Plate Tectonics for Environmental Science

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Purpose

Environmental Science is an interdisciplinary subject. Understanding the environment as a whole requires one to understand the dynamics which shape the earth. In this unit students were learning about earth science, specifically plate tectonics and geology. Our goal was for the students to gain a qualitative understanding of the processes that shape the earth, connecting with basic concepts of crust composition, pressure and temperature with forces. Keeping with the interdisciplinary theme, this lesson strives to emphasize connections with physics and chemistry but stops short of requiring quantitative calculations. To integrate computational thinking we require students to observe the effect of changing parameters in the simulation and plot graphs of data in order to draw conclusions from them.

Overview

Students will use the PhET plate tectonics simulation to better understand the forces that cause plates to move. Students will progress through the worksheet that accompanies this lesson as a guide. The first section focuses on the composition of crust so students can explore the basics of crust temperature, composition and thickness and understand how oceanic and continental crust differ. Then students progress to studying the internal structure of the earth, specifically the change of pressure and temperature as depth increases.

In the second half of the lesson, students study what happens at each fault type, (convergent, divergent, transform) and connect what happens with what they learned about composition, thickness and temperature of plates in the first lesson.

Student Outcomes

SWBAT relate plate temperature and density to plate dynamics.
SWBAT describe the internal structure of the earth.
SWBAT explain the differences between convergent, divergent and transform faults and identify the expected geological activity at each.
SWBAT extract patterns from a series of simulations in order to draw conclusions.

Standards Addressed

HS-ESS2B Plate Tectonics and Large Scale Systems
HS-ESS2A Earth Materials and Systems
HS-PS1A Structure and Properties of Matter
HS-PS2A Properties of Forces and Motion.

Time

This activity will last about 90 minutes or 2 class periods.

Level
This activity is intended for Jr/Sr level environmental science classroom, but best suited for the standard level classes or co-taught classes.

Materials and Tools
1. PhET plate tectonics simulation, available at:
   http://phet.colorado.edu/en/simulation/plate-tectonics
2. Windows computers that are able to run the Java Application - this application didn't work on a Macbook with Yosemite or a Windows tablet, but it did work on the school laptops. As more PhET models are updated to HTML5 this problem may alleviate.
3. Worksheet (Phet-PlateTechtonics-worksheet.pdf)

Preparation
We suggest that the model be loaded onto the computers before the start of class. In addition, we recommend not having students exit out of the simulation at the end so that this lesson can be repeated.

Prerequisites
Ideally, students should have a minimal background about plate tectonics and some understanding of density, temperature, pressure and weight.

Background
Class Period 1
"Yesterday we talked about plate tectonics. Do you remember what that means? 'Plates' are chunks of earth that float on a fluid of magma that we call the earth's mantle. 'Tectonics' is a fancy word that means 'when plates touch each other'. This activity is going to elaborate what can happen when plates touch each other.

You should have received a worksheet from me that you are going to follow. We are going to go through the first front and back today and the second front and back tomorrow. I'm going to demonstrate on the projector how to do each part.

In the first part, you should see these three sliders for composition, thickness and temperature. What is the effect of each slider? We will start by moving all three to the middle, and I will move the composition slider toward "more iron". What happened? The chunk sunk. Why? Because adding iron adds weight to the crust (and increases its density). You are going to do something similar for the other sliders.

For the second part, you will notice a legend switch in the bottom right. How does the middle chunk of crust compare with the oceanic crust in terms of temperature and density? Can you match the temperature and density of the oceanic crust by manipulating the sliders? For the second part you will move the sliders until the two crusts match for first the oceanic and then the continental crust. You will record the locations of the sliders so you can compare the three sliders.

For the third part, you will zoom out. You should see a ruler, a pressure gauge and a thermometer in your toolbox. You will use these to measure the temperature and pressure for each 500 km of depth. Since you have two different quantities to plot, you are going to create a two axes graph. What scale should you use? Choose a reasonable scale which allows you to see the full range of variation as well as the smallest possible variations. Answer the additional equations.

Class Period 2
Everyone, take out the worksheets from yesterday. We are going to continue working on them today. You should have finished making the graph of temperature and pressure versus depth yesterday. If you still need to complete that, finish that after doing today's lesson.
Today we are going to focus on what happens when plates come together. If you have loaded up the simulation, you can see a tab for "Plate Motion" click on it. You will see crust types, drag and place a type of crust on each half of the plate boundary. I will use old oceanic crust on the left and continental crust on the right. You are going to see levers that appear with (up to) three arrows depending on the boundaries that are available. In the table below question number six you are going to see 'Old Ocean' on the left and 'continental on the right' we are going to use the green convergent arrow (in which the two plates move toward each other) to see what happens over time. Based on yesterday, which crust is denser? Which crust subducts? (What does subduct mean?) Do non-volcanic mountains form? does a trench form? Which side do volcanoes form on (if any)? You are going to run the simulations for all the types laid out in Table 6 and fill in the table just as we did here. You are going to use this table to answer question 8 on the next page. To do the question about transform faults, you are going to find a pair of crust with blue arrows. What happens at transform faults? Finally look for pairs of plates with red arrows. These are divergent boundaries. What happens at these plate boundaries? Today you should have time to answer any remaining questions and turn in the worksheet.

Teaching Notes
In the background above, an example of how to demonstrate the use of the lesson is presented. We found that pre-demonstration of what needed to be done was the most time efficient because students retained the instructions and knew how to interact with the model in order to complete the worksheet. If the students respond to other types of direction or if they will read written instruction readily, then writing the instruction of the board or adding to the handout could work. An alternative model would be to break the students into groups and have them each work on different parts of the worksheet and present their findings to the rest of the class. If the number of computers are limited, students could work in groups at three stations and rotate during the class periods. Students are encouraged to work in pairs or small groups which can limit the number of computers needed.
We recommend allowing students to direct their progress through the activity instead of moving through it as a class which allows the instructor to move through the classroom and address questions one-on-one which lowers the intimidation factor for students to speak up.

Assessment
Teachers can assess the each student's understanding by looking at their answers to the worksheet. Teachers may also choose to assess how on task the students are and how well they work in a group and explain concepts to their fellow students or ask for clarification or understanding.

Additional Information
N/A