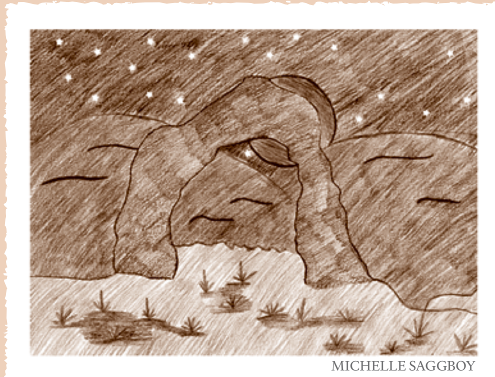

MICHELLE SAGGBOY

FIELD TRIP

Physical Features

Theme
Geologic processes cause continuous changes in the earth's physical features.

Utah State Science Core Curriculum Topic
Standard Two: Students will understand that volcanoes, earthquakes, uplift, weathering, and erosion reshape Earth's surface.

Objective One: Describe how weathering and erosion change Earth's surface.
Objective Two: Explain how volcanoes, earthquakes, and uplift affect Earth's surface.
Objective Three: Relate the building up and breaking down of Earth's surface over time to the various physical land features.

Field Trip Location
Bloody Mary Wash, immediately west of the Arches National Park Visitor Center parking lot. This site is unique in having a fossiliferous limestone in the wash bottom and a beautifully exposed geologic fault. All stations could be adapted for various geologic settings in southeastern Utah, but perhaps nowhere would have all the combined features of this site.

Times
Field trip stations are 30 minutes each. Pre and post trip lessons are 45 minutes

Science Language Students Should Use
Earthquakes, erode, erosion, faults, uplift, volcanoes, weathering, buttes, arches, glaciers, geological, deposition

Background

The rock layers and fault exposed at the entrance to Arches National Park are of textbook quality. The layers are easy to see; they have different colors as well as different compositions.

By looking at the rocks close-up, we learn about the ancient environments in which the sediments of the rock layers were deposited. Most *mudstones* and *siltstones* formed in low-gradient streams or tidal-flat environments. Some *sandstones* were deposited in steeper streams or on beaches. *Sandstones* made up of very rounded sand grains that are all the same size (*well-rounded* and *well-sorted*, in geological terms) indicate aeolian or windblown deposition in a relatively dry environment.

Limestones usually indicate a marine environment, and many contain fossils. (A few thin limestone layers in the Moab area were deposited in freshwater lakes.)

Any plant or animal that dies on earth can be fossilized if the conditions are correct. In order for a creature, or evidence of a creature, to be preserved as a fossil, the creature cannot be broken down or disintegrated. Many fossils are formed at the bottom of oceans, where deposition is continuously occurring and dead organisms are quickly buried. This, and the fact that many marine creatures have hard shells that don't decompose easily, is why most fossils are of marine organisms. Fossils of land-dwelling creatures are less common. The Honaker Trail

Delicate Arch

Formation, found in the bottom of Bloody Mary Wash, contains an abundance of fossils. This limestone layer was deposited in an offshore marine environment about 300 million years ago. There are fossils of crinoids, brachiopods, bryozoans, horn corals, and occasional clams, snails, and trilobites.

A *geologic fault* is a break or fracture in the rock, along which there is displacement of the strata. Most faults form during earthquakes or volcanic activity associated with the shifting of tectonic plates. In southeastern Utah, however, much faulting is associated with an unusual phenomenon, the movement of underground salt layers. Faults are commonly buried by sediment and difficult to see, but the Moab fault is spectacularly exposed at the field trip site. The Honaker Trail Limestone has been shifted 2,500 feet upward on the west side of the fault, past seven other rock layers. It is now on the same level as the Entrada Sandstone (Dewey Bridge Member) east of the fault.

Arches National Park's erosional landscape of valleys, towers, fins, canyons, pinnacles, and arches began to form about 10 million years ago. That's relatively young in geologic terms; the rock layers in the park were deposited roughly 300 million to 150 million years ago.

Based on the definition of an arch as an opening at least three feet in one direction, there are over 2,000 named arches in Arches National Park, most within the Entrada Formation. Water is the main culprit in arch formation. Rainwater is usually slightly acidic, which weakens the cement between grains in the sandstone. The process of frost wedging involves water freezing (expanding) and thawing (contracting) in pores and cracks. This process is key in breaking apart sand grains, especially because of the large temperature fluctuations of the high desert climate. In addition to water, wind and gravity aid in the process of erosion by removing the weathered parts of rocks. Arches can be classified by their shapes; categories include free-standing arches, cliff-wall arches, and jug-handle arches. Natural bridges, unlike arches, are formed by flowing streams.

Plate tectonics is the driving force for faulting, earthquakes, and the melting and pressure that recycles rocks into new igneous and metamorphic rocks. The Earth has several layers: crust, mantle, outer core and inner core. The lithosphere, which is the crust plus the upper part of the mantle, is broken up into different pieces called plates that move around in different directions on the Earth's surface. There are three basic types of boundaries between these plates. Convergent boundaries are where plates crash together. In this case, one plate usually descends beneath the other. Plates made up of oceanic crust are thicker and heavier, so they sink below the lighter, thinner continental plates. Here, friction causes massive pressure, earthquakes, faulting, and mountain building. The descending plate melts, only to rise up as a liquid magma and form volcanoes along the edge of the overriding plate. In a few cases, when both of the lithospheric plates are made up of continental crust, neither plate descends, and the earthquakes and faulting create massive mountains such as the Himalaya. Divergent plate boundaries or rifts, where plates spread apart, are usually in the middle of oceans. Basaltic lavas flow from these boundaries, creating new crust. Transform plate boundaries, where plates slide by each other, are illustrated by the San Andreas fault in California.

A Piece at a Time

Friction at these boundaries creates earthquakes and faulting.

Objectives

Students will be able to:

a. Name the three main types of rocks.

b. Describe the processes that created four different landforms.

Materials

Igneous, metamorphic, and sedimentary posters; rock cycle jigsaw puzzles; question sheets; a set of numbered pictures of local landforms for each group.

PROCEDURE

1) Write *geology* on the board, and define it as the study of the earth's history. Inform students that geologists study the earth by looking at rocks, particularly those rocks found very near the earth's surface. Explain that there are many kinds of rocks and that geologists group them into three types based on how the rocks formed.

2) Quickly review the three major types of rocks: igneous, metamorphic, and sedimentary. Explain that the names give clues about how the rocks form: *sediments* make up sedimentary rocks, *metamorphosis* means changing form (as in insect life cycles), and they can think of *ignite* for igneous. Tell the students that given enough time rocks change, what form they change into depends on the amount of and the type of elements they are exposed to (i.e. heat, pressure, weathering). This process is called the rock cycle. Stress how slowly this takes place.

3) Divide the students into groups, and distribute rock cycle jigsaw puzzles. Ask the students to complete the jigsaw puzzle. Specify 2 or 3 questions for each group to answer from the questions included in the package on a separate piece of paper. Tell students that they are welcome to answer other questions but they will report on the questions they are assigned.

4) On their answer sheet, have the students write the part of the rock cycle that caused the creation of each numbered landform. Go over the answers to the rock cycle questions as a class.

5) Inform students that they live in a fantastic place for exploring rocks. Tell them that, on this field trip, they will be both looking at sedimentary rocks near the entrance to Arches National Park and exploring how these rocks formed and changed over time. Review field trip expectations and the items students need to bring on the field trip.

PUZZLE QUESTIONS

1. What types of rocks were most recently liquid?
2. Name a local landform created by intrusive igneous rock?
3. Name three types of extrusive igneous rocks?
4. Eroded material turns into what types of rock? What quickly happens to this rock?
5. How old is the earth?
6. Three times in the past, almost all the life on earth was extinguished how long ago did each one occur?
7. Describe the change in the continents on earth?
8. How are metamorphic rocks created?
9. What types of rocks can melt and become metamorphic?
10. Name a characteristic of metamorphic rock?
11. Is the rock cycle a one way cycle?

Puzzle currently unavailable.

INTRODUCTORY ACTIVITY
Rock and Roll

(adapted from Fluegelman 1976, 69)

Objectives
Students will be able to:
a. Name sand grains as the main component of sandstone.

Materials
None

PROCEDURE

1) This game works best with 6 to 10 people. Have students stand elbow-to-elbow in a circle, and tell them to imagine they are sand grains.

2) Instruct students to step forward and each grasp two hands, of two different people, with their hands. Once they have all completed this step, tell them to imagine that they have now hardened into sandstone.

3) Guide students in untying the knot they have made without letting go of each other's hands. This involves climbing between arms, stretching in unusual ways, and laughter. As they begin to untie, orally create the image of rain, frost wedging, and erosion of the sandstone.

4) Once they are standing in a circle, hand in hand, have them drop hands and become individual sand grains again.

An outdoor education instructor discusses faults near the Moab Fault in Bloody Mary Wash

STATION #1

Fossil Frolic

Objectives

Students will be able to:

a. Name three types of marine fossils.

b. Describe the environment in which the limestone was deposited.

Materials

Fossils; fossil field guides; *What was it like here 300 million years ago?* poster (enlarged illustration from Rhodes, Zim, and Shaffer 1962, 42).

PROCEDURE

1) Show students the poster of the ancient marine environment, and explain that this is what it looked like here 300 million years ago. Briefly explain that environmental conditions change slowly through time, partly because of plate tectonics. Tell the students that this spot was near the equator and that the sea here was shallow, allowing sunlight to reach the bottom and supporting lots of creatures. Discuss how remains of sea life were turned into fossils and the length of this process.

2) Show examples of fossils. When applicable, have students find the creature in the poster that corresponds to each fossil. Briefly discuss each fossil creature, disclosing how the creature lived or how to recognize the fossil. For example, explain that crinoids were animals rooted on the ocean bottom and were filter feeders. (Have students suck air in between clenched teeth.)

3) Save much of the time in this station for finding fossils. Give boundaries, and reinforce that students may look at and show others fossils that they find, but they are not to take any. Be sure to bring reference books with you, and have an idea of what you'll be finding. Guide students to some rich fossil areas to get them started in their search. Share their enthusiasm.

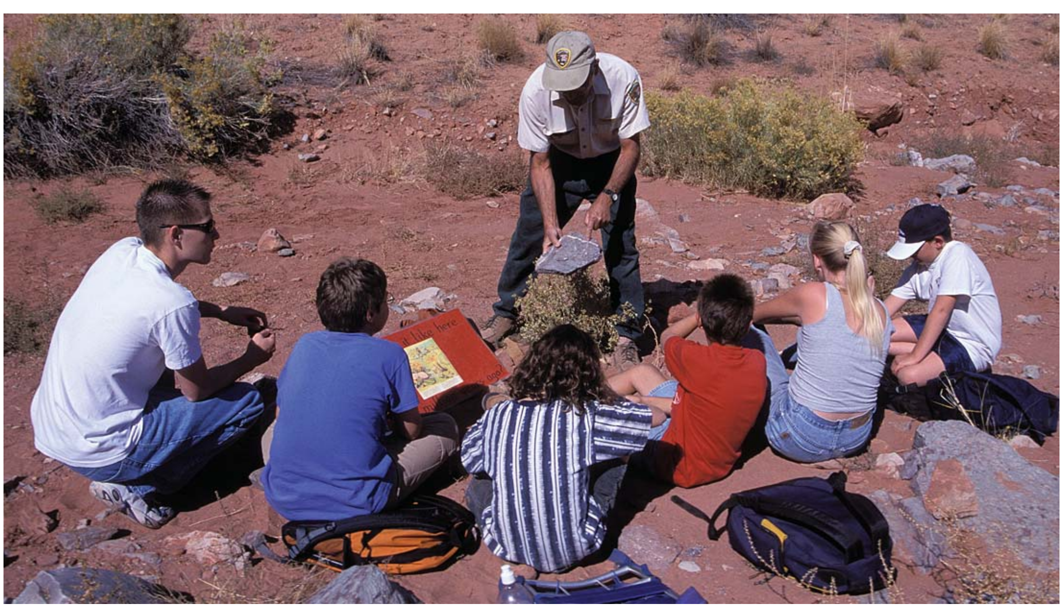
4) Gather students and have them stand in a circle for a game that strongly reinforces the names of the common fossils in the area. Have an example of each of these fossils for the "A What?" game. Direct the first round of the game. First show a brachiopod, for example, and hand it to a student to your right (student A) and say "This is a brachiopod." Instruct that student to ask "a what?" Respond, "a brachiopod." Then have student A pass the fossil to the student to her right (student B), saying, "This is a brachiopod." That student responds "a what?" and then student A turns to you and says "a what?" You respond "a brachiopod." The "a what?" question must always come back around to the person who first passed the fossil, and then the answer ("a brachiopod") must be passed all the way back to the student holding the fossil. Continue until the brachiopod comes all the way around the circle, and then start a different fossil. After two or three rounds, start two fossils at the same time, going in opposite directions around the circle.

EXTENSIONS

Have students name three kinds of fossil creatures and tell something about how each lived.

Have students describe the environment in which these creatures lived.

Studying fossils



STATION #2

Who's Fault Is It Anyway?

Objectives

Students will be able to:

a. Define a geologic fault.

b. Describe how the rock layers moved along the Moab fault.

Materials

Fault definition cards, fault cross-section, plastic knives, clay, cardboard bases for clay work

PROCEDURE

1) Hand out a fault definition card to each student. Have students take turns reading their definitions. Ask which definition they think we'll be exploring in this station. Ask students if they have ever experienced an earthquake. Have students tell the others what the earthquake was like. Tell the students that an earthquake is what we feel when rocks move along a fault. Explain that the more the rocks move, the bigger the earthquake. Use your hands to demonstrate this concept. Discuss and/or demonstrate the different types of earthquakes.

2) Walk students over to the fault area. Have them put their faces against the fault. Is the rock cold or hot? Have them step back and describe the rock. Point out the *slickenside* scratches on the rock, explaining that these resulted from rocks moving past each other along the fault. To demonstrate the rocks' movement, have students put their hands together and move one side past the other. This is the action of a fault. Show the students this action with the tri-colored card.

3) Seat students in limestone amphitheater. Tell students that they will be making their own rock layers out of clay and then faulting them. Distribute cardboard workboards and one color of clay at a time. Tell the students to flatten each piece of clay into a pancake shape and place each flat layer on top of another. After the students have made at least two or three layers, have them cut the layers at a steep angle to form a fault plane.

4) Ask the students to bring their clay and stand with one shoulder to the fault. Have students move their rock layers so the one closest to the fault goes up, just like in the real rock. Then, tell the students to move the clay so that the rock layers move past each other along the fault. Be sure to make appropriate rock crushing noises! Remove the top layer on the uphill side of the clay faults to simulate how the upper layers have been eroded away. Discuss how their models are similar to what actually happened along the Moab Fault, but on a much faster time scale.

EXTENSION

Assign students to research and make models of different types of geologic faults.

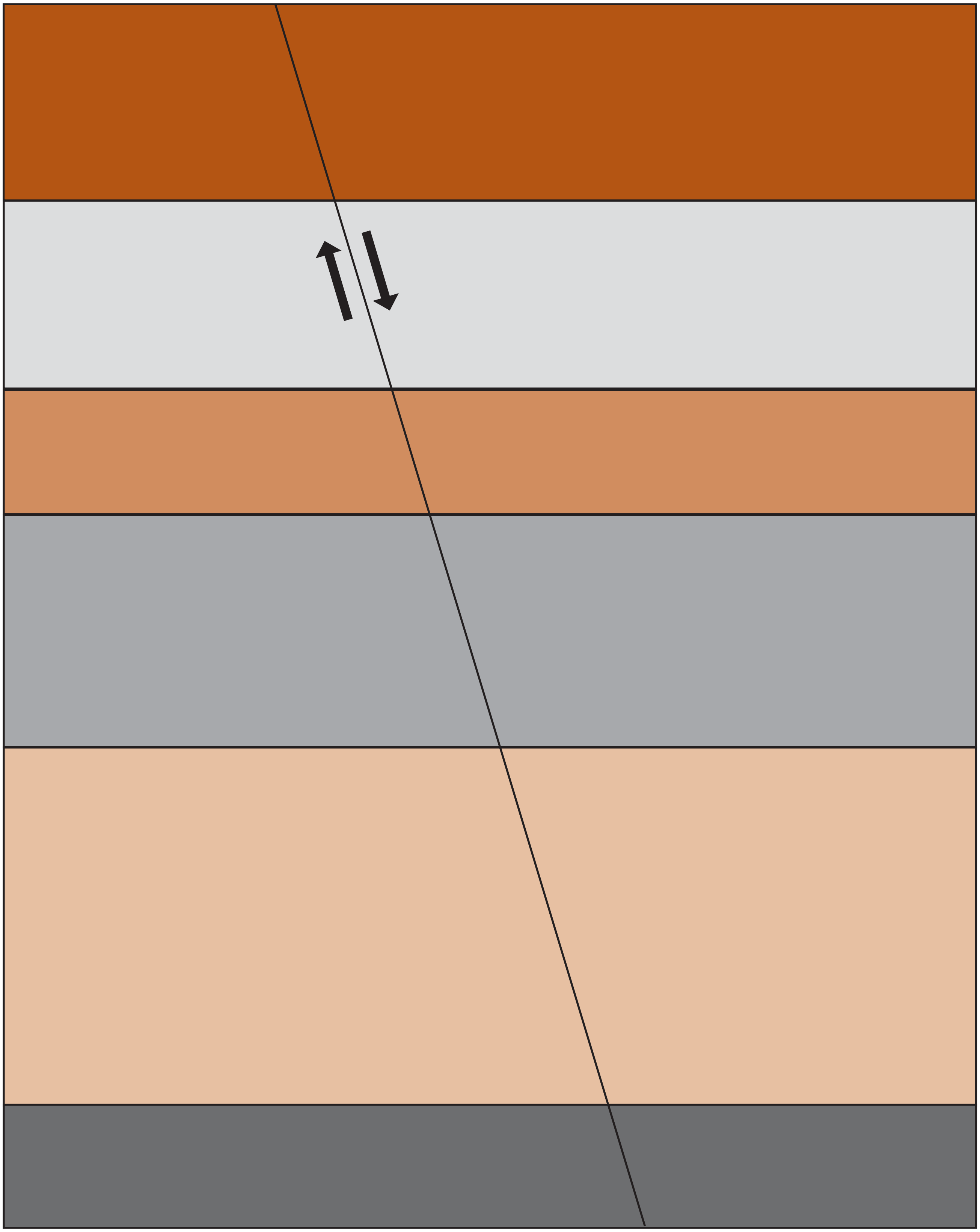
Insert fault definition cards and fault cross section from current guide

FAULT DEFINITION CARDS

Fault: Responsibility for something wrong	**Fault:** A mistake or small violation
Fault: A bad service, as in tennis	**Fault:** A break in rocks along which the rocks have moved.

FAULT CROSS-SECTION

Print on tagboard or glue printed paper to cardboard, then cut out block and cut block into two pieces along the diagonal fault line.



STATION #3

Falling Arches

Objectives
Students will be able to:
a. Name three types of arches.
b. Describe two weathering processes involved in arch formation.

Materials
Deep tray of moist sand; *types of arches* poster; drawings or photographs of specific arches; paper, pencils and clipboards; cardboard strips (for relay) with names of three types of arches

PROCEDURE

1) In the Arches Visitor Center, review the rock cycle, making sure the students know that the rocks in Arches are all sedimentary rocks. Introduce arches as the subject of this station. Inform students that there are over 2,000 named arches in the park. Review the size definition of an arch. Using the displays, show students that most arches in the park are in the sandstone layer called the Entrada Formation. Go over the processes involved in arch formation, including chemical weathering by rainwater, frost wedging, gravity, and wind. Emphasize that water is the main factor in arch formation. Contrast arches with natural bridges.

2) Outside, use the bucket of sand to demonstrate the creation of an arch. Introduce three types of arches, showing the *Types of Arches* poster and modeling them in the sand. Ask students the names of any arches they've seen, and see if they can figure out which types of arches they were.

3) Have each student choose one of the cards with drawings or photographs of named arches, read the arch name, show the card to the group, explain why they think that arch was given its name, and place the card by the correct type of arch on the *Types of Arches* poster. Hand out paper, pencil, and clipboard to each student. Have each student draw an imaginary arch, name it, write what type of arch it is, and present it to the group.

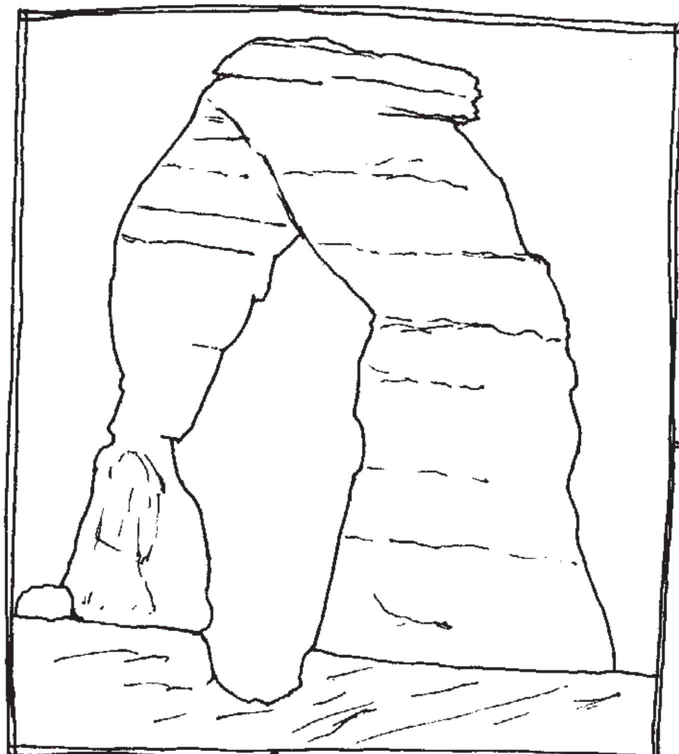
4) Choose one of the following review activities:

a. Human Arches: Keeping the *Types of Arches* poster visible, divide the group into pairs and whisper an arch type to each pair. Instruct pairs to create their arch type with their bodies, joining hands, kneeling, or whatever works! Have each pair show their arch while the rest of the group guesses which type it is. If time allows, have the group work together to make one last human arch.

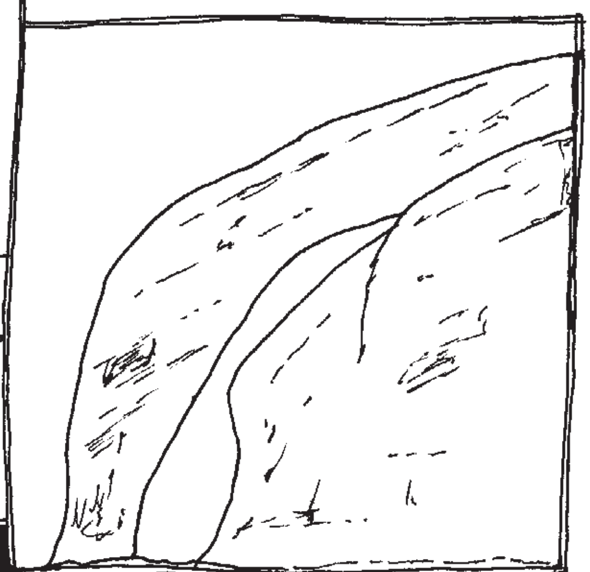
b. Arch-Type Relay: Divide the group into two teams, in two lines. Show a picture of an arch and read its name. Then, say, "go!" Instruct the first person in each line to run to a pile of cards, each with one of the three arch-types printed on it. The goal is to pick up a correct card and run back to their team members. The first runner back gets a point for their team, if they have a correct card. If not, the other team has a chance to get a point, if they have a correct card. Play until time runs out or the students are exhausted.

One student's imaginary arch

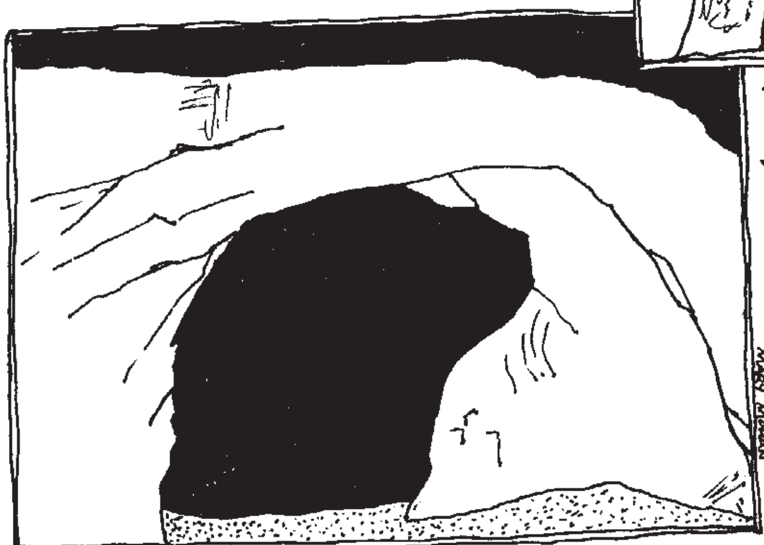
Types of Arches



Free Standing



Jug Handle



Cliff Wall

STATION #4
Picture This

Objectives
Students will be able to:
a. List three of the rock layers in Arches National Park.
b. Describe three environments in which the rock layers were deposited.

Materials
Rock layers and environments of deposition poster; pictures of environments: *Ocean, Tidal Flats, Stream, Sand Dunes*; laminated formation names; rock samples

PROCEDURE

1) Point out the distinct, relatively flat layers of the surrounding rocks, correlating the different layers with the *Rock Layers-Environment* poster. Use food analogies for the different layers, such as Navajo whipped cream and Entrada cherries for the sandstone east of the Visitor Center or a few chunks of Kayenta peanut brittle atop the Wingate cliffs on the western skyline.

2) Have students line up from oldest to youngest. Discuss the concept that each of the rock layers began as sediments deposited in different environments. Using the poster, hand a formation name to the corresponding student in the lineup, pointing out the layer and its look and discussing the environment in which it was created. Hand out pictures of the environments in which the layers were created to the corresponding students as well. Have each student introduce her layer and tell what environment created it. If students are having difficulty, leave the poster within site. Emphasize the huge amounts of geologic time involved.

3) Hand rock samples to corresponding students, and reinforce the understanding of superposition by having students attempt to stack their rocks, with the oldest formation on the bottom and the youngest on the top. Have students see how high they can stack their rocks, without touching any of the ones underneath, before they fall. To review, again ask each student what type of environment existed when his layer was deposited.

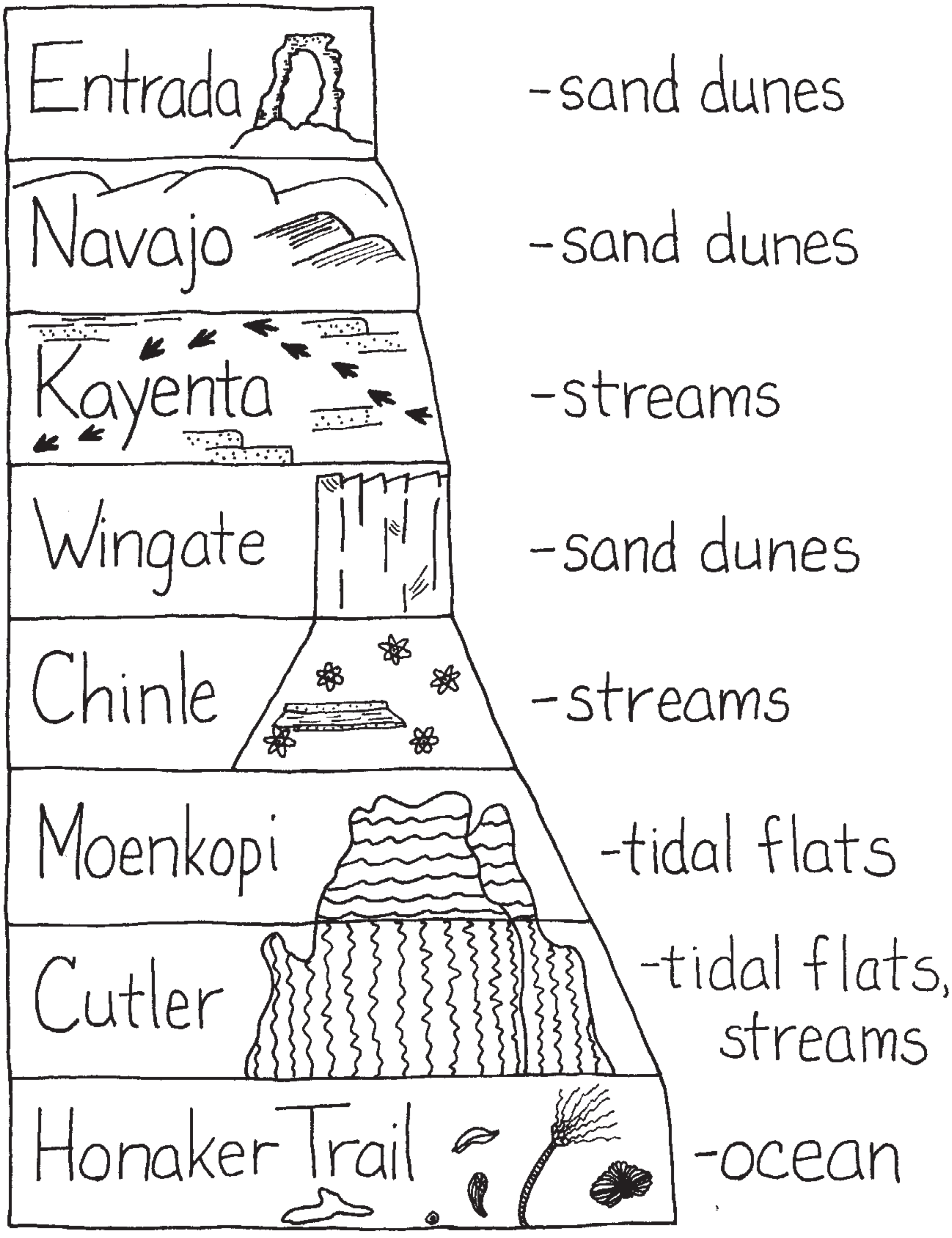
4) Reinforce these layers and their names with a relay. Place formation names 25-50 feet from a starting line, and have students line up in two teams. Instruct the two starting runners to retrieve the correct formation name based on a clue that you give. Instruct other students to help out by whispering (or shouting) the answer to their team runner. The first runner back with the correct formation wins a point for her team and goes to the back of the line. Vary the clues to relate to environment of deposition, what the layer looks like, or the layer's age relative to other layers.

EXTENSION

Have students draw a profile of the wall east of the visitor center, labeling the depositional environment of each layer: stream, sand dune, or tidal flat. (There are no layers representing ocean environments east of the Moab fault.)

The rock formation relay

Rock Layers and Environments



POST-TRIP ACTIVITY
Plates on the Go

(adapted from *Geology: The active earth*, 1988, 11-12.)

Objectives
Students will be able to:
a. Explain why earthquakes are most common along plate boundaries.
b. Explain how plate tectonics creates new igneous and metamorphic rocks.

Materials
Earthquake Data; laminated world map with latitude and longitude lines, cut into sections corresponding to the sets of data; erasable markers; cloth for erasing; masking tape; phone books; plate overlay transparency (enlarged from *Geology: The active earth*, 1988, 16).

PROCEDURE

1) Review the rock cycle, incorporating concepts and experiences from the field trip into the discussion. Comment that they learned about erosion and deposition of sedimentary rocks on the field trip, but in this activity they will learn about the forces in the earth that cause much of the pressure and melting that can lead to the formation of new igneous and metamorphic rocks. Tell the students that whereas they had previously been discussing changes in rocks that took place over long periods of time. Today they are going to discuss a very quick way the appearance of rocks can change.

2) Discuss earthquakes, incorporating what an earthquake is, how long earthquakes normally last, earthquake magnitude, and how scientists measure an earthquake's magnitude. Show the students pictures of a rictor scale recording earthquake data. Explain how a 5.5 quake is ten times more intense than a 4.5 quake. Be sure that students know that earthquakes are caused by the movement of rock along fractures, or faults, in the earth. Tell the students they will be mapping all the earthquakes of magnitude 6.6 or greater that occurred during 1997, 1998, and 1999, on a world map. Review longitude and latitude, and plot one or two earthquakes on the map to demonstrate. Inform students that you've divided the **Earthquake Data** and maps into seven sections, and divide them into seven groups. Give each group one map section, corresponding earthquake data, and a marker.

3) When groups finish, have them tape the map sections together in a visible place. Discuss the earthquake patterns, particularly the lines or curves that the earthquakes delineate. Review or introduce the layers of the earth. Discuss the lithosphere (crust) and plate tectonics. Demonstrate how thin the lithosphere is by telling them that if the earth was an apple, the lithosphere would be thinner than the apple's skin. Explain, however, that the Earth's crust is not solid like an apple's skin, but rather made up of lots of pieces that are constantly bumping into each other (like boats in a river).

4) Describe what happens to the rocks at the different types of plate boundaries, using phone books to illustrate, and relate the forces created to the forces that drive the rock cycle. Reiterate that almost all faulting and earthquakes are caused by the forces at plate boundaries, so that's also where almost all earthquakes occur. Tell the students that if we had plotted small earthquakes (in addition to the larger ones) and used a longer period of time (instead of only three years), we would have seen an even clearer outline of the plate boundaries. Tape the plate overlay over the plotted earthquakes. Ask the students why the two maps might correspond. Discuss where new metamorphic and igneous rocks might be created on the map.

EARTHQUAKE DATA (1997-1999)

From National Earthquake Information Center

DATA SET 1

0-5S, 0-14N; 100-180E

Latitude	Longitude
8N	128E
4S	144E
1N	123E
5S	148E
4S	129E
5S	152E
3S	142E
3S	139E
5N	127E
1N	126E
2S	125E
1N	126E
4S	153E
5N	122E
5S	151E
4S	152E
5S	153E
0	120E

DATA SET 2

16-90S; 0-99E, 0-179W

Latitude	Longitude
22S	66W
43S	43E
32S	179W
36S	108W
30S	72W
42S	80E
29S	178W
22S	177W
31S	71W
31S	71W
16S	179W
16S	179W
24S	70W
18S	179W
40S	75W
22S	179W
18S	65W
30S	179W
29S	71W
22S	176W
21S	176W
30S	178W
19S	69W

DATA SET 3

6-90S; 100-180E

Latitude	Longitude
6S	147E
13S	167E
20S	169E
32S	179E
16S	124E
27S	178E
15S	167E
22S	171E
50S	163E
63S	150E
11S	166E
8S	112E
7S	129E
7S	129E
13S	167E
6S	150E
6S	149E
6S	149E
16S	168E
7S	106E
11S	165E

DATA SET 4

15-90N; 0-49E, 0-179W

Latitude	Longitude
18N	103W
19N	107W
51N	179W
16N	98W
36N	22E
38N	21E
53N	34W
80N	2E
37N	35E
39N	29W
53N	169W
52N	178W
18N	97W
16N	88W
41N	30E
16N	97W
35N	116W
41N	31E
57N	154W

DATA SET 5

0-15S, 0-14N; 0-99E, 0-179W

Latitude	Longitude
11N	61W
11N	63W
15S	179W
15S	176W
4N	76W
4S	77W
14S	69W
14N	91W
1S	99E
8S	74W
12S	68E
1S	80W
12N	88W
15S	179W
6N	83W
9N	84W
1S	89E

DATA SET 6

15-90N; 50-135E

Latitude	Longitude
38N	57E
30N	68E
34N	60E
35N	87E
30N	58E
22N	125E
37N	70E
23N	126E
28N	57E
31N	79E
44N	130E
24N	121E
16N	120E

DATA SET 7

15-90N; 135-180E

Latitude	Longitude
44N	149E
51N	179E
55N	162E
54N	162E
54N	162E
52N	179E
24N	142E
53N	160E
29N	139E
52N	159E

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