VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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STRATIGRAPHY

Fall 2012

Goal: To teach students how to determine the relative ages of sedimentary rock layers. Students will create a geological column which includes fossils and an igneous layer.

Fits Metro schools standard **GLE: 0807.5.6**

I. Reviewing Sedimentary Rocks
- **A.** Creating a Model of Sedimentary Layers
- **B.** Explaining the Column

II. Dating the Layers
- **A.** Types of Dating
- **B.** Using Index Fossils
- **C**. Finding the Rock Ages in Our Column

III. Stratigraphic Correlation
- **A.** The Law of Original Continuity
- **B.** National Park Rock Sequences
- **C.** Correlating Stratigraphic Columns

Materials:

32 stratigraphy laws worksheets
9 plates
9 column containers (jars containing water)
9 jars of sand (to represent different types of rocks):
  Jar 1: White sand containing black rocks
  Jar 2: Orange sand containing white rocks
  Jar 3: Black sand
  Jar 4: White sand containing white rocks
  Jar 5: Tan sand containing white rocks and red rocks
16 models of rock layers/fossils encased in boxes
16 column analysis sheets
16 Handout #1 (picture of Grand Canyon and National Park locations)
16 Handout #2 (with correlation diagrams)
16 sets of real National Park columns paper-clipped together
32 sets of 3 stratigraphic sequences
16 stratigraphic columns compiled from sequences

Write these key terms on board:

- Stratigraphic Column, Geological Column
- Principle of Original Horizontality, Law of Original Continuity, Law of Superposition, Principle of Faunal Succession
- Index Fossils; Trilobite, Ammonite and Brachiopod Fossils
- Relative Dating and Absolute Dating

Students will share model rock layer columns, instruction sheets, and observation sheets in pairs.

When there is a question we recommend asking the students to foster participation and engagement, there will be a Q before it with the answer in italics afterwards

I. Reviewing Sedimentary Rocks

• A VSVS member should pass out the stratigraphy laws worksheet to the class. Tell students it is for their future reference and that VSVSers will write the laws on the board as the lesson progresses and they can write it down. As laws are introduced throughout the lesson, write them out on the board.

• Q. Ask students to raise their hands if they have seen large rock walls on the sides of the highway in Nashville with multiple layers of rock.

• Today, we are going to create a model of sedimentary rock layers and look at methods geologists use to determine the age of each layer.

• 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.
  - Rock layers are called strata.
  - They are very common all over the world.
  - Types of sedimentary rock include sandstone, limestone, and shale.

A. Activity - Creating a Model of Sedimentary Layers

• Set up at the front of the class the apparatus to create the sedimentary rock column:
  - 1 plate
  - 1 column (tennis ball container)
  - 1 bottle of water

Your Notes:

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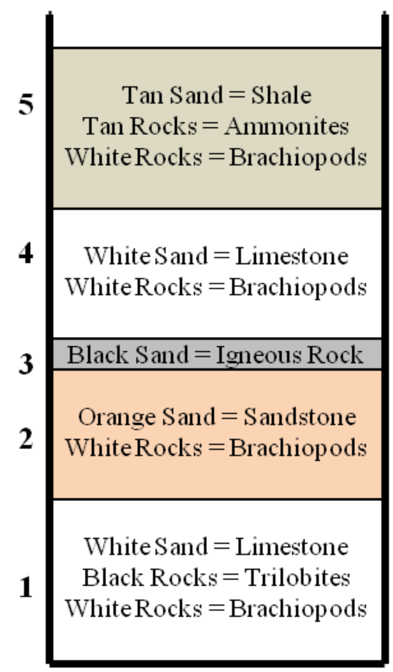
- 5 numbered jars of sand, with different colors of sand representing different types of sedimentary rock and different stones representing fossils:
    - Jar 1: White sand containing black and white stones.
    - Jar 2: Orange sand containing white stones.
    - Jar 3: Black sand.
    - Jar 4: White sand containing white stones.
    - Jar 5: Tan sand containing white 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.
- Make sure students are adding the jars of sand to the column in the correct order.

• The other VSVS members should hand out the columns, jars of sand, water, and plates (1 per pair of students).

• A VSVS member will create the demonstration column at the front of the class, while VSVS members move around and help students make their own columns at their tables. Make sure that all students in the class can see the demonstration column.
- Put the column on the plate to catch spills.
- Pour the container of water into the column, reminding students that sedimentary rocks form when sediments settle out of water and form layers.
- Pour all of the sand and rocks from container #1 into the column.
- Explain to students that we are using different colors of sand to represent different types of sedimentary rock (except for the black sand, which we will explain later), and different color stones to represent fossils.



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- Q. After pouring in the first layer of sand, ask students to describe what happened.
  - *Sand settles through the water to make a flat layer at the bottom of the column.*
  - Explain that sediment is deposited in horizontal layers, and it stays that way unless something disturbs it.

Explain The Law of Original Horizontality:
Sediments are deposited in flat, horizontal layers.

- 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.

- Tell students that they are now looking at a rock core sample and that they are going to interpret the layers in the column in the same manner that a geologist would interpret a real rock core.

B. Explaining the Column

Pass out 1 model of rock layers/fossils encased in boxes and 1 observation sheet to each pair of students.

- Tell students to place the models on top of the matching drawing on the observation sheet. Make sure the columns are oriented correctly. Point out that the layers in the sand-and-water column are the same as in the models but that the models contain real fossils instead of rocks.
- Go through the boxed model column layer by layer, and tell the students what rock types and fossils are represented in the columns.
- Tell them that their models contain real fossils listed on the board.
- Have students fill in the Rock Type and Fossils Present columns on their sheet as you go through the layers.
- Q. What type of sedimentary rock exists in Nashville? (*Limestone)*

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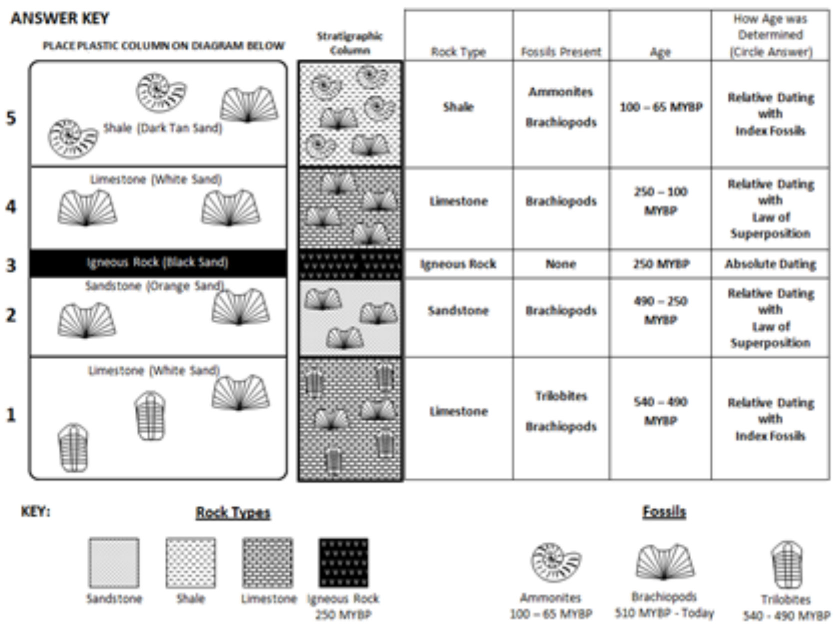

• Explain that the second column (called Stratigraphic Column) on the worksheet is the way geologists would represent such a column and that the key on the bottom of the page shows what each symbol means.

II. Dating the layers

A. Types of Dating

- Tell students they are now going to use their model to determine the ages of the "rock" layers.

- Q. Can anyone think of some ways that geologist might come up with the ages of rock layers?

Your Notes:

- Geologists determine rock ages in 2 ways:
  - Relative dating tells us which rocks are younger or older than other rocks, but doesn't give us an actual date.
  - Absolute dating gives us the actual age of the rock (in years old).

- Have students consider the construction of a building.
  - A VSVS member should hold up a picture of the building on the right.
  - Q. Tell the students that this building was completed 10 years ago. (This isn't necessarily accurate, but will suffice for the sake of this exercise). Can we tell exactly when each floor was built?
    - *No, because we don't know how long it took to build. We do know that the middle stories are older than the top because they have to be built first in order to support the weight above.*
  - This is **relative dating**.
  - Tell students that a construction worker tells us that the ground floor was finished 15 years ago and the top finished 10 years ago.
  - Determining actual ages like this is like **absolute dating**.
  - With this knowledge and relative dating, we now know that the middle stories must be between 10 and 15 years old.

- Tell students to look back at the sand-and-water columns they have created.
  - Which layer was deposited first? *(The bottom layer)*
  - So which layer is the oldest? *(The bottom layer)*
  - Which layer is the youngest? *(The top layer – it was the last one deposited into the column.)*

Explain the Law of Superposition:

Older layers are always below younger layers, i.e. oldest layers on bottom and youngest on top.

  - 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.)*

Your Notes:

Relative Dating:

When we cannot tell the exact age of a rock but can get an idea of its age in comparison to rocks around it (recall the floors of the building).

- 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. (Make sure the students know what igneous rocks are.)

- Igneous rocks contain radioactive elements like uranium, rubidium, thorium, and potassium – scientists can use these elements to determine the exact age of these rocks!

- Radioactive elements can only be used to determine the age of igneous rocks, not sedimentary rocks. (If the students ask why this is, tell them it is because sedimentary rocks are made up of tiny grains of preexisting rocks; we can get ages for the individual grains of a sedimentary layer, but that does not tell geologists when it was deposited as a sedimentary rock, just when each individual grain was deposited.)

Absolute Dating:

Absolute dating is figuring out a rock layer's actual age through dating of radioactive elements or other techniques.

B. Using Index Fossils

- Review the information that they learned from the Fossils lesson:
  - 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.
  - Fossils succeed each other in a definite order – the oldest fossils in a series of layers will be in the lowest layer.

Principle of Faunal Succession:

Fossils succeed each other in a definite order and the oldest fossils will be in the lowest layer.

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- Geologists do not use all fossils to help identify the age of rock layers. The most useful are called **index fossils**. Remind students that fossils are chosen to be index fossils if they:
    - Lived only a short time.
    - Are found in many areas world-wide.
    - Are easy to find (abundant).
    - Are easy to identify.
- Index fossils have exact time ranges in earth's history when they were produced – this can be used to find the age of rock layers they are found in.

C. Finding the Rock Ages in Our Column

- With these methods, work as a class to find the ages of the rocks in the columns.
    - Write time ranges on the board next to your column as you explain how you found them, and have the students fill them out on their worksheet, as well as the dating method they used to find the age.

- 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 case, we will say that this layer is 250 million years old.

- Q. The tan layer (on top) and the white layer on the bottom 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 range they were deposited.*
    - Ammonites (in the tan layer on top) 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 white layer on bottom) 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?
    - *Relative dating.*
    - We know that the white layer second from the top must have been deposited between the top layer (100 million years ago) and the third layer (250 million years ago)
    - The orange layer (fourth from the top) must have been deposited between the bottom layer (490 million years ago) and the third layer (250 million years ago).

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III. Stratigraphic Correlation

A. The Law of Original Continuity

- One VSVS member should pass out handouts #1 and 2, (in sheet protectors, one set per pair of students) while another member goes on with the lesson. Go slowly through this material and make sure the questions students have are answered, as this is traditionally a difficult section to understand.

- The history of earth is preserved in its rock layers. Unfortunately, no single location on earth has a continuous set of layers due to erosion or ceased deposition. Instead, geologists study rock sequences at many different places around the world, measure the depth of the layers, record what kind of rock is in each layer, and see if there are any fossils present. Geologists represent the layers of rock by drawing a picture of the sequence – this is called a **stratigraphic column**. Tell students that the schematic drawing next to their model on the column analysis sheet is a stratigraphic column.

- Geologists then match, or **correlate**, the different shorter sequences to create a **geological column** that spans further back into earth's past.

- Geologists use different methods to identify rocks of similar ages in different places around the world, depending on how far apart the sequences are.
    - Tell students that one of the easiest ways to tell if a rock layer at one point is the same age as at another point is by physical inspection. It is easy to identify rock layers that are continuous and look the same.

- Tell the students to look at the picture of the Grand Canyon (next page) on Handout #1 and to trace the layer starting at A and ending at B. Say that the **Law of Original Continuity** tells them that it has the same geological age across the entire layer.

Explain the Law of Original Continuity:

Discontinuous layers that have the same rock type and age and are close together were once a continuous layer.

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- Tell students that the first diagram on Handout #2 (next page) simulates the continuous rock layers.
  - It is also easy for geologists to match sequences of layers of rocks that look the same even if they are separated by a short distance such as points B and C in the Grand Canyon picture. The second diagram on Handout #2 simulates this (the dotted lines show the correlations).
  - However, when rock layers are separated by long distances (even continents!), geologists need more evidence to correlate layers. Note the middle diagram on Handout #2 – these layers cannot be correlated.
  - Geologists can assume that rocks containing identical index fossils are the same age. Note the bottom on Handout #2 – these layers can be correlated!

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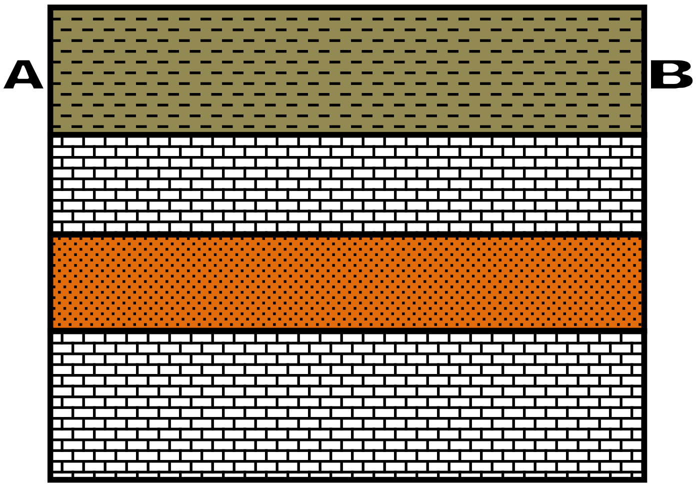
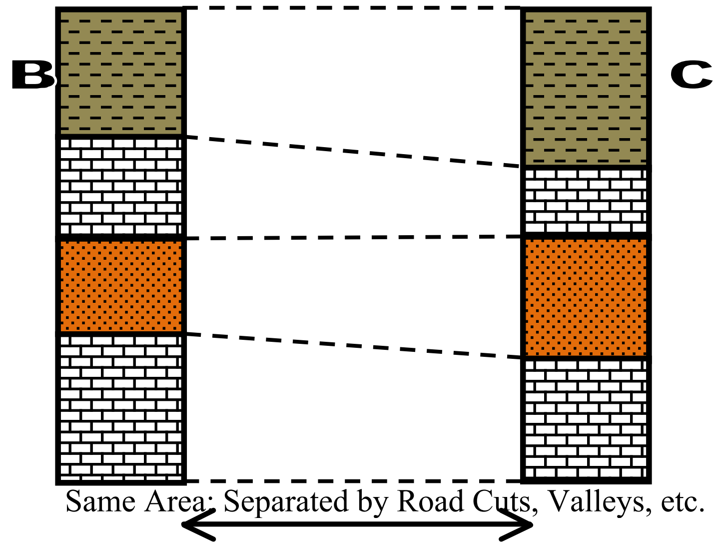
Stratigraphic Correlations – Handout #2

1. Continuous Rock Layers

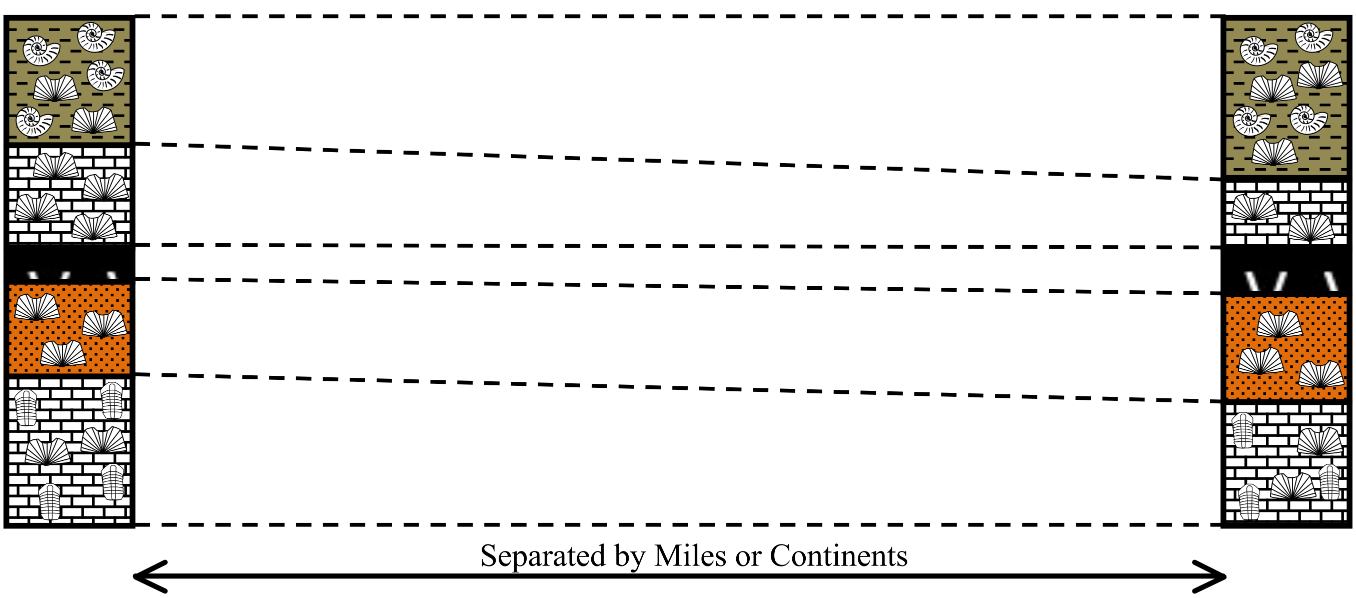


2. Rock Layers Separated by a Short Distance



3. Rock Layers Separated by a Long Distance WITHOUT Key Layers (Fossils or Igneous Rocks)

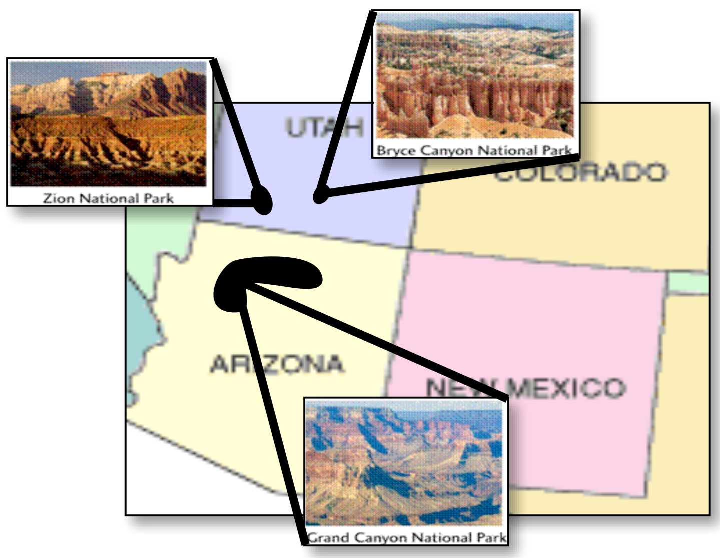
4. Rock Layers Separated by a Long Distance WITH Key Layers (Fossils or Igneous Rocks)



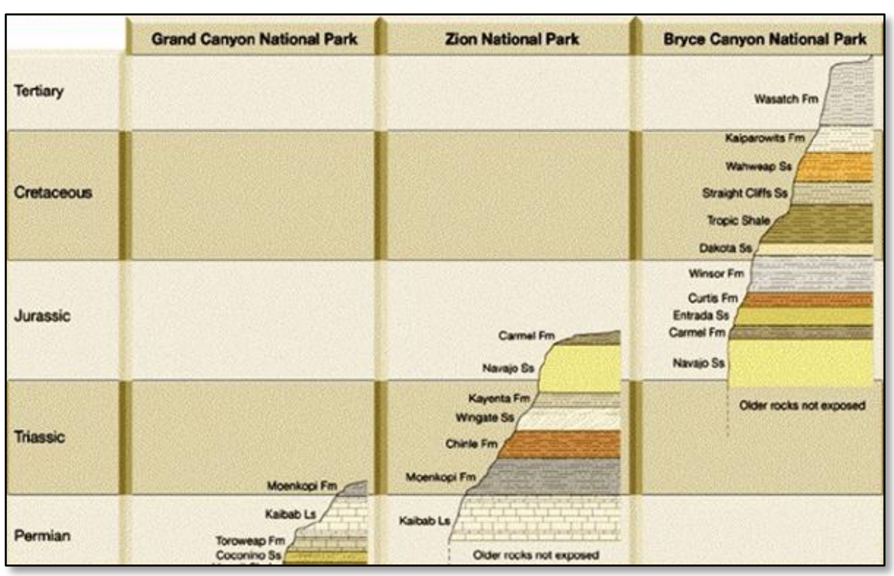
B. National Park Rock Sequences

- Pass out the paper-clipped together colored stratigraphic columns to students. (These columns represent actual sedimentary layers taken from the National Parks in Graphic A; they have been cut from the stratigraphic columns in Graphic B, on Handout #1.)
  - o Have students un-paper clip 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.
  - o 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)



C. 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.
    - Note – if students ask you to explain this, tell them that they don't have to be the same depth because uplift or faulting (think near mountains) can raise or lower rock layers (as on either side of a valley), but they were originally continuous units.
  - 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 come around and collect the 3 partial columns and complete columns and answer any questions the students have.

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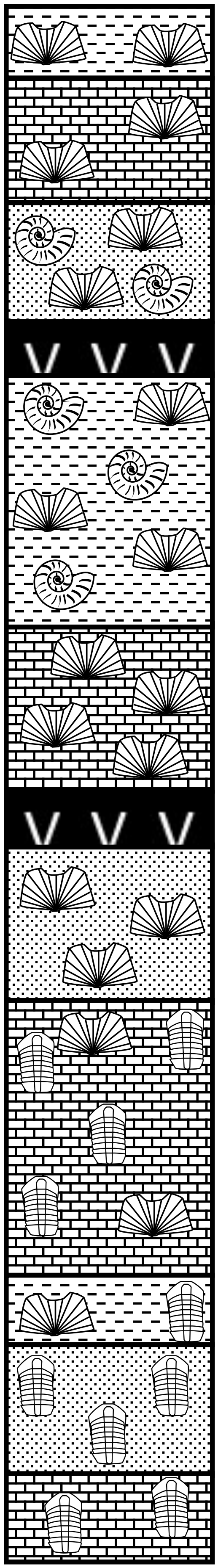
Reference: Chernicoff, S., & Whitney, D. (2007). *Geology: An Introduction to Physical Geology.* Upper Saddle River, New Jersey: Pearson.

Geological Column



Stratigraphic Sequences