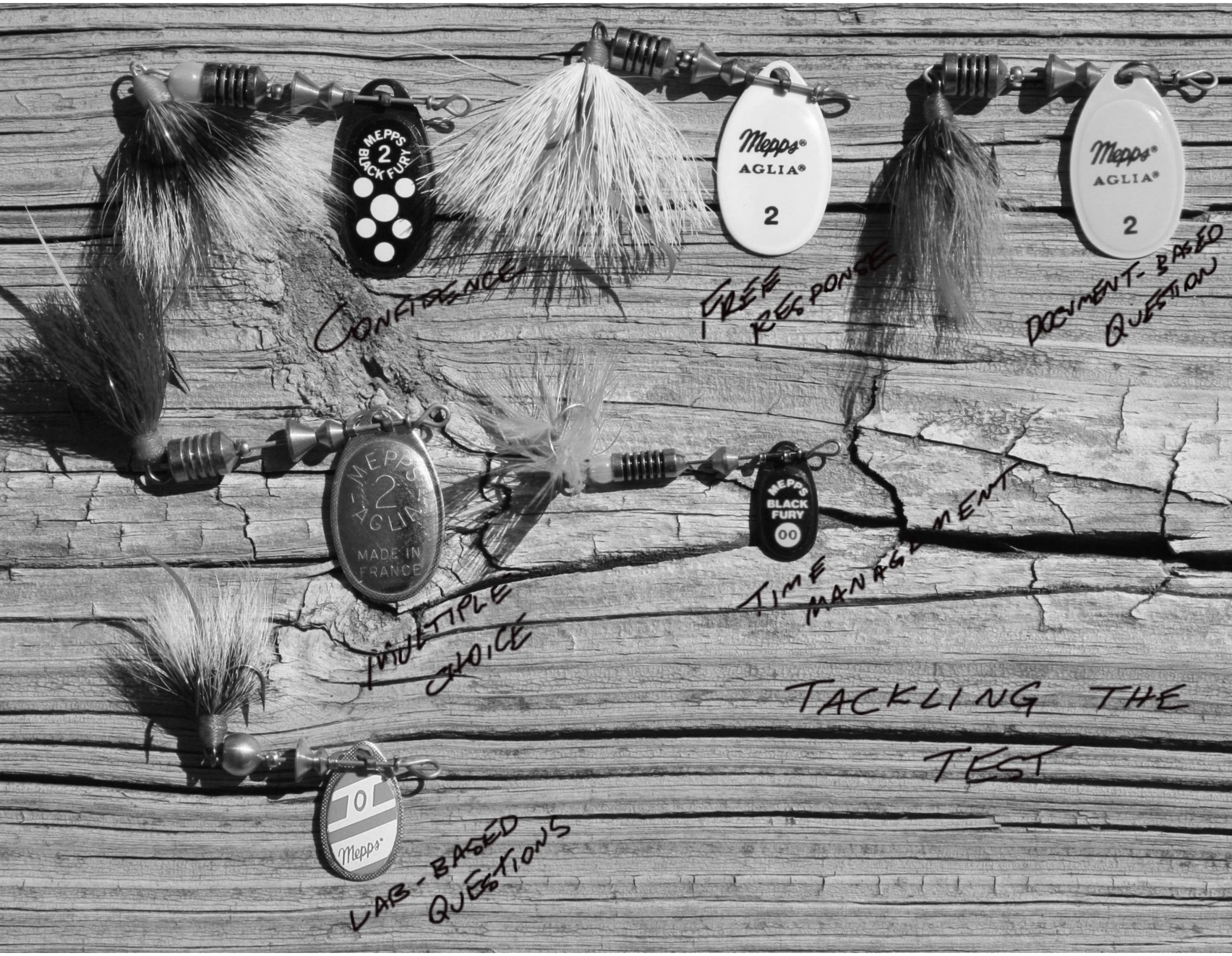
Advanced Placement

ENVIRONMENTAL SCIENCE

Geologic Processes & Soil



NATIONAL MATH + SCIENCE INITIATIVE

Student

2014

Geologic Processes and Soil

Geologic Processes

The age of Earth is best measured by the geologic time scale. The idea that Earth is approximately 4.5 billion years old is hard to conceptualize. The geologic time scale relates vast amounts of time to important geologic and evolutionary events. Important time periods and events are indicated in Fig. 1.

The Earth is made up of three zones. The innermost zone is the **core**. The inner core is solid iron and nickel. The outer core is liquid iron and sulfur. The **mantle** covers the core. It is a thick solid zone that consists of iron, silicon, oxygen and magnesium. The **asthenosphere** is a thin plastic-like layer of the mantle that is composed of partially molten rock. The **lithosphere** is made up of the outermost layer of the mantle and the last zone, the **crust**. The crust is made up of 47% oxygen, 28 % silicon, 8% aluminum, and 5% iron. It is the source of nonrenewable resources and soil.

Fig. 1

Plate Tectonics

The lithosphere is broken into large pieces called **tectonic plates**. These plates move on the plastic-like asthenosphere. The movement of these plates moves the continents that rest on them. This phenomenon is called **continental drift**. The interactions of these plates, with one another, produce areas of earthquakes, volcanoes, oceanic trenches and mountain building. There are three types of boundaries between these plates:

1. **Convergent Plate Boundary** - plates are pushed together
   Ex. Himalayas (see Fig. 2)
2. **Divergent Plate Boundary** - plates move apart in opposite directions
   Ex. Mid-Atlantic Ridge (see Fig. 2)
3. **Transform Fault** - plates slide past each other in opposite but parallel directions
   Ex. San Andreas Fault (see Fig. 2)

Earthquakes are violent vibrations in the earth that are often a result of these interactions, especially transform faults. The **focus** of the earthquake is the point where it originates. The **epicenter** is the point on the earth's surface directly above the focus. **Seismographs** measure earthquakes. Scientists report the magnitude of the earthquake on the Richter magnitude scale. This scale is **logarithmic**. Logarithmic scales, such as the Richter magnitude scale and the pH scale examine values that span many orders of magnitude without losing important information that would be lost on a smaller scale.

Geologic Processes and Soil

Volcanoes

Geologists group volcanoes into four main kinds: cinder cones, composite volcanoes, shield volcanoes, and lava domes. Cinder cones are the simplest forms and are comprised of small fragments that solidify around the vent and form a circular cone. They generally do not exceed a few thousand feet in elevation. Composite volcanoes are typically steep-sided and may rise to 8000 feet in elevation. They are the product of lava flows, cinders, blocks and bombs. Shield volcanoes are built almost entirely of fluid lava flows. The Hawaiian Islands are examples of shield volcanoes. Lava domes are formed by small masses of viscous lava piled over and around its vent.

The **Pacific Ring of Fire** (Fig. 2) is an area of earthquakes and volcanoes that encircle the Pacific Ocean. It is associated with a series of oceanic trenches, volcanic arcs and plate movements.

Fig. 2

Rock Cycle

The rock cycle (Fig. 3) describes the formation and transformation of rocks. Magma solidifies either at or below the surface of the earth and forms igneous rocks. Igneous rock is exposed to weathering and erosion and breaks down into smaller particles. This sediment is transported by wind, water and gravity. These sediments become sedimentary rocks through compaction and cementation. Changes in temperature, pressure, and chemistry of the rock can changes igneous and sedimentary rocks to form metamorphic rocks. The cycle begins again when igneous, metamorphic and sedimentary rock is melted with extreme heat.

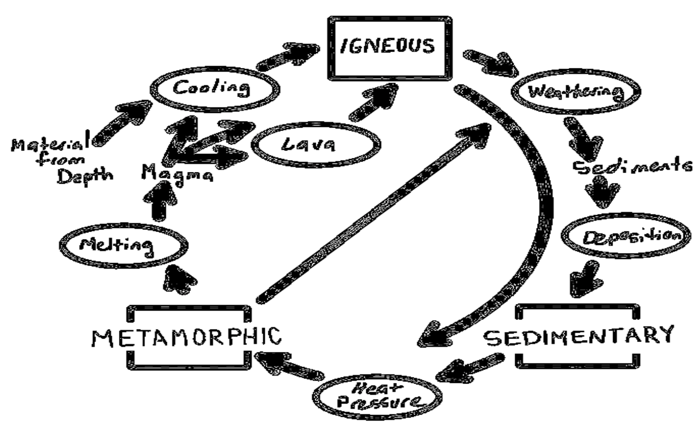


Fig. 3

Soil

Soil is created when chemical, physical, and biological processes break down rock. Chemical and physical weathering breaks rock into smaller pieces. During **primary succession, pioneer species**, such as mosses and lichens, break down rock and add organic material to the sediment forming soil.

Soil has several distinct layers (**soil profile** Fig. 4):

O Horizon – leaf litter / organic material (**humus)**
A Horizon – topsoil
E Horizon – mineral layer low in organic material
B Horizon – subsoil
C Horizon – bottom layer of soil composed of larger pieces of rock
R Horizon – bedrock

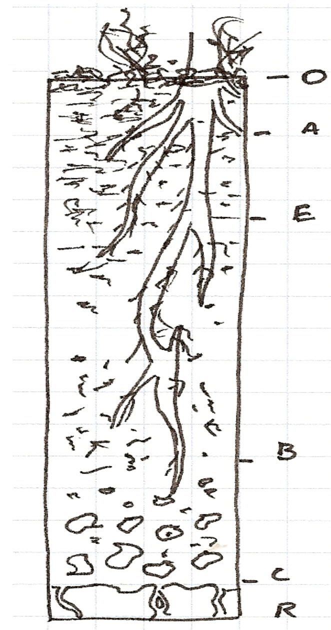


Fig. 4

Soil is classified based on its composition of three categories of sediment: clay (smallest), silt, and sand (largest). The combination of these sediments helps give soils unique physical characteristics. The soil texture triangle is used to classify the texture class of the soil. (Fig. 5) The texture of the soil affects its **porosity** (how many spaces between particles) and **permeability** (how water can flow through particles), which in turn affects **percolation** (rate of water movement through soil). **Loam** is generally considered ideal for agriculture.

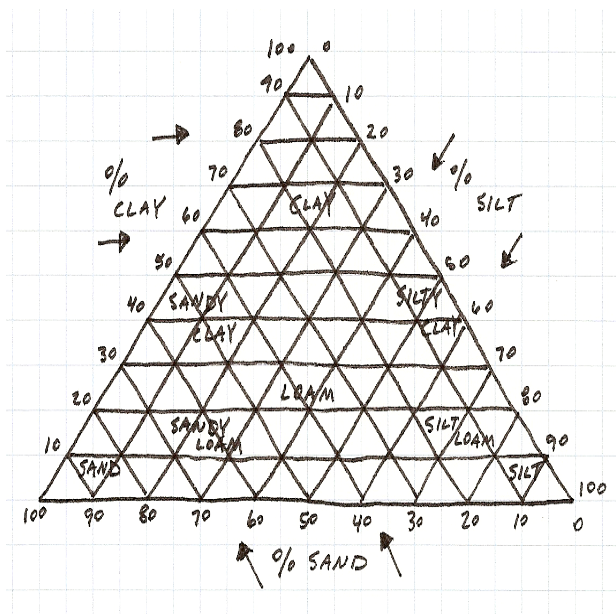


Fig. 5

Soil is under constant pressure from erosion. Erosion is the movement of soil from one place to another usually by wind and water. Vegetation protects the soil in which it grows. Farming, overgrazing, and removal of trees increase the erosion of soil. Loss of topsoil decreases fertility and the ground's ability to hold water. Sediment loss to erosion is also a major contributor to water pollution. Soil can be renewed, but the process can take several hundred years. In the United States, approximately one-third of the original topsoil in major agricultural areas has been lost to erosion.

When topsoil is lost and productivity falls, **desertification** can occur. This is often a result from surface mining, overgrazing, improper irrigation techniques and deforestation.

Soil Conservation

Soil conservation reduces soil erosion and increases fertility by keeping soil covered with vegetation. **No-till farming** is an alternative to conventional farming that uses special equipment to plants seeds without the topsoil being turned. This not only conserves soil, but also saves fuel and time due to the reduction of plowing. The addition of **terraces** to sloping land reduces erosion on steep slopes by controlling water runoff. Alternating crops within a field or planting crops within rows of trees (alley-cropping) also reduces erosion and increases soil fertility.

Using organic fertilizers instead of inorganic fertilizers also creates more sustainable soil. Inorganic fertilizers are easy to deliver and apply, but they often are lost in runoff and do not add humus to the topsoil. Organic fertilizers, such as animal manure, green manure, and compost, not only adds essential nutrients, but also adds humus to the soil that helps retain moisture and ensures soil will be properly aerated. **Crop rotation** also benefits soil by planting legumes every other year to add nitrogen to the soil naturally.