Natural Hazards Case Study

***Where Are Volcanoes Located, What Kinds of Eruptions Do They Have, How Are They Related to Earthquakes, and What Effect Do They Have on the Environment?***

Volcanoes occur because the Earth’s crust is broken into 17 major tectonic plates that are rigid (**lithosphere**) but float on a hotter, softer layer (**asthenosphere**) in Earth’s mantle. Within the Earth’s mantle, temperatures are hot enough to melt rock and form a thick, flowing substance called **magma**. Magma is lighter than the solid rock that surrounds it—buoyant like a cork in water—and, being buoyant, it rises. As the plates shift, they spread apart, collide, and/or slide past one another. Volcanoes grow because of repeated eruptions. Most occur near the edge of plates or along the edges of continents where one plate overlaps a second plate; this is called a **subduction zone**. Active volcanoes seen on land occur where plates collide; however, most of Earth’s volcanoes are hidden from view, occurring on the ocean floor.

Volcanic eruptions occur only in certain places and do not occur randomly. Some tend to be explosive when they erupt, whereas others tend to be loosely flowing and nonexplosive. Explosive volcanic eruptions can be dangerous and deadly. The fiery clouds and hot lava that race down mountainsides destroy nearly everything in their path, including trees, plants, insects and other wildlife. Ash erupting into the sky falls back onto the Earth, creating a blanket that can suffocate plants, crops, animals and humans. They can also spark forest fires near the volcano.

**Lahars** are rapidly flowing mixtures of rock debris and water that originate on the slopes of a volcano. They are also referred to as volcanic mudflows or debris flows. Volcanic eruptions may directly trigger one or more lahars by quickly melting snow or ice on a volcano or ejecting water from a crater lake. They form in a variety of other ways, including through intense rainfall on loose volcanic rock deposits and as a consequence of debris avalanches.

When moving, a lahar looks like a mass of wet concrete that carries rock debris ranging in size from clay particles to large boulders. As it rushes downstream, its size, speed, and the amount of water and rock debris it carries are constantly changing. Lahars have the strength to rip huge boulders, trees and man-made structures from the ground, carrying them for great distances. They cover the surfaces they travel over with mud, particularly those of mountain and valley systems, and can destroy wildlife that exists on the Earth’s surface and in its bodies of water.

Volcanic eruptions can also affect climate and weather patterns. Eruptions produce sulfuric acid aerosols that form a layer of haze in the stratosphere. This haze, which can remain in the atmosphere for years, reflects the Sun’s radiation and reduces surface temperatures. On the other hand, volcanoes also provide many benefits to the environment. The gaseous emissions from volcanic vents over hundreds of millions of years formed the Earth’s earliest oceans and atmosphere, supplying the ingredients vital to evolve and sustain life.

***Where and How Often Do Earthquakes Occur, How Is Their Magnitude Expressed, How Are They Related to Volcanoes, and What Effect Do They Have on the Environment?***

An earthquake is a sudden movement of the Earth caused by the abrupt release of energy that has accumulated over a long time. Most earthquakes occur at the boundaries where the plates of the Earth’s outer layer meet. In fact, the location of earthquakes and the kind of ruptures they produce help scientists define the plate boundaries. Most destructive quakes, however, are caused by dislocations of the crust. The crust may bend and then, when the stress exceeds the strength of the rocks, break and “snap” to a new position.

Geologists have found that earthquakes tend to recur along faults, which reflect zones of weakness in the Earth’s crust. If a fault zone experiences an earthquake, there is no guarantee that all of the stress will be relieved. Another earthquake can still occur.

Earthquakes may occur in an area before, during, and after a volcanic eruption, but they are not the cause of result of volcanic activity; rather they are the result of the active forces connected with the volcanic eruption.

The vibrations produced by earthquakes are detected, recorded, and measured by instruments called seismographs. From this data, scientists can determine the time, the epicenter, the focal depth, and the type of faulting of an earthquake and can also estimate how much energy was released.

The Richter scale is the best-known scale for measuring the magnitude of earthquakes. The scale is logarithmic, so a recording of 7, for example, indicates a disturbance with ground motion 10 times as large as a recording of 6. A quake of magnitude 2 is the smallest quake normally felt by people. Earthquakes with a magnitude of 6 or more are considered major; great earthquakes have magnitudes of 8 or more.

Initial effects of earthquakes are violent ground motions which can produce cracks or fractures in the ground and **liquefaction**, where loose sandy soils with a high moisture content separate and give the surface a consistency much like that of quicksand. As destructive as earthquakes are, the resulting secondary effects such as landslide, tsunamis, fires, and floods can be even more devastating. Landslides are especially damaging and often account for the majority of lives lost. **Tsunamis**—large sea waves caused by an earthquake abruptly moving the ocean floor—can move at high speeds and cross thousands of miles before they run up on shore, wiping out everything in their path. While travelling through deep water the waves may only reach a foot or two in height. The waves slow down as they reach shallow water, causing water to pile up into very high (and still very fast) waves as tall as 34 feet. Tsunamis can have negative effects on the natural environment when they cause damage to already fragile coral reefs and mangrove swamps, which are vital feeding and breeding grounds for fish. Destruction of these environments can leave coastlines vulnerable to erosion and local communities without a vital source of food.

The risk of fire immediately after an earthquake is often high due to broken electrical lines and gas mains. Finally, subsoil disturbances can cause changes in groundwater flows, which in turn can cause abrupt changes in the level of the water table and a sudden drying up of surface springs.

***How Can the Risk Associated With Earthquakes and Volcanoes Be Reduced?***

The worst earthquakes in the world poses little risk if no one lives in or uses the region that is affected. The consequences of earthquake activity in December 2003 exemplify this point. On December 22, a magnitude 6.5 earthquake in central California killed two people and severely damaged 40 buildings. Four days later, a magnitude 6.6 earthquake near Bam, Iran, killed 30,000 people, injured another 30,000 and damaged approximately 88% of all buildings and infrastructure. The next day a magnitude 7.3 earthquake occurred in the southwest Pacific Ocean; it went largely unreported.

Like other hazards, the risk associated with earthquakes and volcanoes is strongly dependent on the manner in which humans use and interact with the environment. Geoscientists have had more success predicting volcanic eruptions than they have had with earthquake prediction. A common warning of an impending volcanic eruption is a series of earthquakes that increase in both magnitude and frequency. Volcanoes often give other clues indicating that an eruption may be near—changes in the shape of a volcano can be detected by satellites and sensitive surveying instruments, and monitoring the composition of gases emitted from active volcanoes might indicate an eruption is near. Still, a great many volcanoes are not well monitored, and there are volcanoes that do not give obvious visual signs that they are about to erupt.

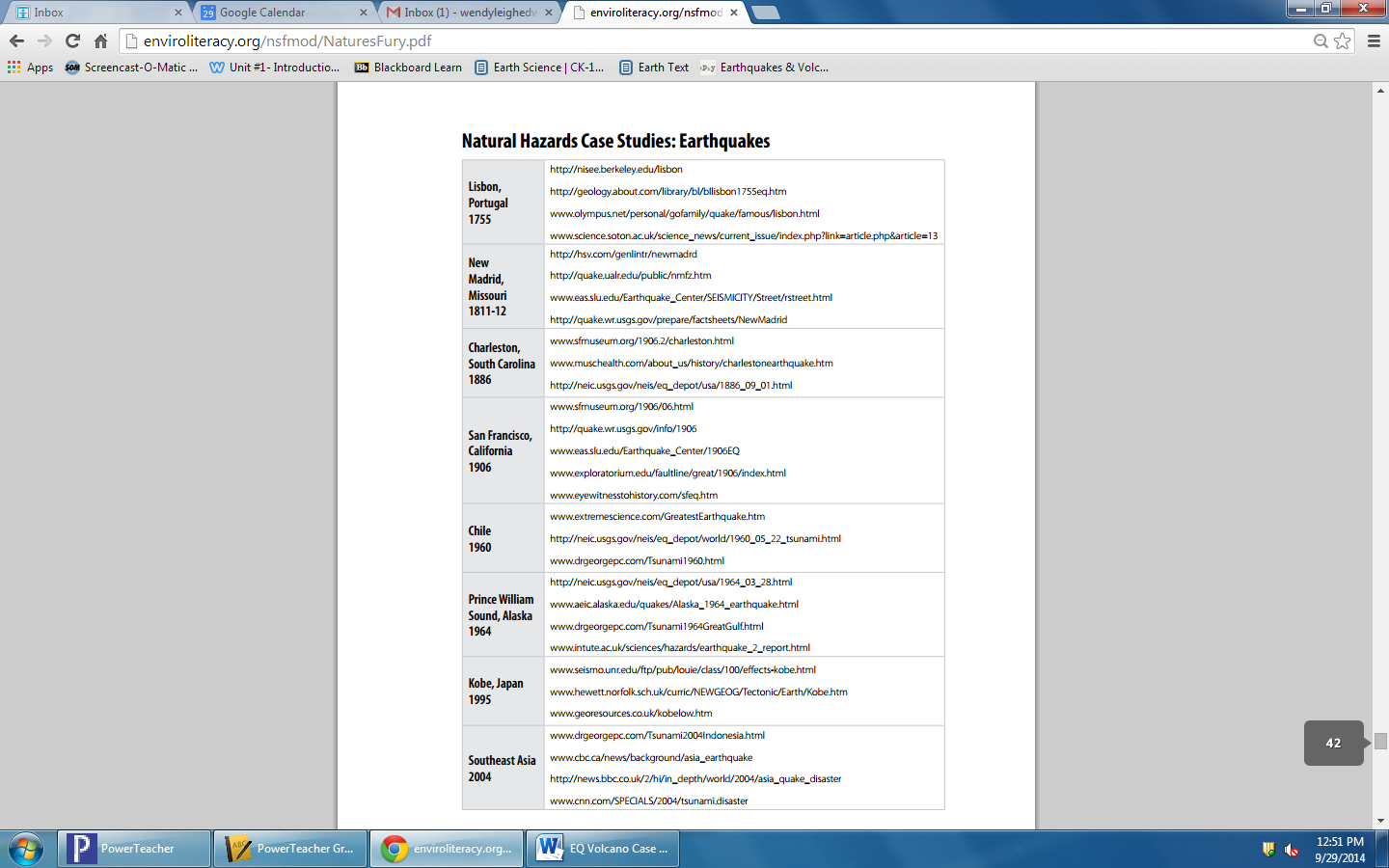
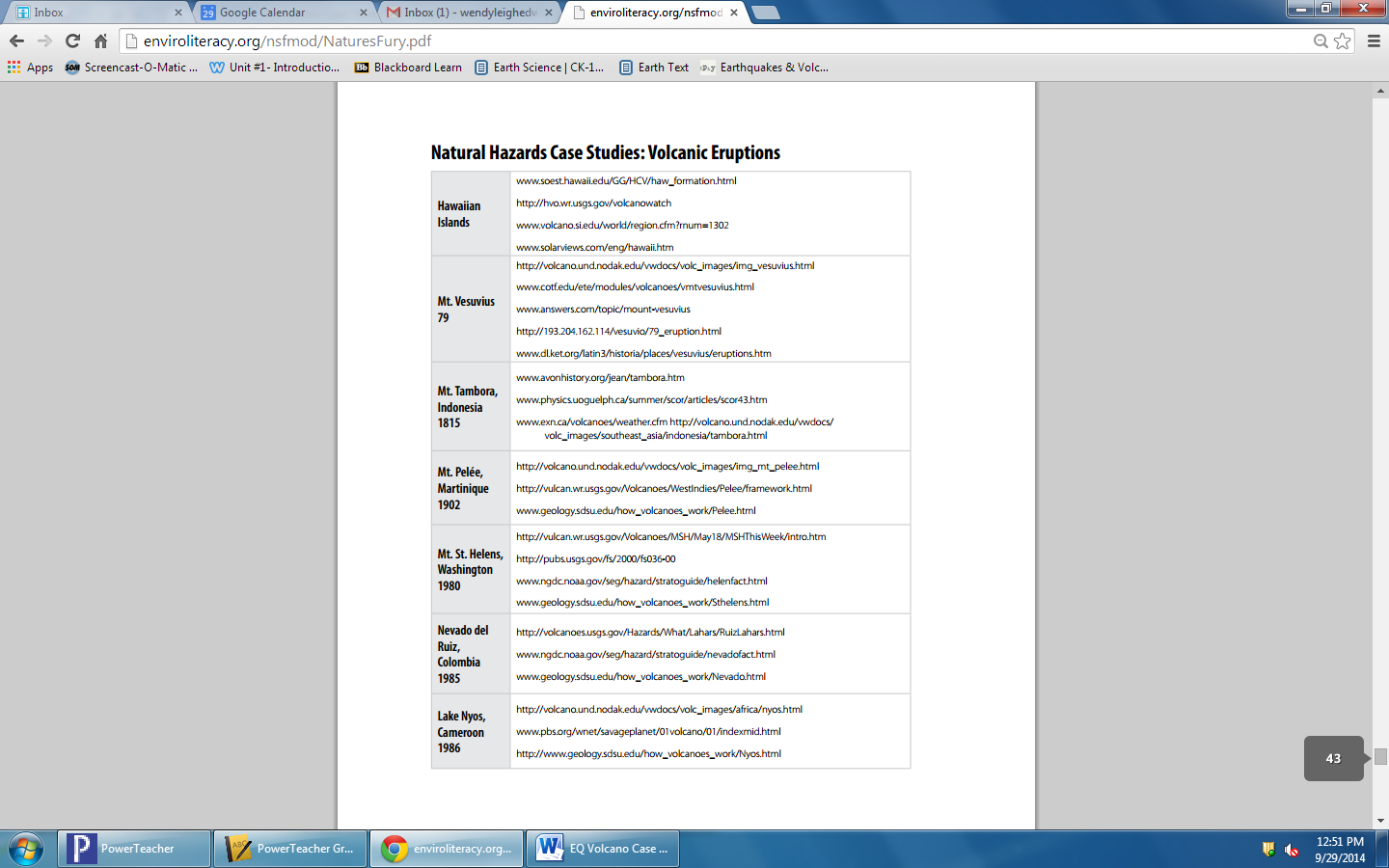
Earthquake prediction had also not been very successful. Because large earthquakes associated with a particular fault are infrequent, geoscientists are forced to hypothesize earthquake precursors such as animal behavior, electrical field measurements, and foreshocks. Much of earthquake prediction today relies on looking for patterns of past earthquake behavior associated with a specific region or fault. Although short-term earthquake prediction is not very successful, longer-term earthquake forecasting can be a valuable tool for policy makers. This forecasting can identify both earthquake-prone areas and man-made structures that are especially vulnerable to damage from the effects of earthquakes. Based on this information, policy makers can develop increasingly sound and cost-effective building codes and emergency-response plans.

**Case Study Instructions**

You are a member of a team that is charged with investigating a past earthquake and volcanic eruption. You will be provided with some internet references to get you started on your topic, but you will want to find other sources. **Each** member of your team will keep a written journal of your data, ideas, and questions. From these journals, your team will prepare a written report and make a presentation to the class. The presentation and report should describe the event(s)—**where, when, magnitude, and what happened to people and to the environment**. The report should also address the following questions:

1. Which of the systems making up the Earth’s surface—atmosphere, biosphere, geosphere, hydrosphere—were involved? How?
2. What was the source of the energy that made the event(s) possible?
3. How does the theory of plate tectonics explain what happened?
4. When is a similar event likely to occur in the same general area? What is the basis for making such predictions, and how trustworthy are they?
5. How can the event(s) be characterized using the concepts of hazard and risk? In this case, what was at risk? What steps could have been taken to reduce (mitigate) the risk to which people were exposed?
   * Risk – the probability that something bad, harmful, or negative could happen
   * Hazard – an agent or circumstance known to cause an adverse effect under certain conditions
6. How does the risk associated with such events complete with that of other hazards, such as accidental poisoning, motorcycling, cigarette smoking, skin cancer, and air travel? On what basis?

**To turn in**: journals and group evaluation sheets (completed by each individual), written paper and references (1 per group)



http://enviroliteracy.org/nsfmod/NaturesFury.pdf