Moving Rocks

SUBJECT: Science
GRADES: 3-8
DURATION: 30-40 minutes
ACTIVITY SUMMARY: Students will physically manipulate clay models to demonstrate changes in the Earth's crust.

OBJECTIVES:
Students will learn to:
1. Observe and represent the natural work using models such as rivers, faults, and geologic features.
2. Identify slow changes to Earth's surface.

VOCABULARY: strata, sedimentary, limestone, weathering, erosion, anticline, syncline, bedrock

MATERIALS:
For each student:
- 3-4 different colors of clay or similar material
- Piece of fishing wire
- Sheet of wax paper

BACKGROUND:

Over the last 600 million years, much of the area that is now the United States was intermittently covered with warm, shallow seas. Much of the algae and many of the sea creatures that lived in these seas had skeletons made of calcium carbonate. When they died, their remains were deposited in layers, or strata, on the sea floor. After a long time, these layered deposits became hardened and compacted into limestone. Often fossils of ancient marine creatures can be observed in the limestone as visual evidence that the rocks were once part of an ocean floor.

At varying times and locations around the globe, the crustal plates of the Earth's surface have collided, forming mountain ranges. During these collisions, termed orogenies, sedimentary strata including thick limestone layers were deformed (bent and broken) and lifted high above sea level. These upheavals also produced fractures, faults, and folds in the rocks. The upward folds are called anticlines, while the downward folds are synclines. Weathering and erosional processes at the earth's surface work continually to expose the underlying rock. Resistant rock layers stand out to form peaks while the more easily eroded rock layers, either softer or more soluble, form valleys.

Around 20 million years ago, a number of faults formed in Texas due to settling of the coastal regions. These movements created an extensive series of faults known as the Balcones Fault Zone. Underground water moving along the joints eventually carved the passages at Natural Bridge Caverns.

The activity of the ancient seas produced a variety of sedimentary rock layers in addition to limestone. One example is black shale, which generally formed from very fine-grained particles of materials deposited in very deep water. This layer of hardened clay will not readily transmit water unless broken. However, the clay minerals are very soft, and shale exposed at the surface tends to form valleys. Another common sedimentary rock, sandstone, is formed by sand grains deposited by ancient rivers and along ancient coastlines being cemented together by minerals deposited from ancient groundwater. Sandstone can vary dramatically in its resistance to erosion. In many areas of the United States, sandstone is made up of quartz sand cemented together by microscopic quartz crystals. Called orthoquartzite, this rock is very resistant to erosion, and when exposed at the surface, forms mountaintops.

Rock which has not been significantly eroded and is still connected to the underlying strata is called bedrock. The decomposition of bedrock by the forces of weathering produces a zone of weathered rocks and soil. This layer has been most affected by the forces of weathering (breaking up of rocks, both chemically and physically) and erosion (removal of the weathered materials). Wind, water, and freezing and thawing are constant contributors to the weathering and erosion processes and explain the varying sizes and shapes of sediments found within this top layer. This fairly porous layer has a relatively flat rate of water permeability when compared to the underlying bedrock.

Chemical weathering changes the minerals within the rock, typically softening and weakening them. Rainwater dissolves carbon dioxide in the air and in the soil, where it is produced by organisms and during the decay of organic material. This forms a weak acidic solution of carbonic acid that moves through the ground toward the water table. Some minerals react with the acid to make new minerals and release chemicals into solution. The best examples of this are the feldspars, a group of minerals commonly found in granites and some sandstone. Other minerals are soluble—they dissolve completely into the acidic water but at varying rates. These soluble materials include halite (table salt), gypsum, calcite, and dolomite, in order of decreasing solubility. Because halite is highly soluble, it dissolves completely when exposed at the surface except in the driest of deserts. Gypsum, calcite, and dolomite dissolve more slowly and produce a characteristic landscape (called karst) when exposed at the earth's surface. Because limestone (dominantly calcite) and dolostone (dominantly dolomite) are much more common than rock gypsum, most of the world's karst topography forms where these rocks are exposed at the earth's surface. A notable exception is the Guadalupe Mountains of New Mexico, which have karst topography developed dominantly in gypsum.

PREPARATION:
Younger students may benefit from a model prepared ahead of time as a visual aid.

PROCEDURE:
1. Tell students they will be making a model of the earth's bedrock. This will be done in three layers of different colored dough representing different layers, or beds, of sedimentary rocks. Have students soften and flatten the dough to make 3 patties about the size of their hands. Place the layers on top of each other to form a stack.
2. Have students place the stack on a sheet of wax paper so the layers will not stick to the table. Have students draw, color, and label your layers, mountain, and valley below.
3. If there is a model prepared, have students note the mountains and valleys. Explain that one way a mountain can be formed is through the slow movement of the earth's crustal plates and the resulting pressure. Have students demonstrate this by gently squeezing their layers from the sides, allowing their earth's crust to slowly fold into a new shape. Note the profile, commenting on the anticlines and synclines.
4. Have students use a piece of fishing wire to slice through the dough to reveal a cross-section of the rock layers. Students should be able to see how the rock layers form the mountains and valleys. Have students draw, color, and label your layers, mountain, valley, and fault below.
5. Take one of the cross-sections and use the fishing wire to cut it in half, perpendicular to the original cut. Have the students hold the pieces together again with the pieces off line from each other. This illustrates a fault.
6. Ask how natural weathering processes may affect the land. Look for examples of physical weathering such as erosion. Then ask how this might affect the peaks. Would the weathering and erosion, over millions of years, remove the soil (which includes broken up rocks)? Consider that valleys may be filled in or be deepened with additional erosion. Have students demonstrate the effect of erosion with the fishing wire. Starting near a peak, have them slowly cut through the layers at an angle, exposing a lower layer, and continuing into the valleys.
7. Ask for discussion of what might happen if there were any breaks or cracks in the ground or the underground rock structures. Remind students that limestone is very soluble. Ask how it may be further weathered and eroded, both through physical and chemical processes. Fill in with background as needed to bring students to the understanding that it is through this process that most passageways and caverns are eroded and dissolved in beds of limestone deposits.

Analysis Questions:
1. Name at least three changes that might happen in the earth's crust over millions of years. *(Examples include seas covering an area, depositing of layers of sedimentary rock; formation and erosion of mountains and valleys; further erosion or filling in of valleys; further weathering and erosion within top layer of rocks and soil; formation of passageways and caverns in limestone.)*
2. How might a limestone rock layer become exposed to weathering processes?
3. Why might caves form in beds of limestone?

HELPFUL HINT:
Play-Doh is softer than modeling clay and will be easier for students to manipulate.

Name: ________________________________

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Chemical weathering changes the minerals within the rock, typically softening and weakening them. Rainwater dissolves carbon dioxide in the air and in the soil, where it is produced by organisms and during the decay of organic material. This forms a weak acidic solution of carbonic acid that moves through the ground toward the water table. Some minerals react with the acid to make new minerals and release chemicals into solution. The best examples of this are the feldspars, a group of minerals commonly found in granites and some sandstone. Other minerals are soluble—they dissolve completely into the acidic water but at varying rates. These soluble materials include halite (table salt), gypsum, calcite, and dolomite, in order of decreasing solubility. Because halite is highly soluble, it dissolves completely when exposed at the surface except in the driest of deserts. Gypsum, calcite, and dolomite dissolve more slowly, and produce a characteristic landscape (called karst) when exposed at the earth's surface. Because limestone (dominantly calcite) and dolostone (dominantly dolomite) are much more common than rock gypsum, most of the world's karst topography forms where these rocks are exposed at the earth's surface. A notable exception is the Guadalupe Mountains of New Mexico, which have karst topography developed dominantly in gypsum.

PROCEDURE:

1. Soften and flatten the dough to make 3 patties about the size of your hands. Place the layers on top of each other to form a stack and place on a sheet of wax paper.
2. Gently squeeze your layers from the sides, allowing their earth's crust to slowly fold into a new shape. Draw, color, and label your layers, mountain, valley below.

3. Using a piece of fishing wire, slice through the dough to reveal a cross-section of the rock layers.
4. Take one of the cross-sections and use the fishing wire to cut it in half, perpendicular to the original cut. Hold the pieces together again with the pieces off line from each other. This illustrates a fault. Draw, color, and label your layers, mountain, valley, and fault below.

5. Would the weathering and erosion, over millions of years, remove the soil? ____________________________
6. Consider that valleys may be filled in or be deepened with additional erosion. Starting near a peak, slowly cut through the layers at an angle, exposing a lower layer, and continuing into the valleys.
7. What might happen if there were any breaks or cracks in the ground or the underground rock structures?
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8. Limestone is soluble. How may it further be weathered and eroded, both through physical and chemical processes?
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Analysis Questions:

1. Name at least three changes that might happen in the earth's crust over millions of years.

2. How might a limestone rock layer become exposed to weathering processes?

3. Why might caves form in beds of limestone?

TEKS ADDRESSED:

Science

3rd Grade

1(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations
1(B) use scientific practices to plan and conduct descriptive investigations and use engineering practices to design solutions to problems
1(C) demonstrate safe practices and the use of safety equipment during classroom and field investigations as outlined in Texas Education Agency-approved safety standards
1(D) use tools, including hand lenses; metric rulers; Celsius thermometers; wind vanes; rain gauges; graduated cylinders; beakers; digital scales; hot plates; meter sticks; magnets; notebooks; Sun, Earth, Moon system models; timing devices; materials to support observation of habitats of organisms such as terrariums, aquariums, and collecting nets; and materials to support digital data collection such as computers, tablets, and cameras, to observe, measure, test, and analyze information;
1(E) collect observations and measurements as evidence
1(F) construct appropriate graphic organizers to collect data, including tables, bar graphs, line graphs, tree maps, concept maps, Venn diagrams, flow charts or sequence maps, and input-output tables that show cause and effect; and
1(G) develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem
3(A) develop explanations and propose solutions supported by data and models
3(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and
3(C) listen actively to others' explanations to identify relevant evidence and engage respectfully in scientific discussion.
10(B) investigate and explain how soils such as sand and clay are formed by weathering of rock and by decomposition of plant and animal remains; and
10(C) model and describe rapid changes in Earth's surface such as volcanic eruptions, earthquakes, and landslides.

4th Grade

1(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations
1(B) use scientific practices to plan and conduct descriptive investigations and use engineering practices to design solutions to problems
1(C) demonstrate safe practices and the use of safety equipment during classroom and field investigations as outlined in Texas Education Agency-approved safety standards
1(E) collect observations and measurements as evidence
1(G) develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem
2(A) identify advantages and limitations of models such as their size, scale, properties, and materials
2(B) analyze data by identifying any significant features, patterns, or sources of error
2(D) evaluate a design or object using criteria.
3(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats
3(C) listen actively to others' explanations to identify relevant evidence and engage respectfully in scientific discussion
10(B) model and describe slow changes to Earth's surface caused by weathering, erosion, and deposition from water, wind, and ice

5th Grade

1A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations
1(B) use scientific practices to plan and conduct descriptive and simple experimental investigations and use engineering practices to design solutions to problems
1(C) demonstrate safe practices and the use of safety equipment during classroom and field investigations as outlined in Texas Education Agency-approved safety standards
1(D) use tools, including calculators, microscopes, hand lenses, metric rulers, Celsius thermometers, prisms, concave and convex lenses, laser pointers, mirrors, digital scales, balances, spring scales, graduated cylinders, beakers, hot plates, meter sticks, magnets, collecting nets, notebooks, timing devices, materials for building circuits, materials to support observations of habitats or organisms such as terrariums and aquariums, and materials to support digital data collection such as computers, tablets, and cameras to observe, measure, test, and analyze information;
1(E) collect observations and measurements as evidence
1(F) construct appropriate graphic organizers used to collect data, including tables, bar graphs, line graphs, tree maps, concept maps, Venn diagrams, flow charts or sequence maps, and input-output tables that show cause and effect
1(G) develop and use models to represent phenomena, objects, and processes or design a prototype for a solution to a problem.
2(A) identify advantages and limitations of models such as their size, scale, properties, and material
2(D) evaluate experimental and engineering designs
10(B) model and describe the processes that led to the formation of sedimentary rocks and fossil fuels

6th Grade

1(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations
1(B) use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems
1(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards
1(D) use appropriate tools such as graduated cylinders, metric rulers, periodic tables, balances, scales, thermometers, temperature probes, laboratory ware, timing devices, pH indicators, hot plates, models, microscopes, slides, life science models, petri dishes, dissecting kits, magnets, spring scales or force sensors, tools that model wave behavior, satellite images, hand lenses, and lab notebooks or journals
1(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence
1(F) construct appropriate tables, graphs, maps, and charts using repeated trials and means to organize data
1(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems
2(A) identify advantages and limitations of models such as their size, scale, properties, and materials
2(B) analyze data by identifying any significant descriptive statistical features, patterns, sources of error, or limitations
2(C) use mathematical calculations to assess quantitative relationships in data
2(D) evaluate experimental and engineering designs.
3(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories
3(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats
3(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence
10(C) describe how metamorphic, igneous, and sedimentary rocks form and change through geologic processes in the rock cycle

TEKS CONTINUED:

7th Grade	8th Grade
1(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations **1(B)** use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems **1(C)** use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards **1(G)** develop and use models to represent phenomena, systems, processes, or solutions to engineering problems **2(A)** identify advantages and limitations of models such as their size, properties, and materials **2(B)** analyze data by identifying any significant descriptive statistical features, patterns, sources of error, or limitations **10(A)** describe the evidence that supports that Earth has changed over time, including fossil evidence, plate tectonics, and superposition; and **10(B)** describe how plate tectonics causes ocean basin formation, earthquakes, mountain building, and volcanic eruptions, including supervolcanoes and hot spots.	**1(A)** ask questions and define problems based on observations or information from text, phenomena, models, or investigations **1(B)** use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems **1(C)** use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards **2(A)** identify advantages and limitations of models such as their size, scale, properties, and materials **2(B)** analyze data by identifying any significant descriptive statistical features, patterns, sources of error, or limitations. **2(C)** use mathematical calculations to assess quantitative relationships in data