

Lesson Outline for Teaching

Lesson 1: Forces That Shape Earth

A. Plate Motion

1. The theory of plate tectonics states that Earth's surface is made up of a number of rigid plates that move on top of the fluid, uppermost layer of the mantle.
2. Mountains and valleys form where Earth's plates collide, move away from each other, or slide past each other.

B. Vertical Motion

1. You need to understand the forces that act on Earth's plates to understand how they can rise to form mountains.
2. Earth's plates float on the surface of Earth's mantle for similar reasons as icebergs float on the surface of water.
 - a. Plates formed of continental crust are less dense than the fluid rock that forms the mantle, and part of the continental crust floats above the surface of the mantle.
 - b. The continental crust displaces some of the mantle below it until an equilibrium is reached, which is called isostasy.
 - c. If the continental crust gets thicker, it will sink deeper into the mantle, but the mantle will also push up on the thicker crust until a(n) balance is reached.
 - d. Weathering and erosion remove the top part of a mountain. After this happens, the crust rises to maintain isostasy.
 - e. The mountain stops moving when the mass of the mountain equals the mass of the mantle it displaces.
3. Twenty thousand years ago, part of Earth's crust was covered by ice, which pushed down on the crust, forcing it to sink into the mantle in a process called subsidence.
4. The melting of the glaciers and the draining of the water upset the isostatic balance, and the crust started moving upward in response in a process called uplift.

C. Horizontal Motion

1. A force acting on a surface is called stress.
 - a. A stress that squeezes against a surface is called compression.
 - b. Tension is a stress that pulls something apart.
 - c. Shear forces include forces that act parallel to one another but in opposite directions.

Lesson Outline continued

2. Strain occurs when stress acting on rocks causes the rocks to change shape.
 - a. Elastic strain does not permanently change, or deform, rocks; the rocks return to their original shapes.
 - b. Plastic strain creates a permanent change in a rock's shape and affects hot or weak rocks.
3. In the upper crust, the rocks are cold, and forces cause the rocks here to break rather than to change shape.
 - a. When strain breaks rocks rather than just changing their shape, it is called failure.
 - b. Fractures, or faults, form when rocks fail.

D. Plate Tectonics and the Rock Cycle

1. Rocks are always moving through the rock cycle, both vertically and horizontally.
2. Together, plate motion, uplift, and subsidence keep rocks moving through the rock cycle.
3. Uplift brings metamorphic and igneous rocks from deep in the crust up to the surface, where erosion breaks down rocks into sediment.
4. Buried sediment becomes sedimentary rocks, which with pressure and temperature eventually become metamorphic rocks.
5. Subduction takes all types of rocks deep into Earth, where they can melt and become new igneous or metamorphic rocks.

Discussion Question

Compare how compression, tension, and shear affect layers of rock. Imagine you see three similar outcrops of layered sedimentary rock, each under one of these stresses. Compare and contrast how each would look.

Rock layers that are under compression bulge upward and look like they have been folded in pleats. Rock layers that are under tension sink downward in the middle and look like they have been stretched in long, thin layers. Rocks that are subject to shear stresses have layers that are offset from each other or are turned horizontally relative to each other.