Waves, Earthquakes and Mapping of the Earth's Interior

Objectives:

- Students will understand what a wave is
- Students will be able to identify the different types of waves (P, S and L)
- Students will understand how waves travel differently in different types of materials, and how this can be used to infer properties of materials deep inside the Earth.

I. What is a Wave?

Given that the point of these activities is just to introduce students to waves and not to go in depth about the physics of waves, we have avoided putting in long activities or investigations about waves.

1. What is a Wave?

   Many resources are available to show what waves are. Simple demonstrations using rope, slinkies and other wave-making apparatus can demonstrate how energy can move through material in periodic motion.

2. Different Types of Waves

   Two types of earthquake waves - P (compression) and S (transverse) - can easily be demonstrated with ropes or slinkies. Make the connection between different examples of these types of waves (such as sound waves). P-waves can be shown by lining up the students and gently pushing one into another. Have them watch the "wave" travel through them. S-waves can be demonstrate in another "human model" by having the kids bend forward as they stand shoulder to shoulder and then observe the "wave" move down the line. This is a good place to demonstrate how S-waves are more complex than P-waves.

   L waves (circular) are more difficult to demonstrate – this is probably a good place for a video clip. Make the connection between L waves in Earthquakes and water waves

   You can also help students understand why P waves travel faster and more easily through solid materials than the other types of waves in terms of how much energy it takes to move the material – in a P wave the material only has to move back and forth as opposed to side to side or up and down.

   The other concept you may want to introduce is how wave intensity diminishes as the wave front spreads out. This can be shown by filling a large plastic bin with water and placing floating objects in the bin at different distances from where you would set up a disturbance. Drop a small ball in the bin and you can observe the difference in displacement as the distance from the "epicenter" changes.

3. Some animated gif files showing the three types of waves and the damage they can cause: http://www-rohan.sdsu.edu/~rmellors/lab8/l8maineq.htm

4. Another fabulous resource for all things related to earthquake waves: http://web.ics.purdue.edu/~braile/edumod/slinky/slinky.htm

II. How waves travel differently through different materials

1. Show students how the different types of waves travel faster or slower depending on the density of the material – this can be shown by sending an S wave through a thin rope that's tied to a thick rope. The students should observe that the rope slows down as it

moves into the thick rope (the mass of the thick rope is greater, so it would take more energy to move it at the same speed).

2. This can also be shown using dominoes – set up a long line of dominoes and change the spacing. Students will observe that the rate at which the dominoes fall changes depending on the spacing. This is a model for how P waves travel through materials of different density. (Beware, however, that the model is inaccurate in that the domino "wave" travels faster when the dominoes are farther apart, or more "dense", which is the opposite of the real phenomenon – P waves travel faster through materials of higher density and slower through materials of lower density.

3. Explain to students that only P waves can travel through liquids (including molten rock) and that the energy from S- and L- waves would either dissipate or be reflected at the interface between solid and liquid. This is very difficult to demonstrate, but there are several great pictures or animations to show.

4. The other concept that is important to include is the concept of refraction, and how density affects how much waves bend.

III. How the Earth's interior is mapped using Earthquake waves

This is a good place to use animations or pictures that illustrate how earthquake waves propagate through the interior of the Earth and how they can be used to infer the internal structure of the Earth.

Discuss how Earthquakes can be detected thousands of miles away from the epicenter because of the way the waves travel through the Earth.

An example of how earthquake waves propagate through and around the Earth that would help reinforce the idea of mapping the Earth interior is to discuss how waves from the Sumatra Earthquake were detected on the other side of the globe. (An interesting article in Science Magazine discusses waves felt in Alaska as a result of the Sumatra quake http://www.sciencemag.org/cgi/content/full/308/5725/1144).

Concepts to review are density, refraction and reflection.

Some resources that you might want to use:

1. Savage Earth Animation: Earthquake! (from PBS online): http://www.pbs.org/wnet/savageearth/animations/earthquakes/index.html

2. Some animated gif files showing the three types of waves: http://www-rohan.sdsu.edu/~rmellors/lab8/l8maineq.htm

3. Some really nice background information about our understanding of the interior of the Earth from USGS: http://www.seismo.unr.edu/ftp/pub/louie/class/100/interior.html

For an excellent series of teacher friendly lessons on earthquake waves, highly recommended, visit

Seismic Waves and the Slinky: A Guide for Teachers
http://web.ics.purdue.edu/~braile/edumod/slinky/slinky.htm