DOCUMENT RESUME

ED 417 088 SE 061 223

AUTHOR	Weisgarber, Sherry L.; Van Doren, Lisa; Hackathorn, Merrianne; Hannibal, Joseph T.; Hansgen, Richard
TITLE	Hands On Earth Science.
INSTITUTION	Ohio State Dept. of Natural Resources, Columbus.
PUB DATE	1997-00-00
NOTE	21p.
AVAILABLE FROM	Ohio Dept. of Natural Resources, Div. of Geological Survey, 4383 Fountain Square Court, Bldg. B-2, Columbus, OH 43224-1362.
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Classification; *Concept Formation; *Earth Science; Elementary Secondary Education; Geology; *Hands on Science; Learning Strategies; *Minerals; Models; Plate Tectonics; Science Activities
IDENTIFIERS	Ohio

ABSTRACT

This publication is a collection of 13 hands-on activities that focus on earth science-related activities and involve students in learning about growing crystals, tectonics, fossils, rock and minerals, modeling Ohio geology, geologic time, determining true north, and constructing scale-models of the Earth-moon system. Each activity contains detailed instructions and a list of necessary equipment. (DDR)

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 1

CRYSTAL GARDEN

by Sherry L. Weisgarber

This often used project provides wonder and excitement as the crystals grow.

Materials:

6-7 barbecue charcoals or stones (1 to 2 inches across)
shallow bowl (aluminum pie pan works fine)
4-6 tablespoons table salt
4-6 tablespoons liquid laundry bluing (see NOTE below)
4-6 tablespoons water
1 tablespoon ammonia (be careful using ammonia around children)
food coloring

Collect several small pieces of limestone, brick, coal, or barbecue charcoal. You may want to try a bowl of each to determine which material grows the best crystals. Place the charcoal or stones clustered together in the bowl. Mix all of the ingredients together, except the food coloring, in the order listed using the same amount of salt, bluing, and water for each batch made. Pour the mixture very slowly over the stones with a spoon. The mixture may not be dissolved depending on the number of tablespoons of ingredients used. You may want to make different batches using different amounts of ingredients to see which works best. Drop food coloring over the coated stones. Using different colors produces a variegated crystal garden. Crystals should begin to form in about 20 minutes and continue growing for a day or two. Adding any excess mixture to the bottom of the bowl over the next few days may keep the garden growing longer. This creation will crumble very easily, so don't move it around too much.

NOTE: Laundry bluing comes in a small blue bottle and generally can be found in the laundry section of a grocery store next to the starch and bleach products.

SOURCE: *Kids create!*, Laurie Carlson; and Nevada Mining Association, Lois K. Ports.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 2

EGG TECTONICS

by Sherry L. Weisgarber

Plate tectonics, or the continental drift theory, was first suggested in 1912 by the German scientist Alfred Wegener. The theory, which states that the Earth's surface, or crust, is divided into six to nine major plates that slowly move and change in size, was not widely accepted until the late 1960's. The theory supposes that all the continents were once part of a supercontinent called Pangea. This theory explains why continents that are now widely separated from each other possess rocks and fossils of the same extinct plants and animals. Geologic events and features such as earthquakes, volcanoes, mountain ranges, hot springs, and geysers also can be explained using plate tectonics.

The slow (1-4 cm per year) movement of tectonic plates causes one of three types of boundaries: *divergent boundaries*, where plates separate; *convergent boundaries*, where plates collide; and *transform boundaries*, where plates slide past each other. The following activity simulates these plate boundaries using a cracked eggshell.

Materials:

3 (or more) hard-boiled eggs
3 (or more) water-based markers

Gently tap the eggs repeatedly on a table while rotating them to produce cracks all around the eggs. Trace along the major cracks with a water-based marker. Gently squeeze the eggs until slight movement of the shell pieces occurs. Look for places where pieces of the eggshell separate. This area represents a divergent boundary. Most divergent boundaries on the Earth are hidden beneath the oceans and are characterized by volcanism, earthquakes, and massive heat flow due to molten rock (magma) rising up from the mantle, which is the thick layer of rock separating the crust from the core at the center of the Earth. The Mid-Atlantic Ridge on the bottom of the Atlantic Ocean is an example of a divergent boundary; here the North American Plate and the Eurasian Plate are separating, causing sea-floor spreading and new oceanic crust to form. Next, look for places where two pieces of eggshell are colliding. This area represents a convergent boundary. Two events can occur when plates converge. If denser oceanic crust collides with lighter continental crust, the oceanic crust will buckle under the continental crust down into the mantle. This process is called subduction and is characterized by earthquakes, rock deformation, and volcanism. The volcanic Cascade Range of the Pacific Northwest was formed by subduction of the Juan de Fuca Plate under the North American Plate. If two equally dense continental crusts collide, both plates will resist being subducted. In this process, the continental crust folds and deforms into a mountain range. The Himalayas are an example of a mountain-building episode which began 25 million years ago and is still occurring today as India travels northward, colliding with Asia. Finally, look for places where one piece of eggshell slides past another. This area represents a transform boundary. The crust is not destroyed here as it is at a convergent boundary, nor is crust created as it is at a divergent boundary. As the two plates slide past each other, earthquakes occur. The San Andreas fault in California is an example of this type of boundary.

NOTE: After this experiment, use the eggs to illustrate the layers of the Earth. Cut the egg in half. The shell represents the crust. The thick egg white represents the mantle. The egg yolk represents the core.

SOURCE: *Terrific Science & Math* (Miami University), Fall 1993; and *Earth and Its Resources*, Creative Teaching Press.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 3

EVERYONE LOVES FOSSILS

by Sherry L. Weisgarber

What exactly are fossils? Fossils are the remains of past life. This definition includes anything that is a clue to past life, such as the bones of dinosaurs and mammoths, the tiny shells of one-celled animals, trails and footprints, worm burrows, leaves, tree trunks, seeds, and microscopic spores of fungi.

Fossils occur in sedimentary rocks such as limestone, shale, and sandstone. Because Ohio is covered with sedimentary rocks, fossil collecting is a popular hobby for many Ohioans.

How do fossils form? Some of the plants and animals that died in the geologic past were buried by sediments before they could decompose. After burial, the soft tissue of the organism slowly decomposed, but the harder parts of the plant or animal remained intact. The sediments eventually were hardened into rocks, preserving the harder parts of the organisms, such as bones, shells, teeth, leaves, and stems, that we find as fossils today.

Fossils are preserved in a variety of ways. The hard parts of some organisms are permeated by minerals in a process called permineralization. Petrified wood is an example of permineralization. Many plants are preserved as compressions. In this process, the remains of the organism are squeezed by the rocks that surround it until all of its liquids and gases are removed, leaving only a thin film on the surface of the rock. The hard parts of many Ohio fossils were dissolved by ground water moving through the sediment or rock and replaced with minerals in the water. This process is called replacement. In Ohio, common replacement minerals are pyrite and silica. Ground water also may dissolve the original material without replacing it with other minerals. If the sediment hardened into rock before the fossil was dissolved, the rock retains the imprint of the fossil, which is called a mold. A mold may later be filled with other sediment or minerals precipitated from ground water, making a cast of the fossil. A cast is a replica of the original fossil in a different material.

The following classic activity illustrates the concepts of molds and casts.

Each student will need the following materials:

sea shell, twig, or other small object	plastic fork	petroleum jelly
$^{1}/_{4}$ to $^{1}/_{2}$ cup plaster of paris	$^{1}/_{4}$ to $^{1}/_{2}$ cup water	paper cup
small plastic margarine dish		

Cover the small object, representing a dead organism, with a thin layer of petroleum jelly to keep it from sticking in the plaster of paris when it hardens. Put the plaster of paris into the margarine dish. Add water gradually to the plaster of paris, stirring gently with the fork until the plaster is thick and creamy. Gently tap the bottom of the dish onto the table to force out any air bubbles in the plaster. This layer represents the soft sediment that the organism fell into when it died. Let the plaster harden for about 1 minute so the object won't sink to the bottom of the container. Press the small, petroleum-covered object into the plaster and allow it to dry thoroughly, preferably overnight. Remove the object from the plaster. You now have a mold of your object. Leave the mold in the container and coat the entire surface of the dry plaster with a thin layer of petroleum jelly. Mix another batch of plaster of paris in the paper cup. Pour this mixture over the mold and allow it to dry. This layer represents the overlying sediments or the minerals precipitated from ground water that fill in the mold, making a cast of the original object. When the plaster is dry, separate the cast from the mold. It should separate easily along the layer of petroleum jelly. You now have a fossil cast and a fossil mold of your original object.

SOURCE: *Ohio fossils*, ODNR, Division of Geological Survey; *Water, stones, & fossil bones*, National Science Teachers Association; and *The earth science book*, Dinah Zike.

Division Of Geological Survey

HANDS ON EARTH SCIENCE

No. 4

OHIO GEOLOGY WORD SEARCH

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

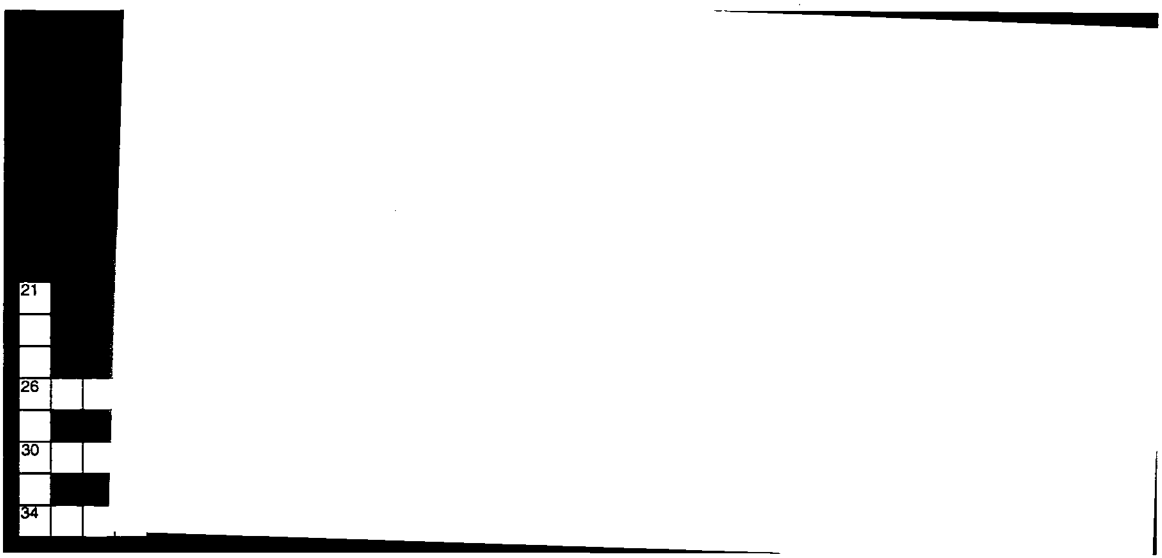
Look for these words, all related to Ohio geology, within the arrowhead diagram. The words may read forward or backward, and across, down, or diagonally. Further information on these words and their relation to Ohio geology is included in the Ohio Geology Crossword Puzzle (Hands On Earth Science No. 5).

BRINE	ISOTELUS
CAVES	KAMES
CLAY	LANDSLIDES
COAL	LIMESTONE
EARTHQUAKES	MAMMOTHS
ERIE	PALEOZOIC
FLINT	RIVERS
FOSSILS	SALT
GAS	SAND
GLACIERS	SANDSTONE
GRAVEL	SHALE
GYPSUM	TEAYS
ICE	TOPOGRAPHIC
IRON	TRILOBITE

Created by Sherry L. Weisgarber and Lisa Van Doren

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 5

OHIO GEOLOGY CROSSWORD PUZZLE



ACROSS

4 The period of the Paleozoic Era that includes the oldest (about 450 millon years old) rocks exposed in Ohio. They are exposed in southwestern Ohio and contain the state fossil.

6 These glacial features are channels gouged into bedrock surfaces by abrasion by rock fragments contained in the glacier and high-pressure, sand-charged meltwater along the bottom of the glacier. The largest and best known are on Kelleys Island in Lake Erie.

8 This mineral resource is commonly associated with **33 DOWN**. In the late 1880's, Findlay, Ohio, was famous for its plentiful and cheap supplies of this mineral resource.

10 This sedimentary rock formed by lithification of clay-size fragments. It is mined in Ohio for use in the brick industry.

11 This mineral resource forms in the same manner as **34 ACROSS**. In Ohio, it is mined and used exclusively for the manufacture of wallboard (sheetrock), although other uses include plaster of paris and as an additive in cement.

13 A glacial feature composed of sand and gravel, generally in the shape of a conical hill. These features commonly are mined for their sand and gravel or are used as sites for cemeteries.

14 The era of geologic time in which all the surface bedrock of Ohio was formed. During much of this time, from about 600 million years ago to about 225 million years ago, Ohio was in tropical latitudes and covered by a warm shallow sea.

17 Natural features in which water flows from a higher to a lower elevation. Many of these features in Ohio formed when glacial meltwater eroded channels in bedrock or thick sediments.

20 This geologic hazard happens where slopes are steep and rock layers weather easily. This phenomenon is common in shales and clays of southwestern Ohio, southeastern Ohio, and along the Lake Erie shore.

22 This type of map depicts the elevation of the land surface using contour lines and also shows lakes, streams, roads, houses, and more.

25 This rock is made up mostly of calcium carbonate and forms as a precipitate from sea water or by accumulation of shell fragments on the bottom of tropical seas. This rock is mined for a variety of uses, especially as a construction material.

26 These elephantlike animals became extinct about 10,000 years ago. They lived in Ice Age spruce forests typical of Ohio at that time, so many fossil remains of these creatures have been found here.

27 This mineral resource formed by the accumulation, compression, and alteration of plant remains deposited in widespread swamps in Ohio about 300 million years ago. Ohio ranks second nationally in the consumption of this mineral resource for electrical generation.

29 This group of fossils is characterized by two grooves that divide the animal into three distinct lobes, giving these animals their name. These fossils are common in the Ordovician- and Devonian-age rocks of western Ohio.

30 This huge river flowed northward across Ohio more than 2 million years ago and was destroyed by the glaciers. Its valley and tributary valleys were filled with several hundred feet of glacial sediment and are now important sources of water (aquifers).

more ☛

31 By Civil War time, Ohio was a leading producer of this mineral resource. Native ore was heated in a furnace using limestone for a flux and charcoal from trees for fuel.

32 Several specimens of this precious gemstone have been found in Ohio. It is the hardest mineral known and is used as an industrial cutting tool. It is speculated that the glaciers scraped up them up from Canada or the Upper Peninsula of Michigan and deposited them in Ohio.

34 Thick deposits of this mineral resource, also known as halite, precipitated from sea water during the Silurian Period, 400 million years ago. Two underground mines in Ohio produce this mineral resource from about 2,000 feet beneath Lake Erie. Ohio ranks fourth nationally in the production of this mineral resource.

35 A mineral resource formed by the decomposition of plant matter in glacially associated bogs. It commonly is used in soil mix.

36 At least 120 of these geologic phenomena have been experienced throughout Ohio since 1776, especially in western Ohio.

DOWN

1 Geologic features formed beneath the ground surface by dissolution of limestones and dolomites by weak acids in ground water. These features can be found in the Silurian- and Devonian-age rocks of western Ohio.

2 The remains or traces of past animal or plant life.

3 Tiny flakes of this precious metal can be found in nearly any stream in the glaciated portion of the state. It comes from rocks that were scraped up by the glaciers from Canada and deposited in Ohio.

5 This mineral resource is found in two types of deposits in Ohio—beneath coal seams in eastern Ohio and in association with glacial lakes. Two uses for this mineral are in pottery and bricks.

6 Masses of ice that flow in a specific direction and originate from the compacting of snow by pressure. Over two-thirds of Ohio was covered by at least three of these ice sheets during the Pleistocene Epoch (about 2 million to 10,000 years ago).

7 The raw material, especially of a metal, that is mined to be processed into a final product.

8 A pebble- to boulder-size sediment of variable composition. It commonly occurs with **12 DOWN**. Many homes have this material in their driveways.

9 Genus name of the trilobite that is Ohio's state invertebrate fossil.

11 A type of map that shows the distribution of rock units at the surface as if all overlying unconsolidated materials have been removed.

12 A fine- to coarse-grained sediment of variable mineral composition that was formed by erosion and carried by glacial meltwater in Ohio to be deposited as outwash. This deposit and **8 DOWN** are mined and used extensively as construction materials.

15 This lake was formed when the glaciers deepened the basin north of Ohio, allowing a large meltwater lake to form.

16 This era of geologic time began about 70 million years ago and continues to the present. Erosion rather than deposition was the dominant force during this time because Ohio was high above sea level.

18 The most abundant mineral in Ohio 19,000 years ago. It has a low melting point, hardness of 1 to 2, and specific gravity of less than 1.0. In many areas of the state this mineral was more than 1 mile thick.

19 This rock is composed of sand-size rock fragments cemented by calcite, silica, or iron. These rocks commonly formed as beach, river-channel, or delta deposits. Ohio ranks first nationally in the production of building stone from this type of rock.

21 These animals were related to the modern Indian elephant and became extinct about 10,000 years ago. They lived in Ice Age grasslands, so their fossil remains are not common in Ohio.

23 The period of the Paleozoic Era that includes the youngest (about 280 million years old) rocks exposed in Ohio. They are exposed in southeastern Ohio.

24 Type of chemical used for radiometric dating.

28 This mineral resource is Ohio's official gemstone and has been used longer than any other mineral commodity in the state. Items made from this resource by American Indians have been found from the Atlantic Coast to Louisiana.

33 This complex hydrocarbon formed when the plants and animals that lived in Ohio's shallow Paleozoic Era seas died and were chemically altered. In the late 1800's, Ohio was the leading national producer of this important energy resource.

WORD LIST

caverns • Cenozoic • clay • coal • diamonds • earthquakes • Erie • flint • fossils • gas • geologic • glaciers • gold • gravel
grooves • gypsum • ice • iron • isotope • Isotelus • kame • landslide • limestone • mammoths • mastodons • oil
Ordovician • ore • Paleozoic • peat • Permian • rivers • salt • sand • sandstone • shale • Teays • topographic • trilobite

The idea for this puzzle came from the New Mexico Bureau of Mines and Mineral Resources *Lite Geology* (Fall 1993) and Robert F. Kunst.
Created by Sherry L. Weisgarber & Merrianne Hackathorn

Division Of Geological Survey

HANDS ON EARTH SCIENCE

No. 6

ROCKS AND MINERALS ARE EVERYWHERE

Ohio's rocks and minerals can be used for a variety of items. Match the rock or mineral to the item for which it is used. There may be multiple matches.


plastic toy

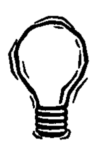

paper

peanut butter


paste toothpaste


bakery cake icing


asphalt road


electricity

sandstone

oil

clay

limestone

gypsum

salt

shale

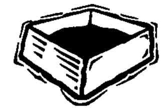
coal

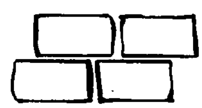
sand/gravel

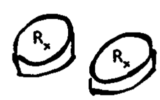

dinner glass


gel toothpaste


hand lotion


kitty litter


bricks


cold tablets


dandruff shampoo

ANSWERS

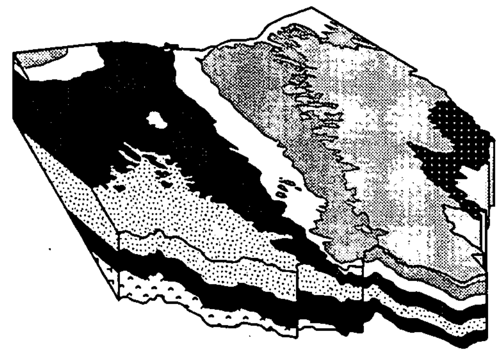
gel toothpaste = sandstone • dinner glass = sandstone, limestone • hand lotion = oil, clay • plastic toy = oil
kitty litter = clay • paper = clay, limestone • paste toothpaste = limestone • bakery cake icing = gypsum
peanut butter = salt • bricks = shale, clay • dandruff shampoo = coal • asphalt road = sand/gravel, limestone

Created by Sherry L. Weisgarber and Lisa Van Doren

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 1

MODELING OHIO'S GEOLOGY

by Joseph T. Hannibal, The Cleveland Museum of Natural History



Geologic maps are representations of the geology of an area. For example, the geologic map of Ohio shows the distribution of bedrock belonging to six geologic systems, that is, rock laid down during corresponding geologic time periods.

Geologic maps generally are colorful, and commonly are accompanied by cross sections that help in their interpretation. Still, it's not always easy for the student to understand what these maps represent. One hands-on way to help understand such maps is to make your own three-dimensional model. It is quite easy to make such a model of Ohio—all you need is plaster, a mold shaped like Ohio, paints, and a geologic map of Ohio. Many craft stores sell plaster and molds for making plaster objects. If your craft store does not have an Ohio mold, the store can order molds of Ohio and other states from the Deep Flex Plastic Mold Co., Murfreesboro, Tennessee. Their Ohio mold produces casts that are 5.5 x 5.5 x 1.0 cm in size. Multiple molds can be purchased for classroom use. Inexpensive acrylic paints can be used for painting your model. Six colors will be needed for the top view and two additional colors for the cross-sectional view. A simple, page-size geologic map illustrating the geologic systems can be ordered from the Ohio Division of Geological Survey.

To make your three-dimensional model, mix plaster according to the recipe on the container and pour it into the plastic mold. Let it dry for at least two hours. Then, using the geologic map of Ohio as a guide, paint the area representing rock belonging to each geologic system a different color. The top view will be easy—it's the same as the map. The sides of the model will be more difficult, requiring an understanding of the tilting (dip) of the rock layers beneath the surface and a basic understanding of geologic principles. The accompanying illustration will help. When painting your model, be sure to remember that younger rock layers in Ohio overlie older layers; this is the Law of Superposition. In a classroom, students can either work in small groups or make individual models. The final model can be protected by spraying it with an acrylic fixative. Teachers may want to make a large-scale plaster map; directions for such a map are given in the reference cited below.

Geologic maps also can be made using different colors of play clay or similar materials to represent rocks belonging to different systems. However, because of shrinkage during drying, these models will not be as attractive as well-painted plaster models.

The geological gourmet might prefer to make edible geologic-map cookies. This project requires a state cookie cutter (available, for instance, from the Ohio Historical Society, 1982 Velma Ave., Columbus OH 43211). A simple sugar cookie recipe from any general cookbook can be used. A glaze frosting can be made using powdered sugar, a tad of warm water, and a few drops of food coloring; again, a recipe can be found in any general cookbook. At least six colors of frosting will be needed for a geologic map of Ohio. You can try making three-dimensional cookies by cutting out a thicker than usual cookie. However, if you are not an expert cookie maker you will find it difficult to frost the sides of the cookies, so it may be best to simply do the top view of the map. Add a chocolate chip to identify your city. One warning—making edible geologic maps takes time! If this project is done for the classroom the cookies can be baked at home by the teacher or by parent volunteers the day before frosting in class.

SOURCE: "A simple, inexpensive method for making a three-dimensional geologic model of your state," by Suellen Hopfer and J. T. Hannibal, in *On the rocks: earth science activities for grades 1-8*, S. G. Stover and R. H. MacDonald, eds., SEPM (Society for Sedimentary Geology), 1993.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 8

UNDERSTANDING GEOLOGIC TIME

by Sherry L. Weisgarber

Time. A simple concept we take for granted every day. "I have a karate class in two hours." "One more day until the weekend." "My birthday is in eight months." "I have worked here for 12 years." "The Ohio Geological Survey originated nearly 160 years ago." "The Age of the Dinosaurs began 245 million years ago." "The Earth is 4.6 billion years old." Well, wait a minute. Maybe the concept of time, especially geologic time, is not so simple. It's easy to comprehend the time span of "one more day until the weekend." However, it is not so easy to comprehend the time span of "the Earth formed 4.6 billion years ago."

How much is a billion? One billion seconds from the beginning of 1996 would be the year 2029. How much is a million? If a person lived for 1 million days, they would be 2,740 years old. These analogies may help put into perspective the immensity of geologic time. We hope the following activity of making a human time line will help even more.

This activity is easier to do outside. You will need an area approximately 260 yards in length, 260 yards of twine, and some masking tape. Mark off the twine in yards using the masking tape and a yard stick. The last yard measured should be marked off in feet. The last foot measured should be marked off in inches. Assign each student an event from the list below. The outdoor scale used here is 2 inches = 1 million years.

The student representing the formation of the Earth should pace off 254 yards from the present. The rest of the students should then pace off their respective distances from the present for their assigned events. For example, the student representing the beginning of life on Earth would pace off 194 yards from the present, and the student representing the first reptiles would pace off 18 yards from the present.

When the human time line is complete, start with the formation of the Earth and have the students shout out what event they represent and how long ago they happened. For example, "I am the first reptile. I appeared 330 million years ago." Remember, the student representing the beginning of the Earth will have to shout very loudly, as they will be more than two football fields away from "the present"!

The students representing "recent" events, those events closer to the present, will be crammed together at the end of the time line. If the students cannot fit closely enough together, use longer pieces of tape to mark the event on the twine and have the students stand to the side.

This activity can be done inside using a smaller scale, such as $^{1}/_{10}$ inch = 1 million years. The time line can be made on adding machine paper and then taped to the wall. The students could also draw pictures of their events and tape them under the time line on the wall. For "recent" events, a larger scale could be used. This larger scale time line could be taped under the longer time line, indicating that much has happened in a relatively short period of time.

SOURCE: *Ranger Rick's nature scope: digging into dinosaurs,* National Wildlife Federation; *Historical geology of North America,* by Morris Peterson, J. Keith Rigby, and Lehi Hintze, Wm. C. Brown Company Publishers; *Understanding and collecting rocks & fossils,* by Martyn Bramwell, Usborne Publishing; *Fossils, rocks, and time,* by Lucy Edwards and John Pojeta, Jr., U.S. Geological Survey.

NOTE: Maps showing the geology and glacial deposits of Ohio are available from the Division of Geological Survey.

—Timeline starts on reverse—

TIME LINE EVENTS

Distance from present, indoor scale (1/10 inch = 1 million years)	Distance from present, outdoor scale (2 inches = 1 million years)	Years ago	Events
38 feet	254 yards	4.57 billion	Formation of Earth • Precambrian
31.5 feet	210 yards	3.78 billion	Oldest known rocks
29 feet	194 yards	3.5 billion	Life on Earth begins • oldest known fossil (anaerobic bacteria)
12.5 feet	83 yards	1.5 billion	Oxygen accumulates in atmosphere • granite-rhyolite emplaced in western Ohio • one-celled algae appear
10 feet	67 yards	1.2 billion	Oldest animal fossil (jellyfishlike organism)
8 feet	56 yards	1 billion	Formation of iron, copper, and nickel ores • rifting in western Ohio, Grenville Mountains form in eastern Ohio
6 feet	37 yards	670 million	Abundant soft-bodied, wormlike animals in the sea • Precambrian rocks deeply eroded in Ohio
5 feet	32 yards	570 million	Cambrian Period • numerous hard-shelled animals (trilobites) appear in the sea
4 feet	28 yards	500 million	Ordovician Period • oldest rocks exposed in Ohio—limestone and shale in southwestern Ohio • North America situated close to Equator • diverse sea life (trilobites, brachiopods, clams, snails, corals, fish without jaws)
3 feet 7 inches	24 yards	435 million	Silurian Period • salt and gypsum deposits in northern and northeastern Ohio • first life on land (ferns and mosses) • first fish with jaws • giant sea scorpions abundant
3 feet 5 inches	23 yards	410 million	Devonian Period • black shale deposits in northern and central Ohio • Age of Fishes • first sharks • first land animals (amphibians and wingless insects) • first forests
3 feet	20 yards	360 million	Mississippian Period • sandstone and shale deposits in eastern, central, and northwestern Ohio • Age of Crinoids • supercontinent Pangea is forming
2 feet 10 inches	18 yards	330 million	Pennsylvanian Period • coal deposits in eastern Ohio • coastal swamps and tropical forests common • formation of Appalachian Mountains • supercontinent Pangea is complete • large winged insects, spiders, and scorpions abundant on land • first reptiles • first evergreen trees • large trees and plants
2 feet 5 inches	16 yards	290 million	Permian Period • youngest rocks exposed in Ohio—sandstones and shales in southeastern Ohio • widespread extinctions occur among land and sea life (trilobites, brachiopods, ancient corals, many amphibians, trees, and ferns) • great fin-backed reptiles (*Dimetrodon*) dominant
2 feet	13 yards	240 million	Triassic Period • no deposits in Ohio • Pangea begins to split apart into Laurasia and Gondwana • Age of Reptiles begins • first dinosaurs • pine forests • abundant clams, snails, modern corals, ammonoids, marine reptiles (ichthyosaurs and plesiosaurs), and land reptiles (phytosaurs) • first small mammals
1 foot 8 inches	11 yards	205 million	Jurassic Period • no deposits in Ohio • North American Plate moves westward at a rate of 6 miles per million years • dinosaurs (*Stegosaurus, Allosaurus, Brachiosaurus, Diplodocus*) rule the Earth • flying reptiles (pterosaurs) appear • marine reptiles common • first known bird
1 foot 2 inches	8 yards	138 million	Cretaceous Period • no deposits in Ohio • formation of Rocky Mountains • North America continues to move west • ammonoids, clams, snails, corals, bryozoans, ichthyosaurs, and plesiosaurs abundant in seas • *Tyrannosaurus* and *Triceratops* abundant on land • large pterosaurs abundant in the air • first snakes • first grasses and flowering plants
6 inches	4 yards	65 million	Tertiary Period • Teays-age stream deposits in southwestern Ohio • North American Plate and Pacific Plate collide • huge extinction (dinosaurs and many other species) • Age of Mammals begins • beginning of modern shell life in seas • North America begins to cool
5 inches	3 yards	45 million	Pangea splits into modern continental masses
4 inches	2 yards	37 million	First elephants, horses, deer, bears, and ancestors of cats and dogs
2 inches	1 yard	24 million	Apes abundant • huge sharks in seas • plant life similar to today
0.04 inch (1 mm)	10 inches	5 million	Early forms of humans • first tool-using primitive humans
0.01 inch (0.3 mm)	3 inches	1.6 million	Quaternary Period • beginning of the Ice Age • abundant horses, mastodons, beavers, porcupines, and large ground sloths
0.008 inch (0.2 mm)	2 inches	1 million	Abundant sabertooth cats, wooly mammoths, bison, and rodents
0.001 inch (0.03 mm)	0.02 inch	10,000 years	End of recent Ice Age • two-thirds of Ohio covered by unconsolidated glacial deposits • many large land mammals become extinct
	0	the present	Humans dominate the Earth • North America continues to move west

Division Of Geological Survey
HANDS ON
EARTH SCIENCE No. 9

HOW TO DETERMINE TRUE NORTH

by Richard Hansgen, Education Department, Bluffton College

Can you mark on the ground a true north-south line? Is the Sun directly overhead at noon? Does midday coincide with noon? Such questions can form the basis of an excellent inquiry-based experiment for students ranging from fifth graders through college undergraduates. Although this activity is simple enough to use with middle-school students, it is also worthwhile to pursue with high-school and college students because the vast majority of such students have not made, or even considered, these fundamental determinations.

A straightforward method to lay out a north-south line is to first determine midday. Midday is simply that time halfway between the times of sunrise and sunset, which can be ascertained by calling the local television station or watching the local evening news. The times given will be accurate to within a couple of minutes, depending on your location with respect to the station.

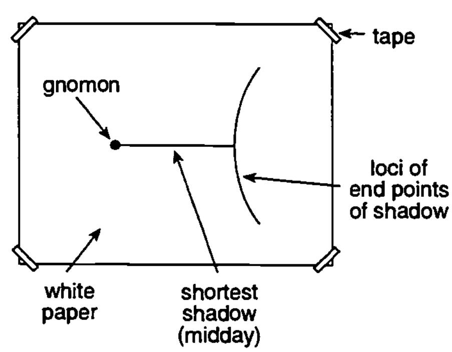
The class can be divided into small groups. Each group will need two large sheets of white paper, masking tape, a standard laboratory support stand with rod (the vertical rod serves as the shadow-casting object, or gnomon), a meter stick, a watch, and a sharp pencil. You should also have available a scout or army-type compass and a large protractor.

Take the class outside on a sunny day about a half hour before your calculated value of midday. They will need a horizontal surface, such as a sidewalk, on which to work. Place the support stand on the level surface and arrange the large sheet of paper so that the shadow of the tip of the rod falls on the paper. Tape the paper to the level surface. (Remember, the shadow is going to move; that is why we have an extra sheet of paper.) The position of the base of the stand should be outlined by pencil on the paper so that if the stand gets bumped, it can be returned to its original position.

To add a worthwhile flair to this experiment, the instructor can set up a similar apparatus in the morning and mark positions of the tip of the shadow every half hour. Record the times on the paper near the appropriate mark. The teacher can then connect these points with a smooth curve, providing a dramatic representation of how far the shadow (or "Sun") moves in just a couple of hours.

Students should begin their measurements at least 20 minutes before the calculated value for midday and should measure the length of the shadow every 2 minutes for approximately 40 minutes. They should mark the position of the tip of the rod's shadow and note the time beside each mark. Measurements should continue until the length of the shadow begins to noticeably increase. Midday is when the length of the rod's shadow is shortest. A line drawn on the paper between the mark representing the tip of the minimum shadow and the center of the base of the support rod provides a true north-south line.

What the students are witnessing is empirical evidence that the Earth is rotating about its axis. They



Bird's-eye view of set up for determining midday.

are watching the Earth spin. One should keep in mind, though, that this is evidence, not proof. A stationary Earth about which the Sun makes a daily orbit provides an alternative explanation. A field trip to a local science museum where a Foucault pendulum is on display would provide more direct evidence that the Earth is rotating.

With the aid of the compass and the protractor, students can now determine the angle of deviation between the direction the compass needle points and the line they have drawn on the paper. They should compare this angle with the accepted value for the angle of magnetic declination given on a U.S. Geological Survey topographic map of their area. If this experiment is done with moderate care, the students will be pleased with the comparison.

Further questions and experiments come immediately to mind. How did the measured value for midday compare with the computed value? Why wasn't midday at noon? What were sources of error in this experiment and how might they be minimized? For any given time, will the length of the shadow change from day to day? If so, why? On what date will shadows be shortest? Longest?

These questions can best be answered by further shadow measurements. Students can calculate the latitude of their school. This experiment is best done at midday on either the vernal or autumnal equinox. The shadow measurement of midday provides a straightforward technique. All the class needs in order to determine their latitude is either a knowledge of elementary trigonometry or an accurate and large scale drawing of the length of the support rod (from ground to tip) and the length of its shadow. Then simply measure the appropriate angle.

Shadow experiments demonstrate that excellent science can be done with simple apparatus. After all, the old Greeks did remarkably well with what nature provided: a stick, the Sun, and some human ingenuity!

FURTHER READING

McClure, Bruce, 1987, Watching the Earth move with the shadow clock: Astronomy, v. 15, no. 8, p. 32-35.

(This article originally appeared in The Physics Teacher, 1995, v. 33, p. 116-117.)

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 10

TWO SCALE MODELS OF THE EARTH-MOON SYSTEM

by Richard Hansgen, Education Department, Bluffton College

Given the diameters of the Earth and the Moon and the distance between the two bodies, students can construct a scale model of the Earth-Moon system which will prove very useful in their classroom. The following activity is written in an inquiry mode and should be presented to students as a set of activities and questions. Answers for the instructors are provided in italics in brackets.

Diameter of the Earth	=	12,800 km
Diameter of the Moon	=	3,500 km
Mean distance from Earth to Moon	=	385,000 km

MODEL I

First, calculate to the nearest whole number how many times as large as the Earth (its linear diameter) the Moon is. [4]

If we choose a basketball (diameter of approximately 25 cm) to represent the Earth, what size ball would represent the Moon? [~6 cm, a tennis ball. For any scale model, the Earth must be four times as large as the Moon.]

We now have our system to scale with respect to size. Next we scale for distance. To the nearest whole number, how many Earths can fit between the Earth and the Moon? [30] This is a fascinating answer. Does it surprise you? Did you think it should be smaller or greater?

According to our scale above, how many basketballs must fit between the Earth and the Moon? [30. For any scale model, the Moon must be 30 "Earths" from the Earth.]

Now obtain a long piece of heavy string. Using our scale, how long should the string be to represent the distance between the Earth and the Moon? [30 x 25 cm = 750 cm = 7.5 meters]

With masking tape, attach one end of the string to the "Earth" and the other end to the "Moon." You now have a very flexible Earth-Moon model which is to scale for both size and distance—the Earth and Moon in your classroom!

With this model, how far away would the sun be, in units of our Earth-Moon distance? Hint: the Earth-Sun distance is 150,000,000 km. [400] If we took our model outside into the street, how far away would the sun be in meters? [400 x 7.5 meters = 3,000 meters = 3 km] This exercise should provide the students some food for thought as to the immense size and vast emptiness of our solar system!

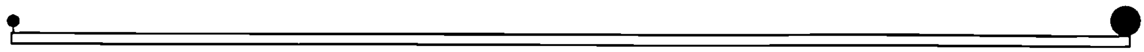
MODEL II

The second model is less flexible than the one above but has the advantage of clearly simulating both solar and lunar eclipses.

Let the Earth be represented by a 10-cm styrofoam ball. What size styrofoam ball should represent the Moon? [2.5 cm. Remember, our scaling factor for size is 4.]

What is the Earth-to-Moon distance with our new scale? [30 x 10 cm = 300 cm = 3 meters. Remember, our scaling factor for distance is 30.] Go to your local lumber yard and have them cut an inexpensive 1-inch x 1-inch board whose length correctly represents this Earth-Moon distance.

Attach the larger ball (the Earth) to one end of the board with glue or large rubber bands. Place the smaller ball (the Moon) at the other end. However, in order to keep the shadow of the Moon distinct from the shadow of the board, raise the smaller ball above the surface of the board by attaching it to a nail or a stiff wire. A bent paper clip works well.



Scale diagram showing the styrofoam balls and board for model II.

Armed with this model (and it is an armful), take your class outside on a sunny day and demonstrate eclipses. It really works! You will discover that the "Moon" will be completely covered by the "Earth's" umbra as you simulate a lunar eclipse just as in the actual event, but during your "solar" eclipse only a portion of the "Earth's" surface will fall into the "Moon's" total shadow. Again, this is what actually happens. Our model illustrates nicely why one must live within that narrow zone of totality in order to experience a total solar eclipse! The strip of totality is generally about 241 km wide, which explains why most people have never seen a total solar eclipse.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 11

IS IT A ROCK OR A MINERAL?

by Sherry L. Weisgarber

Kids love rocks and minerals. However, many kids (and adults!) do not know the difference between a rock and a mineral. This activity is designed to train K-5 young scientists to observe and classify while learning how to tell the difference between a rock and a mineral.

What is a mineral? A material must fit the following four general criteria to be called a mineral:

1. Minerals are inorganic, meaning they typically do not form from the remains of plants or animals.

2. Minerals are naturally occurring. True minerals are not manmade.

3. Minerals have the same chemical makeup wherever they are found. For example, the mineral quartz always consists of one part silicon (an element) to two parts oxygen (another element). Some minerals, like gold, copper, and sulfur, are made up of only one element. However, most minerals are combinations of several different elements.

4. Minerals have specific repeating patterns of atoms. This orderly arrangement of atoms forms the mineral's characteristic crystal shape. For example, a crystal of quartz is always hexagonal because of the way the atoms of silicon and oxygen join together. However, if a quartz crystal does not have much room to grow, it may not look hexagonal on the outside, even though the atoms on the inside are arranged in the same orderly pattern.

What is a rock? Minerals are the building blocks of rocks. A rock is made up of one or more minerals. Rocks can be placed in one of three categories depending on how they form:

1. Igneous rocks form from magma (molten rock) either deep within the Earth (for example, granite), or on the Earth's surface when lava cools and hardens (for example, pumice).

2. Sedimentary rocks are layered rocks that form primarily from the accumulation and compaction of sediment which is derived from preexisting rocks by erosion (weathering by water, wind, or ice) (for example, sandstone). Some sedimentary rocks form by precipitation from solution (for example, gypsum).

3. Metamorphic rocks form when preexisting rocks—igneous, sedimentary, or metamorphic—are subjected to extreme temperatures and pressures deep within the Earth. The intense heat and pressure cause the mineral composition and grain size to change. For example, limestones become marbles and shales become slates.

Now that you know the general definitions, how can you tell the difference between rocks and minerals? This is where observation and classification becomes important. Minerals are homogeneous (the same throughout). A mineral will generally have the same appearance both on the interior and exterior of the sample. The properties of color and texture generally do not vary sharply because of this homogeneity. However, color and texture generally do vary sharply in rocks because rocks are made up of a variety of different minerals.

Before having the students classify actual rocks and minerals, have them observe and classify some things they may like better . . . candy. For this exercise you will need to choose bags of the following candies. Make sure you have some candies from both the "rock" list and the "mineral" list. The more variety, the better the exercise. The "rock" list includes: Peanut M & M's™, Nestle's Buncha Crunch™, Butterfinger BB's™, and Hershey Kisses with Almonds™. The "mineral" list includes: Hershey Kisses™, gummy bears, jelly beans, and chocolate or peanut butter chips. (This activity assumes that none of the students is diabetic or allergic to chocolate, peanuts, or almonds.)

After explaining to them the difference between rocks and minerals, distribute to each child a variety of candies making sure each child has some "rocks" and some "minerals." Tell the students that geologists generally break open rocks and minerals to help them identify (or classify) a rock or mineral sample. Therefore, the students should bite open their "rocks" and "minerals" to help them with their classification. Remind them that half of each sample is to be eaten and half is to be saved to observe and classify. They can eat the other half after the exercise is finished.

Have the students keep a record of their observations. Which samples seem to be homogeneous? Which samples are made up of more than one substance or "mineral"? Which samples would they classify as "minerals"? Why? Which samples would they classify as "rocks"? Why?

After they are through classifying the candy, they may want to try classifying real rocks and minerals. You can have them bring in their collections (if they have one) from home, take them outside and let them do some collecting during class time, or give them a homework assignment to collect a variety of rocks and minerals on their own.

When the students bring their collections into class, have them classify (group) the samples as rocks or minerals. Once again, have the students keep a record of their observations. Let them decide on their own criteria for classification. They will probably find it difficult to classify the real thing. It may take a while for them to get the hang of it. However, after they catch on, you may want to suggest that they classify their groups of rocks into subgroups, determining which rocks are the same and which are different. They will probably end up with two subgroups: igneous/metamorphic and sedimentary.

After the classifying is complete, have the students say how they decided which samples were rocks and which were minerals. Then ask how they decided to subdivide their rock group. Remind them that no criterion is dumb, and what appears dumb may even be a better way to classify. You will probably find that they used color, shape, texture, and possibly a few unique criteria! Let them know that the exercise they just completed on observation and classification is what scientists do in real life. Now, they are scientists too!

SOURCES: *Food For Thought: Edible Earth Science*, Betty Crocker, Barbara Reed, and Eddie Shaw, 1992, Idea Factory, Inc. (1-800-331-6204); and *Fairly Simple Exercises in Geology*, John J. and Barbara R. Thomas, 1994, Geology Department, Skidmore College, 100 p.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 12

DO ROCKS LAST FOREVER?

by Sherry L. Weisgarber

We think rocks last forever. The boulder we played on in our parents' front yard when we were children is still there for our grandchildren to enjoy. The rock steps to the church are still in use a hundred years later, and the gravestones in the cemetery still mark where our ancestors were laid to rest. These rocks, to us, have lasted forever. But, if you look closely, change is taking place.

This change is called weathering. The term weathering refers to the destructive processes that change the character of rock at or near the Earth's surface. There are two main types of weathering, mechanical and chemical. Processes of mechanical weathering (or physical disintegration) break up rock into smaller pieces but do not change the chemical composition. The most common mechanical weathering processes are frost action and abrasion. The processes of chemical weathering (or rock decomposition) transform rocks and minerals exposed to water and atmospheric gases into new chemical compounds (different rocks and minerals), some of which can be dissolved away. The physical removal of weathered rock by water, ice, or wind is called erosion.

Weathering is a long, slow process, which is why we think rocks last forever. In nature, mechanical and chemical weathering typically occur together. Commonly, fractures in rocks are enlarged slowly by frost action or plant growth (as roots pry into the fractures). This action causes more surface area to be exposed to chemical agents. Chemical weathering works along contacts between mineral grains. Crystals that are tightly bound together become looser as weathering products form at their contacts. Mechanical weathering continues until the rock slowly falls apart into individual grains.

We often think of weathering as destructive and a bad thing because it ruins buildings and statues. However, as rock is destroyed, valuable products are created. The major component of soil is weathered rock. The growth of plants and the production of food is dependent on weathering. Some metallic ores, such as copper and aluminum, are concentrated into economic deposits by weathering. Dissolved products of weathering are carried in solution to the sea, where they nourish marine organisms. And finally, as rocks weather and erode, the sediment eventually becomes rock again—a sedimentary rock.

Four experiments that illustrate the effects of mechanical and chemical weathering are presented below.

PLASTER AND ICE (MECHANICAL WEATHERING)

What you need: plaster of paris, water, a small balloon, two empty pint milk cartons (bottom halves only), a freezer.

What to do: (1) Fill the balloon with water until it is the size of a ping-pong ball. Tie a knot at the end. (2) Mix water with plaster of paris until the mixture is as thick as yogurt. Pour half of the plaster in one milk carton and the other half in the other. (3) Push the balloon down into the plaster in one carton until it is about 1/4 inch under the surface. Hold the balloon there until the plaster sets enough so that the balloon doesn't rise to the surface. (4) Let the plaster harden for about 1 hour. (5) Put both milk cartons in the freezer overnight. 6) Remove the containers the next day to see what happened.

What to think about: What happened to the plaster that contained the balloon? What happened to the plaster that had no balloon? Why is there a difference? Which carton acted as the control? Why? How does this experiment show what happens when water seeps into a crack in a rock and freezes?

What should have happened: The plaster containing the balloon should have cracked as the water in the balloon froze and expanded. Explain that when water seeps into cracks in rocks and freezes, it can eventually break rocks apart.

A SOUR TRICK (CHEMICAL WEATHERING)

What you need: lemon juice, vinegar, medicine droppers, two pieces each of limestone, calcite, chalk, and quartz.

What to do: (1) Put a few drops of lemon juice on one of each of the four rock samples. (2) Put a few drops of vinegar on each of the other four samples. (3) Look and listen carefully each time you add the lemon juice or the vinegar.

What to think about: What happens when you put lemon juice on each rock? What happens when you put vinegar on each rock? Did the lemon juice and vinegar act the same way on each rock? Why did some of the rocks react differently? What does this experiment have to do with weathering?

What should have happened: Lemon juice and vinegar are both weak acids. The lemon juice contains citric acid and the vinegar contains acetic acid. These mild acids can dissolve rocks that contain calcium carbonate. The lemon juice and vinegar should have bubbled or fizzed on the limestone, calcite, and chalk, which all contain calcium carbonate. There should not have been a reaction on the quartz, which does not contain calcium carbonate. Explain that water commonly contains weak acids that dissolve rocks containing calcium carbonate and other minerals.

SHAKE IT UP (MECHANICAL WEATHERING)

What you need: 15 rough, jagged stones that are all about the same size, three containers with lids (like coffee cans), three clear jars, a pen, paper, masking tape.

What to do: (1) Separate the stones into three piles of five. Put each pile on a sheet of paper. (2) Label each pile A, B, or C. Label each can and jar A, B, or C. (3) Fill Can A halfway with water and put in the stones from Pile A. Do the same with Can B and Pile B and Can C and Pile C. Let the stones stand in the water overnight. (4) The next day, hold Can A in both hands and shake it hard 100 times. (5) Remove the stones from Can A with your hands and pour the water into Jar A. Observe the stones and the water. (6) Give Can B 1,000 shakes (you can rest between shakes). Remove these stones and pour the water into Jar B. Observe the stones and the water. (7) Do not shake Can C. Remove the stones and pour the water into Jar C. Observe the stones and the water. (8) Compare the three piles of stones and the three jars of water.

What to think about: How do the piles of stones differ? Why? Which pile acted as the control? Why? How do the jars of water differ? How does this show what happens to stones that are knocked about in a fast-moving river?

What should have happened: The stones that were shaken should have more rounded edges than the stones that weren't shaken, and the stones in Can B should have rounder edges than the ones in Can A. Both jars should have some sediment in the bottom, but Jar B should have more sediment because more shakes would have broken off more bits of rock. The same thing happens to rocks that are carried along in rivers or are tumbled about by waves.

STEEL WOOL AND WATER (CHEMICAL WEATHERING)

What you need: Three shallow dishes, three pieces of steel wool, salt, water, gloves.

What to do: (1) Place each piece of steel wool in a shallow dish (wear gloves because steel wool can give splinters). (2) Pour equal amounts of water over two of the pieces of steel wool. Leave the third piece dry. (3) Sprinkle one of these wet pieces with plenty of salt. (4) Observe and compare the pieces every day for a week.

What to think about: What happened to each piece of steel wool? Which piece changed the most? Why do you think the steel wool changed? Which piece of steel wool acted as the control? What does this experiment have to do with weathering?

What should have happened: When iron gets wet, the water acts as an agent to speed up oxidation (oxidation occurs when oxygen combines with another substance). In this case, oxygen in the water combined with the iron in the steel wool to form an iron oxide, or rust. Rust is a weaker material than the original metal and erodes quickly. When salt is added to the water, it speeds up the oxidation of iron. So, the steel wool in the salt water should have changed the most. The same thing happens to rocks that contain iron as happens to cars during northern winters when salt is put on the roads.

SOURCE: *Ranger Rick's Nature Scope: Geology: the Active Earth*, National Wildlife Federation, 1988.

Division Of Geological Survey
HANDS ON
EARTH SCIENCE
No. 13

PLAYING ROBINSON'S WALL GAME

by Joseph T. Hannibal, The Cleveland Museum of Natural History

There is probably a stone wall somewhere near you. The wall may be a fence or a foundation or other part of a building. Such stone walls can be fascinating geologically, especially if they are constructed of more than one kind of stone. For students at any level, they make excellent places for hands-on discovery.

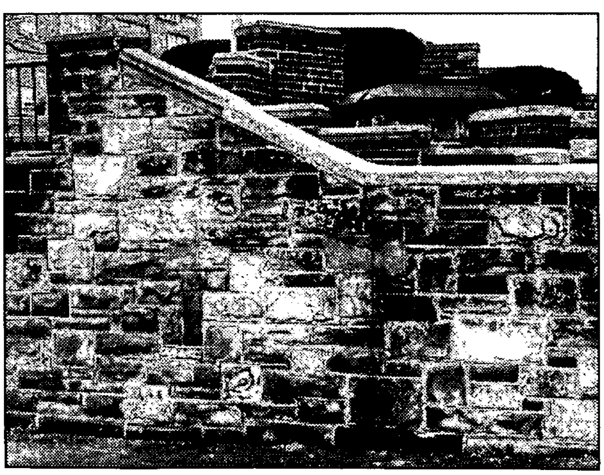
Stone fences generally are made with local bedrock or, in glaciated areas, with local glacial erratics. In the case of buildings, many older structures are made of local stone; more recent buildings may be made of more exotic stones imported to the area for a particular project. In some cases, stone may have even been reused from other projects.

Eric Robinson, a geologist in London, England, has promoted the study of stone walls and other structures in Great Britain, devising exercises for those who might want to examine stone in cities and cemeteries. The techniques outlined here are adapted from Robinson's exercises ("Wall Games") first designed for cathedral precincts (including Gloucester, Ely, and Winchester) in Great Britain.

My favorite local stone wall for such projects is part of an old foundation in Cleveland, Ohio. This wall is now on the campus of Urban Community School. Two cornerstones can be found on the wall. They mark the dates of churches that once stood on the site, providing information on the time spans when this foundation—and its predecessor—were erected.

Several types of sandstone are used for this wall. Each of these stone types differs in color, weathering characteristics, and provenance (origin). The main stone used is a gray to beige sandstone that has medium-sized grains. Red, yellow, and purple sandstones also are used. The gray to beige sandstone is the famous Berea Sandstone, long quarried in northern Ohio. The red stone appears to be the Jacobsville Sandstone, shipped to Ohio from the Upper Peninsula of Michigan. The other stone types are more difficult to place.

Students can study such a wall by carefully sketching it, then noting color, grain size, sedimentary structures, weathering characteristics, etc. Alternatively, and to move the project along at a quicker pace, the instructor can provide a sketch of part of the wall, thus giving students more time for analysis. Eric Robinson has found, however, that too much detail is not good; a simple skeleton sketch, like that shown here (but larger in scale and covering a smaller area) is best. It should depict the outline of each



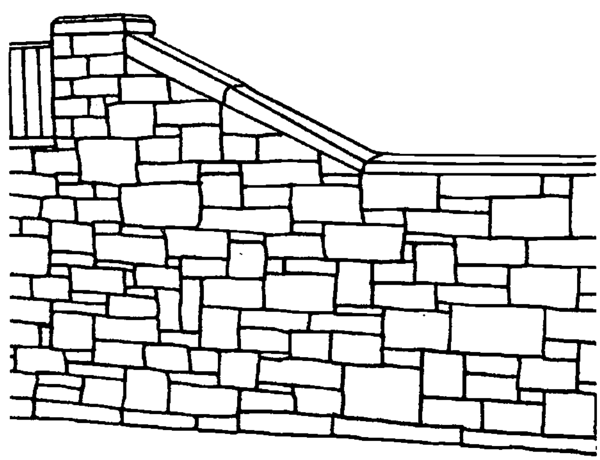


Photo of stone wall at Urban Community School in Cleveland, and a sketch of the wall.

block in the area of interest, enough so that the student may orient himself or herself. The easiest way to make such a sketch is to photograph the wall and trace the outlines of the stone blocks onto a sheet of tracing paper. The drawing can then be enlarged using a photocopier.

Younger students will enjoy coloring the blocks according to stone type using crayons; older students can use colored pencils or just pencil shading. Once the rocks are colored in, a key should be devised and notes on grain size and weathering can be jotted down on the diagram or in a notebook. Follow-up discussions in the field or the classroom can include simple comparisons of weathering characteristics or more advanced comparisons of grain size and composition among the stones. More good ideas on this topic and additional information on stone used for Ohio structures can be found in the publications listed below.

FURTHER READING

Hannibal, J. T., and Davis, R. A., 1992, Guide to the building stones of downtown Cincinnati: a walking tour: Ohio Division of Geological Survey Guidebook 7, 44 p.

Hannibal, J. T., and Schmidt, M. T., 1992, Guide to the building stones of downtown Cleveland: a walking tour: Ohio Division of Geological Survey Guidebook 5, 33 p. (Reprinted 1994 with additional notes.)

Melvin, R. W., and McKenzie, G. D., 1992, Guide to the building stones of downtown Columbus: a walking tour: Ohio Division of Geological Survey Guidebook 6, 33 p. (Reprinted 1997 with additional notes.)

Robinson, Eric, no date, The Gloucester Wall Game: London, Geologists' Association, 11 p.

Robinson, Eric, 1996, A version of "The wall game" in Battersea Park, *in* Bennett, M. R., and others, eds., Geology on your doorstep: the role of urban geology in Earth heritage conservation: Bath, The Geological Society Publishing House, p. 163-170.

Sandy, M. R., 1992, Geologic glimpses from around the world—the geology of monuments in Woodland Cemetery and Arboretum, Dayton, Ohio: a self-guided tour: Ohio Division of Geological Survey Guidebook 8, 29 p.

Acknowledgments: Thanks are due to Michael Sandy, and, especially, Eric Robinson, for references and other information.

SE061233

ERIC

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Division of Geological Survey - HANDS ON EARTH SCIENCE (13 One-page publications)	
Author(s): Various (Sherry L. Weisgarber, Lisa Van Doren, Merrianne Hackathorn, Joseph T. Hannibal, Richard Hansgen	
Corporate Source: **Ohio Department of Natural Resources Division of Geological Survey 4383 Fountain Square Court, Bldg. B-2 Columbus OH 43224-1362**	Publication Date: no dates

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ______ Sample ______ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
X	X	X
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here,→ please

Signature: Thomas M. Berg	Printed Name/Position/Title: Thomas M. Berg, State Geologist and Chief	
Organization/Address: Ohio Division of Geological Survey 4383 Fountain Square (B-2), Columbus, OH 43224	Telephone: 614-265-6576	FAX: 614-447-1918
	E-Mail Address:	Date: 02/25/98

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com