Differentiation

Purpose

To see how minerals separate from each other in a magma ocean.

Background [also see "Teacher's Guide" Page 12]

When planets begin to melt, the materials in them begin to separate from one another. The heaviest materials, such as metallic iron, sink to form **cores**. Low density magmas rise forming **crusts**. This process is called **differentiation**.

Soon after formation, the Moon melted substantially forming a large body of **magma** that completely surrounded it. This is called the **lunar magma ocean**. The main evidence that this actually happened on the Moon is the presence of large amounts of the **mineral plagioclase feldspar** in the ancient, lunar **highlands** crust. Scientists surmise feldspar floated in the magma ocean and accumulated at the top, while denser minerals such as olivine and pyroxene sank and accumulated at the base of the magma ocean.

This same process happens in lava lakes and in magma chambers beneath **volcanoes** on Earth. Minerals denser than the melt sink; those less dense float. It is an important geological process that leads to the production of a wide variety of **igneous rocks**.

Preparation

Review and prepare materials listed on the student sheet. Students will simulate the process of differentiation using readily-available materials: water, a transparent container (1000-milliliter beakers are good because they look scientific, but any wide-mouthed glass will work), pennies or metal shot, sand, and toothpicks.

In Class

Take a handful of pennies, sand, and toothpicks and dump them into the water. The pennies (or metal shot) sink faster than the sand. The toothpicks float. The floating toothpicks lie at a variety of angles and are analogous to the feldspar that formed the initial lunar crust. There ought to be more pennies than sand on the very bottom, with sand on top of that pile. (The pennies are much denser, 8.9 grams per cubic centimeter, than the sand, about 2.6 grams per cubic centimeter, so the pennies sink faster.) The clear water in between represents still-molten magma.

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This activity can be done as a demonstration if you prefer.

Wrap-up

Relate the sinking and floating objects to the differentiation of the Moon's magma ocean.

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Key Words

differentiation

density

magma ocean

Materials

pennies

sand

toothpicks

bowl

transparent container

water

Procedure

1. Mix the **pennies, sand, and toothpicks** in the **bowl**.

2. Fill the **container** with **water** to about 2 cm from the top.

3. Predict what will happen when you drop a handful of the pennies-sand-toothpicks mixture into the water. Will they all sink to the bottom? Will some sink faster than others?

4. Now drop the mixture into the water. Wait until the objects stop moving and look at the deposits. What do you see?

5. Can you explain what causes the differences in the way the objects sink or float?

6. Suppose the mineral feldspar in the lunar magma ocean responded like the toothpicks in the water. What does this tell you about the formation of the original crust on the Moon?

7. What makes up the highlands of the Moon? Based on this experiment, does this make sense?