Activity Description & Estimated Class Time

Over the course of two 50-minute class periods, students will make models of geologic strata and then manipulate them to simulate the action of geologic processes. They will also examine and analyze photographs and diagrams of geologic processes.

Correlations to NC Science Standards

ESS.8.1.1 Analyze and interpret data to conclude the relative age of Earth and relative age of Earth and relative age of rocks and fossils from index fossils and ordering of rock layers

ESS.8.1.2 Engage in argument from evidence to explain the use of fossils, composition of sedimentary rocks, faults, and igneous rock formations found in rock layers as evidence of the history of the Earth and its life forms.

Learning Target

Students will demonstrate knowledge and understanding

- that the relative age means the age of one object compared to the age of another object.
- of the major laws that help understand geology

Brief Science Background

Relative age does not tell the exact age of an object. **Relative age** means the age of one object compared to the age of another object. The relative age of rocks and fossils can be determined using two basic methods: ordering of rock layers and index fossils. In this activity students will explore the ordering of rock layers.

Scientists read the rock layers knowing that each layer is deposited on top of other layers. The **law of superposition** states that each rock layer is older than the one above it. This law is used to read rock layers. Using this understanding of layering, scientists infer that the relative age of the rock or fossil in the rock is older if farther down in the rock layers. Relative dating is best used when the rock layers have been preserved in their original sequence. Over millions of years, tectonic plate motion can distort these layers. As a result of this, the youngest layers of rock are not always found on top, because of folding, breaking, and uplift of layers.

Sedimentary rock makes up about 75% of the rocks on the Earth's surface. Sedimentary rocks form on the surface of the Earth, anywhere that sand, mud, or other types of sediment collect. Scientists can gain an understanding of Earth's climate, biological, and geologic history by examining the contents of different layers of sedimentary rock. Sedimentary rock layers can be disturbed by igneous rock. This happens when molten rock forces it way up through the layers above it. This forms igneous rock sections within and across the sedimentary layers. The sedimentary rock layers must be there first, therefore the igneous rock intrusions are younger than the layers it cuts through. Sometimes the molten rock will force its way to the surface and erupt, creating a younger igneous layer at the surface. With time, more sedimentary layers can form on top of the igneous rock. Igneous rock is always younger than rock layers it cuts through.

A fault is a break in the rocks that make up the Earth's crust that is formed due to the movement of rock on either side of the fault. Generally, faults occur where there is movement (a slip) of tectonic plates. Sudden movement of this type is associated with earthquakes. The two main types of faults involve dip slips and strike slips. In a dip slip, two pieces of land change their vertical position compared to one another. Afterward, one side of the fault is higher than the other. In a strike slip, two pieces of land move horizontally.

Part 1 — Strata Viewing Trays

Materials

Materials for the whole class

- supplies of clay, flour, potting soil, and sand
- 1 utility knife
- scissors (provided by teacher)

Materials for groups of 4 students

- Paper trays of clay, flour, sand, and potting mix (1 each for 4 students)
- 8 plastic spoons (2 per paper tray)
- 4 clear deli containers and lids to be glued by students and then cut by the teacher (see **Preparation** section below)
- 2 paint stirring sticks
- 4 craft sticks
- 1 glue bottle
- 1 sample strata viewing tray (see **Figure 2** below)
- 2 copies of Photograph A
- 4 How'd that Happen? student activity sheets (SD 1)

Preparation

allow approx 60 min.

1. Two days before the strata viewing trays are needed, have students glue them. Prepare enough for 1 empty tray per student.
2. Students should squeeze a bead of glue into the groove in the lid (gray area in **Figure 1)** and then snap the lid in place onto the bottom of the tray. The trays should be set aside to dry for at least a day.

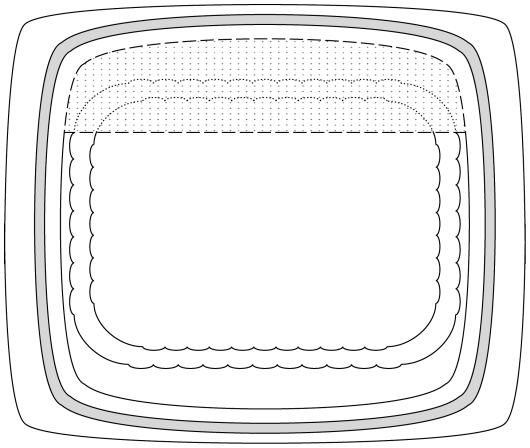


Figure 1. Preparing the strata viewing tray.

3. After the glue is dry, the teacher can remove the dotted portion of the bottom piece by cutting along the dashed line with scissors or the utility knife provided.
4. Set up one strata viewing tray for each group of four students as shown in **Figure 2.** All the trays should look fairly similar. Flour will be placed first, then sand, potting soil, and clay.

Preparation cont.

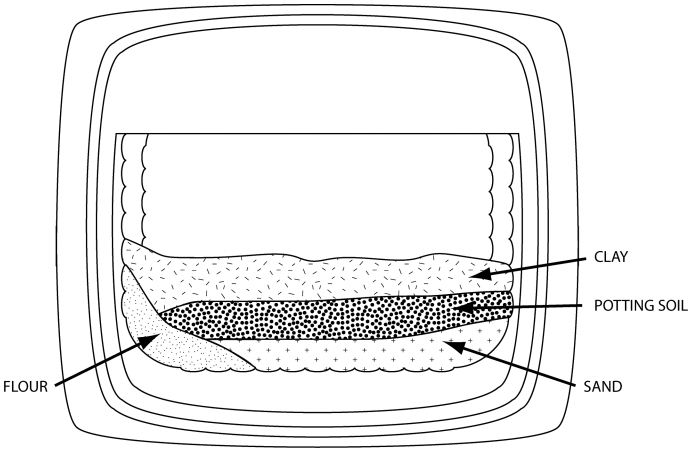


Figure 2. Sample strata viewing tray.

5. Prepare a few sample trays showing examples of pressure applied with paint stirring sticks or craft sticks or create other interesting formations.
6. Prepare paper trays of clay, flour, sand, and potting soil for student groups of four. Prepare enough for 1 sample each per group of 4 students.

Procedure

1. Distribute Photograph A and the How'd That Happen student activity sheets (SD 1). Ask the students to write down 5 observations of the scene with particular attention to the rock wall on SD 1. Discuss the student observations.
2. Inform students that there are dramatic surface features all over the Earth, and people look at them and wonder how they were formed. Ask the students if they can see any evidence of how this cliff face was formed based on what they know about the Earth and rocks. Explain that this was the problem faced by early Earth scientists. What could have made that rock or layer or mountain look like that? How can one find out about things that happened long ago over very long periods of time? What kinds of evidence can one gather long after an event happened to be able to explain that event?
3. Pass out the sample strata viewing trays that you have prepared (Figure 2) and ask the students to draw and label a diagram of the strata on SD 1. It is appropriate to tell the students what the materials are in the strata. Ask the students to look at the strata and see if they can tell which layer came first. Ask them for their evidence and any other observations they have to support their ideas of how the strata were laid down.
4. Pass around a few more examples of pre-made trays that have evidence of pressure applied with a paint stirring stick or craft stick or other interesting formations in the strata and have the students speculate on how they could have been made.
5. Give each group of 4 the trays of clay, flour, sand, and potting mix, plastic spoons, 4 strata viewing trays, paint stirring sticks, and craft sticks Ask the students to make a tray of their own, document the steps that they took to make the tray and draw a diagram of their tray on SD 1. Be sure to mention that pushing or poking the strata with sticks is allowed.
6. Once students have built and documented a strata tray that they like, have them trade with students at other tables. Ask the students to draw and label these new

Procedure cont.

trays and to write down how they think the trays were made. This activity can be repeated until the materials run out.

Content Connection

Discuss the results of the students' experiences trying to figure out how these strata layers were made. This is a good time to point out that they have just used two major laws that help in the understanding of geology. The **Law of Superposition** in which the oldest material is on the bottom and the **Law of Uniformitarianism** that states that things behave now as they always have—i.e., flour does not fall up or turn into clay.

Formative Assessment/ Guided Practice

Make several different strata viewing trays and ask the students to provide analyses with evidence on how the layers were formed.

Part 2 — Strata Diagrams

Materials

Materials for the whole class

- ability to project
  - strata diagram 1 (SD 2)
  - strata diagram 2 (SD 3)
  - strata diagram 3 (SD 4)
  - strata diagram 4 (SD 5)
  - strata puzzle 1 (SD 6)
  - strata puzzle 2 (SD 7)
  - strata puzzle 3 (SD 8)
  - strata puzzle 4 (SD 9)
  - strata puzzle 5 (SD 10)
  - killer strata puzzle (SD 11)

Materials for groups of 4 students

- 4 strata diagram sets (SD 2-5)
- 4 strata puzzle sets (SD 6-11)
- 2 sets of photographs B, C, D, and E

Procedure

1. Pass out the strata diagram sets and display Strata Diagram 1 (SD 2). Explain that this diagram represents a cross-sectional slice of the Earth much like the road cut photograph through the hill (**Photograph A**). Ask students to describe what they see and record under **observations** on SD 2. Ask only for simple observations. Simple observations may include: four different rock types, different symbols for the rock types, straight lines between different layers.
2. Next, ask the students for possible meanings of the two types of lines at the upper and lower edges of each layer. Discuss the **Law of Original Horizontality**, the notion that sedimentary rock layers are generally laid down in horizontal layers and that in these diagrams a straight line indicates a transition from one type of deposition to another. The curvy line indicates that erosion or non-deposition has taken place and something is missing or time has passed without deposition—an **unconformity**.

Procedure cont.

3. As a class discuss what the Strata Diagram 1 shows and have students record on SD 2 under **this diagram shows.**
   Strata Diagram 1 shows: The Law of Orginial Horizontality, Law of Superposition, Uniformitarianism, Unconformity represented by the uneven line on top that indicates **erosion** taking place and material missing, only sedimentary rocks are in this cross section.

4. Next, As a class discuss the order of events in Strata Diagram 1.
   Most Recent
   - Erosion
   - Deposition of siltstone
   - Deposition of shale
   - Deposition of limestone
   - Deposition of conglomerate

   Oldest

5. Display Strata Diagram 2 (SD 3) and ask students to make observations and record them on SD 3 under observations.
   Simple observations include: four different rock types, different symbols for the rock types, straight lines between different layers, the layers are tilted, erosion occurs at the top.

6. After students make their make their observations, point out that the previous diagram supported the Law of Original Horizontality. What is going on in this diagram and what does it indicate? Explain that there are tectonic forces that can actually lift entire sections of Earth and leave them tilted relative to how they originally formed. Also point out that deep in the Earth, perhaps miles below the surface, layers can be bent or bowed due to the intense heat and pressure deep in the crust. Have students record what the diagram shows and the order of events of Strata Diagram 2 on SD 3. Discuss as a class.
   Strata Diagram 2 shows: The Law of Original Horizontality, The Law of Superposition, and Uniformitarianism. The diagram shows the layers can be tilted by tectonic forces (layers can also be bent and lifted). We see straight lines of deposition and boundaries between rock types and curvy lines as in Diagram 1 indicating erosion. Once all of the layers were laid down, they were lifted and tilted and then eroded. In this diagram we can see that deposition of all of the layers occurred first. This is indicated by the parallel relationship between the layers. Deposition was followed by lifting and tilting. This was followed finally by erosion. The fact that the erosion plane is not parallel to the plane of deposition of the rock layers indicates that erosion occurred after the tilting.

   Most Recent
   - Erosion
   - Tilting of the layers
   - Deposition of siltstone
   - Deposition of sandstone
   - Deposition of limestone
   - Deposition of conglomerate

   Oldest

7. Display Strata Diagram 3 (SD 4) and ask students to make observations and record them on SD 4 under observations.

Procedure cont.

Simple observations include: three different rock types, different symbols for the rock types, straight and curvy lines between different layers, the layers are shifted, there is a fault.

8. Discuss that this diagram shows a fault and the results of faulting tectonic activity. The half to the right of the fault has been lifted up relative to the section to the left of the fault. This is indicated by the increased erosion of the sandstone and greater exposure of the siltstone.

9. Next, have students record what the diagram shows and the order of events of Strata Diagram 3 on SD 4. Discuss as a class.
Strata Diagram 3 has a few new twists. Using the aforementioned laws of geology, we can see that siltstone was deposited first, followed by deposition of limestone. Note the curvy layer between the limestone and sandstone. This indicates erosion of the limestone before the sandstone was deposited.

   The fault cuts across all of the layers indicating that it is more recent than the deposition of the layers. This is referred to as the **Law of Crosscutting Relationships.** Note that the sandstone to the right of the fault is a thinner layer than the sandstone to the left of the fault, and that the siltstone is thicker on the right side of the fault than on the left side of the fault. These clues indicate that sandstone was deposited on the eroded limestone and that the layers on the left side of the fault dropped relative to the layers on the right. (If we could look deeper, we would probably see more siltstone on the left side of the fault, below what is visible in the diagram.) Erosion of the limestone occurred before the faulting and dropping, since that erosion line has been split by the fault. Erosion at the surface occurred after the movement at the fault.

   Most Recent
   - Erosion of sandstone
   - Fault and dropping
   - Deposition of sandstone
   - Erosion of limestone
   - Deposition of limestone
   - Deposition of siltstone

   Oldest

10. Display Strata Diagram 4 (SD 5) and ask students to make observations and record them on SD 5 under observations.
Simple observations include: different rock types, different symbols for the rock types, straight between different horizontal layers, there is a igneous intrusion and a contact metamorphism zone. The **Zone of Contact Metamorphism** indi-cates that the molten igneous rockwas hot and caused some degree of meta-morphosis of the rock layers that it moved through.

11. Discuss these observations, the meaning of igneous intrusion, the symbol for the Zone of Contact Metamorphosis, and the process that causes this metamorphism.

12. Next, have students record what the diagram shows and the order of events of Strata Diagram 4 on SD 5. Discuss as a class.
Strata Diagram 4 introduces the fact that igneous rocks can move through cracks in existing rock or "intrude" into existing rocks and leave material and other traces behind. Once again (as in the faulting in Diagram 3) if the intrusion cuts across a layer it is younger than that layer (the Law of Crosscutting Relation-

Procedure cont.

ships. The symbol for the Zone of Metamorphism is always shown in the layer that was affected by the intrusion. This is also an indication of the order of events, in that a layer must exist first before it can be metamorphosed by an intrusion. Intrusion of magma can result in different types of rock, depending on the conditions at the time of that intrusion. Two hints to remember are that granite is an igneous rock and can be the result of an intrusion and that an intrusion does not always result in straight lines.

Most Recent

- Erosion
- Igneous intrusion (accompanied by metamorphism)
- Deposition of siltstone
- Deposition of shale
- Deposition of limestone

Oldest

13. Pass out the Strata Puzzles (SD 6-11). Turn the students loose on the rest of the puzzles or go through them together as a class. If there is time, discuss and compare their results. Answers for the puzzles are on pages 15-17.

Formative Assessment/ Guided Practice

1. Pass out photographs B, C, D, and E.
2. Ask the students to record their observations and analyses of what might explain the features in each of the photographs.

Answers for the Strata Puzzles

Strata Puzzle #1

Most Recent

- Erosion of both the limestone and the igneous intrusion (labeled Erosion 1), indicated by the curvy line on top.
- Intrusion of the black igneous rock cuts across all layers and the zone of contact metamorphism is apparent in all layers.
- Intrusion from below of igneous granite into the limestone, indicated by the zone of contact metamorphism. (This seems odd because the limestone is above the granite. But note that the symbol for the zone of contact is drawn in the affected material.)
- Deposition of limestone. It had to be there first to be acted upon by the granite.

Oldest

Strata Puzzle #2

Most Recent

- Erosion 2 of limestone and igneous intrusion, indicated by the curvy line on top.
- Igneous intrusion. It cuts across all layers and affects all layers with contact metamorphism.
- Deposition of limestone.
- Deposition of siltstone 2.
- Erosion 1 of both the conglomerate layer and the shale layer.
- Bending of sandstone, siltstone 1, shale, and conglomerate layers. This bending is indicated by the curve of the layers and the uneven amounts of conglomerate at the edges.
- Deposition of conglomerate.
- Deposition of shale.
- Deposition of siltstone 1.
- Deposition of sandstone.

Oldest

Strata Puzzle #3

Most Recent

- Erosion 2 of conglomerate.
- Igneous intrusion. (This could have occurred any time after the deposition of the sandstone. That is, it could have happened either before or after the deposition of the conglomerate.)
- Deposition of conglomerate.
- Deposition of sandstone.
- Erosion 1 of limestone and granite.
- Granite intrusion of limestone and contact metamorphism.
- Deposition of limestone.

Oldest

Strata Puzzle #4

Most Recent

- Erosion 4 of glacial till and formation of the river channel.
- Deposition of glacial till.
- Erosion 3 and glacial scraping of siltstone 2 and the igneous intrusion surface.
- Igneous intrusion, younger than all of the layers it cuts across.
- Deposition of siltstone 2.
- Deposition of sandstone.
- Erosion 2 of basalt layer.
- Lava flow that created the basalt layer (note the zone of metamorphism affecting all four of the sedimentary layers below).
- Erosion 1.
- Tilting of the four lower sedimentary layers.
- Deposition of conglomerate.
- Deposition of siltstone 1.
- Deposition of limestone.
- Deposition of shale.

Oldest

Strata Puzzle #5

Most Recent

- Igneous intrusion 3, volcano, and basalt.
- Erosion 5 of sandstone 2.
- Deposition of sandstone 2.
- Erosion 4 of siltstone 2.
- Igneous intrusion 2.
- Deposition of siltstone 2.
- Erosion 3 of limestone 2 and igneous intrusion 1.
- Fault and uplift (affecting all the layers and igneous intrusion 1 below erosion 3).
- Igneous intrusion 1 (affecting all the layers below erosion 3).
- Deposition of limestone 2.
- Erosion 2 of siltstone1 and sandstone 1.
- Tilting of siltstone 1, sandstone 1, limestone 1, and granite.
- Deposition of siltstone 1.
- Deposition of sandstone 1.
- Deposition of limestone 1. (Note that there is no zone of metamorphism from the granite below, so the limestone must have deposited after erosion 5 and after the granite was fully formed.)
- Erosion 1 of granite.
- Granite layer formed.

Oldest

Killer Strata Puzzle

Most Recent

- Erosion 5 and deposition of loose river sediments.
- Deposition of siltstone.
- Erosion 4 of sandstone 4.
- Fault 2 and uplift.
- Tilting of limestone, old lava flow, and sandstone 4.
- Deposition of sandstone 4.
- Erosion 3 of hardened lava flow.
- Lava flow.
- Deposition of limestone.
- Erosion 2.
- Igneous intrusion.*
- Bending of sandstone 3, sandstone 2, shale, and sandstone1 layers.
- Deposition of sandstone 3.*
- Deposition of sandstone 2.
- Deposition of shale.
- Deposition of sandstone 1.
- Erosion 1 of granite and schist.
- Fault 1 in granite.
- Intrusion of granite into schist (note the zones of metamorphism).
- Formation of schist.

Oldest

* In this diagram, the age relationship between the igneous intrusion and sandstone 3 is ambiguous because they are not in contact with each other. It is possible that the igneous intrusion predates sandstone 3.

SD 1

How'd That Happen: Student Activity Sheet

Name:

1. Write down five observations of the scene in photograph A.

2. Draw and label a diagram of the strata.

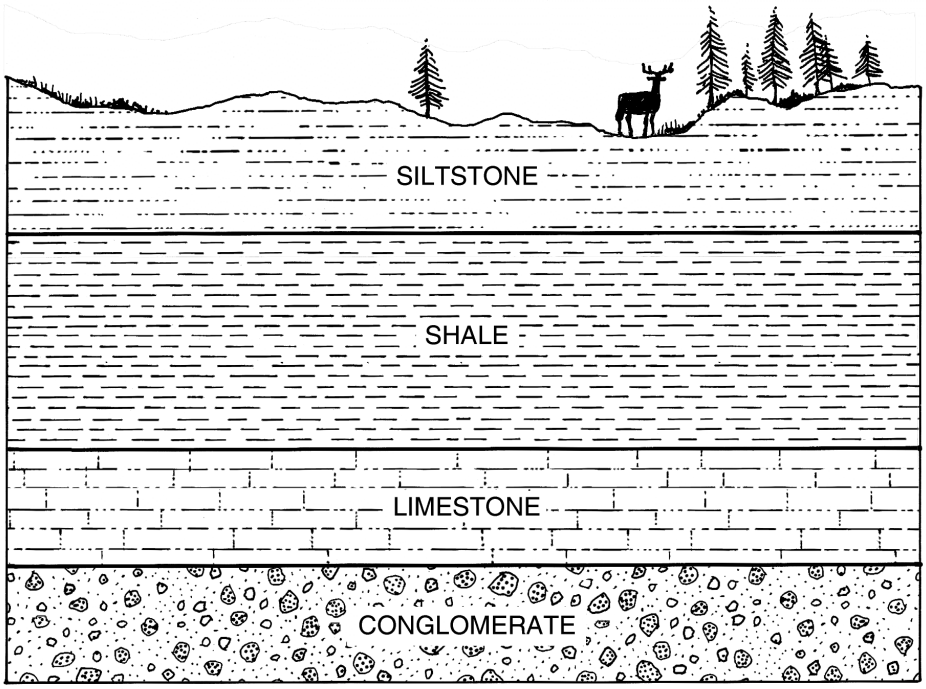
3. Make a strata tray of your own. Draw a diagram of the strata and document the steps you took to create the tray below.

4. Trade strata trays with other students. Draw a diagram of each strata and document the steps that were taken to create them.

SD 2

Strata Diagram #1

Name:



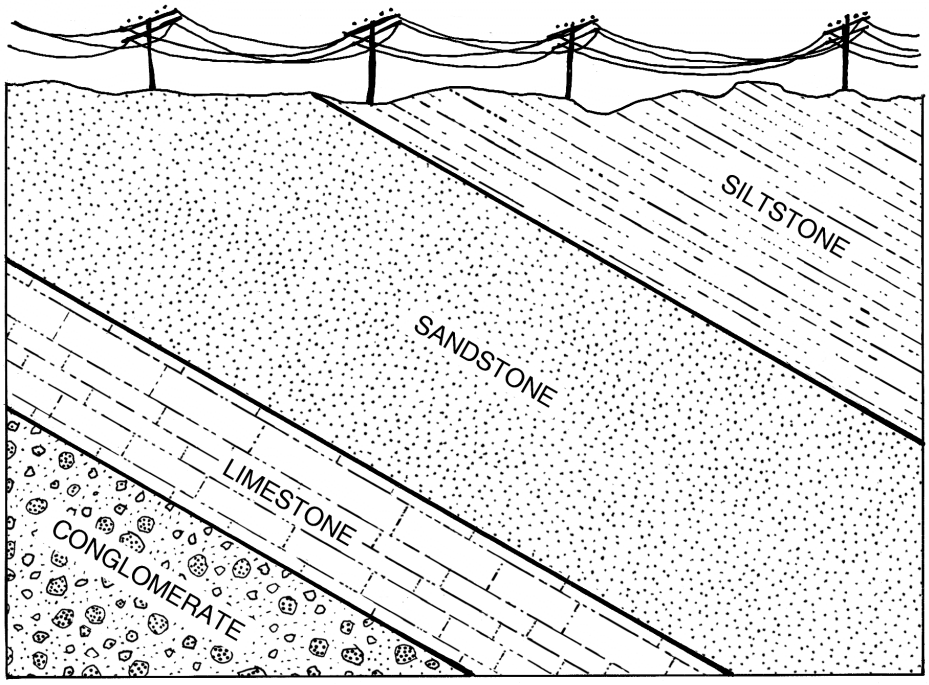
Observations:

This diagram shows:

SD 3

Strata Diagram #2

Name:



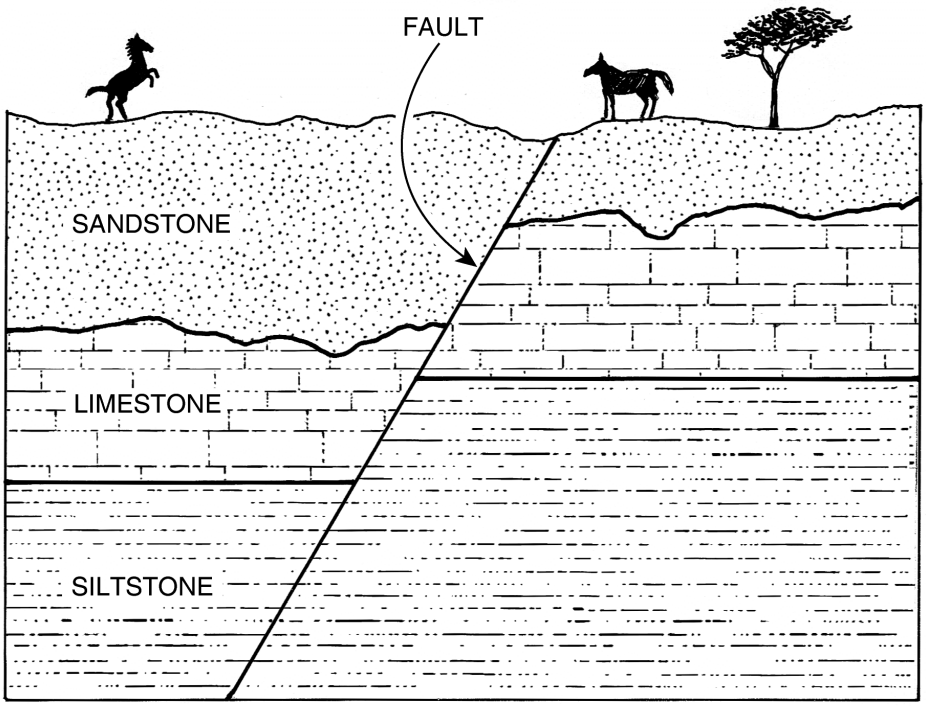
Observations:

This diagram shows:

SD 4

Strata Diagram #3

Name:



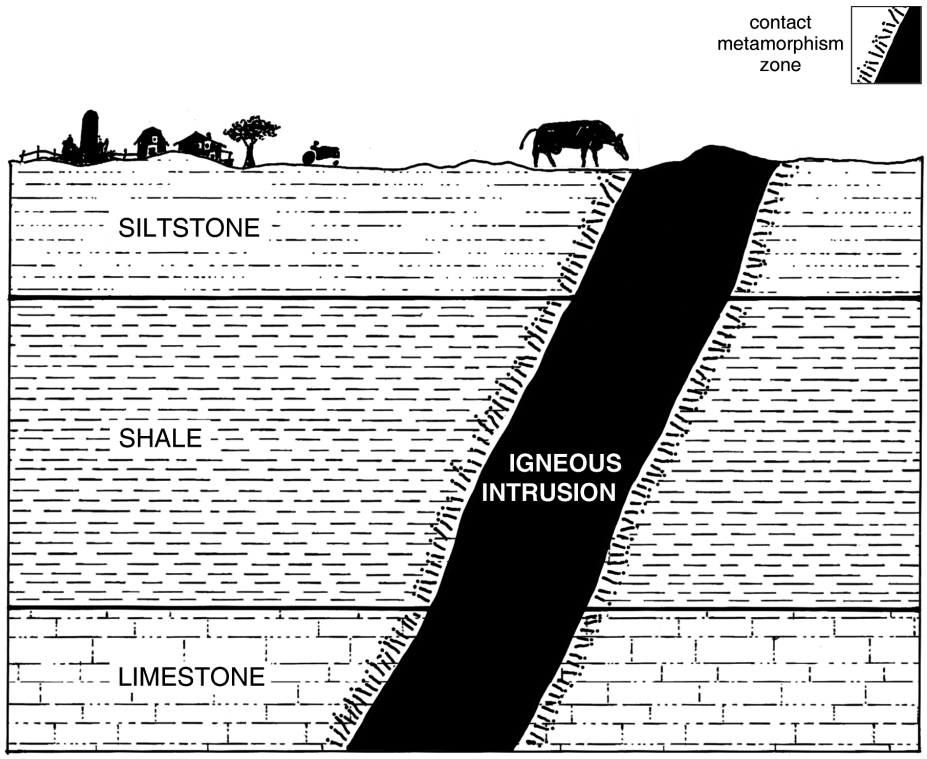
Observations:

This diagram shows:

SD 5

Strata Diagram #4

Name:



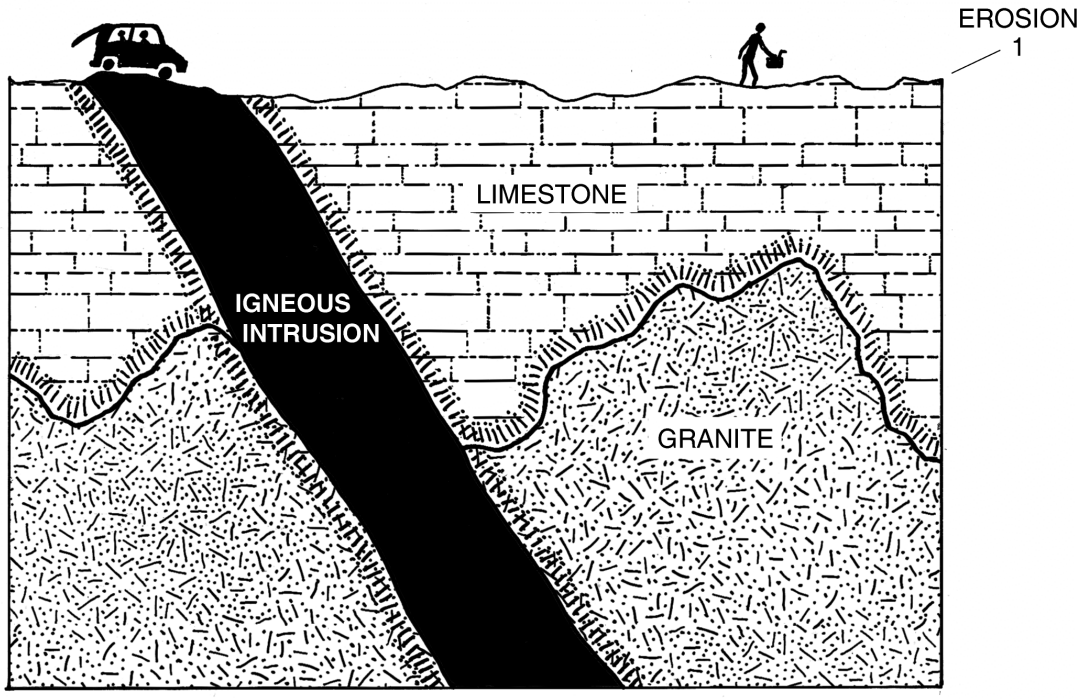
Observations:

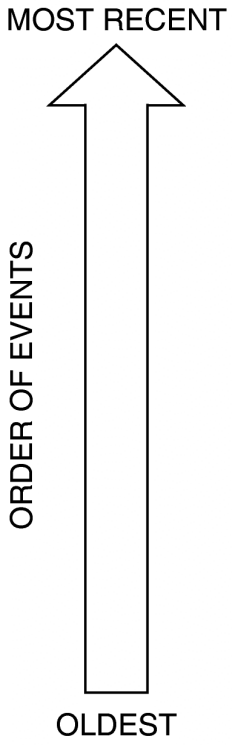
This diagram shows:

SD 6

Strata Puzzle #1

Name:

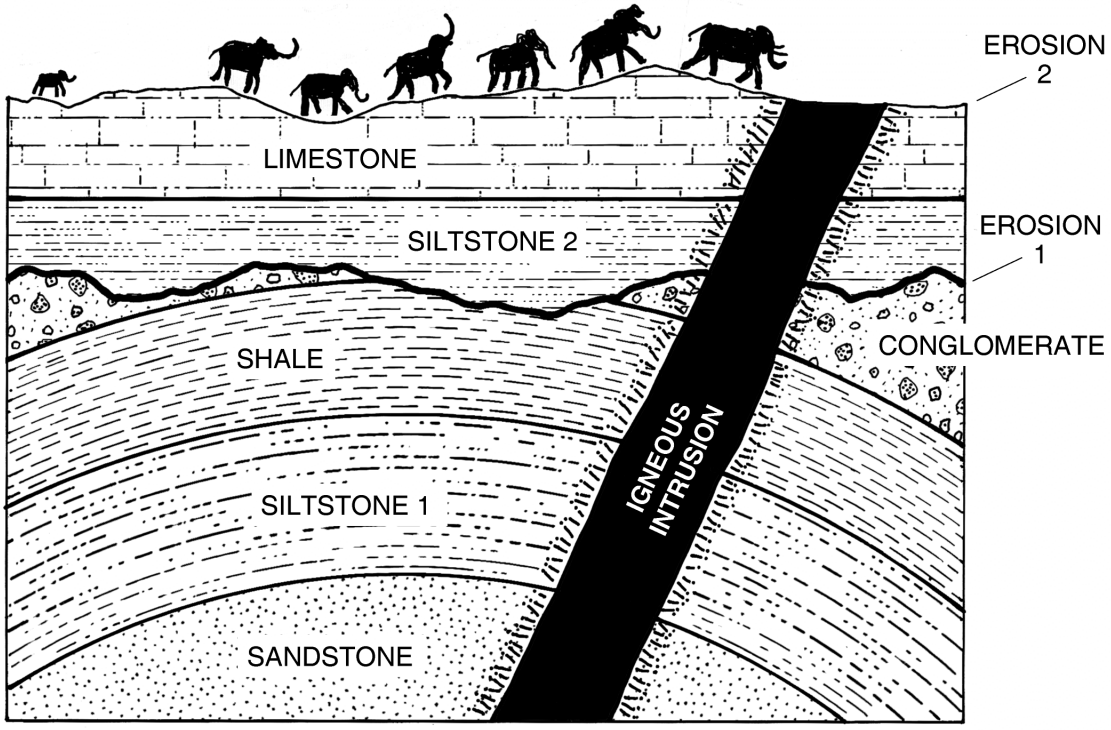


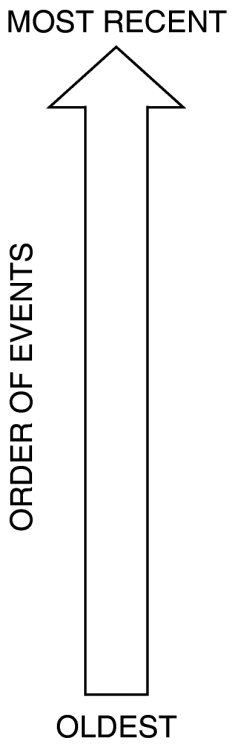


SD 7

Strata Puzzle #2

Name:

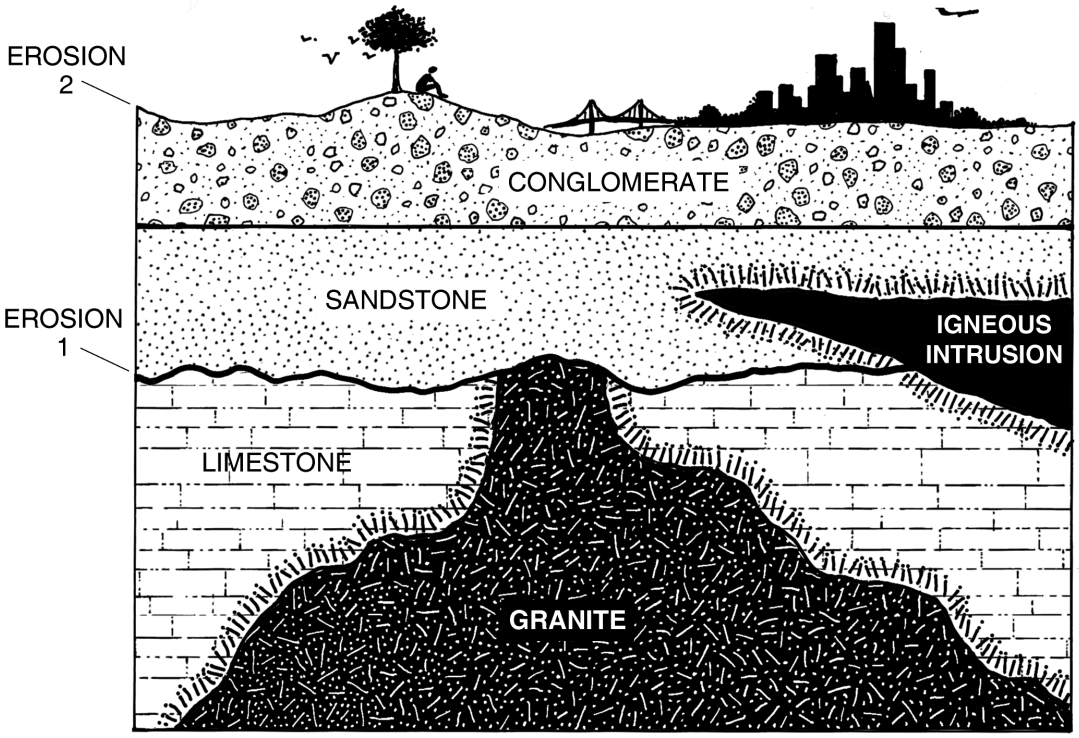


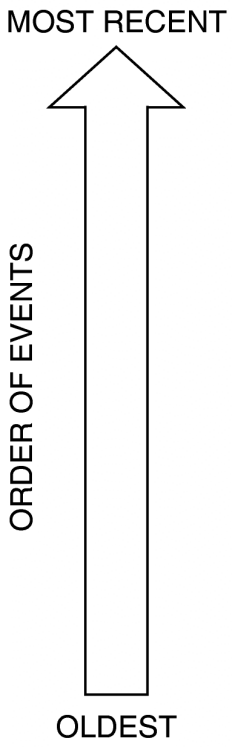


SD 8

Strata Puzzle #3

Name:

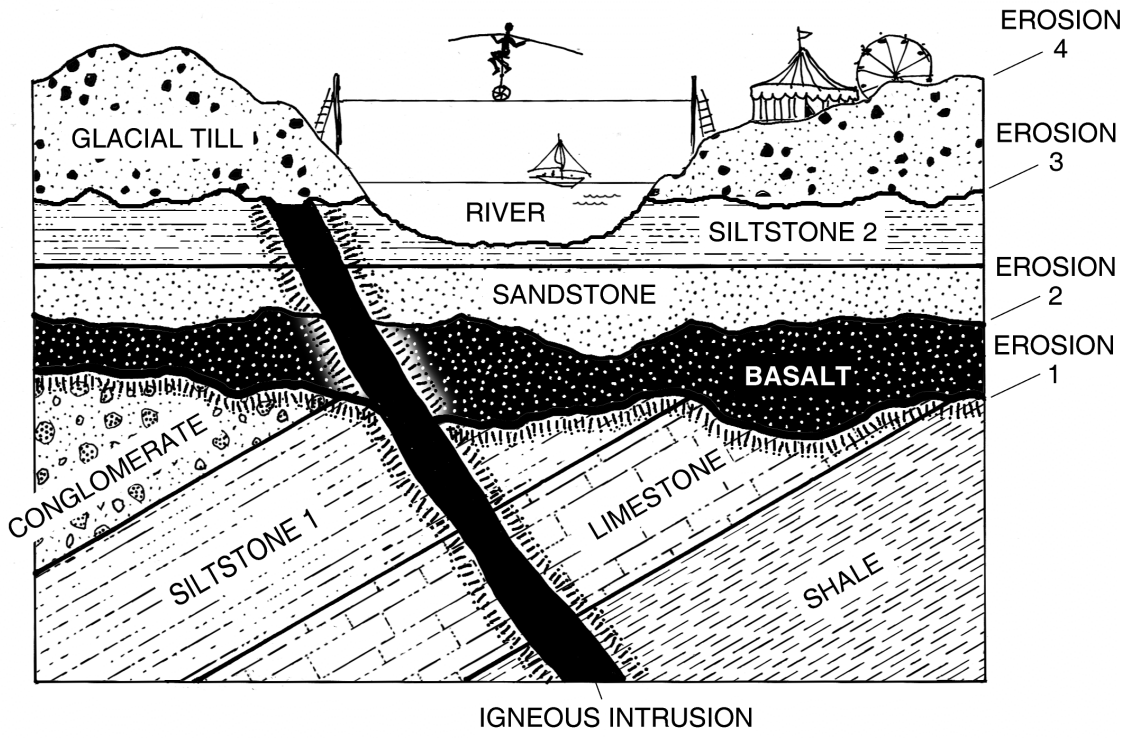


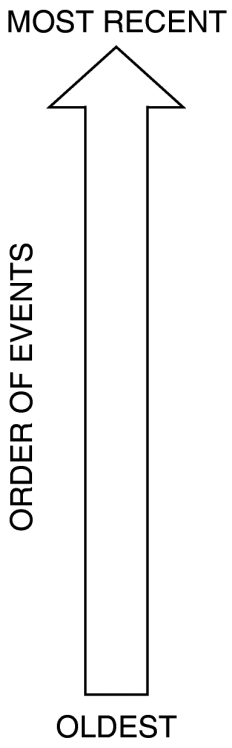


SD 9

Strata Puzzle #4

Name:

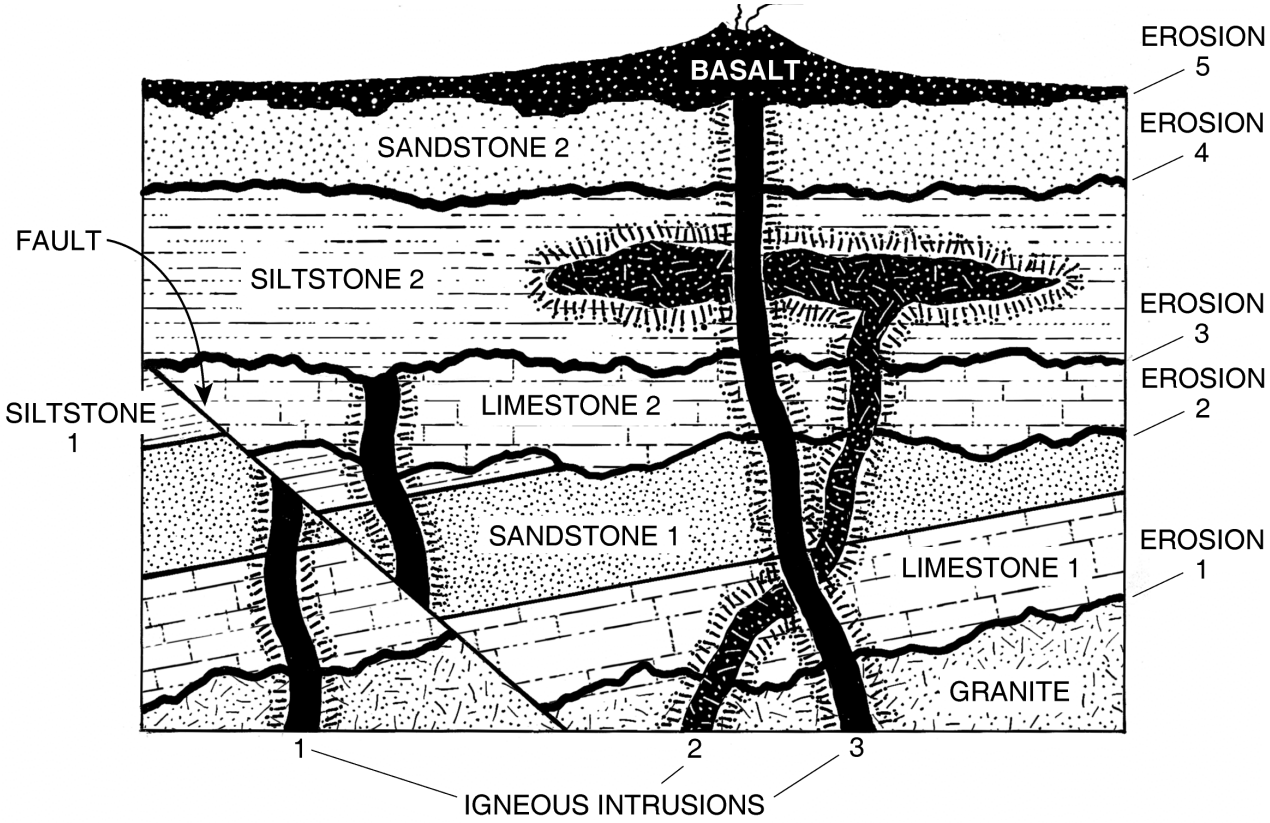


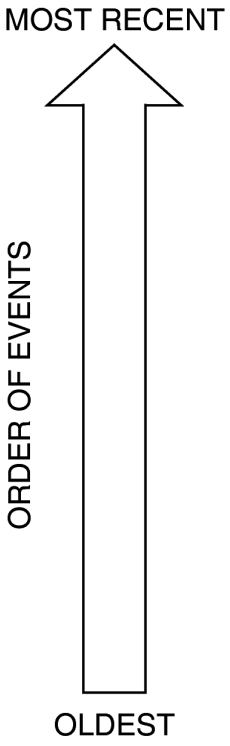


SD 10

Strata Puzzle #5

Name:





SD 11

Killer Strata Puzzle

Name: