Earth & Space Science Expo Investigation Handbook

Activity Resources for Volunteers and Elementary School Teachers

The "Earth & Space Science Expo Investigation Handbook" was created to assist volunteers with presenting science activities to the third-, fourth-, and fifth-grade students attending the annual Science Expo presented by the UC Davis Tahoe Environmental Research Center. The Science Expo is held annually each March and rotates between Earth & space science, life science and physical science thematic activities. Teachers scheduled to participate at this year's annual Science Expo event may benefit by learning more about the science presented at the Science Expo for follow-up discussions and reflection with their students.

The design and format of the handbook is as follows: Each page details a specific science investigation. Investigations are divided into three categories: Geology & Earth Science, Weather & Climate, and Space Science. Each investigation uniquely considers various aspects of Earth or space science including weather, air pressure, cloud formation, stream-modeling, groundwater modeling, geology, fossils, space science, and more. Activity descriptions include the learning objective or "Passport Question, "Materials List," "Procedure," and "Talking Points."

This handbook is designed to meet the intellectual needs of students enrolled in grades three through five as well as particular curricular standards that are determined and designated by Nevada and California departments of education. Procedures outlined in the "Earth and Space Science Expo Investigation Handbook" are for student use.

For other questions or comments, please contact Heather Segale, UC Davis Tahoe Environmental Research Center education and outreach director at hmsegale@ucdavis.edu or 775-881-7562.

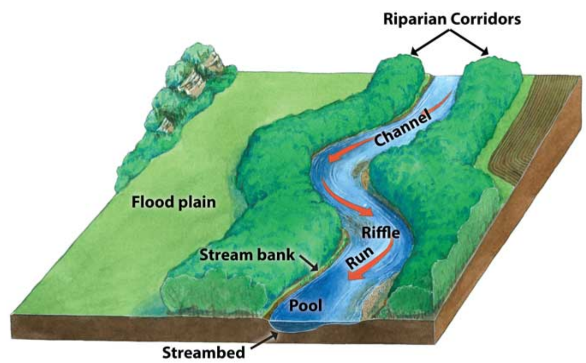
[Page blank intentionally]

Geology & Earth Science

Just Around the Riverbend

Brief Description: Students observe landforms taking shape as water flows through a streambed model.

Passport Question: Name three landforms created by water flowing over earth's surface.
Passport Answer: Answers will vary. Potential responses: alluvial fan, canyon, channel, delta, drainage basin, fjord, gorge, etc.



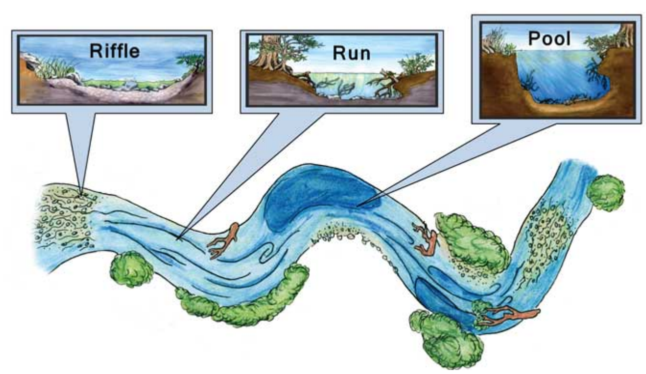
Materials:

- Streambed Table Model (with variable flow valve) – EM river2
- Water
- Bucket

Background:

- By looking at a stream model we can better understand how streams and rivers shape the Earth's landscape.
- Water naturally flows downhill, but never in a straight channel. Erosion occurs and sediment is carried downstream.
- A stream is a body of water with a current, confined within a bed and stream banks.
- Streams are important because they serve as conduits in the water cycle, instrument in groundwater recharge, and corridors for fish and wildlife migration.

Parts of a Stream:



- Confluence: The point at which two streams merge.
- Run: A somewhat smoothly flowing segment of the stream.
- Pool: A segment where the water is deeper and slower moving.
- Riffle: A segment where the flow is shallower and more turbulent.
- Stream bed: Bottom of a stream.
- Waterfall or cascade: The fall of water where the streams goes over a sudden drop.
- Mouth: The point at which the stream discharges, possibly via an estuary or delta, into a static body of water such as a lake or ocean.

Landforms Vocabulary:

- *Alluvial fan:* A fan-shaped landform deposited at the end of a steep canyon where the slope becomes flatter.
- *Canyon:* A V-shaped valley cut by a river or stream.
- *Channel:* The course a stream follows; the deepest part of a river, stream, or harbor.
- *Dam:* A construction or wall across a river that holds back the water flowing through the river, creating a reservoir or lake.
- *Delta:* A fan-shaped (triangular) deposit of earth materials at a mouth of a stream.
- *Deposition:* The process by which eroded earth materials settle out in another place.
- *Drainage basin:* A system of rivers and streams that drains an area like the Colorado Plateau.
- *Erosion:* The breakdown and removal of soil and rock by water, wind, or other forces.
- *Flash flood:* A flood that rises and falls rapidly with little or no advance warning, usually as the result of very heavy rainfall over a relatively small area. Flash floods can be caused by sudden heavy rainfall, dam failure, or the thaw of an ice jam.
- *Flood:* A very heavy flow of water, which is greater than the normal flow of water and goes over the stream's normal channel.
- *Floodplain:* Land that is covered by water during a flood, formed from sediments deposited by a river.
- *Landform:* A shape or feature of the Earth's surface, like a delta or canyon.
- *Levee:* A natural or artificial wall of earth material along a river or sea that keeps the land from being flooded. Artificial levees are built to control flooding.
- *Meander:* A curve or loop in a river.
- *Plateau:* A large, nearly level area that has been lifted above the surrounding area.
- *Sediment:* Tiny bits of rock, shell, dead plants, or other materials transported and deposited by wind, rain, or ice.

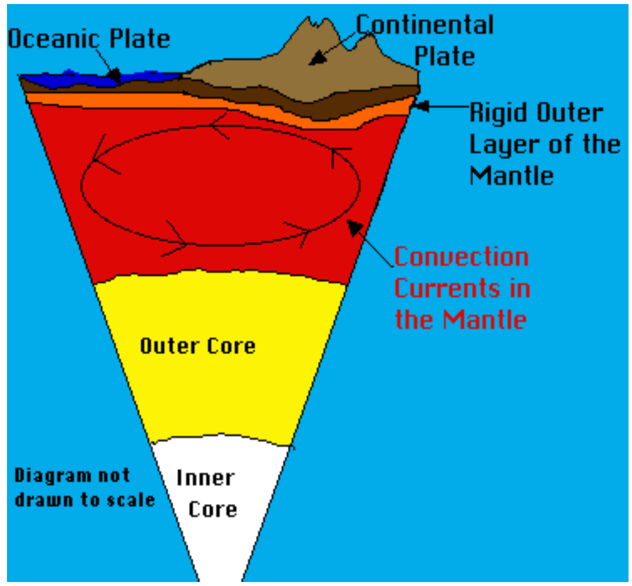
Procedure	
	Streambed model should be set-up on arrival.
1	Have students (with their hands behinds their backs or off the model) predict what shape the water is going to make in the land form.
2	Turn the valve to release the water. Have students observe the formation and flow of a stream/river.
3	Ask the students what they think will happen if the volume of water flow changes.
4	Identify the streambed channel, an alluvial fan, erosion, V-shaped valley, and meander, or ask them if they can point out the landform.

Discussion:

- Ask the students: *Where is erosion occurring? How would an increase in foliage (vegetation) affect the flow and shape of the stream? What's the difference in the size of the sediment pieces left in the streambed and those that have run off?*
    - Most erosion occurs on the outside edge of a bend in a river.
    - Increasing foliage will slow the water flow
- Ask the students: *Have you seen examples of this in real life? Where? How might erosion affect Lake Tahoe?*
    - When sediments erode and are carried into Lake Tahoe they can impact the Lake's clarity.

Modeling Convection Currents, Quakes, and Plates

Brief Description: Part 1: Students are given a demonstration on mantle convection currents. **Part 2:** Then, using sandpaper and rubber banded blocks, students learn how these mantle convection currents are the source of earthquakes, as currents drive the build-up and release of tension in tectonic plates.



Passport Question: What happens when stress and tension build up along a fault line?
Passport Answer: Earthquakes

Materials:

Part 1

- Glycerin
- Glitter
- Beaker
- Hot plate
- Crushed Ice
- Foam Continents

Part 2

- Wooden sandpaper blocks with rubber bands
- Styrofoam Fault Model
- Cardboard Plate Model
- Foam fault model

Background:

- The **upper mantle** is made of a much denser, thicker material than the mantle underneath and because of this the plates "float" on it like oil floats on water. Geologists believe that the mantle "flows" because of the convection currents.
- **Convection currents** are caused by the very hot material at the deepest part of the mantle rising to the upper mantle, then cooling. The cool material sinks back into the deep mantle where it is once again heated and rises, repeating the cycle over and over. When the convection currents flow in the mantle, they also move the crust and the tectonic plates on it. A conveyor belt in a factory moves boxes like the convection currents in the mantle moves the plates of the earth.
- Types of tectonic plate boundaries:
  - o **Convergent**: Two plates are moving towards each other. Crust is destroyed as one plate dives under another. At continental-continental boundaries, mountains are formed from the uplift of continental crust. At oceanic-continental boundaries, the oceanic plate goes under the continental plate. At oceanic-oceanic boundaries, one of the oceanic plates dives under the other.
  - o **Divergent**: This plate boundary occurs along spreading centers where plates are moving apart and new crust is created by magma pushing up from the mantle.

- **Transform (Strike-Slip)**: A plate boundary where two plates are sliding past one another.

Part 1 Procedure: Demonstration of Convection Currents	
Set-up	This demo will show convection currents within the mantle. The beaker and hot plate will be going upon arrival. The beaker is filled with glycerin and glitter. For the volunteer to add will be crushed ice to help encourage the current and two foam “tectonic plates”. These convection currents are responsible for the movement of plates and ultimately builds up stress and tension between plates.
1	Tell students this demo illustrates why stress and tension happens. The glycerin represents the mantle, the hot plate is the core, and the glitter helps show the movement of the convection currents. The glycerin should already be hot, so students can maybe already see some glitter movement.
2	Add crushed ice on top will help the glitter move back down the beaker so that the current can be observed.
3	Have students observe the movement of the foam “plates” on the surface. Ask if they know why the plates are moving on the surface of the glycerin. Discuss how this model is like the convection currents happening within the mantle.

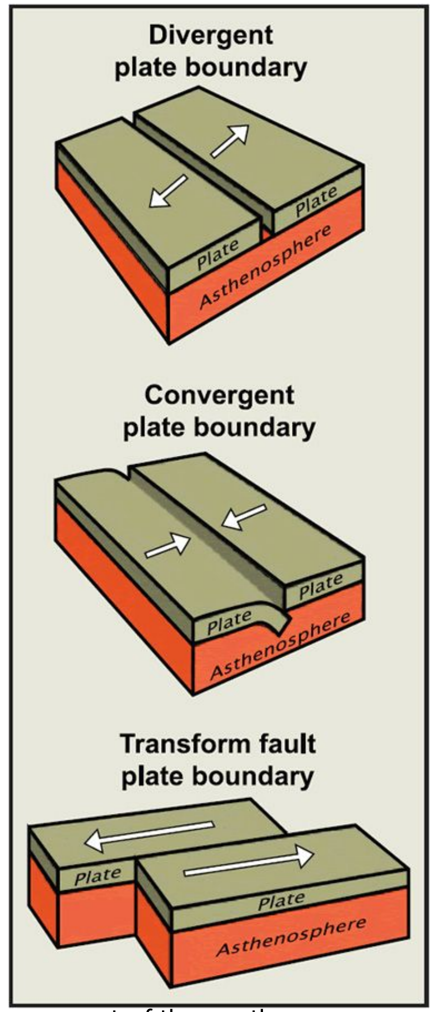
Part 1 Discussion:

- *Where does the heat that creates the convection currents come from?*
  - O The core.
- *How does the plate movement create earthquakes?*
  - O Link back to building up tension that eventually releases as an earthquake. The convection currents move plate tectonics around, and as the plates move past each other, stress and tension builds up.
- *Discuss what could happen if the convection currents were to stop.*
  - O If the currents stopped, then we could assume the outer core would solidify, causing the plates to stop moving and Earth’s climate to change. The Earth would either become extremely cold or hot, and it would be harder for life to exist on Earth.
- *How does density come into play with the magma in the convection currents?*
  - O Hot air rises when you heat it because it expands. When air expands, it becomes less dense than the air around it; the less dense hot air floats in the

more dense cold air much like wood floats on water because wood is less dense than water. Similarly, the hotter magma will rise because it has expanded and is less dense, while the cooler magma will sink because it is more dense.

Part 2: Quakes and Plates

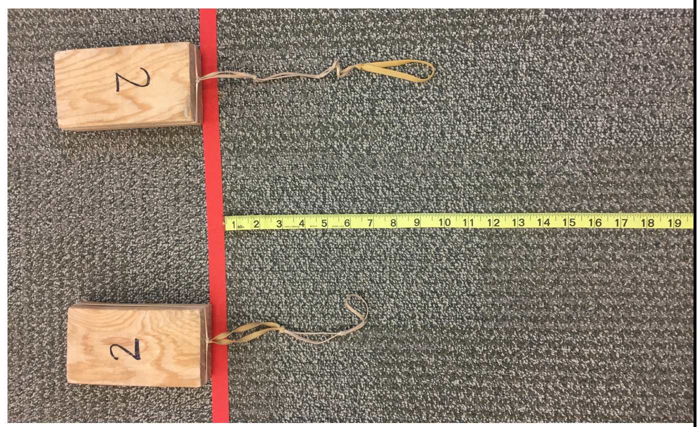
Part 2 Background for Volunteer:



- Types of tectonic plate boundaries:
  - o **Convergent**: Two plates are moving towards each other. Crust is destroyed as one plate dives under another. At continental-continental boundaries, mountains are formed from the uplift of continental crust. At oceanic-continental boundaries, the oceanic plate goes under the continental plate. At oceanic-oceanic boundaries, one of the oceanic plates dives under the other.
  - o **Divergent**: This plate boundary occurs along spreading centers where plates are moving apart and new crust is created by magma pushing up from the mantle.
  - o **Transform (Strike-Slip)**: A plate boundary where two plates are sliding past one another.

- Earthquake Vocabulary:
  - o **Seismic Wave**: Two types that move through the earth's crust and upper mantle
    - § **Primary (P) waves** are compressional waves that are longitudinal in nature. They travel at about twice the speed of secondary waves (S waves) and can travel through both liquids and solids.
    - § **Secondary (S) waves** are shear waves, so they are transverse in nature, meaning that they move perpendicular to the direction of energy transfer. They can only travel through solids.
  - o **Seismograph**: An instrument that continuously measures the movement of the earth, including those generated by seismic waves.
  - o **Elastic Rebound**: As rocks on either side of a fault shift in relation to each other, they build up energy until their internal strength is overcome and sudden fault movement occurs. This release of accumulated energy is called elastic rebound.
  - o **Friction**: This is the force resisting the relative motion of solid surfaces.

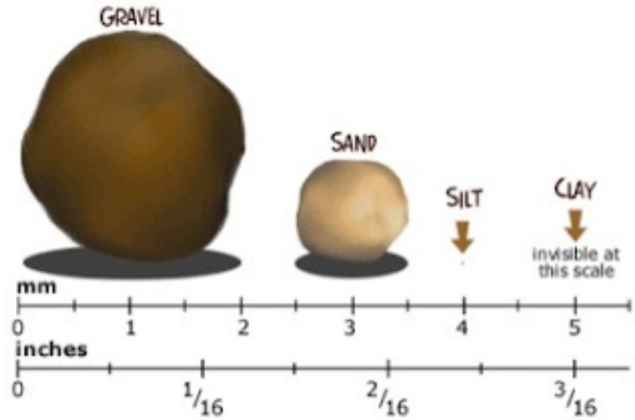
- Pieces of the earth's crust can break or fracture which releases energy. Crustal blocks can also "stick" and "slip" along a fault. When a large block "slips" it releases energy, causing an earthquake.
- Lake Tahoe was formed 2-3 million years ago when the Carson Range (East) and Sierra Nevada (West) blocks uplifted, and the blocks in-between down-dropped creating the Tahoe Basin.

	Part 2 Procedure: Earthquakes and Plate Movement
1	Ask students if they know the names of any types of continental plate boundaries **(convergent, divergent, transform)**. Use the styrofoam model to explain the 3 different types of plate boundaries. Explain how Lake Tahoe was formed. Demonstrate using the cardboard model. The movement of the plates causes stress and tension, which can result in an **earthquake.**
2	Give each student a block and place block sandpaper-side down on the carpet. Have the student's blocks side-by-side so they compete. 
3	Have students slowly pull the rubber band (attached to the block) away from the block parallel to the carpet. The block should stick at first, but eventually slide. Have students compete to see how much tension can be created before the energy releases.
4	Explain to students how greater tension build up leads to a more uncontrolled release of energy.
5	After discussing how earthquakes are the release of built up stress and tension, bring students back to the convection currents model to remind that these currents and the buildup of stress and tension are constantly occurring.

Discussion:

- *How does this model represent how an actual earthquake releases energy?*
  - Tension and stress build up until the blocks overcome friction. The blocks released energy when they slid. Earthquakes occur because of energy behind release in the crust.
- *How fast do you think tectonic plates move each year?*
  - Earth has between 10-20 crustal plates, each moving at different rates. The slowest (Eurasian Plate) moves less than an inch per year, while the fastest (Cocos Plate) grinds across the west coast of the Central America at approximately 8.55 inches per year.
  - Your nails grow approximately 1.5 inches per year.

Shake and Break Down



Brief Description: (Part 1) Students look at examples of different rock sizes and examples while learning about weathering and how this impacts rocks. **(Part 2)** Students then explore physical weathering by shaking a container of rocks to observe how they break down.

Passport Question: What are the two types of weathering? Chemical and _____.
Passport Answer: Physical

Materials:

- Part 1:
  - Large Shallow Plastic Containers of various sized granite pieces and sand
  - Sediment samples from various locations around Lake Tahoe
  - Hand Lenses
  - Microscope
- Part 2:
  - Plastic containers with large screw top lids (e.g., mayo jars, peanut butter jars, coffee jars)
  - Sediment to be shaken and broken apart
  - Multi-layer sieve
  - Baking tray
  - Towels

Background:

- **Weathering** is the breakdown of the earth's rocks, soils, and minerals caused by the earth's atmosphere. **Erosion** causes the same break down from the movement of rocks, soils, and minerals from forces like water, ice, wind, and gravity.
- There are two types of weathering: **Physical** and **Chemical**.

Vocabulary:

- *Physical (mechanical)* weathering causes changes through processes such as thermal stress, frost, or pressure which are not related to chemical changes. Wind, ice and water are also mechanisms for physical weathering because they transport materials that scour and weather other rocks. Rocks become smaller in size but are still made of the same material. Examples include wind, ice, gravity, water freezing in rocks, or plants growing in cracks of rocks.
- *Chemical* weathering changes the composition of rocks including dissolution from acid rain, hydrolysis of silicates and carbonates, and oxidation.
- *Erosion:* Moving of rock material by water, ice, wind, and even animals and humans.
- *Ice wedging:* when water between rocks freezes and forces them apart.

Part 1 Procedure: Observing Rocks to Understand Weathering	
Set-up	Display rocks will be set out on the table when volunteers arrive.
1	Have students observe the big granite rock and the granitic sand. Ask them if the two look similar. Tell them the big rock does become the sand, but ask them how they think it does. Brainstorm different types of weathering and then go over the weathering and the two types. Let students observe the different types of rocks and sand with the hand lenses and microscope.
2	Use the hand lenses and microscope to encourage students to get a closer look and see that these two rocks are in fact the same though they are different sizes.
3	Discuss how, in nature, rocks change size, shape, and form. The following discussion questions can be discussed before and after part two of the activity.

Discussion:

- *What causes physical/mechanical weathering?*
    - Ice wedging, pressure release, plant root growth, and abrasion.

- *What is an example of mechanical weathering occurring in real life?*
    - The Grand Canyon was formed by mechanical weathering (winds and the Colorado River) and erosion.
    - Soil can be created from weathered rock mixed with plant and animal remains
    - Trees' roots can break large rocks.
    - Animals that tunnel underground also work to break apart rock and soil.

- *Why is the size of the sand important in Tahoe?*
    - Granite weathers into rather large sediments that would sink to the bottom of Lake Tahoe which helps keep the lake water clear.
    - Clarity has dropped in Lake Tahoe due to an increase in fine particles and sediments (from car exhaust and pollution). You could ask students where they think these come from and what they can do to prevent that.

- *What are some factors that may affect the rate of weathering?*
    - Humidity, rainfall, temperature, and sunlight all determine how fast or slow weathering will occur. Weathering also depends on the type of rock. For instance,

limestone generally dissolves more easily in rainwater, because rainwater is becoming increasingly acidic from pollution.

Part 2: Break Down

Part 2 Procedure: Witnessing Physical Weathering Activity	
1	In the Break Down, students learn about weathering. In this activity, they will see physical weathering happen before their eyes. Talk about physical weathering and examples of physical weathering.
2	Ask students to observe the rocks. *What do the rocks look like and how do the rocks feel?* Put a couple of rocks in a plastic jar and screw the lid tightly onto the jar. Ask students to make a hypothesis about what will happen to the rocks if they shake the jar, or why do they think they are shaking it.
3	Students then shake the rocks vigorously. They will only need to shake the container for 15-30 seconds to cause enough physical weathering. Feel free to turn on high-energy music!
4	Have the students pour the contents of their container into the top layer of the sieve. Then students will shake the sieve which will cause the sediments to separate based on their size. Separate the sieve into each layer to observe the outcome. Observe the rocks now. *What do the rocks feel like and look like?*

Discussion:

- *What happened to the rocks as you continued to shake them?*
    - o They got rounder, smaller, smoother, etc.
- *What do you think would happen if you shook the rocks for several hours or several days?*
    - o The rocks would become very round and smooth. Eventually, the rocks would completely transform to sand.
- *Have students think about rocks they find at the ocean, are they usually jagged or round and smooth?*
    - o Usually smooth, due to the wave action churning rocks over and over again.
- The rocks changed size and shape due to **abrasion** - the rocks rubbed against each other- breaking small pieces of the rock off. The small grains that break off feel like sand. Over time, the rocks become rounder and smoother.

Rock Detective

Passport Question: After completing your investigation, what is one type of rock that you discovered?

Passport Answer: Answers may vary but include: Calcite, Granite, Limestone, Pumice, Quartz, or Talc

Materials:

- Complete Rock Mineral Testing Kit (6)
- Magnifying Glasses (6)
- Safety Glasses

Background:

- 3 main types of rocks:
    - **Igneous** rocks like obsidian, pumice, granite and basalt are formed through the cooling and solidification of magma or lava.
    - **Sedimentary** rocks like lime stone, sand stone, and shale are formed by the **lithification** (compaction) of sediment layers under great *pressure*. Sedimentary rocks compose 5% of the volume of the earth's crust.
    - **Metamorphic** rocks such as marble and quartzite have been changed from existing sedimentary rock types, limestone and sandstone respectively, and require *heat* and *pressure*.
- A **mineral** is a natural occurring solid with a unique and definite chemical composition.
- **Rocks** are aggregates of one or more minerals. Rocks and minerals can be identified by testing their hardness, luster, color, streak, cleavage, fracture, and specific gravity.
- Many rocks can look alike. Sometimes telling the difference between a limestone or marble and other rocks such as shale and quartzite can be difficult. Geologists use a variety of methods to determine the type, which students will experience in this experiment
    a. **Mohs Scale Scratch Test** rates mineral hardness; diamond is the hardest mineral where talc is the least hard.
    b. **Acid or "Fizz" test**. Rocks that contain calcium carbonate (limestone, oolitic limestone, coquina and marble) should "fizz". The bubbles are telling you that your rock is a limestone or contains calcite like limestone.
    c. **Float Test** gives an idea of the rock's relative density
    d. **Streak Tests** on ceramic plates give an idea as to the rock type based on the presence of a streak and the color

Procedure	
1.	Tell them that today they are going to be rock detectives!
2.	Observe the different types of rocks on the table. *Are there any rocks you don't*

	know? How would you test the rock to find out what it is? Talk about different types of tests used.
3.	Try to scratch each rock. Use your fingernail first, then the nail. Record what happened. Put an X on the chart if the rock was scratched.
4.	Put on gloves and put a very small drop of acid on each rock. *Was there a reaction?* Record what happened. Put an X on the chart if the rock reacted (bubbled).
5.	Drop the rock into the bowl of water. *Does it sink or float?* Put an X on the chart if the rock floated.
6.	Do a streak test on the ceramic plate. Run the rock lightly across the plate. *Did it leave a streak? What color was it?* Record your observations in the chart.
7.	Compare your chart to the Rock & Mineral Identification Key. *Which rocks are which?*

Discussion:

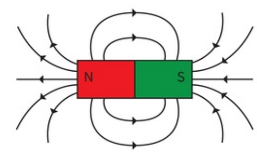
- *Which was the hardest/ softest rock?*
- To determine if various rocks are composed of dolomite or calcite, you would need to conduct an acid test. *What happens in the acid test?*
- Using a magnifying glass, observe the characteristics of other minerals and rocks. *What do you see? Why is this information useful?*
- *Were you successful in determining your rock's type?*

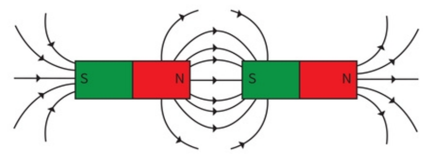
<u>Exploring Magnetic Field Lines</u>

Passport Question: Magnets have an invisible force field known as a ___________________.

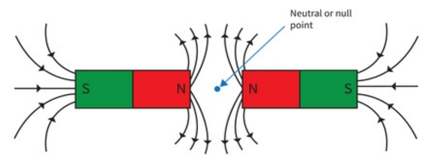
Passport Answer: Magnetic field

Magnetic Field of a Bar Magnet





Attraction between opposite poles



Repulsion between like poles

Materials:

- 2 sheets of 8.5” x 11” paper taped together lengthwise or 1 sheet of 17” x 11”
- Bar Magnet
- Compass
- Cow Magnet and Iron Filing Demo
- Cow Magnet and Magnaprobe Demo
- Magnetic Field Pattern Window Demo

Background:

- A typical magnetic compass is actually made with a tiny magnet that aligns itself with strong magnetic fields.
- Now imagine the Earth as a big bar magnet, with the poles at the North and South Poles. The pointed needle tips of our compasses are attracted to the North Pole and help us find our way no matter where we are on Earth.
- Cow magnets have a pole at each end. Farmers place them in cows’ stomach to attract nails or small pieces of iron that the cow may ingest to prevent Hardware Disease.

Procedure	
1	Ask students if they know anything about magnets (try to guide them to attraction and repulsion). Use the red and blue magnets to explain that, and then the magnaprobe to prove there are poles on the cow magnet. Ask students what it means when it flips form side to side.
2	Use the magnetic field pattern window to demonstrate a magnet’s magnetic field. Have students list some magnets that they know of; ask them what’s the biggest magnet they know (bigger than the moon?).
3	Tell students that you have a game for them. Ask students if they know what a compass is made of. Explain to them that a compass has a tiny magnet inside and that they will use a compass to trace out the magnetic field of a magnet. Divide up the magnets and compasses between the students. *Ask them what they think will happen if they put a compass next to a magnet, what will happen when they take the compass further away, and what will happen when they put it close to a different part of the magnet.*
4	Tape the bar magnet in the center of the two sheets of paper.
5	To make the tracing, have students do the following:

	• Place the compass somewhere around, but not touching the magnet. • Draw a dot where the compass needle points away from the magnet. • Now move the center of the compass directly over the dot that was just drawn. • Draw a new dot where the compass needle points away from the magnet. • Continue to move the center of the compass over the recently drawn dot. • Draw a line to connect the draw dots to show how the magnetic field moves. • Repeat the steps above until the other end of the line meet the magnet or paper edge. • When finished with the first line, pick another spot near the magnet and repeat the process to trace more field lines.

Discussion:

- *Have you used a compass before? Discuss your experience/ how it helped/ how you think it could be useful for others.*
- *Discuss how magnets are used in the "real world."*
    - In electrical motors, generators, and speakers
    - Sort magnetic and non-magnetic substances from scrap
    - In TV screens, computer screens, and telephones
    - Used in refrigerator to keep the door close
- *If you were standing on the North Pole, where would your compass point?*
    - There are actually TWO North Poles- one at the top of the earth (North Pole) and one that is known as Magnetic North- and two south poles.
    - At the North Pole, if you hold the compass horizontally the needle which is supposed to point north will point south, toward the north magnetic pole (which is in northern Canada). If you were standing exactly on top of the magnetic north pole, your compass would point nowhere in particular since the place it is used to pointing to is at your feet.

Discovering Fossils

Brief Activity Description: Part 1: Students mimic paleontologists and dig through diatomaceous Earth to learn how fossils are formed and understand the "story" of sedimentary layers. **Part 2** Then students recreate the process of fossilization using bread, gummy candies, and lots of pressure.

Passport Question: What is evidence of past life preserved on Earth?
Passport Answer: Fossils

Materials:

- Diatomaceous Earth
- Fossil examples from diatomaceous Earth
- Fossil example images and models
- Paper towels
- 3 half slices of bread (one of white, wheat, and rye)
- Gummy candy fish (Swedish Fish)
- Magnifying lens
- Clear drinking straws
- 2 large wooden boards (one for a base, one for a top)

Background:

- Paleontologists are scientists who study fossils to understand ancient landscapes, climate, and life on Earth. **Paleontology** is the study of prehistoric times through the discovery and interpretation of fossils. Paleontologists search for and collect fossilized clues to piece together a picture of the environment and ecosystems of the distant past. As a historical science, paleontology incorporates mainly biology (the study of plants and animals) and geology (the study of rocks) to puzzle together facts to explain the past. In contrast, experimental scientists conduct experiments in order to disprove hypotheses.
- Fossils provide information about the environmental conditions that existed when the fossil organism was alive, as well as where, when, and how the organism lived.
- Fossils are formed by various ways. The dead organism can be preserved in amber (hardened tree resin), peat bogs, tar pits, or in ice. Casts or impressions (such as foot prints) could be covered by layers of sediments, which eventually become rocks preserving the casts.

Fossil Discovery Procedure	
1	Students can touch the sediment in the large boxes of diatomaceous Earth. Show students the layers of this earth and where fossils could be found in these samples.

2	Show students some of the examples of fossils that have been found in this earth as well as some of the other fossil models that we have. Explain how sediments layer over time and show us geologic history.
Fossil Formation Procedure	
1	Place a piece of white bread (which represents the sandy ocean floor) on the paper towel. Put a gummy fish on the bread to represent dead marine life (say a whale from a million years ago). Place a piece of rye bread on the white (which represent sediment deposited by ocean currents), and a piece of wheat bread on top (which represents more sand and sediment deposited by wind and ocean currents over the millions of years). 
2	Fold the paper towel to cover your bread fossil. Have students guess the two missing ingredients to make a fossil **(time and pressure)**. Place the bread between two wooden boards. Have students stand on it, to simulate the natural process of pressure over the millions of years.
3	Have students observe the bread fossil. Gently push the clear, glass straw straight down the bread and pull it back up to “extract” a core sample. Volunteer should use the straw so students don’t break the glass. Observe the layers through the straw. Ask them what the different layers or colors represent.
4	Have them try to separate the layers of the bread. *Ask them why they think the layers are difficult to separate.* Have them try to extract the fish. *Can they identify the fish fossil’s mold (impression in the bread)? How about the fossil’s cast, which is the mineral material that fills the hole left when the fossil is gone?*

Discussion:

- *What can fossils tell us?*
- *How are fossils formed?*
- *What qualities should a paleontologist have to be successful at finding and excavating fossils?*
- *What did you enjoy about the process of “digging out” your fossils?*
- *What is another name for gasoline?* Fossil fuel.
- *How are fossil fuels formed?* Through pressure on decaying living organisms over long periods of time in geologic history.

Volcano Loco

Brief Activity Description: Students discover how magma composition and the structure of volcanoes affect magma flows by simulating various eruptions with paper cones over dry ice.

Passport Question: Which type of volcano erupts most violently?

Passport Answer: Composite Volcanoes

Materials:

- Dry Ice, Scotch tape, warm water, scissors, small beaker or cups, globes, brown construction paper, supplemental images, water, honey, pipettes

Background:

Earth's Layers:

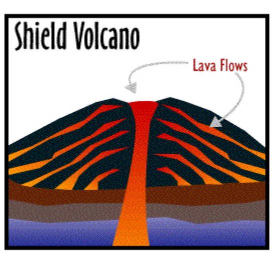
- **Crust**: The crust is the outermost layer of the earth, comprising the continents and ocean basins. It has a variable thickness, anywhere from 35-70 km in the continents and 5-10 k in the ocean basins.
- **Mantle**: Just under the crust is the mantle. It is composed mainly of dense ferro-magnesium silicates (iron, magnesium, and silicon). It is about 2900 km thick and is separated into the upper and lower mantle. This is where most of the internal heat of the Earth is located. Large convective cells in the mantle circulate head heat and may drive plate tectonic processes.
- **Inner and Outer Core**: There are two very distinct parts of the core; the outer and inner core. The outer core is 2300 km thick and the inner core is 1200 km thick. The outer core is composed mainly of nickel-iron alloy, while the inner core is almost entirely composed of iron. The outer core contains as much as 10% lighter elements than iron alloy. The inner core is thought to rotate at a different speed than the rest of the Earth and which contributes to the presence of the Earth's magnetic field.

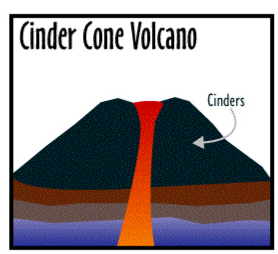
Volcano Formation: Sometimes high temperatures and pressure cause the mantle to melt and become *magma*. When a large quantity of magma forms, it moves up to the surface through the crust, and then releases pent-up gas and pressure that makes the volcano erupt. Once magma escapes to the Earth's surface, air or water turns the magma into *lava*.

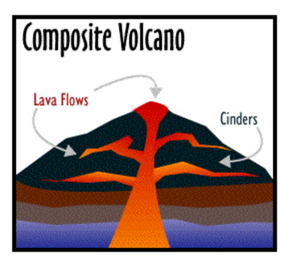
Magma Types: There are many different types of magma. They produce different types of lava ranging from fluid, fast moving basalt to slower, thicker, vicous lava. Since rocks are made of different materials that melt at different temperatures, the type of rock that is melted in the mantle will affect the magma that results, and therefore the lava that erupts from volcanoes.

Types of Volcanoes:

- **Composite Cone Volcanoes** (Strato volcanoes) have some of the most explosive eruptions. The volcano is built of andesite or







rhyolite lava, cinders and ash, and the overall size of the volcano tends to increase after an eruption. Strato volcanoes have very steep sides as a result of the viscous lava that builds up high pressures and stacks high on top of itself.

- **Cinder Cone Volcanoes** are named so because they were formed by lava fragments called cinders. This type of volcano only has one vent in which the magma can flow, unlike the composite and shield volcanoes. Since there is only one vent from which the magma can escape, the lava fragments burst into the air and then fall around the vent of the volcano. These volcanoes also have steep sides, but they are typically smaller than composite or shield volcanoes.
- **Shield Cone Volcanoes** got their name because they look like shields due to their gentle sloping sides. These gentle slopes are a result of the thin, runny lava that erupts out and spills over large distances. As the lava erupts more readily without massive pressure build-up, their eruptions usually have enough time for animals and people to move to safety. Shield Volcanoes can be some of the largest volcanoes in the world.

Vocabulary:

- **Ash**: Fragments of volcanic rock that explode from the vent of a volcano in solid or molten form.
- **Eruption**: The process that ejects solid, liquid, and gaseous materials onto the Earth's surface and into the atmosphere by volcanic activity. These eruptions can range from violent explosions to quiet overflow of magma.
- **Lava**: Magma that is exposed to air or water on the Earth's surface.
- **Magma**: Hot, molten rock that forms beneath the Earth's surface.
- **Magma Chamber**: The chamber where the rising magma is collected before a volcano erupts.
- **Vent**: An opening from which volcanic material is released.

Procedure	
1	Ask students if they know how a volcano erupts. Talk about the layers of the earth and how high temperature and pressure pushes the magma up as it is a lower density (similar to air pressure if they've done those activities). Now tell students to find two differences in the three volcanoes (the difference in slope and size of the opening). They can build their own volcanoes to see how different volcanoes erupt differently.
2	Using paper, scissors, and tape make cones of varying size to model conic and shield volcanoes. Use images as examples. Use laminated volcanoes as examples or for quick use. Optional: while students make their volcanoes, illustrate how lava of 2 different viscosities erupts by using water and honey in 2 different pipettes onto a plate.
3	Prediction: How do you think the shape of the volcano is related to the type of eruptions that formed it? Which volcano will produce the more explosive eruption, and how will its shape contribute to that?
4	Place the paper cones over the beaker with dry ice and warm water to observe the "lava" behavior and compare to your predictions.

Discussion:

- Observations: *What do you observe about the eruption? Why do you think they look different based on the shape of the volcano?*
- *Which volcano do you think had the most explosive eruption and why?*
    - Composite Cone Volcanoes are steep sided and have some of the most explosive eruptions.

Shaky Sediments

Passport Question: Liquefaction is when wet ground temporarily loses strength and acts like a liquid during an earthquake. (Circle one)

Passport Answer: True

Materials:

- Large plastic tub
- Several pounds of fine-grained sand
- Water
- Large spoon/spatula
- Extra sediment
- Ping-pong balls
- Brick/weight to represent a building
- Rubber mallet

Background:

- Soil **liquefaction** occurs when a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress such as shaking during an **earthquake** or other sudden change in stress condition, in which material that is ordinarily a solid behaves like a liquid.
- Sands feel solid because grains touch and support each other. Between the sand grains are pores—empty spaces that make up to 50 percent of the volume of the sand. Porosity or **pore space** refers to the volume of soil voids that can be filled by water and/or air. Often, these spaces are filled with water, called groundwater.
- Soil liquefaction is most often observed in saturated, loose (low density or uncompacted), sandy soils. This is because a loose sand has a tendency to compress when a load is applied.
- When loose or unconsolidated sediments are shaken, they try to settle into new positions. However, when seismic waves from an earthquake hit an area, the sand and water are rapidly compressed. This can cause the water pressure in the ground to go up significantly. Ground failure happens when this high-pressure water causes a reduction of friction between sand grains. When grain-to-grain contact is lost, sediments can flow like liquid. This phenomenon is called **liquefaction.**
- **Seismic waves** occur during an earthquake in the Earth's crust and upper mantle. The shaking caused by these waves can lead to liquefaction.
- In the case of the weight "building", liquefaction causes uneven support of the base, so it topples over. As for the ping-pong ball "storage tank," its density is less than that of the surrounding sediments. It's held underground by the weight of the solid sediments above—until an earthquake takes place. If the sediment undergoes liquefaction, the buoyancy of the ping-pong ball causes it to float up and through the temporarily liquid sediment.

Procedure: Demonstrating liquefaction as a result of an earthquake	
Set-up	1. Pour sand and water together into your basin. There should be enough sand to make a layer several centimeters thick, and just enough water to soak through the sand. Mix thoroughly and adjust your mixture so that all your sand is damp with no visible puddles. 2. On one side of the pan, use your spoon to scoop out a hole in the damp sand. Then place the ping-pong ball inside the hole. This will represent an underground storage tank. 3. Cover the ping-pong ball (but not too deep), flattening and smoothing out the damp sand to make sure the ball is not visible. 4. On the other side of the pan, wiggle the skinny end of the weight into the sand so it stands up like a building would.
1	Begin by asking students to tell you if they know of anything that happens during earthquakes. Some may respond with buildings falling down. If not, tell them that this is something that can happen when earthquakes happen. Ask them to predict why this might happen.
2	The container and sediment should be prepared before the volunteer arrives, but will need to be reset after each demonstration. The demo can be reset by using the spoon to “fluff” the sediment. This will unconsolidate the soil. There is a weight representative of a building as well as a ping-pong ball buried in the sediment to demonstrate how man-made objects such as pipes and water tanks can be unearthed when liquefaction occurs. It’s a fun surprise for students to not know the ping pong ball is buried, so try to reset the ball discreetly.
3	Gently and repeatedly tap the side of the bin with the mallet. Ask students to observe what happens to the sand, the brick, and anything else that may appear in the bin (the ping pong ball). The tapping causes the grains of sand to try to resettle and increases the water pressure in the pore space between the grains of sand. This results in the sediment appearing and acting as a liquid. The “building” may topple over or sink into the sediment.
4	“Fluff” the sediment to reset the demonstration. Rebury the ping pong ball. Show the students the demonstration multiple times as you talk through what is happening with the sediments.

Discussion:

- Observations: *What do you observe happen during the earthquake?*
  - *How did the surface of sand change?*
  - *Did your building topple over?*
  - *Did anything emerge out of the sand?*
- *If you had to build in this sort of wet sand, what would you do to keep your building up?*