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Materials needed:
Large sheets of butcher paper
Markers or pencils

Time: 30 minutes in class plus a homework assignment (give them at least one week)

"Landforms" Investigation 1 page 11:

Activity 1: "Family Travel Maps"

TEACHER PREPARATION:
This activity would tie in really well to a study of the state of Arizona (either history or geography). Maybe get students started in thinking about their travels around Arizona by having them write a story about a trip that they have taken.

PLACE-BASED ACTIVITIES:
•**Cartography:** After you have defined landforms and the class has a good understanding of the definition, give them the Family Map project to do for a homework assignment.
1. "Family Travel Maps"
How?:
1. Have the class brainstorm all of the landforms in our area, Northern Arizona and the rest of Arizona.
2. Ask the class how many of them have been to one or more of the landforms listed on the brainstorm.
3. Tell the class that their job is to create a Family Map of the state and to label all of the landforms that they have been to.
4. Let them know that this is a project that the whole family can participate in creating.
5. Pictures, brochures, postcards etc can be used to create their map.
6. When maps are due have the students share their maps with the class.

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Materials needed:
Grid paper
Pencils
Rulers (for use at home)
Have students ask their parents for a tape measure

Time: 45 minutes in class plus a homework assignment (give the students a few nights)

"Landforms" Investigation 1 page 11:

Activity 2: "House Maps"

TEACHER PREPARATION:
Make sure all students understand some basic geometry of squares and triangles, how to use a ruler and grid paper, and how to make a map to scale.

PLACE-BASED ACTIVITIES:
•**Cartography:** Have the students find the perimeter and area of each of the rooms in their house using grid paper.
1. "House Maps"
How?:
1. Have the class make a map of their own homes.
2. Have them measure the perimeters of each of the rooms in their home and map it out on graph paper. Talk about taking good notes before you start measuring so you are sure that you will stay within the confines of the grid paper.
3. In addition to the make a map of your own house activity, you could also have your class write directions on how to get to their house from the classroom.

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References:

Accent Arizona. 1988. Pg. 29. [NAEERC: AZ 027].

Materials needed:

Topographic map of the Flagstaff area
Overhead transparencies of each landform
Xeroxed copies for students of the section of the map they are mapping
Tag board from which to cut templates
Cardboard to make pattern pieces
Cardboard knife
Metric rulers
Glue

Time: 3- 1 hour periods

"Landforms" Investigation 1 page 11:

Activity 3: "Mountains to Molehills"

BACKGROUND INFORMATION:

The San Francisco Peaks are a complex volcanic landform. There are many other really interesting landforms around in northern Arizona: Kendrick's Peak, Sunset Crater, Sitgreaves, Woody Mountain, Bill Williams, etc. Contour maps (or topographic maps) can tell a person a lot about the structure of landforms. The closer the lines are together on a topo map, the steeper the terrain is.

TEACHER PREPARATION:

This activity will teach your students how to create a relief map from a topographic map. Obtain a topo map of the area around Flagstaff. Blow up different landforms from around this area and put them on 8 ½ x 11 pieces of paper. Each group of students should have a different landform to map.

PLACE-BASED ACTIVITIES:

•**Science/Cartography:** Provide your class with some more hands-on mapping skills.

1. "Mountains to Molehills"

How?: Discuss contour maps. Show the overhead of the contour map and discuss what each line shows you. Have students calculate the height of the landform they are mapping using only the contour lines and the contour interval (how many feet you ascend per line). Have students shine their transparency on the board and cut out the tag board templates. Have them trace a few and then let the next group go. Save the templates for a future lesson. Decide how many layers of cardboard will give you the desired contour interval (1 cm cardboard = 1 m?) and have students cut out that many copies of their template and glue them together. You should have a blown-up version of the different landforms when the students are done!

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References:

Ranger Rick's Nature Scope. Geology: The active Earth. Washington, D.C.: National Wildlife Federation. Pg. 31-35. [NAEERC: GEO 001].

"Landforms" Investigation 2 page 1:

Activity 4: "Shaping the Landscape"

This activity was modified by Corey Hoelz, NAU

BACKGROUND INFORMATION:

Weather and erosion are the two major forces that break down the Earth's crust. Weathering causes rocks to fragment, crack, or break down through chemical weathering processes. Erosion looses and carries away the debris. This is continually occurring so that particles are always getting smaller and smaller. Rocks eventually become sand or silt, which are very fine particles found in soils. Soils also include decayed plant and animal materials, which provide nutrients that plants need to grow.

There are three main agents of erosion: water, wind and ice. Rivers move very fast and carry large amounts of sand and silt. Some water seeps into the ground and becomes groundwater. If water comes into contact with limestone, it may dissolve it causing depressions called sinkholes. Near beaches, water moves in waves and can erode away cliffs, arches and caves. Wind can carry dust and sand because they are very fine particles that can be lifted up and carried away. High winds that contain sand are responsible for creating towers, pinnacles, and polished rocks. Ice is also an agent of erosion. In very cold areas, snow falls in very large amounts to create glaciers. Once a glacier is large enough, it slides over the land. As it flows it helps grind and gouge the land. Glaciers form steep peaks, U-shaped valleys and narrow ridges. Mountains, volcanoes, and faults are formed as rocks are moved around. Over years and years, layers or rocks are dumped onto old layers of rocks.

TEACHER PREPARATION:

Take photographs of Sunset crater, Mt. Elden, Mars Hill, Old Caves Crater, Kendrick Peak, the San Francisco Peaks, rocks, plants and animals that are found in and

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Materials needed:
Paper or Field notebooks
Pencils

Time: 45 minutes

Materials needed:
Photos of local mountains
Photos of local plants and animals
White drawing paper
Crayons or markers
Glue & tape
Scissors
Map of Arizona
Construction paper

Time: 45 minutes to 1 hour

Materials needed:
None

Time: 45 minutes to 1 hour

"Shaping the Landscape" cont'd:

around Flagstaff. Examine the area around your school to see what landforms or landscapes the students could observe from the school.

PLACE-BASED ACTIVITIES:

•**Science:** Describe what mountains are made of, how the may change over time, and where they are located in Flagstaff.

1. "Local Mountains"

How?: Go outside of the school and have students look to see if they can see any mountains around the school or from the school yard. If you can't see any from the school yard, take a short walk down the street to see if you can see anything. Have students write down what they observe and sketch the mountains you see. Go back inside and talk about the process of building a mountain.

•**Art:** Have students create a cube made from a collection of mountain pictures.

1. "Mountain Madness Cube"

How?: Bring in pictures of the local mountains. Let the students look at them and draw their own pictures. Have them label the mountains, plants or animals. Let them color and cut the pictures out. Then make a square out of the construction paper. Paste or tape the pictures on each side of the cube.

•**Science:** Discuss all the different ideas students have about the process of mountain building.

How?: Get the class into a group and have the students give their ideas on how mountains are built. Then include any mechanisms that the students did not include. Discuss how each of these processes work and why they are important.

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Materials needed:
None

Time: Determined by the students

•**Inquiry:**
How?: These activities might spur questions in your students like: How are rocks weathered? What is erosion? How do water, wind and ice cause erosion? How do humans use the land? What animals live in the mountains? Are mountains found underwater in the ocean? Try to pick some good tough questions from those posed to you for inquiry activities and discussions.

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References:
Van Cleave, Janice. 1991. Janice Van Cleave's Earth Science for Every Kid: 101 Easy Experiments That Really Work. United States and Canada: John Wiley & Sons, Inc. Pg. 90-117. ISBN: 0-471-53010-7

Materials needed:
2 hard plastic containers with lids (32 oz.)
8 medium-sized local rocks
1 cup measuring cup
Water

Time: 30 minutes the first day, 15 minutes per day for the last two days

"Landforms" Investigation 2 page 7:

Activity 5: "Rocks to Sand"

This activity was modified by Seton Sobolewski, NAU.

Use the book that is now located in your kit!

BACKGROUND INFORMATION:
When water moves in a stream, river or as runoff, rocks often run into each other by the force of the water moving them around. The rocks run into each other, causing them to chip. The chips then tumble around and break into smaller pieces. The small pieces of rock continue to get knocked around and finally break down into sand.

TEACHER PREPARATION:
Survey your school grounds to make sure rocks that are common all over Flagstaff are found on your school grounds. Landscaping with non-native rocks and building construction can make this task difficult. You should find different types of sandstones, limestone (sedimentary rocks) and basalt (volcanic) rocks around Flagstaff.

PLACE-BASED ACTIVITIES:
•**Science:** Creating a simulation of rocks breaking down into sand in running water.
1. "Rocks to Sand
How?: Take students out on the school grounds to collect 8 medium-sized common Flagstaff rocks per group. Set up a control situation by placing 4 of these rocks in one plastic container with one cup of water. This container will be left alone during the experiment. Set up a variable situation by placing the other 4 rocks in the other plastic container with one cup of water. Seal the lids of both containers. Have the students shake up the variable situation container for 5 minutes a day for 3 days. After every shaking session, have students record their observations on both the variable and control containers. After day 3, record final observations on both containers and formulate some conclusions. Which container (unshaken or shaken) showed the most erosion?

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Materials needed:
Paper
Colored pencils
Rulers

Time: 40 minutes

•**Art:** Draw a picture showing the stages of a rock breaking down into sand.
2. "Rock Breakdown" Describe in a drawing the process of rocks breaking down into sand.
How?: Using colored pencils, have students draw the stages of a rock in running water breaking down into sand. Have students draw their rocks in natural settings (rivers, streams, oceans, arroyos).

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References:
Roth, C. E. et al. 1988. Beyond the Classroom: Exploration of Schoolyard & Backyard. Lincoln, MA: Massachusetts Audubon Society. Pg. 44-45. [NAEERC: EE 053].

Materials needed:
Rulers
String

Time: 30 minutes

"Landforms" Investigation 2 page 8:

Activity 6: "School Yard Erosion"

TEACHER PREPARATION:
This activity works best after a few days of heavy rain.

PLACE-BASED ACTIVITIES:
•**Measurement/Science:**
1. "Schoolyard Erosion"
How?: Have students explore their school grounds to find places where erosion is actively happening. Look for erosion under downspouts and gutters, paths and trails, swing sets, etc.

Measure the perimeters of any craters formed under swing sets or in batter's boxes with a string. Measure the depth of the crater by stretching the string across the hole and measuring down to the center of the hole with a ruler. The slope of the crater can be measured by placing a ruler along the slope and placing a protractor alongside it.

Take these measurements every two months and calculate the rate at which different areas are eroding. Brainstorm ways to reduce the effects of erosion.

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References:
Sheehan, K. & M. Waidner. 1991. Earth Child: Games, Stories, Activities, Experiments & Ideas About Living Lightly on Planet Earth. Tulsa, OK: Council Oak Books. Pg. 167-8. Call Number: [NAEERC: EE 034].

Materials needed:
Balloons (one for every five students)

Time: 30 to 45 minutes

"Landforms" Investigation 3 page 9:

Activity 7: "Raindrop Relay"

BACKGROUND INFORMATION:
The water cycle is complex and never-ending. Water is constantly moving through different states and substrates to arrive in your faucet each morning. Water moves as a liquid through river beds, oceans, and the ground and it moves through the atmosphere as water vapor. Sometimes freshwater gets locked up in glaciers and ice caps for many years before it is released again into the water cycle. A healthy water cycle is crucial for the survival of plants, animals and humans.

TEACHER PREPARATION:
Wait for a nice day to do this activity with your students outside. Divide your students into groups of five. Give one student in each group the name of one of the paths a raindrop takes to get to our faucets: cloud, mountain, stream, river, and ocean. This is one raindrop relay team.

PLACE-BASED ACTIVITIES:
•**Physical education:** Have your students participate in a relay that follows a raindrop's course through the water cycle.
1. "Raindrop relay"
How?: Give each relay team a water balloon to represent their raindrop. Give the balloon to the cloud child and ask them to float around until they reach their mountain child. Tell the students that, "the water falls onto the mountain in the form of a snowflake." Continue by saying that, "the drop remained frozen throughout the long winter until spring came and the snow began to melt and begin its journey down the mountain in the stream." Have the mountain child run a zigzag path until s/he reaches the stream child. Then say that, "many drops of water come together to form a stream. The stream gushes along until it meets the river." Have the stream child pass on to the river child. "Many mountain streams empty into the river. The river twists and turns until it reaches the ocean." Have the river child hand off to the ocean child.

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<u>"Raindrop Relay" cont'd:</u>

"Many rivers empty into the ocean, where the water sloshes and is pulled back and forth by the moon. The sun warms the water and changes it to water vapor." Have the ocean child hold the raindrop and rock it back and forth in her/his arms then pass it off to the cloud child once more. "The water vapor rises into the sky and forms clouds. The clouds travel over the land and eventually the raindrop falls on a mountain top."

After this activity have the class continue to build on their mapping skills while using a little creativity as well.

1. Have the class map out the flow of a raindrop from the time it leaves the cloud to when it reaches their home.
2. You can give them a variety of choices for their presentation:
    a. Poster
    b. Diorama
    c. Zigzag book
    d. Mobile
    e. Pamphlet or brochure
    f. anything else!

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References:

Russell, H. R. 1993. Ten-minute field trips (second edition). Washington, D.C.: J. G. Ferguson Publishing Company. Pg. 116. [NAEERC: EE 038] ISBN: 0-87355-098-6

Materials needed:

Long green trays (from the Landforms FOSS kit)
Soil
Chalkboard
Chalk (NOT the anti-dust variety)
Water

Time: from 30 minutes to 1.5 hours

"Landforms" Investigation 2 page 15:

Activity 8: "Water & Soil: Beyond the Stream"

This activity was modified by Nathan Marler, NAU.

BACKGROUND INFORMATION:

Water is an excellent force when it comes to erosion and the deposition of sediments. One can witness this phenomenon in progress anywhere water contacts a surface and carries bits of it away. The size and shape of whatever is being carried away will eventually determine the composition of whatever layer is deposited, and the size and shape depend, in turn, upon the speed and turbulence of the water. Fast, smoothly-moving water may transport more and larger particles than slow-moving water, but not as much as rapid, turbulent water, which can churn objects up, suspend them, and transport them away.

TEACHER PREPARATION:

Look around the school grounds to find bits of running water (especially after a rain or snow). If none is available (a distinct possibility), follow the activity to create your own.

PLACE-BASED ACTIVITIES:

•**Science:** Examination of "close-to-home" kinds of runoff and erosion can introduce students to these concepts without limiting them to the grand, textbook examples of idealized erosion and deposition.

1. "Water and Soil: Beyond the Stream":

How?: Examine school grounds for instances of water run-off and erosion. Notice that man-made materials (i.e. concrete) can be eroded by water as effectively as soil and natural rock.

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"Water & Soil: Beyond the Stream" cont'd:

Attempt to locate sources of water runoff and describe how this water created the observed erosion. Return to the classroom and employ the FOSS trays. Divide students into groups of two to three and have them load their trays with soil. Run water over the soil with the tray tilted at an angle so that a stream is formed. What happens with the trays are allowed to dry? What formations remain?

As a second activity, use pieces of chalkboard chalk in the tray and run water over them (use warm water to expedite the process, or extend the activity overnight to allow the chalk to soften). Be sure to use regular, dusty chalk—the anti-dust variety is coated with a wax that makes it all but impervious to water. Let the trays sit overnight with the chalk in contact with the water. The next day, run more water over the chalk and observe what happens. Pour off the excess water and let the tray dry. Have the students hypothesize what might be happening when the water (a) runs over the fresh chalk, or (b) runs over the chalk that has been soaked in water overnight. Note that continual contact with water promotes faster erosion than intermittent contact between water and a mostly dry surface.

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References:

Russell, H. R. 1993. Ten-minute field trips (second edition). Washington, D.C.: J. G. Ferguson Publishing Company. Pg. 116 #5. [NAEERC: EE 038] ISBN: 0-87355-098-6

Materials needed:
Trowels (small shovels)

Time: 30 minutes

"Landforms" Investigation 3 page 15:

Activity 9: "Flooded Foundations"

TEACHER PREPARATION:
Scout out what you think may be different types of soil on the school grounds. Compare soil in flowerbeds with soil in the field, or soil along the road. Find a few different soil types.

PLACE-BASED ACTIVITIES:
•**Science/Inquiry:** Explore the ways different soils flood with water
1. "Flooded Foundations"
How?: If it has recently rained, go out on the school grounds with small trowels and dig holes in different types of soils. Try to determine how deep the water has penetrated the soil in different places. Ask the students why they think different soil types might be infiltrated with different amounts of water (soil composition, slope of the land, plants, animals, organic materials, clay, etc.). Fill your holes in and return to the classroom.

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References:

Russell, H. R. 1993. Ten-minute field trips (second edition). Washington, D.C.: J. G. Ferguson Publishing Company. Pg. 122. [NAEERC: EE 038] ISBN: 0-87355-098-6

"Introduction to Petrology" University of British Columbia. EOSC 221. Available at: http://www.science.ubc.ca/~geol202/petrology/rock.html

"Landforms" Investigation 3 page 20:

Activity 10: "Local Geology in Roads and Sidewalks"

This activity was modified by Eric Bennett, NAU.

BACKGROUND INFORMATION:
Rocks that are used for roads and sidewalks are chosen for their physical properties. Some of these rocks may reflect local geology. Every school is located on soil and earth that can be used to teach students about geology. Many locations have unique characteristics that will enhance this experience. A teacher must research briefly the types of soil and rock that are located in and around their area. Often, the gravel used in asphalt and concrete is made up of metamorphic rock. Metamorphic rock is usually very hard and durable and can hold up well in roadways and sidewalks. This metamorphic gravel is used to give strength and form to roads and sidewalks. These rocks include slate, phyllite, hornfels and schist.

Cinders are igneous rock that is used to gain traction in slippery conditions in northern Arizona and as the top layer of some dirt roads. Cinders are not as durable as metamorphic rock and break down into a granular consistency that works well for traction on icy roads, etc. Topsoil varies greatly and consists of clays, silts, organic materials and rocks.

Flagstaff, AZ: Rocks used in roads and sidewalks do not generally reflect our local geology. Many roads and sidewalks are made with durable metamorphic rock. Cinders however are very easy to see in this area. Volcanic activity in this area has created many local cinder cones. These ciders are mined and spread on roads for traction during icy winter conditions. Some good field trips might be: Cinder pit, Wupatki N. M./ Sunset Crater Volcano N. M., Walnut Canyon, Grand Canyon, Kaibab Formations out by Mountainaire and Lake Mary.

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Materials needed:
Magnifying glasses
Field notebooks

Time: about 30 minutes

Materials needed:
Art supplies
Shovels or trowels
Rock boxes

Time: about 1 hour (may be extended)

"Local Geology in Roads and Sidewalks" cont'd:

TEACHER PREPARATION:
In order to make this activity successful, you should try to investigate some local geologic features to determine the make up of the topsoil and local rock formations. You might want to prepare for inclement weather and provide students with rock collection equipment and containers, and geology notebooks. Other considerations would include permission to leave the classroom, and possibly having a teaching assistant help guide the class through the activity. You will probably want to walk around the school grounds to determine what features and examples you will want to show the class and discuss. You may also want to prepare an investigation sheet including questions the students must find answers to.

PLACE-BASED ACTIVITIES:

•**Earth Science:**

1. "Road Rocks"

How?: Take students to areas around the schoolyard and look at various rocks. Observe rocks in concrete and asphalt as well as any other rocks in the soil, etc. Have students try and identify the type of rock and where it may have come from. If it appear to be from outside the local area, have students identify its properties. Was this rock brought here because of its properties? What things might determine how a rock is used? Is it durable? Does it have a rough surface?

•**Art:**

2. "Rock Art"

How?: Have students collect rock samples for an art project. Have students list why they chose the rocks they did, and how they will use them in their project. Have students create a collage, sculpture, painting or any other project using rocks and soil collected from the schoolyard.

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Materials needed:
Field notebooks

Time: about 1 hour

"Local Geology in Roads and Sidewalks" cont'd:

•**History:**
3. "Uses of Rock"
How?: Take students to any local destination that may have ruins or old roads. Have students predict and determine uses for various rocks and geologic formations in the area. Show students the uses of soil as adobe, rock cliff dwellings and the manner in which people may have lived in your local area. Cliff dwellings in the Flagstaff area represent how rocks and soil were used in the past. Discuss soil uses in the area, were there farms? Forests?

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References:

Russell, H. R. 1993. Ten-minute field trips (second edition). Washington, D.C.: J. G. Ferguson Publishing Company. Pg. 116. [NAEERC: EE 038] ISBN: 0-87355-098-6

"Landforms" Investigation 2 page 21:

Activity 11: "Observing geologic processes in the snow"

This activity was modified by Eric Bennett, NAU.

BACKGROUND INFORMATION:

Snow provides a visual teaching tool that represents many geologic processes. There are three states that matter can exist in on Earth: liquid, gas or solid. Water exists in these three states at temperatures that are observable on the surface of the Earth. Minerals are naturally occurring inorganic substances with a definite and predictable chemical composition and physical properties. Snow has some properties that are similar to minerals and when it precipitates to the Earth's surface it is deposited in layers. It behaves like a sedimentary rock and as it melts is flows like molten lava. As it freezes it becomes an igneous rock. These processes are easily observable wherever snow falls. Pressure and temperature also effect minerals and these effects can be shown with snow.

Snow accumulates as it falls. You may want to point out that air can be trapped in snow as it falls and that it is less dense than water. Because of this, 10 inches of snow generally equals about 1 inch of rain. Wind can blow freshly fallen snow and create ripples and drifts like sand dunes (sandstone).

TEACHER PREPARATION:

Teacher preparation for this activity consists of planning the activity to be ready when fresh snow is on the ground. January to April are the best month in northern Arizona for snowfall. This activity will be more effective after a fresh snowfall. You may want to locate an isolated area on the school grounds where you can dig down to the ground and create a cross section in the snow that can be viewed by the class.

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Materials needed:
Snow

Time: about 1 hour

Materials needed:
Snow
Thermometer
Meter stick

Time: about 1 hour

"Observing Geologic Processes in the Snow" cont'd:

PLACE-BASED ACTIVITIES:

•**Earth Science:**

1. "Snow Rocks"

How?: Explain that snow represents normal sediment or dirt. Have students describe how snow forms and how it accumulates on the ground. Take the students outside to a location on the school grounds with undisturbed snow. What happens when it gets warm? Explain how rock and sediment can melt with extreme heat. Have students connect this process with lava and magma. Show similarities of water and molten rock, for example, water's ability to flow, etc. Explain that pressure also effects the formation of rocks. Investigate the difference between old snow on the ground and newer snow. The weight of new snow will cause older snow to become more dense and harder (metamorphic rocks!). Have students grab a handful of snow and compress it in their hands. What happens? Does the snow change as you push on it? Explain that the heat and pressure of their hands has created a "snow rock" similar to a metamorphic rock. If available, find some melted snow that has frozen into ice. Have students relate this to the formation of rocks as lava cools (igneous rocks!). Ask the students what new substance is formed. Explain that ice, in this case is an igneous rock.

•**Weather:**

2. "Snow Fields"

How?: Take the class outside to a location with undisturbed snow. Have students describe what they see. Measure the depth of the snow. Use the thermometer to take the temperature of the snow. Is it colder than the freezing point? (32° F, 0° C). Take the temperature of the air. In this temperature will the snow melt? Is the snow melting right now? Have students dig down to the ground and record any visible separations in the snow layers. Is some of this snow old? What does the surface of the snow look like? Are there any drifts or ripples? How could these characteristics have developed? Relate the snow formation to sedimentary rock formations.

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References:

Criswell, Susie Gwen. 1994. Nature Through Science and Art. Blue Ridge Summit, PA: TAB Books. Pages 12-14. [NAEERC: EE 004]

Materials needed:
None

Time: 1 to 2 hours

Materials needed:
Rocks
Sand
Twigs
Leaves
Cardboard boxes
Plastic lining (optional)

Time: 1 to 2 hours

"Landforms" Investigation 4 page 7:

Activity 12: "Creating Landscapes"

This activity was modified by Kim Pomeroy, NAU.

TEACHER PREPARATION:
Collect rocks, gravel, sand, leaves, sticks and other items from the local environment. Gather cardboard boxes, paper, pencils, markers, paint, scissors, and other art supplies for the activity. Provide plastic bags or a shallow bowl for those students who wish to include water in their ecosystem. Schedule a field trip to go to the San Francisco Peaks and to the overlook above Oak Creek Canyon (89S)

PLACE-BASED ACTIVITIES:
•**Science:** Create an earth surface
1. "What is a landscape?"
How?: Visit the San Francisco Peaks and spend time discussing the volcanic activity that occurred creating the mountain that we see today. Point out the differences in the landforms and explain what happened to the formations that made them appear this way. Next, go to the overlook above Oak Creek Canyon. Discuss the lava flow, the fault line and the creek that created the canyon. Spend time looking at the different rock formations.

•**Art:** Create a model of a land surface
2. "Creating landscapes"
How?: Divide the students into groups. Each group should create a model of a land surface. Using the rocks, sand, twigs, leaves and other supplies the students can create landforms of their choice within the cardboard box. Water can be incorporated by lining the cardboard box with plastic or by using a plastic tub or bowl. Each group should present their creations to the rest of the class. Have them explain what happened to the earth's surface that made it look like it does now and then have them tell you what types of changes landforms face today and in the future.

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Materials needed:
None

Time: 1 hour

Materials needed:
None

Time: Determined by the students

"Creating Landscapes" cont'd:

•**Science:** Discuss the mechanisms of erosion
3. "Exploring erosion"
How?: Discuss the mechanisms of erosion and change that students can think of as well as those that they don't mention. Discuss faults and other changes that occur under the surface of the earth that we cannot see. Discuss the effects earthquakes, volcanic eruptions, and erosion can have on plants, wildlife and humans.

•**Inquiry:** Talk about volcanoes in northern Arizona
4. "We have volcanoes here?!"
How?: Start the students asking questions about the volcanoes we have in northern Arizona. Will the San Francisco Peaks ever erupt again? Are there any active cinder cones in the Flagstaff area? Why are there so many cinder cones in the Flagstaff area? How do plants grow in basalt after it has scorched the soil and covered it with a layer of solid rock?

•**Arizona State Science Standards:**
5SC-E1: Examine, describe, compare, measure, and classify objects and mixtures of substances based on common physical and chemical properties (e.g., states of matter, mass, volume, electrical charge, density, boiling points, pH, magnetism, solubility)

5SC-E4: Identify and predict what will change and what will remain unchanged when matter experiences an external force or energy change (e.g., boiling a liquid; comparing the force, distance and work involved in simple machines)

6SC-E3: Describe the composition (including the formation of minerals, rocks and soil) and the structure of the earth

6SC-E5: Explain how earth processes seen today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past

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References:
Roth, C. E. et al. 1988. Beyond the Classroom: Exploration of Schoolyard & Backyard. Lincoln, MA: Massachusetts Audubon Society. Pg. 44-45. [NAEERC: EE 053].

Materials needed:
Magnifying glasses
Glass jars

Time: 30 minutes

"Landforms" Investigation 4 page 8:

Activity 13: "Rocks About the School Ground"

TEACHER PREPARATION:
Look around the school grounds for different types of soils. Man-made soils with rubble work well, potting soil works well, natural soils found in less disturbed sites will also work well.

PLACE-BASED ACTIVITIES:
•**Science:**
1. "Rocks about the School Ground"
How?: Go out and dig up some different types of soil with your class. Have each group choose a soil type to work with. Have them fill the jar half full with soil and add water. Shake well. Let the jar settle for at least 24 hours. Have students delineate which layers they see and guess as to what the layers are made out of. Draw the jar.

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"Landforms" Investigation 4 page 8:

Activity 14: "How was this mountain made?"

Use this book now located in your kit!:

Farndon, J. 1992. How the Earth Works 100 Ways Parents and Kids Can Share the Secrets of the Earth. Pages 64-71.

PLACE-BASED ACTIVITIES:
This is a great activity to give the class some hands-on experience to find out more about how the earth works and how mountains are created.

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"Landforms" Investigation 4 page 8:

Activity 15: "Roadside Geology"

Use this book now located in your kit!:

Chronic, Halka. 1994. Roadside Geology of Arizona. Pages 191-205.

TEACHER PREPARATION:
This book contains roadside tours of local geology. You might want to drive these tours before hand so you understand what you are seeing and showing students.

PLACE-BASED ACTIVITIES:
Use this book as a reference for some reading material to share with the class about interesting places to see in our area. Also use it to plan field trips in our local area.

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References:

Cuff, Kevin, et al. 1995. Stories in Stone. LHS GEMS: Lawrence Hall of Science, University of California, Berkeley. Pg. 77-81.

Rawlins, Carol. 1995. Grand Canyon. Raintree Steck-Vaughn Publishers. Pg. 33-40.

Snyder, et al. 1991. Earth science and the challenge of discovery. D.C. Heath & Co. Pg. 370-373.

Reboka, Bob. 1999. Grand Canyon Explorer: The geology of the Grand Canyon. Http://www.kaibab.org/geology/gc_geol.htm.

"Landforms" Investigation 4 page 17:

Activity 16: "The Ancient Lake Bed: The formation and mapping of sedimentary rock"

This activity was modified by Jeffrey Hines, NAU

BACKGROUND:

Due to our close proximity to the Grand Canyon, it only makes sense to explore our own local, natural wonder as an in-classroom model while studying the formation of sedimentary rock. The instructor must provide reference material on the Grand Canyon and formation of sedimentary rock for students to gain a greater understanding of the concept. Bob Rebokas' web site is a great resource for a "crash" course in the formation of the Grand Canyon. For this activity to really succeed the students must have an understanding of the passage of time.

I do like the visual and hands on activity that GEMS provides for illustrating the subject of sedimentary rock formations. What I do not condone is the waste of materials that the activity produces. What do you do with a bunch of mixed-up modeling clay? If you have an agreement with an art teacher that the discarded material would have a use in their class, then by all means, follow the activity accompanied by the added modifications. However, if you do not have a means of recycling the modeling clay, follow the suggested alternative.

The following information is taken directly from Bob Rebokas' Grand Canyon website. The Rocky Mountains begin to form 60-70 million years ago and at some point later the Colorado River was born. At this point there are at least two popular theories which describe what happens next:

1. Around 20 million years ago the Colorado River begins to carve into the Grand Canyon at its eastern end, Marble Canyon, and probably exiting via Kanab Canyon.

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Materials needed:
Modeling clay
Butter knives

Time: 45 minutes to 1 hour

Materials needed:
1 plastic soda bottle with the top cut off
2 cups of red crushed cinder
2 cups of white sand
2 cups of red clay
2 cups of yellow powdered chalk
2 cups potting soil
Plant leaves
Shells
Cross-section map of the Grand Canyon

Time: 1.5 hours

"The Ancient Lake Bed" cont'd:

Around 17 million years ago the Colorado Plateau begins to uplift and causes the river to cut deeper. Around 5 million years ago the uplift ceases and another river working its way northward along the San Andreas fault and eastward along the western Colorado Plateau captures the Colorado River.

OR another theory…

2. Around 35 million years ago the Kaibab Plateau begins to uplift and diverts the ancestral Colorado, which was already established on a course very similar to that of today, to the southeast. The cut-off western portion, now named the Hualapai Drainage System, continues to drain the western region. About 12 million years ago the Colorado's path to the sea is blocked and a huge lake, Lake Bidahochi, is formed. Eventually the Hualapai cuts back through the southern portion of the plateau and recaptures the Colorado. Lake Bidahochi is drained and becomes the Little Colorado River (Reboka 1999).

PLACE-BASED ACTIVITIES:

•**Science:** Create your own Grand Canyon

1. "The Ancient Lake Bed"

How?: Have a map of the various layers of the Grand Canyon; you will not be able to build all ten layers, so chose just the top four or five. Emphasize the passage of time. Create the layers of the Grand Canyon with modeling clay (or do the alternative activity presented next). After the layers have been described and deposited, have the students cut a small stream in their model. Piece by piece have the students remove a small cut wedge to represent the formation of the canyon. Have one-minute equal one million years of erosion at work. The students should get the idea that both the act of sediment formation and erosion take a great amount of time.

•**Science (Alternative):**

2. "Ancient Lake Bed" (alternative)

How?: Have students break up into groups of three. Each student group should have the materials listed in the materials needed section. Place four small holes at the base of each groups' container using an ice pick or

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"The Ancient Lake Bed" cont'd:

completely cut off bottom of bottle, (this procedure can get messy). Describe to the students stories of the formation of the Grand Canyon. Begin the story of the formation of the Grand Canyon with the last five layers that we see on the cross-section map of the Grand canyon. Begin with the layer of **clay**, the Supai group, consisting of silt, clay and sand deposited by migrating ocean shorelines and slow rivers. The Supai Group which rests atop the Redwall is dated at 300 million years ago and indicates that it was formed in an above water and coastal environment. Have students add crushed shells to layer.

If bottom is cut out make sure the bottle is placed on a paper plate to minimize the mess. Make sure students pack down each layer well. Have each group tear pieces of plant leaf and place on clay. State that this would represent species of plant that lived during this time. Possibly have students research plants and animal species found during this time period. Continue the stories and have students lay down the layer of **crushed red cinders** with more leaf pieces. This layer represents the red Hermit shale formed by the drainage of rivers. This layer is rich in fossils. The Hermit Shale which was deposited around 280 million years ago contains many plant fossils which indicate that it was also above water

Continue story and have students lay down a layer **sand** to represent the layer of Coconino sandstone. This formation was created by the wind depositing sand into great sand dunes. Several reptiles have left their footprints in the sand. Have the students develop a technique to create tiny footprints of reptiles roaming the sand dunes. The Coconino Sandstone represents the remains of a vast sea of sand dunes which was blown down from the north around 270 million years ago. Continue the story. The sea returned and with it deposited many marine fossils creating the pale yellow and gray limestone layer known as the Toroweap formation. Have students deposit the **yellow powdered chalk** to represent this layer. The layers found within Toroweap Formation contains both sandstone and limestone, indicating that it was sometimes

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Materials needed:
Poster board (or flat, cut-up cardboard boxes)
Markers
Water colors
Colored pencils
Magazines to cut pictures from
Scissors
Glue

Time: 1 hour (if presenting to class, add an extra hour and a half)

"The Ancient Lake Bed" cont'd:

coastal and sometimes submerged. Have students add a small amount of crushed shells. These layers date to around 260 million years.

Continue the story. The last layer the students will place is the layer of **potting soil.** This layer will represent the layer of Kaibab limestone, which was deposited by the sea and contains fossilized marine life. The Kaibab deposit marks the end of the Paleozic Era. The top layer of the Grand Canyon, the Kaibab Limestone, contains many marine fossils that indicate that it originated at the bottom of the sea. This layer is around 250 million years old. Have students add crushed shells.

The finished layers reflect the 5 last layers of sedimentary rock in the Grand Canyon. Now lets form the Canyon. Using plastic knives have the students carefully carve out and remove the formation of the canyon. If using bottomless bottles (really) pack down the layers and carefully remove the bottle leaving the layered sediments. Have the students carve a small stream in their layer, if possible take the layers outside to add water to erode a small stream in the layers. Continue with the stories of the formation of the Grand Canyon. At the end of the unit save all materials and make bottled terrariums for future activities.

•**Art/English/Natural History** Have the students create a map of their model and write a brief story about the formation of the Grand Canyon.
2. "Model Maps"
How?: Have students create a blow-up map of their model Grand Canyon. Have students label the layers of the formations, and color them (or paint them).

•**Arizona State Science Standards:**

1SC-E2: Create a model (e.g., a computer simulation, a stream table) to predict change.

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References:
Catherall, Ed. 1990. Exploring Soil and Rocks. Wayland Ltd.

Rawlins, Carol. 1995. Grand Canyon. Raintree Steck-Gaughn Publishers. Pg. 18-25.

Snyder, Robert E. et al. 1991. Earth Science: The challenge of discovery. Lexington, MA: D.C. Heath and Co. Pg. 342-345.

Wiebe, Arthur, et al. 1984. Down to earth: Solutions for math and science. AIMS Education Foundation. Pg. 23, 34 & 35.

Materials needed:
Water troughs
A variety of local soils
Graphing paper

Time: 4 45 minute parts

"Landforms" Investigation 4 page 17:

Activity 17: "Graphing and mapping erosion"

This activity was modified by Jeffrey Hines, NAU.

TEACHER PREPARATION:
Instructor should familiarize themselves with the type of soils and minerals in the Flagstaff area. Collect soil types from different areas; such as a landscape business, creek beds, backyard, etc. The instructor should also provide reference to geology and the formation of the Grand Canyon for student use. Have each student bring in a soil sample, one zip lock bag full, from Flagstaff or surrounding areas. Instructor must collect soil from Flagstaff area as well.

PLACE-BASED ACTIVITIES:
•**Science:** Test the effects of the stream's slope and the rate of flow on the rate of erosion.
1. "Graphing and mapping erosion"
How?: The students and instructor will gather different soil types that are located in the Flagstaff area for experimentation. Each group will chose one soil type to test; one group will test sand (from Landforms kit). The experiment will test the flow rate necessary to erode different soil types. Have the students make predictions or hypotheses as to the amount of time it will take to erode their particular soil type at different flow rates. The flow rates will be calculated based on the amount of time it takes 200mL of water to flow down a sloped trough. Relate the final information to the nearest stream (example Shultz Creek). Possibly take a field trip to test flow and erosion rates. Shultz Creek only flows during the spring melt.

•**Inquiry:** Does a faster moving stream erode more soil than a slower moving stream?
1. "Speedy Streams"
How?: Part One: Set up the water troughs. Each group will set the slope of their trough at 5°. Open the two

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References:

Catherall, Ed. 1990. Exploring Soil and Rocks. Wayland Ltd.

Rawlins, Carol. 1995. Grand Canyon. Raintree Steck-Gaughn Publishers. Pg. 18-25.

Snyder, Robert E. et al. 1991. Earth Science: The challenge of discovery. Lexington, MA: D.C. Heath and Co. Pg. 342-345.

Wiebe, Arthur, et al. 1984. Down to earth: Solutions for math and science. AIMS Education Foundation. Pg. 23, 34 & 35.

Materials needed:
Water troughs
A variety of local soils
Graphing paper

Time: 4 45 minute parts

"Graphing and Mapping Erosion" cont'd:

siphons to maintain a constant flow. Record the time it takes to collect 200 mL of water. Caluculate the flow rate (mL/sec). Place 50 mL of the assigned or chosen soil type in the middle of the trough. Record the time it takes to erode all of the soil (run through five trials). A gentle rocking of the trough will help wash all the soil away at lower angles. Repeat the other slope settings using a fresh 50 mL of soil for each trial. This would be a good activity for the first day.

Part Two: Set the trough to a slope of 10° (this will not change throughout the rest of the experiment). Place the volume measure at the low end of the trough. Open one hose and obtain a constant flow. Time and record how long it takes to collect 200mL of water. Place 50 mL of test soil in the middle of the trough. Time and record the erosion of the 5 trials. Compile the results and graph the data.

Graph Rate of Flow (mL./sec) on X- axis and Time to erode (sec) on Y-axis. Create graph with degree of Slope as x-axis and Time for erosion (sec) as the Y-axis. Students' graphs on both parts of the experiment will drop off rapidly initially and then level out. This is opposite from other activities because the vertical axis is not the rate, but instead is time. Students may need help understanding the graphs that they produce.

***Alternative Plan**

As an alternative to the Water Works kit, use a small bucket of water to pour down a trough and collect and measure in the same method? If there is only one set up how are 25 students going to remain engaged? Does the water pressure of the water works kit effect the flow rate? If each group has a water works set up then there are no worries. If not, then I propose that each student have a trough that is adjustable from 5^{o} and 10^{0} and water pouring bucket and a water collection bucket. The students would follow the regular procedure as explained. A second alternative is to line several shallow boxes with plastic and cut a 2 inch wide by 1 inch tall hole in each.

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Materials needed:
Water troughs
Protractors
Stop watch
200 mL container

Time: 2 to 3 hours

Materials needed:
Water troughs
Sand
Calculators

Time: 45 minutes

"Graphing and Mapping Erosion" cont'd:

Place different soil types in each box, slightly packing the soil. Pour a liter of water over each soil type while at the desired slope and collect out flow from hole. Time and record the data sing the same technique from the original experiment. Repeat at different slopes.

Discussion:
- What are the similarities and differences in the graphs produced by the different soil types?
- What are the similarities and differences in the graphs produced by the different degrees of slope in the trough?
- Explain the differences.
- Which stream slope carried away soil the fastest?
- In nature, is the rate of water flow dependant on the slope of the stream?
- Could this change?
- Why is it important to study flow rates?
- How did the Grand Canyon form? How long did it take?

- **Field trip:**
Take a field trip to Shultz creek during the spring snowmelt. Conduct a flow and erosion rate experiment in the creek. Have the students develop the experiment. Ask the students how they would measure flow rate? Suggest placing a trough in the stream, allow water to flow through the trough at the same slope, angle the end of the trough away from the stream, and record the amount of time it takes to collect 200 mL of water from the stream. Conduct the erosion activity in the same way as the classroom experiment. Compare classroom experiment data and graph with field experiment data and graph. Is the data similar or different? Explain.

- **Art/Math:** Have each group construct a sand castle out of the same amount of sand and calculate the erosion rate of water flow it will take to destroy the castle, based on the data from the prior experiment. Have prizes for Most Beautiful castle, Strongest Castle, etc.

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Materials needed:
Art supplies
Paper
Pencils

Time: 45 minutes

"Graphing and Mapping Erosion" cont'd:

•**Art, English and Geology:** Have students either write or draw a story about how a stream uncovered dinosaur bones, petrified wood, an ancient civilization or some other artifact. Stress the importance of the passage of time and the occurrence of significant change in the stream flow, such as a flood or heavy snowmelt.

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References:
BSCS Science T.R.A.C.S. 1999. Investigating Earth Materials. Dubuque, IO: Kendall/Hunt Publishing Company. Pg. 39-41.

Materials needed:
1 jar per two students
Samples of local sand, loam, and clay
Water

Time: First day: 1 hour, Second day: 30 minutes

Materials needed:
Paper
Drawing materials

Time: 30 minutes

Materials needed: none

Time: 30 minutes

"Landforms" Investigation 4 page 17:

Activity 18: "Jar Observations"

This activity was modified by Amy Lord, NAU.

TEACHER PREPARATION:
Have plenty of sand, clay, and loam from the Grand Canyon or any other local landform. Another option is to use sediments similar to other well-known sites to compare to local sites.

PLACE-BASED ACTIVITIES:
•**Science:** Observe how sand, clay and loam settle in water
1. "Jar Observations"
How?: Fill each jar half full with water. In each jar add each of the three sediments. Shake well. Set aside for a day.

•**Art:**
2. "Jar Journaling"
How?: Have the students draw before and after pictures of what they see happening in the jars. You could also have the students draw their predictions before observing the finished product. Have the students guess which materials might sink to the bottom and which might float to the top.

•**Science:**
3. "Sediment Studies"
How?: Discuss all of the different sediments that the students used in their experiments. Discuss how knowing different sediments, and how they are eroded and deposited can tell geologists many things about landforms and their formation.

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Materials needed:
None

Time: Determined by students

"Jar Observations" cont'd:

•**Inquiry:**
4. "Sedimenquiry!"
How?: Most of the inquiry in these activities may take place after the jars are made and set aside. Students will practice scientific inquiry while predicting what their jars might look like the next day and explaining why they think they will look that way.

•**Arizona State Science Standards:**
1SC-E1: Identify a question, formulate a hypothesis, control and manipulate variables, devise experiments, predict outcomes, compare and analyze results, and defend conclusions

PO3: Predict an outcome based on experimental data

1SC-E2: Create a model (e.g., a computer simulation, a stream table) to predict change

PO1: Construct a model that demonstrates change within a system

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References:
Van Cleave, Janice. 1991. Janice Van Cleave's Earth Science for Every Kid: 101 Easy Experiments That Really Work. United States and Canada: John Wiley & Sons, Inc. Pg. 90-117. ISBN: 0-471-53010-7

Materials needed:
Modeling clay
Or peanut butter, jelly and bread

Time: 45 minutes to 1 hour

Materials needed:
Drawing supplies
Paper

Time: 30 minutes

"Landforms" Investigation 2 page 20:

Activity 19: "Depositing Layers"

This activity was modified by Amy Lord, NAU.

Use the book now located in your kit!

TEACHER PREPARATION:
Have an assortment of clay in different colors and have each represent different types of sediment to correlate with landforms in your area, state, or well-known site (i.e. Grand Canyon) The class should know about sediment and how erosion and deposition works.

PLACE-BASED ACTIVITIES:
•**Science:** Discuss how layers are deposited and how geologists do core sampling to observe deposition in certain landforms.
1. **"**Depositing Layers"
How?: Each color of modeling clay represents a different type of sediment (i.e. clay, sand, silt, pebbles, or mud). Have each student choose their layers of sediment and stack them on top of each other. Using what they know about erosion and deposition, have them decide what the layers would look like after erosion and have them model it. Students can sample their landforms by cutting a slab of their clay or using a straw to section off a piece. Cut the straw to free the cylinder of clay. Relate their sample to real landforms discussed in class earlier. This activity can also be done with a peanut butter and jelly sandwich representing the different layers of sedimentary rock (less modeling clay will be wasted!).

•**Art/Writing:**
2. "How are our landforms different?"
How?: Have the students draw what their landform looks like and label it (including its layers). Another idea is to have each student's landform displayed with an explanation that he/she has written that describes their landform.

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Materials needed:
Projects from part 1

Time: 30 to 45 minutes

Materials needed:
None

Time: Determined by students

"Depositing Layers" cont'd:

•**Science:**
3. "Sediment science"
How?: Discuss all of the different sediments that the students used in their landforms. Discuss how knowing different sediments, how they erode and are deposited can tell geologists many things about landforms and their formation.

•**Inquiry:**
4. "Erosional Inquiry"
How?: Try to get the students to start asking questions about geology, erosion, landforms and science. Start them off with questions like: Why is it important to know how land was formed or how it reacts to erosion? What are the real instruments used by geologists to do core sampling?

•**Arizona State Science Standards:**
1SC-E1: Identify a question, formulate a hypothesis, control and manipulate variables, devise experiments, predict outcomes, compare and analyze results, and defend conclusions

PO2: Describe the functions of variables in an investigation

1SC-E2: Create a model (e.g., a computer simulation, a stream table) to predict change

PO1: Design a model to illustrate a system

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"Landforms" Investigation 5 page 11:

Activity 20: "Tour Guides"

PLACE-BASED ACTIVITIES:
Have class design a tour of the Northern Arizona Region describing each of the landforms. Or you could have the class make a travel brochure, commercial, jingle etc of the landforms.

Have the class research the landforms around the Northern Arizona Region and create a model and topographic map. (This would tie in great with Build a Mountain)