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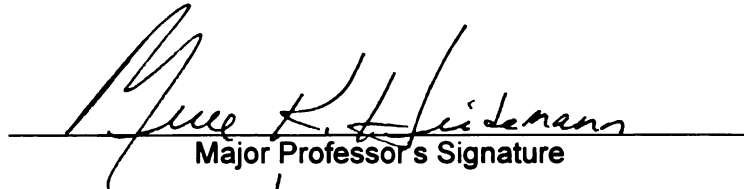
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**THE EFFECTIVENESS OF TEACHING FROM SMALLER CONCEPTS TO
LARGER USING DATA AND OBSERVATIONS IN PLATE TECTONICS**

By

Matthew L. Schuchardt

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
For the degree of**

MASTER OF SCIENCE

Physical Science- Interdeparmental

2010

ABSTRACT

THE EFFECTIVENESS OF TEACHING FROM SMALLER CONCEPTS TO LARGER USING DATA AND OBSERVATIONS IN PLATE TECTONICS

By

Matthew L. Schuchardt

This purpose of this project was to test the effectiveness of teaching from smaller concepts toward larger concepts, using data and observations in plate tectonics. By following this method the students became more like the scientists themselves who took observations from the physical world to build theories of plate tectonics.

It was presented in three sections earthquakes, volcanoes, and plate tectonics. Each section had a pre and post assessment to measure student learning. Within each section there were labs and active learning activities that build upon each other so students could activate prior knowledge and construct the theory of plate tectonics.

Overall student learning showed a significant increase.

Acknowledgements

I would like to thank my parents for always pushing me to do my best in school and the encouragement along the way. Also thank you to my 2009-2010 Earth Science students for being willing to take part in this project. Most of all thank you to my wife Ashleigh for her support while I have been completing this graduate program.

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Introduction

Rationale:

Since every rock tells a story, it is the expectation of the middle school student to look at evidence in those rocks to learn about what happens on the Earth. The setting for the Earth Science student is the outside world. It is a different type of science where direct experimentation is not used as often in the classroom as making inferences based on evidence and data that students manipulate, and use to draw conclusions. This evidence can range from things that can simply be seen with the naked eye to data collected in the field and brought to the student. More specifically I wanted to study aspects of learning the overall theories of plate tectonics using data collected in the field and data studied with the naked eye.

The question is whether it is effective to teach the overall concepts of plate tectonics first, followed by the smaller concepts that support it, or to teach from the smaller concepts and build up towards the larger theory. In my 8th grade class this meant determining which order to teach the topics of Earthquakes, Volcanoes and Plate Tectonics. These topics are all inter-related. Essentially, the question is which way is easier for students to learn the concepts. This is a question that I, and fellow Earth Science teachers in my building, have discussed and have not formally found an answer.

When looking at various textbooks from middle school level up to college level, there does not seem to be a clear answer as to which order to teach the material related to plate tectonics. At the college level, *Earth: An Introduction to Physical Geology* 6th edition (Tarbuck and Lutgens 1999) differs in order from their 8th edition (Tarbuck and Lutgens 2005). On the middle school level, *Earth Science* published by Heath in 1994

(Spalding et. al 1994), differs in order from *Earth Science* published by Prentice Hall in 2002 (Exline et. al 2002). I have spoken to a few teachers in other districts and get answers that indicate both ways have been done. If you look at the history of science, scientists have had to work from smaller observations and data towards forming larger concepts, which is the way that material was presented to students in this project

The school year 2008-2009 was my first year teaching Earth Science in a middle school. Before this I have taught mixes of physical science, chemistry, life science, and some aspects of Earth science at various grade levels from seventh grade to high school seniors. The unit in my classroom on earthquakes, volcanoes and plate tectonics needed to be improved with more labs based on student interpretation of data and observations, making them more like the work of scientists who developed the theories. Based on the research presented in the literature review, incorporating these types of activities is critical to student learning. The unit was designed to answer the question of the effectiveness of teaching from small to big concepts. It also served to make the students be able to think more critically, which is one of the most important aspects of science. I taught this unit in three smaller sections of Earthquakes, Volcanoes, and finally Plate Tectonics. Within each of those smaller units I will also teach from small concepts towards large.

These units were taught in the fall semester of 2009. The course is broken into two semesters with the first being mostly about solid earth geology and the second more about the hydrosphere. I expected this unit to take several weeks (upwards of 9) to be completed. My time on campus was mostly spent developing labs/activities that work

from the small perspective to the large concepts. I also spent time developing pre/post tests that reflect this type of learning.

This project addressed the effectiveness of teaching a unit on plate tectonics from smaller observable concepts and data towards the overall theory. I predict that by working from smaller observations and evidence students can grasp concepts easier and build on that knowledge to understand bigger concepts.

Literature Review:

How do students learn? That seems to be the question that teachers continue to try to solve. The basis of teaching this unit is that students will build knowledge based on their experiences in the labs and activities implemented. Students will work on labs and activities to interpret patterns, examine evidence, work collaboratively, critically think, and solve problems. Ultimately, my goal of this unit was to show that students who utilize smaller observable concepts first would better understand global tectonics.

Much of the following review of literature on how students learn falls into the broad category of constructivism, which means how students generate knowledge and meaning from their experiences. In my unit I used several constructivist methods, such as hands on lab work, analysis of data, observations, small group work, and discussion. It is my point of view that it is effective for students to learn from smaller observable concepts and data towards larger theories and is part how a student can construct knowledge through inquiry. My research of the literature did not find much information specifically about plate tectonics or Earth Science, however, there was information on inquiry and the construct of knowledge in general.

Students learn from building on prior experiences. It is a part of our minds to associate new material with something for which we already have a construct. “The principle that people learn by using what they know to construct new understandings can be paraphrased as “all learning involves transfer from previous experiences (Bransford, Brown, et al. 2000).” According to Colburn (2007), students will do this in their minds and connect prior experience and knowledge. In 1938, John Dewey had similar ideas in that students brought with them a set of behaviors and expectations from the past. He

argued that students had to construct knowledge by the process of solving problems (Hickman, 2009). After doing these activities they should get more experiences to build on and clear up misconceptions.

Learning is an active process. An inquiry based classroom environment has students mentally engaged and figuring out things on their own. It often has hands on based experiences for them to do (Colburn 2007). The use of labs and activities includes observation, imagination and reasoning to understand content. What it does for the student is to allow them to make a connection to what they have experienced in daily life and use that to provide insight to the new information. (Bransford, Brown, et al 2000). Including these types of activities in instruction is important to learning any science. Without the hands on experience the amount of critical thinking skills are lessened, and the students are not as engaged. This makes the learning of concepts harder for a student (Johnston and McAllister 2006). It is important for a student to understand the thinking process of a scientist. When a student develops the skills of critical thinking and problem solving, they can be applied to various aspects of their lives beyond school. Problems solving, and thinking skills are important to any field.

Learning from smaller concepts towards larger concepts through the use of data and observations requires students to think critically. What thinking critically does for students is to have their thinking focused and more deliberate and shape scientific ideas into an answer that fits the observation. "Thinking enables you to distinguish between what you see, what you think you see, and what it means (Moriarty 1997)." This is the basis for the objective approach that science requires. According to the National Science Teachers Association (Texly and Wild 2004), once students have been given this

opportunity to think critically and examine evidence, they will not be satisfied with traditional textbook bound lessons. They suggest the way to facilitate this type of thinking is through the use of inquiry learning.

The use of inquiry in a science classroom has been around since the times of Dewey, who lived from 1859-1952. Inquiry learning became a more debated topic than traditional lecture style learning around his time period. “Before 1900 most educators viewed science primarily as a body of knowledge that students were to learn through direct instruction (National Research Council 2000).” Inquiry learning is important for understanding how scientists solve problems. “The use of inquiry teaching and learning has many aims: to develop student process skills, to develop critical thinking skills, to better learn science content, and to better illustrate the nature of science by mimicking scientist’s work (Martin-Hansen 2009).”

Scientific inquiry is similar to learning from data and evidence. When using scientific inquiry, a scientist needs to study the natural world and give an explanation based on the evidence their work presents. The units in this study followed a similar line of thinking as it implied that inquiry learning should reflect the nature of scientific inquiry (Anderson 2002).

The role of the small group is critical for active learning. It is important for the students to interact socially with each other to discuss and construct new knowledge. When a student works in a small group they can challenge each other’s thinking. Any type of discussion or extended response allows a teacher and the students to uncover misconceptions. Once misconceptions have been identified, they can be discussed with

the larger group. The small group facilitates an environment for students to explore concepts rather than being told concepts (Colburn 2007).

Cooperative learning has positive impacts on student learning, according to Robert Marzano and his coworkers (2001). His findings show that grouping of students is important to their learning. Not only is it important for them to group, but also that they have a heterogeneous group, where students of all levels can share their ideas with each other. His findings also suggest that when there is some form of competitiveness among the groups, that more is learned. This is similar to a real world environment where scientists routinely work with other types of scientists to solve problems.

The way a teacher approaches a classroom also plays an important role to students being more willing to participate. According to Brooks and Brooks (2001) the classroom environment should be organized so that student-to-student interaction is encouraged, cooperation valued, and assignments and materials are interdisciplinary. This will produce a situation where students are more likely to take some risks and accept challenges to their current construct of an idea. The atmosphere of an inquiry classroom is one that students feel that the teacher, as well as their peers, has value in their ideas and thoughts (Llwelllyn 2005). It is important for students to feel they are discovering and learning concepts rather than just passively listening to a lecture on concepts. Science is for solving problems, not the memorization of fact.

Others, such as Piaget, have looked into how students construct knowledge in general. According to Piaget, middle school students are in the Concrete-Operational Stage (Woolfold, 1998). Some guidelines for teaching this age include:

1. Use props and visual aids, such as three dimensional models

2. Use familiar examples to explain more complex ideas.
3. Give opportunities to classify and group objects and ideas on increasingly complex levels.
4. Present problems that require logical, analytical thinking.

Following Piaget's thought process, it seems that learning plate tectonics from a scale of smaller observable ideas and working towards larger concepts is a logical approach. The activities and labs presented in this project follow all four of these ideas, and the results of the project support them.

The process of learning from smaller concepts to larger concepts using data and observations, students gain more knowledge of the nature of science. Science is more than remembering facts that are written about the natural environment, it is a process. This can sometimes be forgotten when thinking about the amount of material that has to be covered in a given year, with more being added to the curriculum and expectations. "The nature of science addresses the importance of creativity and imagination in scientific work; how scientists invent explanations for phenomena; the difference between observation and inference; how scientific ideas are subject to change; and how culture and society influence science (Hanuscin & Lee 2009)." Plate tectonics, in particular, is an area of science that has changed with time, as new evidence is uncovered. Many students are uncomfortable with the idea of science changing.

Not understanding that science is a process can lead to the public misunderstanding concepts in science. As McComas et. al (1998) puts it, "all levels of science teaching and textbooks emphasize the factual recall of science and not the process that generated the science." Understanding that science is a process is

increasingly important as science topics continue to be part of the main stream, for example, green technologies and alternative energies. These “new” fields of science are being played out in front of students through everyday media.

It is important for students to understand that scientific ideas are always changing. Knowledge in science is a temporary construct, by which we attempt to make sense of the world. It is subject to change when new evidence is uncovered. Scientific knowledge is constantly being questioned, re-evaluated, and tested, so that changes in what we teach will inevitably occur (Matson & Parsons 1998). Because of this nature of science it is important for students to be able to look at evidence and be able to form inferences based on what they observe, even if that evidence is presented to them and they do not generate it themselves. Not all sciences follow a hypothesis-experiment-conclusion model. In the geological sciences a hypothesis, observation, conclusion model can be more common. It is difficult in Earth Science for students to directly collect some types of data, especially in Michigan, where we have few earthquakes and no volcanoes. In my classroom the students used data generated by other people to make their observations and draw conclusions.

Science demands evidence. Ultimately, how valid a scientific claim is will be decided by observations of phenomena. These observations and evidence can come in a variety of ways. Sometimes these observations are passive, such as data generated by seismometers during earthquakes. Some are from active probing, like drilling a borehole in the Earth. Others take place in controlled lab settings such as measuring the strength of different rock types (AAAS 1990). In the case of Alfred Wegener, his theory of

continental drift had some evidence, but it was not until after his death that enough evidence was found to support his hypothesis.

Middle School students are able to look at data sets or evidence and follow the process of analyzing it, discussing it with peers, and building it into a scientific theory. In the context of this study, much of what the students will do falls into the category of “guided inquiry” and “student directed inquiry.” (Liang and Richardson 2009). In guided inquiry the teacher provides the question, while students design the procedure and analyze the data, and present conclusions. In student directed inquiry the teacher presents a problem, and lets the students develop their own questions and designs (Liang and Richardson 2009).

In summary, students who are engaged in inquiry are able to become more like the scientists who first discovered concepts of plate tectonics. The use of problems solving, critical thinking skills, small group discussion, and activities that use inquiry, allows students to be able to tie prior experiences together to understand science as a process. This study was designed to be this way so that students could learn from small observable concepts and data and build towards the larger overall theory of plate tectonics.

An Overview of the Science:

I like to start out the school year by asking the students a very simple question. That question is “why study the Earth?” In other words why are we going to be spending the next year together talking about and discussing different parts of the Earth? The range of answers is usually interesting (aside from “my mom makes me come to school”). Some of the better ones are:

“To learn about what happened in the past about Earth”

“To learn about Earth’s physical features”

“To learn about the Earth so we can protect it”

“To see how the Earth has changed and how its changing affects people”

I particularly like the last answer. That seems to strike at what Earth Science is all about. I tell the students that it is because we live on the Earth and everything we do is related to the Earth. Throughout the year I will ask them this same question about each unit that we learn about. Why study this?

The plate tectonics unit is tied to the units on earthquakes and volcanoes. Really, these topics are connected and interrelated, as is much of Earth Science. In this thesis, I am using evidence and knowledge of earthquakes and volcanoes to build into the plate tectonics theory.

Earthquakes: (Source–Tarbuck and Lutgens 1999)

Earthquakes are felt when energy is released in the form of seismic waves as parts of the crust move past each other along faults. The energy released radiates in all directions from its source, the focus. There are three types of faults each caused by

different types of stresses in the Earth that are discussed in my classroom. Normal faults are caused by tension, Reverse faults are caused by compression and shearing causes Strike-Slip faults.

The seismic waves travel through the Earth (which is how we understand the layers of the Earth) and scientists can use these to quantify earthquakes. A seismograph is used to create a seismogram that can be interpreted to determine the size, depth, location, and type of earthquakes. Larger earthquakes produce more energy and can cause a variety of damage depending on the geology of an area as well as the building materials. The depth of earthquakes can help to determine the type of plate boundary present. Deep earthquakes are associated with convergent boundaries, while shallow ones can be associated with passive boundaries.

Primary and secondary waves arrive first and are both “body” waves that travel through the Earth. A surface wave travels along the surface of the Earth. P waves are “push-pull waves” which means they compress and expand. S waves shake the particles at right angles to direction of travel and are transverse. Surface waves arrive later and are the destructive waves. One of the key reasons that these waves are studied is to understand how to prevent damage to human life, and infrastructure.

When plotting the locations of earthquakes there is a distinct pattern that emerges around the globe. The locations of these earthquakes help to solidify the location of plate margins and give more evidence to continental and plate tectonics theories. There is also a strong correlation to the location of volcanic activity. The motion between the Earth’s tectonic plates is the cause of most of these earthquakes and volcanic activity. Why the

plates move to begin with is another question that scientist's such as Alfred Wegener began to address in the 20th century.

Volcanoes: (Source-Tarbuck and Lutgens 1999)

A volcano is a mountain formed from lava flows or pyroclasts that erupt from the mountain. Scientists can study them to understand more about how the tectonic plates of the Earth interact, much like earthquakes. Different types of volcanoes emerge depending on the tectonic boundary.

What determines the type of volcano and eruption that it has is related to the magma's composition, its temperature, the amount of dissolved gases it contains, and ultimately its tectonic setting. The major composition of a rock depends on its silica content. Granite and rhyolite are high in silica and therefore are very "sticky." Dissolved gases also play an important role; the harder it is for the gas to escape, due to relatively low temperatures, the more violent the eruption as well. An example of a composite volcano is Mt. St. Helens, which erupted very explosively and violently sending ash for miles into the air.

Shield volcanoes are on the other end of the spectrum with lower amount of silica, higher temperatures, and gas that escapes easily. Volcanoes, such as those on Hawaii and Iceland, tend to erupt less explosively and have much more fluid lava that flows on the surface.

Between these two types is another called cinder cones. They tend to form near composite volcanoes and erupt mostly with loose pyroclastic materials. These are the smallest type, while shield volcanoes are the largest.

Why we have volcanoes to begin with also leads us towards plate tectonics theory as well. Earthquakes are often associated with volcanoes as magma from beneath the surface rises towards the top.

The types of volcanoes and rocks are directly related to their location at plate boundaries. Much of the volcanic rock that is made on the Earth forms at mid-ocean ridges. As the lithosphere pulls apart, the pressure on the rock below lessens, this lowers the melting point of the rocks and partial melting forms along the diverging plates, which tends to form basalts. Basalt is a fine-grained igneous rock of mafic composition, so it is high in iron and magnesium and low in viscosity.

Composite volcanoes tend to form along converging plate boundaries. Oceanic crust made of basalt is denser than granitic rock that forms continents. As the ocean plate slides beneath the continent it drags volatiles like water down with it. As these melt they rise towards the surface as magma.

The evidence and observations seen from both volcanoes and earthquakes contribute to model for plate tectonics.

Plate Tectonics: (Source-Tarbuck and Lugens 1999)

Global maps were not something readily available until after the “Age of Exploration” from the latter half of the fifteenth through the sixteenth centuries. (Voorhies 2002) when people like Christopher Columbus starting making the world economy more global. Most middle school students can see the continents and how they look like a jig saw puzzle waiting to be put together. They do fit crudely together and much better when you include continental shelves.

Alfred Wegener took this idea even further with more lines of evidence that the continents were once lumped together in a “super continent” called Pangaea. His theory was called continental drift. Wegener had help from other researches from a few different fields of science. The other lines of evidence, aside from fit of the continents, came from: fossil evidence, rock type and structural similarities, and paleoclimatic evidence. Wegener ultimately was openly criticized for his idea, mainly for his inability to explain the mechanism to move such great amounts of rock. Sadly, he died before being shown correct. New evidence emerged later from paleomagnetism, polar wandering, geomagnetic reversals, and greatest the evidence from seafloor spreading. Plate tectonics is a newer theory for continental drift that encompassed all of this evidence.

Seafloor spreading gave continental drift its driving mechanism. It explains how new ocean floor is created at mid-ocean ridges, and how old ocean floor is destroyed at subduction zones. The evidence from earthquake data and from volcanic eruptions shows us today in real time the dynamics of the boundary zones.

There are three types of plate boundaries: Divergent boundaries, Convergent boundaries, and Transform boundaries. Their names describe the motions associated with them.

Divergent boundaries are where plates move apart, from an upwelling of new basaltic ocean crust. These boundaries are not limited to oceans and can be found on land; for example in Iceland or the East African Rift Valley. Typically this results in new ocean basins after millions of years. The motion of this type of boundary results in shallow earthquake data and shield volcanoes.

Three types of convergent boundaries exist: Ocean-ocean, continent-continent, and ocean-continent. The plate that is denser will sink below the other plate. Ocean-ocean, and ocean-continent this interaction results in earthquakes and volcanoes. Continent-continent interactions results in large mountain ranges such as the Himalayas as neither plate can subduct due to low density.

Transform boundaries do not produce or destroy parts of plates, but they do allow for the motion of the plates to occur. Their motion will result in the production of earthquakes. The driving mechanism for the plates is somewhat debatable.

A popular mechanism for the driving mechanism of plate tectonics is convection currents in the mantle. Warm mantle rises at ocean ridges and slides beneath the lithosphere dragging the plates like a conveyor system. As it cools it sinks down dragging the plate with it at subduction zones.

A more recently proposed mechanism is slab-push, slab pull. Again, this is driven by density. As ocean plates age they become cooler and therefore denser. When it gets cool enough the ocean plate sinks into the asthenosphere, pulling the lithosphere with it at a subduction zone. At ocean ridges the lithosphere slides under the influence of gravity. It is less dense due to being warmer and forms small mountain ranges like the mid-ocean ridge.

In other theories, both convection and slab-push/pull work together.

Demographics: (Source Mona Shores Annual Report)

This study was conducted at Mona Shores Middle School, located in Norton Shores, which is a suburb of Muskegon located in Muskegon County. The city has an area of 24.5 square miles and a population of 22,500 people. The average household income is \$59,300. There are 4,072 students district wide. The percentage of homeowners in Norton Shores is 77%, and 30% of people over the age of 25 have a college degree (Public School Review 2008). There are (4) elementary buildings, (1) middle school of grades 6-8, and (1) high school with grades 9-12. The teaching staff in the district is 226 teachers. All of the teachers in the middle school are “highly qualified” for their positions.

The middle school has 959 students, the majority of them are Caucasian. The next highest student population is African American. The percentage of students who are eligible for free lunch is 18%, with another 8% for reduced lunch (Public School Review 2008)

Mona Shores consistently does well on standardized tests, such as the MEAP, which is taken in the middle school, and is measured by the AYP/Education YES, as an “A” school. On the science section of the MEAP (taken in 8th grade) in the last three years, the middle school has scores of 90%, 85% and 91% respectively.

The community cares greatly about the success of its students. In the 2007-2008 school year 92% of parents were at the fall parent teacher conferences. Mona Shores has taken great initiative to include technology in the classroom. Bond issues have been passed to improve the way technology is used in the classroom. The middle school has a student to computer ratio of about 1 computer for every 3 students. This includes six sets

of computers on wheels, “COWs” as we call them. Each COW has 15 laptops for student use. All classrooms are equipped with a “smart cart” which includes a computer, projector, document camera, a speaker system, and Internet connection among other features. The “smart cart” truly improves a teacher’s ability to integrate technology into the classroom.

During the year this study was conducted (2009-2010) I taught 8th grade science for three of my five hours a day. We were on a traditional 55-minute semester class schedule. My other two sections were 7th grade science, based on the Grade Level Content Expectation Standards (GLCES). My 8th grade class was Earth Science and was based on the High School Content Expectation Standards (HSCES). There were other teachers in the science department that taught the same classes as myself, with me being the only “split” science teacher. All students were required to take 8th grade science.

Implementation

Over the course of my unit, the focus for the student learning was centered on labs and activities. There were forty eight (48) participating students in the study. The unit was broken into three sections. Part 1 was on earthquakes, Part 2 on volcanoes, and Part 3 on plate tectonics. At the beginning of the unit I gave the students a pre survey (Appendix I-A), which gauged their thoughts on how they perceived how they learned using “small” concepts and data. At the end of the unit there was a similar post survey (Appendix I-A) given, as well as their evaluation of each lab activity. At the beginning of each part there was a pre test (Appendix I-A, I-C, I-E) to be compared to their post test (Appendix I-B, I-D,I-F). I used these for each part to measure the amount of material that the students learned. The activities/labs (Appendix II) in each part were designed to emphasize learning small concepts using data and observations and build towards larger concepts in plate tectonics. Each part also followed the trend of learning from small concepts to larger concepts.

Tables 1,2,and 3 show the schedules that were followed in my classroom for this unit. They do not include notes/discussions or other worksheets. The activity number corresponds to the post survey order, where students evaluated the usefulness of the activity. The order taught is listed chronologically. Note that students on the post survey did not rate a couple of the activities. Each activity was scored for correctness on any questions that were assigned within the activity and lab. The students also received some points for completion of different sections of the activities.

In the first part of my unit I taught them about earthquakes and their relationship to plate tectonics. The sequence of activities was designed for students to learn from smaller concepts and evidence and build towards larger theories.

Part 1 – Earthquakes Schedule

Date	Activity and Titles (See Appendix II)	HSCE Objective Addressed (See Appendix III)	Brief Description of Activity
Wednesday 10/6	Pre Survey Given	Comparison piece	5 question survey
Thursday 10/7	Earthquake Pre Test	Comparison piece	20 point Pre Test
Friday 10/16 and Monday 10/19	Investigating a Faulty Diagram (Activity 1)	E3.4f, P1.1f	Make 3D models of Faults
Monday 10/26	Seismic Waves Lab (Activity 2)	E3.4, P1.1D	Use Slinky to model Earthquake waves
Tuesday 10/26 - Thursday 10/28	Earthquake Proof Buildings Lab (Activity 5)	E3.4, P1.1g	Build a building and test with shake table
Monday 11/2	Locating an Epicenter Virtual Earthquake Lab (Activity 4)	E3.4A, E3.4B, E3.4C, P1.1D, P1.1E	Use computer to find epicenter of an earthquake
Tuesday 11/3 - Wednesday 11/4	Mercalli's Scale Lab (Activity 3)	E3.4C, P1.1g, P1.1D	Earthquake intensity lab.
Wednesday 11/11- Thursday 11/12	Location of Earthquakes and Volcano's Lab (Activity 6)	E3.4A, E3.4C, E3.3d, P1.1g, P1.1D	Shows how Earthquakes and volcanoes relate to plate boundaries
Tuesday 11/17	Earthquake Post Test	Comparison piece/assessment	20 point Post Test

Table 1 – Earthquake Section Schedule

Overview of each activity: (All activities found in Appendix II)

Investigating a Faulty Diagram:

The purpose of this activity was to introduce the ideas of faulting. The students made a 3D paper model of a piece of “crust” out of paper. They then colored it in and modeled how the earth moves along a Normal, Reverse, and Strike Slip faults to see the

effects of them on the surface of the Earth. This activity served as a starting point for observable effects and corresponded with the notes that show pictures of these types of faults. The average score on this assignment was a 85%, and was rated a 3.6 out of 5 for effectiveness on the student post survey.

Seismic Waves:

After understanding how the Earth moves along fault lines, the students explored how energy travels through the Earth. The focus was on body waves and not surface waves. The students used a slinky to model the motion of energy through the Earth. How the energy traveled through the slinky also served to introduce the idea of how a seismometer works, and how scientists use evidence to understand earthquakes and ultimately plate tectonics. We did more with surface waves in notes and pictures in addition to this lab activity. The average score on this assignment was 80%, and was rated a 4.0 out of 5 for effectiveness on the student post survey.

Earthquake Proof Buildings Lab and Activity:

The purpose of this lab was for the students to determine that seismic waves and earthquakes have an effect on human lives. Tectonic plates shifting under their feet result in the earthquakes that damage buildings and people. In this lab the students built and tested their own “buildings” on a shake table that I built. It represented a real world problem and allowed them an opportunity to solve this problem using their knowledge of seismic waves. The average score on this assignment was a 79%, and was rated a 4.7 out of 5 for effectiveness on the student post survey. Most of the errors on this lab were from neglecting to finish the written part.

Locating an Epicenter Virtual Earthquake Lab

Students used an online program (<http://www.sciencecourseware.com>) to help them locate the epicenter of an earthquake. The program modeled for them plate boundaries. They were also able to find the magnitude, or how much energy released, of an earthquake similar to how a scientist would do this. The average score on this assignment was 93%, and was rated a 3.4 out of 5 for effectiveness on the student post survey.

Mercalli's Scale Lab:

Students worked with real data collected from an earthquake in southern California to determine its intensity on the Mercalli Scale. The data given were from the 1994 Northridge earthquake. Students worked with actual data in a way that a scientist would to understand how the tectonic plates of the Earth shift and move. The students read through eyewitness experiences to determine the intensity and location of an earthquake. The average score on this assignment was a 85%, and was rated a 3.5 out of 5 for effectiveness on the student post survey

Location of Earthquakes and Volcanoes Lab:

In this activity students plotted on a map the locations of various earthquakes that have occurred around the world. This allowed them to have a visual representation using data to make the connection to the location of plate boundaries using evidence. The activity also served as a link to volcanoes (Part 2) and their connection to tectonic plate locations. After they noted the location of both earthquakes and volcanoes and saw that they are they same, it also shows the students that the two are connected. The activity was the most important one in allowing students to discover and experience how

earthquakes relate to plate tectonics. It was completed after they have seen the smaller data and have applied it towards the larger theory of plate tectonics. The average score on this assignment was a 91%, and was rated a 3.4 out of 5 for effectiveness on the student post survey.

Part 2-Volcanoes Schedule

In the second part of my unit I taught them about volcanoes and their relationship to plate tectonics. Again, in this section I start with smaller concepts and evidence and build towards larger theories.

Date	Activity and Titles (See Appendix II)	HSCE Objective Addressed (See Appendix III)	Brief Description of Activity
Wednesday 11/18	Volcano Pre Test	Comparison piece	22 point Pre Test
Thursday 11/19	Observations of Rock Lab (Activity 7)	E3.1A, E3.1B E3.1d, E3.2C	Granite and Basalt comparison
Tuesday 11/24	Famous Eruptions lab (Not rated by students on post survey)	E3.4C, P1.2k	Familiarize with world wide eruptions and locations
Monday 11/30- Tuesday 12/1	Types of Volcanoes and Eruptions (Activity 8)	E3.4d, E3.1A, E3.1B	Understand different types and tectonic settings
Monday 12/7	Assessing Volcanic Hazards (Activity 9)	E3.4C, P1.2k	Real world problem
Friday 12/11	Volcano Post Test	Comparison piece/assessment	22 point Post Test

Table 2 – Volcano Section Schedule

Overview of each activity: (All activities found in Appendix III)

Observations of Rock Lab:

This activity began with small differences students can observe between granite and basalt. After making observations and discussing the different rock types, the students drew the tectonic settings where basalt formed and granite is located. They learned the differences in silica content and the corresponding eruptions that occur based

partially on silica content. They also measured the differences in density of the two rocks, which come out very small. After doing this lab I found the differences to be small, and probably inaccurate due to the small differences and the measuring techniques of middle schools students. This served as an introduction to the role density plays in tectonic settings. The average score on this assignment was 91%, and was rated a 3.4 out of 5 for effectiveness on the student post survey.

Famous Eruptions Lab:

The purpose of this activity was to illustrate to the students the impact that volcanic eruptions have had on human activity throughout history. This is an important piece considering the 2010 eruption of Eyjafjallajökull in Iceland. It also was pointed out to the students how different types of volcanoes occur in different tectonic settings. The average score on this lab was 84%.

Types of Volcanoes and Eruptions Activity:

Students drew a diagram of each type of volcano in its tectonic setting. They needed to label the different parts of each volcano and point out differences in size, what is ejected, size of eruption, amount of silica and trapped gases present, and type of rock present for examples. The main goal was to explore how the types of volcanoes are made because of their different tectonic settings. The average score on this assignment was 82%, and was rated a 4.0 out of 5 for effectiveness on the student post survey.

Understanding Volcanic Hazards Activity:

Students played the role of a geologist on the Caribbean island of Montserrat. After analyzing data from maps of ancient pyroclastic flows, students were asked to make a prediction on where people should be relocated on the island. It allowed them to make

a real world type of decision based on scientific data and facts. The average score on this assignment was 93%, and was rated a 3.4 out of 5 for effectiveness on the student post survey.

Part 3 – Plate Tectonics Schedule

After working through the first two parts of this unit, the students should have a fairly good idea of the concepts underlying Plate Tectonics. The third part presented some of the other lines of evidence that support the theory of Plate Tectonics. Again, this unit built from smaller ideas and concepts towards larger ones.

Date	Activity and Titles (See Appendix II)	HSCE Objective Addressed (See Appendix III)	Brief Description of Activity
Monday 12/14	Plate Tectonics Pre Test	Comparison piece	25 point Pre Test
Wednesday 12/16	Wandering Continents Evidence (Not rated by students on post survey)	E3.3A, P1.1g, P1.2g, P1.2k	Wegener's Evidence
Friday 12/18	Ocean Profile Lab (Activity 10)	E3.3A, P1.1g, P1.1D	Map's Ocean Floor showing ridge
Monday 12/21	Crustal Plate Map (Activity 11)	E3.3, E33B	National Geographic Map with Plate Names and Boundaries
Wednesday 1/6- Thursday 1/7	Plate Tectonics Computer Lab (Activity 12)	E3.3, E3.3A, E3.3B, E3.3C	Animations and questions showing boundary types and mechanisms
Monday 1/11- Tuesday 1/12	Hawaii Lab (Not rated by students on post survey)	E3.3C, P1.1g	Shows movement rates of Hawaii
Thursday 1/14	Plate Tectonics Post Test	Comparison Piece/Assessment	25 Point Post Test
Friday 1/15	Post Survey	Comparison Piece	Survey of activities

Table 3 – Plate Tectonics Section Schedule

Overview of each activity: (All activities found in Appendix II)

Wandering Continents Evidence Activity:

Students retraced the lines of evidence that Alfred Wegener used for his wandering continents hypothesis. They used the library and computers to find out what Wegener had to say about the following: the fit of the continents, fossil evidence, rock type and structural similarities, paleoclimatic evidence, paleomagnetism, and geomagnetic reversals. This was a simple activity that showed students how evidence is used to build a theory.

Ocean Profile Lab:

Students worked with depth to the ocean floor data between Nova Scotia, Canada, and Soulac, France on the 45th parallel. From these data they plotted a graph, which revealed that the ocean floor is not flat, but has mountain ranges. In the second part of the lab they colored in the age of each part of the ocean floor showing the symmetric pattern around the mid ocean ridge. This allowed them to discover the driving mechanism that Wegener was missing, sea floor spreading. The average score on this assignment was 81 %, and was rated a 3.4 out of 5 for effectiveness on the student post survey.

Crustal Plate Map Lab:

How the plates move around the earth was illustrated in this lab. It showed the different geologic features around tectonic boundaries. After doing this lab the students should have a firm grasp on how the plates of the earth interact and move to produce the surface features that we see around the world. It also asked them to make some small calculations on how fast certain plates are moving. A goal of this lab was to have the

students be able to look at surface features and infer some of the processes involved in producing them.

Plate Tectonics Computer Lab:

This lab was based on information from the computer program that accompanied *Earth: An introduction to Physical Geology* (Tarbuck and Lutgens 1999). It had very useful animations and helped to reinforce and relate the ideas of how the tectonics plates of the earth move to produce surface features. In many ways it is similar to the Crustal Plate Map Lab (Appendix II). The computer helps to visually show similar ideas in a more engaging way for the students. One of the more important aspects of this lab was that it discussed driving mechanisms for plate motion. The average score on this assignment was 82 %, and was rated a 3.8 out of 5 for effectiveness on the student post survey.

Hawaii Lab:

The GLG 201 course instructors at Michigan State University wrote this lab. It did, however, meet the needs of our students and addresses the HSCES. Students performed calculations for the rate of movement of the Pacific plate, using the Hawaiian Islands as a reference. In the end of the lab it also has the students make predictions on how the plate has moved over the course of its history.

Results and Evaluation

Each of the three sections of this unit had a pre test and a post test (Appendix II) to gauge student learning over the course of the time spent on it. A pre test was administered before I did any teaching on each part, so any knowledge they used to answer the questions was based on prior learning experiences. The post test for each part was given after teaching and served as the assessment for each of the three sections as well. There was also a pre survey and post survey (Appendix I) given which did not seem to tell me as much as the actual non-subjective numbers did. Each section showed student performance increased significantly after instruction. This was based on a paired t test (http://www.physics.csbsju.edu/stats/Paired_t-test_NROW_form.html) for each of the three pre and post tests. Also a significant increase in percentage was found from each pre test to post test.

Earthquake section (Part 1):

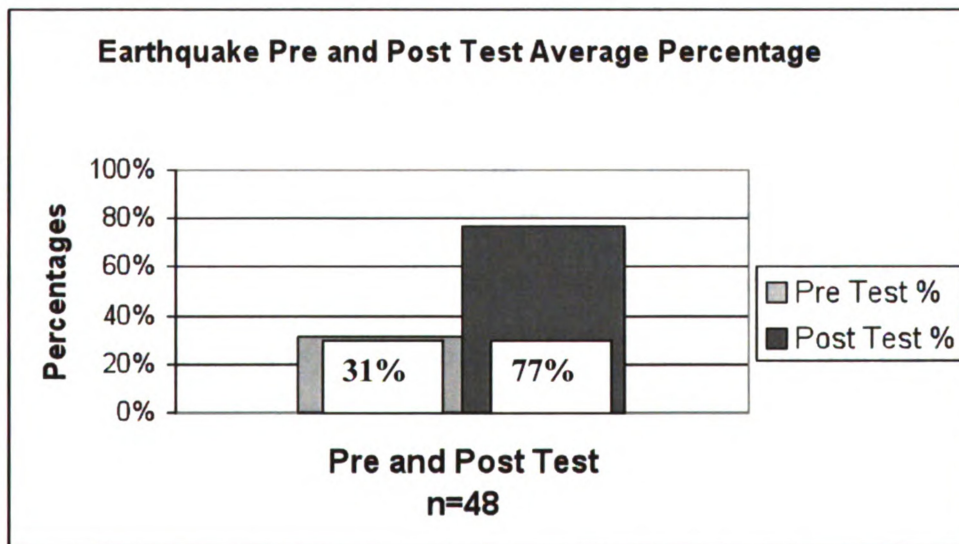


Figure 1 – Earthquake Pre and Post Test Average Percentage

The pre and post tests had a possible 20 points to be scored and there were 12 questions.

On the pre test the scores ranged from a low of (1) correct to a high of (12) correct. The

post test had a range of scores from (9) up to (20). The average score increased from a 31% before any formal instruction up to a 77% after formal instruction. The t-test indicates a significant increase in student understanding.

The post test for part 1 showed that there were still misconceptions about fault types. Many students were still not able to distinguish between normal and reverse type faults which accounts for most of the missing points from this assessment. The average on the post test was 77%.

Volcano Section (Part 2):

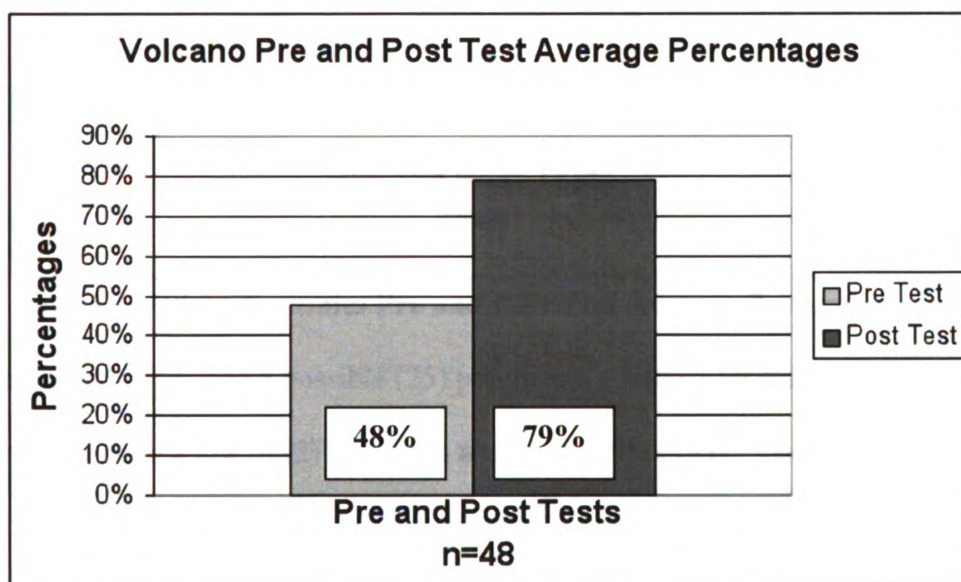


Figure 2 – Volcano Pre and Post Test Average Percentages

The pre and post tests had a possible (22) points that could be scored. On the pre test the scores ranged from a low of (4) correct to a high of (16) correct. The post test had a range of scores from (9) up to (22). The average score increased from a 48% before any formal instruction up to a 79% after formal instruction. This shows a significant student increase in understanding as indicated by the t-test results.

A common mistake made on the post test for Part 2 was in labeling the differences between a composite and shield volcano. Even after instruction the

misconception that a composite volcano is larger than a shield volcano still existed. Many students labeled them in reverse because the composite volcano has “bigger” eruptions, and is therefore the “bigger” volcano, when this is not the case.

Plate Tectonics Section (Part 3):

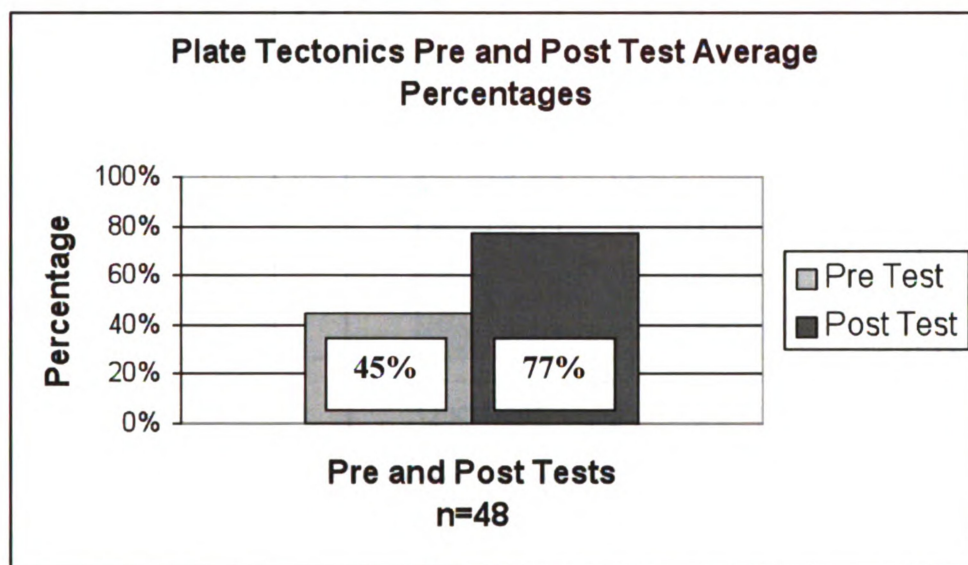


Figure 3 – Plate Tectonics Pre and Post Test Average Percentages

The pre and post tests had a possible (25) points that could be scored. On the pre test the scores ranged from a low of (2) correct to a high of (20) correct. The post test had a range of scores from (9) up to (25). The average score increased from a 45% before any formal instruction up to a 77% after formal instruction. This shows a significant student increase in understanding as indicated by the t-test analysis.

Students seemed to struggle with their explanations for how the San Andreas fault, and how the Mt. St. Helens eruption in 1980 are related to plate tectonics. The questions (Appendix II) were designed to make the students apply what they had learned to a real life situation.

The results from each section are encouraging and indeed show that learning from smaller concepts to larger concepts using evidence and data is an effective method.

Student Pre and Post Survey Results: (Appendix I)

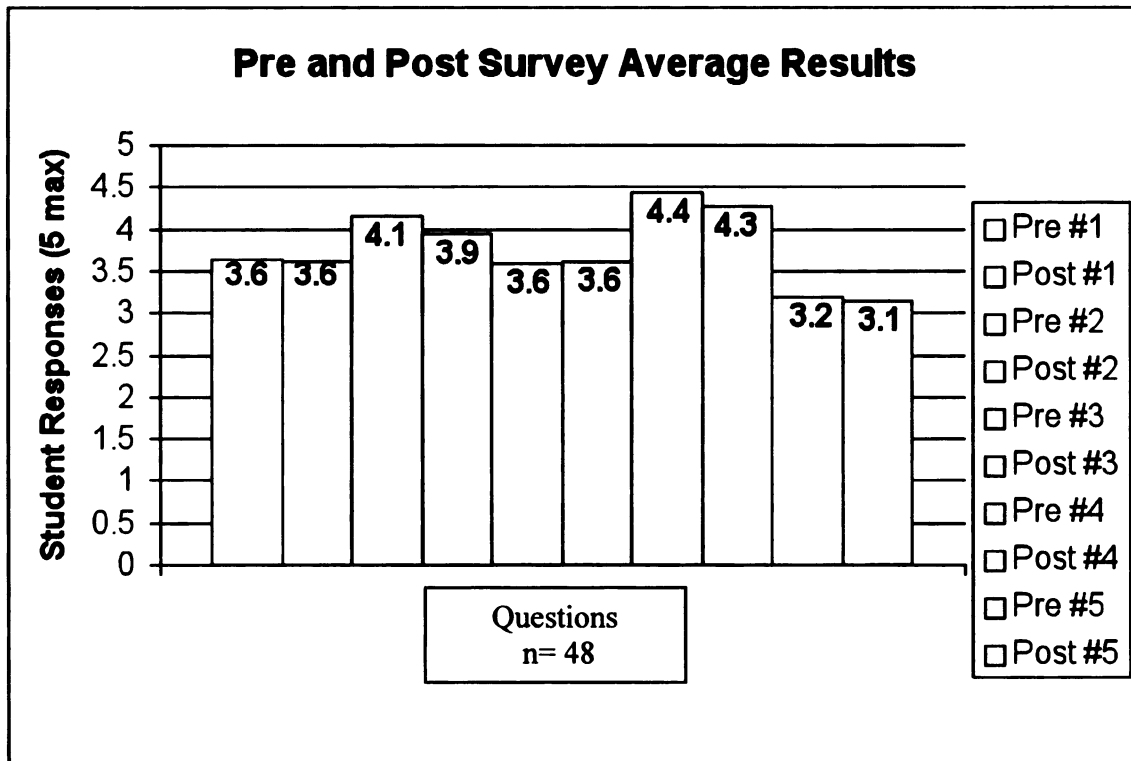


Figure 4 – Pre and Post Survey Average Results

The surveys gave a baseline for comparison to opinions and ideas after they were taught using this paradigm. The results did not show a noticeable change. I found this interesting since the pre and post tests showed such a large difference.

The two items from both of the pre and post surveys that stand out as most interesting to me is that students consistently ranked learning from things they can see, like data (question #2), and doing labs with real examples (questions #4) as being important to them. As a teacher, that is valuable information and agrees with what I learned during my teacher preparation. It also agrees with my hypothesis that learning is effective when students work with smaller observable concepts to build towards a larger theory.

Student Rating of Effectiveness for Activities Taught: See appendix for questions

On the post survey I had an additional section than the pre survey in which I asked the students to rank each of the learning activities that we did through the unit and smaller sections.

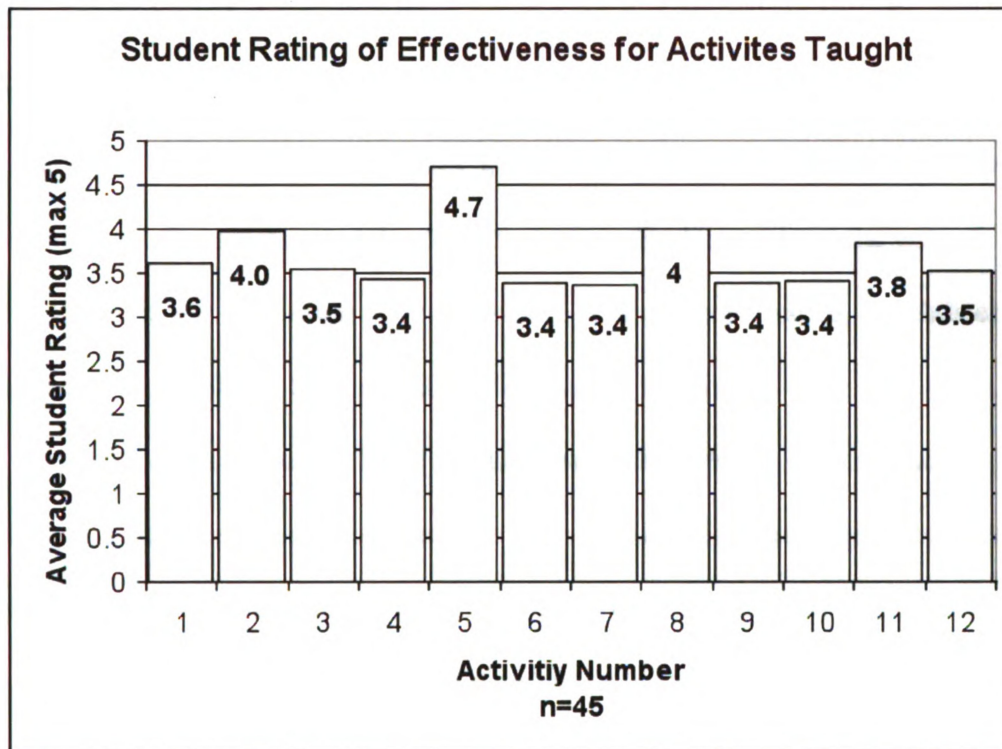


Figure 5 – Student Rating of Effectiveness for Activities Taught

Each activity ranked in a range that I would consider to be helpful to a student, but what I found to be interesting about this rating is that the only activities that scored a (4) or above were ones that had a lot of hands on involvement. Their ratings told me that students did find the method effective. However, to a larger extent, it suggests that students who are engaged in hands on activities is an even more important aspect of learning.

Discussion and Conclusion

The purpose of this study was to address the effectiveness of teaching from relatively small-scale observations of earthquakes and volcanoes data towards the larger, encompassing theory of plate tectonics. It started with the concept of seismic waves and how they move through the earth, giving us what we feel as earthquakes. From there the unit progressively addressed larger scale ideas: folds and faults, how waves transfer energy, how the crust of the Earth moves, how and why volcanoes erupt ultimately upwards in size of concepts towards global tectonics. Each step along the way of teaching this unit was built upon prior knowledge that was constructed, which is critical (Bradsford et. al, 2000 and Colburn, 2007) for student learning.

The study of how people build and understand knowledge, or construct knowledge, is not a new one. How students learn is still an important question today. The question that was asked at the beginning of this project was about the effectiveness of teaching a unit on plate tectonics from small-scale observable ideas to larger theories. The lab activities in this unit were to provide data and evidence for students to look at, manipulate, and build/discover the theories of plate tectonics. This is similar to how scientists have discovered scientific phenomena, by making small-scale observations. Bradsford et. al (2000) suggested these types of activities were important for learning. Many of the activities that students experienced were hands on, which are important for student learning (Johnston and McAllister, 2006).

This method was effective in educating and constructing knowledge among my middle school students. The data generated support this idea. Figures 1, 2, and 3, as well as the t-tests show that significant learning took place in each of the smaller parts within

this unit. That said, it would be interesting to me to try teaching the smaller sections in the order of “earthquakes,” “plate tectonics,” and concluding with the topic of “volcanoes,” since some textbooks follow this order. I chose the order that I followed because it seemed to be a logical approach to building from smaller concepts towards larger concepts. It would be an interesting comparison to this study. As stated earlier in the introduction, both orders of presentation can be found depending on which textbook it is that you use. Even among teachers the order can be different. The way that I taught the unit for this project was effective, as indicated by my data, suggesting a good order of presentation.

Some of the individual lessons were more effective than others. The student survey (Figure 4) does not show a large difference in how the students rate the effectiveness of the activities. However, as someone who has spent time educating youth, some lessons seem to “stick” better with students than others, for example activities (2), (5), (8), and (11). In the post survey (Appendix I) I asked a few open ended questions of the students to answer and explain what they liked and disliked about the activities. One of the more consistent answers that showed up on the survey was the students liked doing “labs” the best because they make “learning easier.” Other students mentioned how they liked observing rocks, or building earthquake proof buildings. There was a consistency in the students’ need for active learning. This supports the findings of Martin-Hansen (2009) that students can learn the nature of science by mimicking scientists’ work.

Something that also struck me as interesting was how many students mentioned that the direct instruction portion of the class did not teach them as much, or at least they

said it was the least interesting portion of the class. This was similar to what The National Research Council (2000) mentioned in their work and how scientists use inquiry to solve problems. One student even mentioned how working with small groups was nice because it allowed them to interact socially, and at the same time do the process of science. This echoes what Brooks and Brooks (2001) and Llweellyn (2005) found.

Activities (2), (5), and (8) were rated the highest by the students. Activity (2) simulated Primary and Secondary waves observed in an earthquake. It had the students simulate two different types of earthquake waves using a small slinky and it required them to connect what they had learned in the notes with what they had witnessed in experimentation. Activity (5) had the students make and experiment with a “building” made of cardstock paper, tape, and a few other items. Both of these activities were very student centered and hands on oriented. My observations of the students while they were working through the lab indicated to me that they were highly engaged during these times, and were solving problems. I found this type of learning to be very useful to the students. Activity (8) was centered on diagramming the various types of volcanoes. I suggest that they found this activity effective because they like to see how different volcanoes work and perhaps they enjoyed drawing diagrams and using colored pencils. It is a dynamic topic that seems to engage students.

The modified Mercalli lab (Activity 3) seemed to be effective for students because it had a tie in to real world experiences of the observers. I would use this lab again, but most likely shorten it, as the students said that there were too many observations to examine. Since this lab was also based on the Northridge earthquake of 1994, there were many great visuals to use with the activity.

Each one of the labs had an advantage and disadvantage. The more I teach these subjects in the future, the more they can be fine-tuned. There were, of course, things we discovered along the way while doing the labs that could be changed for next year as well. For example, in the *earthquake proof building* lab, I would limit the tape more carefully for the next time I teach it. The seismic waves lab needed some clarification on the questions. Mercalli's Scale lab needs fewer observations for the students to look at and reach the same conclusions. These are the types of things as an instructor can improve upon after many students have gone through the activity.

What seemed to work well was that every step of the way through this unit I could refer back to the previous activity to draw out prior knowledge and help students to make connections. That seemed to be a powerful aspect of teaching the unit from smaller observable concepts to larger theories. Each lab flowed into the next. With the addition of class discussion, notes, video clips, and photographs, it seemed like the students were able to make the connections that they needed to retain information and even make predictions. If the students were given enough help through class discussion, they were able to develop hypothesis and theories.

After completing this study, I believe that every lab used would be good to use again after minor revision. After using something for the first time in a classroom situation, there is always something that can be changed to be made clearer, or to help student understanding more. Based on the findings of this study, I will continue to develop activities that have students work with real data/observations and to build small ideas into larger ones. I see potential for developing activities like these in other areas of science that I teach, such as the astronomy unit. To have a student that is able to think

and problem solve is what makes for a good scientist, and citizen. McComas et. al (1998) stated the understanding of the science process to be important, as science becomes more reported in the everyday media. The importance of understanding Earth Science is apparent when you look at the news headlines. Examples from the year 2009-2010 include: magnitude 7.0 Haitian earthquake, the eruption of the Eyjafjallajökull Volcano in Iceland, and the Gulf of Mexico oil spill. Students must understand the importance of the process of science and of the Earth.

Appendix I: Assessment Instruments

Appendix I-A Pre-Survey

Please answer the following questions honestly while thinking about the way that you learn in science class.

Use the following ranking system to answer the questions with 5 being strongly agree and 1 being strongly disagree.

1) Science is a class that I have interest in taking.

Strongly Disagree				Strongly Agree
1	2	3	4	5

2) Learning from things that I can see, like data, helps me.

Strongly Disagree				Strongly Agree
1	2	3	4	5

3) Understanding smaller concepts helps me get the big picture.

Strongly Disagree				Strongly Agree
1	2	3	4	5

4) Doing labs with real examples helps me understand larger concepts.

Strongly Disagree				Strongly Agree
1	2	3	4	5

5) Answering questions related to labs helps me understand larger concepts.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Post-Survey

Please answer the following questions honestly when thinking about your experience in our plate tectonics unit.

Use the following ranking system to answer the questions with 5 being strongly agree and 1 being strongly disagree.

1) Science is a class that I have interest in taking.

Strongly Disagree				Strongly Agree
1	2	3	4	5

2) Learning from things that I can see, like data, helps me.

Strongly Disagree				Strongly Agree
1	2	3	4	5

3) Understanding smaller concepts helps me get the big picture.

Strongly Disagree				Strongly Agree
1	2	3	4	5

4) Doing labs with real examples helps me understand larger concepts.

Strongly Disagree				Strongly Agree
1	2	3	4	5

5) Answering questions related to labs helps me understand larger concepts.

Strongly Disagree				Strongly Agree
1	2	3	4	5

Having done these labs/activities, think back to them and rate them on effectiveness in helping you understand the bigger picture of plate tectonics. Use the scale of 1 being not helpful and 5 being very helpful.

1) Investigating a “Faulty” Diagram

Not Helpful				Very Helpful
1	2	3	4	5

Why:

2) Seismic Waves

Not Helpful				Very Helpful
1	2	3	4	5

Why:

3) Mercalli’s Scale

Not Helpful				Very Helpful
1	2	3	4	5

Why:

4) Locating an Epicenter Virtual Earthquake computer activity

Not Helpful				Very Helpful
1	2	3	4	5

Why:

5) Earthquake Proof Buildings

Not Helpful				Very Helpful
1	2	3	4	5

Why:

6) Location of Earthquakes and Volcanoes

Not Helpful				Very Helpful
1	2	3	4	5

Why:

7) Observations of Rock

Not Helpful				Very Helpful
1	2	3	4	5

Why:

8) Types of Volcanoes and Eruptions

Not Helpful				Very Helpful
1	2	3	4	5

Why:

9) Assessing Volcanic Hazards

Not Helpful				Very Helpful
1	2	3	4	5

Why:

10) Ocean Profile and the Sea Floor

Not Helpful				Very Helpful
1	2	3	4	5

Why:

11) Plate Tectonics Map Lab

Not Helpful				Very Helpful
1	2	3	4	5

Why:

12) Computer lab: Plate Tectonics

Not Helpful				Very Helpful
1	2	3	4	5

Why:

This next section is free response. Feel free to share your thoughts and opinion with me. They will be helpful for my thesis and more importantly for next year's students. Your thoughts count!

1) The parts of this unit that I liked the best were what, and WHY.

2) The parts of this unit that I disliked the most were what, and WHY.

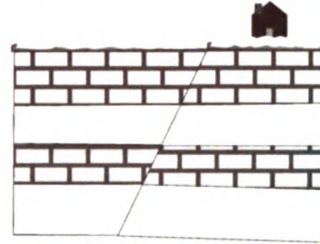
3) If you were Mr. Schuchardt, what would you do differently for next year's students?

Appendix I-B

Earthquake Pretest

1. What direction of force would have to be applied to the following diagram to make the house appear to move upward (normal fault)?

- A) A Push from both sides (compression)
- B) A pull from both sides (tension)
- C) A push from the right
- D) A push from the left



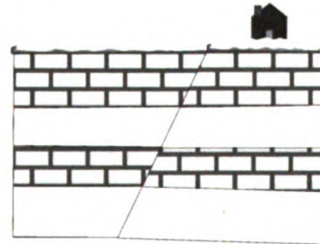
I chose this answer because...

Figure 6

(source: www.geology.ar.gov)

2. What direction of force would have to be applied to the following diagram to make the house appear to move downward (reverse fault)?

- A) A Push from both sides (compression)
- B) A pull from both sides (tension)
- C) A push from the right
- D) A push from the left



I chose this answer because...

Figure 7

(source: www.geology.ar.gov)

3. Write a sentence explaining why there is an off set in the row of trees in the following picture.

Explanation:

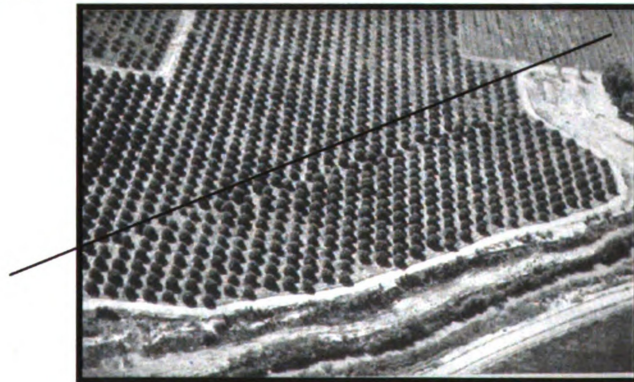


Figure 8

(Source <http://www.geology.wisc.edu>)

4. Which type of seismic waves causes rock particles to move in the same direction as the wave movement?

A) P –Wave
B) S-wave
C) Tension Wave
D) Shear Wave

I picked this answer because...

5. Which type of seismic waves causes rock particles to move in the opposite direction as the wave movement?

A) P – Wave
B) S – Wave
C) Tension Wave
D) Shear Wave

6. Label the following parts of a fault/earthquake diagram. Put the letter on the diagram next to where it belongs and explain what each one is.

Word	Explanation:
A) Hanging wall	A)
B) Footwall	B)
C) Epicenter	C)
D) Seismic Wave	D)
E) Focus	E)
F) Fault	F)

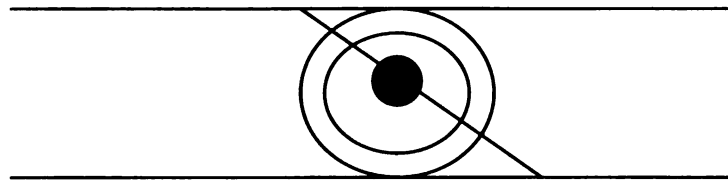


Figure 9

7. Why would the Modified Mercalli scale be something that a middle student can use to determine the intensity of an earthquake without seismic equipment?

8. Why would an engineer in California have different building standards than one in New York? What could some of these be?

9. Geologists know that wherever plate movement stores energy in the rock along faults,

- A) Earthquakes are not likely
- B) Earthquakes are likely
- C) An earthquake is occurring
- D) An earthquake could never occur

I picked this answer because...

10. Label the following seismogram with P, S, and Surface wave locations.



(Source <http://iphoneincubator.com>)

Figure 10

11. On the following map place dots, on the locations where you would expect to find the most earthquakes in the world.

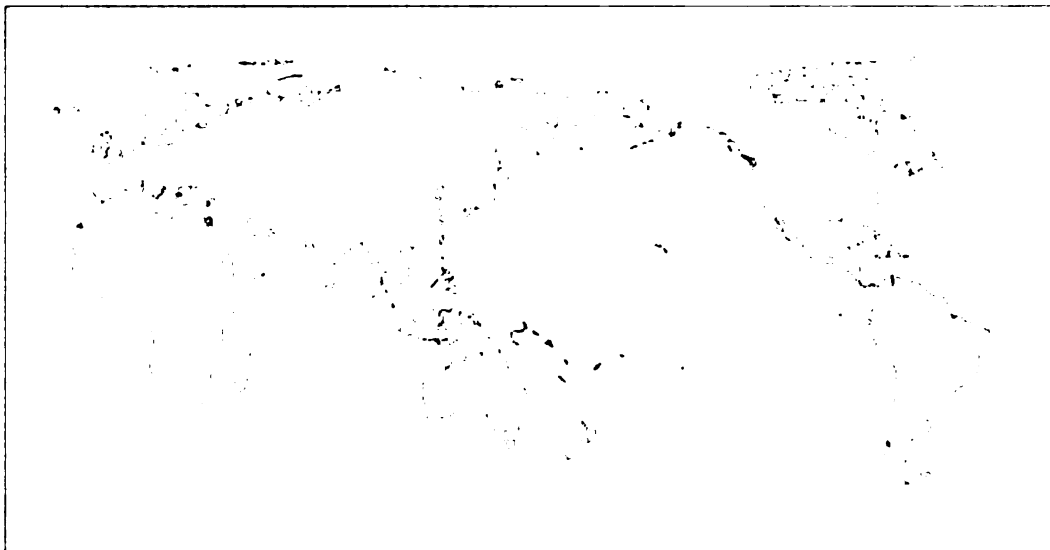


Figure 11

(Source: <http://www.ejumpcut.org>)

Explain why you chose these locations.

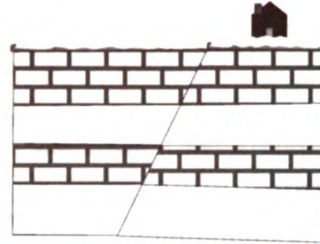
12. Give a short explanation of how these locations relate too global plate tectonics.

Appendix I-C

Earthquake Post-test

1. What direction of force would have to be applied to the following diagram to make the house appear to move upward (normal fault)?

- A) A Push from both sides (compression)
- B) A pull from both sides (tension)
- C) A push from the right
- D) A push from the left



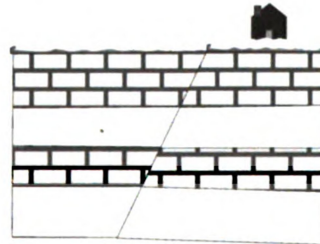
I chose this answer because...

Figure 12

Source: www.geology.ar.gov)

2. What direction of force would have to be applied to the following diagram to make the house appear to move downward (reverse fault)?

- A) A Push from both sides (compression)
- B) A pull from both sides (tension)
- C) A push from the right
- D) A push from the left



I chose this answer because...

Figure 13

(source: www.geology.ar.gov)

3. Write a sentence explaining why there is an off set in the row of trees in the following picture.

Explanation:

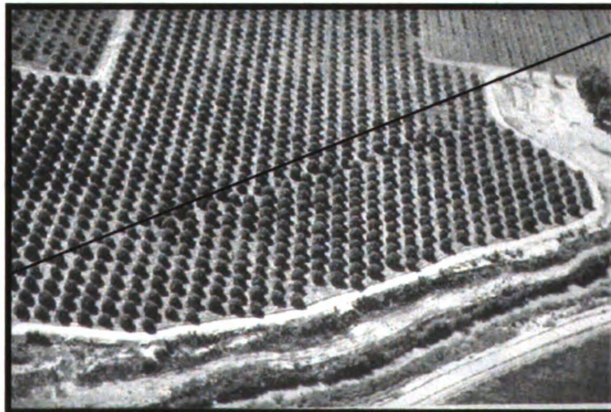


Figure 14

(Source: <http://www.geology.wisc.edu>)

4. Which type of seismic waves causes rock particles to move in the same direction as the wave movement?
- A) P –Wave
 - B) S-wave
 - C) Tension Wave
 - D) Shear Wave

I picked this answer because...

5. Which type of seismic waves causes rock particles to move in the opposite direction as the wave movement?
- A) P – Wave
 - B) S – Wave
 - C) Tension Wave
 - D) Shear Wave
6. Label the following parts of a fault/earthquake diagram. Put the letter on the diagram next to where it belongs and explain what each one is.
- | Word | Explanation: |
|-----------------|--------------|
| A) Hanging wall | A) |
| B) Footwall | B) |
| C) Epicenter | C) |
| D) Seismic Wave | D) |
| E) Focus | E) |
| F) Fault | F) |

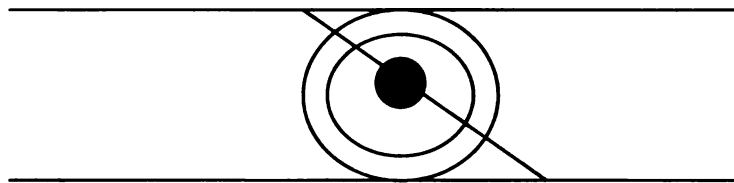


Figure 15

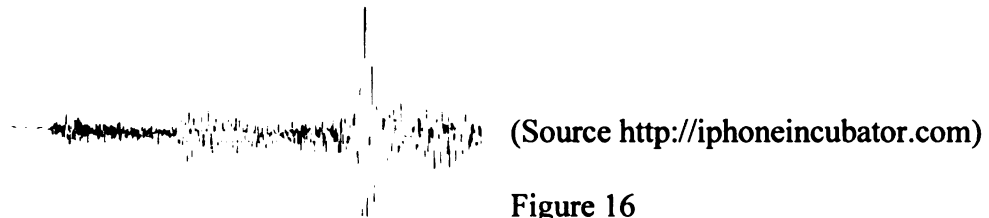
7. Why would the Modified Mercalli scale be something that a middle student can use to determine the intensity of an earthquake without seismic equipment?
8. Why would an engineer in California have different building standards than one in New York? What could some of these be?

9. Geologists know that wherever plate movement stores energy in the rock along faults,

- A) Earthquakes are not likely
- B) Earthquakes are likely
- C) An earthquake is occurring
- D) An earthquake could never occur

I picked this answer because...

10. Label the following seismogram with P, S, and Surface wave locations.



11. On the following map place dots, on the locations where you would expect to find the most earthquakes in the world. (Note: the dark squares represent large cities)

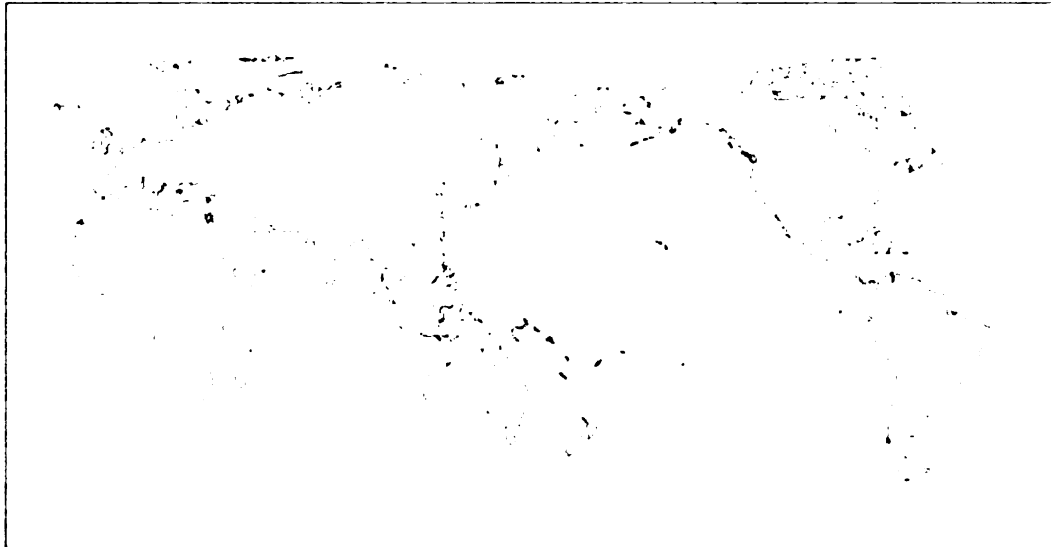


Figure 17
(Source: <http://www.ejumpcut.org>)

Explain why you chose these locations.

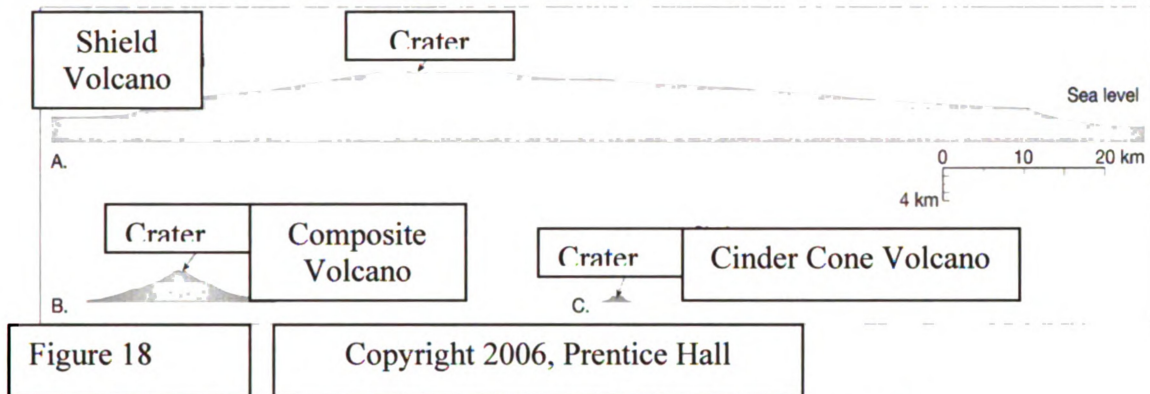
12. Give a short explanation of how these locations relate too global plate tectonics.

13. A rock that bends upward into an arch is called a(n)
- A) anticline
 - B) syncline
 - C) plateau
 - D) canyon
14. The point beneath Earth's surface where rock breaks under stress and triggers an earthquake is called the
- A) Syncline
 - B) Footwall
 - C) Epicenter
 - D) Focus
15. What does the seismograph record?
- A) The Mercalli scale rating for an earthquake
 - B) The speed of the seismic waves
 - C) The ground movements caused by seismic waves
 - D) The location of the epicenter
16. What is the primary cause for a Tsunami?
- A) Continental earthquakes
 - B) Earthquakes under the ocean
 - C) Volcanoes erupting on land
 - D) Meteor impacts in oceans.

Appendix I-D

Volcano Pretest

Look at the following diagram to answer the first two questions. From big to small in size is a shield volcano, composite, and then cinder cone.



1) Which volcano is most likely to have a large explosive eruption?

I chose this type because....

2) Which volcano is mostly likely to have flowing lava come out of it.

I chose this type because....

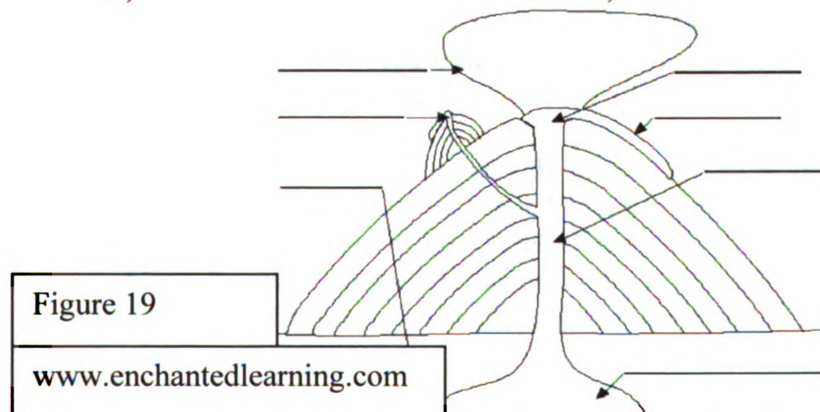
3) Label the following parts of a volcano: Pyroclastic Material, Pipe, Magma Chamber, Crust, Lava, Side Vent, Vent. Put the letter on the diagram next to where it belongs and explain what each one is.

Word:

- A)
- B)
- C)
- D)
- E)
- F)

Explanation:

- A)
- B)
- C)
- D)
- E)
- F)



- 4) Before lava reaches the surface it is called
- a. Rock
 - b. Magma
 - c. Volcanic ash
 - d. Liquid fire

I chose this answer because....

- 5) The formation of the Hawaiian Islands is one example of
- a. Volcanoes forming over a hot spot
 - b. Volcanoes forming along plate boundaries
 - c. The Ring of Fire
 - d. Continental drift

I chose this answer because....

- 6) Which of the following helps to determine how easily magma flows?
- a. The amount of silica in the magma
 - b. The diameter of the pipe
 - c. The size of the crater
 - d. The number of vents on the volcano

I chose this answer because....

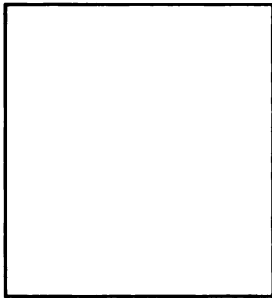
- 7) If a volcano is made out of rocks that are made of granite and rhyolite you can determine that the type of eruption that it will most likely take place will be
- a. Small/non violent because there is not much silica content
 - b. Large/ violent because there is not much silica content
 - c. Small/non violent because there a lot of silica present
 - d. Large/violent because there is a lot of silica present
- 8) If a volcano is made of rocks that are made of basalt and gabbro you can determine that the type of eruption that will most likely take place will be
- a. Small/ non violent because there is not much silica content
 - b. Large/violent because there is not much silica content
 - c. Small/non violent because there a lot of silica present
 - d. Large/ violent because there is a lot of silica present
- 9) Where is a volcano that explodes violently most likely to be found?
- a. Along the west coast of the United States because of a subduction zone.
 - b. Along the east coast of the United States because of a subduction zone.
 - c. Along the west coast of Africa because of a spreading center.
 - d. Near Hawaii because it is in the middle of the ocean.

10) The reason that magma rises to the surface is because of

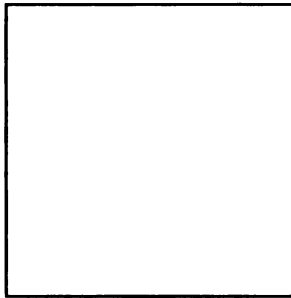
- a. Density differences
- b. Differences in salinity
- c. Plates that melt
- d. It is hot

I chose this answer because...

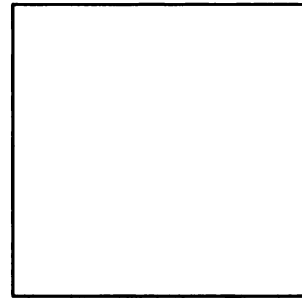
11) Draw an example of each type of the following types of areas and the location of any possible volcanic activity. Label the major rock types present. (Granite and Basalt)



Convergent Boundary
(Like Mt. St. Helens)



Hot spot
(Like Hawaii)

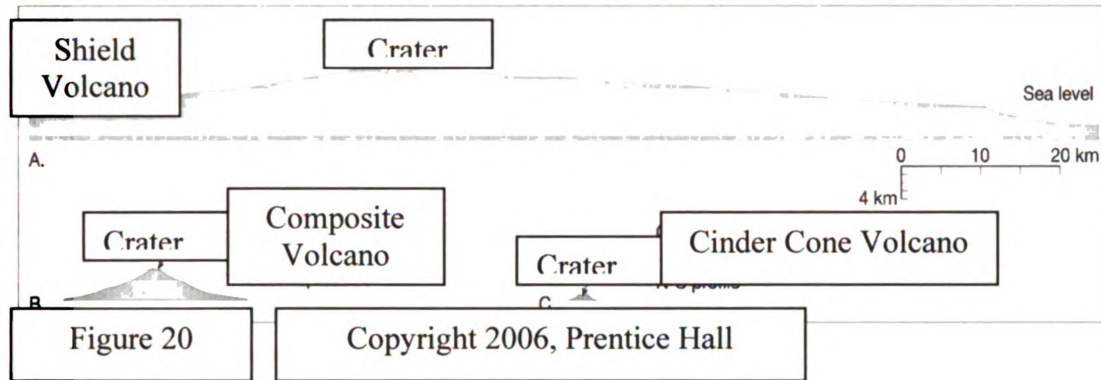


Divergent Boundary
(Like Mid-ocean ridge)

Appendix I-E

Volcano Post-test

Look at the following diagram to answer the first two questions. From big to small in size is a shield volcano, composite, and then cinder cone.



1) Which volcano is most likely to have a large explosive eruption?

I chose this type because....

2) Which volcano is mostly likely to have flowing lava come out of it.

I chose this type because....

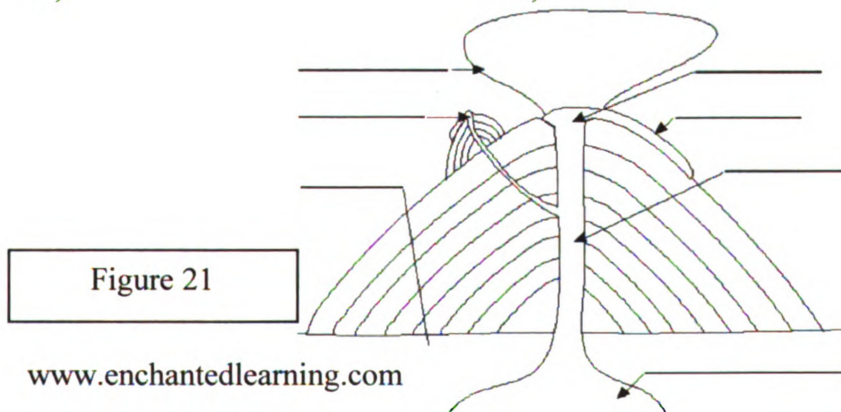
3) Label the following parts of a volcano: Pyroclastic Material, Pipe, Magma Chamber, Crust, Lava, Side Vent, Vent. Put the letter on the diagram next to where it belongs and explain what each one is.

Word:

- A)
- B)
- C)
- D)
- E)
- G)

Explanation:

- A)
- B)
- C)
- D)
- E)
- F)



4) Before lava reaches the surface it is called

- 3) Rock
- 4) Magma
- 5) Volcanic ash
- 6) Liquid fire

I chose this answer because....

5) The formation of the Hawaiian Islands is one example of

- e. Volcanoes forming over a hot spot
- f. Volcanoes forming along plate boundaries
- g. The Ring of Fire
- h. Continental drift

I chose this answer because....

6) Which of the following helps to determine how easily magma flows?

- i. The amount of silica in the magma
- j. The diameter of the pipe
- k. The size of the crater
- l. The number of vents on the volcano

I chose this answer because....

7) If a volcano is made out of rocks that are made of granite and rhyolite you can determine that the type of eruption that it will most likely take place will be

- a. Small/non violent because there is not much silica content
- b. Large/ violent because there is not much silica content
- c. Small/non violent because there a lot of silica present
- d. Large/violent because there is a lot of silica present

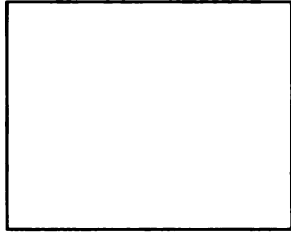
8) If a volcano is made of rocks that are made of basalt and gabbro you can determine that the type of eruption that will most likely take place will be

- a. Small/ non violent because there is not much silica content
- b. Large/violent because there is not much silica content
- c. Small/non violent because there a lot of silica present
- d. Large/ violent because there is a lot of silica present

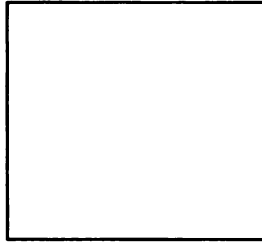
9) Where is a volcano that explodes violently most likely to be found?

- a. Along the west coast of the United States because of a subduction zone.
- b. Along the east coast of the United States because of a subduction zone.
- c. Along the west coast of Africa because of a spreading center.
- d. Near Hawaii because it is in the middle of the ocean.

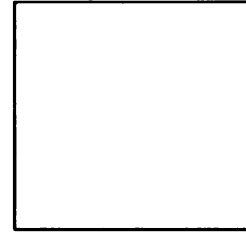
- 10) The reason that magma rises to the surface is because of
- a. Highly fluid
 - b. Less dense than the surrounding material
 - c. Highly magnetic
 - d. More dense than surrounding material.
- 11) Draw an example of each type of the following types of plate boundaries and the location of any possible volcanic activity. Label the major rock types present. (Granite and Basalt)



Convergent Boundary



Hot Spot



Divergent Boundary

- 12) What are the three major gasses that erupt out of a volcano? Which gas is the most abundant?
- 1.
 - 2.
 - 3.
- Abundant _____
- 13) In one complete paragraph, explain what the “Ring of Fire” is all about and where it is located
- 14) Which of the following volcanoes is likely to erupt in the near future.
- a. Dormant
 - b. Active
 - c. Extinct
 - d. Old
- 15) Tall, steep, mountains in which layers of lava alternate with layers of ash are called
- a. shield volcanoes
 - b. cinder cone volcanoes
 - c. composite volcanoes
 - d. lava plateaus

- 16) When many layers of thin, runny lava build up high, 3-10 degree sloped area, the result is a
- lava plateau
 - shield volcano
 - cinder cone volcano
 - composite volcano
- 17) Pahoehoe is
- Cooler, slower-moving lava
 - Fast-moving hot lava
 - Volcanic ash
 - Lava with a rough, chunky surface
- 18) In volcanic area, groundwater heated by magma is a source of
- Lava flows
 - Silica
 - Geothermal energy
 - Pyroclastic flows
- 19) If geologist detect many small earthquakes in the area near a volcano, what can they infer about the volcano?
- It is dormant
 - Its is probably about to erupt
 - It is extinct
 - It is a good source of geothermal energy
- 20) The main hazard from a quiet volcanic eruption is
- Volcanic gases
 - Lava flows
 - Geysers
 - Pyroclastic flows

Appendix I-F

Plate Tectonics Pretest

- 1) Continental crust consists mainly of the rock
 - a. Nickel
 - b. Basalt
 - c. Mantle
 - d. Granite
- 2) In the convection current of a pan of soup, the cooler, denser fluid
 - a. Rises to the top
 - b. Sinks to the bottom
 - c. Stays where it is
 - d. Stays on top

I chose this answer because...

- 3) Scientists think that convection currents flow in Earth's
 - a. Continents
 - b. Asthenosphere
 - c. Lithosphere
 - d. Inner core

I chose this answer because...

- 4) Which rock type is less dense compared to the other: (Circle one): Granite or Basalt
- 5) Subduction is
 - a. The process by which oceanic crust sinks beneath continental crust
 - b. The direct transfer of heat through solid materials
 - c. The process that continually adds ocean floor
 - d. A device that bounces sound waves off underwater objects
- 6) What erupts through the valley of the mid-ocean ridge?
 - a. Molten material
 - b. The lithosphere
 - c. Deep-ocean trenches
 - d. Continental drift

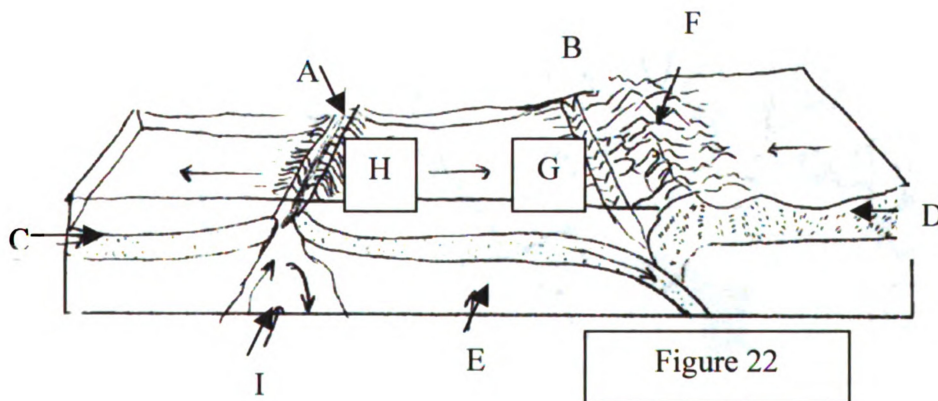
- 7) In a short answer, describe what you think causes the plates of the earth to move.

8) Scientists have used evidence from which fields of study to help the theory of plate tectonics?

- a. Volcanology (study of Volcanoes)
- b. Seismology (study of Earthquakes)
- c. Paleontology (study of Fossils)
- d. Climatology (study of Climate)
- e. All of the Above
- f. None of the Above

9) Label the diagram with the following:, Convergent Boundary, Ocean Crust, Continental Crust, Mantle, , Younger Ocean crust, Convection Current, Divergent Boundary, Older Ocean Crust, Volcano.

- A)
- B)
- C)
- D)
- E)
- F)
- G)
- H)
- I)



10) As ocean crust moves away from the mid-ocean ridge, it cools and becomes more dense. (circle one) True or False

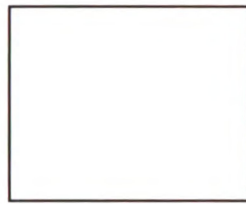
11) Explain in a short answer how plate tectonics is responsible for observable things, such as the San Andreas Fault.

12) Explain in a short answer how plate tectonics is responsible for observable things such as the eruption of Mt. St. Helens.

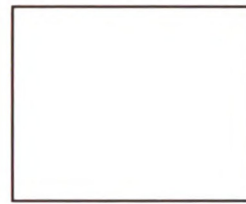
- 13) Draw arrows representing the direction of motion for the Earth's Plates for each of the following boundary zones:



Transform



Convergent



Divergent

- 14) Label the following plate locations: African, North American, South American, Indo-Australian, Naza, Eurasian, Antarctic, Arabian, Philippine, Caribbean, Juan De Fuca, Pacific Plate.

- | | |
|----|----|
| A) | G) |
| B) | H) |
| C) | I) |
| D) | J) |
| E) | K) |
| F) | L) |

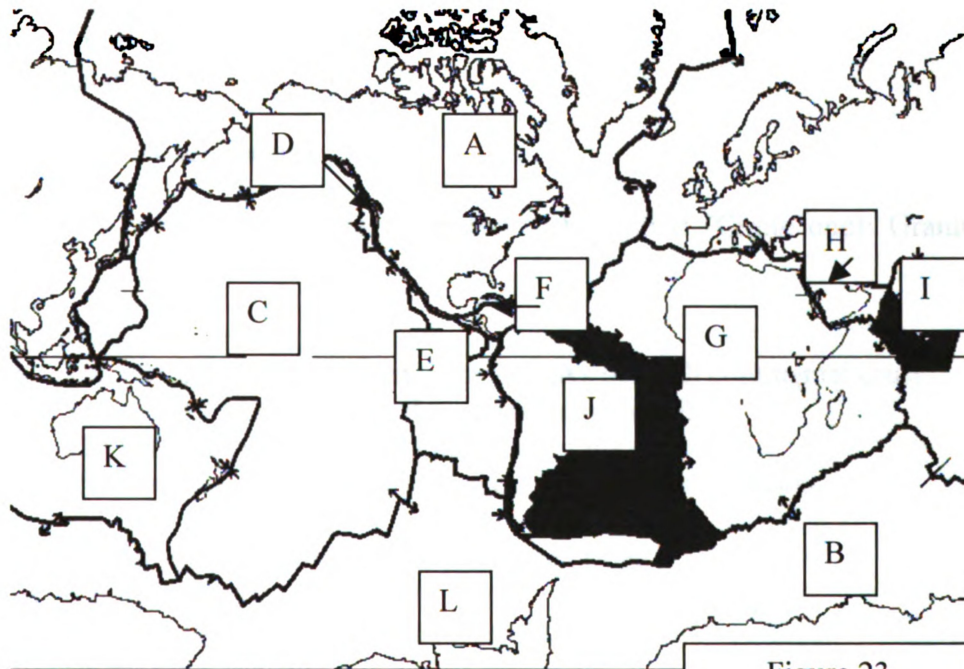


Figure 23

(source: www.geographyalltheway.com)

- 15) If new ocean floor is continually being created, why does the Earth remain the same size?

Appendix I-G

Plate Tectonics Post-test

- 1) Continental crust consists mainly of the rock
 - a. Nickel
 - b. Basalt
 - c. Mantle
 - d. Granite
- 2) In the convection current of a pan of soup, the cooler, denser fluid
 - a. Rises to the top
 - b. Sinks to the bottom
 - c. Stays where it is
 - d. Stays on top

I chose this answer because...

- 3) Scientists think that convection currents flow in Earth's
 - a. Continents
 - b. Asthenosphere
 - c. Lithosphere
 - d. Inner core

I chose this answer because...

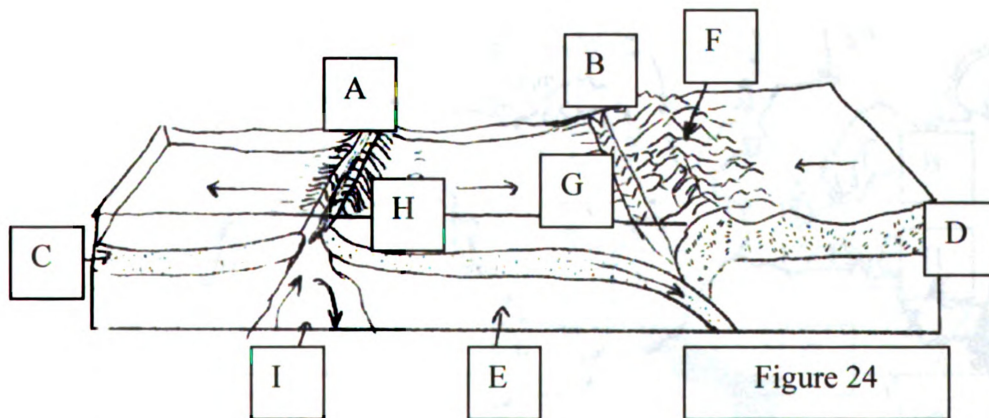
- 4) Which rock type is less dense compared to the other: (Circle one): Granite or Basalt
- 5) Subduction is
 - a. The process by which oceanic crust sinks beneath continental crust
 - b. The direct transfer of heat through solid materials
 - c. The process that continually adds ocean floor
 - d. A device that bounces sound waves off underwater objects
- 6) What erupts through the valley of the mid-ocean ridge?
 - m. Molten material
 - n. The lithosphere
 - o. Deep-ocean trenches
 - p. Continental drift
- 7) In a short answer, describe what you think causes the plates of the earth to move.

8) Scientists have used evidence from which fields of study to help the theory of plate tectonics?

- a. Volcanology (study of Volcanoes)
- b. Seismology (study of Earthquakes)
- c. Paleontology (study of Fossils)
- d. Climatology (study of Climate)
- e. All of the Above
- f. None of the Above

9) Label the diagram with the following: Convergent Boundary, Ocean Crust, Continental Crust, Mantle, , Younger Ocean crust, Convection Current, Divergent Boundary, Older Ocean Crust, Volcano.

- A)
- B)
- C)
- D)
- E)
- F)
- G)
- H)
- I)

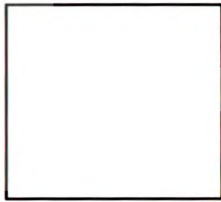


10) As ocean crust moves away from the mid-ocean ridge, it cools and becomes more dense. (circle one) True or False

11) Explain in a short answer how plate tectonics is responsible for observable things, such as the San Andreas Fault.

12) Explain in a short answer how plate tectonics is responsible for observable things such as the eruption of Mt. St. Helens.

13) Draw arrows representing the direction of motion for the Earth's Plates for each of the following boundary zones:



Transform

Convergent

Divergent

14) Label the following plate locations: African, North American, South American, Indo-Australian, Naza, Eurasian, Antarctic, Arabian, Philippine, Caribbean, Juan De Fuca, Pacific.

- | | |
|----|----|
| A) | G) |
| B) | H) |
| C) | I) |
| D) | J) |
| E) | K) |
| F) | L) |

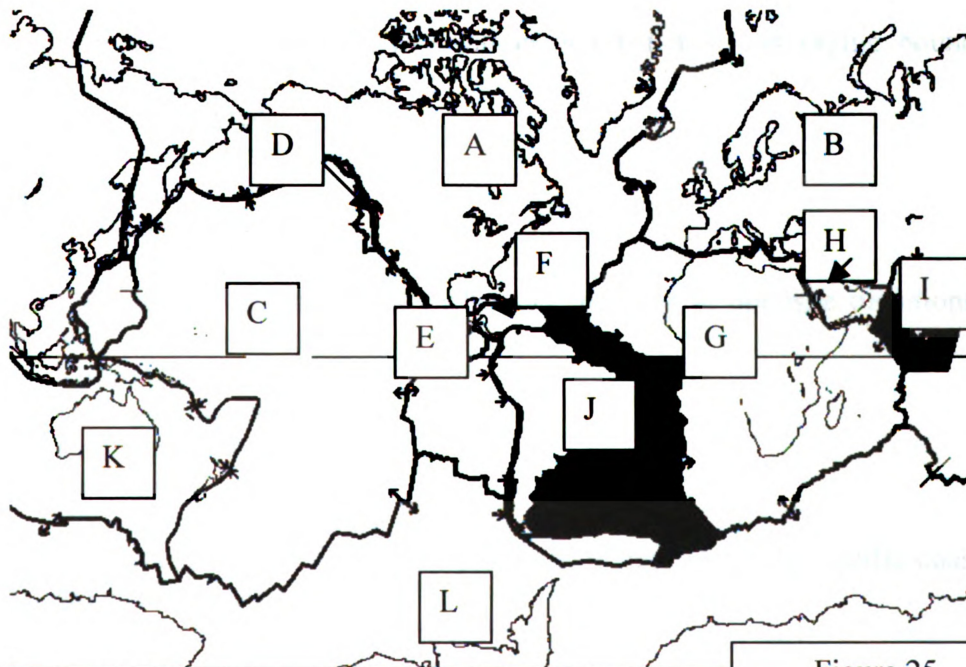


Figure 25

(source: www.geographyalltheway.com)

15) If new ocean floor is continually being created, why does the Earth remain the same size?

16) Describe the mechanisms we discussed in class on what drives the motion of the plates(3sentencesminimum)

17) Scientists rejected Wegener's theory because he could not

- a. Explain why continental crust was denser than oceanic crust
- b. Describe the climate of Pangaea
- c. Explain what force pushes or pulls continents
- d. Describe how seeds moved from Africa to South America

18) In the process of sea-floor spreading, where does molten material rise from the mantle and erupt?

- a. Along the endges of all the continents
- b. Along the mid-ocean ridge
- c. In deep-ocean trenches
- d. At the north and south poles

19) A collision between two pices of continental crust at a converging boundary produces a

- a. mid-ocean ridge
- b. deep-ocean trench
- c. rift valley
- d. mountain range

20) A place where to plates slip past each other, moving in opposite directions, is known as a

- a. Transform boundary
- b. Divergent boundary
- c. Convergent boundary
- d. Rift valley

21) The risk of earthquakes and volcanic eruptions is high along the Pacific coast of the United States because

- a. There have been no earthquakes there lately
- b. Serious earthquakes are rare east of the Rockies
- c. Satellites have detected increasing elevation of the ground surface
- d. That's where the Pacific and North American plates meet

22) Write a short answer about the following: How have scientists used evidence from earthquakes, volcanoes, paleontology, paleoclimatic, and sea floor spreading to build a larger theory of plate tectonics. (5 sentences minimum)

Appendix II: Activities

Activity 1 Investigating a “Faulty” Diagram

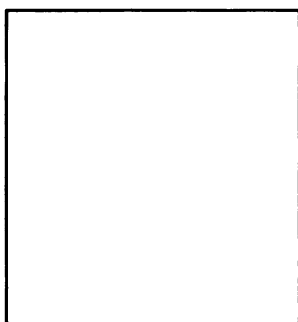
Introduction:

Faults are fractures in the crust along which displacement has taken place. The many rock types making up the Earth’s crust and will break when enough stress is applied to quickly or when it is too great. The motion of the Earth along the fracture that occurs is called an earthquake. We will be studying three types of faults; Normal, Reverse, and Strike Slip. In this activity you will be making a 3D model representing all three of them and analyze some of the effects of them.

Background:

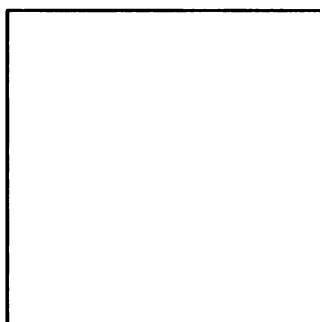
Use your textbook as a reference to make a small diagram of each type of fault. This must be colored and labeled. When you are finished make sure you label the type of stress associated with each type of fault.

Normal:



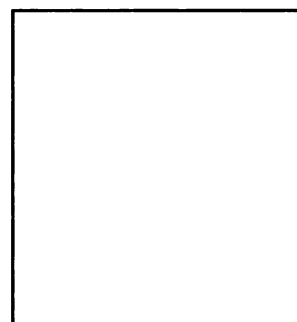
Stress Type:

Reverse:



Stress Type:

Strike Slip



Stress Type

Directions:

- 1) Color each of the templates labeled “template 1” and “template 2.” You should maintain the same color scheme for Limestone, Clay, and Granite. Make sure you color in the water main running on panel E of template 1.
- 2) Color panel “B” of Template 1 in your own scheme.
- 3) After you have them colored cut out each template. Cut along the solid lines, and fold along the dotted for template 1.
- 4) Fold template 1 into a pyramid shape so you can see the colored panels. Tape this together to form a pyramid.
- 5) Repeat for template 2.
- 6) Set the model on your desk so that it makes a rectangle when placed together.

Questions:

- 1). Pull the two half blocks apart. The type of stress associated with this is called _____.
- 2). If the two blocks are pulled apart, predict what will happen to the river on panel B.
- 3) What type of fault does this represent? _____
- 4) Push the two blocks together. The type of stress associated with this is called _____.
- 5) If the two blocks are pushed together, what will happen to the water main running through panels “E” and “4”. Why would it be important for employees of the water company to know about the fault line running through your diagram?
- 6) What type of fault does this represent? _____
- 7) Slide the two blocks past each other laterally. The type of stress associated with this is called _____.
- 8) If the two blocks slide laterally and the fence were to continue further, predict what the new fence line would look like. (You May draw this)
- 9) What type of fault does this represent? _____
- 10) What do you think are some reasons why the Earth would move this way? (Don't worry about using scientific words here)
- 11) Where on the Earth do you think you might find some of these types of motion in the Earth?

Activity 2

Seismic Waves

Lab based on Earth's Dynamic Geosphere "An Earthquake in your community"

Introduction:

Think back to your 3D models that we built. Each time you moved the blocks it represented energy being released in the form of an earthquake. That energy travels through the Earth and we can sometimes feel that energy. Scientists use seismographs to measure this energy and also study the structure of the Earth (more on that another day). The ancient Chinese were some of the first people to attempt to measure these waves of energy. A scientist will collect this information on a seismograph, which records these waves on a seismogram. The information recorded looks like the one below.

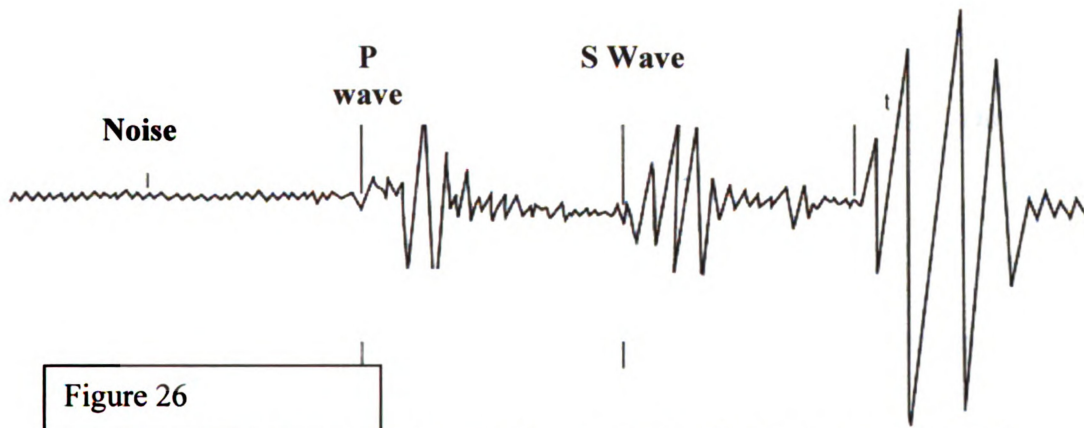


Figure 26

(source: <http://samjshah.files.wordpress.com/2008/07/seismogram-1.gif>)

The waves that travel in the Earth do not all travel in the same way. Some of the waves travel through the Earth itself (body waves) and some travel along the surface of the Earth (surface waves). Our focus of this lab will mostly be about body waves.

Materials:

Slinky

Activity:

Wave A:

- 1). Place the slinky on the ground and stretch it out about 3 meters. Be careful not to stretch it too far.
- 2) Strike the end of the slinky gently once. Observe the motion of the slinky. (you may have to repeat this a couple of times)
- 3) Describe in words what you saw (your observations).
- 4) Draw a diagram of what you saw including the following labels: Direction of energy, direction of slinky motion.

- 5) The energy travels (parallel/perpendicular) _____ to the motion of the slinky.

Wave B:

- 1) Place the slinky on the ground and stretch it out about 3 meters. Be careful not to stretch it too far.
- 2) Quickly jerk one end of the slinky up and then down quickly. You don't have to move it more than a few inches.
- 3) Describe in words what you saw (your observations).
- 4) Draw a diagram of what you saw including the following labels: Direction of energy, direction of slinky motion.

- 5) The energy travels (parallel/perpendicular) _____ to the motion of the slinky.

Questions:

- 1) Which wave appeared to travel across the slinky first?
- 2) Which wave would arrive first in an Earthquake?
- 3) Which wave is a primary wave?
- 4) Which wave is a secondary wave?
- 5) Looking at the diagram in the introduction, which type of wave do you think causes the most amount of damage? Why did you say this?

Activity 3

Mercalli's Scale Lab

Based on lab created by The California Partnership for Safety and Preparedness as well as the United State Geologic Survey

Introduction:

How people feel the earthquake in a given area is described as *Intensity*. In the United States, we use the *Modified Mercalli Intensity Scale*, a qualitative scale of earthquake effects that assigns an intensity number to the ground shaking for any specific location on the basis of observed effects. Mercalli intensity is expressed in Roman numerals. *Intensity* varies from place to place within the disturbed region depending on the location of the observer.

Scientists will use a seismograph to measure the *Magnitude*, or amount of energy released in an Earthquake. Seismographs record the amplitude of the seismic waves, from which *Magnitude* is determined. An earthquake has only one magnitude, although the magnitude might be altered from initial reports as scientists refine the measurement. Magnitude is reported as an Arabic numeral.

In the first part of this lesson, students will record a variety of individual accounts into a zip code map to determine the intensity of the earthquake using the Modified Mercalli Intensity Scale. In the second part of the lab we will investigate the Richter Scale.

Part 1:

Materials:

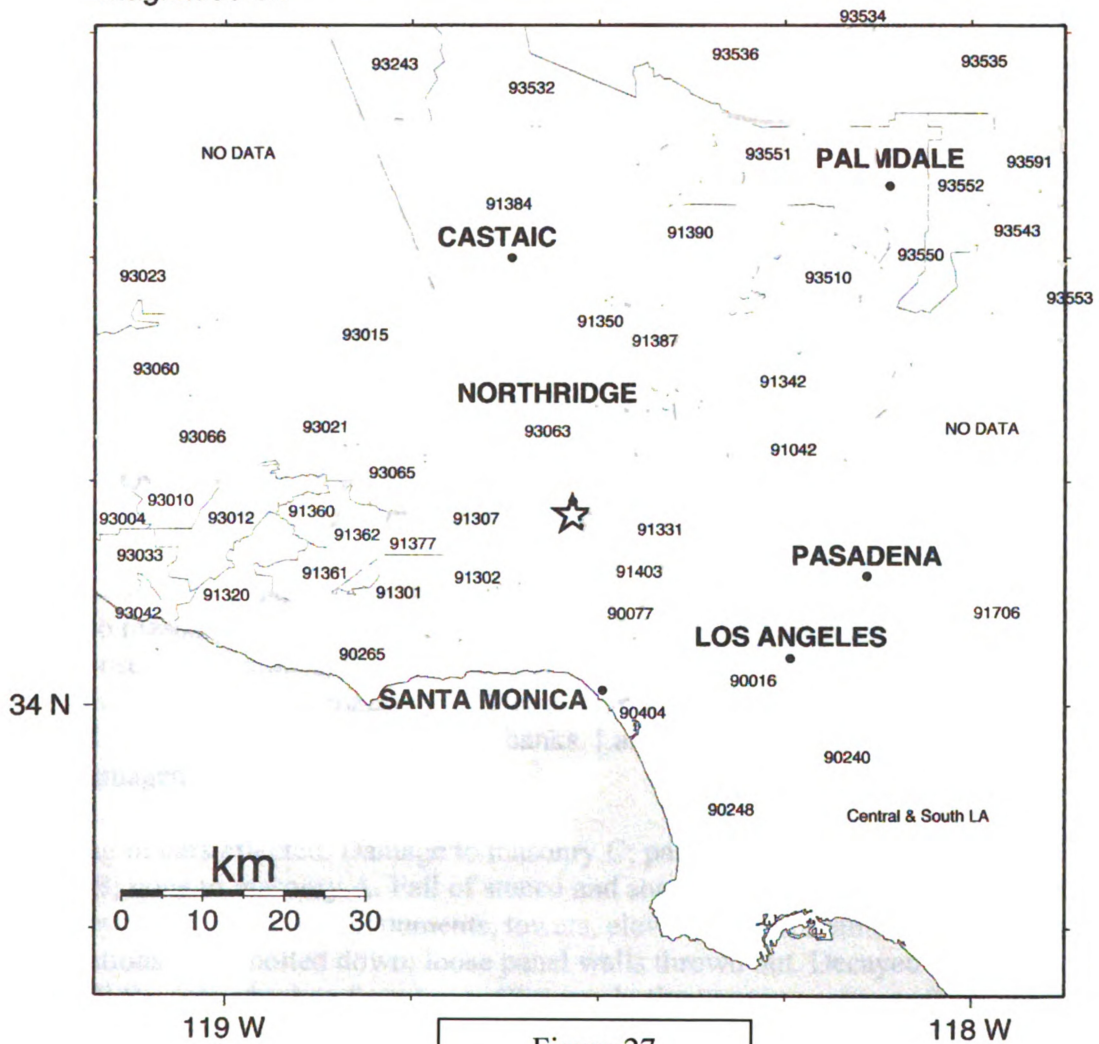
- Copy of Modified Mercalli Scale (classroom set)
- Copy of map with zip codes
- Colored Pencils
- Copy of Earthquake experiences (classroom set)

Directions:

1. Work in groups of 3 or 4 people.
2. Create a color code you are going to use on the bottom of the zip code map
3. Read the narratives and give them an intensity number based on the Modified Mercalli Scale. You WILL want to break this up amongst your group members for time sake.
4. Hint: An earthquake has one magnitude, but many different "intensities."
5. Hint: The intensity of shaking generally decreases with distance from the epicenter.
6. Hint: The intensity of shaking also is influenced greatly by the type of underlying material – soft sediments shake more than hard rock
7. Color in the map to match your assigned values and color code.
8. Answer Questions
9. Move on to part 2



USGS Community Internet Intensity Map for Northridge (JAN 17 1994)
Magnitude 6.7



Modified Mercalli Intensity Scale

- I.** Not felt. Marginal and long-period effects of large earthquakes.
- II.** Felt by persons at rest, on upper floors, or favorably placed.
- III.** Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
- IV.** Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing cars rock. Windows, dishes, door rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.
- V.** Felt outdoors; direction estimated. Sleepers awakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
- VI.** Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle.
- VII.** Difficult to stand. Noticed by drivers. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, also unbraced parapets and architectural ornaments. Some cracks in masonry C. Waves on ponds, water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
- VIII.** Steering of cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells.
- IX.** General panic. Masonry D destroyed; masonry C heavily damage, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas, sand and mud ejected, earthquake fountains, sand craters.
- X.** Most masonry and frame structures destroyed with their foundations. Some well- built wooden structures and bridges destroyed. Serious damage to dams, dikes,

embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Earthquake Experiences Narratives

93065, 91362, 91367--I was driving home from work and it felt like I had a flat tire. I pulled off the road to check and as I stopped the car I saw the chimney on a nearby house collapse. It fell right on a new Lexus that was parked in the driveway.

93012, 91301, 91361, 91360, 93033, 93004, 93021, 93010, 91320-- I had just gotten up to give my baby daughter her bottle when I felt a violent jolt. I knew we were having an earthquake so I tried to run into her room to get her but it was so hard to walk! I could hear things outside falling and hitting the ground, and all of the pictures in the hall were falling and breaking. I was so scared!

90248--I am a nurse at a local hospital. I was attending to Mr. Jones when I first felt the earthquake. He woke up and we watched a glass of juice on his bedside table slide back and forth -- I caught it before it tipped. Most of the patients woke up -- let me tell you, it was a long night!

90265--My parents were out of town visiting my brother at college so my best friend John and I decided to have a party. The party was pretty much over and we were doing damage control in the back yard when I felt something weird. I thought it was just me but then everything started to shake. I mean, even the pool had waves in it and the water was spilling out over the edges! And so much stuff in the house had fallen over and broken you couldn't even tell we had a party!

91387--I work the late shift at Denny's. I was outside on my break when I felt the first shake. Then everything started shaking so hard I could even hear the bushes rattling! The people inside felt it too. Their plates and glasses were shaking and bouncing and a bunch of them came running outside. I don't know where they thought they were going to go, it was shaking outside too!

93510--I am from Virginia and I was in California visiting my grandchildren. In the very middle of the night I woke up and felt a strange rumbling. Then things started to shake a bit and my grandson ran into my room and told me to stand in the doorway, that we were having an earthquake. Well, that door was swinging back and forth and I told him that I would stay right where I was thank you very much! I wasn't going to get knocked out by some door and have to be taken to the hospital in my nightclothes!

91706--I am a really heavy sleeper and I didn't even wake up, but my husband was up getting a snack and he said he felt it. He said the dishes in the cupboard rattled and he could see the hanging plants swaying.

91042--I am a seismologist with the USGS and my first thought when I felt the earthquake was "I'm going to work tonight!" My husband and I watched as several picture frames slide off the mantle, and then we ducked under the table. We had to hold on because the table was trying to slide away. Lots of our dishes were broken and we have a lot of cracks in the walls to fix.

90016--I was sleeping soundly when I was suddenly thrown out of bed. I could hear my kids crying and I was trying to run, trying to get to them. The walls were shaking and cracking and pieces of plaster were falling from the ceiling. I could barely stand. The noise was deafening. By the time I got to my kids, the whole thing was over. We have a lot of damage to our house but not as much as our neighbors. Their house partially collapsed.

91331--I'm a night watchman at an apartment complex. It was pretty late and everything was real quiet. I was making my rounds when I felt a strong jolt-it almost knocked me off my feet! I ran out into the middle of the street and it's a good thing I did too! Bricks were falling off of the building and the trees were shaking so hard that branches were breaking and falling off. All of the parked cars around me were shaking and bouncing and the car alarms were all going off.

91384--My daughter had just arrived home (WAY past her curfew) and we were arguing in the den. When we felt the shaking, we just stared at each other. The sound of a glass smashing snapped us out of it. We both ran to the China hutch where I keep my mother's china-- it was just about to tip over! We held it up and we could hear other things around the house falling and breaking. Needless to say I wasn't worried about the curfew violation anymore!

93015--I was up late working on a briefing when I first felt the earthquake. It didn't seem too bad at first so I stayed put to see if it would get worse. It did! I tried to get up and could barely stand. I remembered that you're supposed to get under a table if it's a bad earthquake so I got down on my hands and knees and crawled under my table. Just as I got under there, my big bookcase fell and smashed on the table. If I had still been sitting there it would have crushed me.

93543--We were out of town when the earthquake hit. Of course, we were scared for our friends and family and for our home. We called our son and he said that everyone was all right, but they had a lot of structural damage to their house, and had lost some personal items. We called the neighbors and they gave us a grocery list of damage to our house: chimney broken at the roofline, cracks in the masonry, fallen bricks, stuff like that. I'm afraid to go home and see the damage inside.

93532, 93243, 93536--My husband woke me up yelling that we were having an earthquake. We stayed in bed and held on tight. I could hear the plates and cups banging and rattling, and all of the pictures were falling off the walls. I knew we were going to be all right because our house is retrofitted and all of our things are secured, but I was worried about my mom and dad, who live in an older home.

93060, 93023--I was asleep when the earthquake came. I was so scared and I didn't know what to do. The house was shaking so bad that I couldn't even walk. My dad came into my room and got me and we got under the table. We could see the refrigerator sliding back and forth across the kitchen with its door opening and shutting and all of the stuff

falling out onto the floor. Our TV went flying across the room and smashed into the wall. All over we could hear things breaking. Then the lights went out. After it stopped and we went outside we could see all of the other people outside too. They were crying and looking around. Part of our apartment building fell down and now those people have to find another place to live. We might have to too.

93591--I was just finishing a great Tom Clancy novel when I felt the earthquake. At first I thought it was a passing truck but then I noticed that the blinds were swinging a little bit. I thought about calling my buddy to see if he had felt it but it was late and I was pretty sure it wouldn't have woken him up.

93551, 93534--I was sleeping over at my friend's house when the earthquake came. We were supposed to be asleep but we were telling stories so we felt it first. She said that her family had an earthquake plan and we were supposed to go into the dining room and get under the table. It was kind of scary because all of the furniture was moving around and her dad's computer fell on the floor and broke, but I wasn't really scared because her mom and her dad said that we were prepared and we'd be okay.

91377, 91301—I was driving home from my late shift when it felt like the car wasn't driving normally. Then I noticed dirt sliding down the steep side of the ditch next to the road. I stopped the car on the side of the road and got out. That's when I noticed the new cracks in the concrete wall on the other side of the ditch. By that time, the shaking had stopped, so I got back in my car and drove home.

93552, 93535, 93550—I was working on my computer when the earthquake struck, and it was scary. My desk chair was rolling back and forth across the floor, and all the pictures fell off the bookshelves. My computer almost fell off the table too!

91342—I had fallen asleep watching TV when I felt a tremendous jolt. Things were things flying through the air and I ran to get under cover. There was a huge crash and part of my ceiling fell in. My chimney had collapsed!

91302—It was exam week and I was coming home late from the library when I felt the shaking. I had to run into the middle of the street to get away from the tree branches. They were breaking off and falling all around me!

90404—I was out of town for the earthquake, but my neighbor says our house has sustained a lot of damage. It fell off the foundation. I guess we shouldn't have put off that retrofitting.

93066—I thought the earthquake was great! What a ride! Our panel walls fell down, and we have some damage to the masonry, but it was such a fun experience! I can't wait to tell my friends back east!

91350—I'm a bus driver on the graveyard shift. I thought I must have blown out a tire because it was so hard to drive. I pulled over to the side of the road and turned my head just in time to watch the old factory tower fall down!

91390—Our big surprise from this earthquake was the next morning when we went outside and saw big cracks in the hillside behind our home. Scary!

90240—My wife woke me up and asked me if I felt anything. I told her the only thing that I felt was her shaking me! She said she thought we were having an earthquake, and when I stopped and listened I could hear the glasses in the kitchen rattling and clinking. There was an earthquake-and a pretty big one! Who knew?

93553—I was sleeping when I felt the first jolt. I got out of bed but it was hard to stand, so I sat down and held on. I was amazed by all the noise -- car alarms were going off, things were falling and breaking, and the church bells across the street were even ringing! Can you imagine? Those things are huge!

91403—I had just gotten up to go to the bathroom when the earthquake came. It was unbelievable. It threw me off my feet. My roommate and I ran to get underneath the dining room table. As I was running I saw my computer flying through the air. Once we got under the table we held on for dear life! It felt like it lasted forever but really it was only a few seconds. Once it stopped we went outside and saw the mess. Pipes had broken and everything was flooding, there were little sand volcanoes in the front yard. There was lots of damage to people's houses and chimneys but nobody on our block was badly hurt. It was the most frightening experience of my life.

93063—I was at a soccer game when the ground started shaking really hard. Our whole team was really scared, and most of us sort of fell to the ground because it was so hard to stand up. It was really weird when some sand sprayed up from a couple of places in the field. When the shaking stopped, we saw some of the houses on the street looking lopsided, with collapsed porches. There was even one that had collapsed!

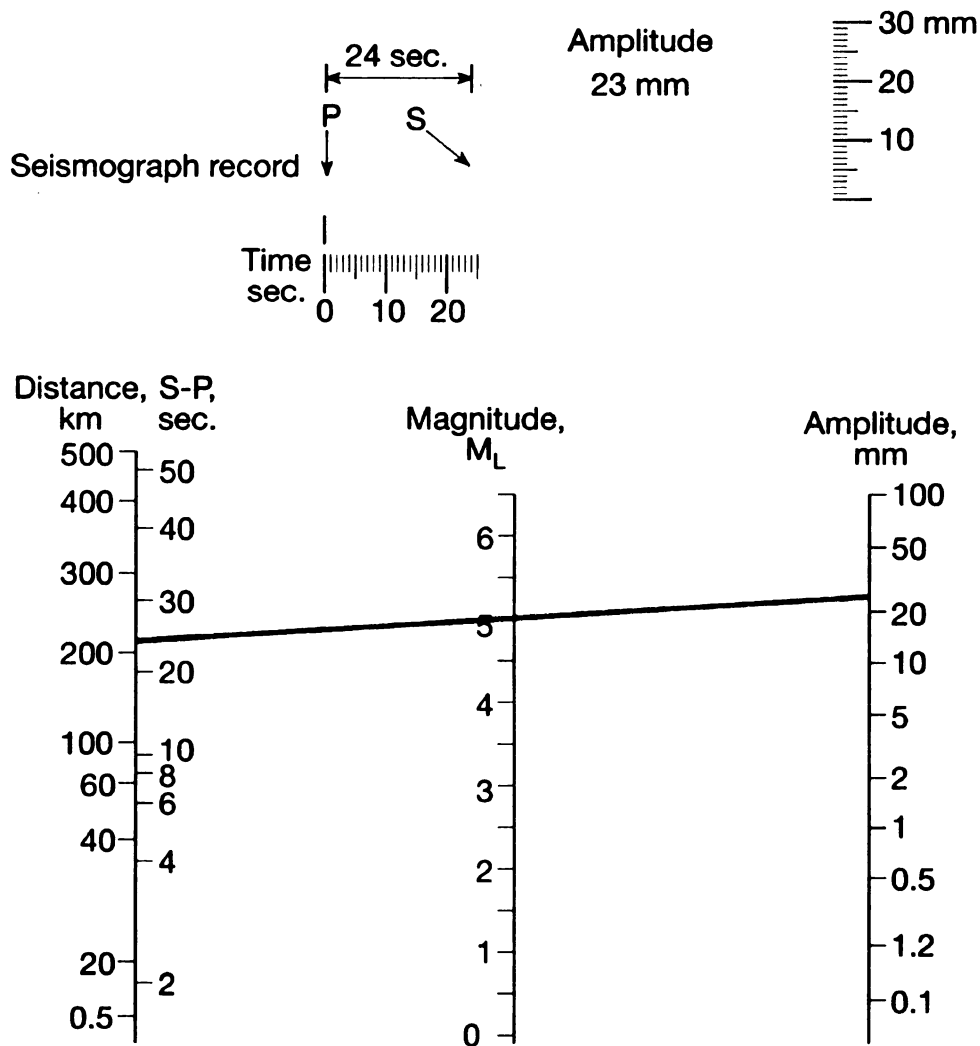
Central & South LA--I was asleep in bed when I felt the earthquake. It woke up my whole family, and we shouted to each other to stay put and hold on. It shook pretty hard, and we heard the rumbling of the ground and a lot of rattling. A glass fell off the table and broke, but that was all. It was a thrilling way to experience the power of nature.

Questions

1. Based on your findings, where would you place the epicenter of this Earthquake?
2. Is it possible for people who are equally as far from the epicenter to experience different things during an earthquake? Explain why you think this might be.
3. If scientists use seismographs to determine the amount of energy released and therefore the “size” of an earthquake, why does the modified mercalli scale exist?

Part 2 – Magnitude Scales Discussion

The Richter magnitude scale was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. There is a pattern in the richter scale. Every time the magnitude increases by 1 unit, the amount of energy released is 32 times greater. For example, a magnitude of 5.0 earthquake releases 32 times more energy than that of a 4.0. Scientists use the seismic waves discussed in our prior lab to determine that magnitude number the following way:



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Figure 28

Activity 4
Locating an Epicenter
Virtual Earthquake Lab

<http://www.sciencecourseware.com/VirtualEarthquake/VQuakeExecute.html>

Introduction:

In this lab you will be combining your knowledge of seismic waves and seismographs to locate an epicenter and also predict a location and magnitude in a similar way that a scientist would.

Directions:

1. You may work with a partner.
2. Go to the following link and follow the instructions provided.
<http://www.sciencecourseware.com/VirtualEarthquake/VQuakeExecute.html>
3. Make sure you print your certificate at the end of your lab experience.

Activity 5

Earthquake Proof Buildings

Introduction:

Depending on where you live, there are different building codes that architects and builders must accommodate. These laws are set into place for good reasons, as they help to protect the people that live in the structures. Fortunately larger earthquakes are more rare than smaller ones that occur all the time. As of today we can not accurately and reliably predict earthquakes.

Historic Earthquakes:

Largest Earthquakes:

1960 Chile 9.5
1964 Alaska 9.2
2004 Indonesia 9.0
1952 Kamchatka 9.0

Deadliest Earthquakes:

2004 Inodnesia 200,000 Deaths
1556 China 830,000 Deaths
1976 China 255,000 Deaths
2005 Pakistan 54,000 Deaths

When looking at this information it is important to note that the largest earthquakes do not necessarily result in the most amounts of deaths. Only one reason for this could be because of building standards, but many others exist. What others can you think of? List five other reasons:

- 1.
- 2.
- 3.
- 4.
- 5.

Procedure.

In this lab you will work with your group members and design a building that can withstand our simulated earthquake waves. **HINT: THINK BEFORE YOU WORK**

Rules:

Building must stand 30 cm tall	Must hold a weight on each floor
Building must have 3 floors	
Only use materials provided	

Materials:

4 strips of 30 cm cardstock paper
12 strips of 10 cm cardstock paper
4 "floors"
2 Popsicle sticks
10 toothpicks
80 cm of tape
Scissors
glue stick

Questions:

1. What were some of the difficulties that you had building this?
 - 1)
 - 2)
 - 3)
 - 4)
2. What would happen if a building was constructed properly but was built on a sandy foundation?
3. Describe the three types of seismic waves discussed in class.
 - 1)
 - 2)
 - 3)
4. List a few examples of what made the more successful buildings work
 - 1)
 - 2)
 - 3)
 - 4)
5. Where in the United States would you expect the strictest building codes to exist with respect to earthquakes? Why would you expect this?

Where:

Why:

6. Look at the map of the 1895 New Madrid earthquake and the 1994 Northridge earthquake. The darker shaded areas represent a larger magnitude.

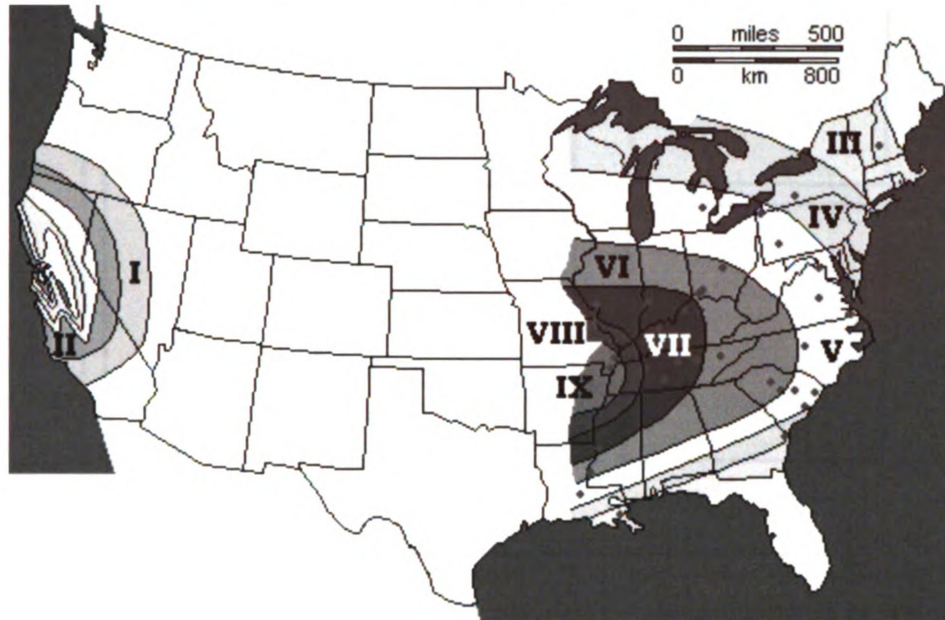


Figure 29

(Source <http://www.showme.net/>)

Based on what you see here, where in the United States should there also be building codes that call for earthquake safety?

Locations:

Considering the deadliest earthquakes take place in areas with no building standards, the debate is if we should consider new standards as far as Michigan. Tell me what you think about this in one paragraph.

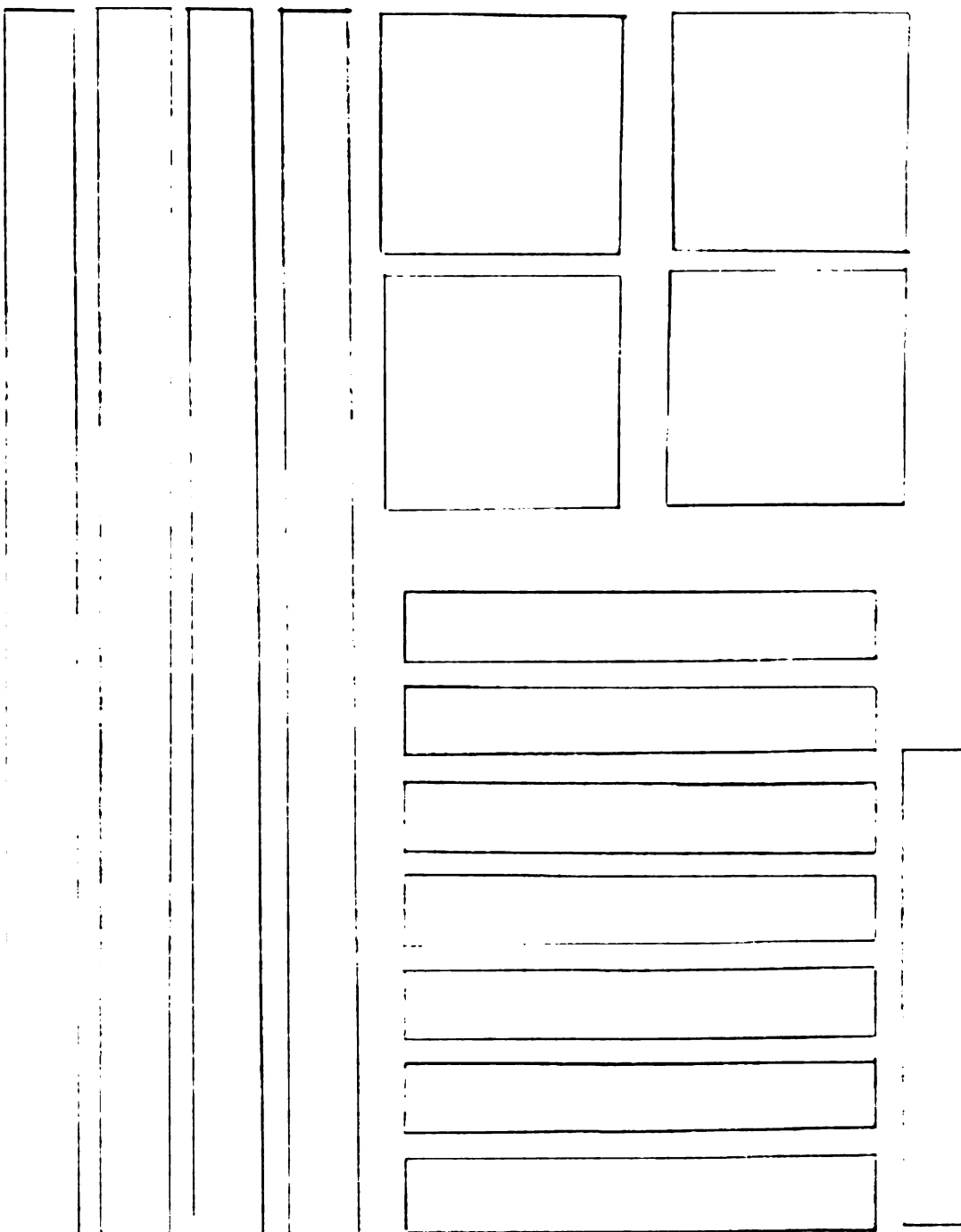


Figure 30

Activity 6 Location of Earthquakes and Volcanoes

Introduction:

Searching for patterns in data is often something that a scientist will do to help explain observable things. In part 1 of this lab you will be looking at the locations of earthquakes globally and searching for a pattern. In part 2, you will also take a look at the locations of volcanoes. The larger pattern that you observe is something scientists have used as evidence for larger plate tectonics.

Procedure:

Part 1:

Plot the following earthquake locations on the map using longitude and latitude. Plot them with ONE COLOR even though there are two columns of colors here.

The RED coordinates go together and the BLUE coordinates go together. (Saves Paper)

Earthquake Locations			
Latitude	Longitude	Latitude	Longitude
9.8 N	124.7 E	6.0 S	77.2 W
9.7 N	124.6 E	45.8 N	26.7 E
31.7 N	121.0 E	45.8 N	26.8 E
34.1 N	117.7 W	3.6 S	144.4 E
22.1 S	175.2 E	11.8 N	121.9 E
51.5 N	175.0 W	47.9 N	85.1 E
9.9 N	84.8 W	27.4 N	65.7 E
11.4 N	86.3 W	37.0 N	49.4 E
15.1 N	147.6 E	21.6 S	176.5 W
39.4 N	74.9 E	15.7 N	121.2 E
1.2 N	122.9 W	16.5 N	121.0 E
36.0 N	100.2 W	154.4 S	167.5 E
37.9 N	122.0 E	48.0 N	85.0 E
6.9 N	82.6 E	29.6 N	137.6 E
49.0 N	141.8 E	19.4 S	169.1 E
40.3 N	176.1 E	11.2 S	162.0 E
5.3 N	31.8 E	33.3 N	138.6 E
5.1 N	32.1 E	23.5 S	179.0 E
5.4 N	31.9 E	11.0 S	70.8 W

Table #4 –Earthquake Locations
(table from www.saratogaschools.org)



Figure 31

Source: www.enchantedlearning.com

Part 2:

Plot the following earthquake locations on the same map using longitude and latitude.

Plot them with ONE COLOR that is different than the Earthquake one, even though there are two columns of colors here.

The RED coordinates go together and the BLUE coordinates go together. (Saves Paper)

Volcano Locations			
Latitude	Longitude	Latitude	Longitude
0.1 N	77.7 E	6.1 S	105.4 E
16.2 S	70.8 W	12.2 N	93.8 E
34.2 S	69.9 W	36.4 N	25.4 E
52.3 S	73.4 W	40.8 N	14.4 E
38.6 N	28.0 W	29.0 N	13.7 E
63.6 N	18.9 W	50.3 N	155.3 E
71.0 N	8.0 W	58.3 N	155.0 W
13.6 N	40.6 E	46.9 N	121.8 W
1.5 S	29.2 E	40.5 N	121.3 W
11.9 S	43.3 E	27.5 N	112.7 W
19.5 N	155.9 W	19.5 N	102.1 W
77.5 S	168.0 E	10.2 N	84.2 W
18.1 N	145.8 E	51.9 N	177.2 W
2.9 S	38.1 E	30.2 S	178.9 E
33.4 N	126.5 E	18.8 S	174.6 W
13.3 N	123.7 E	22.3 S	172.1 E
0.3 N	127.4 E	10.4 S	165.8 E
1.4 N	124.8 E	5.6 S	150.6 E
6.3 S	130.0 E	35.4 N	138.2 E

Table #5 –Volcano Locations

(table from www.saratogaschools.org)

Discussion Questions:

1. Write in this space any observations that you notice about the locations of earthquakes
 - 1)
 - 2)
 - 3)
2. Write in this space any observations that you notice about the locations of volcanoes.
 - 1)
 - 2)
 - 3)
3. Which coast of North America has the greatest amount of earthquakes and volcanoes?
4. Which ocean has the greater amount of earthquakes and volcanoes along its coasts?
5. According to your map what is the probability of either an earthquake or volcano occurring in your region?
6. How are earthquakes distributed on the map? Are they scattered evenly over Earth's surface? Are they concentrated in definite zones?

Did you notice the pattern in the location of the earthquakes and volcanoes? Take a look at the following map of locations of tectonic plate boundaries.

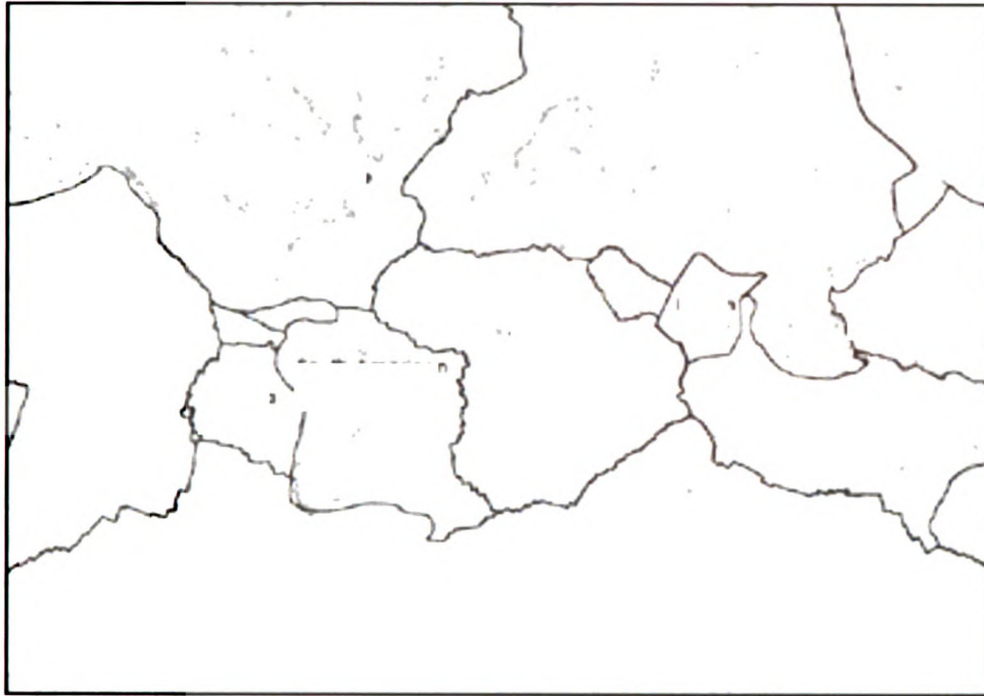


Figure 32
(Source: <http://earthobservatory.nasa.gov>)

Preliminary Determination of Epicenters
358,214 Events, 1963 - 1998

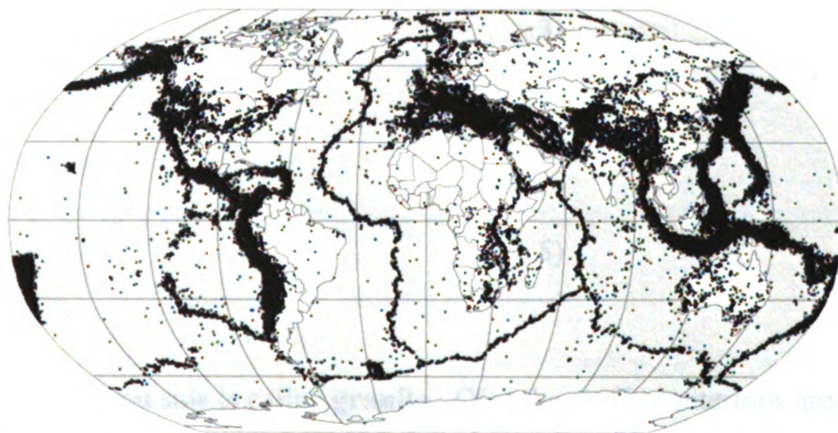


Figure 33
(Source: <http://jupiters.narod.ru/puls/zem01.png>)

Scientists have used the evidence from earthquakes we have studied as well as volcanoes to understand a more global concept called plate tectonics. The energy that is released as these plates move past each other are what we call earthquakes. In the next unit we will discuss volcanoes and understand more about these tectonic plates.

Activity 7

Observations of Rock

Introduction:

Every rock tells a story. When a geologist looks at the rocks and “reads” them, they are looking into the past history of an area. By simply noticing what types of rocks are present a person can get a general idea of a tectonic setting. This is an over simplified explanation, and there are many other types of rock.

The following two rock types that you will be looking at are granite, and basalt.

Activity:

In your small group look at the two rocks sitting in front of you. Make a minimum of three observations you notice about the rocks. In the second column give a reason why you think this rock looks like this.

Observations:

1)

2)

3)

4)

5)

Reason:

1)

2)

3)

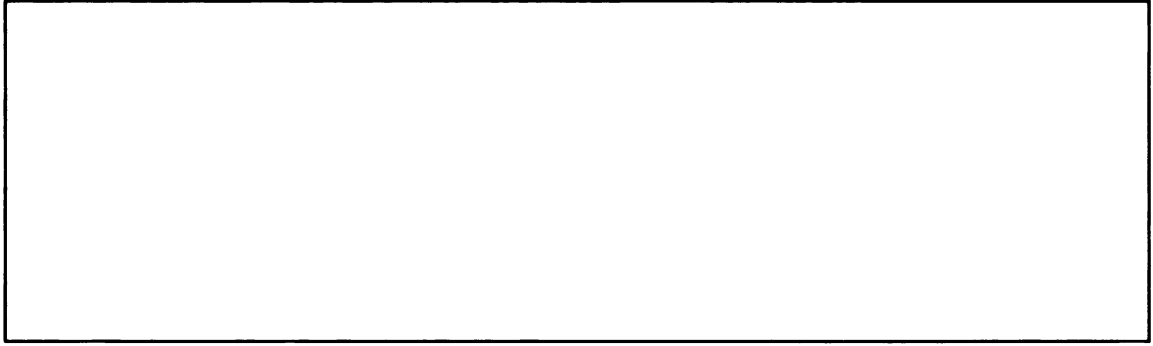
4)

5)

Discussion:

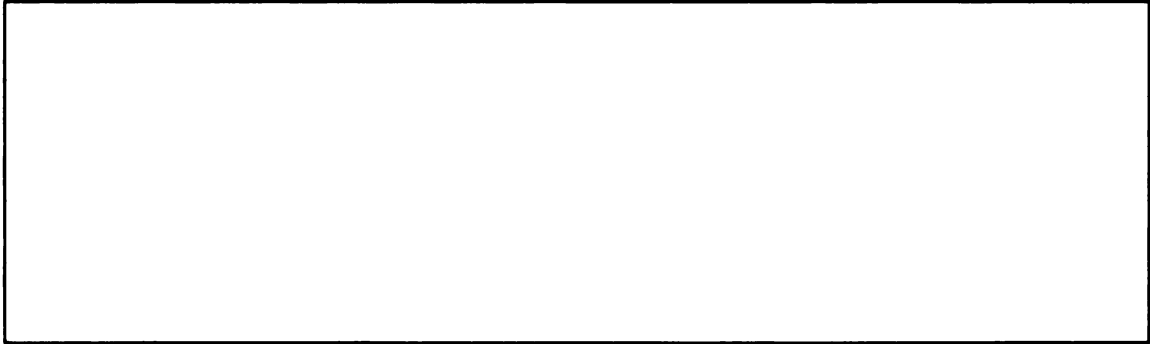
The first type of rock that you saw is called **granite**. (Yes the stuff countertops are made of). This term is BROAD and includes a lot of types of textures and colors. What is important to us is that it is an intrusive rock, which means it forms and cools under the ground. When tectonic plates collide it can form volcanoes in the following setting:

Draw This from the board....yes color it too. This rock is HIGH in silica, which makes it very sticky and hence has large eruptions. Type of location: Cascade Mountain Range.



The second type of rock that you saw is called **basalt**. This type of rock comes from magma that is very fluid and flows out onto the surface before cooling. The tectonic setting that this can form at is the following:

Draw this from the board...yes color it too. This rock is LOW in silica, which makes it less sticky and can flow easily. Type of location: Hawaiian Island.



Determine the density of the two rock types using the submersion method. Remember that $\text{Density} = \text{Mass}/\text{Volume}$

Mass of Basalt _____

Mass of Granite _____

Volume of Basalt _____

Volume of Granite _____

Density of Basalt (g/ml) _____

Density of Granite (g/ml) _____

Activity 8 Types of Volcanoes and Eruptions

Intro:

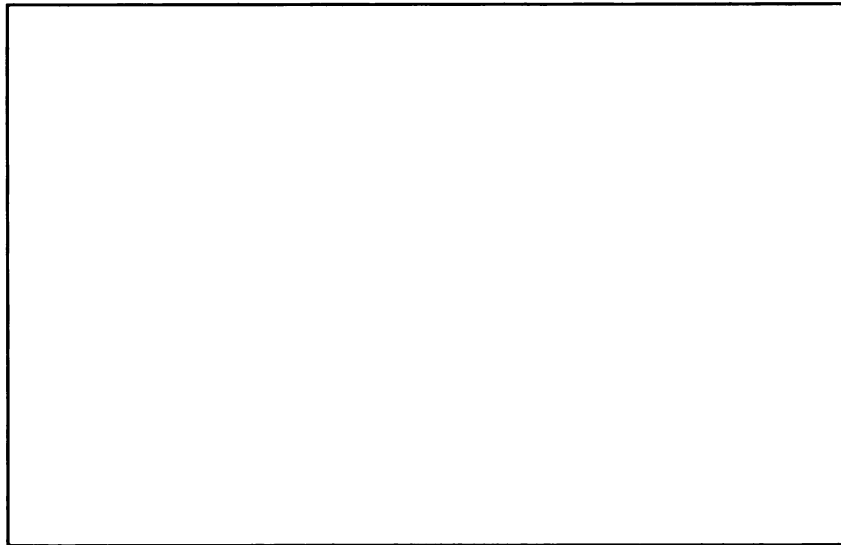
We will be looking at three types of volcanoes in this activity and how they erupt differently. When taking into account different tectonic settings we can understand why this is. The three types are Shield, Composite, and Cinder Cone. You will need to make a diagram of each type, as well as answer the questions. Your textbooks will be very helpful for this from pages 193-197 as well as your NOTES.

Shield Volcano:

An example of a shield volcano would be the Hawaiian Islands.

Diagram including:

Slope of sides
Scale for size
Rock Type
Magma Chamber
Vent
Lava Flow
Crater
Temperatures
What is ejected
Lava
Magma
Yes Color it



Questions:

1. The type of eruption associated with a shield volcano is (explosive/non-explosive/mixed) _____.
2. In terms of danger to people, how dangerous is a shield volcano eruption?
3. The type of lava that comes from a shield volcano would flow (easily/not flow) _____.
4. Describe the role of trapped gasses and silica in the eruption of a shield volcano.

Gasses:

Silica:

5. Based on your answer to number 2, what would the rock type that you expect to seen be in Hawaii.

Rock Type:

6. Describe the tectonic setting that a shield volcano is found.

Composite Volcano:

An example of a composite volcano would be Mt. St. Helens.

Diagram including:

Slope of sides

Scale for size

Rock Type

Magma Chamber

Vent

Lava Flow

Crater

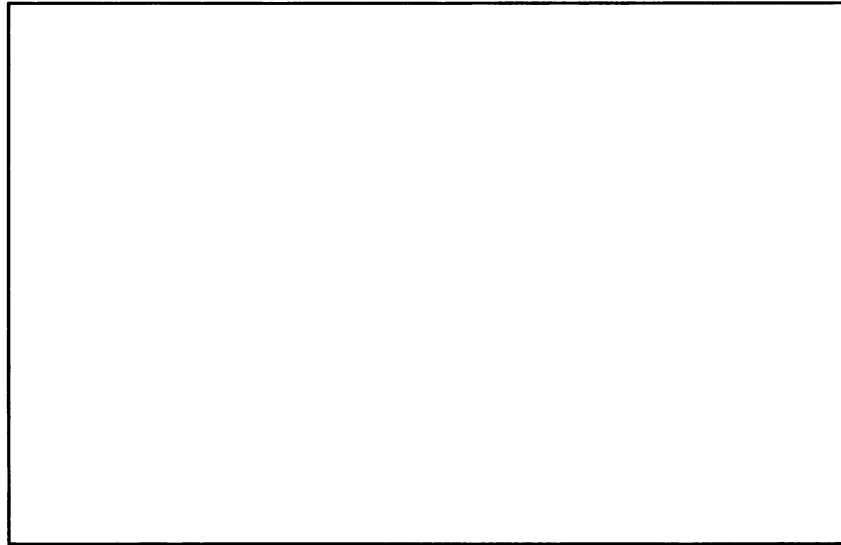
Temperatures

What is ejected

Lava

Magma

Yes Color it



Questions:

1. The type of eruption associated with a composite volcano is (explosive/non-explosive/mixed) _____.
2. In terms of danger to people, how dangerous is a composite volcano eruption?
3. The type of lava that comes from a composite volcano would flow (easily/not flow) _____.
4. Describe the role of trapped gasses and silica in the eruption of a composite volcano.

Gasses:

Silica:

5. Based on your answer to number 2, what would the rock type that you expect to seen be in the cascade mountain range? (Where Mt. St. Helens is).

Rock Type:

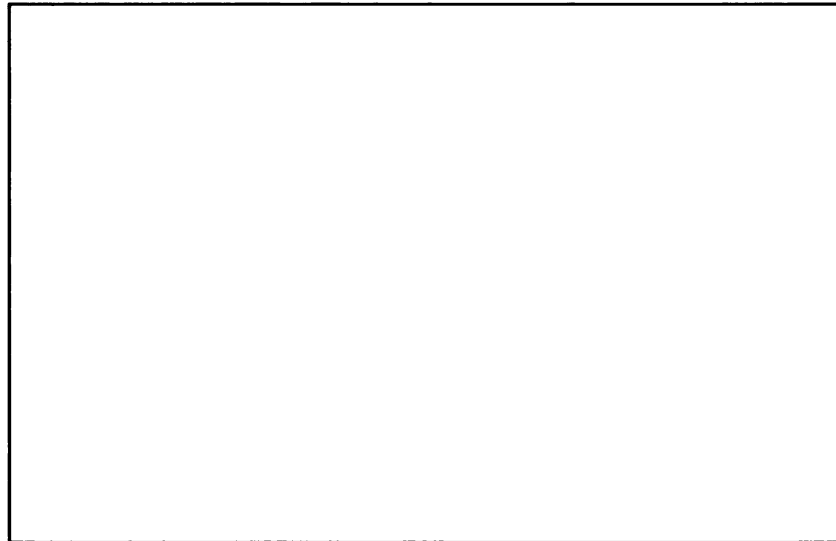
6. Describe the tectonic setting that a composite volcano is found.

Cinder cone volcano:

An example would be Mt. Pelee, located in the Caribbean.

Diagram including:

Slope of sides
Scale for size
Rock Type
Magma Chamber
Vent
Lava Flow
Crater
Temperatures
What is ejected
Lava
Magma
Yes Color it



Questions:

1. The type of eruption associated with a cinder cone volcano is (explosive/non-explosive/mixed) _____.
2. In terms of danger to people, how dangerous is a cinder cone volcano eruption?
3. The type of lava that comes from a cinder cone volcano would flow (easily/not flow) _____.
4. Describe the role of trapped gasses and silica in the eruption of a cinder cone volcano.
Gasses:

Silica:
5. Based on your answer to number 2, what would the rock type that you expect to seen be in the Caribbean? (Where Mt. Pelee is).
Rock Type:
6. Describe the tectonic setting that a cinder cone volcano is found.

Activity 9

Assessing Volcanic Hazards

Lab by Dr Jess Trofimovs, Dr Howard Falcon-Lang and, Alexandra Borowik.

Background: Montserrat is a volcanic island in the Caribbean. It has three volcanic centers: an extinct volcano in the northern part of the island (Silver Hills), an extinct volcano in the middle part of the island (Center Hills) and an active volcano in the southern part of the island.

You are a geologist working on Montserrat and the volcano has started to erupt lava and produce small volume rock falls. All the signs from monitoring the volcano point to a future large explosive eruption forming pyroclastic flows. This could be extremely hazardous to the 12,000 people living on the island.

You decide to map out where past volcanic pyroclastic flow and mudflow deposits have been emplaced. You produce the following map (see over the page).

Based on the signs pointing to an impending eruption, the closeness of the capital city to the volcano and the distribution of the prehistoric deposits, what do you propose to do?

Exercise:

- Draw on the map overleaf where you think the safe areas to live would be (if any).
- In a letter to the Governor of the island, explain where you think the safe areas will be, and why.
- Include advice on whether or not the capital city of Plymouth should be evacuated, explaining your reasons.
- If you do recommend evacuation of Plymouth, where would you relocate the residents?

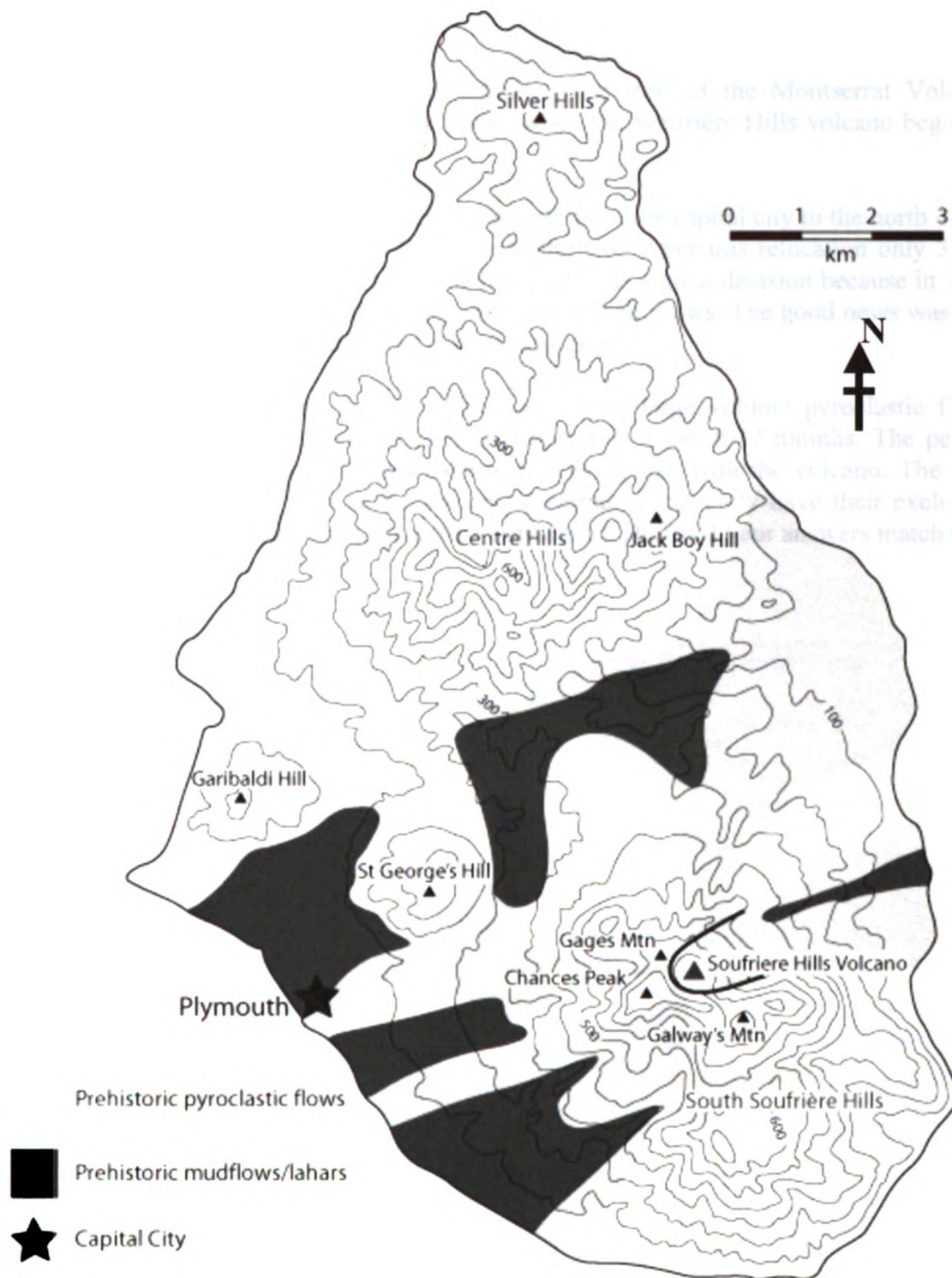


Figure 34

Source(http://www.earth4567.com/talks/volcanoes/volcano_ex2.pdf)

Solution:

This exercise is based on a real-life scenario. The staff of the Montserrat Volcano Observatory had to make the same decisions when the Soufrière Hills volcano began to erupt in 1995.

The decision they made was to relocate the people from the capital city to the north of the island, to other islands in the Caribbean or to the UK. After this relocation only 3,500 people were left living on the island. This however, was a good decision because in 1997 the capital city of Plymouth was destroyed by pyroclastic flows. The good news was that no one was injured in this eruption as the city was empty.

The Soufrière hills volcano is still active today with large volume pyroclastic flows traveling down the sides of the volcano approximately every 6-12 months. The people left on Montserrat (4,500 residents) have to live every day with the volcano. The map below shows where the staff at the volcano observatory currently have their exclusion Zone (the area that no one except scientists may enter). How did your answers match up?

Activity 10
Ocean Profile Activity
Part 1

Based on Prentice Hall: Science Explorers: Earth's Waters:

The first attempt at measuring the ocean floor's depth was by the H.M.S. Challenger from 1872-1876. The problem was this required the lowering of a weight until it struck bottom. Time consuming, yet gave us a new image of the ocean floor, that is NOT flat!

Electronic depth sounding was invented in the 1920's, which gave us an easier way to plot depth in the ocean. This, coupled with Harry Hess's later discoveries, gave Alfred Wegners' Continental Drift hypothesis more evidence.

Imagine you are an oceanographer traveling across the Atlantic along the 45° N latitude lines. You and your crew are using sonar to gather data on the depth of the ocean between Nova Scotia, Canada, and the town of Soulac on the coast of France. In this activity, you will plot depth data to create a profile of the ocean floor. After that we will look at some of Hess's discoveries as well.

Activity:

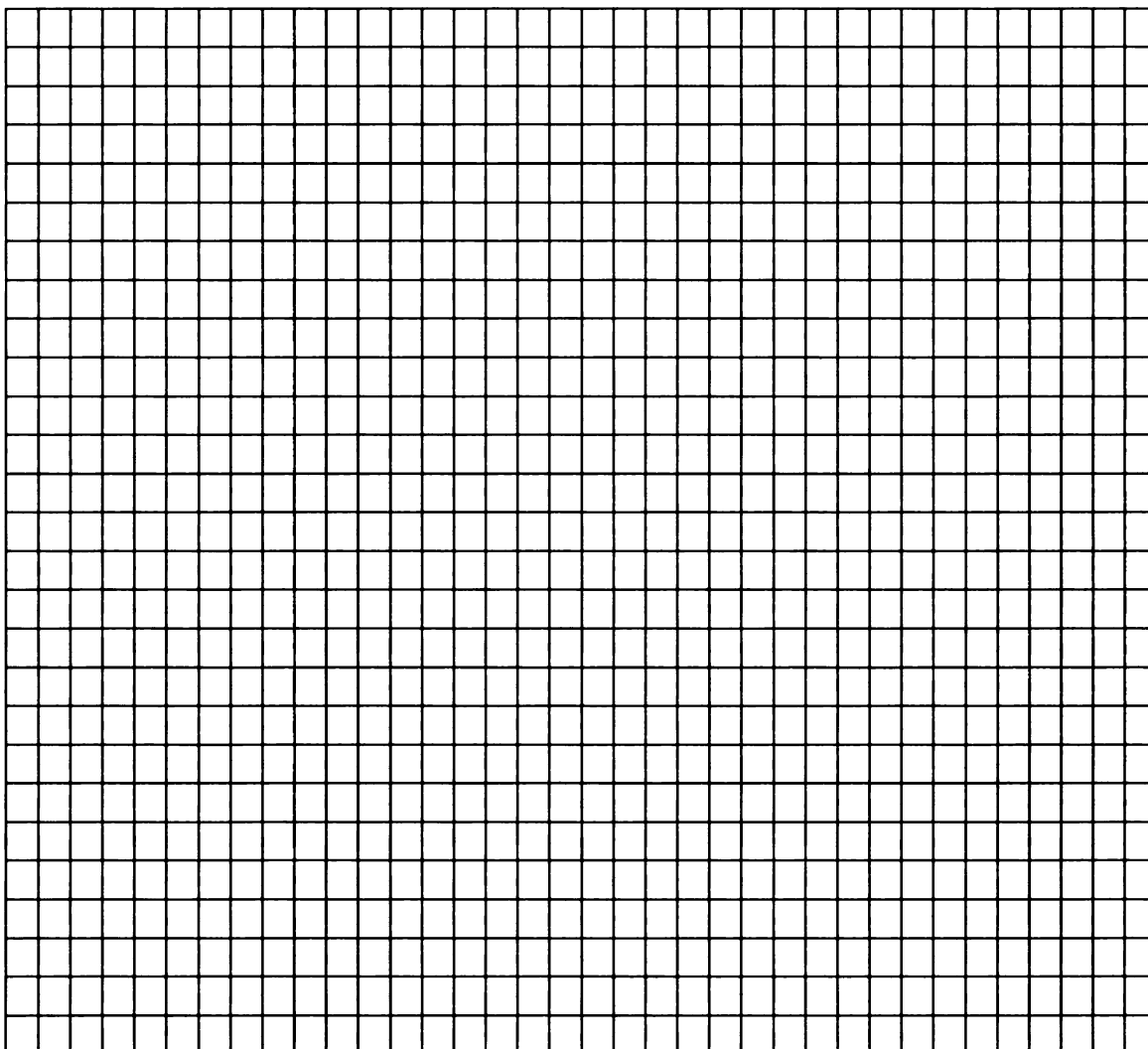
Your group will need to plot the following points in the graph on the next page.

Ocean Depth Sonar Data	
Longitude (° W)	Ocean Depth (m)
1. 64	0
2. 60	91
3. 55	132
4. 50	73
5. 48	3512
6. 45	4024
7. 40	3805
8. 35	4171
9. 33	3439
10. 30	3073
11. 28	1756
12. 27	2195
13. 25	3146
14. 20	4244
15. 15	4610
16. 10	4976
17. 05	4317

18. 04	146
19. 01	0

Table #5 -

1. Draw the axes of a graph. Label the horizontal axis Longitude. Mark from 65° W to 0° from left to right. Label the vertical axis Ocean Depth. Mark 0 meters at the top of the vertical axis to represent sea level. Mark -5000 meters at the bottom to represent the depth of 5000 meters below sea level. Mark depths at equal intervals along the vertical axis.
2. Examine the data in the table. The numbers in the Longitude column give the ship's location at 19 points in the Atlantic Ocean. Location 1 is Nova Scotia, and Location 19 is Soulac. The numbers in the Ocean Depth column give the depth measurements recorded at each location. Plot each measurement on your graph. Remember that the depths are represented on your graph as numbers below 0, or sea level.
3. Connect the points you have plotted with a line to create a profile of the ocean floor.



Question:

- 1) What do you notice in the middle of the ocean profile?

Part 2

The following map shows the ages of basaltic ocean crust in millions of year on either side of the mid-ocean ridge you just plotted in the previous graph. Color in the picture based on age ranges using a color scheme. You will need to extend the lines to the end of the picture.

0-20 million years _____, 21-35 million _____, 36-55 million _____,
56- 84 million _____, 85-118 million _____, 119-156 million _____, 157+ million _____

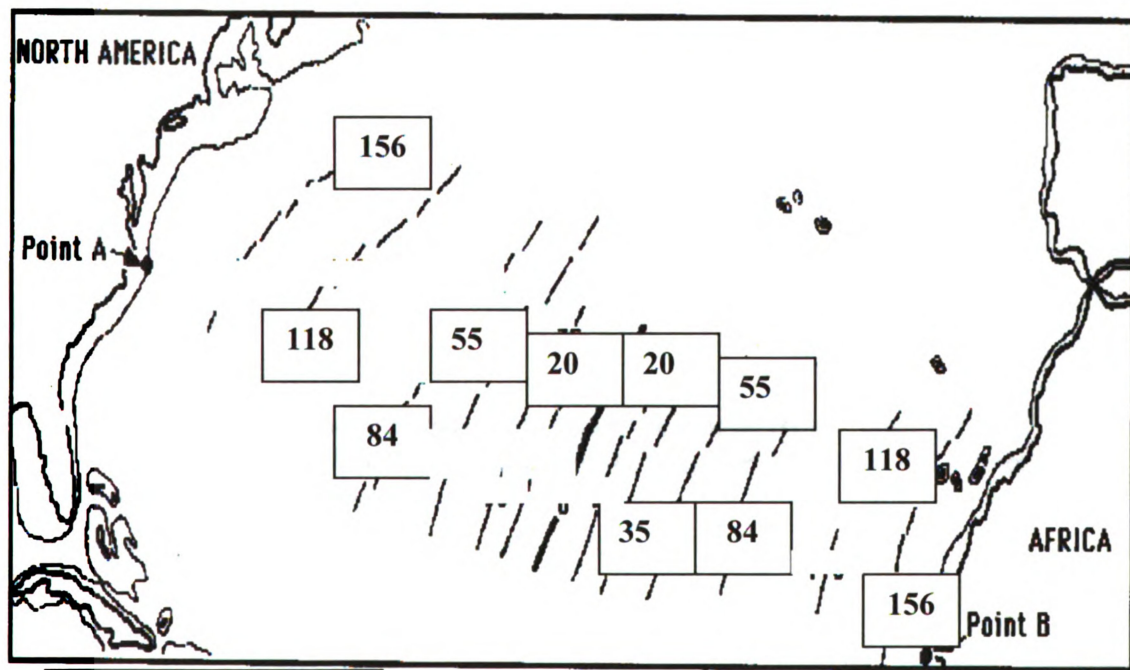


Figure 35

Question:

- 1) What is the pattern you see between the United States and Europe in ocean floor age?
- 2) What does this suggest about what is going on at the mid Atlantic ridge?

Activity 11 Crustal Plate Map Lab

Directions:

Using the map provide (National Geographic), answer the following questions.

1. Name the minor plate that is causing the volcanic activity in the Cascade Mountains and Mt. St. Helens. _____
2. What do the yellow spots represent in the areas of Hawaii, Yellowstone, and Iceland? _____
3. Name the volcano in south central Mexico that has had a devastating effect on that region. _____
4. Movement of what minor plate subducting beneath Mexico caused the 8.1 earthquake that destroyed Mexico City in 1985. _____
5. Locate the Mariana Trench in the Pacific Ocean. What is the Latitude and Longitude of this trench? What is the significance of this trench?

6. List the famous volcanoes in and around the Mediterranean Sea (List 3)
 - 1)
 - 2)
 - 3)
7. What does the pink color along the mid-ocean ridges represent. The bold red line shows the ridges. See the paragraph near 0 degrees longitude and 60 degrees south latitude for a hint!

8. Into what trench is the Nazca Plate subducting? _____
9. The Pacific Plate is being subducted into what two trenches in the northwest?

10. Name the great composite volcano in Northern California. _____
11. Locate the North Magnetic Pole. What is the Latitude and Longitude of this point? _____

12. Explain what happens to lava as it cools in relation to the North Magnetic Pole.
(Think of paleomagnetism)
13. How far does the Cocos Plate move each year to the north into the Middle America Trench? _____
14. Locate Iceland. What is the unique thing about this island?
15. Where would the oldest rocks be found in Iceland (central part, or eastern & western shorelines)?
16. Explain "Hot Spots". Give an example of a surface feature produced by Hot Spots.
17. Explain in detail how the Himalayas were created.
18. The African plate is moving into the Eurasian plate. What type of boundary is occurring there? _____ What is happening to the size of the Mediterranean Sea? _____
19. Locate the Eltanin fracture zone in the southern Pacific Ocean. In which direction is the seafloor crust moving on the north side of the fracture? _____ In which direction is it moving on the south side of the fracture? _____ What type of boundary is the Eltanin fracture zone? _____
20. Use the handout to label the direction the plate is moving on your map. Some may NOT be moving.

_____ American plate	_____ Australian-Indian plate
_____ Philippine plate	
_____ Pacific plate	_____ Eurasian plate
_____ African Plate	_____ Arabian plate

Activity 12
Plate Tectonics Computer Lab
Lab based on Tarbuck and Lutgens GEODe II CD

Directions:

*Log on. Click on the "GEODe" file on the desktop. Double click on the "GEODe16.exe" icon. It looks like a movie projector. Click on **Internal Processes**. Choose **Plate Tectonics** (frame 744)*

1. Watch frame **745** and replay as many times as you need to answer the following questions.
Look at specific continents and explain which direction they have moved through time.

- | | |
|---------------------|------------------------|
| a. N. America _____ | c. Eurasia _____ |
| b. Australia _____ | d. South America _____ |

2. Locate India and replay a few times. Explain how its location changed over time (where did it begin and where is it now?)

3. Frame **746-750**. What is happening to the Red Sea? It is becoming a

What happens to old seafloor?

What 3 boundary features (or characteristics) are caused by plate movement?
_____, _____, _____

4. Frames **755-759**. What portion of the earth do the plates form?

Where is this located? (notes)

How does the asthenosphere differ from the lithosphere? _____,

5. Where are the lithospheric plates the thickest?

Where are the lithospheric plates the thinnest? _____

6. What role does the asthenosphere play in Plate Tectonics?

7. Frames **760-763**. Where do mountain building, volcanoes, and earthquake activity happen? _____. Why do these things happen here and not at the center of plates?

8. Frames **764-67**. There are _____ types of plate boundaries: List them and include the type of plate and movement

Boundary type (continental/oceanic)	Movement	Plate type
_____	_____	_____
_____	_____	_____
_____	_____	_____

9. Frames **767-762**. Explain how new seafloor is produced -

At what rate is seafloor produced? _____

10. Frames **773-76**. If new seafloor is produced at the divergent boundaries, why is the Earth staying the same size?

11. Fill in the table below with the type of convergent boundary and the type of crust involved.

Boundary type	Arrows showing movement	Crust type(s)
involved		

_____	_____	_____
_____	_____	_____
_____	_____	_____

12. Frames **777-783**. What type of “zone” occurs when oceanic plates collide with continental plates?

_____. Why does it get this name?

13. (Notes) What is now thought to be “driving” the subduction zones?

14. What is the name of the volcano-types in frames **781, 782**? “(notes)

What is peculiar about the lava in these volcanoes?

How do they occur?

15. What causes the “trench” in these boundaries?

16. Frames **784-89**. What causes the volcanoes of the Philippines and Japan?

The islands of Japan and the Philippines are part of

17. Frames **790-95**. Collision zones. What accounts for ocean sediments and rocks found at collision zones (think!)

18. What (3) mountain ranges were built from this process?

19. Frames **796-805**. Transform faults occur when _____ without _____ or _____ of crust.

Locate and label the transform faults on the diagrams. Include arrows showing plate motion and motion at the fault.

Appendix III
High School Content Expectations Standards (HSCES)

http://www.michigan.gov/documents/Earth_HSCE_168206_7.pdf

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