A Solid or a Liquid—What is the Mantle (Asthenosphere) Like?

Modeling with taffy and oobleck.

Objectives

The purpose of this activity is to investigate and observe how certain materials can, under some circumstances, act like a solid and under other circumstances act like a liquid. This information will be used to gain a better understanding of how plates on the Earth's surface may move. Students will compare and contrast Silly Putty© and Oobleck, both of which demonstrate properties of both solid and liquids, as a concrete model for Earth's asthenosphere

Description

Because S-waves are able to travel through Earth's asthenosphere scientists infer that it is nearly solid. However, one of the fundamental concepts of plate tectonics is that this hot, weak solid flows over long periods of time (a property generally associated with liquids). For most students, the notion of a "solid flowing" is discrepant. Given both the fundamental and discrepant nature of the concept, it is important that learners have an opportunity interact with concrete models of the Asthenospehere so they can add this to their own mental model of plate tectonics.

Background

Most people have a good understanding of the characteristics of solids and liquids. We all know that solids, such as rocks, will shatter if hit hard enough with a hammer. We also know that liquids can be easily poured from one container to another because of their ability to flow. However, if presented with the statement that some substances can behave as both a solid and a liquid, seeing is believing! In this activity you will have the opportunity to investigate two of these interesting materials which have characteristics of both solids and liquids.

This idea is important because it provides a basic foundation for the understanding of plate tectonics. Geologists know there is solid rock underneath the plates covering the Earth. However, they believe that this solid rock is flowing and it is this flowing rock that causes the plates to be moved around. The theory of plate tectonics suggests that where this material flows to the west, for example, the overlying plate moves to the west. If the flow is downward, the plate goes down into the Earth to become a part of this flowing material; if the flow is upward, this material is added to and becomes a part of the plate.

Level: Grades 5 to 12

Materials

- Silly Putty
- Cornstarch
- Water

Food coloring (optional)

Video resources

Lecture on Silly Putty© analogy
http://www.iris.edu/hq/inclass/video/102

Oobleck: Dr. Seuss Science Experiment
http://www.instructables.com/id/Oobleck/

Big Hunk© models brittle vs. ductile (related demo and video lecture.)
www.iris.edu/hq/inclass/demo/brittle_vs_ductile_rocks

Credit

The following activity is from Project Earth Science © 1990, Horizons Research, Inc.

Dr. Robert Butler (geophysicist, Univ. Portland) describes how Silly Putty© can be used as an analogy for the asthenosphere. (See video link above)

Flow of solid rock within the Earth is slow, probably varying from about 1–10 cm/year. North America and Europe are moving apart at about 2–3 cm/year. This movement began about 200 million years ago. That rate over this period of time results in the continents being separated by > 4828 km (3000 miles)! (Do the math.)

Name: _____

Modeling the Asthenosphere with Silly Putty© and Oobleck

Procedures:

Part A:

1. Roll the Silly Putty© into a ball and bounce it off the table. Pull it, stretch it, mash it. Describe what happens on the data sheet. Is it behaving like a solid or a liquid?

2. Place Silly Putty© on the floor and strike with hammer. This may also be done as a demonstration by the teacher or a selected student. Record your observations.

3. Now roll the Silly Putty© into a ball and leave it alone for 20–30 minutes. How has the shape changed during that time? Record your observations.

Part B:

1. Your teacher will give you a small amount of a mixture of cornstarch and water. Roll the mixture around in your hands. What are the characteristics of this substance? When does it act more like a solid? When does it act more like a liquid?

2. Roll the mixture into a ball and then break the ball apart. Let each piece of the ball sit in your hand. Describe its behavior.

Observations:

Substance	Conditions	Behavior	Acts like a:	
			Solid	Liquid
Silly Putty©	Roll into a ball and drop onto the floor			
	Pull and stretch it			
	Mash it			
	Hit it with a hammer			
	Roll it into a ball and let it sit for 10 min.			
Cornstarch and water	Roll mixture around in hands			
	Let piece just sit in the palm of your hand			
	Other observations:			

Conclusions/Questions :

Answer AFTER following the procedures and filling out the data table on the previous page.

1. How is the Silly Putty© different from a solid object such as a baseball or a rock?

2. How is the cornstarch and water mixture different from liquids like water?

3. If you use either of these two substances as models of the Earth's mantle, how would you describe the behavior of the mantle? Describe how the properties of these "solids" help explain the movement of the Earth's plates.