New Jersey Geology

Awareness and Activity Package

A co-operative effort with the
Division of Water Resources,
Geological Survey

New Jersey Department of Environmental Protection · Environmental Awareness and Education Program

New Jersey Department of Environmental Protection

New Jersey Geological Survey
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Contents

Key: I - Intermediate (Grades 4-6)
J - Junior High (7-8)
S - Senior High (9-12)

Glossary

ERA - The longest subdivision of geologic time. From earliest to most recent the eras are the Precambrian, Paleozoic, Mesozoic and Cenozoic.

GEOLOGIST - A scientist who studies the Earth's composition, structure and development.

HEAVING - Upward movement of ground surfaces from expansion, as from swelling of clay or freezing of water.

INTRUSION - The injection of magma into pre-existing rock. The igneous rock which has been emplaced by injection.

LAVA - Magma which has erupted onto the Earth's surface through a volcano.

LITHOSPHERE- The solid outer portion of the Earth as compared with the more fluid hydrosphere and hot interior deep below the crust.

MAGMA - Hot, molten rock material beneath the Earth's surface.

MINERAL - A naturally occurring, inorganic substance having a characteristic chemical formula, crystal structure and physical properties. Sometimes used to mean non-crystalline, organic materials such as coal.

ORE - Any rock from which a metal or mineral can be mined at a profit.

OROGENY - The process of mountain building.

PARENT MATERIAL - The rock or unconsolidated material from which a soil formed.

PERIOD - In geologic time, a subdivision of an era.

SEDIMENT - Material, such as sand, silt and clay, formed from the weathering of rock and transported by water, wind or ice. Includes materials deposited from solution, such as salt, or by organisms, such as shell and peat.

SOIL - Unconsolidated sediment or disaggregated bedrock at the ground surface, which may furnish conditions necessary for plant growth.

TERMINAL MORAINE - A ridge of heterogeneously mixed rock and soil deposited by a glacier at a time of its furthest advance.

Rock Sheet

Rocks can be classified into three categories: sedimentary, igneous and metamorphic.

BACKGROUND

Rock Categories

Sedimentary: Formed from sediments (materials that came from: (1) the erosion of older rocks, (2) minerals dissolved in water, or (3) living organisms). Sedimentary rocks are usually layered. Pebbles, sand, clay, and fossils in sedimentary rocks can often be identified by looking, feeling, or scratching. Limestone chips bubble in warm vinegar. Sedimentary rocks make up 70% of the surface of the Earth's crust.

Metamorphic: Changed from another rock by heat, pressure, or chemical action. Usually layered. Pebbles, sand, clay, or fossils can seldom be identified. May have crystalline appearance analogous to that of an iceball formed by pressure from snow. Marble is metamorphosed limestone and will bubble in warm vinegar.

Igneous: Formed from molten material. Usually not conspicuously layered. Volcanic rocks cooled quickly and are usually fine-grained. Bubbles from steam or volcanic gases may be present. Intrusive rocks cooled more slowly, below the Earth's surface, and had time to form larger crystals. The Watchung Mountains and the Palisades are composed of igneous rock.

ACTIVITIES

1. The rocks listed below are common in New Jersey. Classify each rock.

Sedimentary	Igneous	Metamorphic
a. basalt		f. marble
b. limestone		g. shale.
c. slate		h. sandstone
d. granite		i. quartzite
e. diabase		j. gneiss

2. In your schoolyard or around home, see how many different types of rocks you can find. Examine each rock.
   a. Can you tell which ones are sedimentary, igneous, or metamorphic?
   b. Can you identify any of the rocks?
   c. Describe the physical attributes of these rocks including color, texture, and weight.
   d. Identify the areas in New Jersey where these rocks can be found (refer to Geologic Map).

3. Write lyrics to "Rocking With Geology." Make sure to include geologic vocabulary and concepts.

   (See Metz, R. "Rocking With Geology." *The Science Teacher.* Vol. 50, #4,1983.)

Answers

a. igneous	f. metamorphic
b. sedimentary	g. sedimentary
c. metamorphic	h. sedimentary
d. igneous	i. metamorphic
e. igneous	j. metamorphic

Rock and Mineral Information Sheet

NAME OF ROCK OR MINERAL	NOTES ON ORIGIN AND OCCURRENCE	LOCATION OF DEPOSITS	PRINCIPAL USES
Traprock	Quarry term for diabase (a dark-colored rock cooled from intruded magma) or basalt (a fine grained rock cooled more quickly from identical magma erupted from a volcano.)	Piedmont Province of New Jersey	Used in concrete aggregate, road beds, railroad ballast, riprap, jetty construction and roofing granules.
Coal	Solid fossil fuel formed by the partial decomposition of buried plant material under temperature and pressure.	Eastern and Southern U.S.	Burned for heat and electrical power.
Iron	A metal that occurs in large deposits as oxides, sulfides, and carbonates. Small amounts are present in most rocks and soils. A necessary nutrient for plants and animals.	NJ Highlands	Formerly used in the production of iron and steel. No iron mines are now operating in NJ.
Limestone	Solidified lime muds made from broken from broken and ground-up masses of shells or from lime that was precipitated from sea water like "lime" in a kettle.	Kittatinny Valley, NJ	Formerly used for dimension stone, crushed stone, cement production, and calcinated into lime for the chemical, agri-cultural, and manufacturing industries.
Outwash Sand and Gravel	Stratified sand and gravel deposited by water that flowed from the ice during melting of the continental glaciers.	Northern NJ	Used as aggregate in the manufacturing of concrete for highway and building construction.
Salt	Mineral deposited from ancient oceans by evaporation of sea water.	Permian: Texas Silurian: New York, Ohio, Pennsylvania, Michigan	Used in production of baking and washing soda, bleaches, other chemicals and for livestock, meat packing, water softening, and seasoning.
Brownstone	Red or brown sandstone made of sand grains deposited by water & cemented into rock layers.	Piedmont of NJ, Connecticut and Massachusetts	Formerly an important building stone.
Zinc	A metal which does not occur in a pure form in nature. In New Jersey, occurs in the ores zincite (ZnO), willemite (Zn_2SiO_4), and franklinite ($ZnFe_2O_4$). New Jersey was once a leading producer.	Franklin area of Sussex County, NJ	Used in pharmaceuticals, for galvanizing iron, in brass and batteries, as a roofing material, and in alloys of silver and gold.
Glass Sand	Pure white quartz sand usually deposited by wind or on beaches.	Cumberland County, New Jersey	Mixed with other minerals to lower melting point, then melted to make glass.
Clay	Fine-grained aluminum silicate mineral formed by the weathering of feldspar.	Coastal Plain, NJ	Formerly supported major brick, tile and pottery industries. Now dug for landfill liner and sealer.
Slate	Fine-grained metamorphic rock formed from shale. Splits into smooth slabs.	Kittatinny Valley, NJ	Formerly used for roofing, now for crushed stone. High quality slate used in pool tables.

Rocks in the Making

Background Information-Examples of Sediment

Peat: Brown to black, fibrous, moss-like aggregate of plant remains with some silt and sand. Originates in swamps and marshes. Four types of peat: (1) moss peat-occurs in shallow accumulations in only a few swamps; (2) sedge and reed peat-fibrous with a considerable proportion of wood fragments; (3) fluffy forest peat-dead leaves; and (4) sedimentary peat-coarse, woody organic material mixed with sediment or sand. If under pressure these peat deposits might be converted to coal. The metamorphic sequence is:

Peat → Lignite Coal → Bituminous Coal → Anthracite Coal

Clay: Extremely fine-grained sediment (some particles are less than 1/256 mm). Usually the result of the decay of feldspar minerals. If clay remains buried in the earth and is subjected to pressure it may, over time, become a shale or argillite.

Greensand or Greensand Marl: Light green to dark green to almost black, sandy mixture of glauconite (a dull green, hydrous silicate of iron and potassium), clay and quartz sand. Glauconite is the most abundant-70% to 90%-of the sediment. Most of the glauconite forming today is accumulating near the edge of the continental shelf in ocean depths of about 600 feet. Hence, about 60 million years ago, when the New Jersey glauconite formed, the coastal plain must have been submerged some 600 feet. These old marine deposits are rich in fossils. If nature continues the slow conversion of the buried greensands, mudstones and perhaps later schists might develop.

Limesand: Yellow to light brown, coarse sand with flat grains formed from fossil fragments. More than 80 species of "moss animals" (very tiny animals, about 1 mm in diameter which live together in near-shore colonies) and a large number of simple shells have been described from the limesand of New Jersey. Common fossils include clams, snails, sea urchins, the shells of protozoa and the tubes of worms. Further compaction with the addition of calcareous cement could convert this sediment into limestone.

Glass Sand: Very white sand consisting almost entirely of quartz grains. The pure white deposits of quartz grains were built by waves and currents and by wind along an ocean shore of the Tertiary Period. Should these sands remain buried and later be invaded by a mineral cement, sandstone would be formed.

Limonite or Bog Iron: Earthy, yellow-brown to dark brown iron ore. Limonite is iron oxide plus water and is very similar to iron rust. Limonite often imparts the yellowish-brown coloring to clays and frequently serves as a cementing agent in sedimentary rocks. Workable deposits of relatively pure limonite in southern New Jersey are referred to as bog iron. Rainwater percolating through the ground is charged with carbon dioxide from the atmosphere and organic acids from rotting vegetation. These corrosive waters dissolve iron in their passage through sand containing glauconite, pyrite, or other iron-rich minerals, then issue forth at the surface as springs. At the surface the waters lose carbon dioxide into the atmosphere, iron oxide is dropped as a precipitate and bog iron accumulates. Iron-bearing springs are constantly at work recharging the old ore zones so that the limonite in the bog iron deposits is renewed.

Rocks weather and break up to form inorganic soil particles. Over time, soil particles become cemented together and again become rock.

ACTIVITY

Using the **New Jersey Rock Set** students identify the rocks which change into various soils over time.

Have the students make a map delineating areas of soil and rock on the school's grounds or a designated site. Use shovels or post-hole diggers at these areas and respond to the following questions.

- Did the soil form from the rock at the study area or from sediment that was carried to the area by water, wind or glaciers?
- What evidence, if any, is there that the soil is being cemented to form rock?

Weathering Rocks

Students participate in one or more of the following activities to observe the breakdown of rocks to smaller mineral particles and eventually soil.

ACTIVITIES

1. With an eyedropper, drop warm vinegar on limestone. Observe and record the reaction. In nature, how do organic acids and carbonic acid from carbon dioxide dissolved in rainwater break down mineral matter?

2. To demonstrate that water expands when frozen and contracts when warmed, hence has the capacity to break apart rocks when it enters rock fractures, fill a plastic deli container to the brim with water then cover. With a metric measuring tape, measure water depth and the circumference of the container directly under the brim. Record the measurements. Freeze the container then observe the container's shape. Measure the container again while frozen. Compare the two measurements. Let the water in the container melt. Measure a third time and compare data.
3. Observe cracks in sidewalks, curbs and any other hard surfaced areas around the school. Discuss the physical processes that caused the fracturing (e.g. tree roots & heaving of the soil).
4. At a beach, stream or intermittent streambed, examine rocks that have been smoothed as water rolled them or scoured them with sand. At the beach glass pieces are commonly smoothed by the water and sand action.

Rock Hunt

Students select rocks from around their school grounds and record their similarities and differences.

MATERIALS: Bags or cans for collected rocks-one per student. Magnifying glasses.

ACTIVITY

1. Students go outdoors to collect rocks. The collection process should last no longer than 15 minutes.
2. Students return indoors and proceed to group their rocks. Grouping criteria could be-shape, color, weight, and texture.
3. Use magnifying glasses to explore rocks more closely.

DIGGING DEEPER

Distribute a small sheet of black and of white paper to each student. Have students divide their rocks into light colors and dark colors. Also give students coal, chalk, dried clay and other real or simulated rocks. Using the light colored rocks and the black paper, instruct the students to draw lines on the paper then place the rock by its line. Follow this line of questioning:

-Did all of the rocks leave a line when you wrote with them?
-Did some rocks make a darker line than others?

Number the lines and rocks from the darkest line to the lightest.

Repeat the same procedure with the dark colored rocks and the white paper.

ASK

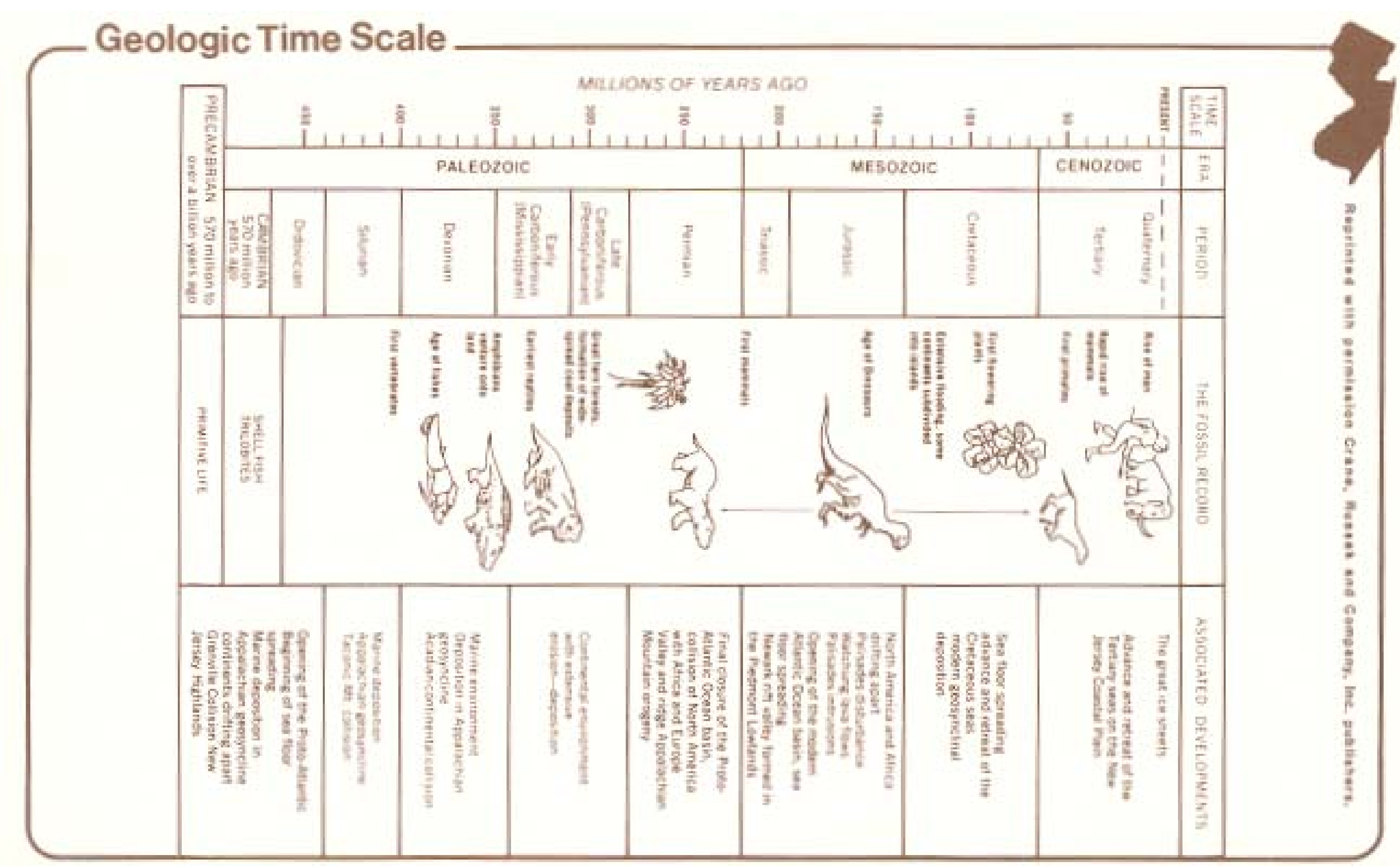
Why do some rocks write better than others? (Explanation: Just like pencils with different hardnesses, rocks have different hardnesses. The rocks that break up easiest or leave the darkest mark are the softest and, conversely, rocks that leave no mark are harder).

Scrambled Rocks, Minerals and Gems

I. Find the hidden rocks, minerals and gems.

1. RILSEV ____________________
2. MOOIONA ____________________
3. MRELAB ____________________
4. TUQAZR ____________________
5. OZPAT ____________________
6. LASEH ____________________
7. ONETLMSEI ____________________
8. SASTOEONN ____________________
9. LYACSRT ____________________
10. NRITGAE ____________________
11. RECPOP ____________________
12. YRBU ____________________
13. OEMAREL ____________________
14. PEIRPSAH ____________________
15. ANGTRE ____________________
16. LCAO ____________________
17. SSOTAONEP ____________________
18. EL TAS ____________________
19. JEAO ____________________
20. CLOG ____________________

ANSWERS
1. silver
2. diamond
3. marble
4. quartz
5. topaz
6. shale
7. limestone
8. sandstone
9. crystal
10. granite
11. copper
12. ruby
13. emerald
14. sapphire
15. garnet
16. coal
17. soapstone
18. slate
19. jade
20. gold



New Jersey Fossil Facts

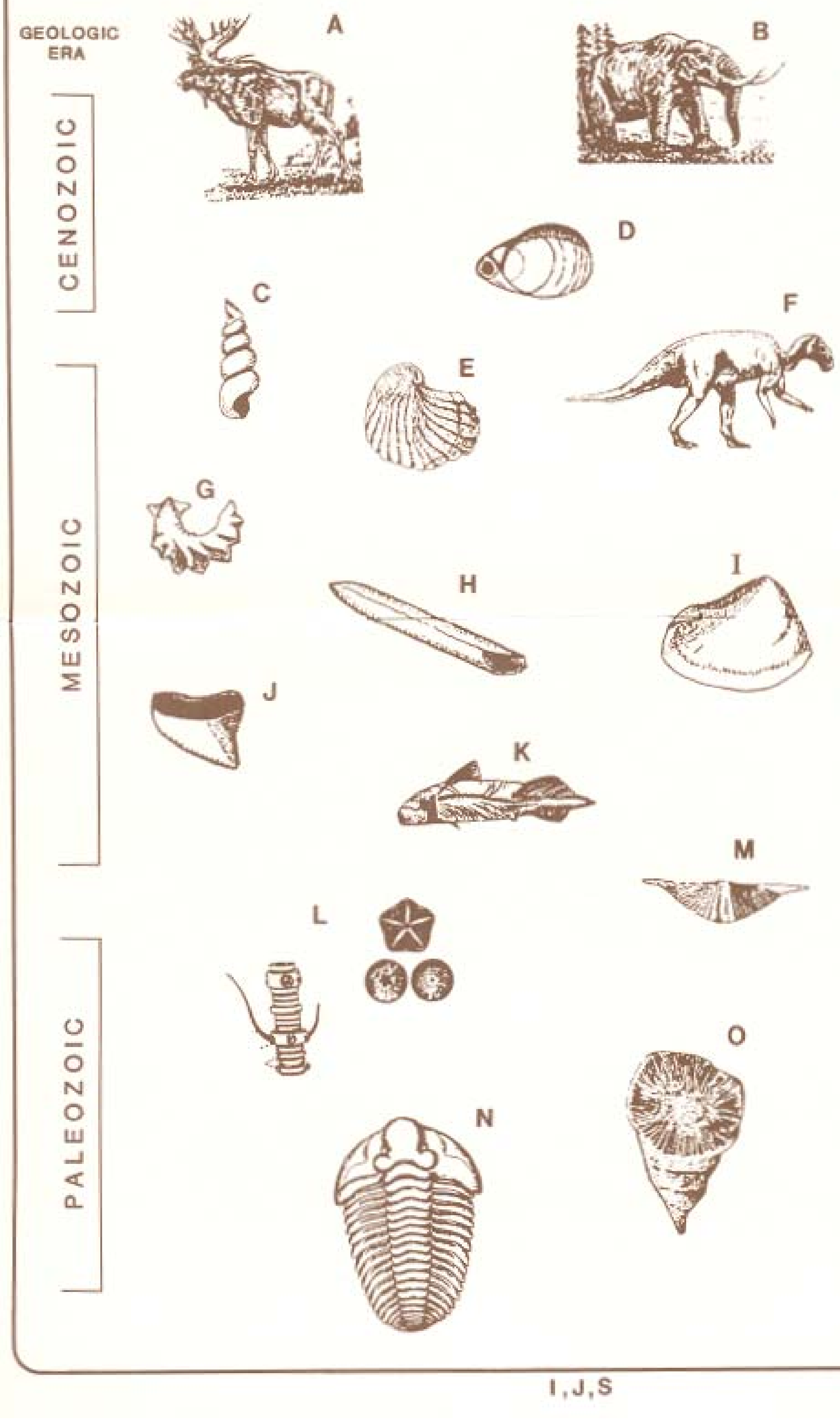
- Fossils are evidence of life prior to recorded history. They can be whole remains (mammoths frozen in ice), parts (shells or dinosaur bones), mineral replacements (petrified wood) or traces of past life (footprints, feeding trails, excreta).
- Paleontologists (geologists who study fossils) estimate that in the last 570 million years as many as 4112 million different species of animals and plants existed at one time or another, although only about 150,000 fossil species have been described. There are over 1112 million known species living today. The horseshoe crab and some sharks are among the very few species that have remained unchanged for millions of years. Other species either adapted to changes in their environment, or became extinct.
- Hard body parts and rapid burial are necessary for fossilization. Shallow water is the most common environment in which large numbers of fossils are formed. In New Jersey fossils are most abundant in (1) the Ridge and Valley Province in northwestern New Jersey, which was below sea level during the early part of the Paleozoic Era; and (2) the Coastal Plain Province, southern New Jersey, which was below sea level during much of the late Mesozoic and Cenozoic Eras. During the Mesozoic Era dinosaurs roamed central New Jersey, but few bones exist today because they disintegrated before they could be buried.
- Fossils are used to date rocks, determine past environments, predict sites for finding oil, minerals and other resources, and to discover how the Earth has changed. Finding the same species of marine brachiopod in the Appalachian Mountains and in England helped geologists to develop theories of crustal plate movement and mountain building.
- Major eras of geologic time can be characterized by the predominance of certain types of fossils.

Precambrian Era	(over 570 million years ago)	Primitive Life Forms
Paleozoic Era	(570-220 million years ago)	Age of Invertebrates, Fish & Plants
Mesozoic Era	(220-65 million years ago)	Age of Reptiles
Cenozoic Era	(65 million years ago to present)	Age of Mammals

- Fossils are classified according to their physical characteristics. For most fossils, living relatives do exist.
  - ♦ Invertebrate fossils-no backbone, but may have hard body parts (shells)
  - ♦ Vertebrate fossils-have backbones
  - ♦ Plant fossils-includes leaves, cones, stems and bark.

Prehistoric Life in New Jersey

Match the illustrations of these prehistoric animals and fossils to their common and scientific names.



__ 1. Shark Tooth (*Squalicorax*)

__ 2. Hadrosaur (*Hadrosaurus*)

__ 3. Mastodon (*Mammut*)

__ 4. Brachiopod (*Oleneothyris*)

__ 5. Clam (*Cucullaea*)

__ 6. Snail (*Turritella*)

__ 7. Elk-Moose (*Cervalces*)

__ 8. Oyster (*Exogyra*)

__ 9. Oyster (*Ostrea or Agarostrea*)

__10. Trilobite (*Calymene*)

__11. Coral (*Heterophrentis*)

__12. Belemnite Pen (*Belemnitella*)

__13. Sea-Lily Stem (*Crinoid*)

__14. Coelacanth Fish (*Diplurus*)

__15. Winged Brachiopod (*Mucrospirifer*)

Continued

Prehistoric Life in New Jersey

ANSWERS (Includes approximate time of existence and province where it can be found in New Jersey)

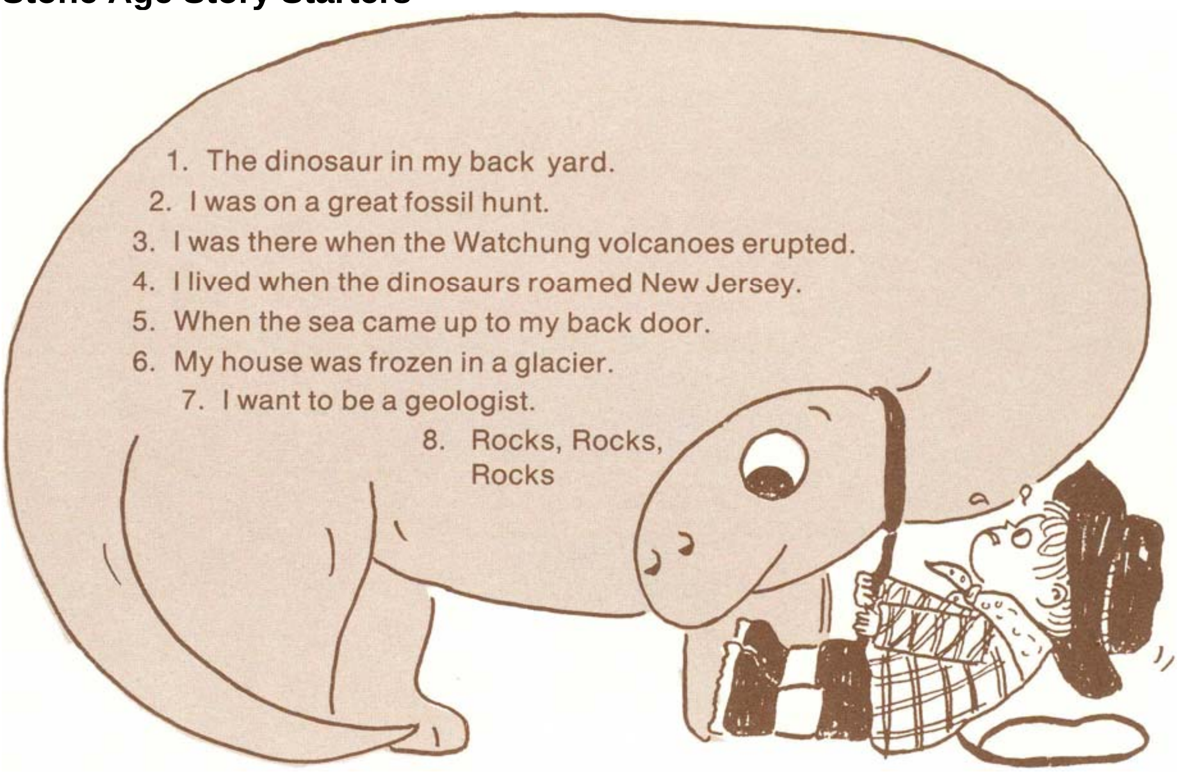
J 1. Cretaceous, Coastal Plain
F 2. Cretaceous, Coastal Plain
B 3. Quaternary, All of New Jersey
D 4. Tertiary, Coastal Plain
I 5. Cretaceous to Tertiary, Coastal Plain
C 6. Cretaceous, Coastal Plain
A 7. Quaternary, All of New Jersey
E 8. Cretaceous, Coastal Plain
G 9. Cretaceous, Coastal Plain
N 10. Cambrian, Ridge and Valley & Highlands
O 11. Devonian, Ridge and Valley & Highlands
H 12. Cretaceous, Coastal Plain
L 13. Ordovician to Devonian, Ridge and Valley & Highlands
K 14. Triassic, Piedmont
M 15. Devonian, Ridge and Valley & Highlands

ACTIVITIES

1. *Classification Game.* Put various objects in a box and have students classify them (by size, shape, color, etc.)
2. Draw a picture of an imaginary "ancient animal" Identify the different parts of the animal and tell their uses.

3. Did cave people live with dinosaurs?
   What animals did the cave people live with?
4. Using the Geologic Map, discuss where you might find these fossils:
   Paleozoic fossils (in the Ridge and Valley and Highlands Province.)
   Fish (in the Piedmont Province)
   Mammals (entire state of New Jersey)
5. Investigate the different invertebrate phyla. Identify the invertebrate fossils shown.

Stone Age Story Starters

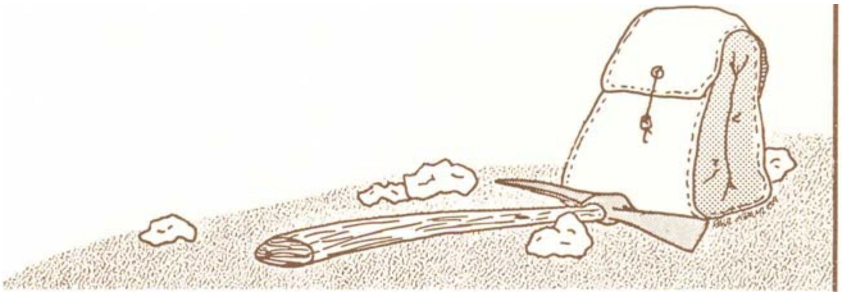


Become a Geologist for a Day

Go on a geological survey in your classroom. Investigate New Jersey's geology, layer by layer, age by age. Use sand layers to represent the rocks of New Jersey. The oldest rocks are at the bottom; the younger rocks were deposited on top.

MATERIALS:

Clear box, aquarium or bowl
Colored sand (white, red, brown and black)
Chicken bones (fossils)
Drawings of trilobites (fossils)
Small sea shells
Bottle caps
Small stones, pebbles
Plastic straw
Pottery chips
Scraping tools, brushes for excavating
Plaster of paris, clay for making imprints and casts



ACTIVITY: Construct a Geological Box

- Bottom layer *(Precambrian rock)-Brown* sand
- Second layer *(Paleozoic rock)-White* sand with several drawings of trilobites and small pebbles within layer to show age and deposition in the ocean
- Third layer *(Triassic and Jurassic rock)-Red* sand. Chicken bones *(dinosaur bones)* to show age and dry land conditions -Intrusion *(Igneous intrusion of Jurassic Age)-Poke* hole to bottom of box with straw near edge of box, fill with black sand, then carefully remove straw
- Fourth layer *(Cretaceous and Tertiary sand and c/ay)-Brown* sand. Chicken bones to show dinosaurs and dry land conditions and seashells within layer to show that the sea advanced and retreated several times
- Fifth layer *(human history)-White* sand with broken pottery, circle of stones
- Sixth layer *(present)-Brown* or black sand with bottle caps and plastic chips

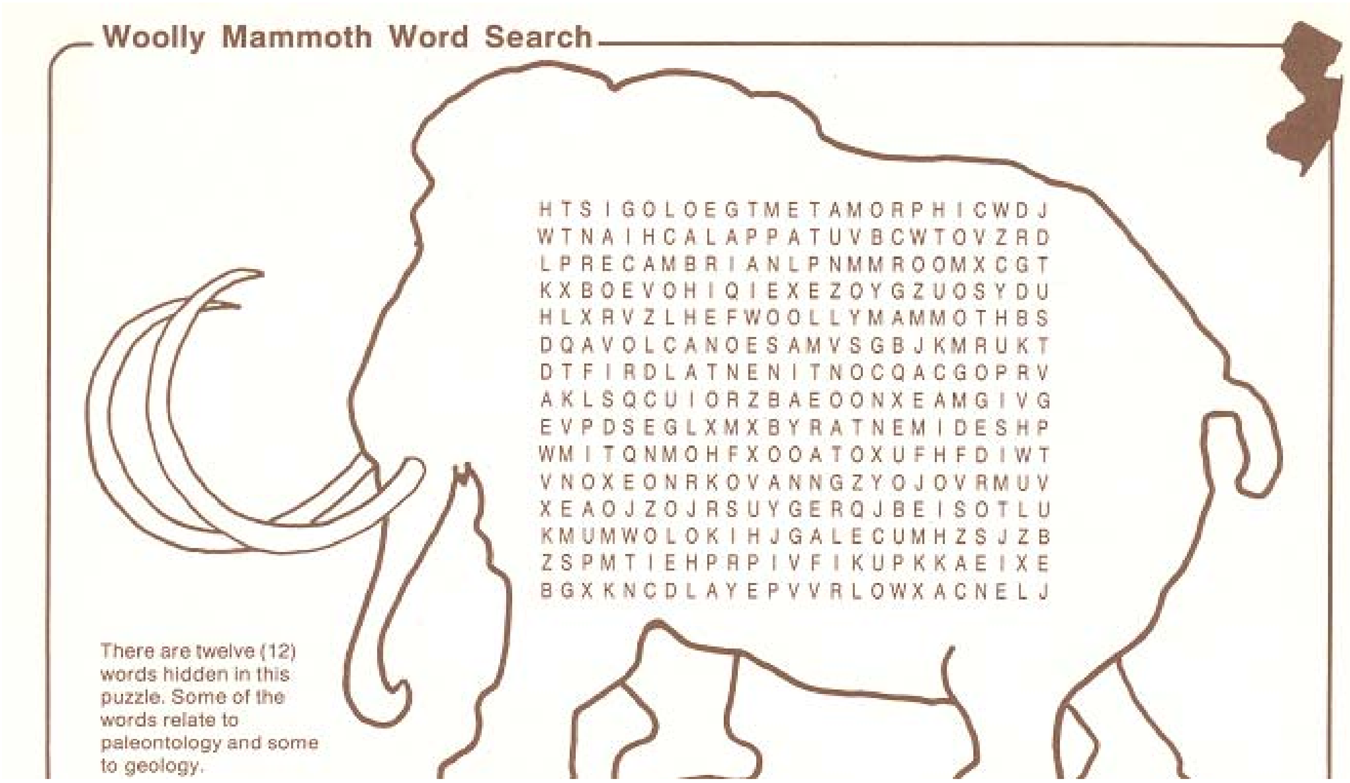
Suggestion: Copy and cut drawings from *Prehistoric Life in New Jersey.*

DIGGING DEEPER

1. Draw the layers and objects found in each.
2. Discuss the objects found and what they mean. Think about:
   During what era of geological time was each layer formed? What life existed at this time?
   How was this type of rock formed?
3. Exchange geological boxes with another class.
4. Make imprints and casts of the objects you found.
   a. Make imprints in clay
   b. Cast fossils out of plaster

TEACHER, PLEASE NOTE

- The younger rock is on the top.
- Fossils date the rock.
- Geological history can be interpreted from fossils and sediments.
- Fossils can be remains, imprints or casts.



Woolly Mammoth Word Search

Fill in the blanks below, then find those words in the Woolly Mammoth.

1. When the American, African and European plates collided the _______________ mountains were formed.
2. The _______________ Era is the most recent era of the Earth's history. It includes the Ice Age and the development of mammals.
3. A theory that continents have moved or drifted relative to one another is called __________________.
4. An ______________ is a unit of geologic time consisting of two or more periods.
5. Any evidence of life in past geologic time is called a _______________.
6. A scientist who studies the Earth's composition and structure is called a ______________.
7. ____________ rock was formed from molten material.
8. A rock which has undergone extreme change due to heat, pressure or chemical action is _____________.
9. The earliest geologic era is known as the ____________.
10. When sediment becomes cemented together by pressure and chemical action a ________ rock is formed.
11. Hot lava is forced to the surface through ______________.
12. The _______________ is an extinct elephant that roamed the Earth during the Quaternary Period.

WORD LIST:

1. APPALACHIAN	7. IGNEOUS
2. CENOZOIC	8. METAMORPHIC
3. CONTINENTAL DRIFT	9. PRECAMBRIAN
4. ERA	10. SEDIMENTARY
5. FOSSIL	11. VOLCANOES
6. GEOLOGIST	12. WOOLY MAMMOTH

Time Changes All

Data Card

GEOLOGIC PERIOD	APPROXIMATE MID-DATE OF PERIOD (years ago)	LOCATION ON TIME LINE (1 step = 4 million years)	IMPORTANT ROCK AND MINERAL DEPOSITS	LIFE FORMS
PLEISTOCENE EPOCH (Ice Age)	500,000	1 step	1.	1.
TERTIARY PERIOD	30,000,000	8 steps	2.	2.
CRETACEOUS PERIOD	100,000,000	25 steps	3.	3.
JURASSIC PERIOD	170,000,000	42 steps	4.	4.
TRIASSIC PERIOD	205,000,000	51 steps	5.	5.
PERMIAN PERIOD	260,000,000	65 steps	6.	6.
MISSISSIPIAN-PENNSYLVANIAN (Carboniferous) PERIODS	300,000,000	75 steps	7.	7.
SILURIAN-DEVONIAN PERIODS	410,000,000	103 steps	8.	8.
ORDOVICIAN PERIOD	460,000,000	115 steps	9.	9.
CAMBRIAN PERIOD	550,000,000	138 steps	10.	10.
PRECAMBRIAN ERA	2,000,000,000	500 steps	11.	11.

Notes

Continued

Time Changes All

ACTIVITY

Using 2" wide tape or adding machine paper, post a time line within the school's hallways or spiraling on the walls within the classroom. The time line equates footsteps with geologic periods. The geologic periods are matched with associated rock and mineral deposits and life forms.

Ways to Construct Time Line

1. At each geologic period along the time line, students are given clues to determine the rock and mineral deposits and life forms. The clues are written on oaktag or construction paper and posted at the appropriate point on the tape. Students should be provided with the Rock & Mineral Information Sheet, the Geologic Time Scale, and the Data Card.

OR

2. The rock and mineral deposits and life forms are posted at the geologic period written on the tape. The students post the clues with the appropriate period.

Clues to Match Rock or Mineral Deposit with Geologic Period

1. Deposited by glacial meltwater streams. Used in construction
2. Used for making bottles and windows
3. Used for making brick
4. A common New Jersey rock, used for crushed roadbed material
5. A common New Jersey building stone
6. A mineral vital to the diet
7. A fuel composed of fossil plants
8. A mineral vital to the diet
9. Formerly used for making roofs
10. Soil conditioner
11. Two metals: one easily rusted; the other used to prevent rust

Events in History of Life to be matched with Period

A. First snails
B. Dinosaurs prominent
C. Fish become prominent
D. Rise of man
E. Primitive life, first plants
F. Mammals come into prominence
G. Vast forests of non-woody plants, insects become prominent
H. First vertebrates
I. First mammals
J. First flowering plants
K. Reptiles come into prominence

DATA CARD ANSWERS

Rock and Mineral Deposits

1. Outwash sand and gravel
2. Glass sand
3. Clay
4. Traprock (basalt and diabase)
5. Brownstone (a variety of sandstone)
6. Salt
7. Coal
8. Salt
9. Slate
10. Limestone
11. Iron, zinc

Associated Life-Forms from Pleistocene Epoch to Precambrian Era

1 - D	5 - L	9 - H
2 - F	6 - K	10 - A
3 - J	7 - G	11 - E
4 - B	8 - C	

Mountain Building

BACKGROUND

Folding - in the Appalachian Mountains flat layers of sedimentary rock came under horizontal pressure when the continents of Africa and America collided. As a result these layers folded upward or downward, or fractured.

Anticline - a fold in which rock layers are bent convex upward.

Syncline - a fold in which rock layers are bent convex downward.

ACTIVITY
To demonstrate folding, anticlines and synclines students lay a piece of notebook paper on their desk. Putting a hand at each end of the paper, students push inward to cause an example of folding.

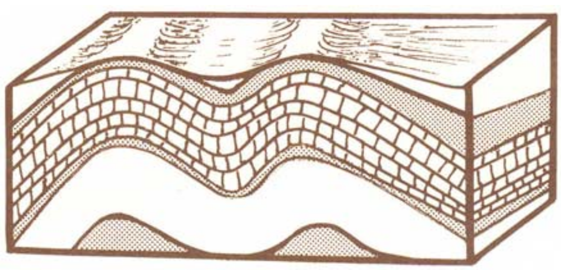
MATCH WITH THE DRAWING

1. Anticline 2. Syncline

a. ______________________________________

b. ______________________________________

c. ______________________________________



A B C

DIGGING DEEPER
1. Follow the Appalachian Mountains outside of New Jersey's borders.
2. Locate other mountains in the U.S. Investigate how they were formed? (Volcanoes, Folding, Faulting)

Continental Puzzle

Mountain ranges, continents and oceans are parts of our world. How did they come to be?

PLATE TECTONICS is a geologic theory in which the outer layers of the Earth are composed of rigid plates whose movements cause **CONTINENTAL DRIFT,** the movement of continents from place to place on the Earth's surface. Volcanic activity, earthquakes and mountain building occur primarily where plates move against one another.

Examples:

Africa and Saudi Arabia drifted apart to create the Red Sea.
India has drifted into Asia to create the Himalayan Mountains.
Earthquakes and volcanic eruptions are evidence of this movement.

ACTIVITIES

1. Trace and cut out the world map. Put the continents together, matching the footprints.
2. Trace this "super" continent known as Pangaea. It existed in the Paleozoic Era after the closing of the Proto-Atlantic Ocean. (The Proto-Atlantic Ocean opened near the end of the Precambrian Era when North America drifted apart from Africa and Europe. It closed *in* the Paleozoic Era when these continents drifted together again.)

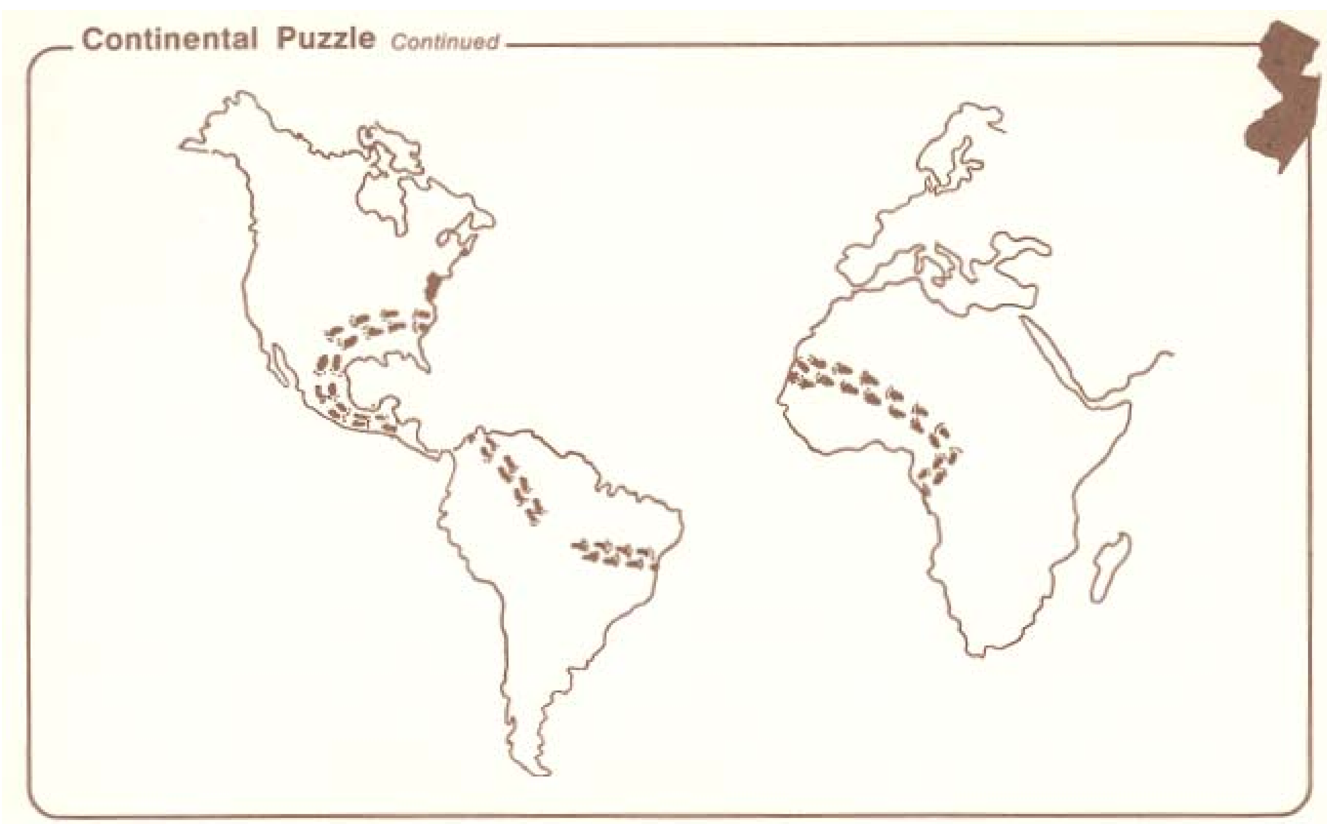
DIGGING DEEPER

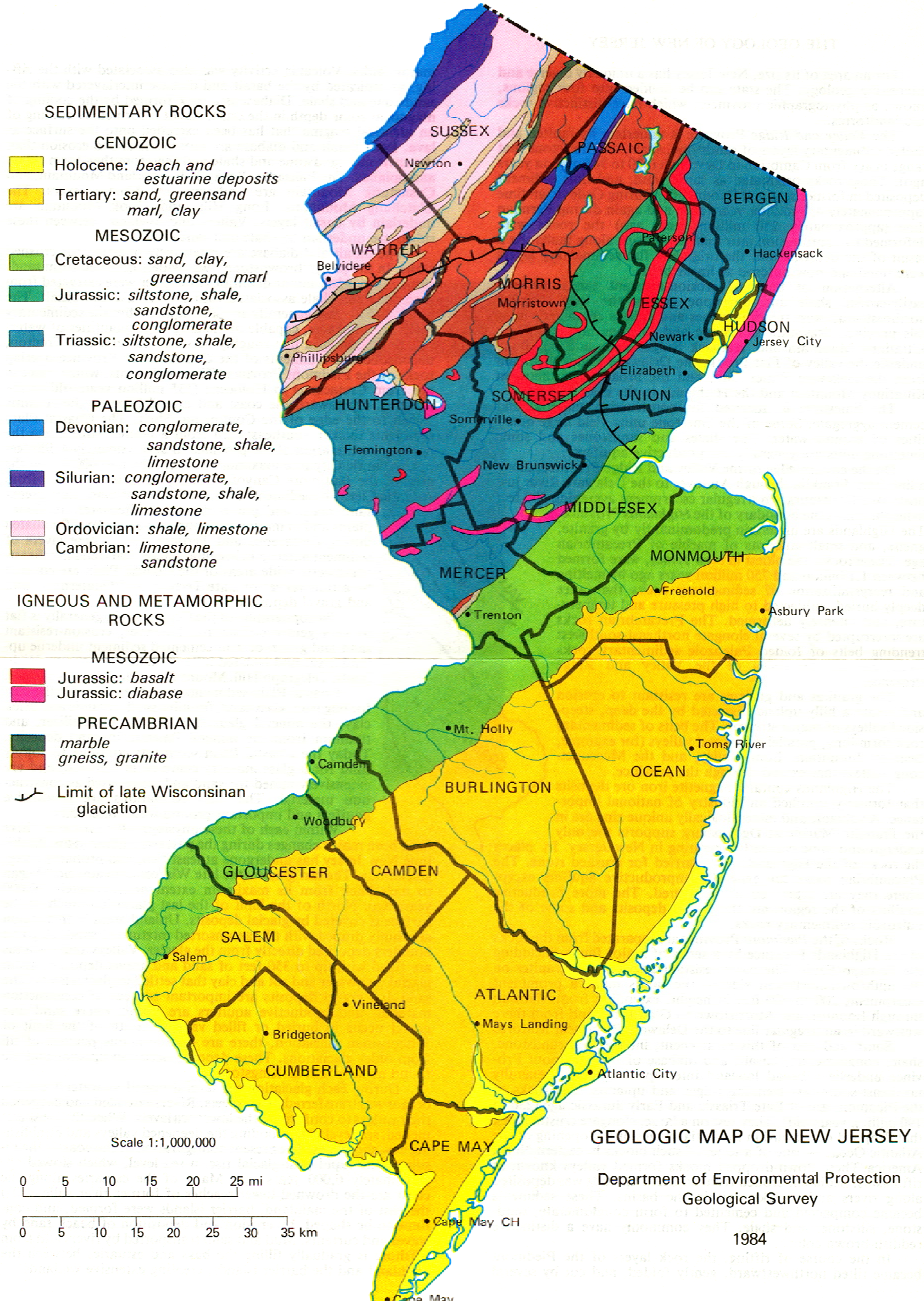
1. Investigate what happened in New Jersey when the continents collided and then separated again.
2. List the countries you would have traveled through if you had walked east from Atlantic City to Egypt in Pangaea.

TEACHER, PLEASE NOTE

To illustrate the continental drift theory:

1. Duplicate the world map on a large piece of paper. Cut out the pattern and match the footprints. Have students walk from continent to continent following the footprints.
2. Use the pattern and world map as:
   a. a bulletin board
   b. a learning center




SEDIMENTARY ROCKS
CENOZOIC
Holocene: beach and estuarine deposits
Tertiary: sand, greensand marl, clay
MESOZOIC
Cretaceous: sand, clay, greensand marl
Jurassic: siltstone, shale, sandstone, conglomerate
Triassic: siltstone, shale, sandstone, conglomerate
PALEOZOIC
Devonian: conglomerate, sandstone, shale, limestone
Silurian: conglomerate, sandstone, shale, limestone
Ordovician: shale, limestone
Cambrian: limestone, sandstone
IGNEOUS AND METAMORPHIC ROCKS
MESOZOIC
Jurassic: basalt
Jurassic: diabase
PRECAMBRIAN
marble
gneiss, granite
Limit of late Wisconsinan glaciation
Scale 1:1,000,000
0 5 10 15 20 25 mi
0 5 10 15 20 25 30 35 km
SUSSEX
Newton
PASSAIC
BERGEN
Paterson
Hackensack
WARREN
Belvidere
MORRIS
Morristown
ESSEX
HUDSON
Newark
Jersey City
Phillipsburg
Elizabeth
SOMERSET
UNION
HUNTERDON
Somerville
Flemington
New Brunswick
MIDDLESEX
MONMOUTH
MERCER
Freehold
Trenton
Asbury Park
OCEAN
Mt. Holly
Toms River
Camden
BURLINGTON
Woodbury
GLOUCESTER
CAMDEN
SALEM
Salem
ATLANTIC
Vineland
Mays Landing
Bridgeton
CUMBERLAND
Atlantic City
CAPE MAY
Cape May CH
Cape May
GEOLOGIC MAP OF NEW JERSEY
Department of Environmental Protection
Geological Survey
1984

THE GEOLOGY OF NEW JERSEY

For an area of its size, New Jersey has a uniquely diverse and interesting geology. The state can be divided into four regions, known as physiographic provinces, which have distinctive rocks and landforms.

The *Valley and Ridge* Province is underlain by faulted and folded sedimentary layers of sandstone, shale, and limestone that range in age from Cambrian to Devonian (570 to 345 million years ago). These rocks originated as sand, mud, and lime sediment deposited in former seas and floodplains. During Ordovician time (approximately 450 million years ago) and again during Permian time (approximately 250 million years ago) the rocks were deformed by compression into folds and thrust along faults. As a result of the deformation, the originally flat sedimentary layers were tilted and now outcrop as linear belts.

Alternation of belts of erosion-resistant sandstone and easily-eroded shale and limestone creates the long, parallel northeast-southwest trending ridges and valleys characteristic of this province. Resistant sandstone and siltstone layers underlie Kittatinny Mountain and Walpack Ridge; shale and limestone underlie the valley of Flat Brook, the Delaware Valley upstream from the Delaware Water Gap, and the broad valley between Kittatinny Mountain and the Highlands to the east.

The limestone is quarried for construction material and cement aggregate. Some of the limestone units yield large quantities of ground water. The shales and sandstones and some limestone units are generally less productive aquifers.

On the eastern edge of the Valley and Ridge Province, along a line from Franklin through Andover to the Delaware River just north of Phillipsburg, an irregular escarpment averaging 500 feet in height marks the boundary of the *Highlands* Province.

The Highlands are underlain predominantly by granite, gneiss, and small amounts of marble of Precambrian age. These rocks, the oldest in New Jersey, were formed between 1.1 billion and 750 million years ago by melting and recrystallization of sedimentary rocks that were deeply buried, subjected to high pressure and temperature, and intensely deformed. The Precambrian rocks are interrupted by several elongate northeast-southwest trending belts of folded Paleozoic sedimentary rocks equivalent to the rocks of the Valley and Ridge Province.

The granites and gneisses are resistant to erosion and create a hilly upland dissected by the deep, steepsided valleys of major streams. The belts of sedimentary rock form long, parallel ridges and valleys (for example, Bearfort Mountain, Long Valley, and the Musconetcong Valley) that extend through the province.

The Highlands contain magnetite iron ore deposits that formerly supplied an industry of national importance. A valuable and mineralogically unique zinc ore in the Franklin Marble at Ogdensburg supports the only underground mine currently operating in New Jersey. In places the rocks of the Highlands are quarried for crushed stone. The Precambrian rocks are generally unproductive aquifers except where they are fractured or weathered. The more productive aquifers of the region are the glacial deposits and some of the Paleozoic sedimentary rocks.

Rocks ofthe *Piedmont* Province are separated from the rocks of the Highlands Province by a series of major faults, including the Ramapo Fault. The more resistant gneisses and granites on the upthrown northwest side of the faults make a prominent escarpment, 200 to 800 feet in height, extending from Mahwah through Boonton and Morristown to Gladstone, and from there westward in an irregular line to the Delaware River near Milford.

South and east of this escarpment, interbedded sandstone, shale, conglomerate, basalt, and diabase of the Piedmont Province underlie a broad lowland interrupted by long, generally northeast-southwest trending ridges and uplands. The rocks of the Piedmont are of Late Triassic and Early Jurassic age (230 to 190 million years old). They rest on a large, elongate crustal block that dropped downward in the initial stages of the opening of the Atlantic Ocean - one of a series of such blocks in eastern North America. These down-dropped blocks formed valleys known as rift basins. Sediment eroded from adjacent uplands was deposited along rivers and in lakes within the basins. These sediments became compacted and cemented to form conglomerate, sandstone, siltstone, and shale. They commonly have a distinctive reddish-brown color.

In the course of rifting, the rock layers of the Piedmont became tilted northwestward, gently folded, and cut by several major faults. Volcanic activity was also associated with the rifting, as indicated by the basalt and diabase interlayered with the sandstone and shale. Diabase is a rock formed by the cooling of magma at some depth in the crust; basalt is formed by cooling of an identical magma that has been extruded onto the surface as lava. Both basalt and diabase are more resistant to erosion than the enclosing sandstone and shale and therefore they form ridges and uplands. The Palisades, Rocky Hill, Sourland Mountain, and Cushetunk Mountain are underlain by diabase layers. The Watchung Mountains, Long Hill, and Hook Mountain are underlain by basalt layers. Valleys and lowlands between these ridges are underlain by shale and sandstone.

The basalt and diabase are extensively quarried for crushed stone. In the past, "brownstone" was widely quarried from sandstone units. Also, minor quantities of copper were extracted from sandstone and shale associated with the diabase and basalt. The basalt and diabase generally are poor aquifers but the sedimentary rocks are, in places, capable of yielding large quantities of water.

Southeast of a line roughly between Carteret and Trenton, unconsolidated sediments of the *Coastal Plain* Province overlap rocks of the Piedmont Province. These sediments, which range in age from Cretaceous to Holocene (135 million years old to the present), dip toward the coast and extend beneath the Atlantic Ocean to the edge of the Continental Shelf. The Coastal Plain sediments thicken southeastward from a feather edge along the northwestern margin of the province to approximately 4,500 feet near Atlantic City to a maximum of more than 40,000 feet in the area of the Baltimore Canyon Trough, 50 miles offshore from Atlantic City. The sediments consist of layers of sand, clay, greensand marl, and gravel deposited alternately in floodplains and in marine environments as sea level fluctuated during Cretaceous and Tertiary time. These layers of sediment outcrop in irregular bands that trend northeastsouthwest. Wide areas of the Coastal Plain are covered by a thin veneer of Late Tertiary and Quaternary sand and gravel deposited by rivers.

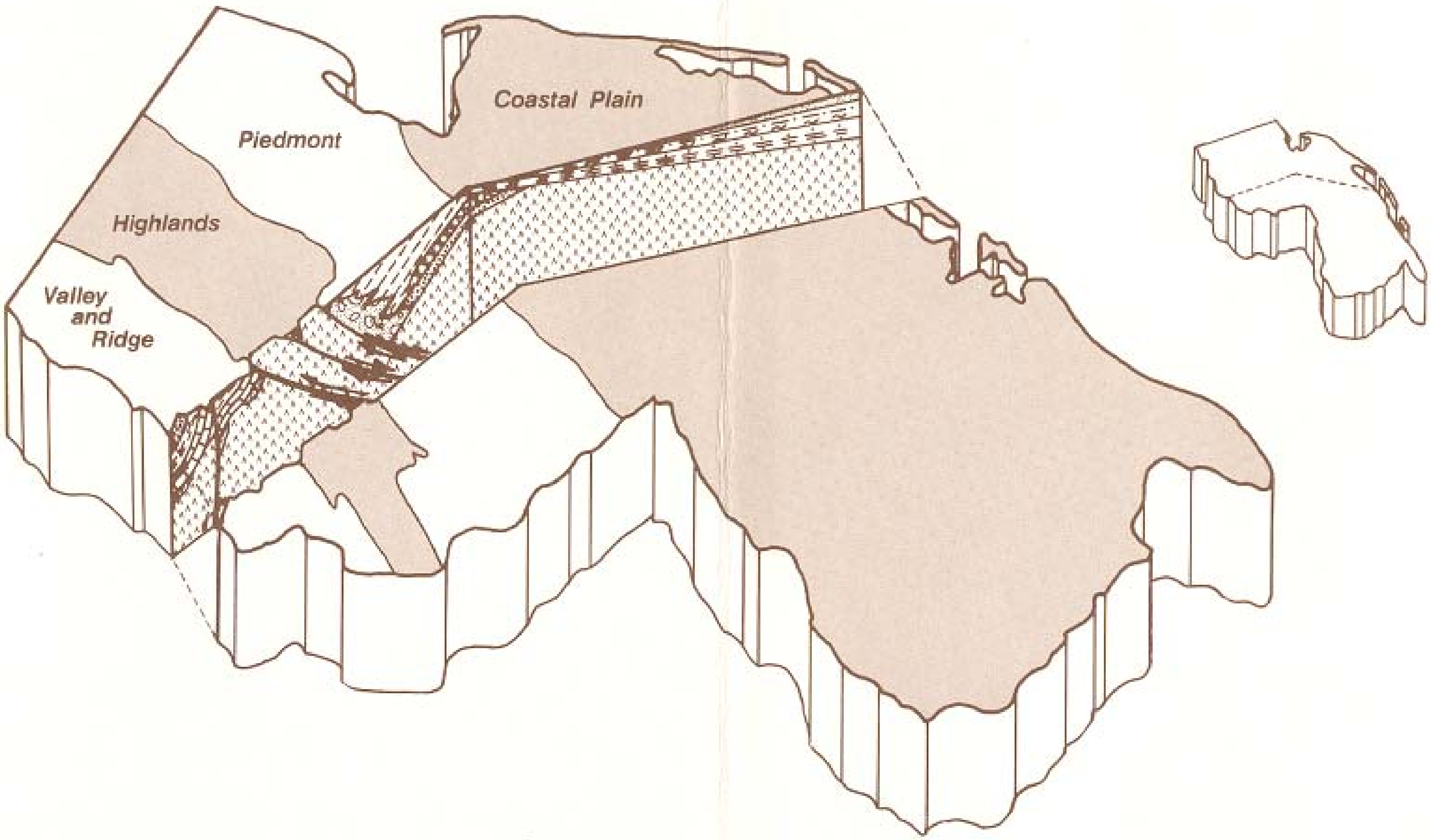
The topography of the Coastal Plain generally is flat to very gently undulating. However, erosion-resistant sand and gravel or iron-cemented sediment underlie upland areas and isolated hills, such as the Atlantic Highlands, Telegraph Hill, Mount Holly, and Arneys Mount.

Coastal Plain sediments have been mined in the past for bog iron, glass sand, foundry sand, ceramic and brick clay, the mineral glauconite for use in fertilizer, and titanium from the mineral ilmenite in sand deposits. Today the Coastal Plain sediments continue to supply sand for a glass industry centered in Millville, and are extensively mined for sand and gravel used as construction material. The sand formations are productive aquifers and important ground water reservoirs.

Within each of these physiographic provinces there have been major changes during the past two million years. In this time New Jersey has undergone at least two, and probably three, glaciations. The last glacier (the late Wisconsinan advance) began to melt back from its maximum extent approximately 20,000 years ago. North of the limit of the last glaciation much of the surface is covered by glacial deposits. Upland areas in this region are thinly draped with till, an unsorted mixture of sand, clay and boulders deposited directly from the glacier. Valleys and lowlands are filled with up to 350 feet of sand and gravel deposited from glacial meltwater and silt and clay that settled in glacial lakes. The sand and gravel deposits are important sources of construction material, and productive aquifers are found where sand and gravel occur in buried or filled valleys. South of the limit of Wisconsinan glaciation, there are discontinuous patches of till from older glaciations. These deposits occur on uplands and are found as far south as Kingston.

During each glaciation sea level dropped as water from the oceans was transferred to ice sheets. Rivers extended and deepened their valleys to conform to the lower sea levels. When the ice sheets melted, sea level rose, flooding the deepened valleys and establishing new shorelines. The present configuration of the coast is the result of the rapid post-glacial rise in sea level, which slowed approximately 6,000 years ago. Many of the estuaries along the coast are the drowned lower reaches of former river valleys. To the east of the mainland, barrier islands were formed, and continue to be shaped, by erosion and deposition of beach sand by waves and currents. Mud and sand transported by rivers and from offshore is gradually filling the bays and estuaries between the mainland and the barrier islands, creating extensive wetlands.

Geologic Cross Section of New Jersey



Igneous & Metamorphic Rock
- Diabase
- Granite, gneiss, schist or marble

Sedimentary Rock
- Conglomerate
- Sandstone
- Shale or argillite
- Limestone

Unconsolidated Sediments
- Sand
- Interlayered sand, clay, greensand marl
- Interlayered sand, clay

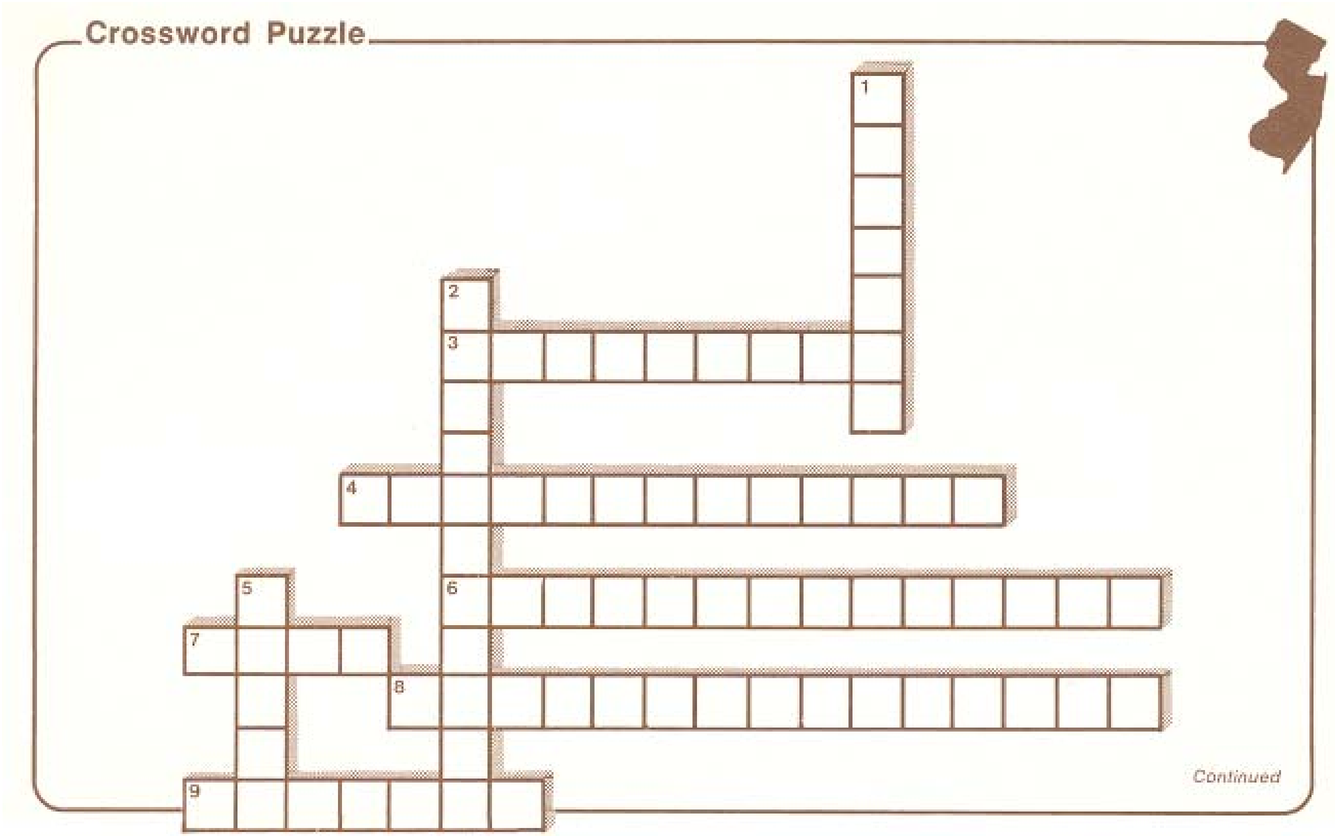
Map and Cross Section Exploration

ACTIVITY:
Students answer the questions below using **Geologic Map of New Jersey** (front and back sides) and the **Geologic Cross Section.**

1. Sediments of the Coastal Plain were deposited during the ______, _______ and __________ times.
2. When digging a building foundation near Englishtown, you would expect to dig into ________, _______ or ___________; near Lakehurst you would expect to find ___________.
3. In New Jersey, geologic formations of the Coastal Plain generally slope to the (northwest, southeast) while those of the Piedmont generally slope to the (northwest, southeast).
4. In the New Jersey Highlands most valleys were formed by erosion of relatively soft _________ rock. Harder, erosion resistant _________ and ________ rock forms most of the ridges and mountains.
5. The oldest rocks exposed in New Jersey are the __________, __________, and ___________ of the Highlands.
6. Beneath the predominately (igneous, metamorphic, sedimentary) formations of the Coastal Plain, Piedmont, and Valley and Ridge Provinces lie (igneous and sedimentary, igneous and metamorphic) rock.
7. The beaches, barrier islands and tidal marshes of New Jersey were formed (before, after) the late Wisconsinan Glaciation.
8. In the Highlands, a well would probably yield more water if drilled in (granite, glacial sands and gravels).
9. The area of estuarine sediments located between Newark and Jersey City is known as the ________ _________.
10. The easternmost point at which diabase can be found in New Jersey is located in _________ County.
11. The southernmost point at which Precambrian rock can be seen at the surface in New Jersey is in __________ County, at the city of ____________.
12. Faulting of surface formations is more intense in (northwestern, southeastern) New Jersey.
13. Lava flows of the Watchung Mountains are evidence of __________ activity during opening of the ________ Ocean.
14. Mineral commodities now produced in New Jersey, or important in the past, include _______, _______ and _______.
15. During the Ice Age glaciers covered approximately ($^{1}/_{2}$, $^{2}/_{3}$, $^{1}/_{5}$) of New Jersey.
16. Limestone and shale with marine fossils in the Valley and Ridge Province show that the ________ covered this part of New Jersey during part of the ________ Era.

ANSWERS:

1. Cretaceous, Tertiary and Holocene
2. sand, clay or greensand marl; sand
3. southeast (Coastal Plain), northwest (Piedmont)
4. sedimentary (valleys), igneous and metamporhic (ridges and mountains)
5. granite, gneiss and marble
6. sedimentary (exposed rock); igneous and metamporhic (deeply buried rock)
7. after
8. glacial sands and gravel
9. Hackensack Meadows
10. Bergen
11. Mercer; Trenton
12. northwestern
13. volcanic activity; Atlantic
14. gravel, sand, glass sand, crushed stone, building stone, iron, greensand, zinc, peat, brownstone, clay, etc.
15. $^{1}/_{5}$
16. seas, ocean, or proto-Atlantic; Paleozoic



Crossword Puzzle

ACROSS
3. The emplacement or injection of a magma into pre-existing rock.
4. The ocean created in the Paleozoic Era when North America drifted away from Europe and Africa the first time.
6. Theory that the earth's lithosphere is constructed of a dozen or so moving plates of continental proportions.
7. Magma that has reached the surface.
8. A ridge consisting of a heterogeneous mixture of stones, sand, silt and clay deposited by a glacier at the time of its farthest advance.
9. Ancient supercontinent containing the Americas, Africa, Europe and Asia.

DOWN
1. Process of mountain building.
2. Relatively rigid outer zone of the Earth: includes the continental plates, the oceanic layers, and part of the mantle.
3. Molten rock beneath the surface of the earth.

ANSWERS

DOWN
1. orogeny
2. lithosphere
3. magma

ACROSS
3. intrusion
4. proto-Atlantic
6. plate tectonics
7. lava
8. terminal moraine
9. Pangaea

DIGGING DEEPER
1. Pick 2 or 3 words and investigate further.

Matching Minerals and Mining in New Jersey

Match the material in column A with the place found and usage in column B:

A	B
__ 1. SAND & GRAVEL	**A.** From glacial bogs in Sussex County. Used for potting soils and soil conditioner.
__ 2. CRUSHED STONE	**B.** Pine Barrens. Formerly used for cast iron products.
__ 3. GLASS SAND	**C.** Cape May "Diamonds"
__ 4. CLAY	**D.** Mined throughout state. Vital for building and road construction.
__ 5. ZINC	**E.** Numerous quarries in central and northern New Jersey. Vital for building and road construction. Made from diabase, basalt and gneiss.
__ 6. PEAT	**F.** Formerly mined in Ridge and Valley Province. Used for pipes, alloys. Never a major industry.
__ 7. GLAUCONITE (GREENSAND)	**G.** Primarily from Cumberland County. Supports major glass-making industry.
__ 8. BROWNSTONE	**H.** Major deposits in Coastal Plain Province. Formerly supported ceramic industry. Now mined for brick and for lining and sealing landfills.
__ 9. CLEAR QUARTZ	**I.** From sands at Lakehurst. Mined in the 1960's and 1970's. Used in special kinds of steel and in paint.
__ 10. MAGNETITE	**J.** Mined from Franklin Marble at Ogdensburg. Used for galvanizing, brass products and pharmaceuticals.
__ 11. TITANIUM	**K.** Mined in Coastal Plain Province. Used for water softening and soil conditioning.
__ 12. COPPER	**L.** Mined in Highlands Province. Used for making iron, inactive since 1960's. Mined during Revolutionary War to make cannons, armaments and ammunition.
__ 13. BOG IRON	**M.** A variety of sandstone from the Paterson, Newark and Trenton areas. Widely used for construction around 1900.

More Minerals and Mines

BACKGROUND

Several towns in New Jersey once depended solely on mining or some other single industry. A good example is Batsto, a historic village that was abandoned when its bog iron process became obsolete. Other towns relied on glass making or turpentine production. Batsto and other towns like it became known as the "Ghost Towns *of* the Pine Barrens."

Today there are many industries that rely on raw materials mined in New Jersey. For example, our state ranks 5th nationally in industrial sand output used for making glass products (southern New Jersey). Almost *50% of* the total value *of* mineral products in the state comes from crushed stone produced for use in roads and foundations (primarily northern New Jersey). Zinc is mined in northern New Jersey.

ACTIVITIES

1. Research Batsto; find out why the bog iron process became obsolete.
2. Investigate other New Jersey "Ghost Towns" and their industries.
3. Identify the industries that use minerals or produce mineral products in your area.

Answers to *Matching Minerals and Mining in New Jersey*
1-D, 2-E, 3-G, 4-H, 5-J, 6-A, 7-K, 8-M, 9-C, 10-L, 11-1, 12-F, 13-B

Pequest - An Actual Case Study

A new state fish hatchery has been built in the Pequest Valley. An older hatchery at Hackettstown was not only too small, but its water quality and supply were inadequate. Pequest was chosen because its unique geology creates a large, dependable, pure water supply for a productive hatchery.

In this valley, several miles west of Hackettstown, rainwater is very quickly absorbed into the farmlands. After drilling test wells, geologists realized that beneath the fields were gravel deposits from Ice Age glaciers. Beneath this gravel was dolomite bedrock (a type of limestone). Fissures in the dolomite had been enlarged by the dissolving action of rainwater. Millions of gallons of water which had soaked into the ground at the farmlands were stored in the gravel and in the bedrock fissures. This is now used to supply the hatchery.

ACTIVITIES

1. How might the kind of rocks or soil beneath an area affect:
   - A. Flooding
   - B. Water supply from wells
   - C. Functioning of septic systems
   - D. Cost of excavating for basements and building foundations
   - E. Types and heights of buildings
2. Visit the Pequest Trout Hatchery and Natural Resource Education Center
   For information, location, and reservations contact:
   201-637 -4125
   RD #1, Box 389
   Oxford, N.J. 07863

Careers in Geology

Geologists are scientists who study the Earth, its composition and the processes which made it how it is today.

Geologists do many different kinds of things. Some specialize in the study of minerals (mineralogists) or the composition of rocks (petrologists). Seismologists study earthquakes and vulcanologists, volcanoes. Marine geologists sample the deep ocean floor and astrogeologists study conditions on the Moon and other planets. Paleontologists study fossils and how life developed. Some geologists specialize in water resources (hydrogeologists) or the impact of development and construction on our environment (environmental and engineering geologists).

Most geologists are hired by private industry to work in energy production, mining, cement and ceramics, sand and gravel production, or engineering projects.

The largest single employer of geologists is the federal government which includes the U.S. Geological Survey, Soil Conservation Service, Bureau of Land Management, National Park Service, Bureau of Mines, Forest Service and U.S. Army Corps of Engineers. In addition, many geologists work for state and local governments. Colleges, universities, and museums employ geologists as teachers, researchers, and curators. Some geologists work as private consultants.

Because of dwindling energy, mineral and water resources and increased environmental concerns, the long-range outlook seems good for employment especially in hydrogeology.

Most geologists divide their time between outdoor and office work. They work with people as well as rocks. A good background in the sciences is essential, as is a solid foundation in communication skills.

For more information, contact a guidance counselor or the American Geological Institute Education Office, *4220* King Street, Alexandria, Virginia *22302* (1-800-336-4764)

New Jersey Update

From the first geological survey of New Jersey in 1835 to the early years of the 20th century, there were two primary needs fulfilled by geologists working with the state government. The first was for accurate topographic and geologic maps. The second was for geologic investigations for the nationally important iron, clay, building stone, zinc and glass industries and the locally important greensand, cement, lime, and sand and gravel industries.

To the present day, topographic maps and the mineral industry remain important to New Jersey. In addition, since about 50 percent of the State's water supplies are derived from ground water, the availability and quality of ground water has taken on an increasing importance. This importance is reflected in work now done by geologists in New Jersey

Approximately 50% of the geologists in the Department of Environmental Protection are in the Geological Survey and perform scientific investigations. The remainder performs regulatory functions within the Division of Water Resources, primarily in the Bureau of Ground Water Quality Management. This bureau issues permits for all significant discharges to the State's ground water.

Within the New Jersey Geological Survey there are three Bureaus:

1) **Bureau of Geology and Topography:** performs geologic and topographic mapping, mineral resources assessment, engineering geology and geologic hazards evaluation.
2) **Bureau of Ground Water Resource Evaluation:** collects and provides information on ground water resources through aquifer mapping, geophysical techniques, computer applications and mathematical modeling.
3) **Bureau of Ground Water Pollution Analysis:** provides expertise on matters pertaining to ground water pollution and conducts pollution investigations for departmental agencies.

For further information on geology, ground water, or maps, please contact:
New Jersey Geological Survey
Box 029 Trenton, New Jersey 08625
Phone: (609) 292-2576

References & Resources

I. BOOKS

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Yolton, James S. 1965. *Fossils of New Jersey.* Geological Society of New Jersey, MacCrellish and Quigley Co.

II. NEW JERSEY BOOKS WRITTEN FOR CHILDREN

Hagaman, Adaline. 1963. *Early New Jersey.* University Publishing Co.
Newberry, Lida. 1977. *New Jersey:* A *Guide to Its' Past and Present.* Hastings House.

III. REGIONAL MUSEUMS WITH EARTH SCIENCE EXHIBITS Academy of Natural Sciences, Philadelphia, Pa
American Museum of Natural History of New York, N.Y.
Bergen Community Museum, Paramus, N.J.
Delaware Museum of Natural History, Greenville, De.
Franklin Mineral Museum, Franklin, N.J.
Geological Museum, Princeton, N.J.
Morris Museum, Morristown, N.J.
Newark Museum, Newark, N.J.
New Jersey State Museum, Trenton, N.J.
Paterson Museum, Paterson, N.J.
Poricy Park Nature Center, Middletown, N.J.
Riker Hill Park Geologic Museum, Roseland, N.J.
Rutgers Geological Museum, New Brunswick, N.J.
Van Wickie Geology Museum, Easton, Pa.

VI. NEW JERSEY ROCKS - Sample *of* 15 rocks (including loose sediments), booklet and map. Contact N.J. Geological Survey (609) 292-2506.

V. SPECIAL THANKS

Ms. Nancy Anderson, Mannington Township School District
Mr. James Wallace, Ridgewood School District
Dr. Jerry Schierloh, N.J. School *of* Conservation
Karen Fischer and Piper Bicanich, Brick Township High School

Geology Awareness

The purpose of this card is to provide additional background information about geology. You may wish to use these facts as the basis for separate lessons, for pretesting and posttesting, or as a basis for further research.

I. WHAT AM I?
Match Column A with Column B.

A

___ 1. I am a geological province in New Jersey. I was covered and uncovered again several times by the sea within the past 100 million years. My surface is mostly covered with sand.

___ 2. I am a range of mountains which extends from Georgia to Canada and crosses northwestern New Jersey. I was created as the Earth's crust folded and faulted when North America collided with Europe and Africa.

___ 3. I am a body of water between the African and European continents and the Americas. I was formed as these land masses drifted apart.

___ 4. 18,000 to 20,000 years ago I covered New Jersey as far south as Perth Amboy. In some places, I was over 1,000 feet thick.

___ 5. I am a New Jersey region of mountains formed by granite and metamorphic bedrock. Iron and zinc have been mined from beneath my slopes.

___ 6. I am a geological region with flat or gently rolling landscapes. The Watchung Mountains are part of me.

B

a. Glacier
b. Piedmont Lowland
c. New Jersey Highlands
d. Coastal Plain
e. Appalachian Mountains
f. Atlantic Ocean

II. FACTS

True or False.

___ 1. New Jersey was at one time attached to Europe.

___ 2. Dinosaurs once roamed New Jersey.

___ 3. The Continental Army used iron mined in the New Jersey Highlands.

___ 4. Some of the rocks in New Jersey are formed from materials over a billion years old.

___ 5. According to tradition, Dutch colonists opened one of the first mines in America to extract copper.

III. ROCK QUIZ

(Yes or No)

___ 1. Can a rock float?

___ 2. Can you tell the age of a rock?

___ 3. Can rocks be magnetic?

___ 4. Do rocks glow?

___ 5. Can glass be made out of rocks?

IV. NORTH OR SOUTH (N OR S)

In which part of New Jersey did the following occur?

___ 1. The land was completely covered by water.

___ 2. A glacier carried a 2,000 ton boulder and dropped it on a mountain.

___ 3. Volcanoes erupted.

___ 4. Most bog iron was mined.

ANSWERS

What am I?

1. d	4. a
2. e	5. c
3. f	6. b

II. Facts

1. False-New Jersey was once attached to Africa. At that same time, Europe was attached to northern New England and Canada.
2. True-In addition to a variety of dinosaurs, fossils of woolly mammoths, mastodons, crocodiles over 36 feet long and turtles 6 feet long have been found in New Jersey.
3. True-Ample supplies of wood (needed for charcoal), limestone (used for flux) and water allowed the operation of many forges. The mountains protected these forges from the British.
4. True-Sediments deposited over a billion years have been heated and recrystalized to become some of the bedrock of the New Jersey Highlands.
5. True-This mine was located in the Pahaquarry deposits, near the Delaware River north of the Water Gap.

III. Rock Quiz

1. Yes-Example-Pumice
2. Yes-If fossils present
3. Yes-Example-Magnetite
4. Yes-Example-Willemite under fluorescent light
5. Yes

IV. North or South

1. North and South-Ocean sediments 400 to 570 million years old have become the bedrock beneath much of northwestern New Jersey. Ocean sands and muds 20 to 100 million years old are present beneath the entire Coastal Plain.
2. North-The glacier dropped the boulder on Jenny Jump Mountain. The boulder is still there.
3. North-Volcanoes erupted in Sussex County about 440 million years ago and in the Piedmont Province about 190 million years ago.
4. South-Low grade bog iron ore was mined in southern New Jersey from colonial times until the early 1800's.