LEARNING SET 3 INTRODUCTION

$14\frac{1}{2}$ *class periods** ▶

Looking Ahead

Consider how you want to use *Section 3.9*. It was designed to be completed independently by students while they are waiting to use the computer, or as homework.
Students should have access to computers for *Sections 3.2, 3.4, 3.6, 3.7, and 3.8.*
Students will need their three-dimensional structures and their work from *Section 1.3* for *Section 3.8.*

*A class period is considered to be one 40 to 50 minute class.

Learning Set 3

What Happens Where Plates Meet?

Students determine Earth's plate boundaries by analyzing earthquake data.

Overview

Students use earthquake data to draw the plate boundaries surrounding the region of their Earth structure. They begin an iterative process of predicting their plate boundaries, by using real time data to see how data is collected, and reading first-hand accounts to see how both qualitative and quantitative data are important. Students plot data for a week, a year, and three years, and refine their plate boundary predictions. They plot their data on *Small World Maps* and their three-dimensional maps they constructed in *Learning Set 2*. Groups from neighboring regions meet to share their data and further refine their plate boundaries. As a class, they then agree upon the plate boundaries of the world and plot them on the *Big World Map*. Students also read and consider real earthquake data to see scientists observe and question earthquakes and the patterns in earthquake data.

Targeted Concepts, Skills, and Nature of Science	Section
Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.	3.1, 3.2, 3.3, 3.4, 3.6, BBQ
Scientists must keep clear, accurate, and descriptive records of what they do so they can share their work with others and consider what they did, why they did it, and what they want to do next.	3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, BBQ
Graphs and tables are an effective way to analyze and communicate results of scientific investigation.	3.2, 3.4, 3.5, 3.6, 3.7, 3.8
Scientific investigations and measurements are considered reliable if the results are repeatable by other scientists using the same procedures.	3.2, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9

Targeted Concepts, Skills, and Nature of Science	Section
Scientists make claims (conclusions) based on evidence obtained (trends in data) from reliable investigations.	3.4, 3.5,3.6, 3.7, 3.8, 3.9
Explanations are claims supported by evidence, accepted ideas, and facts.	3.4, 3.8, 3.9, BBQ
Scientists use models and tools such as *Geographic Information Systems,* and a variety of maps to develop claims and explanations from evidence in the data.	3.3, 3.4, 3.5, 3.6, 3.7, 3.8
Scientists measure and record earthquake activity using the Richter scale and the Mercalli Scale. The Richter scale is used for measuring the magnitude of an Earthquake. The Mercalli Scale is used to measure the intensity.	3.3, 3.9
Earthquake activity, volcanic activity, and topography are all evidence that Earth's crust is moving and changing.	3.2, 3.3, 3.7, 3.8, 3.9, BBQ
Interactions between Earth's crustal plates can result in mountain-building, rift valleys, and geologic activity such as earthquakes and volcanoes. Underwater volcanic activity may form underwater mountains which can thrust above the ocean's surface to become islands.	3.8, 3.9, BBQ

Students' Initial Conceptions and Capabilities

- **Students may have difficulty constructing explanations about the causes of volcanoes and earthquakes. (Duschl, Smith, Kesidou, Gitomer, & Schauble, 1992.)**
- **Students may think that earthquakes are only likely to occur in certain places like California. Others may think they happen everywhere.**
- **Students may not think that there are aftershocks and smaller quakes that follow earthquakes.**
- **Students may believe that earthquakes are rare and always destructive.**
- **Some students may think earthquakes are caused by the influence of heat, temperature, climate, weather, people, animals, gas pressure, gravity, the rotation of Earth, processes in Earth's core, "exploding soil", volcanoes, and/or the Earth expanding. (Libarkin et al., 2005).**
- **Students may believe correctly that plate tectonics is the primary mechanism responsible for earthquakes, and that a secondary incorrect cause is also important. (Libarkin et al., 2005).**

Understanding for Teachers

Data

Scientists use both quantitative and qualitative data to analyze earthquakes. Qualitative data contains descriptions from first-hand accounts. Quantitative data contains measurements.

Students also go through an iterative process using quantitative data to determine how much data is enough for reliable results. This process gives students an insight into the historical determination of plate boundaries by geologists.

Earthquakes and Plate Boundaries

The shake we feel from earthquakes is produced by the energy released when two plates interact. The level of shaking depends on three factors: the energy released, the distance from where slipping began (epicenter), and the type of material the energy is traveling through. The plates can interact in three ways. They may slide past one another, collide into each other (convergent), or move away from each other (divergent). In all cases there is relative motion between the plates.

Neighboring plates are stressed as they recieve force from the mantle acting on them, however friction between these pieces of Earth's crust keeps them in place until the force from the mantle is great enough to cause the plates to move relative to each other.

When the plates are separating, or have a divergent boundary, the crust is stretched away, becomes thinner, and sinks. As the thin crust is torn, lava oozes out, and forms new crust. It is at these boundaries that volcanic activity is greatest because as the crust is being torn open new crust is forming when molten lava from deep down oozes out. Many of these boundaries are located along the sea floor. Examples of this boundary are the East Rift Valley of Africa and the mid-Atlantic Ocean Ridge.

When the plates are moving toward each other it is called a convergent boundary. These boundaries are usually on the other side of a plate that has a divergent boundary. Volcanic activity can occur at convergent boundaries. This happens when one plate is lighter than the other and gets pushed upward as the heavier plate moves downward or is subducted. This is called a subduction zone. This occurs between the Nazca plate and the South American plate. The Nazca plate is being subducted and melts and magma can then move to the surface. This is how the Andes Mountains along the plate border have formed.

When two continental plates converge, neither is lighter, so subduction does not occur and there is no formation of volcanic activity, however mountains can still form. An example of this is the Himalayan Mountains where the

European and Indian plates meet. Some examples of this boundary are: the Pacific plate converges with the Indian plate and diverges from the Antarctic and Nazca plates; the South American plate converges with the Nazca plate.

Transverse boundaries slide past each other. These boundaries usually form fault lines. The forces between these plates as they slide past each other are usually greater than between other plate interactions. Earthquakes form as the plates move past each other. An example of this boundary is along the San Andreas fault.

Earthquakes sometimes occur in the middle of tectonic plates. An example of this is the New Madrid earthquake that occurred in Missouri. Scientists are still trying to determine why these occur.

Earthquake Waves

There are three types of earthquake waves produced, a Primary wave (P-wave), a Secondary wave (S-wave), and a surface wave. The P and S waves are body waves and travel through Earth. The P-wave is a compressional wave that shakes the ground back and forth in the direction the wave is propagating in. This can be thought of as a holding a spring like a coiled spring toy along the floor with one end fixed and moving the other end back and forth along the direction of the coiled spring toy. P-waves are the only waves that can go through Earth's core.

The S-wave is a transverse wave that shakes the ground back and forth in a direction perpendicular to the direction of propagation. This can be thought of as holding a spring along the floor with one end fixed and moving the other end back and forth in a direction perpendicular to the length of the spring. S-waves are shear waves and cannot travel through fluid. Because of this, S-waves cannot travel through Earth's liquid outer core.

P-waves usually travel faster than S-waves, but S-waves are usually larger. These signatures allows seismologists to distinguish an earthquake from other types of seismic waves.

Surface waves move along Earth's surface and are composed of both compressional and transverse waves.

Damage

The amount of damage caused by an earthquake varies with the intensity that the ground shakes and the quality of the structures near the origination of the earthquake or its epicenter. The intensity of the seismic wave is affected by the distance to the epicenter and the type of rock the seismic wave is traveling through.

References:

http://www.extremescience.com/PlateTectonicsmap.htm

http://quake.usgs.gov/

For further information try an Internet search on *plate tectonics,* or *earthquakes.*

$14\frac{1}{2}$ *class periods** ▶

Learning Set 3

What Happens Where Plates Meet?

10 min.

Introduce the Learning Set *to the class.*

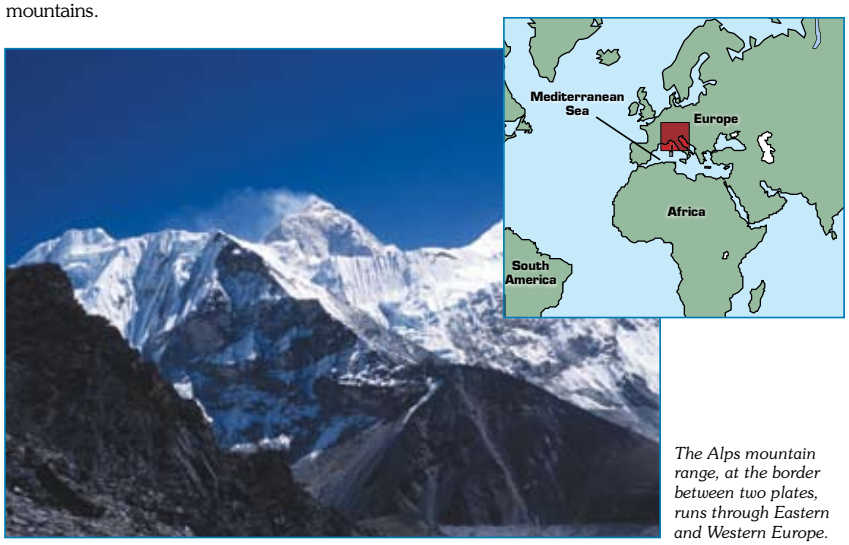
LEARNING SET 3 IMPLEMENTATION

Learning Set 3

What Happens Where Plates Meet?

Areas around plate boundaries usually have amazing stories to tell. Geologists are able to read these stories in the rocks and earth structures found at each site. These stories tell of plate collisions, ocean crusts diving into the Earth's mantle, volcanic eruptions, and continental crust that crumples and folds like bits of brittle candy.

The Alps stretch along the southern parts of Europe. They increase in elevation about a centimeter per year. This great mountain range is near the border between two plates. These plates are colliding and pushing up the mountains.



The Alps mountain range, at the border between two plates, runs through Eastern and Western Europe.

ES 77

EARTH STRUCTURES AND PROCESSES

Engage

Begin by letting students know they will be determining where the plate boundaries meet and eliciting from how they think they will do that.

TEACHER TALK

"In this *Learning Set* you will be determining the boundaries for Earth's crustal plates. What information do you think you will need to determine the boundaries?"

Record students' ideas and return to them at the end of *Section 3.1* when students update the class's *Project Board*.

PBIS *Learning Set 3* • ***Think About What Happens at Plate Boundaries***

The Aleutian Range is a relatively narrow range of mountains in southwest Alaska. This mountain range is noted for its large number of volcanoes and volcanic activity. It is also located near the border of two plates. These plates are also colliding, but one plate is diving under the other plate. This is creating a deep trench where the plates meet.

The Aleutian Mountain range is the result of one plate diving under another.

In the last *Learning Set,* you learned about Earth's cool crust and hot interior layers. The large plates that make up the crust move because of changes that happen in the hot interior layers. There can be a lot of geologic activity where these plates meet. Earthquakes commonly happen at these sites. Because of this, earthquake data can be very useful when trying to identify the plate boundaries.

In this *Learning Set,* you will look at some earthquake data. After plotting this data you will look for patterns in the data and use it to determine the plate boundaries for your earth structure. You can then use this information as you move forward, answering the *Big Question* for this Unit, *How can you explain the changes happening around the regions of certain Earth structures?*

ES 78

Project-Based Inquiry Science

△ Guide

Describe for students the results of some of the interactions between plate boundaries.

TEACHER TALK

"In this *Learning Set* you will begin to learn about some of the mechanics of where the plates meet. Some of the evidence of plate movements lies within the story of rocks. For example, the Alps increase in elevation about one cm per year and is near the border of two plates. The Aluetian Range, noted for its volcanoes, is also located near the border of two plates.

In the previous *Learning Set* you learned that Earth's plates move because of changes that happen in the interior of Earth. At these boundaries, geologic activity such as earthquakes, volcanoes, and mountain formation occurs. In this *Learning Set* we will look for patterns in earthquake data to determine the plate boundaries of your Earth structure and obtain information to answer the Unit's *Big Question: How can you explain the changes happening in the area around certain Earth structures?*"

NOTES