Geology and the Earth

Imagine walking on a rocky shore. You can see the pounding surf, hear stones clink together as waves recede, feel the wind blowing in your hair. But the cliffs don't move and the ground doesn't shake. Even though the Earth appears to be a firm foundation beneath your feet, it is a dynamic planet. Continents slowly shift position; mountains rise and then erode away. These motions escape casual observation because they are generally slow, although every year events such as volcanic eruptions and earthquakes remind us that geologic change can be rapid.

THE SCIENCE OF GEOLOGY

Geology is the study of the Earth, including the materials that it is made of, the physical and chemical changes that occur on its surface and in its interior, and the history of the planet and its life forms.

THE EARTH AND ITS MATERIALS

The Earth's radius is about 6370 kilometers, nearly one and a half times the distance from New York to Los Angeles (figure 1) .If you could drive a magical vehicle from the center of the Earth to the surface at 100 kilometers per hour, the journey would take more than two and

a half days. Most of the Earth is composed of **rocks**. Rock outcrops form some of our planet's most spectacular scenery: white chalk cliffs, pink sandstone arches, and the grey granite of Yosemite Valley. Rocks, in turn, are composed of minerals (Fig. 2). Although more than 3500 different minerals exist, fewer than a dozen are common. Geologists study the origins, properties, and compositions of both rocks and minerals. Geologists also explore the Earth for the resources needed in our technological world: fossil fuels such as coal, petroleum, and natural gas; mineral resources such as metals; sand and gravel; and fertilizers. Some search for water in reservoirs beneath Earth's surface.

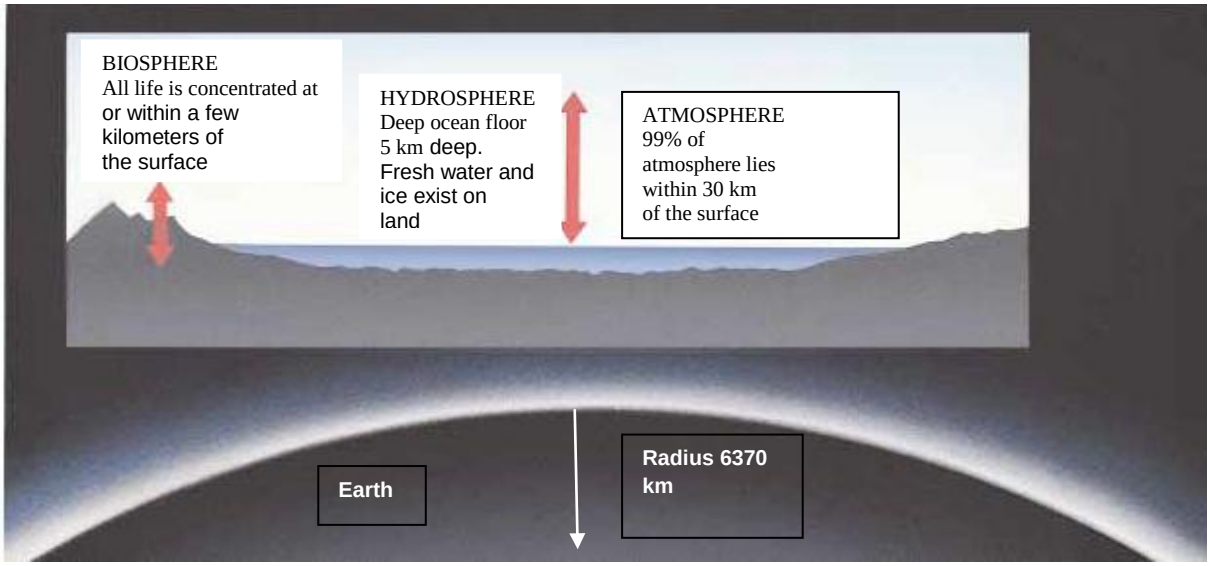

Figure 1 Most of the Earth is solid rock, surrounded by the hydrosphere, the biosphere, and the atmosphere.

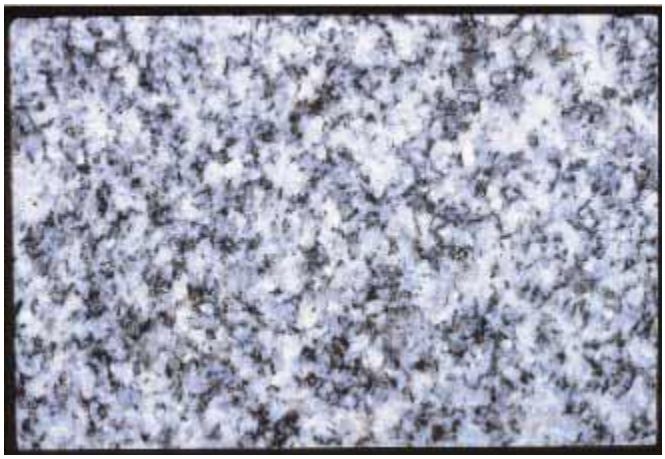

Figure 2 This granite rock is composed of different minerals, primarily quartz, feldspar, and hornblende. The mineral grains are a few millimeters in diameter.

INTERNAL PROCESSES

Processes that originate deep in the Earth's interior are called **internal processes**. These are the *driving forces* that raise mountains, cause earthquakes, and produce volcanic eruptions. Builders, engineers, and city planners might consult geologists, asking, "What is the probability that an earthquake or a volcanic eruption will damage our city? Is it safe to build skyscrapers, a dam, or a nuclear waste repository in the area?"

SURFACE PROCESSES

Surface processes are all of those processes that sculpt the Earth's surface. Most surface processes are driven by water, although wind, ice, and gravity are also significant. The **hydrosphere** includes water in streams, wetlands, lakes, and oceans; in the atmosphere; and frozen in glaciers. It also includes ground water present in soil and rock to a depth of at least 2 kilometers. Most of us have seen water running over the ground during a heavy rain. The flowing water dislodges tiny grains of soil and carries them downslope. If the rain continues, the water may erode tiny gullies into a hillside (Fig. 3). A gully may form in a single afternoon; over much longer times, the same process forms canyons and spacious river valleys. People build cities along rivers to take advantage of the flat land, fertile soil, and abundant water. But the erosion continues. Rivers wear away at their banks and bed and periodically flood adjacent land. Geologists seek to understand these processes and advise builders and planners to minimize loss of life and property.

The oceans cover more than 70 percent of our planet. Although oceanography is a separate scientific discipline, it overlaps with geology. Geologic processes form the ocean basins and alter their size and shape. Weathering and erosion of continents carry mud, sand, and salts to the sea. Earth is the only planet in the Solar System that has oceans. It is also the only planet that supports life. Oceanographers examine the oceans' influence on climate, the atmosphere, life, and the solid Earth.

Figure 3 Over long periods of time, running water can carve deep canyons, such as this of Grand Canyon in the American southwest.

THE ATMOSPHERE

The **atmosphere** is a mixture of gases, mostly nitrogen and oxygen (Fig. 4). It is held to the Earth by gravity and thins rapidly with altitude. Ninety-nine percent is concentrated within 30 kilometers of the Earth's surface, but a few traces remain even 10,000 kilometers above the surface. A brief look at our neighbors in space reminds us that the interactions among air, rock, and life affect atmospheric composition, temperature, and movement. The solid Earth ,,Venus, and Mars are approximately identical in composition. Yet the three planets have radically different atmospheres and climates. Today, the Venusian atmosphere is hot, acidic, and rich in carbon dioxide. The surface temperature is 450ºC, as hot as the interior of a self-cleaning oven, and the atmospheric pressure is 90 times greater than that of the Earth. In contrast, Mars is frigid, with an atmospheric pressure only 0.006 that at the surface of the Earth. Venusian water has boiled off into space; almost all Martian water lies frozen in vast underground reservoirs.

Figure 4 This storm cloud over Mt. Robson, British Columbia, is a visible portion of the Earth's atmosphere

THE BIOSPHERE

The **biosphere** is the thin zone near the Earth's surface that is inhabited by life. It includes the uppermost solid Earth, the hydrosphere, and the lower parts of the atmosphere. Land plants grow on the Earth's surface, with roots penetrating at most a few meters into soil. Animals live on the surface, fly a kilometer or two above it, or burrow a few meters underground. Sea life also concentrates near the ocean surface, where sunlight is available. Some aquatic communities live on the deep sea floor, bacteria live in rock to depths of a few kilometers, and a few windblown microorganisms are found at heights of 10 kilometers or more. But even at these extremes, the biosphere is a very thin layer at the Earth's surface. Paleontologists are geologists who study the evolution and history of life by examining fossils and other evidence preserved in rock and sediment. The study of past life shows us that the solid Earth, the atmosphere, the hydrosphere, and the biosphere are all interconnected. Internal processes such as volcanic eruptions and migrating continents have altered the Earth's climate and atmospheric composition. Life has altered the atmosphere. The atmosphere reacts with rocks.