VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Fossils & Stratigraphy

2018-2019 VINSE/VSVS Rural

Goal: To introduce students to the geological time scale, fossils, sedimentary rock columns, index fossils, and column correlation methods.
Fits Tennessee standards GLE **0807.5.6**

I. Sedimentary Rock Layers/Columns
- A. Sedimentary Rocks
- B. Creating a Model of Sedimentary Layers
- C. Explaining the Column
- D. Index Fossils and Radioactive Dating
- E. Finding the Ages of the Layers in Our Column

II. Stratigraphy (Correlating Columns)
III. Timeline of the Earth
- A. Introduction
- B. Time Scale Model
- C. Timeline Mats

Materials
1 cylinder containing the larger string timeline
1 column container
1 bottle of water
1 set of jars of sand (to represent different types of rocks and fossils):
- Jar 1: Brown sand containing black and green "stones".
- Jar 2: White sand containing pink and green "stones".
- Jar 3: Black sand
- Jar 4: Orange sand containing pink, green and clear "stones".
- Jar 5: White sand containing pink, clear, green and red "stones".

10 models of rock layers/fossils encased in boxes
16 sets of 3 stratigraphic sequences
16 stratigraphic columns compiled from sequences
1 binder containing
- 1 Training ppt
- 1 observation sheet
- 16 Handouts with Column Diagram, Time line diagrams

16 fossil maps

Sedimentary Rock Layers/Columns

Learning Goals:
- **Students understand how sedimentary rocks are formed.**
- **Students experiment with forming sedimentary layers and understand that fossils are deposited at the same time the as the sediment.**
- **Students understand that sediments are deposited in horizontal layers**
- **Students understand that older layers are at the bottom in a sedimentary layer, while younger layers are at the top**

Why is the science in this lesson important?
An understanding of stratigraphy is useful for understanding when and how life originated on Earth, as well as for studying evolution and historical changes in Earth's ecosystems. Potential careers that benefit from an understanding of stratigraphy include paleontologists, archaeologists, and soil scientists.

A. Reviewing Sedimentary Rocks

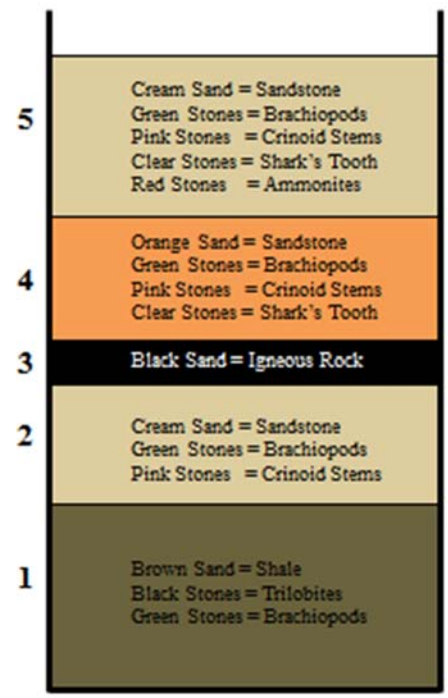
- Q. Ask students what they know about sedimentary rocks. If these answers aren't given, go over them briefly:
  - Most sedimentary rocks are formed from sediments deposited in oceans, lakes or rivers.
  - Sediments form layers that pile on top of each other, which compress over time to create rock.
  - These rocks are very common all over the world.
  - Types of sedimentary rock include sandstone, limestone, and shale.
- Q. Ask for a show of hands of which students have seen rock layers on the sides of the highway while driving around Nashville – this is sedimentary rock! Ask if anyone knows what type of rock this is.
  - *Limestone*
- Tell students that we are going to create a model of sedimentary rock layers.

B. Creating a Model of Sedimentary Layers

- Set up at the front of the class the apparatus to create the sedimentary rock column demonstration

  Materials

  1 plate
  1 column container
  1 bottle of water
  5 numbered jars of sand, with different colors of sand representing different types of sedimentary rock and different stones representing fossils:
  Jar 1: Brown sand containing black and green "stones".
  Jar 2: Cream sand containing pink and green "stones".
  Jar 3: Black sand
  Jar 4: Orange sand containing pink, green and clear "stones".
  Jar 5: Cream sand containing pink, clear, green and red "stones".



- One VSVS member should draw on the board a large diagram to represent the column, based on the diagram on this page.
  - At the start, do not draw the entire finished diagram. Start with the open-top rectangle representing the column (bolder lines). As each jar of sand is added, draw the layer line and write the color of the sand and rocks.

1. Pour the container of water into the column, reminding students that sedimentary rocks form when sediments settle out of water and form layers.

Your Notes:

2. Explain to students that we are using different colors of sand to represent different types of sedimentary rock, and different color stones to represent fossils.

3. Pour all of the sand and rocks from container #1 into the column. Wait until each layer settles (~30 seconds) before pouring the next layer.

4. When settled, pour all of container #2's contents into the column, then container #3's contents, and so forth until all 5 containers are used. Make sure to update the drawing on the board as new layers are added.

C. Explaining the Column

- Q. Ask students to describe what happened when each layer of sand was poured.
    - *Sand settles through the water to make a flat layer at the bottom of the column.*
    - This is similar to sediment settling out of water to form layers; over millions of years the sediment is compressed and turns into rock.
    - Explain that sediment is deposited in horizontal layers, and it stays that way unless something disturbs it.
    - Have students answer Question 1 on their observation sheet.
      1. Sediments settle and form rocks in ____________________ layers.

    - **Fossils are deposited at the same time the rock material is deposited. Therefore the ages of the fossil and rock in which it is found are the same.**

- Tell students to imagine that the process of creating the sand columns took millions of years to occur.
    - Q. Ask students which layer is the oldest in the column.
        - *The bottom layer; it was deposited first and other layers were deposited on top of it.*
    - Q. Ask students which layer is the youngest in the column.
        - *The top layer; it was deposited last, on top of all other layers.*
    - How old are the middle layers? *(You can't tell for sure! But they are older than the top layer and younger than the bottom layer.)*

    - Have students answer Question 2 on their observation sheet.
      #2. Older layers are _______________________ in a column of sedimentary layers, while younger layers are ________________________.

Fossils succeed each other in a definite order – the oldest fossils in a series of layers will be in the lowest layer.

D. Index Fossils and Radioactive Dating

Your Notes:

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Learning goals:

- **Students observe a model of a stratigraphic column that includes fossils.**
- **Students correlate the model with the sedimentary column that they created.**
- **Students learn what an index fossil is and realize that in the model, the ammonites and trilobites are index fossils. Index fossils are used for dating rock layers.**
- **Students learn that radioactive elements are used for dating rock layers.**

Pass out 1 model of rock layers/fossils encased in boxes plus the "Column Analysis" worksheet to each group of students. Have them look at the model and the sand column created by the teacher and tell them that the model has the same pattern of layers from the sand column. The fossils in the box model are real and are represented by different colored stones in the columns.

- Explain that the second column (called **Stratigraphic Column**) on the worksheet is the way geologists would represent such a column and that the key on the bottom of the page shows what each symbol means.

- Tell students that fossils are often incorporated into sedimentary rocks when sediment buries them and then later forms into rocks with the fossils inside.

- Tell students names of type of rock and fossils in each layer.
    - *Bottom layer:* ***trilobites,*** *brachiopods.*
    - *2nd layer: brachiopods and crinoids,*
    - *Black layer: no fossils*
    - *4th layer: sharks teeth, brachiopods and crinoids,*
    - *Top layer:* ***ammonites****, sharks teeth, brachiopods and crinoids,*

Your Notes:

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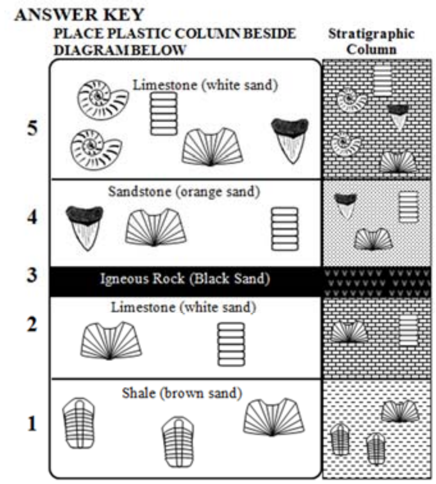
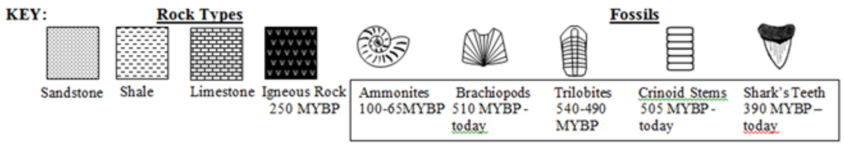


Rock Type	Fossils Present	Age	How Age was Determined (Circle Answer)
Limestone	Ammonites Brachiopods Crinoids Shark's teeth	100 – 65 MYBP	Relative Dating with Index Fossils
Sandstone	Brachiopods, Shark's teeth, Crinoid stems	250 – 100 MYBP	Relative Dating
Igneous Rock	None	250 MYBP	Absolute Dating
Limestone	Brachiopods, Crinoid Stems	490 – 250 MYBP	Relative Dating
Shale	Trilobites Brachiopods	540 – 490 MYBP	Relative Dating with Index Fossils



- Tell students that in real sedimentary rocks, some fossils are found in many layers, while some are found in only one layer.
  - Q. Ask students which type of fossil, one found in many layers or one found in only one layer, would be more useful for identifying/finding the age of a rock layer. (A tough question – give them hints and walk them to the answer if necessary!)
    - *Fossils found only in one layer can be used for identifying/finding the age of a rock layer, because they are unique to that layer. If a fossil is found in many different layers, a layer can't be distinguished as unique based on it.*

- Tell students that fossils that are only found in one layer, and can be used for identification/rock dating purposes, are called **<u>index fossils</u>**.
- Have the students answer Question 3 on their observation sheet.

  #3. ______________________ are fossils found in only 1 layer of sedimentary rock that is used for identification/rock dating purposes.

- Q. Ask students which fossil(s) in their column would be considered index fossils, and which would not be considered index fossil(s)
- *Ammonites and trilobites are only found in one layer, so they would be considered **index fossils**; brachiopods, shark's teeth and crinoids are found in many layers, and are not index fossils.*

Tell students to look at layer # 3 in their column – the thin black layer.
  - When there is a dark, skinny layer in a sedimentary rock column, it is usually the result of lava or volcanic ash interrupting a sedimentary rock layer – it is an igneous rock, not a sedimentary rock.
  - Igneous rocks contain radioactive elements like uranium, rubidium, thorium, and potassium – scientists can use these elements to determine the exact age of these rocks!

Your Notes:

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E. Finding the Ages of the Layers in our Column

Learning Goals: Students will determine the ages of the layers in the model.

- Tell students they are now going to use their model to determine the ages of the "rock" layers.
- Q. The black layer (third layer from the top) is an igneous rock. How can we find the age of this layer?
  - *Via absolute dating with radioactive elements.*
  - In this hypothetical case, we will say that this layer is 250 million years old.
- Ask students how an igneous rock might get into a sedimentary layer?
  - Answers should include **volcanic ash** settling out many miles away from an erupting volcano, **lava flows** above ground, or **magma** intruding into rock layers below the surface.

For VSVS Information only:
Most igneous rocks can *b*e dated radiometrically because they contain unstable radioactive elements that decay.
Carbon-14, uranium-238, rubidium-87, thorium, potassium are the most common (isotopic) elements studied.
Igneous rocks can be given a **numerical age** by radiometric dating methods.

Two layers contain index fossils. Which layers are these?

- Q. The brown layer (on bottom) and the white layer on the top both contain fossils that aren't found in any other layers. How can we find the ages of these layers?
  - *Via index fossils and the span of years they were deposited.*
  - Ammonites (in the top layer) lived from 100 million years ago until 65 million years ago – this is the range in which this rock was deposited in.
  - Trilobites (in the bottom layer) lived from 540 million years ago until 490 million years ago – this is the range in which this rock was deposited in.

- Q. How do we find the dates the other two layers were deposited in?
  - *By Relative dating.*
  - We know that the orange layer (layer 4) must have been deposited between the top (5^{th}) layer (100 million years ago) and the third layer (250 million years ago)
  - The white layer (layer 2) must have been deposited between the bottom layer (490 million years ago) and the third black layer (250 million years ago).

II. Stratigraphy (Correlating Columns)

Learning Goals:
Students look at real life example of stratigraphic columns in 3 National Parks
Students learn how geologists can correlate sedimentary layers many miles apart.

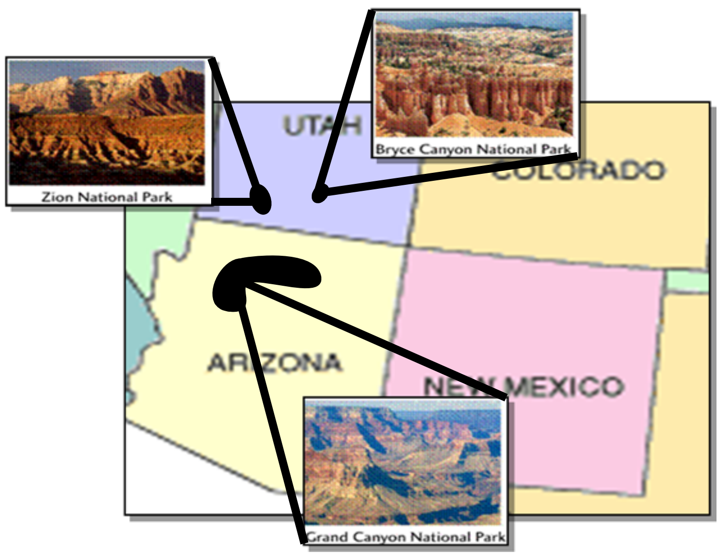
Your Notes:

- Tell students that sedimentary rock layers often stretch across entire continents. Sometimes these layers are connected; however, often layers have been removed in some locations by erosion, and some are buried under other layers and can't be seen by us yet.

A. National Park Rock Sequences

- Pass out a set of colored stratigraphic columns (paper-clipped together) to students.
- Tell students that these columns represent actual sedimentary in the National Parks (Graphic A); they have been cut from the stratigraphic columns in Graphic B, on Handout #1.)
  - Have students separate the columns and put them at their correct National Park locations on the map (Graphic A) in Handout #1. Tell them that although erosion has affected each location differently, they all still show some of the same layers.
  - Have them put the complete, paper-clipped columns back together and collect them from the students.

Map of National Parks (Graphic A)



National Park Correlations (Graphic B)

Your Notes:

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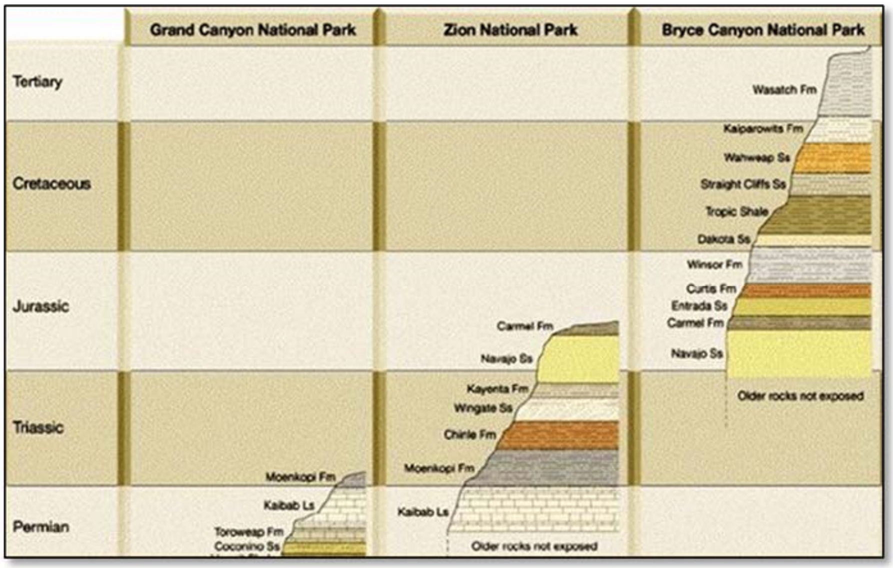

B. Correlating Stratigraphic Columns

- Pass out the set of 3 stratigraphic sequences to each student. Tell students to imagine that these are 3 sequences of rocks found in different places around the US.
  - Tell students to find in sequences A and B at least 2 layers whose index fossils and rock types match.
  - Emphasize that the depth of the layers does not have to be the same.
  - Students should place the sequences side-by-side with matching layers touching.
  - Have them repeat the process with sequences B and C.
  - This can get tricky, so VSVS members should walk around and help students with the task.

- Pass out the longer laminated strip (1 per pair) and tell the students that this geological column is the one they have just compiled from their short sequences. This can tell us a lot more about the geologic history of the earth than the individual columns can.
- Q. Which short strip has the oldest rocks exposed and how do we know?
  - *Location A, because it contains the oldest fossils and has the bottom layers in the geological columns.*
  - These layers still exist at locations B and C, they just haven't been exposed yet.
- Q. Which short strip has the youngest rocks exposed and how do we know?
  - *Location C, because it has the top layers in the geological column.*
  - These layers are missing at locations A and B because of erosion.
- VSVS members should collect the columns and answer any questions the students have.

III. Timeline of the Earth (If Time Permits)

Learning Goals: Students can "see" the time scale of earth's history from a model.

Your Notes:

A. Introduction

- Q. Ask the class if anyone knows how old the earth is.
  - *4.6 billion years old, or 4600 million years old. Write the number out in full on the board so they understand how much time this is (4,600,000,000).*
- Tell students that the timeline of earth's history is called the geologic time scale. We will show them a rope that represents, to scale, this timeline.
- It is divided into eons, which are further divided into eras.

B. Time Scale Model

Tell students to look at the timeline on the observation sheet

Eon:	Hadean Eon	Archean Eon	Proterozoic Eon	Phanerozoic Eon
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago - 540 million years ago	540 million years ago - now
Major Events:	Oldest earth rocks form	Single-cell organisms evolve	Multi-cell organisms evolve	Advanced organisms like plants, mammals, and fish

Era:	Paleozoic Era	Mesozoic Era	Cenozoic Era
Dominant Organisms:	Invertebrates (trilobites, crinoids, ammonites, brachiopods)	Dinosaurs, birds	Mammals

- Hold up the time scale model (the cylinder) with just a small piece of string pulled out so that all students can see it. Tell students:
  - The string represents the timeline of the earth's history – the complete geologic time scale over its entire duration of 4.6 billion years.
  - The string is divided into the 4 eons, and the last eon is divided into eras.

Note – the string is 19 feet long, so make sure you have enough room to "spread".

  - One VSVS member or student volunteer will hold the string and another will hold the container and walk to the right while removing each eon and stopping when a knot is reached.
  - A VSVS member will describe each eon to the students, while another writes the information regarding each eon and era on the board as they are introduced.
  - The string must be kept taught in a straight line so that the students get the concept of the length of time taken for each eon.
- **Hadeon Eon**
  - Pull the first (<u>camouflage-colored</u>) section of the string out, and stop as soon as you get to the first knot (between color changes). Tell students:
  - This is the **Hadeon Eon**, from 4.6-3.8 billion years ago.
  - No living organisms during this time, but the oldest known rocks existed (found in the Canadian Rocky Mountains).

Archean Eon

- Pull the second (<u>tan</u>) segment of the string until the second knot is reached. Tell students:
  - This is the **Archean Eon**, from 3.8-2.5 billion years ago.
  - The first single-cellular organisms lived during this time (fossils found in Australia).

Your Notes:

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Proterozoic Eon

- Pull the third (white) segment of the string until the third knot is reached. Tell students:
  - This is the **Proterozoic Eon**, from 2.5 billion years ago to 540 million years ago.
  - The first multi-cellular organisms lived during this time (fossils found in Michigan)

Phanerozoic Eon,

- Pull out and display the black end of the string. Tell students:
  - This is the **Phanerozoic Eon**, from 540 million years ago to now.
  - Plants, fish, and animals came to exist as we know them today during this time.
  - This last eon is subdivided into 3 smaller time intervals called **eras**.

C. Looking at the Phanerozoic Eon Timeline

- Pass out the timeline mat.
- Tell students to look at the Phanerozoic Eon time line. Focus students' attention on the black (Phanerozoic Eon) section of the rope.

- Briefly explain the layout of the timeline mat:
  - The placemat represents the same time period as the black section of the rope (the Phanerozoic Eon).
  - The different colors (pink, green and yellow) show the different **eras**. The colored string twisted around the black cord corresponds with these eras on the placemat.
  - The organisms shown lived and thrived on earth during the time periods their boxes overlap with; both fossil and living pictures are displayed.

- Tell students that each era ends with the extinction of a large amount of animals on earth.
  - Q. Ask students if they know what extinction means.
    - *When the last remaining members of a species have died out.*
- Point to the pink section of the timescale, and identify it as the **Paleozoic Era**. Tell students:
  - Simple animals called invertebrates dominated the earth in this era. Pictures of different types of invertebrates (trilobites, ammonites, crinoids, and brachiopods) can be seen on the timeline; point them out to the students**. Emphasize that the earliest trilobite is an index fossil.**
  - **Tell students find where the fossils in the rock layer/fossil box are located on the timeline mat.**
  - Early fish, land plants, and reptiles develop but are not common yet. Pictures of sharks and ferns can be seen on the placemat; point them out to students.
  - 90% of all species of animals went extinct at the end of this era. (Emphasize to students the magnitude of this extinction – tell them to imagine 90% of animals on earth dying.) (If students ask why – scientists are still investigating!)

- Point to the green section of the timescale, and identify it as the **Mesozoic Era**. Tell students:
  - Dinosaurs and other reptiles dominated the earth in this era.
  - Small mammals, birds, flowering plants, and flies also were common
  - 50% of all species of animals went extinct at the end of this era. (If students ask why, tell them that most scientists agree that it was due to impact of a large meteorite near Mexico.)

Your Notes:

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- **The later ammonites are index fossils**

- Point to the yellow section of the time scale as the **Cenozoic Era**. Tell students:
  - This era continues up until today. Mammals dominate the earth in this era.
  - Q. Ask students if they've thought about how long humans have existed in the geologic time scale.
    - *Humans have only existed in the very last knot of the rope (the dangling skeleton). This is an extremely short time in the history of the earth.*

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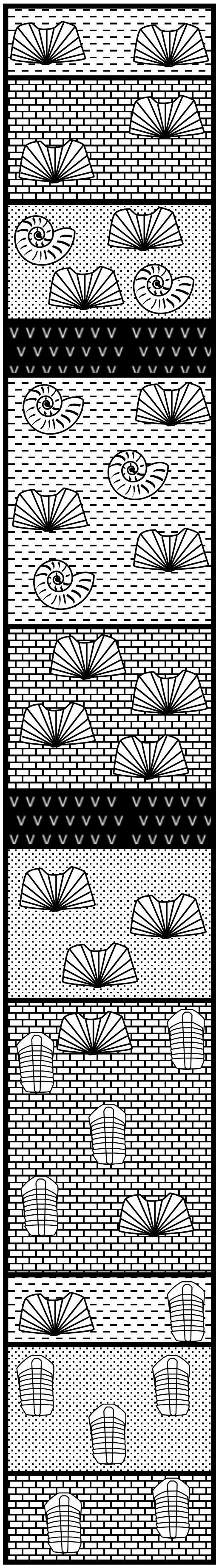
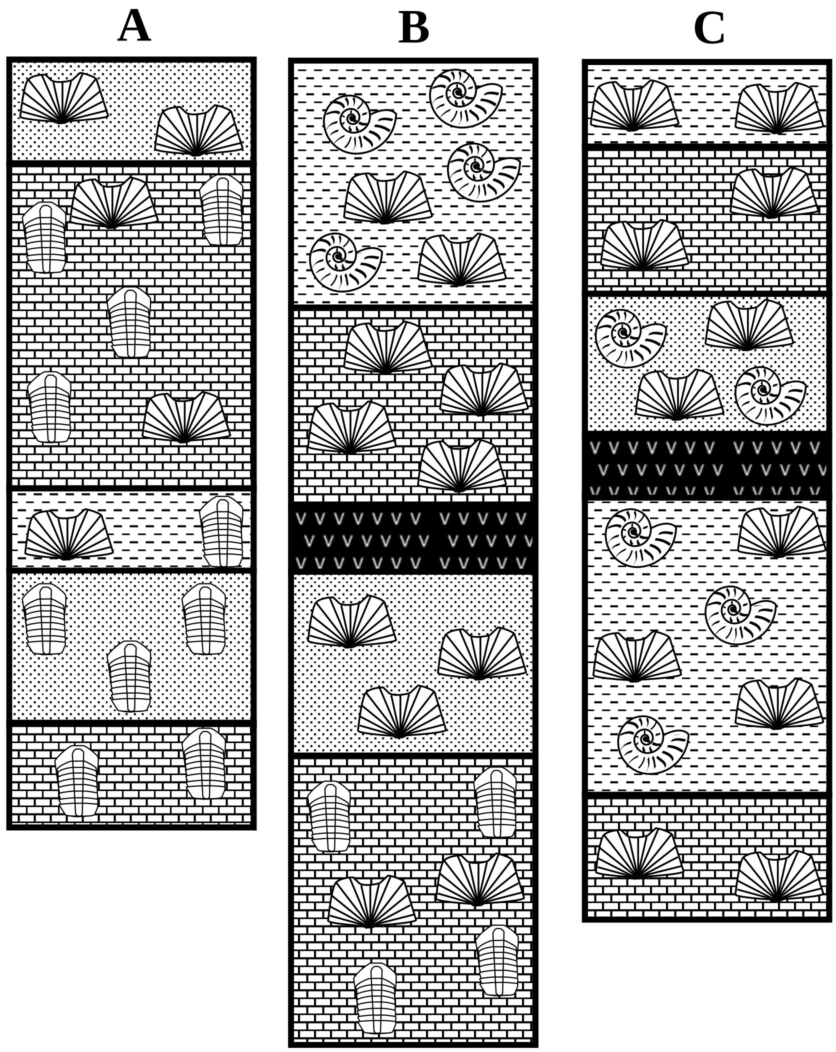
We gratefully acknowledge the assistance of Dr. Molly Miller, Professor of Earth & Environmental Sciences, Vanderbilt University.
Reference:Chernicoff, S., & Whitney, D. (2007). *Geology: An Introduction to Physical Geology.* Upper Saddle River, New Jersey: Pearson

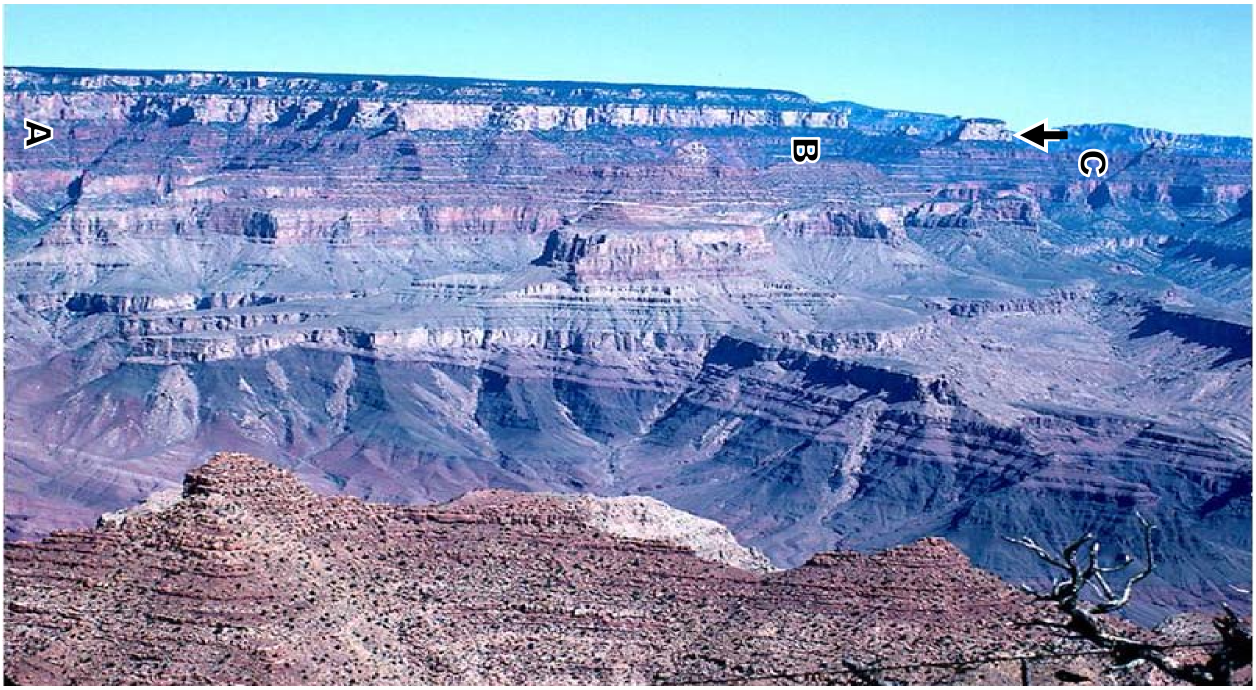
Your Notes:

Geological Column



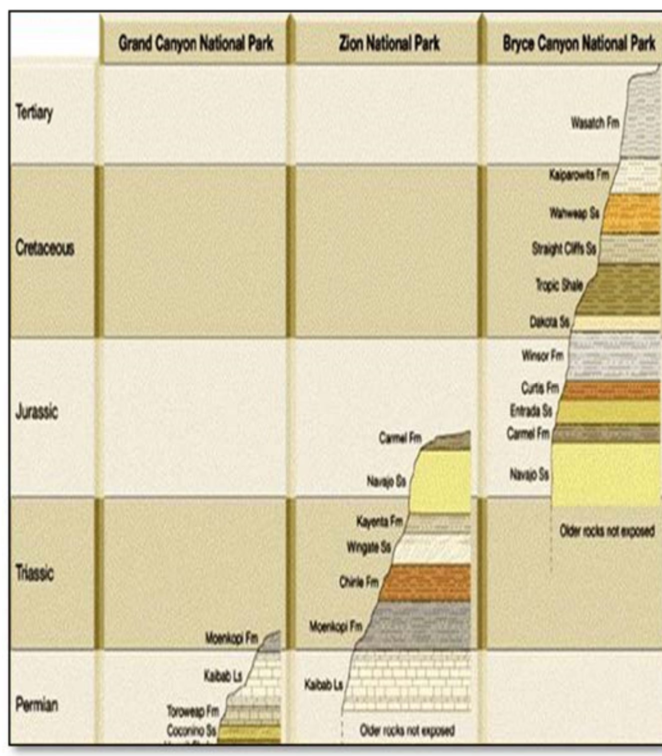
Stratigraphic Sequences





Grand Canyon

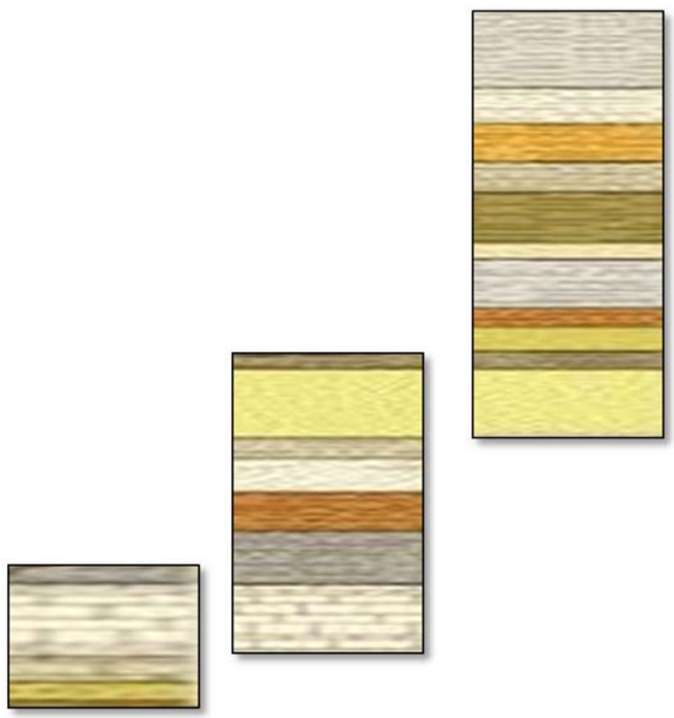
Match up columns to these maps:



Cut out the columns below. On the backs of the columns, write which direction faces upwards, as well as the respective name of the National Park:

Column A: Grand Canyon National Park
Column B: Zion National Park
Column C: Bryce Canyon National Park

Columns should be laminated after text has been written on the back. Paper clip them together where they correlate (places of correlation are next to each other in the diagram below).



<u>Observation Sheet</u>

1. Sediments settle and form rocks in ____________________ layers.

2. Older layers are _______________________ in a column of sedimentary layers, while younger layers are ________________________.

3. ______________________ are fossils found in only 1 layer of sedimentary rock that is used for identification/rock dating purpose

Eon:	Hadean Eon	Archean Eon	Proterozoic Eon	**Phanerozoic Eon**
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago – million years ago	540 million years ago – mow
Major Events:				

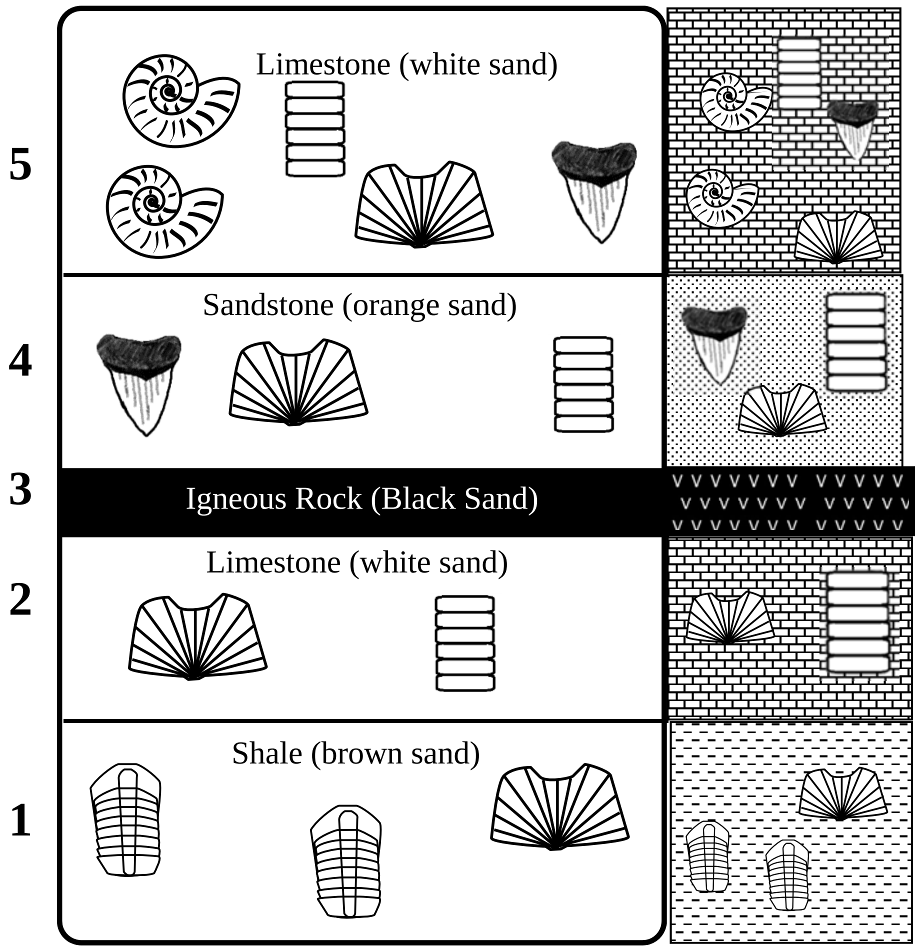
<u>Expansion of Phanerozoic Eon:</u>

Era:	Paleozoic Era	Mesozoic Era	Cenozoic Era
Dominant Organisms:			

Name____

PLACE PLASTIC COLUMN BESIDE DIAGRAM BELOW

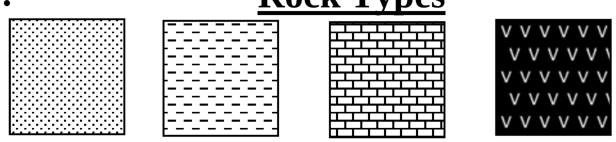
Stratigraphic Column



Rock Type	Fossils Present	Age	How Age was Determined (Circle Answer)
			Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
			Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
			Absolute Dating
			Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating
			Absolute Dating (Radiometric) Relative Dating with Index Fossils Relative Dating

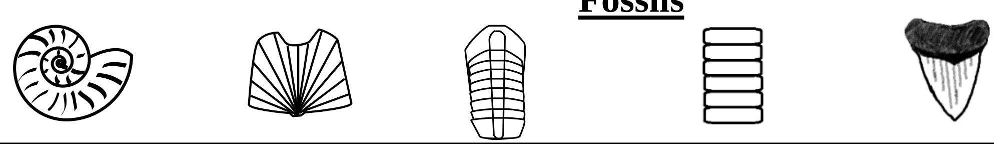
KEY:

Rock Types



Sandstone | Shale | Limestone | Igneous Rock 250 MYBP

Fossils

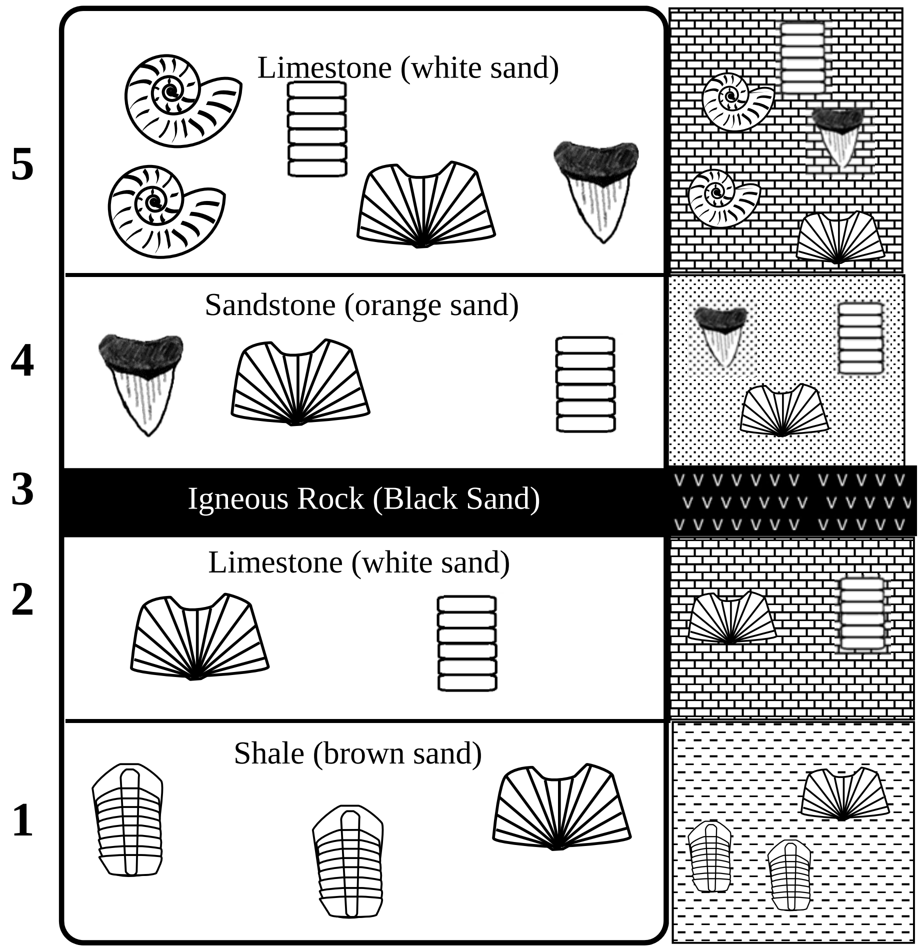


Ammonites	Brachiopods	Trilobites	Crinoid Stems	Shark's Teeth
100-65 MYBP	510 MYBP - today	540-490 MYBP	505 MYBP - today	390 MYBP – today

ANSWER KEY

PLACE PLASTIC COLUMN BESIDE DIAGRAM BELOW

Stratigraphic Column



Rock Type	Fossils Present	Age	How Age was Determined (Circle Answer)
Limestone	Ammonites Brachiopods Crinoids Shark's teeth	100 – 65 MYBP	Relative Dating with Index Fossils
Sandstone	Brachiopods, Shark's teeth, Crinoid stems	250 – 100 MYBP	Relative Dating
Igneous Rock	None	250 MYBP	Absolute Dating
Limestone	Brachiopods, Crinoid Stems	490 – 250 MYBP	Relative Dating
Shale	Trilobites Brachiopods	540 – 490 MYBP	Relative Dating with Index Fossils

KEY:

Rock Types / **Fossils**

Rock types: Sandstone; Shale; Limestone; Igneous Rock 250 MYBP

Fossils: Ammonites 100-65 MYBP; Brachiopods 510 MYBP - today; Trilobites 540-490 MYBP; Crinoid Stems 505 MYBP - today; Shark's Teeth 390 MYBP – today