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When Earth Fails: How Earth's Physical Changes Cause Natural Disasters

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The purpose of this unit is to present some basic principles of physical science to third grade students. I believe that the unit will also be of use to teachers of grades two thru five. The idea for the unit is an outgrowth of having done a previous unit about natural disasters. My original interest in natural disasters as a topic for teaching came from my observation that my students seemed to have a natural fascination with earthquakes, volcanoes, and other disasters. Of a more practical nature, physics is one branch of science that is not readily taught in elementary school and I was interested in learning more.

The basic principles I hope to cover are contained in Newton's second and third laws. The second law states that acceleration of an object at rest is produced when a force acts on the mass of that object. The greater the mass of the object being accelerated the greater amount of force is needed to accelerate the object. Thus, an object won't move until some force pushes it and the amount of force needed to move it depends on its size. The third law states that for every action there is an equal and opposite re-action. According to this when one object pushes another object it gets pushed back with equal force only in the opposite direction (Wiggins, pg. 41-42).

In order to convey this to students the unit focuses on four natural occurrences: landslides and avalanches, earthquakes, and volcanoes. The unit consists of a number of demonstrations simulating aspects of the natural occurrences mentioned with the aim of working backward to figure out how they occurred. While I have been putting the unit together, I have also been teaching aspects of the unit to my class. It has become apparent to me that they will need a lot of visuals and hands on activities.

The overarching purpose of this unit is to have students see that these occurrences are usually the result of some failure of nature. A landslide is the result of the failure of a slope of dirt to withstand the force of gravity. A similar thing happens in an avalanche only the failure is of a slope of snow. The eruption of a volcano is the result of the increasing pressure of the rising magma to fracture the rock above it allowing the magma to escape. Likewise, an earthquake occurs because of the failure of the tectonic plates to avoid collisions. Those earthquakes that are the result of divergent or pull-apart motion are the result of rocks failing (cracking) as a result of the tension placed upon them. Earthquakes resulting from a tranform fault or slide-past motion are the result of the uneven sides of the plates retarding their own movement and resulting in the release of large amounts of energy. Those earthquakes that are most destructive are those that occur at subduction zones where plates are colliding into one another and one is forced down under the other.

Introduction to the Unit

In beginning the unit my first concern is to present to my students information about the structure of the earth and how that leads to the natural occurrences we will be discussing. In order to lay a foundation for students the unit begins with a simple explanation of plate tectonics as a basic cause of volcanoes and earthquakes. I can see that it is a surprise to most of my students that the Earth is so dynamic - meaning it is constantly moving. For them the notion that we sit on moving plates floating on a thick asthenosphere is incomprehensible new information. I realized that the best place to begin a discussion of plate tectonics is with a quick overview of the interior structure of the Earth.

Basically, I wanted to use as simple an explanation of the interior of the earth as possible. I used an illustration from a web site called the Nevada Seismological Laboratory. It shows the Earths layered into four sections: the inner core (solid), outer core (liquid), mantle (plastic), and crust (rocky). I then further explained that the top of the mantle was composed of the crust and a stiffer material called the lithosphere. The lithosphere includes a series of rigid plates that float on the asthenosphere which is extremely hot and has a plastic like consistency.

At this point, I also told my students about Alfred Wegener, the German scientist who in 1915 thought that all the continents were once one super continent called Pangaea (pan-gee-ah). The reason Wegener and others developed this theory was in answer to a question they were trying to answer. How could fossils of the same plants, and animals be found on different continents? There was no way to explain how they could be on such widely separated land masses unless all the land was once joined.

I think Wegener's story is important because most of my students do not understand how scientists develop hypothesis and theories which may or may not be true. My students are use to finding or learning the right answer. The possibility of there not being an answer or of it being wrong is not acceptable. At the third grade level and even younger students have already let their own thinking be subverted by the need to have the correct answer. Taking a stand based on what they believe is correct is a foreign idea. They would rather follow the crowd and be wrong than risk being laughed at and possibly correct. It gives them some more insight to hear that Wegener was maligned by others who thought his ideas were crazy. Wegener's theory became more plausible when it was revealed that the seafloor was spreading apart making a new seafloor while the older part of the seafloor was dipping back down and being absorbed back into the mantle as part of the movement of the earth's plates. (Abbott, pg.53)

As part of this explanation, I decided to do a hands on activity concerning Pangea. There is a classroom activity sheet on prehistoric land masses from DiscoverySchool.com that is perfect for students' use. The page includes the outline of the continents. I gave one to each child and had them cut them out and try to see if they could fit them together as Pangaea was once thought to be. After some hesitation students began to manipulate the pieces and they each glued their pieces to construction paper. The Enchanted Learning web site has a section called "All About Plate Tectonics" (http://www.enchantedlearning.com/subject/astronomy/planets/earth/Continents.shtml) which gives some basic information and illustrations. Following this I showed them an animation of Pangaea and how it split up and moved to its present configuration. There are quite a few available on the web. One such site (http://www:ucmp.berkeley.edu/geology/anim1.html) is basically an animation of the progression of Continental Drift through different eras. It also offers a quick summary that would be helpful to teachers of what happened in each period.

I printed out a world map from a Free Maps website (http://www.yourchildlearns.com/geography.htm) that when connected was 3ft by 3ft. On that I outlined the basic 13 plates and named them. I also indicated in which direction each plate was moving. Students could then see that the plates do not travel in a synchronous fashion. They have over the years bumped -- sometimes crashed into each other which accounts for the variety of topological features on the Earth. In order to illustrate the basic movement of the plates I chose to use a demonstration from *Geology Rocks* by Blobaum which requires Graham Crackers and waxed paper spread with a thick layer of frosting or peanut butter. I tried the peanut butter.

The demonstration went as follows:

1. Two crackers (simulating plates) are put side by side on the peanut butter and are slowly moved apart. There is a rift or crack where the plates separate and magma (peanut butter) oozes up from below and a new ocean floor or mountain.
2. Two crackers are put side by side and moved toward each other. One cracker should slide underneath the earth. The bottom plate will be dragged down into the earth's mantle and is melted down by the heat below. New magma comes up from between the plates and becomes a volcano. Mt. Saint Helen's is an example of this type of plate movement.
3. Wet the edge of one cracker and place it next to another cracker. Move them toward each other. A ridge of cracker will push up much like what happened when mountain ranges such as the Himalayas (including Mt. Everest) were formed as a result of the crashing of India into Asia.
4. Put 2 crackers side by side and slide one up away from you and the other down toward you. When plates move against each other like this they usually get stuck on one another. There may be a sudden movement when the plate jumps. The powerful vibrations sent out by the plates result in earthquakes.

All of these occurrences are caused by forces which are nothing more than pushing and pulling that makes things move. We would begin with a simpler occurrence which most students have experienced namely, landslides.

Landsides and Avalanches

Landslides occur when large masses of a hillside collapse. Landslides can occur because of rain, temperature change, volcanic activity, earthquake shocks, human modification of the land, vibrations from machinery or traffic or the weight of accumulated material on top of a pile such as snow, rock, or ore. In all of these cases

the trigger mechanism for the landslide is the gravitational pull on the earth.

Usually there is an angle at which material on a slope will be stable. This is called the “angle of repose” or “angle of friction”. When this angle is overburdened the slope increases and the mass falls. Avalanches are similar occurrences only involving snow.

One of the easiest things to do with a class of children is allowing them to play with a box of sand trying to build it up in a mound and seeing how it eventually reaches a certain height at which it will collapse and flatten.

I chose to do some things with the class to show them how different materials behave when dealing with stress. The three categories that describe the behavior that most material exhibit are elastic, ductile, and brittle. If you take a thin board and try to bend it there will be some flexibility but the board will return to its normal shape through its elasticity. If you were to bend a piece of clay it would assume its new deformed shape illustrating it to be ductile or plastic. Finally, if you took the same board and bent it in a quick sharp way it would it quickly snap into two pieces. (Abbott, 31-32)

There is an interesting variation of this for students to do in the book: *How the Earth Works* by Michelle O’Brien-Palmer (pg. 170-171) in which students check for the effects of pressure on a piece of uncooked spaghetti, a graham cracker, and a craft stick or tongue depressor. Students record their findings as they bend, then try to snap the materials one at a time. How loud of a sound does it make when the spaghetti snaps? It does bend somewhat showing some elasticity before it breaks. The Graham Cracker snaps with little elasticity and finally the craft stick takes the most energy to snap. That kind of snap is what occurs when an earthquake occurs as the result of the release of stored energy.

In terms of avalanches and landslides material is usually held in place through static friction. For the slide to begin the friction must be overcome. A series of demonstrations can be done to help students see this. The block and slide experiment is suggested. To begin simply you will need to have a piece of wood about meters in height and 30 cm wide and a block of wood similar to a child’s wooden block or brick. If the block is placed on the board there is no movement and the block remains in place. If you raise the board the block will remain in place until the “angle of repose” is overcome and the block will begin to slide. Students can measure the height at which the slide occurs with a meter stick.

You can extend this demonstration by giving students some dirt. Prop the block up so it has a small incline and put a small amount of dirt on the block to show students that the dirt is holding or the “angle of repose” has been reached. If you keep adding soil little by little the pile will be overwhelmed by the addition of extra material and begin to slide. In this case the cause of the landslide would be the addition of more material.

On a third try put a small amount of dirt on the board and begin increasing the angle of the board by slowly raising it. The dirt will begin to slide when the friction has been overcome because of the increased angle of the board. You can continue this demonstration by having students introduce different material in place of the dirt or to the dirt. For example what happens if small pebbles are substituted for the dirt? What happens if pebbles or small sticks are added to the dirt? How does the addition of water change the “angle of repose”?

Earthquakes

To begin talking about earthquakes and volcanoes I began developing a KWL chart with my students. Most elementary teachers are familiar with this graphic organizer that helps to organize students' previous knowledge. This organizer is particularly good at helping students to keep information they learn organized. In filling in this organizer students formulate questions that they wish to answer as they pursue their research. The organizer consists of 3 columns titled: K -- What I know, W- What I want to know, and L- What I learned. The last column is usually completed as students find out answers to their questions or after their study is completed. This is also the place where students might correct erroneously held opinions, or add information they learned that is beyond what they had anticipated. In doing this with my class I found that there was some misinformation contributed by some; while one boy who had read about volcanoes already had a good foundation of some of the basics of volcanoes. I did not correct anyone's mistaken ideas. That will come about as we get further into the topic.

Most earthquakes are caused when stress builds on rock and it cracks making a new fault or when the rock moves along a fault. A fault is a break in the rock that makes up the crust of the earth. Not every crack is a fault. What makes a fault unique is that one side of the rock has moved in relation to the other. You can see faults in certain geographic locations and larger faults like the San Andreas can even be seen from outer space.

Once again the block (brick) and board demonstration can be used to show the slip and slide motion that results in an earthquake. You can tie an elastic band and/or a spring to the block. If an attempt is made to drag the block by pulling the spring or elastic slowly it may resist. Frictional sliding between surfaces does not always occur in this stick-slip motion. Depending on the surface the sliding can be smooth. Along places like the San Andreas Fault in California where the Pacific and North American plates are scrapping by each other there we can be this somewhat smooth or small "creeping"which causes many small microearthquakes but no large ones.

If the block hits some resistance the spring or elastic will stretch simulating the building up of tension along the fault line as two plates try to pass one another. As the block refuses to move more and more energy is in the elastic or spring. The more the elastic or spring stretches the more energy is being stored. The force on the elastic (spring) builds. A lot of energy can build up in the elastic (spring). When the static friction holding the block in place is overwhelmed the block will slip forward and the force in the elastic (spring) drops. When enough of the force in the elastic (spring) is released so that it is equal to the force of the sliding block, the block will stop moving. What we have demonstrated with this demonstration is a very basic explanation of what is called the elastic rebound theory.

The elastic rebound theory was developed by Harry Fielding Reid who was the only non-Californian invited to study the aftermath of the 1906 Earthquake in San Francisco. Reid concluded that the cause of the earthquake was not at the source of the destruction but miles away where pressure had built up over the years. The ground underneath had become unstable and when the pressure became too much the land snapped back like

an elastic band (http://www/ucmp.berkeley.edu/geology/anim1.html). It should be stressed to students that when this movement happens it is usually a big lurch resulting from tremendous pressure and although in time most earthquakes last a few moments the result can be catastrophic.

Another possible illustration of this is to take two rectangular pieces of clay and put marbles into one side of each piece. When the two pieces of clay are put on top of one another the bumpiness of the marbles simulates the roughness of the plates as they try to slide by one another. In trying to move the two pieces children can see that the marbles impede the smooth movement of the clay and they become entangled with one another. If they try to pull one piece past another sometimes a marble will dislodge and the clay will jerk along for a split second only to be caught again by the next marble. (Van Cleave, *Earthquakes* , pg. 15)

In addition it was suggested in some readings that the stress along the fault line is like that of the rope in a tug-of --war game. As long as both sides pull with the same force the rope is taut and nothing moves. As one side gains in force some of the contestants on the other side will drop out. The remaining members try to hold on and the pressure on them increases. Finally when the stress overcomes them they will give up which in terms of a fault slippage would occur and an earthquake would ensue. This is also a good demonstration activity for students to try. It allows them to actually feel the build up of energy as they tug on the rope and experience the release of energy when they are unable to sustain the equilibrium with the other side. As one side releases the rope the others are jerked forward and there is a sudden movement of the participants. One of the ideas that is also difficult for students to understand is that the build-up of tension is usually a long process but the actual release of tension is quick. It was suggested to me that in having children replicating the building tension with the tug-of-war the children might be asked to hold the tension and build it while being timed so that they could see the relative time in tension was significantly longer than the actual release of pressure (Nankivell-Aston and Dorothy Jackson, pg. 28).

Volcanoes

I showed them the Pacific Ring of Fire on a map (there are many good maps on the web) as an example of a place where this pushing and pulling is a constant occurrence. This is the most prevalent area on the Earth for earthquakes and volcanoes. Within this area 75% of the world’s active and dormant volcanoes occur. In the simplest terms the Pacific plate is moving under or subducting beneath a number of other plates. There is a lot energy that builds up surrounding this area so earthquakes and volcanoes are abundant.

Basically the temperature within the earth is hot enough to melt rock. The melting rock forms a thick material called magma. It is lighter than the rock surrounding it and therefore rises. It finds its way through weak areas in the crust and fills into larger areas called magma chambers. The failure of the crust and more specifically the rock on the earth to keep the magma contained is what finally leads to a volcano.

Volcanoes occurring in subduction zones are the most spectacular and destructive. When Mount St. Helens blew up on May 18, 1980 it was just such a volcano.

The volcano had been dormant for 123 years so the pressure of magma pushing up on the top of the mountain was tremendous. There had been at least two months of small earthquakes and eruptions and the north slope of the volcano had developed a huge bulge. When this bulge of magma finally exploded the slope gave way and slid down the mountain.

This is because when an oceanic plate (Pacific Plate) is subducting under a continental plate (North American Plate) some amount of water is included. The water makes rock easier to melt and produce magma. As the

subducting plate dives underneath the pressure builds as the magma tries to find its way up to the surface. The magma formed at subduction zones is also thicker and it takes more strength for the magma to push its way up. It tends to build up in what is called a magma chamber. When the strength of the magma becomes greater than the rock surrounding it the rock breaks. The magma will burst through and the volcano will erupt. Once again it is important to remember that the rock is very strong and the pressure needed to break it is tremendous - so the resulting blast is extremely violent.

The material in this kind of violent explosion includes hot rock fragments which are called pyroclastics, meaning fire fragments. The pieces of rock can range in size from bocks as big as houses to powdery dust that finds its way into the atmosphere and circles the earth. Pyroclastic flows of material move extremely fast and devastate whatever they come in contact with. This is what happened on Mt. St. Helens.

There is another type of extremely violent volcanic occurrence which is somewhat rare called the Caldera or “bathtub” volcano. It is said that these are the nastiest, deadliest volcanoes with eruptions that can have the power of many nuclear explosions and have the potential to leave parts of the earth dark and can effect global climate change. Technically speaking Calderas volcanoes are ones in which the crater is more than one mile wide. This usually occurs because so much magma is blown out of the magma chamber that the top of the volcano collapses in upon the magma chamber itself. Once again the magma chamber which in other volcanoes would be still full enough to support the volcanic structure above now is weakened by its loss of magma. The weight of the top of the volcano causes it to tumble down. There has not been a recent eruption of a caldera volcano since Tambora in 1815 and Krakatoa in 1886. The most famous calderas in North America are Yellowstone, Crater Lake, and Long Valley.

What happened on Mt. St. Helens can be likened to the popping of a balloon where the gradual buildup of pressure is released in a sudden event or “pop”. Through a demonstration that was originally meant to show the development of calderas can also illustrate what happened at Mt St Helens and the sudden popping of the pressure balloon. This demonstration is made by getting a cardboard box, a length of plastic tubing, a balloon (preferably red), and some flour (www.thenakedscientists.com).

1. Line the box with newspaper.
2. Stick the tubing through he bottom of the box and through the newspaper.
3. Attach the balloon to the tubing and inflate the balloon a few inches.
4. Clamp or tape off the tubing so that the balloon does not deflate.
5. Cover the balloon with flour and shape it into a volcano. Note that the pressure of the gas in the balloon is holding up the top of the volcano.
6. Release the clamp on the tubing and you will see the balloon deflating which simulates the emptying of the magma chamber. The pressure of flour forming the top of the volcano is now too great and it collapses forming a caldera.

Curriculum Extensions and a Final Project

As part of the unit students would be taught the basic principles of the scientific method and it would be used as a basic way for students to observe and carry out class experiments or demonstrations. I intend to have students keep a science journal in which they would record the demonstrations; experiments; and activities they do. They would also be asked to draw diagrams; label them and explain what happened and why.

Writing will be included through analysis of some first hand accounts that are available from Pliny's recollection of the disaster at Pompeii; to first hand accounts of the San Francisco earthquake, and other occurrences (see lesson plans). If possible students will read and/or be read either of both of Mary Pope Osborne's Magic Tree House books *Earthquake in the Early Morning or Vacation under the Volcano.* In each story the main characters Jack and Annie are transported back in time to San Francisco prior to the earthquake and Pompeii before Mt. Vesuvius blew. The stories are entertaining and present aspects of life in those historical times s well as information about what happened.

There are also a variety of picture of volcanoes, and earthquakes from the beauty of Mount Saint Helens to the aftermath of the San Francisco earthquake which could spark some creative writing/oral language discussions with students at all levels including special needs children and English as a second language students (see lesson plans).

For a final project I wanted students to produce a report and have some kind of tangible model or project. While working with my students I realized that they needed more specific direction so I decided that since their main interest seemed to lie in earthquakes and volcanoes that each one of them would be given the opportunity to find out about a famous volcano or earthquake. I put together a list of possible subjects and spent some time reviewing each one and giving some highlights of what happened. Students then chose their topics. One boy chose the Mexico City earthquake of 1985 because his dad comes from Mexico. Another child who is a baseball fan chose the World Series Earthquake of 1989 which occurred during the World Series in California. A little girl chose Mauna Loa because her mom has always wanted to go to Hawaii.

Students had to research their specific disaster and answer a series of questions that I provided to help them. They were given a set of rubrics for their report and for the oral presentation. They also looked up their volcano/ earthquake on line. They had to use two sources one of which they found on the Internet. They also filled in a map showing the location of the disaster. Using the map we have of the plates students were able to see how the movement of particular plates had caused the natural disaster they were researching.

Most made models or posters of their disaster. Some showed what their city looked like before and after the disaster. Another student showed how better construction techniques could have saved lives in the earthquake he was researching.

The students read their reports and explained their findings to their classmates. Other students and teachers viewed the projects and questioned the students about what they had learned as part of the end of the year celebration. In all the parts of the unit that were tried with students their enthusiasm and interest remained high. If anything, I found that there was the continuing necessity to simplify and provide actual hands on experience for students in order for them to understand with any sense of clarity what the unit was trying to accomplish. I hope that what is here will make a start but teaching itself remains a dynamic endeavor and this document will only serve as a crude beginning.

Lesson Plan #1

Subject: Science

Objective: Students will understand that a landslide occurs when the stability of a pile of dirt (angle of repose) is overwhelmed. By using various materials students can also understand how the addition of various materials can change the surface of the earth resulting in a landslide.

Materials: a piece of wood about 1/2 meters in length and 30cm wide, meter stick, block or brick, dirt, pebbles, small sticks, water, books on which to rest the board, pencil, chart to record information

Procedure:

Note that students should have science notebooks and/or graphic organizer to help record their observations. They should record what they do and see in words and illustrations.

1. Place the board at a small angle and rest the block upon it. Students should see that the block is at its “angle of repose” because it is stable and not moving.
2. Slowly raise the angle of the board and let students see that as the angle increases the block begins to move as the static friction is overcome. Students should measure the height at which the block moves.
3. Now put the board down at a low angle again and put a small amount of dirt on the board. The dirt will stay in place again showing that it is stable.
4. If you begin to slowly add more dirt to the pile it will eventually fall over and begin to cascade down the slope.
5. Clear the board and set it up again with a small amount of dirt. Slowly lift the board up increasing the angle of the slope. At some point the “angle of repose” will be overcome and the pile will slide.
6. Have students discuss their observations and conclusions about what starts an avalanche.

Extension: Repeat the demonstration using just pebbles. Then add pebbles to the dirt, small sticks, and finally water.

Have students research ways to stop avalanches and what safety precautions are recommended.

Lesson Plan #2

Subject: Writing

Objective: Students will write a personal narrative about what they would take with them if they were fleeing a disaster.

Materials: pictures from the San Francisco Earthquake, paper, pencils. There are quite a few websites dedicated to the 1906 San Francisco Earthquake including: *1906 San Francisco Earthquake Photos* (www.sfmuseum.org/1906/photos.html); *The Great Quake: 1906-2006* (www.sfgate.com/greatquake/), and the *San Francisco Library Historical Photograph Collection* (www.sfpl.lib.ca.us/librarylocations/sfhistory/equake-browse.htm)

Procedure:

1. Students will view a number of photos of the San Francisco Earthquake especially those featuring people fleeing the city and living in encampments. People had to make quick decisions about what belongings they could take with them. In a general way students might be asked to list things they think people would chose to take. Possible choices might range from pieces of furniture, to articles of clothing, jewelry, toys, photographs, etc.
2. Students will be asked to make a personal connection to the people in the photos and try to figure out what important things they would take (not including pets). It might help students to focus on what is really important to them if they are limited to three items.
3. After viewing pictures and discussing the difficult choices people would have to make (some things would be too large to move) students would then be encouraged to write what they would take and why they chose those items. They might also write about the next thing they would have taken but had to leave behind.
4. Students will share their writing with others.

Lesson Plan #3

Subject: Writing/Science

Objective: Students will research safety procedures that should be followed in case of an earthquake, or volcano, or landslide.

Materials: Students may use books and/or websites to find suggestions for safety precautions. Suggestions include: *FEMA: Get Disaster Information* (http://www.fema.gov/index.shtm); *Earthquake Safety Precautions-Love To Know Safety* (www.safety.lovetoknow.com/Earthquake_Safety_Precautions); *Volcano Precautions* (http://www.statefarm.com/learning/be_safe/work/work/work.asp), and *American Red Cross Mount Rainier Chapter* (http://www.rainier-redcross.org/New_web/PROGRAMS/RedCrossVolcanoPreparednessInfo.pdf)

Procedure:

1. Students will research agencies that provide help to disaster victims such as FEMA, the Red Cross, United Way, Children's Disaster Services, UNICEF, World Health Organization, and the Humane Society of the United States are just a few of the agencies that offer assistance.
2. Students will research safety precautions that should be followed before, during, and after a landslide, earthquake and/or volcano.
3. Students will review and act out safety procedures.
4. Students will work in small groups to prepare signs and posters telling other students about one of the safety steps they learned about and why it is important.
5. Students will prepare a disaster plan for their families (see FEMA for Kids website for ideas) and make a list of things they would place in a disaster supply kit.
6. Students will share their posters and signs with other students and classmates.

Lesson Plan #4

Subject: Writing

Objective: Students will write journal entry imagining their experience in a disaster- landslide, earthquake, or volcano.

Materials: First hand accounts of people who survived disaster such as those that can be found at *The Virtual Museum of the City of San Francisco: Eyewitness Accounts* (www.sfmuseum.org/1906/ew.html). They include accounts from the writer Jack London to opera singer Enrico Caruso, as well as, a member of the fire department, a Naval officer describing rescue operation in the harbor, and a couple of doctors describing emergency services. These accounts should be read and discussed with students along with viewing some of the numerous photos that exist of the aftermath of the San Francisco Earthquake.

There is also the famous account of the explosion of the volcano at Vesuvius by Pliny the Younger to his friend, the Roman historian Tacitus. Discovery channel video has a recreation of the explosion and Pliny's letter in which he tells of the death of his uncle Pliny the Elder (www.dsc.discovery.com/convergence/pompeii/pliny/video.html). Either or both of these would help to bring the human toll of these disasters home to students. Of course teachers will have to read and monitor if they feel that any of the accounts are too graphic or inappropriate for their students.

Procedure:

1. Students will view photos and drawings of disasters such as the San Francisco Earthquake or the explosion of Vesuvius and its effects on Pompeii.
2. Students will try to make a connection to a time when they were caught in a strong storm or other potentially dangerous situation.
3. The teacher will help students brain storm a list of describing words they could use in telling about their experience.
4. Students will be asked to use what they felt along with what they saw in the photos to help them write a letter or journal entry to a friend or family member describing their experience and how they felt.
5. Students will be given a rubric in which they have to use vivid language and at least one comparison.
6. Students will share their writings with one another. The class will use copies of the rubric to grade classmates writing.

Lesson Plan #5

Subject: Science/Art

Objective: Students will make a working model of a volcano.

This is one way to make model of a working volcano. There are directions for many volcano models on the web and it is worth looking at different ones and if practical letting students chose which they prefer. There are simple clay models and more elaborate paper mache projects. This volcano requires salt dough, plastic soda bottle, baking pan, red food coloring, baking soda, and vinegar (*Build a Baking Soda Volcano* , http://chemistry.about.com/howtos/ht/buildavolcano.htm). It proved to be easy to make and to work with. It was safe to work with and students requested copies to use at home.

Procedure:

1. In order to do this particular model you first need some salt dough which is made from mixing six cups of flour, two cups of salt, four tablespoons of cooking oil, and two cups of water. Mix the ingredients until the dough is smooth and firm. Add more water if necessary.
2. Stand the bottle in the middle of the baking pan and model the dough around the bottle forming it into a volcano. Make sure that you do not cover the top of the bottle or drop any of the dough inside.
3. Fill the bottle most of the way with water and the red food coloring.
4. Then add six drops of the liquid detergent.
5. Add two tablespoons of baking soda.
6. Slowly pour in some vinegar and jump back quick.

The red lava flows down the side of the volcano because a chemical reaction between the baking soda and vinegar produces carbon dioxide gas which is also produced in a real volcano. The gas builds up and forces the lava out of the bottle (chamber) and down the sides of the volcano.

Bibliography

Abbott, Patrick L. 2006. *Natural Disasters.* New York: McGraw-Hill Publishers.

This book is a college text used in the teaching of natural disasters. It was the main text in a previous Yale Institute seminar of the same title. It has been a useful and practical reference during the writing of this unit.

Berger, Melvin. 1981. *Disastrous Volcanoes.* New York: Franklin Watts.

The book discusses the formation, types, and locations of volcanoes and describes the eruptions of Paricutin, Vesuvius, Krakatoa, Mount Pelee, and Mount St. Helens.

Blobaum, Cindy. 1999. *Geology Rocks!: 50 Hand-on Activities to Explore the Earth.* Charlotte, VT: Williamson Publishing.

This book provides 50 hands on experiments and demonstrations in geology and is an excellent resource.

Lauber, Patricia. 1986. *Volcano: The Eruption and healing of Mount St. Helens.* New

York: Bradbury Press.

This is an account of how and why Mount St. Helens erupted in May 1980 and the destruction it caused, as well as a discussion of the return of life to that area.

Levy, Matthys and Mario Salvadori. 1997. *Earthquake Games: Earthquakes and*

Volcanoes Explained by 32 Games and Experiments. New York: Simon & Schuster.

This book uses numerous activities and experiments to explain the forces and phenomena connected with earthquakes and volcanoes.

Nankivel-Aston, Sally and Dorothy Jackson. 2000. *Science Experiments with Forces.* New York: Franklin Watts Publishing.

This book explores properties of forces such as friction and gravity, through experiments using equipment that is readily available both in homes and schools.

Nicolson, Cynthia Pratt. 2002. *Earthquake!* . New York: Kids Can Press Ltd.

This book deals with the basic causes of earthquakes and tsunamis. It gives some ideas about survival skills and some experiments children can do to understand earthquakes.

O'Brien-Palmer, Michelle. 2002. *How the Earth Works: 60 Fun Activities for Exploring Volcanoes, Fossils, Earthquakes, and More.* Chicago: Chicago Review Press, Inc. This book is a bout the ever-changing Earth. It explores Earth's structure; fossils, rocks, and minerals; crystals, and gems; as well as Earthquakes and volcanoes.

Osborne, Mary Pope. 2001. *Magic Tree House # 13: Vacation Under the Volcano.* New York: Random House. The magic tree House takes Jack and Annie to Pompeii during roman times, on the very day Mount Vesuvius erupts.

_____ *Magic Tree House Research Guide: Ancient Rome and Pompeii.* New York: Random house. A nonfiction companion to *Vacation Under the Volcano* , which includes information about Ancient Rome and Pompeii, and daily life and culture.

_____ *Magic Tree House #24: Earthquake in the Early Morning.* New York: Random House. The magic tree house takes Jack and Annie to San Francisco in 1906, in time for them to experience one of the biggest earthquakes the United States had ever known.

Patent, Dorothy. 2000. *Shaping the Earth.* New York: Clarion Books.

Richards, Julie. 2001. *Quivering Quakes.* Broomall, PA: Chelsea House Publishers.

This book covers the development of earthquakes, where they happen, and the damage they can do, as well as how earthquakes are measured and how people can protect themselves.

Thompson, Luke. 2000. N *atural Disasters: Earthquakes.* New York: Children's Press a Division of Grolier Publishing.

This book explains why earthquakes occur and describes the technology used to study them, the damage they inflict, and some of the more famous earthquakes in history.

Trueit, Trudi Strain. 2003. *Volcanoes.* New York: Franklin Watts.

This book discusses the formation and characteristics of volcanoes, the causes and effects of their eruption, and describes specific volcanic eruptions such as that of Mount St. Helens in 1980.

VanCleave, Janice. 1993. *Earthquakes: Mind-boggling Experiments You Can Turn Into Science Fair Projects.* New York: John Wiley & Sons, Inc.

This book features an array of experiments that could become science fair projects all dealing with different aspects of earthquakes.

_____1994. *Volcanoes: Mind-Boggling Experiments You Can Turn Into*

Science Fair Projects. New York: John Wiley & Sons, Inc. This book features and array of experiments that deal with different aspects of volcanology.

Van Rose, Susanna. 2004. *Eyewitness: Volcano & Earthquake.* New York: DK Publishing, Inc.

This book covers a broad spectrum of topics from the unstable earth to plate tectonics, the spreading sea floor and some of the famous eruptions, earthquakes and landslides. There are plenty of illustrations and photos.

Webster, Christine. 2004. *Natural Wonders: Mauna Loa.* New York. Weigl Publishers Inc.

This book talks about the causes of earthquakes and how they develop. It talks about the specific history of Mauna Loa and life there.

Web Sites

http://www.usgs.gov

This is the web site for the United States Geological Survey and is one of the best web sites to look for information on landslides, earthquakes, volcanoes, and other disasters.

www.enchantedlearning.com/subjects/astronomy/planets/earth/Continents.shtm/

This is a part of the Enchanted Learning website which has a lot of free maps, work sheets, and information for teachers. This particular site contains information titled “all about Plate Tectonics”.

http://www.fema.gov/index.shtm

This FEMA website deals with safety precautions that should be used during major disasters.

http://www.fema.gov/kids/

There is also a FEMA for Kids site that has useful information for teachers and students about developing family emergency plans, etc.

www.sfgate.com/greatquake/

This is the San Francisco Chronicle’s web site with a lot of valuable information about the quake of 1906

www.sfpl.lib.ca.us/librarylocations/sfhistory/equake-browse.htm)

This is the web site for the San Francisco Library’s materials about the earthquake of 1906.

www.sfmuseum.org/1906/ew.html

This is the web site for the Virtual Museum of the City of San Francisco which contains a vast collection of photos and historical documents dealing with the 1906 earthquake.

http://dsc.discovery.com/convergence/pompeii/pliny/video

This web site has a video reenactment of Pliny the Younger’s account of the eruption of Mt Vesuvius in 79 A.D. and the death of his Uncle, Pliny the Elder.