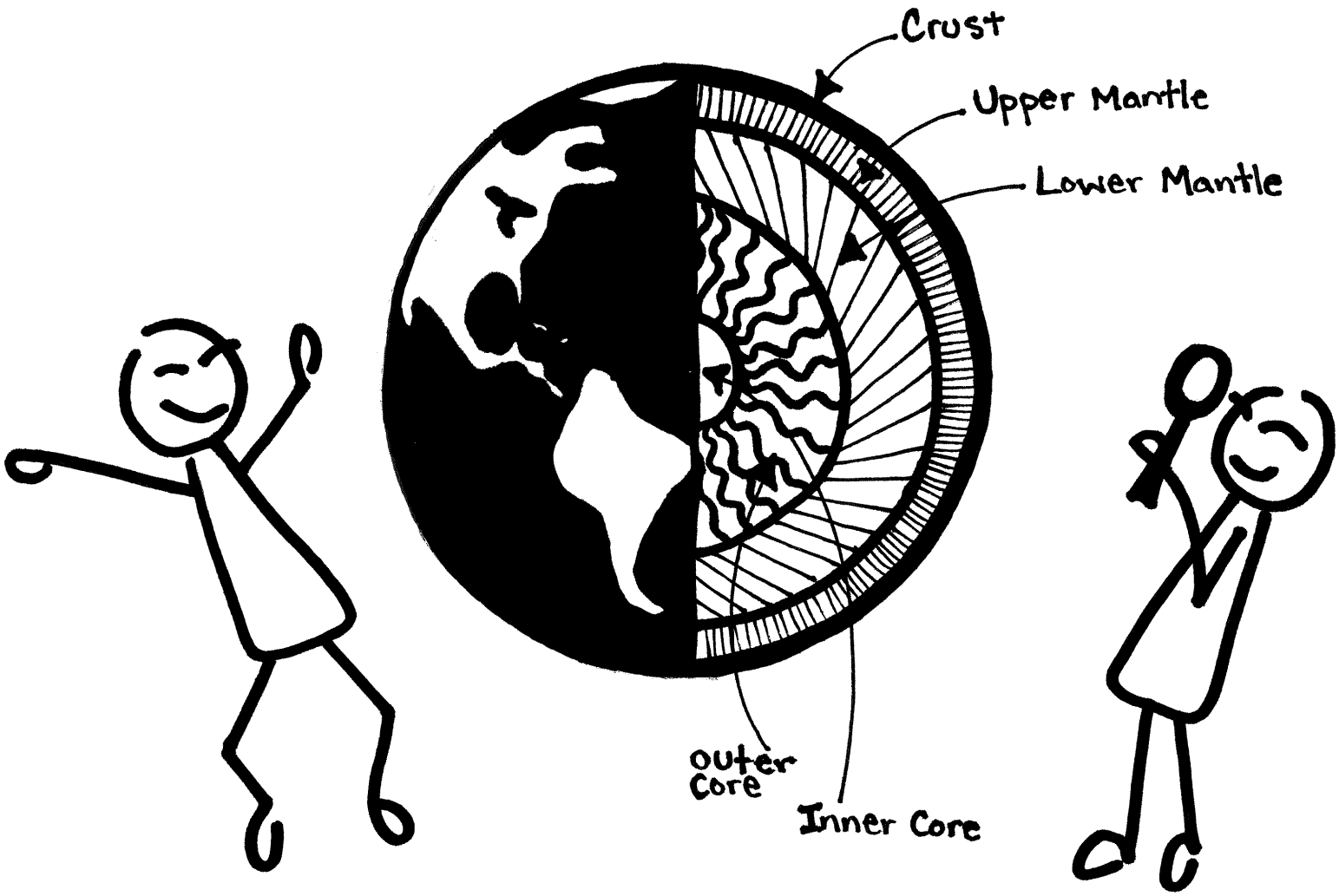
Rock Your World



Rock Your World Unit

Contents:

OBJECTIVES:

The student shall learn:

The basics of geology, including the three main types of rock, the rock cycle, weathering, erosion, and deposition.

To understand and appreciate humans' dependence and impact on the earth's rocks and minerals.

MAJOR CONCEPTS:

~ Igneous (extrusive and intrusive), metamorphic, and sedimentary rocks
~ The rock cycle
~ Weathering, erosion, and deposition
~ Mass wasting
~ Landforms
~ Movement of tectonic plates
~ Soil composition and importance

MATERIALS NEEDED:

~ Raised relief maps of California
~ Writing boards
~ Pencils
~ Magnifying glasses
~ Magnets
~ pH test tape
~ Soil Observations worksheets
~ Rock hammers
~Safety goggles
~ Rock viewers

Located at mass wasting site:

~ Rock cycle poster
~ Rock kit
~ Sedimentators
~ Mohs Hardness Scale Guide

SUPPLEMENTAL RESOURCES AVAILABLE:

Bartholomew, Rolland B., Earth Science: Teacher's Edition, 1984
Busch, Richard M. ed, Laboratory Manual in Physical Geology, 1990
Chesterman, Charles W., The Audobon Society Field Guide to North American Rocks and Minerals, 1978
Heller, Robert L. ed., Geology and Earth Sciences Sourcebook, 1962

Rock Your World - Introduction

Rocks and minerals play an important role in our everyday lives. We use them, not only in landscaping and construction, but as a part of our diets and things we use everyday. To us, the earth can often seem to us to be static and unchanging, but in reality it has always been and will always continue to be dynamic, undergoing processes that change the way land looks and behaves.

Geology is a science that deals with the history of the earth and its life, especially as recorded in rocks. In this unit, students will learn about how the land around them (both at Calvin Crest and at home) was formed. They will see evidence of slow geological processes and changes to the earth that happened more quickly. They will make observations about landforms, rocks, and soil around them and relate those observations to the rock cycle.

Students will learn about weathering, erosion, deposition, and the differences between the three main types of rock (igneous, sedimentary, and metamorphic). They will learn how these rocks and processes are all part of the rock cycle.

Finally, students will have a chance to see Nelder Creek and Gethsemane Falls - a waterfall that has been around for quite some time. They will be able to see ample evidence of the processes of weathering, erosion, and deposition. They will have the chance to break rocks open and discover what is inside.

Rock Your World - Lesson Plan

Activity #1: Mountains and Landforms

Activity Overview

In this activity, students will learn about plate tectonics and other processes that formed and changed the land around them. They will examine raised relief maps of California and discuss the differences between different parts of the state and reasons for those differences.

Focus Questions

1. What is geology?
2. How are mountains and valleys formed?
3. How does weather impact land formation and change?

Main Ideas

1. Geology is a science that deals with the history of the earth and its life, especially as recorded in rocks.
2. The earth is composed of interior layers and large, interlocking plates (called “tectonic plates”) that move slowly and cause the formation of mountains, earthquakes, and volcanic activity.
3. Weathering, erosion, and deposition have a deep impact on landforms and are constantly changing the way the land around us looks.
4. Igneous rocks are one type of rock in the rock cycle, formed when magma cools.

Lesson Organizer

Objectives

By the end of this activity, students should be able to:

1. Explain what geology is and why it is an important field of study.
2. Explain the theory of plate tectonics and how it relates to landforms, earthquakes, and volcanic activity.
3. Identify geologically significant areas in California.
4. Describe the difference between intrusive and extrusive igneous rock.

Materials

Raised relief maps of California (Please make sure students handle maps carefully.)

Time Required
20-25 Minutes

Location
On the back deck of the Dining Hall. (Inside the Dining Hall in wet weather.)

Terms
Geology: a science that deals with the history of the earth and its life, especially as recorded in rocks.
Geologist: a person who studies the history of earth.
Landforms: features of the earth's surface such as mountains, valleys, plains, plateaus.
Topography: shape, configuration of the land.
Lithosphere: "cold," thin brittle crust of the earth.
Mantle: hot, soft, flexible, layer of the earth; convects heat.
Core: hot, dense, central metallic center of the earth.
Weathering: the breaking down of rock into smaller pieces by natural processes.
Erosion: the process by which materials are carried away and redeposited by gravity, water, wind, or ice.
Deposition: the process by which materials are redeposited in a new location.
Sediments: materials that have been weathered away and are carried away in the process of erosion.
Magma: rock which is melted or molten due to extreme heat and pressure.
Igneous Rock: rock formed from the cooling and solidification of molten earth materials.
Extrusive: rock that comes out (erupts) and quickly cools on surface (volcanic - e.g. lava, obsidian, pumice, volcanic ash).
Intrusive: rock that cools very slowly underground, below surface (e.g. granite).

What to Do

Geology

1. Tell students the title of the class, ask what they think the class will be about.
2. Ask for a definition of the word "**geology**": a science that deals with the history of the earth and its life, especially as recorded in rocks. (Have them repeat the definition.) Geo - [earth, ground] + logy - [science, study of]
3. A **geologist** is a person who studies the history of earth in this manner. Students will become geologists for this course. ***Optional: As new terms are being introduced and used during the course, give different students the vocabulary cards

with the terms on them. The student with each card/term will be responsible for giving its definition at the end of the class review.***

4. Ask students to describe how the shape of the land (**landform**) looks different here from how it looks where they live. (Mountainous, steep slopes, with deep, narrow valleys here as opposed to the relatively flat land in the Central Valley.)

a. Have students offer reasons that might answer the following questions:

1. Why are the landforms so different?
2. What causes mountains to form?
3. What causes valleys to form between mountains?
4. Why is the Central Valley so flat, particularly compared to mountain valleys?
5. How does the shape of land change over time?

b. Explain that this class will explore the causes of change to the earth's surface, and look at evidence that shows how the land changes over time. We will also look at how the **topography** (shape, configuration of the land) influences the distribution of both natural and human communities.

Plate Tectonics

5. Describe the interior layers of the earth:

A. **Lithosphere**: "cold," thin brittle crust.
B. **Mantle**: hot, soft, flexible, convects heat.
C. **Core**: hot, dense, central metallic center.

a. Explain that heat, pressure, and movement in the mantle impacts the crust (lithosphere). Tectonic plates the size of oceans and continents move on the surface at a rate of centimeters per year in response to movements in the mantle. Earth's surface may seem solid, but it is made up of many individual interlocking plates (much like a cracked hard-boiled egg).

b. Show on the map of the world how different continents could fit together. What clues did you use? Explain that the surface of the earth (crust/ lithosphere) gives evidence of tectonic plate movement. Identify the "Ring of Fire". Either have a student show where it is or do so yourself. The Ring of Fire goes along the western edge of North and South America, across the Pacific Ocean, along the eastern edge of Australia and Asia. The Ring of Fire forms the fractured, faulted boundary of the Pacific Plate. Many earthquakes, volcanoes, and mountains are formed along the boundaries of lithospheric/ tectonic plates due to the forces of heat and pressure (compression, tension, stress) in the mantle below.

Landforms and Topography

6. Divide students into groups and give each group a raised relief map of California.

A. Have students locate the Sierra Nevada, Coast Range, Central Valley, Pacific Ocean. Show Calvin Crest's location, and the location of your school.

B. Explain that as we look at the raised relief map we are looking at the landforms that make up California.

Landforms include all terrain features such as mountains and valleys.

a. Mountains are formed by uplifting and tilting brought about by movement/collision of continental and oceanic plates (plate tectonics), earthquakes, volcanic activity. Mountains are worn down by chemical and physical **weathering** (the breaking down of rock into smaller pieces by natural processes).

b. Valleys can be created in a variety of ways, including: being formed by the work of rivers and glaciers and as sedimentary deposits. Valleys between mountains are created as water and gravity break down and carry away weathered rock.

c. Topography (landforms) is reshaped by weathering of rock and soil and by transportation (**erosion**) and **deposition** of **sediments**.

d. Landforms affect the distribution of terrestrial and freshwater ecosystems and natural resources. Additionally, they affect humans and their communities.

C. Explain that erosion from the Sierra Nevada and Coast Range has deposited sediments in the Central Valley - *that is why the valley is so flat*. Note the uniformity of the valley from south of Bakersfield to north of Redding, a distance of 400 miles. Generally, only the finest sands, silts, salts, and clays have been deposited over the entire valley. Only the smallest, lightest particles stay suspended in water over the great distances from high in the Sierra down to the Central Valley. This accounts for the rich agricultural soils of the valley made up of sands, clays, silts, and minerals from the surrounding mountains. Heavier rocks and boulders settle out on stream bottoms in the mountains. As they continue to be weathered and eroded, the much smaller sediments generated are carried away. The raised relief map shows how weathering and erosion has created the extensive mountain canyons and valleys as sediments are carried away and the water carves ever deeper into the surface over which it flows. Have

students observe the western slope of the Sierra on the maps to see those canyons shaped by the geologic forces of nature.

D. Show how the Central Valley used to be an inland sea, surrounded by mountains.
    a. Imagine that the valley was a large bathtub. Where is the drain? (The narrow channel of the Sacramento River where it empties into the San Pablo and San Francisco Bays).
    b. Now imagine this bathtub is full of water and that you are going to use wheelbarrows full of dirt to "fill the tub." As the tub is slowly filled with dirt the water is gradually displaced until the only water that remains is that which was trapped and absorbed by the dirt (or that which now flows over the hard-packed surface). That is what happened to form the soils of the Central Valley. It is this trapped water, water transported by canals from dammed reservoirs in the foothills, and water flowing underground from the Sierra that serves the needs of people who live and work in the Central Valley.
E. Have students locate the major metropolitan areas of California. Pose the question, "Based on the map's features, why do people live and work where they do?" (Most of California's 35+ million residents live either on, or near the coast, or in the Central Valley. Most larger towns and cities are located along some waterway, whether it be coastal or fresh water, as water is essential for life, for agriculture, for manufacturing. The landforms affect climate, availability of natural resources, ease of transportation, communication, and trade. As our population has grown and demands for resources has increased, we have spread out over greater and greater areas, and have had increased impact on the natural resources we depend upon.)

Rain Shadow Effect

F. Explain that the Sierra Nevada forms a barrier for clouds moving east from the Pacific Ocean. Water is heavy (over 8 pounds/gallon). The first barrier storms must cross in California is the Coast Range. As low clouds stack up against the Coast Range, they need to lose weight to get over the top. That is why the west slope of the Coast Range often has high annual precipitation rates. Many areas receive over 40" of rain annually, particularly in Northern California. The high levels of moisture are essential for the Coastal Redwoods that grow from the Santa Cruz area up to the Oregon border. Precipitation levels fall as you travel further south,

however, the climate is still very favorable for people to live as is evidenced by the huge population of Southern California.

As clouds pass over the Coast Range barrier there is little need to lose more weight on the eastern downslope so very little rainfall occurs. As a result the native vegetation consists of grasses and wildflowers with few trees. Human population density is low along the east slope of the Coast Range due to limited water resources and less favorable soil and climate conditions.

There is little to impede clouds' progress across the Central Valley and annual precipitation ranges from 6" - 15". The flat, fertile soils of the Central Valley are some of the richest in the world, but naturally dry out in summer heat. However, man has figured out how to manipulate the environment so that water can be pumped, stored, piped, channeled to locations where it is required. The entire valley has been turned into productive agricultural land by design and manipulation. California's Central Valley provides agricultural products to our entire country, as well as to nations around the world. Such productivity has a cost, however. Heavy use of fertilizers and chemicals, as well as pollution from industrial, transportation, and urban living have contaminated our soils, water, and air - impacting people, plants, and animals in numerous, and serious ways. The mountains surrounding the Central Valley not only funnel water, soils, and minerals into the valley - they also serve as barriers that trap pollution in the valley. The Central Valley has some of the worst air quality levels in our country. One of the evidences of this is seen in the increasing numbers of individuals living in the valley who are suffering from air quality-induced asthma.

The clouds that passed over the valley without dumping much precipitation now come up against the huge barrier of the Sierra Nevada. Whereas much of the Coast Range is lower than 4,000 feet elevation, a great deal of the Sierra is over 7,000' - much of the Southern Sierra crest is over 10,000'. The clouds have to lose a lot of weight to get over this huge barrier. That is why so much rain and snow fall in the Sierra. Many areas receive 40"-60" precipitation annually. This large amount of water enables the west slope of the Sierra to have extensive forests, and a great deal of water ultimately becomes available to the Central Valley. Have

students look at the raised relief maps to see where that water ends up. What evidence is on the map to indicate where the water goes? (The deep canyons of the Sierra shows the impact of large quantities of water weathering and eroding the mountain range. The flat Central Valley shows where the sediments ended up.)

The Sierra Nevada's size, location, and north-south orientation are the reasons why the lands east of the Sierra are so dry (rain shadow effect). This mountain range impacts the amount of precipitation in Nevada, Utah, Arizona, and New Mexico. The lack of available water in those areas greatly impacts the size of human populations in those states, as well as the availability of natural resources associated with available water. Those states are characterized by largely arid regions whose chief natural resources used by people are tied to mining and ranching.

Major Geological Features

E. The raised relief maps also show evidence of plate tectonic movement characteristic of the "Ring of Fire." It is helpful to use the maps to point out 4 major features:
    1. San Andreas Fault along the western edge of California (south of Los Angeles - to north of San Francisco. Especially evident through Cholame, Temblor Range, Carrizo Plains), an area associated with some of largest, most devastating earthquakes in America.
    2. North-South orientation of Sierra Nevada, Coast Range tied to Pacific Plate subducting North American Plate which caused folding fault-block mountain ranges to form.
    3. North-South orientation of mountain ranges in Nevada showing similar impacts of plate tectonics.
    4. Mt. Shasta, Mt. Lassen in Northern California - large volcanoes indicative of plate tectonic activity. Long Valley caldera - site of one of largest volcanic eruptions in world history [maybe 10,000 years ago], located just south of Mono Lake (on map follow San Joaquin River northeast from Fresno, go just over Sierra Nevada crest). The small mountain range separating Long Valley caldera from Mono Lake is called Mono Craters and is the youngest volcanic range in North America).

Fresno Dome: Igneous Rock, Weathering

7. Walk to the area just below the dining hall where a small (2'-3' tall) granite rock is located between the walkways.

8. Have students examine the rock in front of you. Note the overall shape, the texture, the joints and cracks, and the color. Explain that the rock is **granite**, the most abundant rock of the Sierra Nevada.

9. Have students look at Fresno Dome, the large dome to the east of Calvin Crest - visible from the hillside below the deck. It, too, is formed of granite. Ask what is different about Fresno Dome from the hillside the dining hall is on.

1. Fresno Dome is solid rock, while the hillside is covered mostly by dirt with few visible rocks.

2. There is little evidence of plant life on the Fresno Dome, but much plant life on the hillside.

3. The rock of Fresno Dome is hard and does not absorb much moisture, while the ground on the hillside is not solid, absorbs moisture, and is also more easily affected by weathering and erosion.

10. Ask students how the dome got there. After hearing answers/discussion, explain that it was formed underground, and then exposed by weathering and erosion. Here, we will deal with dome formation. At the mass wasting site, we'll deal more with weathering and erosion.

11. Point out the following information:

Domes are formed from **igneous** rock. Igneous rock is formed when **magma** (rock which is melted or molten due to extreme heat and pressure) cools down to become solid. [Igneous: relating to, resembling fire: (e.g. ignite, ignition).]

There are two types of igneous rock:

Extrusive: comes out (erupts) and quickly cools on surface (volcanic - e.g. lava, obsidian, pumice, volcanic ash)

Intrusive: rock cools very slowly underground, below surface (e.g. granite). Intrusive rock becomes visible due to surface above being weathered and eroded away. As large pockets of magma intrude into the earth's crust from below, they can push up the rock and soil above. The magma slowly cools underground to become granite masses. As weathering and erosion occur over time, those masses become exposed as the covering of rock and soil are removed. The exposed granite may appear as a dome.

12. Optional: Demonstrate how domes become visible:

A. Have student volunteers scoop up handfuls of dirt to cover a small rock.
B. Have other volunteers slowly pour water over the dirt-covered rock, gradually exposing the rock. This simplistically shows how water weathers and erodes softer materials more easily than hard rock, thus exposing domes over a long period of time.

13. Once the demonstration is completed hike down around the edge of the lake and along the Rock Your World trail to the mass wasting site. See map for details.

Activity# 2: Mass Wasting, Weathering, Erosion, and Deposition

Activity Overview

In this activity, students will learn about the effects of weathering, erosion, and deposition. They will observe these effects at a mass wasting site. They will also learn about the rate of erosion, types of rock, and the rock cycle.

Focus Questions

1. What causes mass wasting?
2. What are weathering, erosion, and deposition? How are they related?
3. How does the rate of erosion factor into stream composition?
4. What are the three types of rock in the rock cycle?
5. How does the rock cycle work?

Main Ideas

1. "Mass wasting" is the term that describes what happens when an area becomes so heavily saturated with water that the force of gravity causes a large amount of material to wash away.
2. Weathering, erosion, and deposition are all processes that involve rocks and rock pieces (sediments.) They are the processes responsible for much of the change and creation of landforms on Earth.
3. There are different factors that may change how slowly or quickly erosion happens. The size of the particles being eroded will impact the way a stream settles.
4. Igneous, sedimentary, and metamorphic rocks are the three major types of rocks. All rocks are part of the rock cycle and are constantly (but slowly) changing from one form to another by way of weathering, heat, and/or pressure.

Lesson Organizer

Objectives

By the end of this activity, students should be able to:

1. Describe weathering, erosion, and deposition
2. Explain how the mass wasting site came to be.
3. Discuss factors that may affect the rate of erosion.
4. Name the three types of rock in the rock cycle.
5. Describe how each of the rocks in the rock cycle is formed, and how they are related to one another.
6. Understand one way that human activities can impact the environment.

Materials (Stored at Mass Wasting Site)

Sedimentators
Rock Kit
Mohs Hardness Scale Guide
Rock Cycle Poster

Time Required

35-40 Minutes (Split between 3 separate stops)

Location

Mass wasting site (On Rock Your World trail, downhill from dam)

Terms

Bedrock: the solid rock forming the bed/base beneath soil.
Mass wasting: downhill movements of large amounts of materials on Earth's surface, due to gravity.
Igneous Rocks: rock formed from the cooling and solidification of molten earth materials.
Sedimentary Rock: rock formed as a result of weathering, erosion, and redepositing of loose earth materials. May be formed by compaction and cementation, or chemical processes.
Metamorphic Rock: rock formed from pre-existing rocks as a result of heat/pressure changes.

What to Do

1. Stop along rim of mass-wasting site, behind rope barrier, have students observe the mass-wasting site. **Emphasize safety - stay back from edge to avoid falls.**
    A. Ask students what caused the site to look the way it does. Discuss answers. (Water, gravity: both physical and chemical weathering).
    B. Ask for time estimates: how long did it take for this to occur?

100 years? 1,000 years? 10,000 years? A day? A week?, etc.

B. Ask students who gave time estimates why they think their answer was correct. What evidence do they see?

C. After the above discussion, explain that the beginning of this *dynamic* process of mass wasting took place during the winter of 2000-2001. We are unsure of whether it happened over a period of a day, or maybe a month, but do know that it happened during the time frame of November, 2000 - March, 2001. It continues today.

Mass Wasting Site Information:

1.First observed March 2001. Had not been observed fall of 2000.

2.When first seen, there was very little plant growth in bottom of site, and that which was visible was seen on small mounds of earth that appeared to have toppled into the bottom from above.

3.Most of the conifers that had toppled into the site were still alive (lots of green foliage) in March, but several showed signs of distress/were dying by summer 2001 (larger amounts of orange, brown needles not seen earlier).

4.In March, many roots were visible protruding from side walls. Roots were still flexible, moist - had not dried out, died yet.

5.Most of side walls were still very wet, sloughing off in March. Entire site had "newly changed" appearance.

*** Since the summer of 2001, changes have continued to occur. The banks continue to erode, slough off, collapse, and fall into the ravine. Several more trees have fallen into the ravine and have been removed by our staff. The waterfall is growing in height. ***

Chemical and physical weathering continue as a dynamic process changing the landscape before you.

2. Hike along the trail from rim to the footbridge leading to the other side of site. Stop at the footbridge to look down at water flowing under bridge, and note the bedrock granite beneath the bridge which forms the edge of small waterfall.

A. **This is an example of how human activities can influence the flow of rivers or streams, and impact the environment.** Human impacts can be beneficial in some ways and detrimental in others. Building dams can lessen the possibility of flooding and provide water and power resources. However, in this case, human practices (the building of the dam and diversion of water down this drainage ditch) were the direct

cause of this mass wasting site. Had the water not been diverted the landslide would not have occurred. (The water was diverted for ~35 years before landslide.)

A. Point out that water in the drainage ditch from dam had cut down to **bedrock** (the solid rock forming the bed/base beneath soil), penetrated the soil in the area that is now the mass-wasting site, saturated the site making the soil much heavier than before, and when the mass became too great, it washed away due to the force of gravity (**mass wasting**). Water running downhill is the dominant process in shaping the landscape.

3. Travel downhill to the mass wasting site storage cabinet. As the mass wasting site has limited space, you might choose to take half of the class into the mass wasting site at a time. If this is the case, leave a cabin leader at the top with half of the class to examine and explore the contents of the storage cabinet while you take the other half of the class into the mass wasting site. When you are finished with one half of the class, have the students trade places. You can choose to discuss the objects in the cabinet (such as the sedimentators, below) before or after all the students have had a chance to see the mass wasting site.

Sedimentators, Rock Cycle Poster, Rock Kit, Mohs Hardness Scale Guide

1. Give students the sedimentators (3-4 students/sedimentator).

A. Have them examine the sediments carefully, without disturbing/shaking the tubes.

B. Describe what's on bottom, in middle, on top, suspended in liquid. Are the sediments loosely, or tightly packed? This shows how sediments can form sedimentary rock.

C. Very slowly tip containers. What particles mix into the liquid first? Last? Why?

D. Shake tubes vigorously simulating movement in a stream, let particles settle, have students describe what they see happening in the tubes based on particle size. Which end up on the bottom? Which remain floating (suspended)? Why?

The same thing happens in real streams and rivers. Weathered (broken down) materials get transported to other places. This is called **erosion** (the process by which weathered particles are carried away and deposited in another location).

Another option for this demonstration is to save one sedimentator undisturbed, let students examine and discuss them, shake them up, etc. on their own first, and then discuss the layering evident in your undisturbed sedimentator.

2. Discuss factors that affect the rate of erosion:

A. Slope of the land. Steeper = faster; more level = slower

B. Barriers to movement (root systems, more level ground slow down erosion).

C. Strength of eroding force (high winds, large volumes of water accelerate erosion).

D. Size of weathered particles being transported.

Explain that you will soon observe this process in the natural environment.

3. Show students the Rock Cycle Poster.

A. Describe the three types of rock in the Rock Cycle:

1. **Igneous Rock**: rock formed from the cooling and solidification of molten earth materials.

2. **Sedimentary Rock**: rock formed as a result of weathering, erosion, and redepositing of loose earth materials. May be formed by compaction and cementation, or chemical processes.

3. **Metamorphic Rock**: rock formed from pre-existing rocks as a result of heat/pressure changes.

B. Get out the rock kit and have students examine the rocks in each of the three major classifications. Describe Mohs Hardness Scale and pass around the guide.

C. Describe the rock cycle process and how one rock can become a "new" rock by the processes of weathering, erosion and deposition and/or heat and pressure.

4. Please return all materials to the storage cabinet.

Mass Wasting Site Observations and Discussion

Carefully hike down the trail to the stairway and then down into the mass-wasting site. Have students gather in the center of the site. ****When conditions are wet and muddy, the trail into the mass wasting site may be very slippery. Encourage students to walk carefully, and, if necessary, have the following discussion without actually going into the mass wasting site.****

1. Point out the two side walls, and note which side has the most roots visible. Ask "Why?" (The left side [as you face upstream] has more roots because it has soil that extends to a greater depth. The right side does not have as many roots because granite formed a barrier preventing roots from reaching as deeply.
2. Observe plant life that is already growing in the newer "landscape." Minerals, nutrients from soil, water, and sunlight are available; there is little competition from other plants. These factors allow the plants to grow well.
3. Observe the stream of water flowing in the bottom of the site. Point out to students that this amount of flow (which does not change too radically from season to season) is responsible for this devastation/change. This is the same water that flowed under the footbridge they crossed when they first walked down the trail from the dam.
4. Explain that we're observing a *dynamic process***.** Water continues to weather rocks and soil at this site; the stream continues to erode/ transport sediments; sediments are

deposited, eroded, redeposited; the stream changes course in natural and recurring pattern.

5. Reintroduce the concept of **weathering** (discussed up at the Dining Hall when viewing Fresno Dome). Describe the two main types of weathering:
   A. **Physical**: materials are broken down into smaller fragments by physical forces such as water, wind, gravity, roots, ice - without changing their composition.
   B. **Chemical**: the minerals that make up rock undergo chemical changes. These changes weaken a rock's structure so that it's more easily weathered physically.
6. Observe the right side wall of the site. Note the granite slabs 2"-3" thick that are beneath the soil, but above the large mass of granite below. There are fragmented slabs in the bottom of the site as well. These are broken as a result of physical weathering.
7. Observe the grayish mass of granite in the wall below the slabs. This is "D.G." - decomposed granite. It is the product of chemical weathering and then physical weathering. Water has chemically reacted with the minerals in the granite to break it down making it possible to actually scratch the surface with your fingernails (physical weathering). Both processes are involved in a wearing down the surface of the earth.
8. Look at the stream again, and note the appearance of the stream bottom. Do so without disturbing the sediments in the bottom. Describe the processes of **erosion** (the process by which materials are carried away by gravity, water, wind, or ice.) and **deposition** (the process by which materials are redeposited in a new location.) This stream, like all others, is a dynamic system that weathers rocks, transports sediments, and changes course over time. If you were to observe this stream a year from now you would likely note changes in appearance.
9. Leave the mass wasting site and follow the trail markers a short distance to the intersection with the Survival trail. Turn left (uphill) and hike up to the trail intersection at the base of the dam. Turn right and travel along the trail across the base of the dam, up onto the dirt road

Activity #3: "Dirt Made My Lunch": Soil Observations

Activity Overview

In this activity, students will make observations about a small area of soil and make inferences about the area in response.

Focus Questions

1. What is soil?
2. What is the soil in this area like?

3. What kinds of tests can I do to learn about soil?
4. What does it mean that “Dirt Made My Lunch”?

Main Ideas

1. Soil is made up of sediments (particles of broken down rock) and organic matter (plant and animal materials).
2. The soil in this area contains iron, is composed of many different types of particles, and is acidic.
3. Plants grow in dirt, and the food humans eat is either composed of plants or animals that eat plants.

Lesson Organizer

Objectives

By the end of this activity, students should be able to:

1. Describe the soil that they observed, in detail.
2. Explain what different tests they performed on the soil and what they inferred.
2. Explain why “Dirt Made My Lunch”.

Materials

Writing boards
Pencils
Soil Observations worksheets (Appendix A)
Magnifying Glasses
Magnets
Water
pH testing tape

Time Required

15-20 Minutes

Location

The dirt road next to the dam, near the lake.

What to Do

1. Ask students to define “soil” - what is soil made of?
2. After volunteers give answers, make sure they understand that soil is made up of sediments (particles of broken down [weathered] rock) and organic matter (plant and

animal materials). It is the material that plants grow in - therefore "Dirt (Soil) Made My Lunch."

1. Divide the students into groups of 2-3. Allow the students to spread out and draw a circle (about 1' diameter) in the dirt road. (Make sure students stay close to you.)
2. Give each group a writing board, pencil, magnifying glass, and worksheet. Instruct them to answer the questions based on the soil in their square or circle.
3. When a group reaches the question where they need a magnet, give them a magnet and have them return it to you.
4. Don't give teams the pH paper until they have completed the other observations and recorded their data on the worksheet.
    A. Explain that **pH is measuring the acidity or alkalinity of the soil**. Most plants grow well when the pH is near neutral (7.0). The lower the number the more acidic the soil. The higher the number the more basic (alkaline) the soil. [Don't tell students this, but they will tend to find the soil in the range of 5.0 - 5.5. Pines and other conifers tend to help make the soil more acidic. Also, most of the rain and snow that falls in the Sierra Nevada is acidic (acid rain), due in part to air pollution.]
    B. To use the pH tape, tear off a 1" piece of the tape on the 0.0 - 6.0 side of the dispenser. Insert this piece of tape in the dampened soil and leave it for about 20 seconds. Remove the tape and compare the color to the color chart to determine the pH of the soil.
7. Bring groups back together and have volunteers discuss what they learned from their soil observations.
    A. Did they see both minerals (particles of rock) and organic (plant/animal) matter in their square? Why might that be important for plants?
    B. What kind of material is attracted by a magnet? (Iron). Do humans need iron in their diets? (Yes, ... have they heard of "iron rich blood"?) Many of the minerals and nutrients we need in our bodies are found in soil. It is important that dirt made our lunch!
8. Collect materials.

Go straight uphill and across the meadow towards the trail marker on the post out in the meadow. Travel across the meadow until the trail intersects another dirt road. At this point you will see a water container, paper cups, and a garbage bag. Allow students to get drinks of water here. With time permitting, review material covered in the first part of class. Please be sure all trash is put in the garbage bag!

Cross the road and proceed downhill along the "Gethsemane Trail." Follow trail markers and signs. You will go through a gate - please make sure the gate is closed when everyone has come through. About 100' after the gate, you will need to turn left. A short while down the trail on the right hand side is a small clearing next to the stream immediately adjacent to the trail.

Caution!! The rocks in and alongside the creek are always slippery. DO NOT LET STUDENTS GO INTO THE CREEK IN THE SPRING. The water is extremely cold, moving rapidly, and is dangerous. Even in the fall - BE CAREFUL!!! This is true for both Lesson #5 and Lesson #6.

Activity #4: "Current Events": Creek Bank Erosion

Activity Overview

In this activity, students will discuss the erosion of creek banks and the reason that streams and rivers wind back and forth.

Focus Questions

1. Why is the land around Nelder Creek shaped the way it is?
2. Why do streams and rivers wind back and forth?

Main Ideas

1. Water is the most powerful agent of erosion on earth.
2. When water moves through land, it changes the way it is shaped, both wearing it away and building it back up.
3. Faster water with a greater power of erosion is on the outside of a stream's bend. Particles settle more easily in slower water, so banks on the inside gradually get built up over time.
4. Heavier particles are usually carried shorter distances, while lighter particles can travel great distances.

Lesson Organizer

Objectives

By the end of this activity, students should be able to:

1. Describe how water can impact land as it flows through it.

2. Describe the difference between the inside and outside of a stream's bend, and why streams tend to flow that way.

Materials

None

Time Required

10 Minutes

Location

Small clearing next to Nelder Creek.

What to Do

1. Have students observe the terrain around them and Nelder Creek, flowing along the bottom of the stream valley you are in. Then ask the question, "Why is the land shaped like it is, and why is the creek in the bottom of this valley?"

Observations and discussion should bring out the following concepts:

A. The hillsides and stream/creek are shaped like they are largely because of water. Be sure students learn that water is by far the most powerful agent of erosion on Earth. It does more to reshape the earth's surface than all other agents of erosion combined.

B. Once precipitation (rain, snow, etc.) falls, the water can

1. Evaporate
2. Soak into the ground
3. Flow downhill on the surface as runoff. Gravity is the force that causes runoff.

C. As water moves downhill, it picks up particles of rock, sand, and soil. As water makes bigger and bigger channels (streams and rivers) gullies and valleys can develop.

D. Normally, roots of vegetation holds rocks and soil in place, but erosion can wear away material. The larger the volume of water, and the greater the amount of soil and rocks carried by the stream/river, the greater the amount of erosion that will take place.

E. The amount of rock and soil carried by water in a stream is called the stream's "load."

F. As the load increases, the creek bank experiences greater erosion and abrasion.

3. Have students walk to the rocky inside curve of the creek bank, being careful not to further erode the bank by standing too near the stream itself. Have them note the height of the opposite bank. At one time the creek ran at this level, but it has over time eroded deeper into the bottom of the stream valley - an ongoing process..
4. Have them examine the current "bends" in the creek, and note how erosion is wearing away the soil and rocks from the root systems of the trees along the bank. Eventually,

the trees standing where the creek turns sharply will most likely fall into the creek due to the creek's undercutting of the bank.

5. Have them observe where the creek seems to be deepest in the bend. Ask whether the water is deeper on the inside of the bend, or the outside of the bend. (Outside.)
   A. Ask why they think that is so. (Faster water and greater flow are always on the outside of the bend in a stream or river. Therefore, it has the greater power of erosion and is the principal cause of streams and rivers changing directions: continually wearing away banks and depositing materials.)
6. Have students observe the inside of the creek bend. Have them note that the slower water on the inside of the bend allows sediments to settle out on the bottom, thus building up the bank on the inside over time.
   A. Note the size of sediments in the creek ranging from very fine silt to large boulders. Silt being very light, can remain suspended in the water and carried great distances. Boulders being much larger and heavier, are moved along the creek bottom at a much slower rate, usually only moving during periods of extremely high runoff.
   B. It is the very fine silts and clays of the Sierra Nevada and Coast Range that have ended up in the Central Valley of California to make it a very large, very flat, very fertile valley. Those characteristics make it wonderful for agriculture, and for conditions that enable large number of people to live there.
   C. The conditions observed here are much more rocky than the Central Valley because the size of the rocks and boulders in the stream require much larger forces to move them.
7. Point out that all "new" rocks are made from "old" rock. Rocks change and are broken down by weathering, can be transported to new locations, be transformed by heat, pressure , and chemical changes into new forms, be worn down, transported to another location, and the process repeated again and again as part of the Rock Cycle. Rocks in this creek bottom may be igneous, metamorphic, or sedimentary, but all are undergoing weathering and erosion. Over time the particles will be reformed into "new" rocks.

When you leave this site, continue travel along the Gethsemane Trail to Gethsemane Falls. Have students pay attention to the creek and its characteristics as they hike the trail.

<u>CAUTION:</u> DO NOT LET STUDENTS GO INTO THE CREEK IN THE SPRING. The water is extremely cold, moves rapidly, and is dangerous. Students are often tempted and ask to climb the rock on either side of the waterfall. **DO NOT LET THEM CLIMB THE WATERFALL. IT IS EXTREMELY DANGEROUS AND SLIPPERY ALL YEAR.** Even in the fall, when water levels are lower, be careful. Allow students to explore the site, but be certain that you and your cabin leader monitor students carefully.

Activity #5: Waterfalls and Bedrock

Activity Overview
In this activity, students will be able to apply the concepts they have been learning as they enjoy and explore a waterfall. They will also have the opportunity to break rocks apart with a rock hammer and examine them with a lighted rock viewer.

Focus Questions
1. How can we see what we have learned at this waterfall?
2. What can I infer about this waterfall by looking at it?
3. What happens when I break rocks apart with a rock hammer?

Main Ideas
1. The concepts covered in this class are evident at Gethsemane falls.
2. It can be fun to explore a waterfall and make observations about the land around me.

Lesson Organizer

Objectives
By the end of this activity, students should be able to:
1. Explain how the waterfall was formed.
2. Describe the processes that have happened and are currently happening involving rocks and water in the area.
3. Compare the waterfall at the mass wasting site to Gethsemane Falls and articulate how the two are different, how they are the same, and why.

Materials
Rock hammers
Safety goggles
Rock viewers

Time Required
15-30 Minutes

Location
Gethsemane Falls

What to Do

1. Give students time to experience and enjoy the beauty of the falls and creek.
   As they explore, encourage the students to:
   A. Relate what they see here to the mass wasting site. The waterfall at the mass-wasting site is a very new, immature waterfall that will no doubt grow in time. Gethsemane Falls has existed for a very long time.
   B. Observe that water has worn away all soil, and most rocks and boulders from the face of the falls. The granite bedrock of these falls is extremely hard and is therefore wearing away at a very slow rate as compared to the D.G. (decomposed granite) at the mass-wasting site.
   C. Observe the very smooth feel of the face of the waterfall. Ask them why they think it is so smooth. (Due to abrasion by water and small rock, sand, soil particles acting in much the same way sandpaper is used to smooth wood surfaces.)
   D. Observe how some of the rocks at the base of the falls are more jagged or rough in texture than others in the creek. The rougher the surface the more recent the weathering. Smooth, polished rocks in creek bottoms have usually been weathered over a much longer period of time. The type of rock also affects the rate of weathering. Some rocks are very resistant to weathering while others weather much more rapidly.
2. If time permits, allow the students to break rocks apart with the rock hammers. There are stumps near the waterfall that serve to hold the rocks as students try to break them. Please be sure that students breaking rocks apart are wearing safety goggles and that other people are several feet away, as some small rock chips tend to fly several feet in all directions. Please also remind students to keep their free hand away from the rock that they are hitting with the hammer. Once a student has broken rocks apart, they can step away and use the lighted rock viewers to get a closer look.

Please explain to students the absolute necessity of leaving this site in as good of shape (or better) as it was when you arrived. The philosophy is to "Leave No Trace". Tell students to take nothing but pictures, leave nothing but footprints. Please do not damage or destroy any plants. Thank you!

Allow 20 - 25 minutes for the return hike to the Dining Hall. Return along the trail in the opposite direction that you came. Continue up the trail to the dirt road where the drinking water container is located. **Don't go back across the meadow.** Instead, travel up this road to your right until you enter the apple orchard (grassy area with apple trees and buildings) approximately 150 feet away. As you walk through the orchard note the paved path that

leads to your left. Note the 2-story homes on your left and single story homes on your right. The return trail passes between them and ends near the back deck of the dining hall.

Activity #6: Application and Review

Activity Overview

In this activity, students will think about the way that rocks and minerals impact their daily lives. They will also review the concepts covered in the class.

Focus Questions

1. What kinds of things do I see around me and use everyday that are made from rocks or minerals?
2. What kinds of minerals do I have in my own body?
3. What should humans take into account when mining and processing rocks and minerals?

Main Ideas

1. Many of the things we wear and use in our daily lives are made partially or completely of rocks or minerals.
2. Minerals are an essential part of the human diet.
3. Rocks and minerals are considered non-renewable resources. Humans should therefore take care when using them to produce products and should seek ways to reduce, reuse, and recycle them. In addition, humans should seek alternatives to the rocks and minerals that we use and examine the way mining for rocks and minerals impacts the environment.

Lesson Organizer

Objectives

By the end of this activity, students should be able to:

1. Identify products that we use in our daily lives that are comprised of rocks or minerals.
2. Explain reasons why humans should pay attention to the production and use of rocks and minerals.

Materials

None

Time Required

Remainder of class, time permitting.

Location

Dining Hall

What to Do

1. Have students look around at all the manmade objects in the immediate vicinity. Have them identify things that were made from rocks or minerals. Answers will vary, but with the exception of wood products, nearly every man-made object they see was manufactured from natural resources that were mined, or extracted from the ground (e.g. concrete, glass, metal, pavement, plumbing and electrical equipment, vehicles, etc.).
2. Have students look at you, and to try to identify things you're wearing that are made from rocks or minerals. Answers will vary, but once again, everything you wear, unless it is made from plant or animal (e.g. cotton or leather), is made from something that was mined, or extracted from the ground (e.g. watches, eyeglasses, earrings, all clothing and footwear made from synthetic fabrics). Have them identify something you're wearing that wasn't made from rocks or minerals.
3. You've talked about your surroundings and about the outside of your body, ask what you have inside that comes from rocks or minerals (e.g. iron, magnesium, potassium....). Minerals are essential for life.
4. Explain that we use rocks and minerals for countless manufactured products that enhance our lives in a multitude of ways. Humans and human communities are extremely dependent upon the availability of these natural resources. Rocks and minerals are considered non-renewable resources because the time required to replace those resources is so great. Therefore, it is essential that we exercise care and sound judgement in extracting, transporting, processing, manufacturing, distributing, and utilizing these resources. We need to continually search for new ways to **reduce** our dependence upon mined resources, creatively **reuse** any materials or products that we can, intentionally **recycle** any materials that can be recycled, and consciously search for **alternatives** that minimize our impact on the environment.
5. If time allows, review concepts covered in the course.
6. Remind students that geology is a science that can be learned over time, but this has just been an introduction into the basics. Also remind them that knowledge of rocks and minerals has enabled people to improve our lives in ways we experience daily from eating (forks, knives, spoons - as well as in the foods we eat), to living in the houses we do (electricity, paint, insulation, flooring, paint, windows, plumbing), to how we travel (bikes, skateboards, scooters, cars, trains, planes, boats.) The list goes on and on and on.

Glossary

Bedrock: the underlying solid "parent" rock beneath soil and fragmented rock.
Chemical Weathering: the weakening of a rock's structure by chemical change, making it easier to break down by physical weathering.
Core: hot, dense, central metallic center of the earth.
Deposition: the process by which materials are redeposited in a new location.
Erosion: the process by which materials are carried away and redeposited by gravity, water, wind, or ice.
Extrusive: rock that comes out (erupts) and quickly cools on surface (volcanic - e.g. lava, obsidian, pumice, volcanic ash).
Fault: a break in solid rock, along which movement can occur.
Geology: a science that deals with the history of the earth and its life, especially as recorded in rocks.
Geologist: a person who studies the history of earth.
Groundwater: water that has seeped/soaked into the ground, filling empty pore space in the rocks and soil beneath the surface.
Hardness: a mineral's resistance to being scratched.
Igneous Rocks: rock formed from the cooling and solidification of molten earth materials.
Intrusive: rock that cools very slowly underground, below surface (e.g. granite).
Landform: the features of the earth's surface such as mountains, valleys, plains, plateaus.
Lithosphere: "cold," thin brittle crust of the earth.
Luster: a physical property of a mineral; the way it reflects light.
Magma: rock which is melted or molten due to extreme heat and pressure.
Mantle: hot, soft, flexible, layer of the earth; convects heat.
Mass Wasting: downhill movements of large amounts of materials on Earth's surface, due to gravity.
Metamorphic Rock: rock formed from pre-existing rocks as a result of heat/pressure changes.
Mineral: a naturally occurring, inorganic, crystalline solid, with a definite chemical composition.
Mountain: an area on Earth's surface that rises abruptly from the surrounding landscape.
Physical Weathering: the reduction of rocks into smaller fragments without changing their chemical composition.
Plate Tectonics: a theory that explains movements of continents and changes in the earth's crust caused by internal forces - responsible for volcanism, earthquakes, mountain formation.

Rock Cycle: the changes that rocks undergo from being magma, to rocks, and back to magma in an ongoing process.

Sedimentary Rock: rock formed as a result of weathering, erosion, and redepositing of loose earth materials. May be formed by compaction and cementation, or chemical processes.

Sediments: materials that have been weathered away and are carried away in the process of erosion.

Soil: a mixture of weathered rock and decayed organic material.

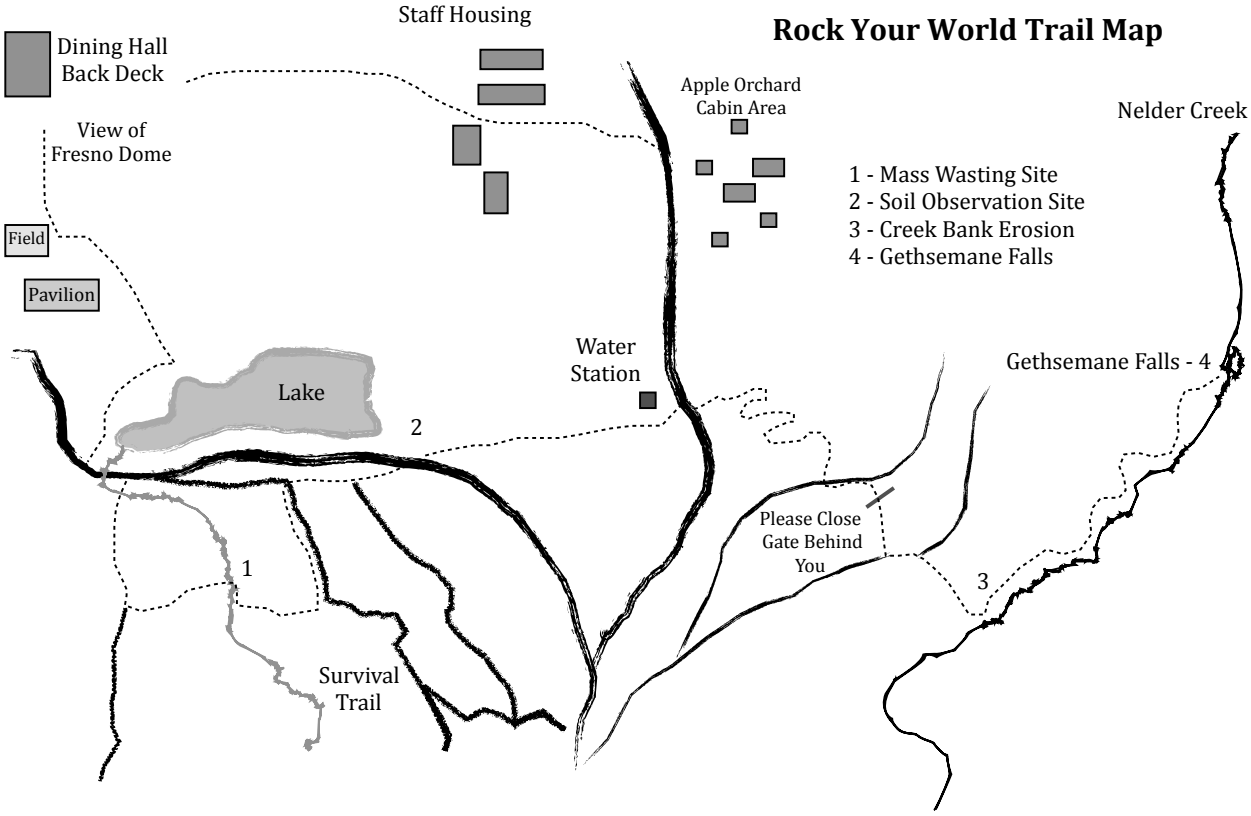
Streak: the color of the powder left when a mineral is rubbed against a hard, rough surface.

Topography: shape, configuration of the land

Volcanism: the formation of rock and mountains from lava flows.

Weathering: the breaking down of rocks into smaller pieces by natural processes.

Rock Your World Map



Appendix A: Soil Observations Worksheet

SOIL OBSERVATIONS

Names of Team Members: _____

What did you find without using the magnifying glass?
Describe how it feels. What are its shapes and colors?

What did you see using the magnifying glass?

Use a magnet. What happens?

Sprinkle water. What changes did you observe?

Use the pH tape. What is the pH of your soil site?