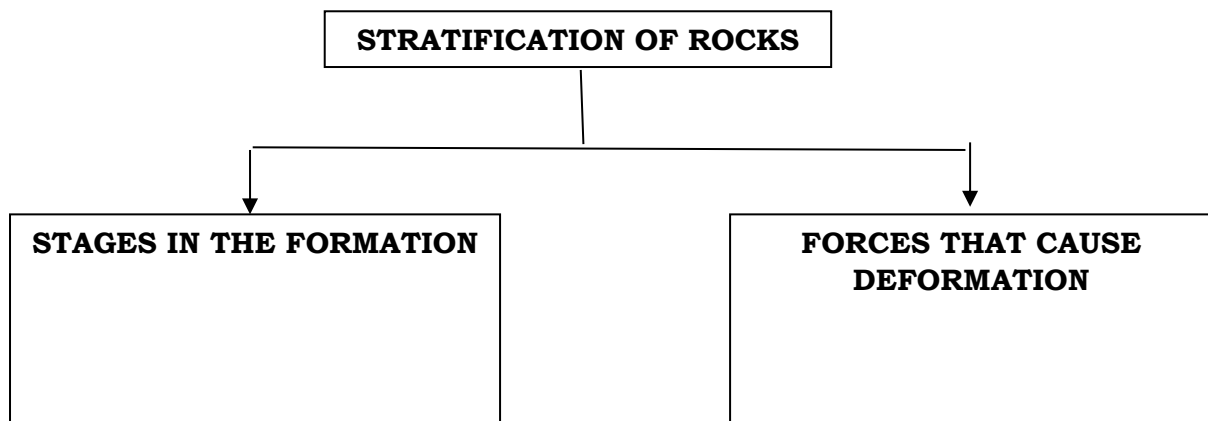
1. What is the oldest layer? _____
2. Which is the youngest rock? _____
3. Which is the youngest fault? _____
4. Which is the oldest fault? _____
5. What is the evidence for erosion? _____
6. How do you know that there was compression in the area? _____



What I Have Learned

Activity 1.3

Fill in the graphic organizer below with concepts that you have learned.





What I Can Do

Activity 1.4. Performance Task

Choose any of the following performance task below. The rubrics below will be used in grading your individual performance task.

Performance Task # 1 Story Board (can be done using computer application or handwritten output). Create a five-frame story board that illustrates the sequence/stages in the formation of rock strata.

Performance Task # 2 Collage-Strata. Using recyclable materials like beads, sticks, coins, pebbles, seeds etc. Create a collage-strata showing layers of rocks. Place captions on how each layer is formed.

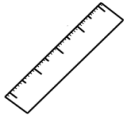
Performance Task # 3 Info-Jar. Make a jar of soft sandstone rocks and different tiny fragments. Inside the jar place small piece of paper with information/ concepts about stratification of rocks. Shake the jar and observe what happens to the resulting fragments.

Rubrics:

Pts.	Creativity/Originality (x 8 pts.)	Effort/Perserverance (x 7 pts.)	Craftsmanship/Skill (x 5 pts.)	Cooperation/Attitude (x 5 pts.)
4	The student explored several choices before selecting one, generated many ideas, tried unusual combinations or changes, used problem-solving skills.	The project was continued until it was complete as the student could make it; gave it effort far beyond that required.	The artwork was beautiful and patiently done; it was as good as hard work could make it.	The student willingly participated in necessary preparation or work for classroom, was sensitive to the feelings and knowledge of others, exhibited a positive attitude toward assignment.
3	The student tried a few ideas before selecting one or based his/her work on someone else's idea, made decision after referring to one source.	The student worked hard and completed the project, but with a bit more effort it might have been outstanding.	With a little more effort, the work could have been outstanding; lacks the finishing touches.	The student participated enthusiastically, performed more than adequately, assisted in preparation and cleanup.
2	The student tried an idea but it lacked originality, might have copied work, substituted "symbols" for personal expression.	The student finished the project, but it could have been improved with more effort, chose an easy project and did it indifferently.	The student showed average craftsmanship; adequate, but not as good as it could have been, a bit careless.	The student was apathetic toward the assignment, complained, assisted in preparation and cleanup when asked.
1	The student fulfilled the requirements of the assignment, but gave no evidence of trying anything unusual	The project was completed with minimum effort	The student showed average craftsmanship, lack of pride in finished work	The student allowed others to do most of his/her work, participated minimally, exhibited no interest in the project
0	The student showed no evidence of original thought	The student did not finish the work adequately	The student showed poor craftsmanship; evidence of laziness or lack of understanding	The student did almost nothing toward completing the assignment, did minimum or no amount of preparation or cleanup, distracted others.

Total possible points = 100





Assessment

Read the question carefully and encircle the letter of the correct answer.

1. Which process is involved in turning sediments into sedimentary rock?
 - A. Carbonization
 - B. Lithification
 - C. Compaction
 - D. Petrification
2. What event leads to lithification?
 - A. When heat and pressure are applied.
 - B. When weathering and erosion occurred.
 - C. When melting and cooling happened.
 - D. When compaction and cementation occurred.
3. During which process does layer upon layer of sediment build up, exerting pressure on layers below?
 - A. Compaction
 - B. Deposition
 - C. Erosion
 - D. Weathering
4. Which of the following is **NOT** one of the possible stages in the formation of rock strata?
 - A. Erosion and deposition
 - B. Lithification
 - C. Melting
 - D. Weathering
5. Which pertains to the movement of Earth's solid materials from one place to another?
 - A. Earthquake
 - B. Erosion
 - C. Lithification
 - D. Weathering
6. Which of the following forces causes deformation in a column of rock?
 - A. Compressional stress
 - B. Fiction
 - C. Erosion
 - D. Magnetism
7. How is unreformed sedimentary layer occurs?
 - A. younger – younger
 - B. older—older
 - C. younger--older
 - D. older- younger
8. Which of the following is used by geologist to determine the relative ages in rock sequence?
 - A. Cross-cutting relationship
 - B. Fossils
 - C. Stratigraphy
 - D. All of these



9. Which rock layer in the diagram seems to be the oldest?

- A. A
- B. B
- C. D
- D. F



10. How can scientists learn from the sequence of rock layers?

- A. Based on recorded geological events.
- B. Based on the geological history of that area
- C. Based on the impact that hikers had on an area
- D. Based on the number of organisms that live in the area.



Additional Activities

Activity 1.5. Creative output

Look for a wall of rock in the vicinity of your house that displays a distinct bedding of rocks. In the event that there is no such place in your area, you may Google similar rock formations found in your locality. Draw creatively the rock stratification of that structure on a bond paper. (see rubrics in Activity 1.4)

Lesson 2

Methods of Dating Rocks

In your previous science class, you have learned how layers of rocks formed from great masses of sand and mud, which build up on the sea floor in layers. In addition, you have discovered the different stages in the formation of rock strata. The different processes such as weathering, erosion, deposition and lithification played major roles in layering of rocks. However, in a long period of time, compressional stress may cause folds and intrusion of new rock forms.

In this lesson, you will discover the different methods used in determining the age of rocks and be able to explain how relative and absolute dating were used to establish the subdivision of geological time.



What's In

In the last module, you studied the different stages in the formation of rock strata and the forces that cause deformation. Before you proceed to the lessons of this module, take time to read the following major concepts about methods of rocks dating:



- **Law of Uniformitarianism states** that the same natural laws and processes that operate in our present day have always operated in the same manner in the past.
- **Geological sequence** is a listing of geological events, objects in a column of rock.
- **Law of superposition** is a sequence of rocks deposited in layers, the youngest layer is on top and the oldest on bottom.
- **Unconformity** means contact between two rock units in which the upper layer is usually much younger than the lower layer. Unconformities represent a missing part of the rock record by any of the geological processes such as weathering, erosion, uplift and subsidence.
- **Law of inclusion** states that rock fragments (in another rock) must be older than the rock containing the fragments.
- **Law of original horizontality** means all sedimentary rocks are originally deposited horizontally. Sedimentary rocks which are no longer horizontal have been tilted from their original position
- **Law of Faunal Succession-** states that other fossil groups through time succeeded fossil groups.
- **Absolute dating** determines how much time has passed since rocks formed by measuring the radioactive decay of isotopes or the effects of radiation on the crystal structure of minerals.
- **Relative dating** allows us to identify sequential order of events relative to the other.
- **Half-life** refers to the length of time it takes for radioactive material to decrease to half its initial mass through radioactive decay.
- **Index fossil** any organism preserved in the rock record that is characteristic of a particular span of geologic time or environment.
- **Fossil Correlation** is a method of telling the estimated age of a layer of rock by comparing the fossils it contains with a set of fossils known as the index fossil.

? What's New

Methods of dating rocks

The belief that the Earth is around 4.5 billion years old is a thought, which has been debated in the past and received a lot of ridicule. There are conflicting ideas between historical time and geological time. Many people saw geological time to be the same duration as historical time while others notion that historical time began when people started to record events and stories. As a result, many account the age of the earth on stories of Creation told in the Judeo- Christian tradition. The earth was computed to come to existence on October 23, 4004 BCE according to the study of Irish bishop James Ussher. He said that he obtained it by adding the generations of patriarchs illustrated in the Old Testament.



"The past is the key to the present" an old adage found in many books pertaining to how different geological processes have shaped the Earth. Even at the beginning of the Renaissance period. There were many speculations that geological time surpassed historical time. It was during the time of a Scottish doctor, James Hutton when he introduced the concept of *uniformitarianism*, which became the foundation of geology.



What Is It

The Law of Uniformitarianism states that the same natural laws and processes that operate in our present day have always operated in the same manner in the past. We can conclude that forces in the past led to the characteristics, shape, forms of rocks in the present Earth.

So, what is the methodology that marks the birth of geology? What is the modern invention of methods that help to obtain the age of rocks?

Relative Dating

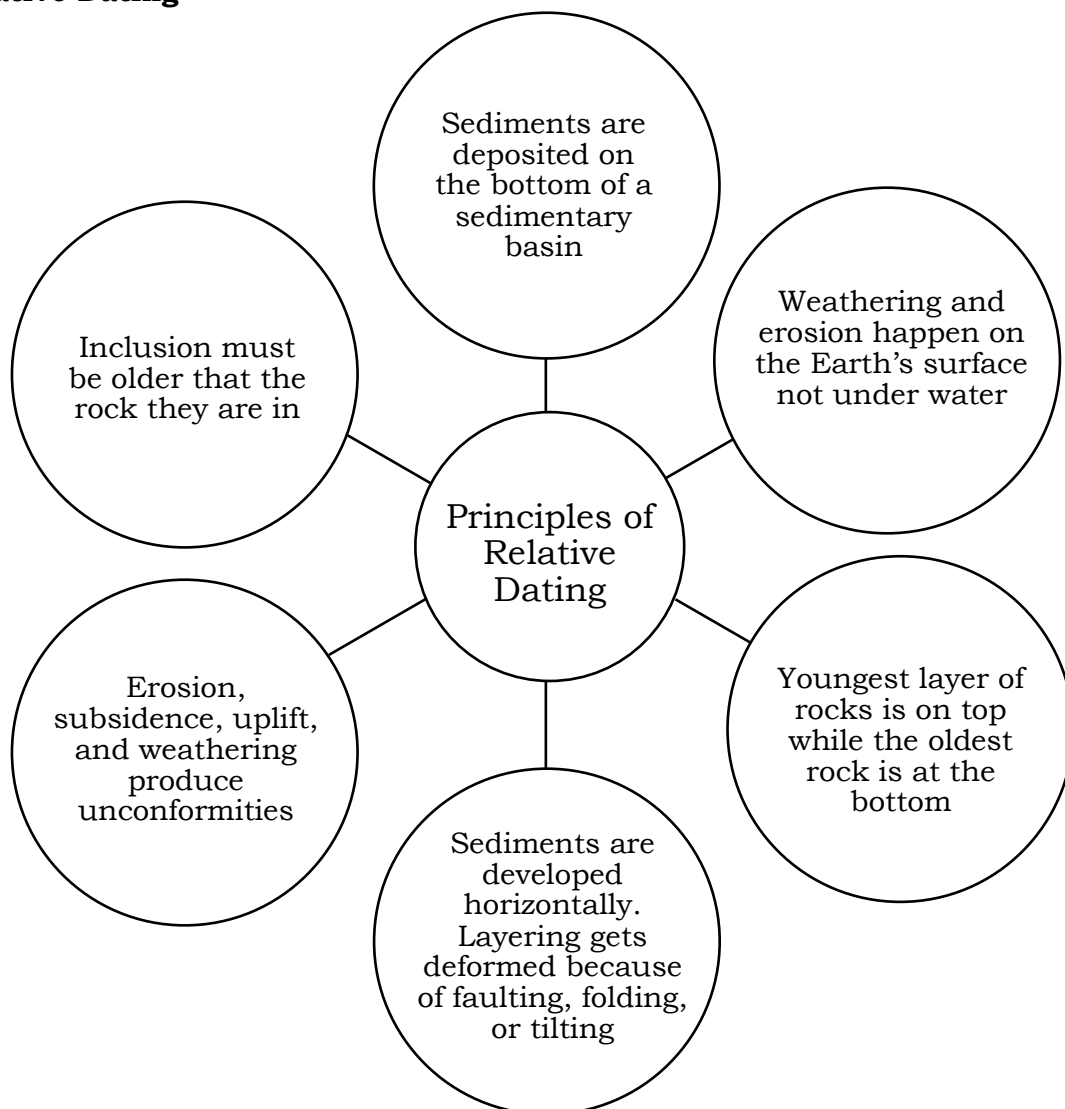


Table 2.1. Principles of Relative Dating



The order of occurrence is used for the basis for relative dating of rocks and fossils. In this manner, without using numerical values, it aims to determine the sequence of geological events or objects from first, second, third etc. So, what is produced is the chronological rank of objects or events based on their relative occurrence. The original appearance of deposition is when sediments are carried into the sediment basins; they organize into horizontal layers of sedimentary rocks. As a result of this action, the layers of rocks at the bottom are the oldest, and each layer of rocks on top is younger. On the other hand, when magma intruded into a stratum, it metamorphoses the rocks it comes into contact with. In that manner the intrusion is younger than the layers of rock into which the magma became implanted.

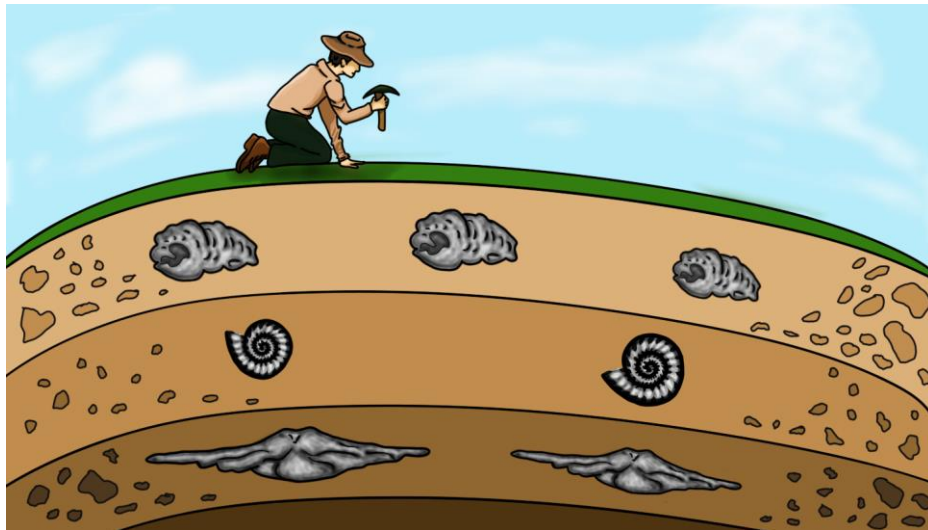


Figure 2.2. Principle of horizontality

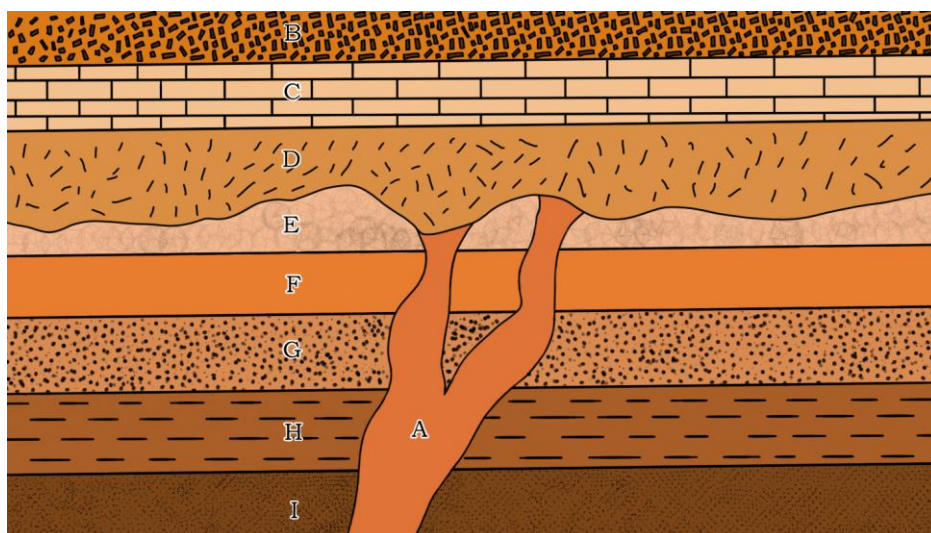


Figure 2.3. Relative age of an intrusion

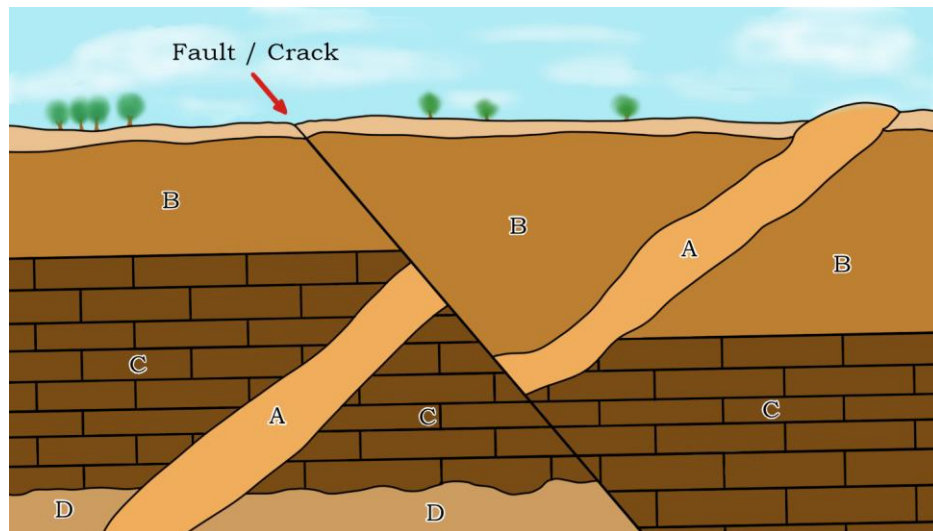


Figure 2.4. fault through rock strata

Absolute Dating

Carbon-14 dating is one of the best-known absolute dating methods. Carbon-14 dating refers to the isotope of the element carbon with an atomic weight of 14. The number 14 gives the combined number of neutrons and protons in a carbon atom. And since we know that carbon has 6 protons, the rest of that number gives the number of neutrons, 8. The method assumes that the amount of carbon -14 found in an organism when it died is the same amount found in the atmosphere today. Use of carbon dating is reliable only for fossils not older than 50, 000 years. More than 50,000 years the amount of carbon-14 that is left is too small to be measured. Given the initial mass of carbon-14. It takes 5730 years for that mass to decrease to half.

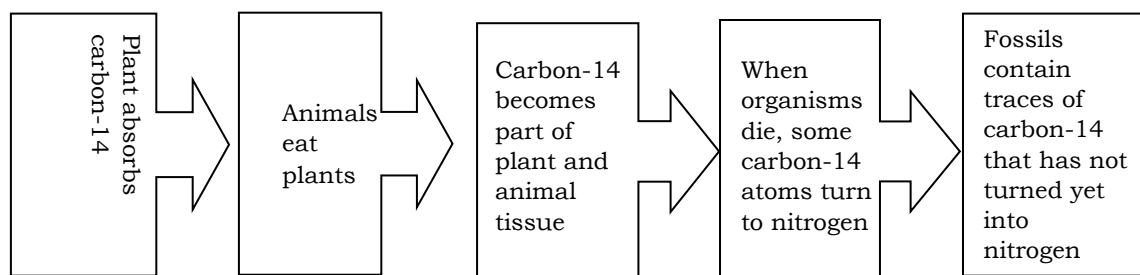
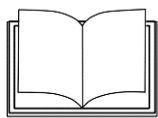


Table 2.2. Carbon-14 Dating

Radiometric dating of rocks is used with longer half-lives which give numeric date to fossils, rocks and other geological forms which are hundred- or million-years old. Isotopes used in radiometric dating of rocks are Potassium-40, Uranium 234-235 and Carbon-14.



What's More

In this section, you are given a task to present each fossil characteristic, which will be designated as index fossil. Then, describe how to date a layer of rock through fossil correlation.

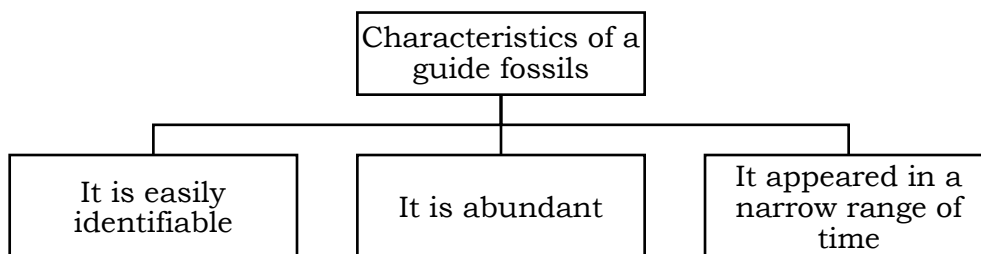


Table 2.3. Characteristics of guide fossils

Activity 2.1 Estimating age of rock stratum through fossil correlation.

Pretend that you are one of the student geologists. Read the scenario below. Copy the illustration in the answer sheet and follow the instructions that follow.

Scenario: A group of student geologists went to Brgy. Wawa, Montalban to study rock outcrops discovered in two separate locations. The students were given the following tasks:

1. Match each layer of rock in outcrop A with the layer of rock in outcrop B which matches its age.
2. Write the geologic sequence of the two rock strata starting with 1 being the oldest.

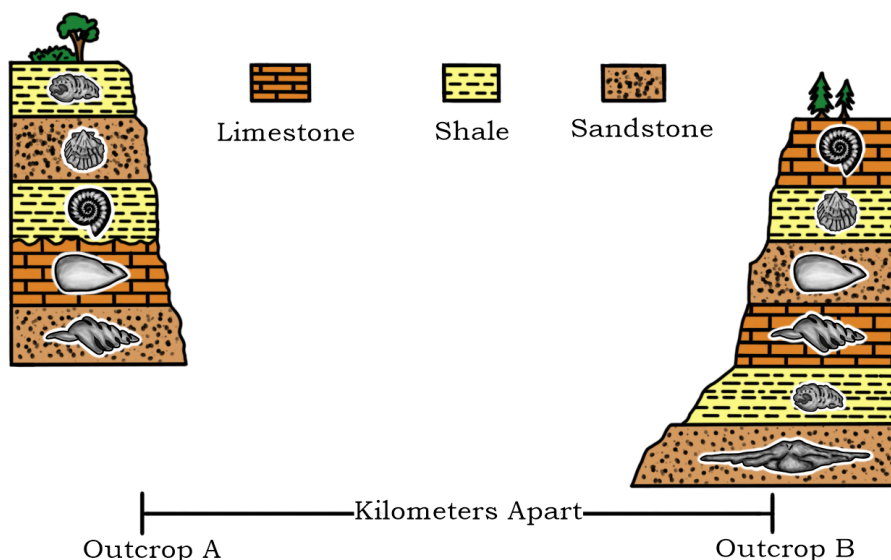


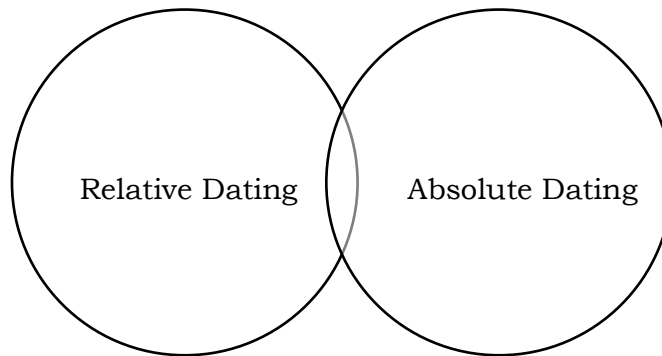
Figure 2.5. Fossil Correlation



What I Have Learned

Activity 2.2

Complete the Venn diagram below.



What I Can Do

Activity 2.3. Matchy-Matchy

Match column A with column B. A term may be used more than once. Refer to the diagram below for the answer.

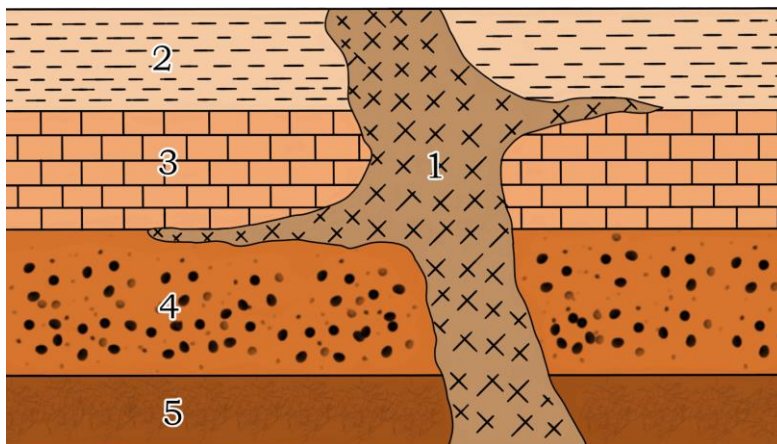


Figure 2.6 Rock correlation

Column A

- _____ 1. Law or principle used to compare the relative age of layer 1 compared to layer 2
- _____ 2. Law or principle used to compare the relative age of layer 3 to layer 4
- _____ 3. Law or principle used to show that events in the present occurred in the past
- _____ 4. Second oldest rock layer in the diagram
- _____ 5. Youngest rock layer in the diagram

Column B

- A) Law of Superposition
- B) Law of Crosscutting
- C) Uniformitarianism Principle
- D) Intrusion
- E) Fault
- F) Layer 1
- G) Layer 3



Activity 2.4. Geologic Sequence

This activity will test your familiarity with fossils and your understanding of the principle of fossil succession and law of superposition. Using the principle of fossil succession and law of superposition, create your own geological sequence. Use a separate paper for your output.

Rubrics for grading Individual Performance Task

Pts.	Creativity/Originality (x 8 pts.)	Effort/Perserverance (x 7 pts.)	Craftsmanship/Skill (x 5 pts.)	Cooperation/Attitude (x 5 pts.)
4	The student explored several choices before selecting one, generated many ideas, tried unusual combinations or changes, used problem-solving skills.	The project was continued until it was complete as the student could make it; gave it effort far beyond that required.	The artwork was beautiful and patiently done; it was as good as hard work could make it.	The student willingly participated in necessary preparation or work for classroom, was sensitive to the feelings and knowledge of others, exhibited a positive attitude toward assignment.
3	The student tried a few ideas before selecting one or based his/her work on someone else's idea, made decision after referring to one source.	The student worked hard and completed the project, but with a bit more effort it might have been outstanding.	With a little more effort, the work could have been outstanding; lacks the finishing touches.	The student participated enthusiastically, performed more than adequately, assisted in preparation and cleanup.
2	The student tried an idea but it lacked originality, might have copied work, substituted "symbols" for personal expression.	The student finished the project, but it could have been improved with more effort, chose an easy project and did it indifferently.	The student showed average craftsmanship; adequate, but not as good as it could have been, a bit careless.	The student was apathetic toward the assignment, complained, assisted in preparation and cleanup when asked.
1	The student fulfilled the requirements of the assignment, but gave no evidence of trying anything unusual	The project was completed with minimum effort	The student showed average craftsmanship, lack of pride in finished work	The student allowed others to do most of his/her work, participated minimally, exhibited no interest in the project
0	The student showed no evidence of original thought	The student did not finish the work adequately	The student showed poor craftsmanship; evidence of laziness or lack of understanding	The student did almost nothing toward completing the assignment, did minimum or no amount of preparation or cleanup, distracted others.

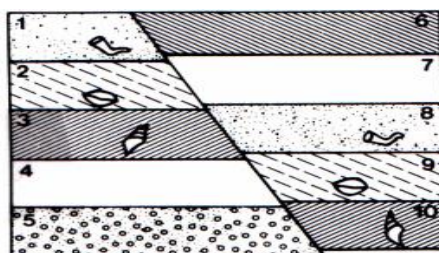
Total possible points = 100



Assessment

Read the question carefully and encircle the letter of the correct answer.

Refer to the following diagram for questions 1-5.



1. What do you call the fossils found exclusively in the rock layers of a particular geologic age?
 A. Metamorphic fossils
 B. Index fossils
 C. Complete fossils
 D. Gastrolith fossils
2. What do you call the tilted break that occurs at an angle down the rock layers?
 A. Bedding plane
 B. Angular unconformity
 C. Fault
 D. Fold
3. Which is the oldest rock layer?
 A. 1-8
 B. 8-10
 C. 4-7
 D. 3-6
4. Which of the following is an example of a trace fossil?
 A. An insect in amber
 B. An intact shark tooth
 C. A dinosaur footprint
 D. A petrified log
5. Which of the following rock layers in the diagram have the same relative age?
 A. 1 and
 B. 3 and 7
 C. 2 and 9
 D. 5 and 10



Additional Activities

Activity 2.5. Creative Output

Make a fossil by using clay and any fish or chicken bone or shells left over from your previous meal. Attach the specimen to the clay until it follows the shape of the bone or shell. Remove the specimen and let the clay dry up.

Example: *Lingula anatine*

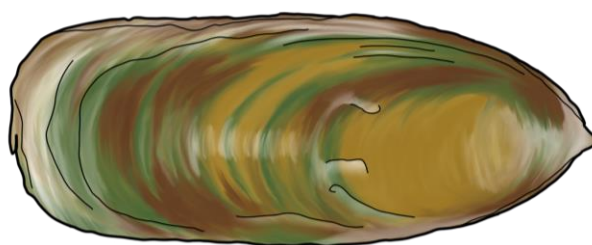


Figure 2.7 *Lingula anatine*

Lesson 3

How Geological time is subdivided

In your previous lesson, you have learned the different methods used to determine the age of rocks and explore how relative and absolute dating were used to establish the subdivision of geologic time. This time, you will further discover how marker fossils are used to define and identify the subdivision of geologic time.





What's In

Before you proceed to the last lesson in this module, take time to read the following major concepts about geologic time:

- **Geological time** refers to a period of geological history which includes eras, periods, and epochs
- **Species** refers to a taxonomic unit of organism having common characteristics or qualities
- **Extinction** refers to loss or dying out of certain species
- **Transition boundary** is a transition zone which shows separation of two areas



What's New

How Geologic Time Is Subdivided

EON	ERA	PERIOD	EPOCH	MYA	
PHANEROZOIC	CENOZOIC	QUATERNARY	RECENT	0.01	← ICE AGE ENDS
			PLEISTOCENE	1.6	← ICE AGE BEGINS EARLIEST HUMANS
		TERTIARY	PLIOCENE	5.3	
				23.7	
			MIOCENE	36.6	← FORMATION OF HIMALAYAS
				57.8	
			OLIGOCENE	66	← DINOSAUR EXTINCTION ROCKY MTS. FORMED
			EOCENE		
			PALEOCENE		
	MESOZOIC	CRETACEOUS	144		
		JURASSIC	208		
		TRIASSIC	245		← FIRST MAMMALS PANGAEA BREAK UP FIRST DINOSAURS
	PALEOZOIC	PERMIAN	286		
		PENNSYLVANIAN	320		← FIRST REPTILES
		MISSISSIPPIAN	360		← FIRST AMPHIBIANS
		DEVONIAN	408		
		SILURIAN	438		← FIRST LAND PLANTS
		ORDOVICIAN	505		← FIRST FISH
		CAMBRIAN	570		
PRECAMBRIAN	PROTEOZOIC EON				← EARLIEST SHELLED ANIMALS
	ARCHEAN EON			2500	← EARLIEST FOSSIL RECORDED OF LIFE

Figure 3.1. Geological Time subdivision

Source: Geologic TimeScale. Wikimedia Commons. Accessed September 4, 2020.
https://commons.wikimedia.org/wiki/File:Geologic_TimeScale.gif



Observe the geological clock above. Notice that geological time is not divided into equal parts. Some take billions of years while others covers a span of only a few hundred years. There are markers that help geologists set subdivisions of geologic time. Each rock strata have a record of events that took place in that certain environment over a specific period of time. These events become the boundaries for the geological time scale. The following are the criteria for significant events in geological history:

- Formation of earliest rocks
- Emergence of life or new species
- Extinction of new species

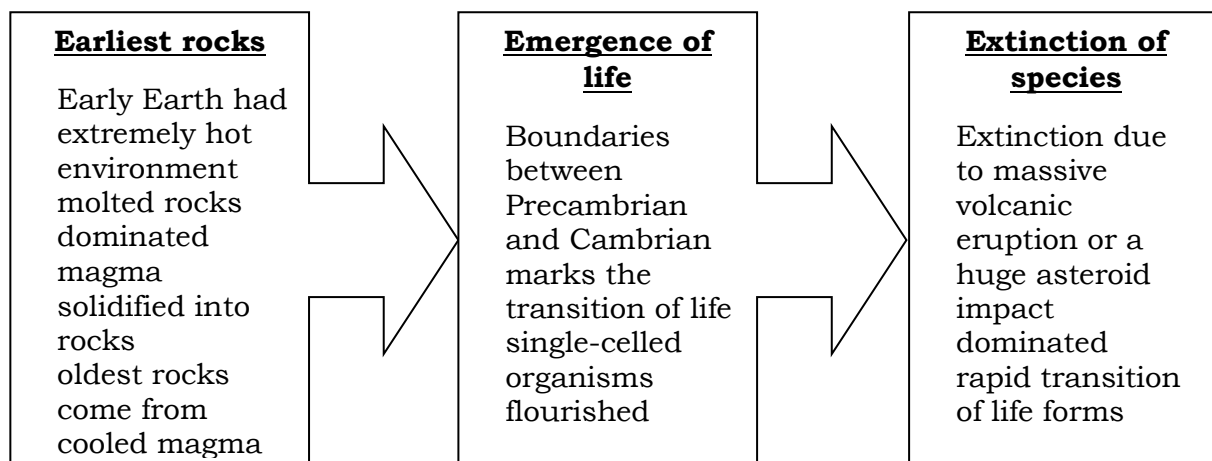


Figure 3.1. Criteria of Significant Events



What Is It

The history of the Earth has been identified and studied through fossil analysis and radiometric dating.

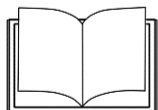
The Earth's 4.6 billion-year history is subdivided into four major units of time

Table 3.2 Units of time and events

Unit of time	Description/Events
<i>Precambrian time</i>	<ul style="list-style-type: none"> • Earth surface was too hot • started to cool down creating bodies of water • key elements combined forming the foundation of life • forming iron oxide, constituting major land mass • large solid continents appear
<i>Paleozoic Era</i>	<ul style="list-style-type: none"> • oxygen rich • development of multicellular organisms or eukaryotes • marine communities flourished • fish amphibians emerged from the ocean and lived on land. • reptiles and insects emerged • volcanic activity filled up the atmosphere with carbon dioxide • species that evolved during the Cambrian time got extinct



Mesozoic Era	<ul style="list-style-type: none"> • age of the dinosaurs • gymnosperms emerged • supercontinent Pangaea began to separate, forming the Rocky Mountains • asteroid hit the surface of the earth causing mass extinction of dinosaurs
Cenozoic Era	<ul style="list-style-type: none"> • mammals become the dominant species • major crustal movement occurred • primate ancestors inhabited the warm climate tropics • Hominid, the first human dominated the planet



What's More

In this section, we will present unit time intervals and index fossils that are studied through fossil analysis.

Activity 3.1. Geological Time

Classify the following events in Earth's geologic history according to the era where they occurred. Write the letter of your answer in the table below.

- | | |
|------------------------------------|----------------------------------|
| a. rule of primates | h. crustal formation |
| b. domination of dinosaurs | i. massive volcanic eruption |
| c. domination of mammals | j. flourishing of gymnosperms |
| d. Pangaea | i. formation of the ocean |
| e. evolution of man | j. single-celled organisms |
| f. formation of Earth's atmosphere | k. emergence of insects |
| g. asteroid impact | l. marine communities flourished |

Precambrian Era	Paleozoic Era	Mesozoic Era	Cenozoic Era



What I Have Learned

Activity 3.2. Reflection Journal

Answer the following questions.

1. What kind of tectonic deformation characterized the Cenozoic Era? Discuss briefly.
2. Which era was marked by the biggest extinction event in Earth's history? Explain this extinction.
3. Would you consider that the current activities of humans today have an impact on the future of the Earth? Explain your answer.



What I Can Do

Activity 3.3. Matchy-matchy

Identify the era in which the following events happened. Choose the letter that corresponds to your answer and write it on a separate sheet of paper. An era may be used more than once. Eras: (A) Cenozoic Era (C) Paleozoic Era (B) Mesozoic Era (D) Precambrian Time

- ____ 1. Era when Earth was first formed
- ____ 2. Era in which angiosperms appeared
- ____ 3. Era when the first mammals appeared
- ____ 4. Contains seven epochs
- ____ 5. Era when the first reptiles appeared
- ____ 6. Era when marine invertebrates first appeared
- ____ 7. Era in which continental shields appeared
- ____ 8. Era in which vertebrates first appeared
- ____ 9. Era in which Pangaea was formed (came together) ____
- ____ 10. Era in which glaciation occurred





Assessment

Read the question carefully and encircle the letter of the correct answer.

1. The Jurassic Period is also known as the Age of which organism?
A. Birds B. Fishes C. Mammals D. Reptiles
2. The presence of cross-bedded sandstone may indicate the existence of which geological structure?
A. Desert B. Lake C. Mountain D. Hills
3. Based on fossil records, which of the following thrived during the Paleozoic Era?
A. Advanced forms of marine life C. Mammals
B. Marine algae and bacteria D. Reptiles
4. Which of the following are the most common Precambrian fossils?
A. Ammonites B. Stromatolites C. Trilobites D. Vargonites
5. The Mesozoic Era was also known as the Age of which animal?
A. Birds B. Reptiles C. Mammals D. Fishes
6. What do you call the fossils that are found exclusively in the rock layers of a particular geologic age?
A. Complete fossils C. Gastrolith fossils
B. Index fossils D. Metamorphic fossils
7. Which of the following is an example of a trace fossil?
A. a petrified log C. an insect in amber
B. a dinosaur footprint D. an intact shark tooth
8. During the Proterozoic, between about 2.5 billion years the development of multicellular organisms with nuclei developed. These organisms eventually led to the development of the plants, spiders, fungi, and protists, and are called _____.
A. worms B. trilobites C. eukaryotes D. cyanobacteria
9. Why is the evolution of the cyanobacteria important to the evolution of an oxygen-rich atmosphere on planet Earth?
A. Cyanobacteria multiplies easily
B. Cyanobacteria make use of carbon dioxide
C. Cyanobacteria produces reproduce more single celled organisms
D. Cyanobacteria utilized photosynthesis to convert light into chemical energy
10. In which era did he first animals with preservable hard parts first appeared?
A. Cambrian B. Cenozoic C. Mesozoic D. Palenzoic





Additional Activities

Activity 3.4. Creative output.

Using an old cardboard and coloring materials, create a storyboard that will show the major subdivisions of geologic time and the index fossils per time intervals.

Rubrics for grading Individual Performance Task

Pts.	Creativity/Originality (x 8 pts.)	Effort/Perserverance (x 7 pts.)	Craftsmanship/Skill (x 5 pts.)	Cooperation/Attitude (x 5 pts.)
4	The student explored several choices before selecting one, generated many ideas, tried unusual combinations or changes, used problem-solving skills.	The project was continued until it was complete as the student could make it; gave it effort far beyond that required.	The artwork was beautiful and patiently done; it was as good as hard work could make it.	The student willingly participated in necessary preparation or work for classroom, was sensitive to the feelings and knowledge of others, exhibited a positive attitude toward assignment.
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Total possible points = 100



Posttest

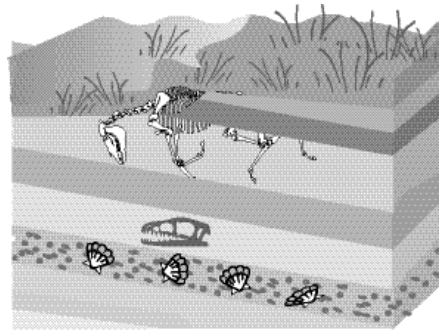
Read the question carefully and encircle the letter of the correct answer.

- Which radioactive element is usually used to date rocks?
 - Carbon-14
 - Nitrogen-12
 - Oxygen-18
 - Uranium-238
- How old do Paleontologists believe the Earth is?
 - 10 billion years old
 - 4.6 billion years old
 - 5.6 billion years old
 - 3.6 billion years old
- Which of the following best explains the content of Law of Superposition?
 - The age of fossils.
 - The super powers of rocks.
 - The relative age of rock layers.
 - The absolute age of rock layers.



4. According to the Law of Superposition, which is the oldest fossil in the illustration below?

- A. Somewhat near the surface.
- B. At the top of the rock layers.
- C. In the middle of the rock layers.
- D. Near the bottom of the rock layers.



6. How can scientists learn from the sequence of rock layers?

- A. For further geological events.
- B. On the Geological history of that area
- C. On the impact that hikers had on an area
- D. On the number of organisms that live in the area.

7. Which rock layer in the diagram seems to be the oldest?

- A. A
- B. D
- C. B
- D. F



8. Which type of dating method can be used on rock layers by applying the Law of Superposition?

- A. Absolute dating
- B. Radiometric dating
- C. Radioactive dating
- D. Relative dating

9. What is the length of time required for half of the radioactive atoms in a sample to decay?

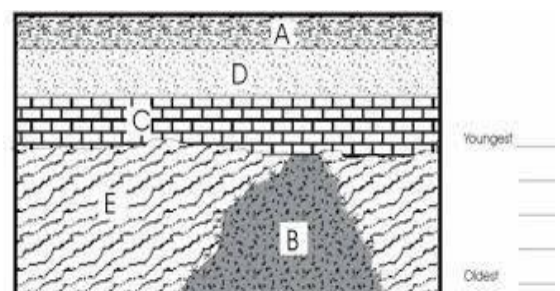
- A. Age
- B. Era
- C. Eon
- D. Half-life

9. Why is radioactive decay important?

- A. It is used to measure absolute time.
- B. It is used to measure relative time.
- C. It is used to measure half lives.
- D. It is used to measure time of day

10. Which of the following correctly lists layers in order from oldest to youngest?

- A. A,B,C,D,E
- B. C,D,A,E,B



- C. E,D,C,B,A
D. E,B,C,D,A
11. A rock formed with 1000 atoms of radioactive parent element, but only contains 250 radioactive parent atoms today. If the half-life of the parent is one million years, How old is the rock?
- A. 250,000 years old
B. 1,000,000 years old
C. 500,000 years old
D. 2,000,000 years old
12. Which of the following does a geologist use to determine the relative ages in rock sequence?
- A. Cross-cutting relationship
B. Fossils
C. Stratigraphy
D. All of these
13. How is radiometric age often referred?
- A. It is absolute.
B. It is geologic.
C. It is historic.
D. It is the totality.
14. How is the under formed sedimentary layer organized?
- A. older—older
B. younger—older
C. older- young
D. younger – younger
15. How does a disconformity occur?
- A. When a rock unit that does not contain fossils.
B. When an erosional surface between different rock types.
C. When an erosional surface between horizontal sedimentary rocks.
D. When an erosional surface between igneous and metamorphic rocks.

A
B
C

Answer Key

What's New

Activity 1.1: Correlating rock layers using index fossils.

Answer in Explanation part may vary

What's More

Activity 1.2 Studying the stratigraphic cross section of rocks.

A. I
B. C
C. B
D. F

Answer in the explanation part may vary.

What I Have Learned

Activity 1.3

Answers may vary depending on their explanation.

What I Can Do

Task

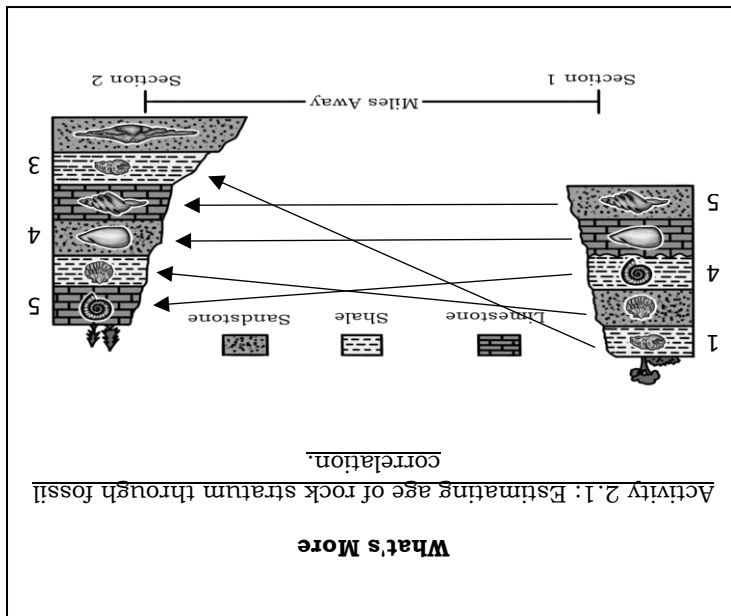
Activity 1.4 Performance

Answers may vary depending on their explanation and chosen activity.

Additional Activities

Activity 1.5 Creative Output

Answers may vary depending on their output.



What I Have Learned
Activity 2.2

Answers may vary depending on their explanation.

What I Can Do
Activity 2.3 Matchy-Matchy

1. A
2. B
3. C
4. G
5. F

What I Can Do
Activity 2.4 Geologic Sequence

Answers may vary depending on their output.

What I Can Do
Assessment

- A. B
- B. C
- C. B
- D. C
- E. C

Additional Activities
Activity 2.5 Creative Output

Answers may vary depending on their output.

Precambrian	F.	D.	B.	A.	Cenozoic
Paleozoic	K.	I.	G.	C.	Mesozoic
	L.	M.	J.	E.	
	N.			H.	

Activity 3.1 Geological Time

What's More

What I Have Learned <u>Activity 3.2</u> <u>Reflection Journal</u> Answers may vary depending on their output.	What I Can Do <u>Activity 3.3 Matchy-matchy</u> 1. D 2. B 3. A 4. A 5. C 6. C 7. D 8. C 9. C 10. A	Additional Activities <u>Activity 3.4 Creative Output</u> Answers may vary depending on their output.	What I Can Do <u>Assessment</u> A. D B. B C. A D. B E. B F. B G. B H. C I. B J. D
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