

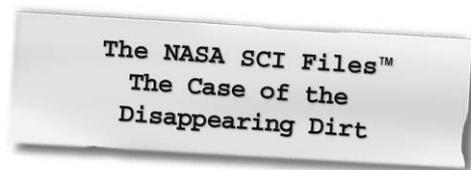


National Aeronautics and
Space Administration

Langley Research Center
Hampton, VA 23681-2199

Educational Product	
Educators	Grades 3-5

EG-2003-12-18-LARC



**A Lesson Guide with Activities in
Mathematics, Science, and Technology**

Please Note: Our name has changed! The NASA "Why" Files™ is now the
NASA Science Files™ and is also known as the NASA SCI Files™.

<http://scifiles.larc.nasa.gov>



The Case of the Disappearing Dirt lesson guide is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: <http://spacelink.nasa.gov/products>

A PDF version of the lesson guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site: <http://scifiles.larc.nasa.gov>

The NASA Science Files™ is produced by the NASA Center for Distance Learning, a component of the Office of Education at NASA's Langley Research Center, Hampton, VA. The NASA Center for Distance Learning is operated under cooperative agreement NCC-1-02039 with Christopher Newport University, Newport News, VA. Use of trade names does not imply endorsement by NASA.



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www.nec.com



www.cnu.edu



www.swe.org



www.sbo.hampton.k12.va.us

The NASA SCI Files™
The Case of the
Disappearing Dirt

**A Lesson Guide with Activities in
Mathematics, Science, and Technology**

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For additional information about the NASA SCI Files™, contact Shannon Ricles at (757) 864-5044 or s.s.ricles@larc.nasa.gov.

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Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail kimlien.vu@swe.org

Captioning provided by NEC Foundation of America



Program Overview

In *The Case of the Disappearing Dirt*, the tree house detectives are puzzled when they realize that some of their beach is missing! With the upcoming beach volleyball tournament, the detectives realize how important it is to find and replace the missing sand because the missing sand could cost the city thousands of dollars! Dr. Textbook informs the detectives that sand is a mineral, so they head to the Houston Museum of Natural Science where they visit Mr. Joel Bartsch to learn about the properties of minerals and how to identify them. During a quick stop at Dr. D's lab, the tree house detectives also discover how the multiple Earth systems all work together. With no answer to the problem in sight, the detectives decide that more research is necessary.

As the tree house detectives continue their research, Kali goes to NASA Johnson Space Center in Houston, Texas where she talks to Mr. John Gruener about plate tectonics. With the help of some very edible props, Kali learns how Earth recycles its materials to create new rocks and minerals. Next stop is the Lunar Lab, where Kali visits Ms. Andrea Mosi and is invited to view some extra special rocks! Ms. Mosi also discusses the three types of rocks found on Earth and explains how the rock cycle works.

Tony and Dr. D go to Alaska for the Salmon Fishing Derby. While enjoying the rugged beauty of Alaska, Dr. D explains the differences between mechanical and chemical weathering. The tree house detectives begin to put the pieces together, but the answer to the beach erosion problem still eludes them, so once again they decide to do additional research.

As the quest to solve the mystery of the missing sand continues, Tony offers to help by going to Mountain View Elementary School in Anchorage, Alaska to learn how mountains are formed. Now that the detectives know how mountains are built, they decide that they need to learn how mountains are broken down. So Tony is off again, this time to talk with Dr. Kristine Crossen at Exit Glacier near Anchorage about the various processes of weathering and erosion. Meanwhile, the detectives back at the beach continue to practice for the upcoming volleyball tournament while Tony enjoys the fishing derby and even learns how to ride a dog sled!

Finally, after much research, the tree house detectives think they have solved the problem, and they begin looking for any new obstructions that could have caused the beach erosion. When they don't find any new structures, they become discouraged but decide to go back to the problem board one more time. The detectives all agree to do just a little more research, and soon they find an article about some very "hot spots" on the beach. The detectives visit Dr. Jesse McNinch at the Virginia Institute of Marine Science (VIMS), and he shows them the new amphibious vehicle VIMS uses in beach research.

With a triumphant "splash," the detectives solve the case and go to share their findings with Dr. D. Now that they finally understand what caused the beach erosion, the detectives get ready for their volleyball tournament, with the hopes of playing well and maybe even winning a few games!

National Science Standards (Grades K - 4)

Standard	Segment			
	1	2	3	4
Unifying Concepts and Processes				
Systems, orders, and organization	x	x	x	x
Evidence, models, and explanations	x	x	x	x
Change, constancy, and measurement	x	x	x	x
Form and Function	x	x	x	x
Science as Inquiry (A)				
Abilities necessary to do scientific inquiry	x	x	x	x
Understanding scientific inquiry	x	x	x	x
Physical Science (B)				
Properties of objects and materials	x	x	x	x
Life Science (C)				
Organisms and their environments	x	x	x	x
Earth and Space Science (D)				
Properties of Earth materials	x	x	x	x
Changes in Earth and sky	x	x	x	x
Science in Personal and Social Perspective (F)				
Type of resources	x	x	x	x
Changes in environment	x	x	x	x
Science and technology in local challenges	x	x	x	x
History and Nature of Science (G)				
Science as a human endeavor	x	x	x	x



National Science Standards (Grades 5 - 8)

Standard	Segment			
	1	2	3	4
Unifying Concepts and Processes				
Systems, order, and organization	×	×	×	×
Evidence, models, and explanations	×	×	×	×
Change, constancy, and measurement	×	×	×	×
Form and function	×	×	×	×
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	×	×	×	×
Understanding scientific inquiry	×	×	×	×
Physical Science (B)				
Properties and changes of properties in matter	×	×	×	×
Motions and forces	×	×	×	×
Transfer of energy	×	×	×	×
Earth and Space Science (D)				
Structure of the Earth system	×	×	×	×
Earth's history	×	×	×	×
Science and Technology (Content Standard E)				
Abilities of technological design	×	×	×	×
Understanding science and technology	×	×	×	×
Science in Personal and Social Perspectives (Content Standard F)				
Science and technology in society	×	×	×	×
History and Nature of Science (Content Standard G)				
Science as a human endeavor	×	×	×	×
Nature of science	×	×	×	×

National Mathematics Standards (Grades 3 – 5)

Standard	Segment			
	1	2	3	4
Number and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems.	x			
Understand meanings of operations and how they relate to one another.	x			
Compute fluently and make reasonable estimates.	x			
Algebra				
Understand patterns, relations, and functions.	x			
Analyze change in various contexts.	x	x	x	x
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	x	x	x	x
Apply appropriate techniques, tools, and formulas to determine measurements.	x	x	x	x
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	x	x	x	x
Develop and evaluate inferences and predictions that are based on data.	x	x	x	x
Problem Solving				
Build new mathematical knowledge through problem solving.	x	x	x	x
Solve problems that arise in mathematics and in other contexts.	x	x	x	x
Apply and adapt a variety of appropriate strategies to solve problems.	x	x	x	x
Monitor and reflect on the process of mathematical problem solving.	x	x	x	x
Communication				
Analyze and evaluate the mathematical thinking and strategies of others.	x			
Connections				
Recognize and apply mathematics in contexts outside of mathematics.	x			



International Technology Education Association (ITEA Standards for Technology Literacy, Grades 3 – 5)

Standard	Segment			
	1	2	3	4
Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	x	x	x	x
Standard 2: Students will develop an understanding of the core concepts of technology.	x	x	x	x
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	x	x	x	x
Technology and Society				
Standard 6: Students will develop an understanding of the role of society in the development and use of technology.	x	x	x	x



National Technology Standards (ISTE National Educational Technology Standards, Grades 3 - 5)

Standard	Segment			
	1	2	3	4
Basic Operations and Concepts				
Use keyboards and other common input and output devices efficiently and effectively.	x	x	x	x
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	x	x	x	x
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and their advantages.	x	x	x	x
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.	x	x	x	x
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x	x	x	x
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x	x	x	x
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	x	x	x	x
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	x	x	x	x
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	x	x	x	x
Use technology resources for problem solving, self-directed learning, and extended learning activities.	x	x	x	x
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	x	x	x	x
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	x	x	x	x
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	x	x	x	x



National Geography Standards, Grades 3 - 5

Standard	Segment			
	1	2	3	4
The World in Spatial Terms				
Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information	×	×	×	×
Places and Regions				
Standard 4: The physical and human characteristics of places	×	×	×	×
Standard 5: That people create regions to interpret Earth's complexity	×	×	×	×
Standard 6: How culture and experience influence people's perception of places and regions	×	×	×	×
Physical Systems				
Standard 7: The physical processes that shape the patterns of Earth's surface	×	×	×	×
Human Systems				
Standard 10: The characteristics, distributions, and complexity of Earth's cultural mosaics	×	×		
Environment and Society				
Standard 14: How human actions modify the physical environment	×	×	×	×
Standard 15: How physical systems affect human systems	×	×		
The Uses of Geography				
Standard 17: How to apply geography to interpret the past	×	×	×	×
Standard 18: How to apply geography to interpret the present and plan for the future	×	×	×	×

The NASA SCI Files™
The Case of the
Disappearing Dirt

Segment 1

While practicing for an upcoming beach volleyball tournament, the tree house detectives discover that the sand on their beach is disappearing! Replacing the sand is just too expensive, so the detectives decide that they must investigate this mystery. First, Dr. Textbook helps them to understand where sand comes from and then they set off to the Houston Museum of Natural Science to check out some amazing minerals with Mr. Joel Bartsch. Next stop is Dr. D's lab, where they learn about the various Earth systems and how they all work together.

Objectives

The student will

- analyze the origins of sand and investigate the connection between parent rocks and sand.
- identify the crystal systems found in minerals.
- observe crystal growth.
- distinguish between rocks and minerals based on physical appearance.
- identify minerals based on their specific gravity, hardness, and streak color.
- interpret the chemical formulas of minerals.
- demonstrate how minerals are extracted from the rock that contains the mineral.
- understand the uses of rocks and minerals.
- investigate the biology of a tide pool habitat.

Vocabulary

atmosphere – thin blanket of air surrounding the Earth, containing gases (oxygen, nitrogen, and trace gases), solids, and liquids that affect the Earth's climate

biosphere – the part of the world in which life such as plants and animals can exist

crystal – a solid having a distinctive shape because its atoms are arranged in repeating patterns

gem – a mineral highly prized because it is rare and beautiful

geosphere – the physical elements of the Earth's surface, crust, and interior

high tide – the highest level of the tide; the time when the tide is highest

hydrosphere – the surface waters of the Earth and the water vapor in the atmosphere

low tide – the lowest level of the tide; the time when the tide is lowest

mineral – a naturally occurring, nonliving solid with a definite structure and chemical composition

ore – minerals or rocks that contain a useful substance, such as a metal, that can be mined at a profit

sand – loose material in grains produced by the natural breaking up of rocks

system – a group of objects or units that combine to form a whole and that work together

tide – the periodic change in the surface level of the oceans due to the gravitational forces of the Sun and Moon on Earth



Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 1 of *The Case of the Disappearing Dirt*, read the program overview (p. 5) to the students. List and discuss questions and preconceptions that students may have about sand, beach erosion, minerals and their formation, and systems.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them better understand the problem. The following tools are available in the "Educators" area of the NASA SCI Files™ website. To locate them, click on the "Educators" menu bar on the home page, then click on "Tools" and then "Instructional Tools." You will find them listed under the "Problem-Based Learning" tab.

Problem Board—Printable form to create student or class K-W-L chart

Guiding Questions for Problem Solving—Questions for students to use while conducting research

Problem Log & Rubric—Printable log for students with the stages of the problem-solving process

Brainstorming Map—Graphic representation of key concepts and their relationships

The Scientific Method and Flowchart—Chart that describes the scientific method process

3. Focus Questions—Questions at the beginning of each segment that help students focus on a reason for viewing. These questions can be printed ahead of time from the "Educators" area of the web site in the "Activities/Worksheet" section under "Worksheets" for the current episode. Students should copy these questions into their science journals prior to viewing the program. Encourage students to take notes while viewing the program to answer the questions. An icon will appear when the answer is near.

4. "What's Up?" Questions—Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These questions can be printed from the "Educators" area of the web site in the "Activities/Worksheet" section under "Worksheets" for the current episode.

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Disappearing Dirt* in 15-minute segments and not in its entirety. If you are watching a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about sand, beach erosion, minerals and their formation, and systems. Have the students conduct research on minerals and how minerals turn into sand. Brainstorm for ideas about how sand is deposited onto beaches and what could be causing it to disappear on the tree house detectives' beach. As a class, reach a consensus on what additional information is needed. Have the students conduct independent research or provide students with the information needed.
4. Have the students complete Action Plans, which can be printed from the "Educators" area or the tree house's "Problem Board" area in the "Problem-Solving Tools" section of the web site for the current online investigation. Students should then conduct independent or group research by using books and Internet sites noted in the "Research Rack" section of the "Problem Board" area in the tree house. Educators can also search for resources by topic, episode, and media type under the "Educators" main menu option "Resources."



5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students “solve” the problem along with the tree house detectives.
6. Have the students work individually, in pairs, or in small groups on the problem-based learning (PBL) activity on the NASA SCI Files™ web site. To locate the PBL activity, click on the tree house and then the “Problem Board.” Choose the “2003–2004 Season” and click on “Coasting Away.”
 - To begin the PBL activity, read the scenario (“Here’s the Situation”) to the students.
 - Read and discuss the various roles involved in the investigation.
 - Print the criteria for the investigation and distribute.
 - Have students begin their investigation by using the “Research Rack” and the “Problem-Solving Tools” located on the bottom menu bar for the PBL activity. The “Research Rack” is also located in the tree house.
7. Having students reflect in their journals what

they have learned from this segment and from their own experimentation and research is one way to assess student progress. In the beginning, students may have difficulty reflecting. To help them, ask specific questions that are related to the concepts.

8. Have students complete a “Reflection Journal,” which can be found in the “Problem-Solving Tools” section of the online PBL investigation or in the “Instructional Tools” section of the “Educators” area.
9. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Careers

gemologist
jeweler
miner
mineralogist
museum curator



Resources

 (additional resources located on web site)

Books

Demas, Corrine: *Disappearing Island*. Simon and Schuster, 1999, ISBN: 068980539X.

Fuller, Sue and Christopher Maynard: *Backpack Books: 1,001 Facts about Rocks and Minerals*. DK Publishing, Inc., 2003, ISBN: 0789490439.

Jacobs, Marian: *Why Do the Oceans Have Tides?* Rosen Publishing Group, 2003, ISBN: 082395272X.

Kittinger, Jo S.: *Look at Minerals: From Galena to Gold*. Scholastic Library Publishing, 1999, ISBN: 0531159256.

Murphy, Stuart J.: *Super Sand Castle Saturday: Measuring*. Harper Collins Children's Books, 1998, ISBN: 0064467201.

Prager, Ellen: *Sand*. National Geographic Society, 2000, ISBN: 0792271041.

Ricciuti, Edward: *National Audubon Society First Field Guide to Rocks and Minerals*. Scholastic, Inc., 1998, ISBN: 0590054848.

Squire, Ann: *Growing Crystals*. Scholastic Library, 2001, ISBN: 0516269844.

Symes, R.F.: *Eyewitness: Rocks and Minerals*. DK Publishing, Inc., 2000, ISBN: 0789458047.

Symes, R.F. and R. Harding: *Eyewitness: Crystal and Gem*. DK Publishing, Inc., 2000, ISBN: 0789457644.

Video

Eyewitness: Rocks and Minerals

Web Sites

Mineral Gallery

This web site provides detailed information, color pictures, and classifications of minerals found throughout the world.

http://mineral.galleries.com/minerals/by_name.htm

USGS: Mineral Information

Use this web site to find statistics and information on worldwide supply, demand, and flow of minerals and materials essential to the U.S. economy, the national security, and protection of the environment.

<http://minerals.usgs.gov/minerals/>

The Dragon's Cave Mineral Search

Enter the Dragon's Cave to find and learn all about this dragon's unusual collection of Earth's natural treasures: minerals. The Mineralogical Society of the United Kingdom hosts this site.

http://www.minersoc.org/pages/education/dragons_cave/entercave.html

Women in Mining: Mineral Resources for Teachers

This site, sponsored by Women in Mining, is dedicated to educating students, teachers, and the general public about the importance of minerals and contains an outstanding collection of hands-on activities.

<http://www.womeninmining.org/>

Mineral Information Institute (MII)

The purpose of MII's educational programs is to help teach students about the importance of our natural resources. Through these free educational resources, students will learn how we use these resources every day. The site also includes homework help for students.

<http://www.mii.org/>

SeaWorld/Busch Gardens Sand Lab

Investigate sand from different locations and classify it according to a sand key. Use a series of web sites to help learn more about sand.

<http://www.seaworld.org/just-for-teachers/lisa/i-024/pdf/4-8.pdf>

National Geographic for Kids: Crazy Crystals

Grow some amazing crystals with the help of an adult.

<http://www.nationalgeographic.com/ngkids/trythis/tryfun1.html>

Earth Science Lessons

This site contains a collection of earth science activities for elementary students that was written by members of the Volcano World Educational Team. A link to a mineral gallery is also available.

<http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/lesson.html>

NASA: Earth Observatory

Visit this web site to learn more about the atmosphere, hydrosphere, biosphere, geosphere, and the cryosphere and how they all work together to form a system.

<http://earthobservatory.nasa.gov/odysseyofthemind/index.html>

Activities and Worksheets

In the Guide **Sandbox Stories**

Explore the differences in sand samples by looking at the size, shape, and color of the sand grains.19

Crystallizing Crystals

Make models of the six crystal structures found in common minerals.20

Rock or Mineral?

Learn to tell the difference between a rock and a mineral in this tasty activity.22

“Mocking” Minerals

Learn about the chemical makeup of minerals as you make your own edible minerals.23

There’s Iron in My Cereal?

Find out what it means to have “iron fortified” foods in this magnetic activity.26

Answer Key

.....27

On the Web **Magic Salt Crystal Garden**

Grow some amazing crystals using common household materials.

Getting Specific About Minerals

Using simple tests for hardness, streak color, and specific gravity, identify unknown mineral samples.

Calling All Systems

Learn about the various Earth systems and how they work together.



Sandbox Stories

Purpose

To analyze the origin of sands

Background

Sand grains form when an existing rock is destroyed by weathering and erosion. Sand is identified by composition, grain size, roundness, and sorting. Since sand comes from a “parent rock” or source rock, it is possible to determine what kind of rock produced the sand. Some sands, such as the black lava beaches in Hawaii or the white sands of New Mexico, are distinctive because of their color. Sand can also be identified by the grain roundness. By examining grains with a microscope or hand lens, the presence or absence of sharp edges and corners can be seen. Sand grains come in a variety of sizes. Poorly sorted sands will contain a wide range of grain diameters. Well-sorted sands will have similar size grains. As sand grains are transported by wind or water, the grain size tends to decrease, roundness increases, and sorting increases.

Procedure

1. Observe the sand sample carefully.
2. Record your observations in your science journal.
3. Using the screen wire or tea strainer, sift your sand sample.
4. Determine whether your sample has grains that are of similar size or many different sizes.
5. Using metrics, estimate the sizes of the sand grains.
6. Record your observations.
7. Cut a small circle in the center of an index card.
8. Cover one side of the hole with clear packing tape.
See diagram 1.
9. Turn the card so the sticky side of the tape is facing up.
10. Sprinkle a sample of the sand on the sticky tape.
11. Using a second piece of tape, cover the sample by sealing the sand sample between the two pieces of tape, making a “sand slide.”
12. Put the sand slide under the microscope or use a hand lens to examine the sand sample.
13. Observe the sample, taking note of the shape (round or angled) and size of the grains. Record your observations.
14. Fill a plastic bottle 2/3 full with water.
15. Pour 60 mL (about 4 tablespoons (tbsp)) of sand into the bottle.
16. Shake well until the water is muddied.
17. Observe the water and record your observations.
18. Place the bottle where it will not be disturbed and let it stand for 24 hours.
19. Observe the bottle the next day and record your observations.

Conclusion

1. How is sand formed?
2. What connection does sand have to a parent rock?
3. How is sand transported?
4. Explain any details you were able to determine about your sand sample: origin, parent rock, length of time it has “traveled,” and so on.

Extension

Remember that sand grain size tends to decrease, roundness increases, and sorting increases the longer the sand is transported by wind and water. Use your scientific observations to write a story about your sand sample. Describe the parent rock. Tell where it could be found and how it began to weather. Tell where the sand was found and how it was transported to that spot. Illustrate your story.

Materials

index cards
sand samples (*may be obtained from sandboxes, rivers, beaches, hardware stores*)
wide, clear packing tape
hand lens or microscope
wire tea strainers or pieces of screen wire
empty plastic soda or water bottles
science journal

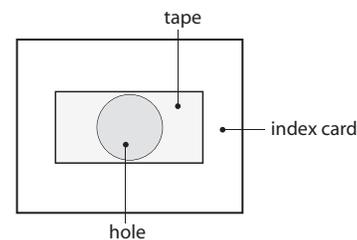


Diagram 1

Crystallizing Crystals

Purpose

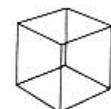
To identify the six crystal systems found in minerals and learn about examples of minerals contained in each system

Background

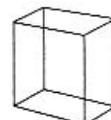
Under the right conditions, atoms or molecules arrange themselves in definite ways to produce solids that have smooth, flat surfaces. Each separate piece of the mineral follows the same pattern and is called a crystal. Mineral crystals can be classified in one of six different crystal systems: cubic, hexagonal, orthorhombic, monoclinic, tetragonal, and triclinic. During the formation of some minerals, impurities (trace elements) occur that create color variation in the mineral. This unique addition of trace elements can create minerals that are very desirable, such as rubies, emeralds, and amethysts. These minerals are called gemstones.

Examples of crystal systems can be found in the following minerals:

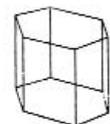
- cubic – diamond, pyrite, galena, fluorite, halite, garnet
- hexagonal – graphite, quartz, hematite, dolomite, calcite, corundum
- orthorhombic – sulfur, olivine, topaz
- monoclinic – borax, gypsum, hornblende, muscovite, talc, malachite
- tetragonal – anatase, zircon
- triclinic – turquoise, kyanite



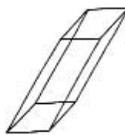
Cubic



Orthorhombic



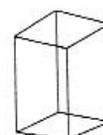
Hexagonal



Triclinic



Monoclinic



Tetragonal

Materials

zipper plastic bag
protractor
52 gumdrops
78 round toothpicks
paper towels
diagrams of the 6
crystal systems
hand lens
mineral samples
scissors (optional)

Procedure

1. Look at the crystal systems diagrams and determine how each is constructed.
2. Using gumdrops and toothpicks, build a model of each system.
 - a. Break or cut toothpicks to the various lengths needed for each side.
 - b. Use the gumdrops as the corner pieces to connect the toothpicks in each model.
 - c. Use a protractor to achieve the correct angle of each side.
3. Observe the model and determine what two-dimensional geometric shape (such as rectangle, square, hexagon, etc.) is represented in the system.
4. In the Crystal Chart on page 21, record how many times each shape is repeated in the system.
5. Draw a picture of the crystal system.
6. Note any other observations in the space provided in the Crystal Chart.
7. Choose two different mineral samples and examine each with your hand lens.
8. After observing the minerals, form a hypothesis as to which type of crystal system is in each sample.
9. Use mineral identification books or a web site to determine if your hypothesis is correct.



Crystallizing Crystals (concluded)

Crystal Chart

Crystal Model	Geometric Shape <i>Number of Repeats</i>	Picture of Crystal	Notes
Cubic			
Hexagonal			
Orthorhombic			
Monoclinic			
Tetragonal			
Triclinic			

Mineral Sample 1:

Mineral Sample 2:

Conclusion

1. What geometric shapes are found in each crystal system?
2. How does the geometric shape affect the use of the mineral?

Extension

Interview a local jeweler. Find out how and where precious gems are cut. Ask what special considerations a jeweler must make based on the crystal structure of the gem.

Put together a pamphlet about the gemstones that have been chosen to represent each birth month. What do the gemstones represent? Where are they found?



Rock or Mineral?

Purpose

To distinguish between a rock and a mineral based on physical appearance, including the presence or absence of phases

Background

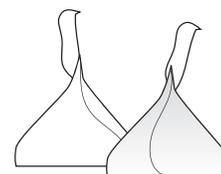
A mineral is normally defined as a solid crystalline substance formed by natural and usually inorganic processes. Inorganic means that it is made up of material that is neither plant nor animal. Minerals have a definite chemical composition and a particular atomic pattern. Because a mineral is made up of entirely the same elements throughout, it is considered physically and chemically homogeneous. Rocks are made of one or more minerals. All minerals are rocks, but not all rocks are minerals. Some rocks, like coal, are organic because they were formed from plants. About 2,000 different kinds of minerals are known, but only 200 of them are commonly mined.

Procedure

1. Carefully unwrap your gold and silver chocolate pieces. Place them on the correct foil wrapper so as to remember which one is which.
2. Bite and eat one half of the silver sample.
3. Place the remaining half on the silver paper.
4. Observe the inside of the sample.
5. Record your observations in your science journal. Be sure to include observations using all the senses!
6. Now bite and eat one half of the gold sample.
7. Place the remaining half on the gold paper.
8. Observe the inside of this sample.
9. Record your observations in your science journal.
10. Based on your observations, determine which sample is a mineral and which one is a rock.
11. Using a hand lens, carefully look at each sample.
12. Classify each sample as a rock or a mineral.

Materials

hand lens
one plain chocolate
Hershey's Kiss®
(silver foil wrapping)
per student
one almond
chocolate
Hershey's Kiss®
(gold foil wrapping)
per student
rock and mineral
samples



Conclusion

1. How do scientists determine the difference between rocks and minerals?
2. Is concrete more like a rock or a mineral? Why?

Extension

1. Using books and other reference materials, make a list of the ten most common minerals and where they are found. On a world map, place a different color sticker for each mineral near the place where it is found.
2. Visit the Mineral Institute's web site at <http://www.mii.org>. Make a list of common rocks and minerals. Identify the uses for each. Did you know there are rocks in your toothpaste and minerals in your lights? Research how much of each rock or mineral the average American uses in a year and make a graph depicting your findings.

“Mocking” Minerals

Purpose

To identify the chemical composition of minerals

Background

Minerals can be identified by their chemical makeup or chemical formula. The chemical formula is a type of shorthand that helps scientists avoid writing out impossibly long descriptions. For example, the formula for zircon is $ZrSiO_4$. This formula means that one unit of $ZrSiO_4$ is one part zirconium (Zr), one part silicon (Si), and four parts oxygen (O). The formula is much like a “recipe” for making a mineral.

Procedure (Teacher)

1. In a large bowl, stir flour and oatmeal together for about 30 seconds.
2. Combine the remaining ingredients in the bowl and mix thoroughly.
3. Knead (work with your hands) until well mixed.
4. If the mixture appears to be too sticky, add more flour until it is no longer sticky but not too stiff.
5. Pinch off a small amount of dough and shape it into a ball the size of a large marble. Make enough for each student to have one.
6. Assign a color of decorating sprinkle to each element and create a class chart like the one below.

SPRINKLES COLOR	ELEMENT	SYMBOL
red	Iron	Fe

7. Create a class chart or student sheet with the formula for each mineral.
8. Write the formula for each mineral on index cards (one per card).
9. Give each student an index card and a ball of dough on a paper towel.
10. Make the sprinkles and measuring spoons accessible to the student.
11. Create a viewing area for the mock minerals by having napkins or small paper plates lying out for each student to place his/her mineral on. Be sure to number each sample area 1, 2, 3, and so on.

Procedure (Student)

1. Read the chemical formula on the index card.
2. Using the chart created by your teacher, determine which colors of sprinkles are needed to make your mineral.
3. Place approximately 1 mL (1 teaspoon) of sprinkles for each color needed and for each part. For example, if you are making a mock mineral of zircon, add 1 mL of one color to represent the zirconium atom, 1 mL of a different color to represent the silicon, and 4 mL of a third color to represent the four atoms of oxygen in a molecule of zircon.
4. Wash your hands with warm soapy water for at least 15 seconds.
5. Mix the sprinkles throughout the dough and reshape into a ball.
6. Divide the ball in half.
7. Put one half of the mineral on display within the mock rock viewing area. Place your card face down behind your sample. What happens to the second half?

Materials

2 cups flour
4 cups oatmeal
1 cup water
1 cup white corn syrup
1 cup peanut butter
1 cup nonfat powdered milk
1 cup confectioner's sugar
cake decorating sprinkles, various colors (*one for each element in your chemical formulas*)
mixing bowl
mixing spoon
measuring spoons
rock samples (*with bright mineral mixes*)
cards with chemical formulas

Materials (Students)

1 ball of dough
sprinkles of various colors
small cup
paper towel

“Mocking” Minerals (continued)

- Using the element chart, identify the elements in each of the mock minerals.
- Estimate the amount of each element that was used to create the mineral. For example, if you observe more of one element than another, then estimate whether it was 2, 3, or more parts of that element.
- Based on your observations and by using a chart with the chemical formulas for each mineral, match each mock mineral to its mineral name.
- Once all students are finished predicting, have the teacher or a student turn over the cards and check your answers.

Conclusion

- How do scientists identify the chemical makeup of a mineral?
- What does each capital letter in a formula represent?
- What does the number in the subscript (below the line) mean?
- In the chemical formula FeS_2 , how many atoms or parts are represented by the formula?

Extension

Make a drawing or model to illustrate each of the mineral formulas. Write a short description of what the formula means. Find out what each of the minerals might be used for and where they are found.



“Mocking” Minerals: Formula Chart

Chemical Formulas

Mineral	Formula	Common name
Copper	Cu	
Diamond	C	
Gold	Au	
Chalcopyrite	CuFeS ₂	Copper Iron Sulfide (most common copper mineral)
Hematite	Fe ₂ O ₃	
Halite NaCl	Rock salt	
Fluorite	CaF ₂	
Calcite	CaCO ₃	Lime
Opal	SiO ₂ H ₂ O	
Pyrite FeS ₂	Fool's Gold	
Quartz	SiO ₂	
Corundum	Al ₂ O ₃	Aluminum Oxide
Galena	PbS	Lead Ore
Zircon	ZrSiO ₄	
Smithsonite	ZnCO ₃	Zinc Carbonate

There's Iron in My Cereal?

Purpose

To demonstrate how minerals are extracted from rock

Background

Valuable minerals must often be extracted from the rock that contains them. Several different methods are used to separate the mineral(s) from rock. Metals, such as copper, uranium, and gold, may be extracted by using processing methods such as gravity separation, flotation, or caustic (acidic) water rinses. Gold panning is an example of gravity separation. When a gold pan is stirred or agitated, the heavier mineral drops to the bottom of the pan and the lighter rocks wash away. Other metals that have magnetic properties, such as iron, are extracted with the use of high-powered magnets. The rocks are pulverized or melted at high temperatures and the magnet is used to remove the mineral particles. Metallic iron is sometimes added to fortified cereals and other food products.

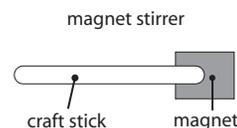
Materials

240 mL iron-fortified cold cereal
480 mL hot water
magnet stirrer
bowl or large glass
science journal
balance

Teacher Prep

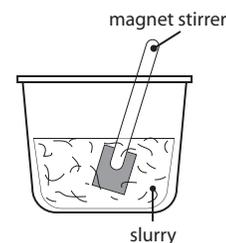
For each student or group of students, paint a magnet with white epoxy paint and allow it to dry completely. Use hot glue or superglue to attach the magnet to a craft stick.

In this experiment, add cold or warm water to make a slurry. The longer the cereal is stirred, the more complete the iron removal. Usually 30 minutes give the maximum iron recovery.



Procedure

1. Put the cereal in the bowl.
2. With adult supervision, carefully add the hot water.
3. Stir the mixture with the magnet stirrer until the cereal is soggy and a mush or slurry is formed.
4. If working in a group, take turns stirring. After 10 minutes, remove the magnet and observe the end.
5. Record your observations in your science journal
6. Repeat steps 4 and 5 at 20- and 30-minute intervals.
7. After 30 minutes, scrape off any substance attached to the magnet and find its mass.
8. Compare the amount with the content of iron listed on the box.



Conclusion

1. What are the dark particles on the magnet?
2. Why is iron added to foods?
3. What other foods might be iron fortified?
4. How much iron is recommended in an adult's daily diet?
5. What effect would crushing the cereal before adding the water have on the iron recovery time?

Extension

1. Try iron extraction from other iron-fortified foods, such as an iron rich drink or cooked hot cereal.
2. Find out what other minerals are important for good health. Investigate how we obtain those essential minerals. Find out about foods that may have been developed to provide essential minerals such as orange drinks or instant breakfasts.
3. Check out this web site and learn about the dietary requirements of astronauts. Plan your own astronaut meals. http://www.space.com/teachspace/module_astronaut_0900/dining_0900.pdf



Answer Key

Sandbox Stories

1. Sand is formed when rocks weather or break down into smaller pieces. The pieces are either fragments of the original rock or pieces that have separated into the individual minerals that make up the rock.
2. Sand is the same chemical makeup as the parent rock.
3. Sand is transported by wind, water, animals, or humans.
4. Answers will vary.

Crystallizing Crystals

1. The six crystal structures are made up of squares, cubes, rectangles, rectangular prisms, parallelograms, trapezoids, and hexagons.
2. The shape of the crystal determines the fracture planes of the mineral, which tells how the mineral will break into pieces. Jewelers must study the crystal formations and cut gemstones along these fracture planes to avoid destroying the gem.

Rock or Mineral?

1. Scientists must determine if the sample is physically and chemically homogeneous. If the rock's chemical composition is the same throughout, it is a mineral.
2. Concrete is more like a rock because it is composed of many different things, such as sand, pebbles, and limestone.

"Mocking" Rocks

1. Scientists use a type of chemical shorthand known as a formula.
2. Each capital letter represents a different element that can be found in the mineral. An element is a substance that contains only one kind of atom and cannot be broken down into simpler substances.
3. The number in the subscript tells us how many parts or atoms of that particular element are found in each molecule.
4. There is one atom of iron (Fe) and two atoms of sulfur (S) for a total of three atoms.

There's Iron in My Cereal?

1. The dark particles are actually slivers of iron.
2. Iron is an essential mineral for good health. It is added to foods to improve the healthy benefit of the food.
3. Although iron can be found naturally in red meats, poultry, and dried beans, many foods such as cereals, instant drinks, and even vitamin supplements have added iron.
4. The recommended dietary allowance for iron is 18 mg per day for adults. Children should have between 12 and 14 mg. Iron is essential for the development of strong muscles and the production of blood.
5. Crushing the cereal would shorten the iron recovery time.

On the Web

Magic Salt Crystal Garden

1. The original salt crystals will be more angular and well defined.
2. As the liquid evaporates from the salt solution, the small particles of blue powder are left behind. These particles become the "seed" around which the salt begins to recrystallize. As more liquid evaporates, more salt crystals begin to attach themselves to the growing formation.
3. Answers will vary.
4. White.
5. Salt is used for seasoning, as a preservative, and as a melting agent. Salt was also used in ancient bartering systems.

Getting Specific About Minerals

1. The streak test is important because it can help to identify minerals that often look similar to other minerals. The powder left behind by the streak test is often a different color than the visible colors of the mineral. The streak is made by the elements that make up the mineral, and the color is often unique to that mineral.
2. The scratch test can be used to determine the hardness of a mineral.
3. Because we know the specific gravity of water (1), we can use it to compare the volume of the mineral sample.

The NASA SCI Files™
The Case of the
Disappearing Dirt

Segment 2

As the tree house detectives continue their search to discover what has happened to their favorite beach, Kali visits Mr. John Gruener at NASA Johnson Space Center in Houston, Texas.

Using some interesting and edible props, Mr. Gruener helps Kali understand how the Earth recycles its materials to create new rocks and minerals. Mr. Gruener also suggests that Kali visit the Lunar Lab to learn more about rocks and to view some extra special rocks—Moon rocks! Ms. Andrea Mosi lets Kali explore the clean room where the Moon rocks are kept while scientists are working with them. She also explains to Kali that there are three different types of rocks: igneous, metamorphic, and sedimentary. Meanwhile, while fishing in Alaska, Tony asks for Dr. D's help to understand the difference between mechanical and chemical weathering. The tree house detectives are starting to put all the pieces together and hope that they will soon be able to solve the mystery of the missing sand!

Objectives

Students will

- compare weathering on the Moon and on Earth.
- identify the characteristics of igneous, sedimentary, and metamorphic rocks.
- observe how geodes are formed.
- demonstrate how plants break apart rocks.
- investigate the difference between mechanical and chemical weathering.
- demonstrate the effect of frost action on rocks.
- investigate oxidation as a process of chemical weathering.
- construct a model of the rock granite.

Vocabulary

agents of erosion – factors that cause erosion to happen, primarily wind, water, ice, and gravity

chemical weathering – the breaking up of rocks due to a change in chemical composition that occurs when water, air, and other substances react with the minerals in the rocks

dissolution – the process of chemical weathering in which rock is dissolved as part of the leaching process

erosion – the process that moves weathered rock and soil from one place to another

hydrolysis – when one or more minerals combine with water

igneous rock – rock formed from magma or lava when it cools

lunar – related to the Moon

mechanical weathering – the breaking up of rocks without changing their chemical composition

metamorphic rock – rock formed from existing rock by changes in temperature and pressure

oxidation – chemical weathering that occurs when a substance is exposed to oxygen and water

plate tectonics – the theory that the Earth's crust and upper mantle exist in sections called plates and that these plates slowly move around on the mantle

rock cycle – the process by which, over many years, Earth materials change back and forth among magma, igneous rocks, sedimentary rocks, and metamorphic rocks

sedimentary rock – rock formed when sediments become pressed or cemented together

sediment – loose materials such as rock fragments and mineral grains that have been transported by wind, water, or glaciers

weathering – the breaking of rocks into smaller pieces, either mechanically or chemically



Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Disappearing Dirt*, discuss the previous segment to review the problem and go over what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site in the “Educators” area under the “Tools” section. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students’ own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Focus Questions—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes while viewing the program to answer the questions. An icon will appear when the answer is near.
5. “What’s Up?” Questions—Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and point out how the information learned will affect the case. These questions can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 on the Video

For optimal educational benefit, view *The Case of the Disappearing Dirt* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the “What’s Up?” questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about sand, beach erosion, minerals and their formation, systems, weathering, erosion, and the rock cycle.
4. Organize the information and determine whether any of the students’ questions from Segment 1 were answered.
5. Decide what additional information is needed for the tree house detectives to determine what happened to the beach. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
7. For related activities from previous programs, download the educator guide for *The Case of the Shaky Quake* and/or visit the “Educators” area and click on “Activities/Worksheets” in the menu bar at the top. Scroll down to the “2002–2003 Season” and click on *The Case of the Shaky Quake*. In that educator guide, you will find the following:
 - a. **Segment 1**—*Layering of the Earth* (pages 18–19); *Did You Catch My Drift?* (pages 21–22); *Plates on the Move*
 - b. **Segment 2**—*It’s Not My Fault!* (page 33); *Shaky Quake Cake* (page 34)In the “Activities/ Worksheet” Section on the Web you will find the following:
 - c. *You Got the Whole World in Your Hands; Just How Do Those Plates Move?; Modeled to a Fault; Plates on a Globe*

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under “After Viewing” on page 16 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, problem-based learning activity:

- **Research Rack**—books, Internet sites, and research tools
- **Problem-Solving Tools**—tools and strategies to help guide the problem-solving process
- **Dr. D's Lab**—interactive activities and simulations
- **Media Zone**—interviews with experts from this segment
- **Expert's Corner**—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

9. Have students write in their journals what they

have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the PBL Facilitator Prompting Questions instructional tool found in the “Educators” area of the web site.

10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. For more assessment ideas and tools, visit the “Educators” area and, in the menu bar, click on “Instructional Tools.”

Careers

marine
geologist
astronaut
lab technician
paleontologist
geophysical
technician
seismologist
chemical
engineer



Resources

Books

Baylor, Byrd: *Everybody Needs a Rock*. Simon & Schuster, 1985, ISBN: 0689710518.

Bial, Raymond: *A Handful of Dirt*. Walker & Company, 2000, ISBN: 0802786987.

Cole, Joanna: *Magic School Bus: Inside the Earth*. Scholastic, 2003, ISBN: 0590407600.

Cuff, Kevin: *Stories in Stone*. University of California, Lawrence Hall of Science, 1999, ISBN: 092488620X.

Downs, Sandra: *Shaping the Earth: Erosion*. Millbrook Press, 2000, ISBN: 0761314148.

Gans, Roma: *Let's Go Rock Collecting*. Harper Collins Children's Books, 1997, ISBN: 0064451704.

Harman, Betty: *Moon Rock Heist*. Eakin Press, 1993, ISBN: 0890156670.

Hiscock, Bruce: *Big Rock*. Simon & Schuster, 1999, ISBN: 0689829582.

Hurst, Carol Otis: *Rocks in His Head*. Harper Collins Publishers, 2001, ISBN: 0060294035.

Kittinger, Jo: *Look at Rocks: From Coal to Kimberlite*. Scholastic Library, 1998, ISBN: 053115887X.

Kosek, Jane: *What's Inside the Moon?* Rosen Publishing Group, 2003, ISBN: 0823952827.

Videos

Bill Nye the Science Guy: *Rocks and Soil*, 1995, Product ID: 68A52VL00.

Bill Nye the Science Guy: *Erosion*, 1998, Product ID: 68E33VL00.

CD-ROM

Microsoft®: *The Magic School Bus Explores Inside the Earth*. ASIN: B000059ZYQ.

Web Sites

NASA: Lunar Sample Laboratory Facility

Come take a virtual tour of the Lunar Sample Lab and learn how the Moon rocks are kept safe and secure as scientists from around the world study them.

<http://curator.jsc.nasa.gov/lunar/lun-fac.htm>

NASA: Moon Questions

Find the answers to commonly asked questions about the Moon and Moon exploration.

<http://image.gsfc.nasa.gov/poetry/ask/amoonm.html>

Edible Rocks

Find delicious recipes for edible rocks on these web sites.

<http://www.womeninmining.org/ROCKCOOKIES.pdf>

<http://www.chariho.k12.ri.us/curriculum/MISmart/rocks/edible.html>

ThinkQuest: This Planet Really Rocks

Play the "Name That Rock" game by using pictures and facts about the rocks to identify some common rocks.

<http://library.thinkquest.org/J002289/name.html>

ThinkQuest: Famous Rock Scavenger Hunt

Investigate the rocks that make up famous monuments and statues in the United States.

<http://library.thinkquest.org/J002289/q1.html>

Science for Ohio: Hard Rock Café

On this site for students and teachers, learn about the three types of rocks and how they are formed.

<http://casnov1.cas.muohio.edu/scienceforohio/Rocks/index.html>

Rock Hounds

Explore a series of animated videos, activities, and information about rocks and rock collecting.

<http://www.fi.edu/fellows/payton/rocks/index2.html>

Rocks for Kids

This site is for kids of all ages who want to learn more about rocks and minerals. Learn how to collect and identify rocks, where to go for more information, and how to order rock samples.

<http://www.rocksforkids.com>

USGS: Weathering vs. Erosion

Learn the difference between weathering and erosion at this United States Geological Survey (USGS) site.

<http://wrgis.wr.usgs.gov/docs/usgsnps/misc/gweaero.html>

Weathering and Erosion

Dig a little deeper to learn about the various types of weathering (mechanical and chemical) and erosion.

<http://www.marshfield.k12.wi.us/science/biology/project/erosion/ero~weather.htm>

Activities and Worksheets

In the Guide	Walking on Moon Beams	
	Perform this toasty experiment to learn how regolith is formed on the Moon and the Earth.	35
	The Incredible, Edible Igneous Rock	
	Mix it up, cook it, and let it cool to make some edible igneous rocks.	36
	It's "Sedimentary," My Dear Watson!	
	Layer it on and then eat and enjoy these sedimentary rocks.	38
	"Metamorphically" Speaking	
	Cook it up to make some great tasting metamorphic "rocks."	40
	Rocking Around the Cycle	
	Play this game to learn how rocks change and cycle from one type to another.	42
	"Splitting" on the Ritz	
	Find out how plants can break apart solid rock.	44
	"Weathering" Heights	
	Conduct an experiment to help you learn the difference between mechanical and chemical weathering.	45
	The Oxidizing Oxygen	
	Find out how minerals combine with oxygen to make dirt turn red.	46
	Answer Key	
	47
On the Web	Edible Rock Families	
	Make your own igneous, sedimentary, and metamorphic rock cookies as you learn about the characteristics of these rock families.	
	Don't Take It for "Granite"	
	Construct a model of granite to learn about the minerals that make up rocks.	
	Frosty Effects	
	See how expanding ice can break rocks into pieces.	



Walking on Moon Beams

Purpose

To compare how regolith is formed on the Moon and on Earth

Background

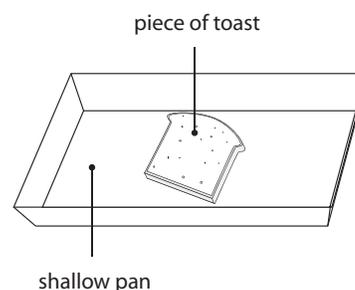
Regolith is the layer of loose, unconsolidated material that forms the surface of the land and covers the bedrock nearly everywhere on both the Earth and the Moon. On Earth, the weathering of the bedrock produces regolith. On the Moon, regolith has apparently been produced by the bombardment of the lunar surface by meteorites, which have broken Moon rocks into smaller and smaller fragments. Generally, on the Moon, the older the surface, the thicker the regolith. Regolith in young areas may be only 2 m thick, while it is perhaps 20 m thick in the older lunar highlands.

Materials

toasted white bread
marbles
aluminum pans
sandpaper
spray bottle with water

Procedure

1. Imagine that the piece of toasted bread is a rock on Earth. The sandpaper is the wind carrying pieces of sand.
2. In your science journal, predict the effect of rubbing the sandpaper across the surface of the bread.
3. Place the toast in a shallow aluminum pan.
4. Rub the sandpaper across the toasted bread.
5. Observe any pieces that are worn away.
6. Record your observations, noting where any pieces fell.
7. Repeat steps 4–6 two or three more times.
8. Using the spray bottle, spray water onto the slice of bread and set it aside.
9. Put a second piece of toast in another pan.
10. Let this piece of toast represent the surface of the Moon and let the marbles represent meteors.
11. Hold one marble about 30 cm above the pan.
12. Drop the marble onto the toast.
13. Observe any pieces that have broken loose.
14. Record your observations in your science journal, being sure to describe the toast and the position of any crumbs that came loose.
15. Continue to drop your meteor 20 times more.
16. Observe the bread and crumbs and record your observation. Note the thickness of the crumb layers.
17. Observe the first bread sprayed with water and note any difference from your first observation.



Conclusion

1. How is the first pan (with the sandpaper and water) like weathering on Earth?
2. What effect do meteors have on the surface of the Moon?
3. What effect do meteors have on the surface of the Earth?
4. In each experiment, where do the crumbs fall?
5. How do the crumbs' locations compare to the location of weathered fragments on Earth and on the Moon?

Extension

- Make your own Moon rocks. Collect several smooth rocks. Paint each rock a light gray color. Create a story about your rocks, describing how they were formed and how they were "collected." Be sure to tell which Apollo mission would have "collected" your rocks.
- Keep a Moon chart for several nights and record your observations of the Moon. Using a telescope or strong binoculars to look at the Moon may be helpful. If you would like to download a Moon chart, visit the "Educators" area of the NASA SCI Files™ web site. Click on "Activities/Worksheets" and then on the 2002–2003 Season. Click on *The Case of the Galactic Vacation* and download "Moonlight of the Night."
- Research the various reasons why it was important for NASA to collect Moon rocks on the Apollo mission. Discuss what we have learned through the years from the Moon rocks. Write a newspaper article explaining what you learned.

The Incredible, Edible Igneous Rock

Problem

To understand how igneous rocks are formed

Background

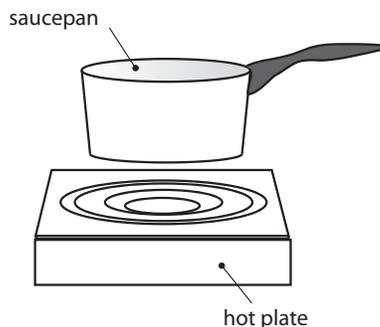
Rocks that have hardened from liquids are called igneous {IG nee us} rocks. The word "igneous" comes from the Greek word for fire. All igneous rocks begin below the Earth's surface in a liquid state of hot melted matter called magma. When magma forces its way to the surface through volcanic eruptions, it is called lava. As magma and lava cool, they form different types of igneous rocks. When magma cools underground, it cools very slowly, forms large crystals, and is called an intrusive igneous rock. When lava cools above ground, it cools more quickly, forms very small or no crystals, and is called extrusive igneous rock.

Teacher Note

This activity can be done as a class demonstration or in groups with adult supervision.

Procedure

1. Gather the "minerals" (ingredients) and supplies needed.
2. Carefully observe the individual minerals and record your observations in your science journal.
3. Predict what will happen to the minerals as they are melted and cooled to become edible igneous rocks. Record your prediction in your science journal.
4. Use a paper towel to generously smear margarine on the inside of the pan.
5. In a saucepan, combine milk, sugar, and salt. Stir.
6. With adult supervision, carefully place the saucepan on the hot plate and gently stir the mixture until it comes to a boil.
7. Reduce the heat and simmer the mixture for about five minutes, being sure to stir constantly.
8. Have an adult or your partner carefully place the candy thermometer into the saucepan and continue cooking until the temperature reaches the "soft ball" stage listed on the candy thermometer.
Optional: If you do not have a candy thermometer, you may test the mixture for a soft ball by dropping a small amount of mixture into a cup of cold water. If a soft ball forms, it's ready; if not, continue cooking and testing until a soft ball stage is reached.
9. When the mixture is ready, use pot holders to carefully remove the pan from the hot plate. To prevent burning the surface, place the pan on a trivet or additional pot holders.
10. Observe the mixture.
11. Continue to stir and carefully add the "minerals": vanilla, marshmallows, and chocolate chips. Observe what happens to each "mineral" as it is added to the mixture.
12. Stir until all "minerals" have melted and mixed into the rock.
13. Spoon the mixture into the pan and let it cool completely.
14. While waiting for the mixture to cool, record your observations for steps 10, 11, and 12. Was your prediction correct?
15. Once the mixture has cooled, cut it into pieces and observe and record your observations. Be sure to illustrate your rocks.
16. Eat and enjoy your edible igneous rocks!



Materials

6 oz evaporated milk
1/4 tsp salt
1 1/2 cup sugar
1 1/4 cup marshmallows
1 1/2 cup chocolate chips
1 tsp vanilla
margarine
hot plate
can opener
spoon
candy thermometer
pot holders
measuring spoons and cups
timer or clock
9" x 9" pan
paper towels
saucepan



The Incredible, Edible Igneous Rock (concluded)

Conclusion

1. What happened to the “minerals” as you put them into the boiling mixture? Why?
2. Which “mineral” took the longest time to blend into the mixture? The shortest time?
3. How do you know that those same “minerals” are present in the edible igneous rock?
4. Describe how a real igneous rock is produced. Use your cooking experience with the edible igneous rock to help you describe the process.

Extension

1. Collect various igneous rock samples and use a hand lens to observe them. Use rock identification books and identify each sample. Determine whether the sample is an intrusive or extrusive igneous rock.
2. Design a rock garden. Cut off the top of a 2-liter soda bottle and fill it halfway with soil. Arrange various rocks that you have collected on top of the soil. Plant some flower seeds and water your garden. Set the garden in a sunny place and watch it grow.
3. Brainstorm for a list of things made from rocks. Collect pictures to represent the items on your list and create a collage on a poster board or piece of construction paper. Share it with your class.

It's "Sedimentary," My Dear Watson!

Problem

To understand how sedimentary rocks are formed

Background

Seventy-five percent of the rocks at the Earth's surface are sedimentary rocks. They form when sediment becomes pressed or cemented together or when sediments fall out of solution. Sediments are loose materials such as rock fragments, minerals, grains, and small pieces of plant and animal remains that have been transported. Sediments come from already-existing rocks that are weathered and eroded. When sediment is transported and deposited, it builds up layer upon layer of sediments. Pressure from the upper layers pushes down on the lower layers, and if the sediments are very small, they can stick together to form solid rock. This process is called compaction. With larger sediments, pressure alone is not enough to make them stick together. They must be cemented together. Cementation occurs when water soaks through soil and rock and dissolves minerals in the rock. These minerals are natural cement. Sedimentary rocks often form in layers, with the oldest layers on the bottom because they were deposited first. There are two classifications of sedimentary rocks—clastic and nonclastic. Clastic rocks are made of the broken fragments of plants, animals, and other rocks that have been compacted and cemented together. Nonclastic rocks are formed by evaporation, precipitation, or organic deposits.

Materials

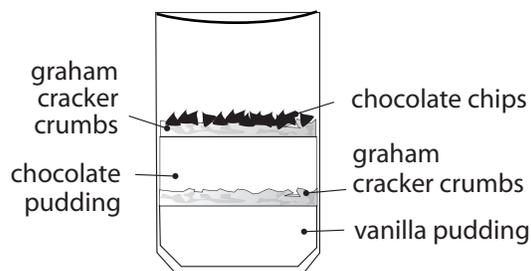
vanilla pudding
chocolate pudding
graham cracker
mini chocolate chips
canned whipping
cream
spoons
small plastic cup
paper towels

Teacher Note

The pudding used in this experiment can either be made in class or beforehand from a mix. Individual premade pudding cups also can be used with approximately one cup for every two students.

Procedure

- Carefully spoon vanilla pudding (about 1/4 of a cup) into the small plastic cup. Make sure to keep the sides of the cup as clean as possible.
- Break the graham cracker in half and crumble it on top of the vanilla pudding.
- Spoon chocolate pudding (about 1/4 of a cup) on top of the graham cracker crumbs.
- Sprinkle a small amount of chocolate chips on top of the chocolate pudding.
- Crumble the other half of the graham cracker on top of the chocolate chips.
- In your science journal, describe the sedimentary rock layers in your cup. Illustrate.
- Place a spoon in the cup so that it rests on the bottom of the cup. Observe and record your observations. Illustrate.
- When given permission, eat a small corner of your sedimentary rock layers (strata). Observe and record your observations. Illustrate.
- Use whipping cream to fill in the corner that you ate. Observe and record your observations. Illustrate.
- When finished, eat and enjoy the rest of your sedimentary rock layers!



It's "Sedimentary," My Dear Watson! (concluded)

Conclusion

1. Are layers of sedimentary rock laid down all at once? Why or why not?
2. How many layers of strata did you have in your cup?
3. Which layer was the oldest? The youngest? How do you know?
4. When you put your spoon into the cup, you crosscut the layers of strata. Was the cut older or younger than the strata? Explain.
5. What did eating a small corner of your strata represent? How does the same thing occur with real sedimentary rocks? What did the whipping cream represent? How does this process occur with real sedimentary rocks?

Extension

1. Investigate the Law of Superposition. Present a report to the class.
2. Add coconut, gummy worms, nuts, and other edible ingredients to represent fossils in the rock layers. Research fossils and present a report on how fossils are formed.
3. Use a geologic time line and other information gained from research to create a story that explains how each layer of your sedimentary rocks was formed and when.
4. Collect samples of sedimentary rocks. Use a rock identification book to identify each sample. Determine whether the sample is clastic or nonclastic.
5. Collect samples of rocks and test them for calcium carbonate to determine which rock type is sedimentary. The main ingredient in sedimentary rocks is calcium carbonate (limestone). To test for calcium carbonate, place a few drops of vinegar on a rock and use a hand lens to check for fizzing. Fizzing means calcium carbonate is present.

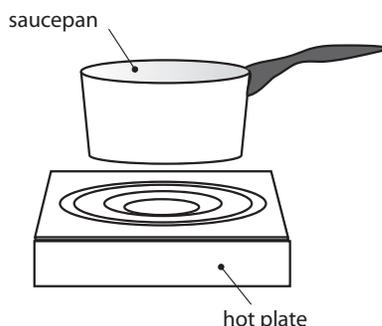
“Metamorphically” Speaking

Purpose To understand how metamorphic rocks are formed

Background Rocks that have changed due to temperature and pressure increases are metamorphic rocks. Metamorphic means “changed in form,” and metamorphic rocks can be formed from changes in igneous, sedimentary, or other metamorphic rocks. Rocks under the Earth’s surface are under great pressure from overlying rock layers. They also experience heat created by the radioactive elements in Earth. If the heat and pressure are great enough, the rocks melt and magma forms. In areas where melting doesn’t occur, mineral grains change in size and shape, creating a new metamorphic rock. Metamorphic rocks are classified as either foliated or nonfoliated. Foliated rocks are formed when the mineral grains in the rock flatten and line up to create bands or layering. Nonfoliated rocks show no bands or particles.

Teacher Note This activity can be done as a class demonstration or in groups with adult supervision.

- Procedure**
1. Gather the “minerals” (ingredients) and supplies needed.
 2. Carefully observe the minerals and record your observations in your science journal.
 3. Predict what will happen to the minerals as they are heated and cooled to become edible metamorphic rocks. Record your prediction in your science journal.
 4. Use a paper towel to generously smear margarine on the inside of the pan.
 5. In a saucepan, combine milk, sugar, and salt. Stir.
 6. With adult supervision, carefully place the saucepan on the hot plate and carefully stir the mixture until it comes to a boil.
 7. Reduce the heat and simmer the mixture for about five minutes, being sure to stir constantly.
 8. Have an adult or your partner carefully place the candy thermometer into the saucepan and continue cooking until the temperature reaches the “soft ball” stage listed on the candy thermometer. **Optional:** If you do not have a candy thermometer, you may test the mixture for a soft ball by dropping a small amount of mixture into a cup of cold water. If a soft ball forms, it’s ready; if not, continue cooking and testing until a soft ball stage is reached.
 9. When the mixture is ready, use pot holders to carefully remove the pan from the hot plate. To prevent burning the surface, place the pan on a trivet or additional pot holders.
 10. Observe the mixture.



Materials

6 oz evaporated milk
1/4 tsp salt
1 1/2 cup sugar
1 1/4 cup marshmallows
1 1/2 cup chocolate chips
1 tsp vanilla
margarine
hot plate
can opener
spoon
candy thermometer
pot holders
measuring spoons and cups
saucepan
timer or clock
9" x 9" pan
paper towels



“Metamorphically” Speaking (concluded)

11. Add the vanilla and continue to stir for about 3–5 minutes to cool the mixture slightly.
12. Carefully add the “minerals”: marshmallows and chocolate chips. Observe what happens to each “mineral” as it is added to the mixture.
13. Stir, being careful not to let the “minerals” completely melt. Let them form “streaks” as you stir.
14. Spoon the mixture into the pan and let it cool completely.
15. While waiting for the mixture to cool, record your observations for steps 10, 11, and 12. Was your prediction correct?
16. Once the mixture has cooled, cut it into pieces. Observe and record your observations. Be sure to illustrate your rocks.
17. Eat and enjoy your edible metamorphic rocks!

Conclusion

1. Explain what happened to the sponge that was put into the Epsom salts solution.
2. Explain how the sponge is similar to the trees in the Arizona’s Petrified Forest.

Extension

1. Use books and other resources to learn more about the Petrified Forest National Park in Arizona.
2. Learn about geologic time and create a geologic time line illustrating the way the Petrified Forest National Park may have looked through each time period, starting with the Triassic Period.
3. The petrified trees of the Petrified Forest National Park were conifers or cone-bearing trees. What kinds of conifers exist today? Make a list of the conifers in your area.
4. Like human beings, trees can become unhealthy and die. Observe nearby trees and note such things as broken branches, holes, unusual leaf color or shape, splits in the wood, or scars. Sketch the tree in your science journal. Develop a hypothesis about what might have happened to each tree. Write a story about the event and share your story with the class.

Rocking Around the Cycle

Problem

To understand the rock cycle

Background

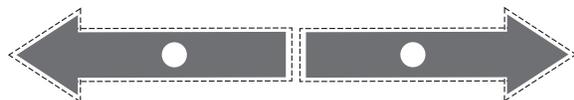
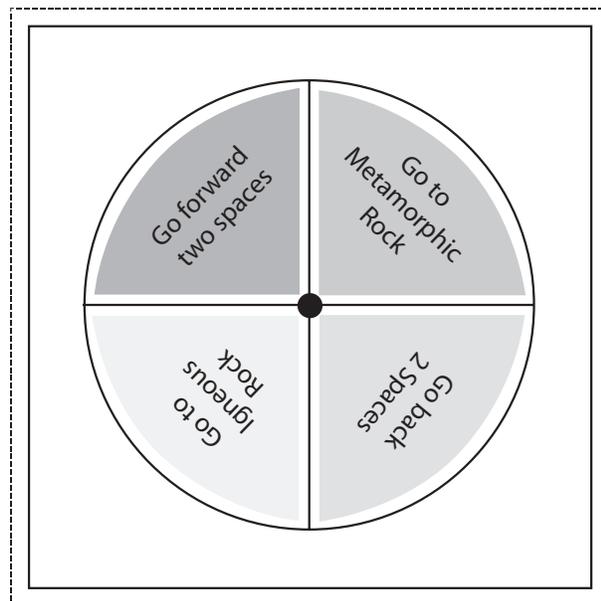
Rocks are classified as igneous, metamorphic, or sedimentary. Igneous rocks form from cooling lava or magma, metamorphic rocks are those that have changed because of temperature and pressure increases, and sedimentary rocks form when sediments become pressed and/or cemented together. Through processes such as weathering, erosion, compaction, cementation, melting, and cooling, rocks can change from one kind of rock to another. The changing of rocks from one form to another is described by the rock cycle. The rock cycle shows how all these things interact to form and change the rocks around you. Play the game to learn more about how the rock cycle works.

Materials

game board
2–4 small pebbles
die
spinner
poster board
brad
glue

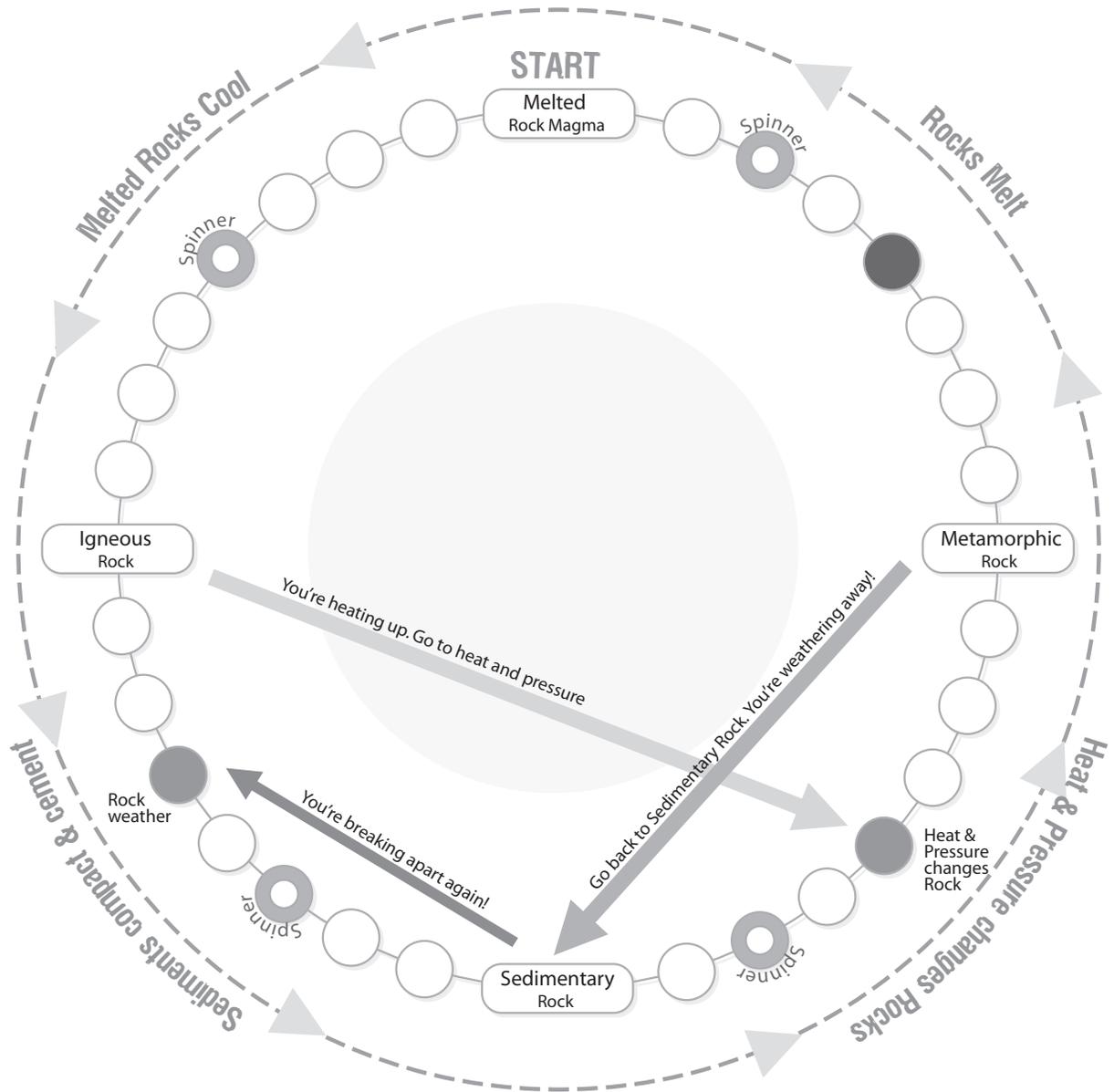
Procedure

- To make the spinner
 - Use scissors to cut along the solid lines of the spinner and arrow piece.
 - Place the spinner and arrow piece on a small section of poster board and trace around the outer edges.
 - Cut along the lines that you traced on the poster board.
 - Glue the spinner and arrow pieces to their appropriate poster board pieces.
 - With adult supervision, carefully punch a hole in the center of the spinner and at the center of the arrow piece with the sharp end of scissors or a compass.
 - Using a brad, connect the arrow piece to the center of the spinner.
 - Spin the arrow to make sure that it spins freely. Adjust it if necessary.
- To play the game
 - Each player rolls the die once, and the player with the lowest number goes first. Play will continue around the game board to the right of the first player.
 - Choose a small pebble to use as your game piece and place it at the "Start" box for magma.
 - Roll the die once and move your pebble the number of spaces indicated by the die.
 - Follow the directions on the game board, and if you land on a "Spinner," spin the spinner and follow the directions that the arrow indicates.
 - The first person to complete the rock cycle and return to magma wins the game.



Rocking Around the Cycle (concluded)

Game Board



“Splitting” on the Ritz

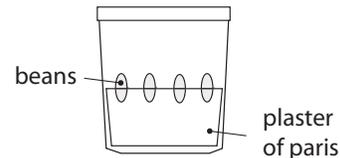
Purpose To demonstrate how plants break rocks apart

Background Trees and small plants grow in the soil that collects in the cracks of rocks. As the plant grows larger, the roots push against the sides of the joint in the rock. In time, the rock will split apart along this crack.

- Procedure**
1. Mix a small amount of the plaster of paris with water in a disposable container and follow the directions on the box. Note: When finished, do not wash the container because the plaster will clog drains.
 2. Fill each plastic cup about 1/3 full with the plaster of paris mixture.
 3. In one cup, place the 4 beans on the surface of the mixture, spacing them as far apart as possible.
 4. Push the beans into the plaster so that half the bean is below the surface.
 5. Use the marking pen to label the container Beans.
 6. Use the marking pen to label the other cup Control.
 7. Observe each cup and record your observations. Illustrate.
 8. Fold each paper towel into fourths by folding it in half twice.
 9. Wet the folded towels so they are moist but not dripping.
 10. Push one towel into each cup so it fits snugly against the surface of the plaster.
 11. Place the cups where they will not be disturbed for a week.
 12. Remove the towels each day for 7 days and observe and record your observations. **NOTE:** It will be necessary to periodically wet the towels to keep them moist.
 13. Return the paper towels after each day's observation.

Materials

plaster of paris
2 3-oz (90 mL)
clear plastic cups
tap water
craft sticks
4 pinto beans
2 paper towels
permanent
marking pen



- Conclusion**
1. What happened to the hardened plaster of paris when the seeds sprouted?
 2. Explain how plant roots can break rocks.

- Extension**
1. Leave the seeds on the surface of the plaster but don't push them down into the wet plaster.
 2. Conduct the experiment with different seeds. Does using different kinds of seeds make a difference?
 3. Use dry paper towels to cover the cups.



“Weathering” Heights

Purpose

To investigate the difference between mechanical and chemical weathering

Background

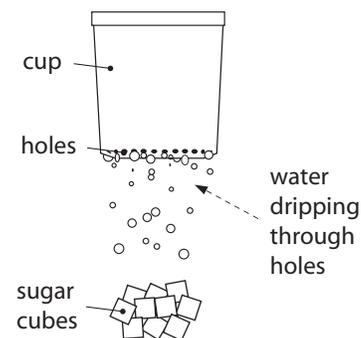
Mechanical weathering is the breaking down of rock into smaller and smaller pieces. The composition of the rock does not change, only its size does. Five different conditions can cause mechanical weathering: temperature, frost, organic activity, gravity, and abrasion. Chemical weathering alters the mineral composition, or the chemical makeup, of the rocks. There are three kinds of chemical weathering: oxidation, carbonation, and acids.

Procedure

1. Put a few sugar cubes in a glass beaker or bowl.
2. With a sharp pencil or scissors, carefully poke several holes in the bottom of the foam cup.
3. Hold the foam cup 30–40 cm above the bowl.
4. Slowly add water to the cup.
5. Observe what happens as the water “rains” down on the sugar cubes.
6. Record your observations in your science journal.
7. Place several marble chips in a glass beaker.
8. Pour white vinegar over the chips until they are covered.
9. Observe what happens to the chips and record your observations.
10. Continue to record your observations of the chips until no further changes can be seen (approximately one to two days).

Materials

foam cup
sugar cubes
water
marble chips
white vinegar
2 glass beakers or bowls
science journals
scissors



Conclusion

1. What happens to the sugar cubes when the water hits them?
2. What happens to the marble chips in the vinegar?
3. Which experiment demonstrates chemical weathering? Why?
4. Which experiment demonstrates physical weathering? Why?
5. Why is important for the tree house detectives to understand weathering?

Extensions

1. Hold the cup at different heights and note any differences in the weathering results.
2. Use a rock tumbler to polish rocks. Rock tumblers can be purchased at local toy stores and/or science suppliers. Examine the rocks carefully before you begin the tumbling. After each stage, observe the sludge you remove. When you have finished, create your own museum of beautiful rocks or make jewelry such as pendants and rings. Mountings are fairly inexpensive and can be purchased at lapidary shops and craft stores.

The Oxidizing Oxygen

Purpose

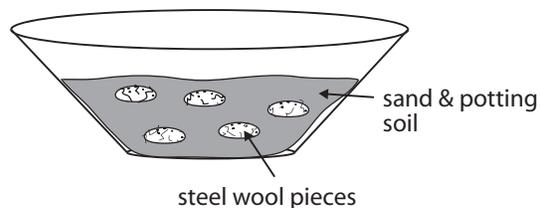
To investigate oxidation as a process of chemical weathering

Background

Chemical weathering changes the mineral composition of rocks. Some minerals react with water, oxygen, and/or acids to form new substances. The products of chemical weathering are often softer and smaller than the original rock. Oxidation is one type of chemical weathering. It is a process of combining oxygen with another substance that results in the creation of an entirely new substance. Iron, for example, combines easily with oxygen to form iron oxide, or rust. Red soil gets its color from iron oxide. If a material is colored differently on the inside than on the outside, it may indicate that oxidation is taking place.

Procedure

1. Mix the sand and potting soil together in a bowl.
2. Cut the steel wool pads into 1-cm pieces and add the pieces to the soil and sand. (*Be careful not to get splinters of steel wool in your fingers.*)
3. Stir all ingredients together.
4. Pour the mixture into the shallow pan.
5. Pour enough water over the soil mixture to just cover it.
6. Observe and record your observations in your science journal. Be sure to note the color and texture of the soil.
7. Set the pan in a sunny window.
8. Check the mixture once a day for seven days and record your observations in your science journal. **NOTE:** Depending on the intensity of the Sun, the water may evaporate in a few days. Add water as needed to keep the mixture moist.
9. After a week of observation, describe the process that you observed.



Materials

steel wool pads
scissors
shallow non-metal pan
750 mL sand
250 mL potting soil
water
mixing bowl
wooden spoon
science journals

Conclusion

1. What happened to the soil mixture after one week?
2. Compare the texture of the original mixture to the texture of the soil after one week. How has it changed?
3. What do you think will happen if you continue to monitor the soil mixture for another week?
4. What caused the changes in the soil?
5. Why are all the rocks and soil on the Moon the same color?

Extension

Investigate soils from other parts of the country. You can get soil profiles on the Internet. What minerals could cause the different colors in the soil and rock? Find out about the Blue Ridge Mountains. How did they get their name?

Learn more about how weathering affects national monuments such as the Washington Monument, the Statue of Liberty, or Mount Rushmore. What steps are taken to slow down or prevent weathering?



Answer Key

Walking on Moon Beams

1. Agents of erosion, such as wind, water, and ice act on rocks, breaking them apart and transporting the pieces to a new location. As the sandpaper moved across the toast, it broke off small pieces of the bread and deposited them either to the other side of the bread or somewhere else in the pan. The sandpaper represented physical weathering. The water simulated the chemical weathering of rocks here on Earth.
2. Meteors have bombarded the surface of the Moon, breaking the rock into a fine, loose material.
3. Billions of years ago, meteors bombarded the Earth just as they did the Moon. Even today, there are meteor showers. A few even hit the Earth; however, because the Earth has oxygen and water, weathering of the Earth's surface has occurred over time. Therefore, the effects of the meteors from long ago are not as visible as they are on the Moon where there is no weathering.
4. In the experiment with the sandpaper, the crumbs are moved to the edges of the toast and off the edge into the pan. In the marble experiment, the crumbs stay in the same location; they just form a deeper layer.
5. On Earth, weathered pieces of rock are transported from where they are broken down by wind, water, ice, and gravity. On the Moon, the loose, fragmented regolith remains near the impact area, forming deeper layers.

The Incredible, Edible Igneous Rock

1. When the "minerals" were put into the hot mixture, they began to melt. They continued to melt until they were no longer recognizable as individual minerals and were blended into the mixture. Each mineral has a melting point, which is the temperature at which it will begin to melt. The mixture was either at or beyond the melting point for each of the minerals added to the mixture.
2. Answers might vary, but generally the chocolate chips take longer to blend into the mixture than the marshmallows because the chocolate chips are more solid. The vanilla took the shortest time to blend because it was already in liquid form.
3. You know the minerals are there because you can taste them and even see the chocolate color (chocolate chips). The texture is also creamy from the marshmallows.
4. Answers will vary but should include that minerals in the Earth's crust are like the minerals in the activity. The high temperatures found beneath the surface of the Earth heat minerals, and once they reach their melting point, they melt and form magma. Magma can either cool under the Earth and form intrusive rocks, or it can come to the surface of the Earth as lava, which, when cool, forms extrusive rocks.

It's "Sedimentary," My Dear Watson!

1. No. Layers of sedimentary rocks are laid down one at a time because sediments are deposited slowly over time.
2. There were five layers: vanilla pudding, graham cracker, chocolate pudding, and chocolate chip.
3. The oldest layer was the vanilla pudding because it was laid down first. The youngest layer was the graham cracker layer on top because it was laid down last.
4. The cut made by the spoon was younger because it happened after all the layers were laid down.
5. Eating a small corner of the strata represented weathering and erosion. Sedimentary rocks are weathered by either mechanical or chemical processes and then are transported (eroded) by wind, water, and ice.
6. The whipping cream represented deposition of new sediment. After sediments are weathered, they are carried by wind, water, and ice to a new location where they are deposited to begin the formation of new sedimentary rocks.

"Metamorphically" Speaking

1. The minerals didn't completely melt because the mixture was not hot enough.
2. Answers will vary, but the chocolate chips usually take longer to melt because they have more mass (are thicker) and are more solid.
3. Answers will vary.

"Splitting" on the Ritz

1. The hardened plaster of paris cracked as the roots began to grow.
2. The plant roots occupy the spaces and small cracks found in rocks. As the plant grows, it pushes against the sides of these joints, causing the rock to split apart.

Answer Key (concluded)

“Weathering” Heights

1. The sugar cubes began to dissolve as the water was added.
2. The marble chips began to dissolve as the vinegar combined with the calcium carbonate in the chips. Bubbles of carbon dioxide were released as a byproduct.
3. The vinegar and marble chips represent chemical weathering because a chemical change is taking place in the minerals that make up the rock.
4. The sugar cubes experiment represents mechanical weathering because the sugar cubes change shape but are not chemically altered.
5. The tree house detectives need to understand how sand is formed to understand where it has gone.

The Oxidizing Oxygen

1. The soil mixture begins to turn red as the steel wool oxidizes.
2. The texture of the soil is softer than the original soil.
3. As the steel wool continues to break down, the soil mixture will become a darker rust color and the larger pieces within the mixture will become smaller and more fragile.
4. As water is introduced to the steel wool, oxygen begins to combine with the iron to form iron oxide (rust).
5. Because there is no water or oxygen, rocks and soils do not oxidize on the Moon.

On the Web

Edible Rock Families

1. Answers will vary but should include characteristics of each rock type.

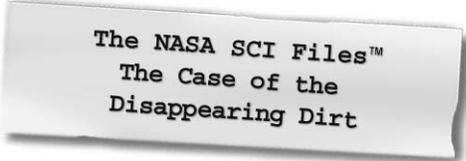
Don't Take It for “Granite”

1. Quartz, feldspar, and mica (hornblende) make up granite.
2. Answers will vary but should include that the granite samples are different colors and/or have crystals of different sizes.
3. The almost endless combination of pressures, temperatures, and cooling rates makes the granite look different. Although all granite is made up of the same minerals, each rock has a unique amount of each mineral.
4. All granite rocks have the same minerals present.
5. As magma cools, crystals form and the liquid rock forms a solid.

Frost Action

1. After the water froze, the plugs were pushed out beyond the ends of the straw to accommodate the water's expansion.
2. As water fills the cracks in rocks and freezes because of lower temperatures, it expands. The ice pushes against the joints in the rocks. Continued freezing and thawing weakens the structure of the rock, eventually leading to its breaking.
3. When the ice inside the straw melts, the plugs move in toward the center of the straw again.
4. No evidence of chemical change occurs; the water simply changes state and occupies more space.





The NASA SCI Files™
The Case of the
Disappearing Dirt

Segment 3

As the tree house detectives continue their quest to solve the mystery of the disappearing beach, Tony offers to help by going to Mountain View Elementary School in Anchorage, Alaska to learn more about how mountains are formed. After learning about mountain building, the other detectives decide that they now need to know more about the processes that tear down mountains. Tony is off again, but this time he visits Dr. Crossen at Exit Glacier near Anchorage, where he learns more about weathering. Once the detectives understand weathering, they set off to learn how the agents of erosion might help them move weathered sediment to their beach. Back at the beach, they continue to practice for the upcoming volleyball tournament while Tony enjoys the salmon fishing derby and learns how to ride a dog sled.

Objectives

The students will

- understand how mountains are formed.
- demonstrate how glaciers changed the surface of the Earth through the processes of erosion and deposition.
- determine how rocks change through weathering.
- collect and graph data.
- simulate how raindrops affect rocks.
- demonstrate how wind can transport sand.

Vocabulary

dome mountains – mountains that are formed when hot, molten material rises from the Earth's mantle into the crust but does not reach the surface and pushes overlying sedimentary rock layers upward to form a dome shape

fault-block mountains – mountains that are formed when the Earth's crust is stretched and pulled apart, causing rifts to form and great blocks of crust to tilt, while other blocks sink between the tilted blocks

folded mountains – mountains that are formed when two plates of the Earth's crust collide, making the crust bend and squeeze the plates together, causing the layers of rock to fold

glacier – a large body of ice moving slowly down a slope or valley or spreading outward on a land surface

lava – melted rock (magma) that comes to the surface of the Earth through volcanoes or fissures and cools and hardens

magma – molten rock inside the Earth

striations – the scratches, scrapes, and gouges left by glaciers on underlying bedrock

volcanic mountain – a hill or mountain composed entirely or in part of the materials thrown out of a volcano

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Disappearing Dirt*, discuss the previous segment to review the problem and find out what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site and have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during Segment 2. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Focus Questions—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.
5. "What's Up?" Questions—Questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. These questions can be printed from the web site ahead of time for students to copy into their science journals.



View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Disappearing Dirt* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the “What’s Up?” questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about the rock cycle, weathering, and erosion. Organize the information, place it on the Problem Board, and determine whether any of the students’ questions from Segment 2 were answered.
4. Decide what additional information is needed for the tree house detectives to continue to determine what has happened to the sand on their beach. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
5. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under “After Viewing” on page 16 and begin the problem-based learning (PBL) activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:

Research Rack—books, internet sites, and research tools

Problem-Solving Tools—tools and strategies to help guide the problem-solving process

Dr. D’s Lab—interactive activities and simulations

Media Zone—interviews with experts from this segment

Expert’s Corner—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the PBL Facilitator Prompting Questions instructional tool found in the “Educators” area of the web site.
8. Continue to assess the students’ learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the Research Rack in the tree house, the online PBL investigation main menu section, “Problem-Solving Tools,” and the “Tools” section of the “Educators” area for more assessment ideas and tools.

Careers

mountaineer
glacial expert
geologist
soil engineer
topographer
cartographer



Resources

Books

Berger, Melvin: *Are Mountains Getting Taller?* Scholastic, Inc, 2003, ISBN: 0439266734.

Bramwell, Martyn: *Mountains*. Watts Franklin, 1994, ISBN: 0531143031.

Brown, Tricia: *Children of the Midnight Sun*. Alaska Northwest Books, 1998, ISBN: 0882405004.

Cole, Melissa: *Mountain*. Gale Group, 2003, ISBN: 1567118062.

Corral, Kimberly: *My Denali*. Alaska Northwest Books, 1995, ISBN: 0882404679.

Fowler, Allan: *They Could Still Be Mountains*. Scholastic Library, 1997, ISBN: 0516261592.

Gallant, Roy: *Glaciers*. Scholastic Library, 1999, ISBN: 0531159566.

Klein, James: *Gold Rush!: The Young Prospector's Guide to Striking It Rich*. Ten Speed Press, 1998, ISBN: 1883672643.

Lobel, Arnold: *Ming Lo Moves the Mountain*. Morrow, William, & Co., 1993, ISBN: 0688109950.

Marsh, Carole: *Alaska Math: How It All Adds Up in Our State*. Gallopade International, 1996, ISBN: 0793364914.

Peters, Lisa Westberg: *Sun, the Wind, and the Rain*. Henry Holt & Company, 1990, ISBN: 0805014810.

Simon, Seymour: *Icebergs and Glaciers*. Morrow, William, & Co., 1999, ISBN: 0688167055.

Wallace, Marianne: *America's Mountains*. Fulcrum Publishing, 1999, ISBN: 1555913830.

Zoehfeld, Kathleen Weidner: *How Mountains Are Made*. Harper Collins Children's Books, 1995, ISBN: 0064451283

Web Sites

Animation: Moving Mountains

See how mountains are made in this simple animation.
<http://earthsci.terc.edu/navigation/visualization.cfm>

The National Snow & Ice Data Center: Glaciers

Find out general information about glaciers and take a quick tour of the life of a glacier on this web site.
<http://nsidc.org/glaciers/>

The National Park Service: Glaciers

Investigate the glaciers of North America on this web site sponsored by the National Park Service.
www.nps.gov/olym/edglac.htm

NASA: Glacier Galleries: Mighty Glaciers

View some awesome pictures of glaciers and explore glacier history and maps depicting their locations.
<http://sdcd.gsfc.nasa.gov/GLACIER.BAY/pictures.glaciers.html>

The Illinois State Museum: The Retreat of Glaciers

Visit this web site for maps and animations that show the extent of glaciers through time.
<http://www.museum.state.il.us/exhibits/larson/glaciers.html>

Travel Alaska: Virtual Tours

Take a virtual tour of Alaska and learn about the history, culture, and geography of this amazing place.
<http://www.travelalaska.com/tours/indextours1.html>

South Dakota Department of Education: Glacier Lesson Plans

Explore classroom activities designed to teach students about glaciers.
<http://www.state.sd.us/deca/DDN4Learning/ThemeUnits/Glaciers/lessonplans.htm>

Wildernet: Mountains of the World

Explore the mountains of the world. Find the elevation of over 1700 mountain peaks. See photos and read journals of people who have climbed these peaks.
<http://www.peakware.com/encyclopedia/>

Alaska Native Heritage Center

Learn about the Native people of Alaska. Explore their cultural heritage. Watch events at the Center with a web cam.
<http://www.alaskanative.net/>

Bureau of Land Management: A Golden Opportunity for Science

Folklore, legends, and science related to one of the most sought after minerals—gold.
http://www.blm.gov/education/going_4_the_gold/gold_poster.html

Science for Ohio: Dig This! Erosion Investigations

Investigate rocks and look at issues related to weathering and erosion on this site for students and teachers.
<http://casnov1.cas.muohio.edu/scienceforohio/Erosion/index.html>



Activities and Worksheets

In the Guide	A Mountain Building We Will Go Use some yummy edibles to learn how mountains form.	54
	Go, Go Glaciers Investigate the power of a glacier as you learn about till, outwash, and moraines.	56
	Split, Splat, I'm Taking a Bath Find out how raindrops affect rock in this drippy experiment.	58
	Honey, I Shrank the Rocks Collect data about weathering as you discover the factors that affect weathering.....	59
	Blowing in the Wind Make your own sand dunes as you investigate the power of the wind as an agent of erosion.	61
	Answer Key	63
On the Web	To Orbit or Not To Orbit, That Is the Question Use this activity to demonstrate how rivers and streams erode and deposit sediment.	



A Mountain Building We Will Go!

Problem

To understand how three basic types of mountains are formed

Teacher Note

Prior to conducting this activity, review with the students plate tectonics and plate boundaries. Activities for review can be found in the teacher guide for *The Case of the Shaky Quake*, pages 21, 24, 33, 34, and 48. The teacher guide can be downloaded from the homepage of the NASA SCI Files™ web site by clicking on the fence post that says "Guides." <http://scifiles.larc.nasa.gov>

Background

Mountains are classified by how they were formed. There are three basic classifications: volcanic mountains, fault-block mountains, and folded mountains. Plate tectonics, or the movement of the Earth's crustal plates, plays an important role in how the mountains are formed. The demonstrations below will help explain the formation of each type.

Procedure

1. Spread a small amount of frosting on the waxed paper.
2. Place two graham crackers very close to each other on top of the frosting.
3. Create a divergent plate boundary by slowly pulling the graham crackers apart.
4. Observe and record your observations in your science journals. As magma wells up through the crack in the crust, volcanic mountains can form along these divergent plate boundaries. The Mid-Atlantic Ridge is a divergent plate boundary and Iceland is a volcanic island formed along that ridge.
5. Create a convergent plate boundary by placing the graham crackers side by side and slowly pushing them together. Observe and record. What would happen if real plates collided? Folded mountains are created in this way by converging plates. This process happens over millions of years, and the Appalachian Mountains are an example of folded mountains.
6. **Optional:** To better demonstrate folded mountains by using food, use two small cakes (such as Twinkies®) and push them together, creating a convergent plate boundary. (Two small, thin bricks of clay can also be used.) Observe and record.
7. Create a second type of convergent plate boundary by pulling the graham crackers apart and pushing them together again, but this time make one slide under the other.
8. Observe and record. Note: When one plate is denser than the other, it will subduct under the lighter plate. As it subducts deep in the Earth, it begins to melt from the intense heat and pressure. As the rock melts, the magma can work its way through cracks and crevices until it reaches the surface, forming a volcanic mountain. Mount Saint Helens is an example of a volcanic mountain.
9. To demonstrate how volcanic mountains are formed from subducting plates:
 - a. Place 118 mL (1/2 cup) of pudding into a zippered plastic bag and seal, leaving a small opening in the middle unsealed.
 - b. Place the sealed bag on a flat surface with the zipper on top in the center.
 - c. Place a graham cracker on each side of the bag and gently push the crackers toward one another, making one go under the other. Observe and record. Note: Sometimes a pocket of magma becomes trapped as it pushes against the crust, but it does not break through onto the surface of the Earth. This uprising of crust is called a volcanic dome mountain.
 - d. Continue to push against the bag until it pops open. (This process can be messy!) Observe the "magma" as it erupts from the bag. Record your observations.

Materials

30 cm waxed paper
frosting
4 graham crackers
2 zippered storage bags
355 mL of pudding (1.5 cups)
2 slices white bread
1 slice wheat bread
peanut butter
grape jelly
strawberry jam
plastic knife
science journal
2 small cakes
(optional)



A Mountain Building We Will Go! (concluded)

10. To create fault-block mountains:
 - a. Spread peanut butter on a piece of white bread.
 - b. Add a layer of grape jelly.
 - c. Place a piece of wheat bread on top of the jelly.
 - d. Spread peanut butter on top of the wheat bread.
 - e. Add a layer of strawberry jam.
 - f. Place a piece of white bread on top of the jam.
 - g. Cut the sandwich into three pieces.
 - h. Place about 237 mL (1 cup) of pudding into the zippered plastic bag and seal.
 - i. Place the sandwich on top of the bag.
 - j. Gently apply pressure to the sides of the bag to push the pudding toward the center.
 - k. Observe and record. Note: The Earth's crust bends on the fluid-like mantle until the pressure is too great and the crust splits. This area is known as a fault. As the pressure continues to push against the rocks, the middle section may move higher than the area on its sides, forming a mountain, or the sections on the side may move up, leaving the middle section lower and forming fault-block mountains. The Sierra Nevada Mountains in Utah are examples of fault-block mountains.

Conclusion

1. Explain the three most common ways mountains are built.
2. Describe the role that plate tectonics plays in the process.
3. Are all mountains the same? Why or why not?

Extension

1. Use a world almanac or web site <http://www.peakware.com/encyclopedia/ranges/> to investigate the elevations of several major mountain chains. Graph the elevations of several of the major mountains such as Mt. Everest, Mt. McKinley, or Mt. Mitchell.
2. Compare and contrast the Appalachian Mountains to the various mountains in Alaska. Create a Venn diagram to show how they are the same and how they are different. Be sure to include the relative ages of each.
3. Read a book about mountains and give a report to the class.
4. Draw or paint a picture of a mountain and create a story or poem explaining how it was formed, when, and what life is like today on the mountain. Share your mountain with the class.
5. Research the Hawaiian Islands and learn how they were formed over a "hot spot" in the Earth's crust.

Go, Go Glaciers

Problem

To understand how glaciers changed the Earth's surface by the processes of erosion and deposition

Background

A glacier is a moving body of ice. Glaciers form during climatic episodes when more snow accumulates in the winter than melts in the summer. Over a period of years, the packed snow gradually changes to solid ice. Gravity causes a glacier to move down a mountainside. On level land, the weight of the ice causes the glacier to move or spread out from its thickest part. Ice at the bottom of the glacier melts where it rubs across the ground, "greasing" the glaciers' movement. Rocks and soil are frozen in the base of the glacier and are dragged along. These materials act like sandpaper to smooth the landscape over which the glacier passes. During cold episodes, the glaciers advance. During warm periods, the glaciers recede (or melt). (Glaciers do not move backwards—receding simply means melting.) When glaciers melt, they leave behind whatever they were carrying. These materials are called

- **till**—may consist of a mixture of rock debris and soils. Till is simply soil, pebbles, and rocks mixed at random and unsorted by particle size.
- **outwash**—sediments laid down in layers and sorted by size that are left behind from the rivers of water that flow from the melting glacier.
- **loess**—fine particles of the outwash blown across the landscape in glacial dust storms that settle across the landscape to form a blanket of silt-sized particles. Loess is the parent material of most of the young rich soils of the United States plains.
- **moraines**—long, thin deposits that mark the sides and front of a glacier. Scientists search for moraines to find the boundaries of glaciers that melted long ago.
- **kettles**—depressions left from melted ice sheets. Many of these kettles filled with water and became lakes.

Procedure

1. Place a handful of sand and the pebbles in the bottom of the plastic tub.
2. Fill the tub with water until it is about half full.
3. Allow the sand to settle to the bottom. See diagram 1.
4. Place the tub in the freezer and leave it until the contents are frozen solid.
5. Put on gloves and remove the ice block from the tub.
6. This ice block represents a glacier.
7. Put the glacier, dirty side down, on top of the brick or tile.

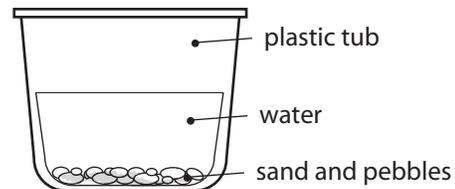


Diagram 1

Materials

several small, sharp stones (*pebble size road gravel works well*)
coarse sand
small plastic tub
unglazed brick or tile
water
freezer
warm gloves
tray or shallow pan

Go, Go Glaciers (concluded)

8. While pressing hard, slide the glacier across the brick in the same direction several times.
See diagram 2.
9. Remove the glacier and observe the brick.
10. In your science journal, record your observations.
11. Repeat steps 7 and 8 several times.
12. Look at the bottom of the glacier and carefully observe any changes in the sediment that is trapped in the bottom of the glacier.
13. Record your observations in your science journal.
14. Place the glacier in a shallow pan and put it where it will not be disturbed.
15. Let the glacier melt.
16. Observe what happened to the sediment the ice was carrying.
17. Illustrate your observations in your science journal.

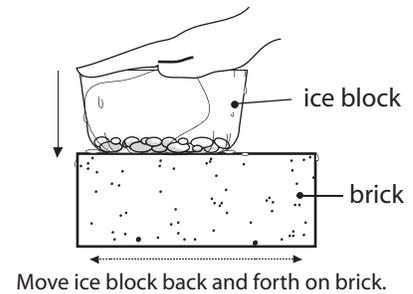


Diagram 2

Conclusion

1. What happened to the surface of the brick after the glacier passed over it? Why?
2. What changes did you see in the glacial sediment after it had passed across the brick several times?
3. What conclusions can you make as to what happens to the bedrock under a glacier?
4. What did you observe after your glacier melted? Why did it happen?
5. What could you learn about the glacier from studying this moraine?

Split, Splat, I'm Taking a Bath

Purpose

To simulate how raindrops affect rocks

Background

As raindrops fall from high in the sky and hit the ground, the water slowly begins to break apart tiny pieces of rock, thus weakening the overall structure. Large amounts of rain may cause rock slides, in which large chunks of rock are carried down a hillside. Water is the most powerful agent of erosion. It can move large amounts of sediment in a short time.

Materials

30 mL flour
eyedropper
one sheet black
construction paper
water
metric ruler

Procedure

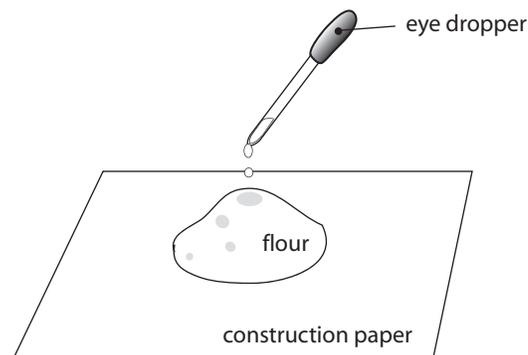
1. Place the flour in a pile in the center of a sheet of black construction paper.
2. Fill an eyedropper with water.
3. Hold the eyedropper about 30 cm above the paper.
4. Release a few drops of water, one at a time.
5. Observe the pattern made by the flecks of flour that are scattered as the water drops splatter onto the flour.
6. Record your observations in your science journal. Illustrate.
7. Experiment by holding the eyedropper at different heights.
8. Observe and record your findings for each height.

Conclusion

1. What happens to the flour when the water drops hit it?
2. Describe how this activity is like rain falling on the surface of the Earth?
3. What other forces cause the movement of sediment and rock fragments?

Extensions

1. Put sand or flour in a rectangular baking pan, making a small hill in the center. Slowly pour water over the hill. Record what happens to the hill. Where does the sand or flour end up?
2. Research any recent major flood or landslide in your area. Explain what and how it happened? Draw a picture of the land before and after the flood or landslide.



Honey, I Shrank the Rocks

Purpose

To determine how rocks change through weathering and to collect and graph data

Background

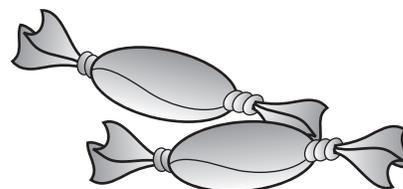
Weathering is a process that changes rocks or breaks rocks into smaller and smaller pieces. There are two types of weathering: mechanical weathering and chemical weathering. Mechanical weathering breaks rocks apart without changing the minerals that make up the rocks. Water is the most common mechanical weathering agent, but weathering can also be caused by air, sun, water, or living things. Factors that affect the rate of weathering include particle size and water speed.

Materials

three identical small, hard candies
graph paper
pens or pencils of three colors
stopwatch

Procedure

1. Pick three identical hard candies to represent "rocks."
2. Observe your rocks and record your observations in your science journal.
3. Find the mass of each rock and record it in the Rock Chart below. Be sure to keep the rocks separated so that you know which one has what mass.
4. To simulate a stream of water weathering rock, put one of the rocks (candies) in your mouth.
5. Start the stopwatch.
6. Hold the rock gently in one place in your mouth. You may suck on the rock (candy) but no biting!
7. When the candy is dissolved, stop the timer and record in the Rock Chart the amount of time it took for the rock (candy) to dissolve.
8. Put a second rock (candy) in your mouth.
9. Start the stopwatch.
10. This time tumble the rock (candy) with your tongue against your teeth. Your teeth represent your rock tumbling against other rocks in the stream.
11. When the rock (candy) is weathered completely away, stop the stopwatch and record the time.
12. Put the third rock (candy) in your mouth.
13. Start the stopwatch.
14. Bite the candy once and begin to tumble it against your teeth (the other rocks in the stream).
15. When the rock (candy) is completely weathered, record the time.
16. Using the data you collected, create a bar graph by using a different color pencil or crayon to represent each rock (candy). Be sure to include a key.
17. Collect data from students and find the average weathering time for each of the three tests.
18. Using the average times, create a class bar graph.
19. Analyze the data and draw conclusions.

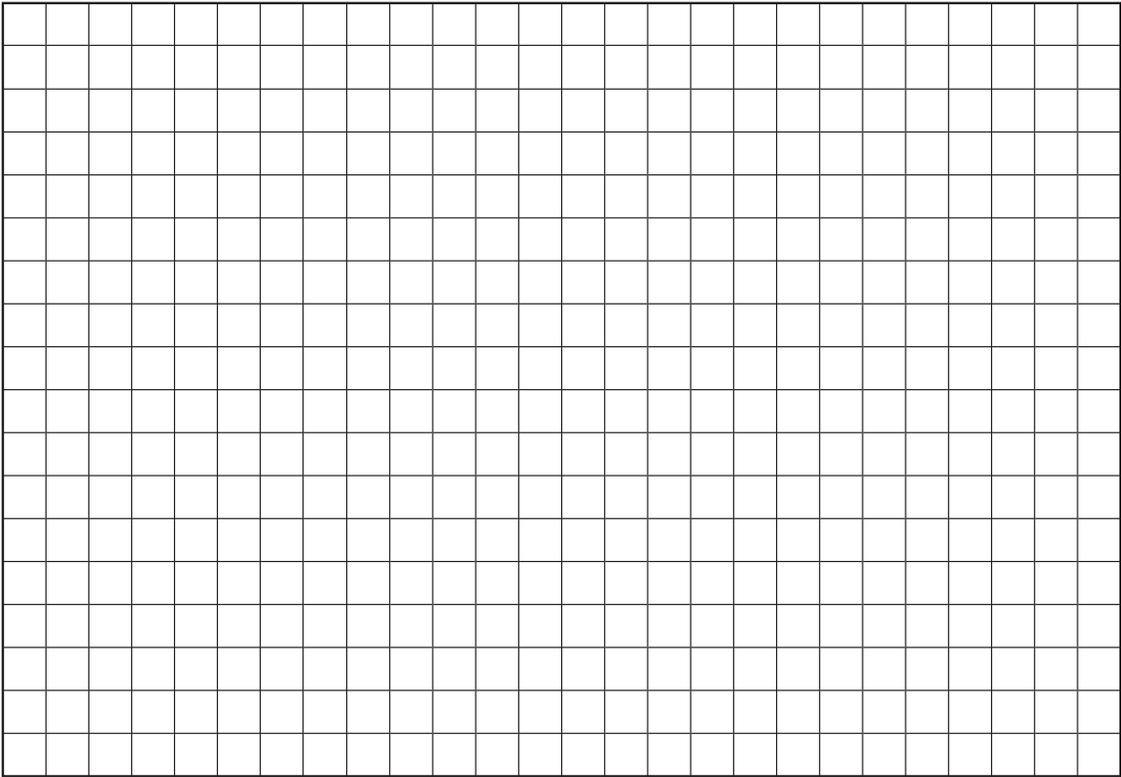


Honey, I Shrank the Rocks (concluded)

Rock Chart

Rock (Candy)	Mass	Time Dissolve
Rock 1-slow dissolution		
Rock 2-mild tumbling		
Rock 3-hard tumbling		

Graph



Conclusion

1. Which rock weathered first? Why?
2. What factor or factors are responsible for the different rates of weathering?
3. What would happen if you increased the size of the rocks (candy)?
4. How did your test data compare to the class average?
5. What can you say about the relationship between the amount of motion and the rate of weathering?

Extension

1. Brainstorm for other factors that could affect weathering rates, such as the minerals that make up the rocks and their hardness. Design and conduct experiments that would test the effect of these variables on weathering. For example, use different kinds of candy.
2. Take a field trip around the school grounds or neighborhood to observe examples of weathering. Take pictures of the sites you find and create a picture book about weathering.



Blowing in the Wind

Purpose

To demonstrate how sand can be transported by wind

Background

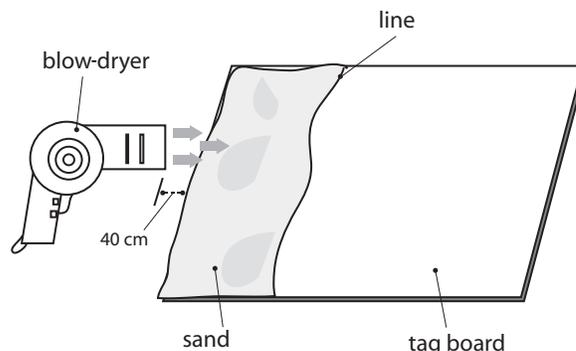
Wind is also an agent of erosion. It transports soil and pieces of rock from one location and deposits them in another. The effects of wind erosion are very dramatic, especially in the dry areas of the world. When the wind blows over dry, bare soil, it causes terrible dust storms. In the 1930s, dust storms were common over the drought stricken mid-western United States. Soil from Kansas, Oklahoma, and Colorado was carried as far away as New England. The amount of soil and sand carried by the wind depends on the size of the pieces and the wind speed. Light winds can lift only fine dust. Strong winds are needed to lift and move rocks and pebbles. Given enough time, windblown sand grains can act like a sandblaster, pitting and destroying rock. As wind blows large amounts of sand from place to place, it forms sand hills (sand dunes). Because the wind is constantly changing, it can move dunes. Sand dunes along the shoreline of Lake Michigan, for example, move as much as five to seven meters a year. Although we cannot stop wind erosion, we can take steps to slow it. One way is by planting vegetation to help hold the soil in place and protect it from the wind. Sometimes fences are also built to help stop the movement of sand.

Materials

m² of heavy tag board
500 mL of sand
250 mL of potting soil
100 mL of baby powder
blow-dryer (hair)
large, plastic bowl

Procedure

1. Mix the potting soil, sand, and baby powder in a bowl.
2. Dump the sand mixture onto the sheet of tag board.
3. Use the mixture to make several small hills or dunes along one edge of the tag board sheet.
4. Draw a line to mark the edge of the sand hills.
5. Point the blow-dryer toward the sand hills, holding it about 40 cm from the tag board sheet.
6. Turn the blow-dryer on low for 30 seconds. See diagram 1.
7. Observe the sand dunes. Record your observations.
8. Draw a second line on the tag board to show the new placement of the dunes.
9. Examine the sand that has been transported.
10. Record your observations in your science journal.
11. Repeat steps 5 and 6 using the blow-dryer's medium speed.
12. Re-examine the sand dunes and record your observations.
13. Draw a third line on the tag board sheet to show the new location of the dunes.
14. Repeat steps 5 and 6 using the blow-dryer's high speed.
15. Observe and record your observations.
16. Draw a final line where the sand is now located.
17. Carefully look at the sand that has moved.
18. Record your observations.
19. Using a metric ruler, measure the distance the sand moved each time. Enter the data into the data chart on page 62.
20. Create a graph depicting your results.



Blowing in the Wind (concluded)

Data Chart

Wind Speed	Distance Dune Moved	Comments
Low speed		
Medium speed		
High speed		

Conclusion

1. What did you notice about the movement of the sand mixture as the wind speed increased?
2. When you examined the shape of the new sand dunes, what conclusions did you make about the effect of wind on sand?

Extension

1. Investigate other ways that people attempt to stop erosion. Set up an experiment using some of these techniques, such as wind fences. Record the differences the various techniques had on the movement of the sand. Evaluate the effectiveness of each technique used.
2. Interview someone from your local farm bureau or the US Department of Resource Conservation. Find out what effect erosion has in your area. Learn what is being done to prevent serious erosion problems.
3. Research areas other than farming where erosion is a problem. Find out what is being done to prevent it and give a report on your findings.



Answer Key

A Mountain Building We Will Go!

1. Answers will vary but should include that folded mountains are formed when two plates of the Earth's crust collide and make the crust bend and fold. Fault-block mountains are formed when the Earth's crust is stretched and pulled apart, causing rifts to form and great blocks of crust to tilt, while other blocks sink between the tilted blocks. Dome mountains are formed when hot, molten material rises from the Earth's mantle into the crust but does not reach the surface and pushes overlying sedimentary rock layers upward.
2. See answer above.
3. Mountains are the same in that they are all made of rock and have formed above the Earth's crust. However, they are also all different because they have formed in different ways and are made of different materials. They are also of varying sizes and shapes and in different stages of development.

Go, Go Glaciers

1. The surface of the brick was deeply scratched because the sediment was trapped in the bottom of the glacier and the pressure applied was harder than the surface of the brick, thus creating grooves and scratches.
2. The sediment at the bottom began to change color (turning the color of the brick) as it picked up the sediment that was being eroded (scratched away) from the brick.
3. The bedrock below a glacier that is beginning to break up will get long, deep scratches and scrapes in the surface.
4. A ridge of sediment. The water flowed away from the glacier and left behind a ridge of the sediment that had been trapped in the ice.
5. You could learn the boundaries of the glacier, telling where it had been and where it had stopped.

Split, Splat, I'm Taking a Bath

1. The flour particles are scattered away from the point where the water drop hits.
2. When rain falls on soil, the fine silt and soil particles are disturbed by the water drops. Large amounts of water can cause rock slides or can carry away sediment, depositing it far from its original location.

3. Wind, gravity, and ice may also affect the movement of sediment. Sediment caught up in a stream or river is dependent on the amount of water in the stream and the speed of the water in the flow.

Honey, I Shrank the Rocks

1. The rock that was broken and tumbled (third test) should weather fastest because it has smaller pieces at the beginning of the process and the tumbling motion allows the pieces to hit against each other, aiding the weathering process caused by the water.
2. The particle size and water speed affect the weathering process.
3. The larger the rock, the longer it takes to weather.
4. Answers will vary.
5. Answers will vary but might include that the faster the tumbling motion, the faster the weathering rate, or the smaller the rock size, the faster the weathering rate. Students should understand that there are many factors that affect the rate of weathering, such as mineral size, rock composition, rock type, location (climate), and so on.

Blowing in the Wind

1. On the low speeds, only the finest silt was transported by the wind. As the wind speeds increased, more and larger particles were moved by the wind.
2. The side of the dune that faces the blowing wind is long and gently sloping. The sheltered side of the dune has a shorter and steeper slope.

The NASA SCI Files™
The Case of the
Disappearing Dirt

Segment 4

The tree house detectives think that some kind of obstruction such as a jetty, bulkhead, or seawall has recently been built and is causing their beach erosion, so they set out to look for any new obstructions that might have been built along the shoreline. When they don't find any new structures, they once again go back to the Problem Board. After conducting a little more research, they read an article about beach erosion that just might be the answer. The detectives contact Dr. Jesse McNinch with the Virginia Institute of Marine Science (VIMS) and learn that their beach is a pretty "hot spot." With the problem solved, the detectives head to Dr. D's for a wrap-up of all that they have learned; then, it's off to the beach for volleyball practice, with the hope of having some fun and playing a good game!

Objectives

The students will

- observe the erosion and deposition of sediment.
- observe wave action and understand terms related to waves.
- investigate the use of special research vehicles, like amphibious vehicles.

Vocabulary

amphibious vehicle – a vehicle that can function both on land and in the water

dynamic equilibrium – balance between the forces of nature

hot spot – a region of the beach that erodes more during a storm than the surrounding beach

jetties – structures built out into the water to protect a harbor or influence the current

recycle – to process items such as glass, cans, and human body waste to regain materials for human use

seawall – a strong wall made to prevent the waves from wearing away the shore

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich the existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Disappearing Dirt*, discuss the previous segment to review the problem and see what the tree house detectives have learned thus far. Download a copy of the Problem Board from the NASA SCI Files™ web site in the “Tree House” section and have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students’ own research.
3. Revise and correct any misconceptions that may have occurred during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 3.
4. Focus Questions—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of the Wacky Water Cycle* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. At the end of Segment 4, lead students in a discussion of the focus questions for Segment 4.
2. Have students discuss and reflect upon the process that the tree house detectives used to solve the problem of the missing sand. The following instructional tools located in the “Educators” area of the web site may aid in the discussion: Experimental Inquiry Process Flowchart and/or Scientific Method Flowchart.



3. Choose activities from the educator guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
4. Wrap up the featured online problem-based learning (PBL) investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Sample evaluation tools can be found in the "Educators" area of the web site under the main menu topic "Tools" by clicking on "Instructional Tools."
5. Have students write in their journals what they have learned about the rock cycle, rocks and minerals, weathering and erosion, and/or the problem-solving process and share their entry with a partner or the class.

Careers

marine biologist
ocean engineer

Resources

Books

- Blobaum, Cindy: *Geology Rocks*. Williamson Publishing, 1999, ISBN: 1885593295.
- Bright, Michael: *Storms at Sea*. Millbrook Press, 2002, ISBN: 076132724X.
- Fletcher, Ralph: *Have You Been to the Beach Lately?* Scholastic, Inc., 2001, ISBN: 0531303306.
- Gallant, Roy: *Story of Dunes: Sand on the Move*. Scholastic Library, 1998, ISBN: 0531158896.
- Green, Michael: *Amphibious Vehicles*. Capstone Press, 1997, ISBN: 1560654600.
- Landalf, Helen: *Moving the Earth: Teaching Earth Science Through Movement*. Smith & Kraus, Inc., 1997, ISBN: 1575251086.
- O'Brien-Palmer, Michelle: *How the Earth Works: 60 Fun Activities for Exploring Volcanoes, Fossils, Earthquakes, and More*. Chicago Review Press, 2002, ISBN: 1556524420.
- Petty, Kate: *Amazing Pop-Up Geography Book*. Dutton Juvenile, 2000, ISBN: 0525464387.
- Publishers Group Advanced: *Let's Start Sand Art*. Silver Dolphin Books, 1999, ISBN: 1571453814.
- Stanley, George Edward: *The Riddle of the Stolen Sand*. Aladdin Paperbacks, 2003, ISBN: 0689853769.

Videos

- Eyewitness: *Ocean*. Dorling Kindersley, 1997, ASIN: 078942147X
- Eyewitness: *Seashore*. DK Publishing, 1996, ASIN 6304165293.
- Eyewitness: *Plants*. Dorling Kindersley, 1997, ASIN: 0789421496.
- Eyewitness: *Rock & Mineral*. DK Publishing, 1996, ASIN: 6304165285.
- Eyewitness: *Volcano*. DK Publishing, 1996, ASIN: 6304165323.

Resources (concluded)

Web Sites

Virginia Institute of Marine Science (VIMS)

Visit this web site to read the top stories and to learn about the latest marine science research at VIMS.
<http://www.vims.edu/>

Virginia Institute of Marine Science (VIMS): Coastal Shoreline Defense Structures

Download this PDF file to learn about the various types of shoreline defense structures that are used to help prevent beach erosion. Great pictures and diagrams.
<http://www.vims.edu/ccrm/wetlands/techreps/coastal-shoreline-structures.pdf>

Office of Naval Research: Research Vessels

Look at the most up-to-date research vessels the Navy uses to learn more about the world under the sea.
<http://www.onr.navy.mil/focus/ocean/vessels/default.htm>

Sea Grant: Marine Careers

Visit this web site to explore various careers in marine science. You can even check out the salary ranges for each career and meet real people currently working in the field.
<http://marinecareers.net>

Sea Grant: Coastal Erosion and Beach Loss in Hawaii

Visit this web site to learn the difference between coastal erosion and beach erosion as you discover some of the most beautiful beaches in the world.
<http://www.soest.hawaii.edu/SEAGRANT/CEaBLiH.html>

AskERIC Lesson Plans: Erosion

Visit this site for a variety of mini lessons that help students understand erosion.
<http://www.reachoutmichigan.org/funexperiments/quick/eric/erosion.html>

The Geological Society of America: Intermediate Rocks, Minerals, and Mining

This web site is a great teacher resource for hands-on activities in Earth Science. Use everyday household items such as towels and candy bars to illustrate important earth science concepts.
http://www.geosociety.org/educate/LessonPlans/i_rocks.htm

Mining Internet Services: Mining Lesson Plans

Outstanding site for hands-on activities related to mining and minerals.
<http://www.coaleducation.org/lessons/middle.htm>

The BBC: The Rock Cycle Experiments

An interactive web site that allows students to learn about the forces that shape and create our Earth. The interactive map allows students to click on a process to learn more, and each item contains an activity that helps to illustrate that concept.
<http://www.bbc.co.uk/education/rocks/rockcycle.shtml>

The Rock Cycle Song

Listen to a song about the rock cycle.
<http://www.chariho.k12.ri.us/curriculum/MISmart/ocean/rocksong.htm>

BrainPop

Pick an animated movie that explains the rock cycle, plate tectonics, and much more. Play a game or participate in an experiment with Bob the Rat. This site also contains dozens of additional science and history topics. Users may register to score points and keep track of activities completed.
<http://brainpop.com/science>

Women in Mining: Games: Minerals through Geography

Find out where in the world we get the rocks and minerals we use in our everyday lives.
<http://www.womeninmining.org/Geography.htm>

Edible Geology

Make your own gelatin rock cycle with eroding cookie crumbs. Just follow the directions on this web site about edible geology.
<http://minerals.state.nv.us/forms/educ/EdibleGeology.pdf>



Activities and Worksheets

In the Guide	Shifty Sandy Learn how sand is eroded and deposited along a shoreline.	70
	To Erode or To Desposit, That Is the Question Use real data to learn about coastal erosion.	71
	Riding the Waves Learn about crests, troughs, and wavelengths with your very own wave machine.	72
	Rockin' and Rollin' Crossword Puzzle Use some of the cool terminology used in the program and create your own crossword puzzle.	73
	Lost on the Beach Word Search You won't need a shovel or pail to find the words on this beach.	74
	Answer Key	75

On the Web	Amphibious Vehicles Design your own research vehicle to use on land or in the water.	
	The Rock Cycle Use crayon shavings to learn about the various stages of the rock cycle.	



Shifty Sandy

Problem

To understand how sand is eroded and deposited along a shoreline

Procedure

1. If using a stream table, tape or plug the drain to prevent water from seeping out.
2. Fill the stream table or large rectangular container with 2.5 cm of water.
3. Pour clean sand at one end of the container and shape it to simulate a beach.
4. In your science journal, illustrate the beach profile and record your observations.
5. Place the block at the end of the stream table opposite the beach.
6. Move the block very slowly to create small waves for 3 minutes. The waves should be just large enough to barely move the sand.
7. Observe the beach profile. Illustrate and record your observations.
8. Move the block more rapidly, creating larger waves for 3 minutes.
9. Observe the new beach profile. Illustrate and record your observations.

Materials

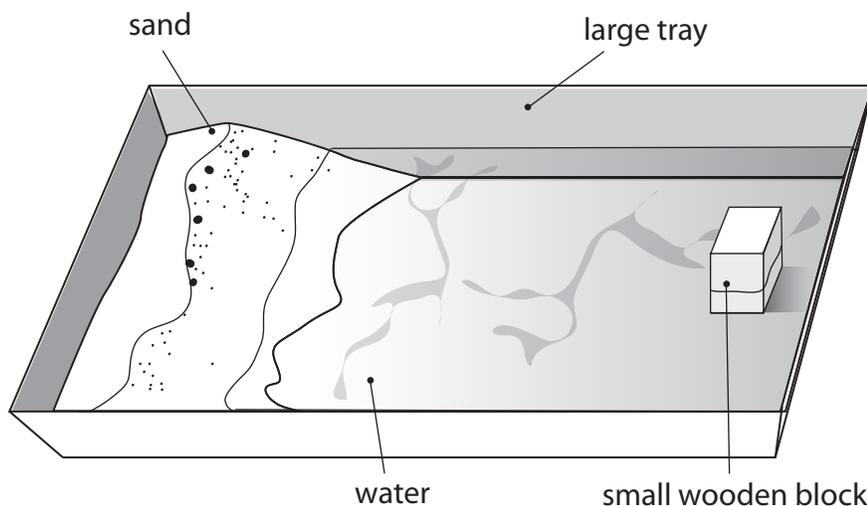
stream table or
other large
rectangular
container
block sand ruler
watch or clock with
second hand

Conclusion

1. Compared to the large waves, how did the small waves affect the beach?
2. How would seasonal changes affect the beach profile? (summer vs. winter)
3. What other factors might affect beach erosion?

Extension

Place structures to simulate jetties, seawalls, and bulkheads along the shoreline and repeat the experiment to learn how they affect erosion.



To Erode or To Deposit, That Is the Question

Purpose

To study coastal erosion and deposition by waves and sea level rise at a particular area

Background

To observe changes in sea level, scientists regularly measure the sea level at certain areas around the world. They look at data from previous years to determine any trends and patterns so they can predict what will happen to the sea level in a particular place. They are interested in knowing whether the sea level at the beach has been rising or falling over the past years. They also need to know whether the sand has been decreasing (erosion) or increasing (deposition) due to the rising and falling of the sea level. After careful evaluation and analysis of the data, scientists can try to predict erosion trends and deposition for various areas.

Materials

graph paper
ruler
pencil

Table—Lefaga, Samoa

Year	1972	1973	1974	1975	197
Sand Volume (m³)	268	331	192	394	201
Year	1977	1978	1979	1980	1981
Sand Volume (m³)	185	386	252	323	351
Year	1982	1983	1984	1985	1986
Sand Volume (m³)	364	385	343	349	377

Procedure

1. Carefully examine the table that shows a study of the estimated volume of sand on a part of the beach at Lefaga, Samoa.
2. Note the volume of sand for each year.
3. Create a graph with “Time in Years” on the horizontal axis (x) and “Volume of Sand” on the vertical axis (y). Determine the increments for each.
4. Plot the information given for each year.
5. Look at the graph and analyze any noticeable trends (patterns).

Conclusion

1. Which years showed erosion? How do you know?
2. Which years showed deposition? How do you know?
3. Looking at the trends, predict what will happen to the beach over a long period of time (50–75 years).

Riding the Waves

Problem

To observe waves in action

Background

All waves share certain characteristics. Each wave has a crest, which is its highest point, and a trough, which is its lowest point. The wave height is the distance from the crest to the trough. The wavelength is the distance from the crest of one wave to the crest of the following wave. Water rises and falls as the wave passes. The wave moves forward on the ocean's surface, but the water itself does not move forward. A particle bobbing on the waves, such as a twig, will rise on the crest, moving forward just a little, and drop on the trough, moving a little backward. This circular loop means that the twig ends up just about where it started.

The speed of the wind and how long the wind blows determine the height and wavelength. As wind blows across the water's surface, it pushes up tiny waves into larger waves. When a wave reaches shallow water, its wavelength gets shorter. The ocean bottom pulls at the wave and slows it down. The crest gets ahead of the rest of the wave and begins to tilt forward. When the front end of the crest is unsupported and the wave collapses, it is called a breaker. After a wave breaks, the foaming water rushes up the beach. The particles no longer move in circles as they did in the wave. The water actually moves forward, taking whatever it is carrying with it. Strong storm waves beating against the shore can change the shape of the shoreline. Gentle waves lapping at the beach may deposit or carry away sand.

Procedure

1. Fill the bottle 1/3 full of water.
2. Add food coloring to get the desired color.
3. Fill the bottle almost to the brim with oil.
4. Wrap the bottle threads with Teflon® tape.
5. Screw the lid on tightly.
6. Turn your bottle on its side and gently move it back and forth.
7. Record the wave action you see in the bottle.

Conclusion

1. What causes the motion inside the bottle to change?
2. How are the movements inside the bottle like those in the ocean?
3. How do waves affect the shore?
4. What can the tree house detectives learn from watching a wave machine?

Extensions

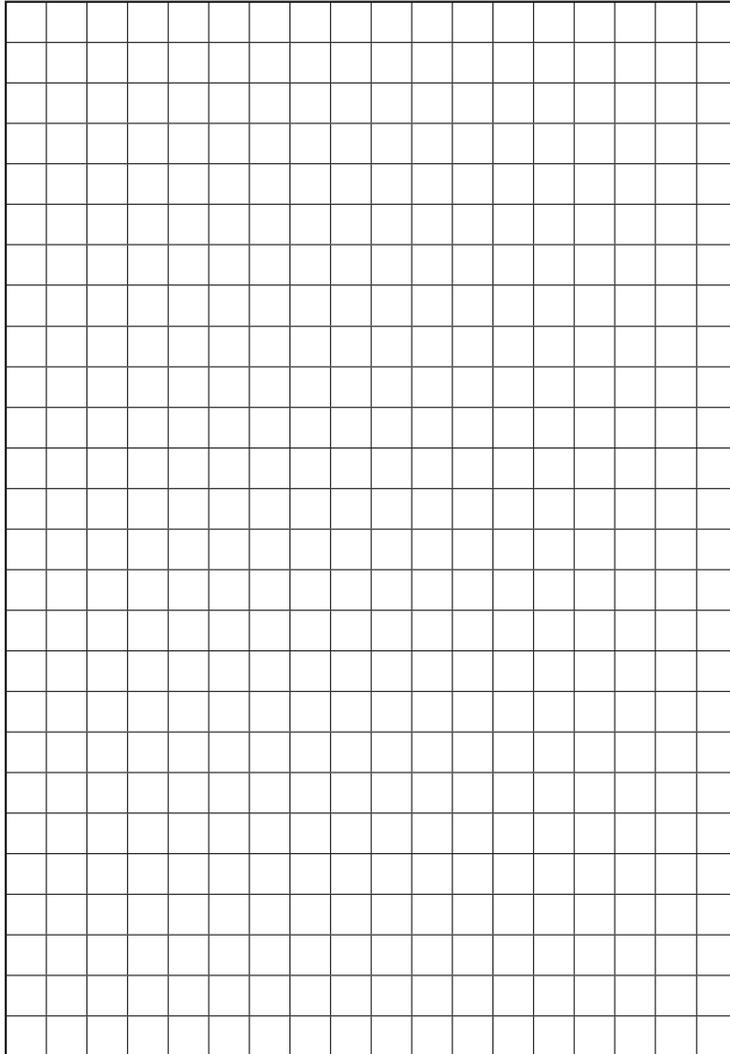
Try adding small pebbles (aquarium gravel works well) or clean sand to the bottle before it is sealed. Observe what happens to the sediment when the waves move. Does it move in the same direction as the waves? Where does it end up when the waves stop?

Materials

1 clear plastic bottle with a screw-on lid
clear baby oil or cooking oil
water
food coloring
Teflon® tape



Rockin' and Rollin' Crossword Puzzle



Use the words below to create your own crossword puzzle.

Vocabulary

- | | |
|-------------|-------------|
| rock cycle | igneous |
| metamorphic | sedimentary |
| hot spot | subduction |
| weathering | erosion |
| mountain | mineral |
| rock | sand |
| gemstone | glacier |
| gravity | water |
| mechanical | chemical |
| Moon rocks | lava |

Add your own:

Across

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Down

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____



Lost on the Beach Word Search

You don't need a pail or shovel to find the words on this beach. Use the word bank below to "dig" up the words in the word find below.

Word Bank

metamorphic	sedimentary	igneous	rock cycle
weathering	gravity	Moon	mountain
plate tectonics	lava	magma	divergent
convergent	subduction	erosion	glaciers
striations	dome	Mohs	mineral
gemstone	luster	color	Earth system

S E D I M E N T A R Y N E A P P A M O O N S
 S N M O U N T A I N B A B E H U G U Y I N I
 D A C A M O R P M E T S Y S H T R A E M D G
 I O F D E P E R I A K M E I C L I P E O E N
 P N M A A I O M B N G E M S T O N E H T R E
 M H E E L T I U A I R A U X S Y L I S H R O
 E K A I W O R K N K I N E T I C I O I Y O U
 T J I L I E S N M D C C I L P L L E R D C S
 A L P L A T E T E C T O N I C S A G O R K U
 M A I E H E R G E H Z N I E S T R V A I C S
 O S M W E T I P E I T V E T H R C A R E Y A
 R Z Q U I C L I A T O E M Y F I T E P U C W
 P N L D S A I N D N R R C T I A N A V A L E
 H G E A R S Z A I E V G O U R T N E Y A E A
 I I V E R T S S N G P E D N A I E N D J K T
 C S N Y K O R Z O R Y N Y I I O W L B O N H
 H I R T J E S C I E W T E L L N U I I D A E
 M E N E I G Y A T V T R K C I S A C S T R R
 U E R C P G S I C I Z U A A T R I S H I C I
 A K A T I I T G U D T B I E B I L L I I I N
 M L B E S B E K D S R I R Y O Y T I V A R G
 G A E M O H S O B T A W P F I S L I Z Q U E
 A G W I N C H E U N Y N I K K I N Y I R P V
 M F A E B Z X R S W R O R L F N O I S O R E



Answer Key

Shifty Sandy

- Answers will vary but should include that the smaller waves did not erode the beach as much as the larger waves did.
- Winter storms cause more erosion than occurs in summer.
- Answers will vary but might include human activity and obstructions such as jetties, seawalls, and bulkheads.

To Erode or To Deposit; That Is the Question

- 1974, 1976, 1977, 1979, and 1984. The volume of sand was less.
- 1973, 1975, 1978, 1980, 1981, 1982, 1983, 1985 and 1986. The volume of sand increased.
- Answers will vary.

Riding the Waves

- The back and forth rocking motion caused the oil and water mixture to move back and forth.
- The movement inside the bottle is similar to the movement of water in the ocean in that the water moves forward and then back again.
- Waves affect the shore by depositing sand as the waves break on the beach; however, if wave action is very strong because of a storm or other force, it can cause erosion.
- If the tree house detectives were to watch a wave machine, they would see that gentle waves slowly move the water and its contents toward the shore. If the wave action is more violent, they would see that waves are capable of eroding the shoreline.

Lost on the Beach Word Search

S E D I M E N T A R Y N E A P P A M O O N S
 S N M O U N T A I N B A B E H U G U Y I N I
 D A C A M O R P M E T S Y S H T R A E M D G
 I O F D E P E R I A K M E I C L I P E O E N
 P N M A A I O M B N G E M S T O N E H T R E
 M H E E L T I U A I R A U X S Y L I S H R O
 E K A I W O R K N K I N E T I C I O I Y O U
 T J I L L I E S N M D C C I L P L L E R D C S
 A L P L A T E T E C T O N I C S A G O R K U
 M A I E H E R G E H Z N I E S T R V A I C S
 O S M W E T I P E I T V E T H R C A R E Y A
 R Z Q U I C L I A T O E M Y F I T E P U C W
 P N L D S A I N D N R R C T I A N A V A L E
 H G E A R S Z A I E V G O U R T N E Y A E A
 I I V E R T S S N G P E D N A I E N D J K T
 C S N Y K O R Z O R Y N Y I I O W L B O N H
 H I R T J E S C I E W T E L L N U I I D A E
 M E N F I G Y A T V T R K C I S A C S T R R
 U E R C P G S I C I Z U A A T R I S H I C I
 A K A T I I T G U D T B I E B I L L I I I N
 M L B E S B E K D S R I R Y O Y T I V A R G
 G A E M O H S O B T A W P F I S L I Z Q U E
 A G W I N C H E U N Y N I K K I N Y I R P V
 M F A E B Z X R S W R O R L F N O I S O R E

On the Web

The Rock Cycle

- The shavings are different sizes because each was scraped and removed from the crayon slightly differently with each turn of the pencil sharpener.
- Rocks come in many different sizes, shapes, and kinds because they come from different parent rock and weather differently.
- Wind, rain, water, ice, gravity, plants, animals, and human beings all cause weathering.
- Deposition is the deposit of sediments that have been moved or transported by water, ice, or wind. Wind and ice deposits are not neatly layered—the different size particles are all mixed up. Water layers sediments according to particle size and density when they are deposited.
- Heat, pressure, and the actions of liquids and gases are factors that create metamorphic rocks.
- Answers will vary.

