Continents in the Sand

Introduction
Plate tectonics is one of the most successful theories in science, explaining earthquakes, mountain ranges, and volcanoes with elegant simplicity. As with all good scientific theories, plate tectonics can make predictions about what will happen as it accounts for what is observed. One way to see how plate tectonics explains the formation of mountain ranges and ocean basins is through the use of a physical analog: a simple model that mimics the earth’s behavior, in this case the motion of continents. These experiments can be performed using just a few pounds of sand and a few sheets of paper (the students provide the motive force); yet they still illustrate many of the basic concepts of relative plate motions.

This analog has a long history in science; the students will be replicating actual experiments, used by scientists to understand the world around them. Sand experiments have been used to examine faulting in extensional terrains (Acocella et al., 1989), compressional folding and faulting (Koopman et al., 1987; Mandl, 1988), the effects of basement topography on faulting (Hornsfield, 1977), and sea mount subduction (Domingez et al., 2000) In our experiment, the students will examine the effects of the three types of continental boundaries (convergent, divergent, transform) and then will predict what will happen if North America collides with Africa as happened 300 million years ago (and could happen again).

In plate tectonics, the outermost part of the Earth is divided into about 17 plates that move about on the surface. We have measured the motion of these plates using GPS, lasers, and other techniques. Plate motions create both the highest places on the Earth and the lowest, and are responsible for the majority of earthquakes, volcanoes, and mountains. And all of this action takes place where two or more plates meet—at the plate boundaries.
There are only three main types of plate boundary; all other boundaries are made by combining two of these in some way. A good analogy for plate motions is car motions. Cars can move side by side as they pass each other. Cars can move toward each other. And cars can move apart from each other. Plates move the same way. Plates moving side-by-side create a transform boundary; the best known example is the San Andreas fault in California. Plates moving toward each other create a convergent boundary where the two meet; this creates mountains such as the Rockies, the Andes, and the Himalayas. And plates moving apart from each other create a divergent boundary where the two plates pull apart; this creates a rift valley in continents and ocean basins when they get far enough apart. This is what has created the African Rift Valley and the Mid-Atlantic Ridge (the world’s longest mountain chain!).

**Preparation:**

You will need:
- 6 sheets of paper (11” x 17” works best)
- 6 cups of sand (or some other dry granular substance, such as salt)
- Magic marker
- North America - Europe sheet (last page)

To set up the experiments, start by dividing the paper into three sets of two sheets each. Place each set at a different lab station.

To make a **transform margin**, take one set of paper and lay it on a smooth, flat surface. (For large classes, performing these experiments with newspaper on a playground or gym floor typically works best.) Next, take another set of pages and lay it so that it overlaps the first set by about 50%; draw an arrow on either set of papers, with the two arrows pointing in opposite directions to indicate that the relative motion is a strike-slip. Place sand on the papers, spreading it out so that it covers a roughly square area and is about ½” thick.

To make a **divergent margin**, place the two sets of papers at right angles. On the papers, draw arrow pointing away from each other (see figure 2). Place sand on the papers, spreading it out so that it covers a roughly square area and is about ½” thick.
To make a convergent boundary, set up the papers as you did the second, only with the arrow pointing in to indicate that this is a compressional regime (see figure 3). Again, cover the papers with sand so that it is roughly square and about \( \frac{1}{2}'' \) thick.

![Figure 3: Convergent Boundary](image)

To perform the experiments, simply ask the students to predict what will happen when they pull the papers in the direction of the arrows, based on what they know of plate tectonics. Once they have recorded their predictions, have them pull the papers in the direction shown by the arrows, about 1” at a time. As the papers move, the students should describe how the sand is changing and what landforms they see developing. (See figures below for typical results.)

![Images of sand changes](images)

**Notes:**
This experiment works best with clean, dry sand or salt. If you use sand, please be sure that it is all about the same size; having different sizes of sand grains can cause the experiments to give strange results.

If the students don’t pull the arrows straight, don’t worry. It just lets you see how different relative plate motions create different results and reflects what we see in nature. For example, the mountains in Los Angeles were created by combination of a transform fault (the San Andreas) and the two plates moving together (North America and Pacific).

A fun puzzle can be made by gluing a large copy of the NASA image onto a thick piece of cardboard and then cutting along the plate boundaries. You may also want to challenge your students to discover what the names of the plates mean; for example, the Kula plate on the Western edge of North America gets its name from a Native American word for “all gone”.
References


Horsfield, W.T., 1977, An experimental approach to basement controlled faulting, Geologie en Mijnbouw, 56, 363-370

Koopman, A., A. Speksnijder, W.T. Horsfield 1987, Sandbox model studies of inversion tectonics, Tectonomics,


Web References:
Society of Exploration Geophysicists http://www.seg.org
Simple geophysics experiments http://www.earth.northwestern.edu/people/seth/Demos/index.html
The Paleomap Project http://www.scotese.com/
Plate tectonics animations http://www.ucmp.berkeley.edu/geology/tectonics.html
This dynamic Earth http://pubs.usgs.gov/gip/dynamic/dynamic.html
Student Worksheet: Plate Tectonics Experiment

Name: _________________________ Date: __________

Note: You do not have to go to the stations in order, but you do have to go to each station. Try the experiment at each station. Be sure to record the results carefully, as you will need them to do the final part of this worksheet!

Basic information: There are three ways that two cars can move. They can move toward each other. They can move away from each other. And they can move side-by-side. The Earth’s hard, outer crust is divided into several plates that also move. Just like cars, they can move in three ways. When plates move toward each other, they make a **convergent boundary**. When plates move away from each other, they make a **divergent boundary**. And when two plates move side-by-side, they make a **transform boundary**.

Continents ride on the plates like passengers in a car. Using a simple model, we can find out what happens to continents when the plates move. We will use paper as our plates. Our continents will be made out of sand. And we will provide the force that moves the plates around.

**Station 1: Transform Boundary**

1. Sketch the plates and continent.

2. Now slowly pull the plates in the direction of the arrows.

3. Sketch the plates and the continents

4. What has changed?

5. Now carefully put everything back the way it was when you started so the next team can run the experiment.
Station 2: Divergent Boundary
1. Sketch the plates and continent.

2. Now slowly pull the plates in the direction of the arrows.
3. Sketch the plates and the continents

4. What has changed?

5. Now carefully put everything back the way it was when you started so the next team can run the experiment.

Station 3: Convergent Boundary
1. Sketch the plates and continent.

2. Now slowly pull the plates in the direction of the arrows.
3. Sketch the plates and the continents

4. What has changed?

5. Now carefully put everything back the way it was when you started so the next team can run the experiment.