LESSON 5 • **Geology: Shaping Landscapes**

Objectives:
Students will:

- identify different landforms and explain how they are formed and changed with time.
- understand the role climate plays in shaping landforms.
- understand and identify how climatic conditions affect soils, vegetation, and wildlife.
- locate and map landforms found within state or regional Wilderness.
- determine how human actions affect local or regional geography.

Background:
Ecosystems include both living, **(biotic)** and nonliving, **(abiotic)** components. Biotic communities contain all living organisms within an ecosystem. Abiotic factors in an ecosystem include climatic conditions such as temperature, moisture, rocks and water. Landforms are the result of **internal processes** such as volcanism, shifting of plates, and uplifting; and, **external processes** like weathering and erosion caused by wind, running water and ice.

Weathering processes, which are all the processes that break down rocks at the Earth's surface, may be divided into two groups, **physical/mechanical** and **chemical**. Both processes incorporate considerations of: **atmosphere** (climatic influences of weather), **hydrosphere** (ground water, oceans, lakes, rivers, streams and cycling); and the **lithosphere** (chemical composition and physical make up of soils and rock materials).

The Earth's surface is the result of **destructional processes** tearing down the land, and **constructional processes**, building it up. **Destructional processes** include; weathering, the in-place breakup of rocks by physical or chemical means; and erosion, which involves the transport of Earth materials from one place to another by moving water as steams, rivers or along coasts, wind, glacial ice, and gravity. **Constructional processes**, include plate tectonic activity that raises the land to provide, with volcanism, more fuel for destruction; and deposition, the laying down of sediment derived by weathering and carried by moving water, wind, and glacial ice.

Climatic conditions play a substantial role in shaping landforms. The resulting landform is made up of various rock and soil types, plant and animal species and human inhabitants which are adapted to a specific region. Vegetation communities dictate species composition which are a function of the ecological conditions within an ecosystem. Species composition is dictated by available moisture, soil porosity and permeability. Vegetation dictates which wildlife species can live in the ecosystem.

Background continued:
Wilderness areas contain a variety of landforms from deserts to mountains. These land forms are the result of variable climatic conditions. Many geologic processes can be studied in Wilderness areas, untouched and uncovered. Humans benefit from preservation of Wilderness as an outdoor study lab.

In the following activities students will learn how to identify different landforms and understand the processes that shape them.

Activity 1: Identifying Landforms

Materials:
- student handout: "Shaping the Landscape", page 383.
- Fundamentals of Geologic Processes illustrations, pages 381-382.
-  aerial photographs in "Contours Stereogram Book"
-  stereoscope

Duration: 1 class period

Location: classroom

Procedure:
1. Review fundamentals of geologic processes. Read the background section and supplement with Student Handout: "Shaping the Landscape". Make overhead transparencies of the geologic processes illustrations to use as a visual aid.

2. In small working groups, assign students to study aerial photographs with stereo glasses to identify different landform types. Stereo glasses can be purchased in scientific supplies catalogs or perhaps borrowed from the city or County Planning Office, the State Foresters Office or the US Forest Service. Provide instruction in using stereo glasses if students are not familiar with them.

3. Ask students to identify prominent landforms in aerial photographs. What is the climate like? How does climate affect soils (determined by availability of moisture and the soil's ability to retain moisture)? Look at vegetation associated with each landform. How do climatic conditions affect vegetation representing each landform? List wildlife species you might find within each landform region. Why would these species choose to live here?

Activity 2: Natural Landforms, What Relief!

Materials:
- U.S. raised relief map
- world relief map of landforms

Duration: 1 - 2 class periods

Location: Classroom

Procedure:
1. Divide students into small working groups. Ask each group to identify four major landforms (such as mountains, deserts, canyons, valleys, rivers, shorelines, volcanoes, etc.). Locate and list each landform at different locations in the U.S. Why does the same landform (located in different parts of the U.S.) have different vegetation and wildlife?

2. Ask students to identify and describe the regional geography where they live. Have students hypothesize how climatic conditions contribute to resulting soil types, vegetation, and wildlife species.

3. In one paragraph, ask students to summarize the usefulness of each landform to humans. What role does Wilderness play in preserving that usefulness?

4. Examine landforms and vegetation zones on the world map. Ask students to explain why deserts are located where they are. Temperate or tropical rainforests?

Supplemental
Activity 3: Branching Out: Take a Look at Landforms

Materials:
- research materials
- art materials: colored pencils or markers, posterboard
- world map

Duration: up to one week, possible homework
Location: classroom and library

Procedure:
1. Assign one landform per student or working group from landforms list.
2. Assign each student to research his/her landform and write a paragraph summary about what it is, how it formed, and why it is unique.
3. Ask each student to draw a picture to illustrate the information. It can be a picture of the landform itself or of something related to the landform, such as vegetation and wildlife species living near or on it.
4. Display the pictures and information on a map of the world. Make a border around the map with pictures and summary paper and attach each one to its exact location.

LANDFORMS IN THE UNITED STATES:

Adirondack Mountains
Appalachian Mountains
Black Hills
Bryce Canyon
Cape Cod
Devil's Tower
Grand Canyon
Great Plains
Mammoth Cave
Mauna Loa
Mississippi Delta
Mount St. Helens
Niagara Falls
Everglades
Sierra Mountain Range
Mt. McKinley

LANDFORMS AROUND THE WORLD:

Alps or Matterhorn in Europe
Amazon River in Brazil
Andes Mountains in South America
Ayers Rock in Australia
Azores in the North Atlantic Ocean
Giant's Causeway in Northern Ireland
Highlands of Northern Scotland
Himalayas or Mount Everest in Asia
Hsi Chiang River Delta in China
Iceland in the Atlantic Ocean
Indus River in India
Island of Surtsey in the North Atlantic
Lake Baikal in the Soviet Union
Nile River in Egypt and Ethiopia
Marianas Trench in the Pacific Ocean
Mount Etna in Italy
Mount Fuji in Japan
Mount Kilimanjaro in Tanzania
Mount Vesuvius in Italy
Pyranees Mountains in Spain and France
Rift Valley in Africa
Rock of Gibraltar off the coast of Spain
Southerland Falls in New Zealand
Victoria Falls in South Africa
White Cliffs of Dover in England
Yukon River of Alaska and CanadaYangtze

Credit: Naturescope, Geology: The Active Earth, National Wildlife Federation

Supplemental
Activity 4: Geology of Wild Places

Materials:
- U.S. raised relief map
- National Wilderness Preservation System Map.

Duration: 1 - 2 class periods, possible homework

Location: classroom

Procedure:
1. In small groups, ask students to identify and locate a Wilderness or National Park in their state or region.

2. Identify and list landform types, specific geologic features, soil types, vegetation, and wildlife unique to this Wilderness. Describe climatic conditions and weather patterns of the area.

3. Create a map of the area portraying all factors students identified in step 2. Students must plan how they will represent each feature (overlays, color-coded, symbols, computer generated, satellite maps).

4. Display maps in the classroom and ask each group to present the geography and geology of the Wilderness or National Park.

5. As an extension, ask students to locate and describe landforms represented in National Parks in their state, region, nation, or other parts of the world.

Evaluation / Follow-up / Extension:
- Evaluate student mapping projects and lab exercises.
- What areas were the most impassable or unfriendly to human habitation? What areas were settled? Why? Are they now parts of designated Wilderness?
- Where are other Wilderness areas found? What environmental or geologic factors and events are present that identified them for preservation?
- Invite a natural resource professional or geographer to present to your class on the Geographic Information Systems (GIS) using satellite imagery for mapping landforms. Ask the speaker to address how GIS can assist in Wilderness management.

Career Options:
geologist, geographer, cartographer, hydrologist, meteorologist, engineer, landscape architect, Wilderness manager, environmental educator

SCIENCE
Ecology; Earth Science; Geology

References:

- Cvancara, Alan M. *A Field Manual for the Amateur Geologist,* Revised Edition. New York, NY: John Wiley & Sons, Inc. 1995
- Scherrer, Wendy and Weisberg, Saul, ed. *Living With Mountains, A Guide for Learning and Teaching About Mountain Landscapes*, Sedro Woolley, Washington: North Cascades Institute. 1991.
- Braus, Judy, et. al. *Naturescope, Geology: The Active Earth*. Washington, DC: National Wildlife Federation. 1987.

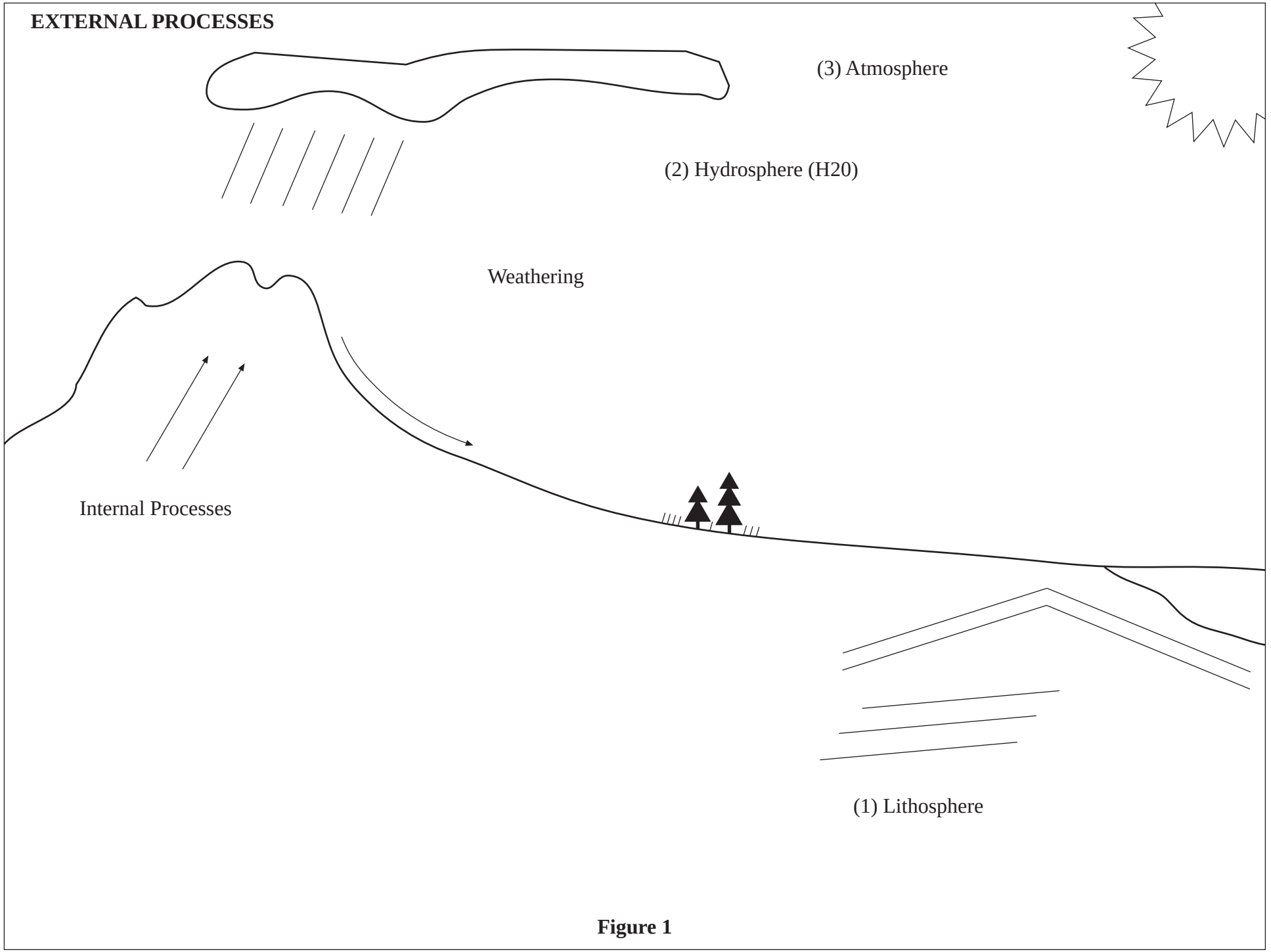
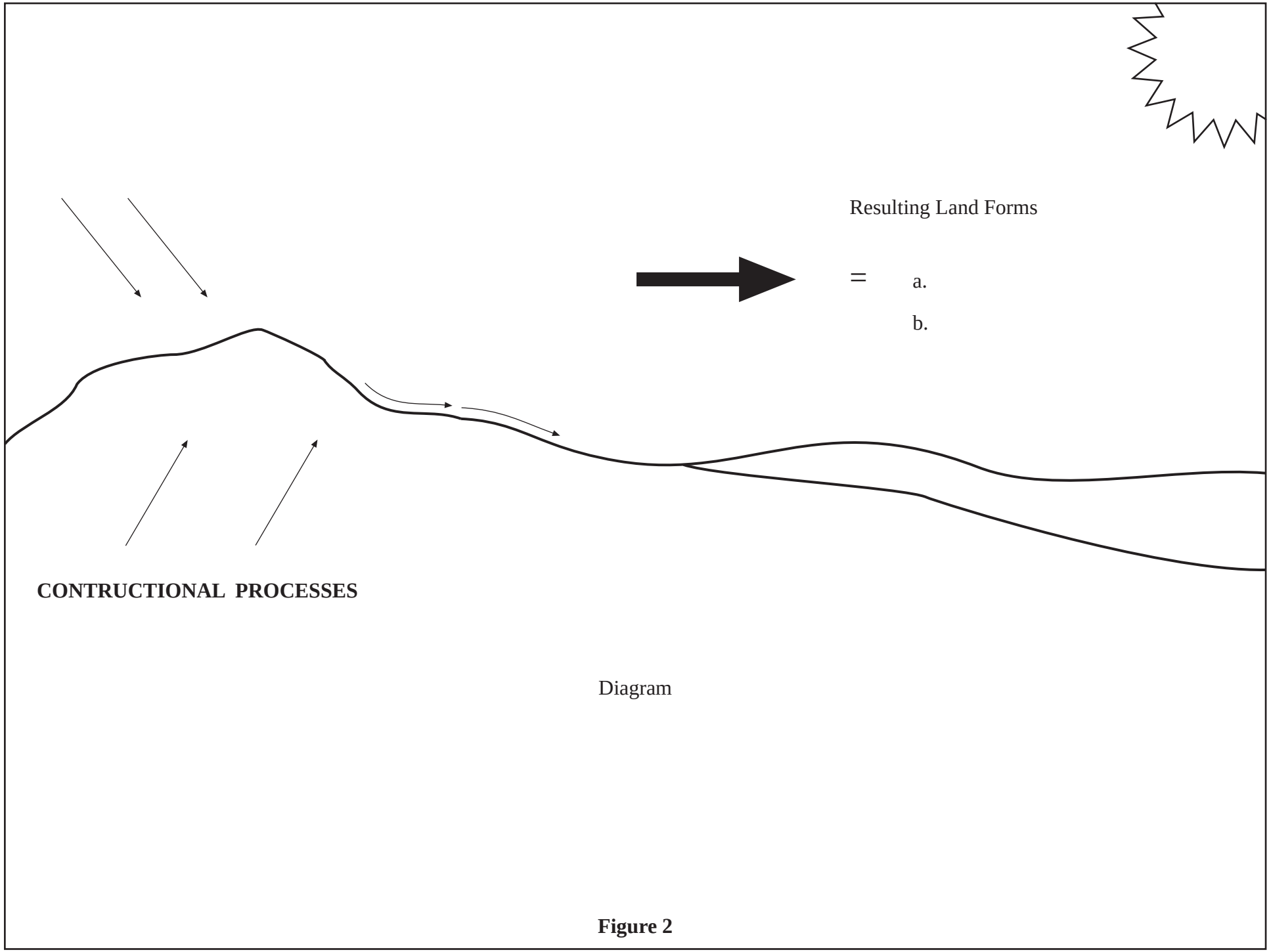

EXTERNAL PROCESSES
(3) Atmosphere
(2) Hydrosphere (H20)
Weathering
Internal Processes
(1) Lithosphere

Figure 1



Diagram

Figure 2

Activity 1: Identifying Landforms

STUDENT INFORMATION HANDOUT

Shaping the Landscape

DESTRUCTIONAL PROCESSES: "The Wear-It-Down Forces"

Two forces, weathering and erosion, are constantly at work building up and moving rocks making up the Earth's crust. **Weathering** causes rocks to fragment, crack, crumble, or break down physically and chemically. **Erosion** loosens and carries away the rock debris formed by weathering. Over time these two forces, working together, change the shape of the land.

As Rocks Crumble: Weathering

All rocks weather, but not in the same way or at the same rate. It all depends on the mineral composition where the rock is located and the local climatic conditions of temperature and moisture. Here's a look at the ways rocks weather:

- **The Freeze and Crack Cycle:** When water seeps into cracks in rocks and freezes, it can force a rock to split. That's because when water freezes it increases in volume. And because it needs more room, it pushes against the rock, eventually causing it to break apart. This is called ice wedging. If freezing and thawing occur over and over again, "solid" rocks can eventually be reduced to rubble.
- **The Roots of Destruction:** Plants do their share of breaking up rocks. (For example, plants can grow in the small bits of soil collected in rock cracks formed from ice and chemical action.) As the plant's roots develop, they expand, and apply pressure to the rock, forcing the crack to widen and deepen. Eventually, roots can split apart rocks, even large boulders and pieces of bedrock.
- **The Chemical Breakdown:** Some minerals are changed into different minerals as they react with chemicals in air and water. But not all minerals react in the same way and some, such as quartz, are very resistant to break down. For example, when iron is exposed to oxygen in the Earth's atmosphere, it changes chemically into iron oxide, or rust. Other minerals, such as pyrite, form weak acids when dissolved in rainwater, and these assist in the decomposition of rock material.

Soil is Important Stuff: There's a big benefit to weathering; a result we couldn't live without. As rocks are continually broken down into smaller and smaller bits, they eventually get so small the particles become fine enough to be called silt or sand, two important ingredients of soil. Although soil is mostly made up of tiny rock fragments, it also contains decayed plant and animal material (called humus), such as rotten leaves and decomposed animal parts. Rock and organic materials provide the nutrients needed for plant growth.

Activity 1: Identifying Landforms

STUDENT INFORMATION HANDOUT

Shaping the Landscape

Water, Wind, and Ice on the Move: Erosion

Raindrops falling on a field in Iowa, a glacier scraping out a valley in the Alps, and blowing sand into dunes along a beach or in the Mohave Desert are all examples of erosion at work. Erosion continues the work that weathering starts by helping to loosen particles and by transporting weathered rock material. The main agent of erosion is running water. It probably does more to wear away land than all other geologic agents combined. But ice and wind are also important landscape sculptors.

Eroder #1: Water

Water, Water, Everywhere: A fast-flowing stream carries a lot more than water. Clay, sand, silt, pebbles, and even boulders are sometimes carried along with the current. As these pieces of rock are carried along, they carve out a variety of different landforms, from stream valleys to mesas.

Underground H20: Some of the precipitation falling on the Earth's surface eventually seeps into the ground becoming **groundwater**. Groundwater can remove underground limestone bedrock by dissolving it and slowly carrying it away. Very weak acids in the water "eat away" at these rocks, often producing underground caverns. Some caverns get so big their ceilings collapse, forming depressions on the Earth's surface called **sinkholes.**

Coast Carvers: Moving water also shapes coastlines of continents. As powerful waves carrying rocks and sand pound against land, they can cause extensive erosion, forming rugged cliffs, arches, and coastal caves.

Eroder #2: Wind

Sand in the Face: Wind by itself isn't much of an erosion agent. But high-speed wind carrying a load of silt and sand is. Wind erosion is responsible for forming a variety of landscape features, especially in desert areas. (Deserts usually have few plants to hold sediment in place with their roots.) Wind erodes by lifting and removing sediment, but it can pick up only very fine, dry particles, sand size and smaller. Wind carrying sand can also sandblast rock and is responsible for many of the towers, pinnacles, and polished bedrock in desert landscapes.

Eroder #3: Ice

A Slice of Ice: In a few places, the climate is so cold most precipitation falls as snow in these areas and more snow accumulates than melts each year. As the snow piles up hundreds of feet thick, it presses down on the bottom layers until the snowflakes are pressed tightly together. Over time they become interlocking ice crystals and form a huge sheet of solid ice called a glacier.

Activity 1: Identifying Landforms

STUDENT INFORMATION HANDOUT

Shaping the Landscape continued

Eventually, the solid mass of ice starts to "flow" slowly downhill. This motion, usually just a few inches per day is due to two processes. First, the layers of ice that make up a glacier start to slide over one another. Then, the ice at the very bottom of the glacier, where pressure is greatest, starts to melt. The thin layer of water forming beneath the glacier allows the ice to slide very slowly over rocks and soil.

Giant Ice Scrapers: As a glacier travels, it plucks out chunks of bedrock which become embedded in the ice. These fragments of rock help grind and gouge the land as the glacier keeps moving. Glaciers scrape out a variety of landforms from steep peaks, such as the famous Matterhorn in the Alps, to U-shaped valleys and narrow ridges.

Ice Ages Gone By: Glaciers from past ice ages shaped many of the landscape features we see today, including many of our northern lakes, hills, and valleys. The last Ice Age ended about 10,000 years ago as the ice sheets covering the northern part of North America, Europe, and Asia slowly melted. As the ice sheets retreated, they left sharp mountain peaks, deep valleys, huge boulders (called "erratics" because they are out of place), scratched rock surfaces, piles of rocky debris, and other evidence that glaciers had once covered the land. The melting of ice sheets also caused the sea level to rise and re-cover the continental shelves adjacent to the continents.

CONSTRUCTIONAL FORCES: THE "BUILD-IT-UP" FORCES

As weathering and erosion wear away the Earth's crust, other forces are constantly at work building it up. Most of the building-especially the "big stuff," is the result of plate tectonics. Mountains, volcanoes, and faults are formed as rocks are pushed up, warped, folded, or fractured. Examples of mountain building include the Cascades, Andes, Himalayas with plate margins caused by plate tectonics. The build-up, or deposition, of sediment creates new landforms. And just like weathering and erosion, deposition is an ongoing process.

Move It and Dump It: Most of the sediment cut from mountains by weathering and erosion is carried and dumped by flowing water and most of it eventually ends up in an ocean. For example, every day the Mississippi River dumps over two million tons of sediment into the Gulf of Mexico. But some of the sediment carried by wind, water, and ice ends up in other places too, such as at the bases of mountains (forming alluvial fans), along river and stream banks (forming flood plains), and at the retreating edges of glaciers (forming huge piles of rock, rounded hills, and other landscape features). Deposition also forms dunes, beaches, and other landforms.

Activity 1: Identifying Landforms

STUDENT INFORMATION HANDOUT

Shaping the Landscape

continued:

The Layered Landscape: Over the years, sediment deposited in oceans by rivers, and streams piles up, forming layers of sedimentary rock as the sediment is compressed. Geologists study sedimentary layers to find out more about the ancient environment and past lifeforms that lived in an area. For example, if sedimentary rock layers are not turned upside-down by the shifting of the Earth's crust, geologists know the oldest fossils will be found in the lowest rock layers and the youngest fossils will be found in layers closer to the Earth's surface.

PEOPLE SHAPE THE LANDSCAPE

So many forces are at work on the Earth's crust at the same time, it's often hard to figure out which geologic agents are responsible for what you see. But some landscape features are not caused by geologic forces at all. They're caused by people. We speed up erosion by clearing land for farming, housing developments, lumbering, and strip mining; we change the course of rivers by building dams and channels; and we cut through mountains of rock to build highways.

All these, as well as other human activities, affect the natural processes of weathering, erosion and deposition. It is important that we try to understand the effects of our activities on the landscape, plant life, and animal life so we can judge the longer term effects and appropriateness of our activities.

The past and present forces of nature affecting the Wilderness landscape capture the need to protect geologic laboratories. Wilderness is the place where we can go to study changes occurring over time. Much of our landscape has changed due to human presence and expanded development. If we can comprehend what has happened over time, we will continue to cherish the power of nature and the need to protect and preserve these wild areas - for future generations.

Aldo Leopold, noted wildlife biologist and leader of the Wilderness idea stated, "Land, then, is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants, and animals. Food chains are the living channels which conduct energy upward; death and decay return it to the soil. The circuit is not closed; some energy is dissipated in decay, some is added by absorption from the air, some is stored in soils, peats, and long-lived forests; but it is a sustained circuit, like a slowly augmented revolving fund of life."

• **Credit:** Adapted from Naturescope, Geology: The Active Earth, National Wildlife