Layers of Earth

NGSS Performance Expectations: HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

The content and activity in this topic will work towards building an understanding of the formation and composition of the interior of Earth.

Formation of the Solar System

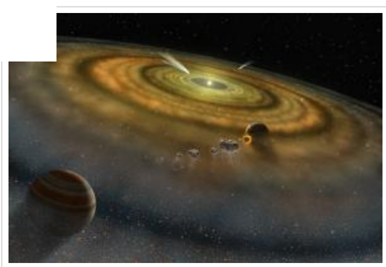

Fig. 7.2. An artist's conception of dust and gas cloud surrounding a young solar system
Image courtesy of National Aeronautics and Space Administration (NASA)

Scientists theorize that our solar system formed about 4.6 billion years ago. Particles of dust were pulled together by gravity until they formed a huge solar cloud. As particles within the cloud were attracted toward the center of gravity, many of them collided, causing friction that began to heat up the solar mass. Some particles underwent radioactive decay, further heating up the solar mass. Eventually, the temperature at the center reached millions of degrees, hot enough that hydrogen atoms began to fuse. Thus, our sun became a star fueled by nuclear fusion in its core (Fig. 7.2).

Many millions of kilometers from the center of the solar cloud, other smaller clouds of particles formed the planets in our solar system. When the earth formed, friction and radioactive decay also heated the center of our planet, but the mass was too small to start nuclear fusion. The earth became a molten planet rather than a fiery sun.

Density Layering

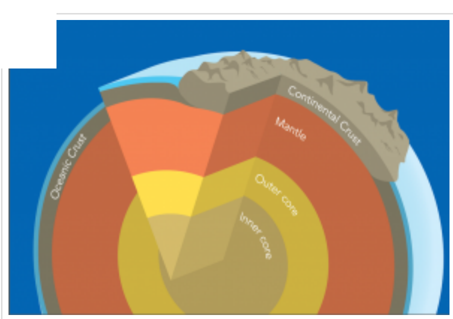

Fig. 7.3. This graphic representation of the earth's layers shows the inner core, the outer core, the mantle, and the oceanic and

As our planet became a molten mass, layers formed (Fig. 7.3). The densest material, containing iron and nickel, settled to the core in the center of the earth. Less dense matter, containing iron rich silicates—compounds of silicon and oxygen—formed the vast interior mantle. The least dense materials, such as common granite and basalt rock, rose to the surface, cooled, and formed the earth's solid, stony crust.

continental crusts (not to scale).
Image by Byron Inouye

Volcanic eruptions through the stony outer crust continued to release heat and pressure from the molten center of the earth. Each eruption brought gases, water vapor, ash, and molten lava to the surface from the interior. When the earth's surface cooled enough, the water vapor condensed into liquid, forming oceans. Volcanic activity continues to reshape the surface features of our planet.

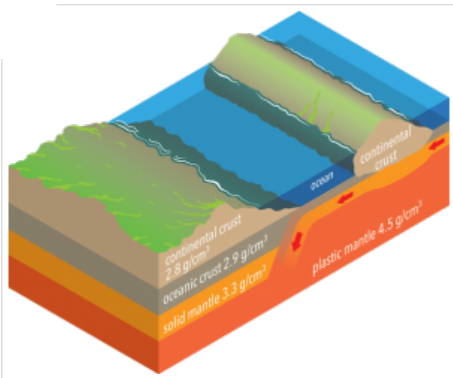

Fig. 7.4. This idealized cross-section of the earth's outer layers shows the densities of the earth's crust and upper mantle.
Image by Byron Inouye

Fig. 7.4 shows an idealized cross-section of the outer layers of the earth. The solid outer crust of the earth is composed of two distinctly different types of material, the less dense continental crust and the more dense oceanic crust. Both types of crust rest on solid upper mantle material. The upper mantle, in turn, floats on a denser layer of mantle called magma.

The earth's crust changes continuously. These changes make the crust more or less dense. For example, erosion or glacial melting reduces continental mass; volcanic eruptions increase continental mass. When a continent loses mass, it floats higher on the mantle; when it gains mass it sinks lower. The mantle is plastic, which means that it is a fluid like molten tar.

Evidence for Density Layering

Different types of evidence support the hypothesis that the earth's interior is composed of layers of materials of different densities. Density is the amount of mass in a given volume of material.

Density = Mass/ Volume

The densities of some materials—granite and basalt, for example—can be determined from rock samples in the laboratory by measuring their mass and their volume. Fig. 7.5 shows the basic procedures for determining mass and volume of a rock sample. For precise measurements of the density of different kinds of rock material, pure samples must be used.

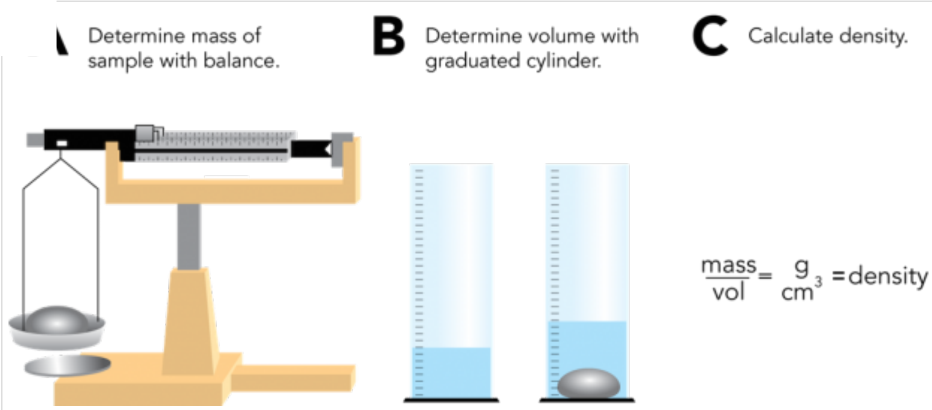

Fig. 7.5. Procedures for determining density of rock samples
Image by Byron Inouye

From direct laboratory measurements of surface rocks, scientists have determined that the average density of the earth's surface is about 2.8 g/cm^3. Indirect evidence indicates that the density of earth as a whole is about 5.5 g/cm^3. This suggests that the interior of the earth must be denser than the crust.

There is evidence that the materials within the earth form distinct layers, each with a different density. Most of this evidence comes from observations of seismic waves, the vibrations generated by earthquakes or explosions. As seismic waves travel through the earth, changes in wave patterns indicate where the waves are reflected or refracted in the earth's interior. Careful measurement of changes in the velocity of these waves as they travel through the earth has provided information about the number of layers, their thickness, and their composition. These data also indicate the probable physical state of each layer, whether it is solid rock, a molten liquid, or a tarry plastic substance.

Scientists are still unable to obtain and test samples of materials from deep within the earth. However, they can compare data from earth vibration observations with data from simulated laboratory tests on materials of known chemical composition. They can also construct and test computer models of the physical features of the earth. From these data, scientists have inferred that our earth is made of layers of material of different densities.

QUESTION SET

Question Set: Layers of Earth

COMPARE-CONTRAST-CONNECT

Compare-Contrast-Connect: Seismic Waves and Determining Earth's Structure

ACTIVITY

Activity: Modeling Earth's Dimensions

Diagram the layers of the earth and the study their physical characteristics.

WEIRD SCIENCE

Weird Science: Earth's Magnetic Field

FURTHER INVESTIGATIONS

Further Investigations: Layers of Earth