Volcanoes

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INTRODUCTION

If we ask people about volcanoes, they will all say that they know what they are. Of course, we all have heard about volcanoes; we have even seen pictures and movies about them. However, if we really want a more elaborated explanation, most of them will not be able to tell us, for example, how volcanoes form, or what are the different types of volcanoes. We tend to believe that the earth does not change, and that geological events, such as volcanic eruptions or earthquakes, happen only in remote places, far away from our neighborhoods. But if we learn more about our planet and its history, we will realize that volcanic eruptions are one of the earth's more dramatic and violent agents of changes. Volcanic eruptions have in the past, and will in the future, cause major economic, environmental, and social changes. Volcanic impacts range from local, temporary evacuations to worldwide changes in climate lasting for years.

When a volcano begins its eruptive cycle, a few days or weeks warning may not be enough time to prevent a tragedy. Students need to know that not all volcanoes are the same, nor are their hazards the same. Considering these differences, planning is the key to saving lives. Those who live in regions near active volcanoes must be educated about volcanic hazards. Evacuation plans must be practiced in every school, university or building. First we need to understand what volcanoes are. Volcanoes and earthquakes are part of our daily life, if we think globally. Human history has recorded these events since ancient times; however, they are not just part of the past, they are a present reality. To know more about volcanoes will help people to better understand our planet, to understand any kind of safety regulation that could be created and/or established by the city or the government; and to be better prepared to survive. Studying volcanoes is also useful to understand that these volcanic events have also influenced the way we live. For example, these events have led people in the past to come up with explanations with a religious connotation instead of a scientific approach. Likewise, the architecture and materials used to build houses and buildings have changed because of these phenomena.

This unit is intended to serve as a primary source of information for elementary students who start to know their world, the long journey of knowing our planet. This unit will give them the background to continue with more advanced studies during school.

Volcanoes represent an extensive field of study, but the first things students need to know are the basics, like "what is a volcano?" Better understanding of magma and the eruption process will further facilitate the understanding of the different types of volcanoes and their eruptions.

WHAT IS A VOLCANO?

Magma that originates in the partially melted asthenosphere rises through the lithosphere to form a magma chamber. Magma is ejected from the magma chamber through central and side vents and accumulates on the surface as lava and pyroclastic material to form a volcano (Dupré HTI).

An active volcano is one that is erupting or liable to erupt. There are about 1300 volcanoes on land around the world thought to be active -- that is likely to erupt at any moment. There are also many volcanoes under the sea. Some volcanoes such as those in Hawaii "simmer" most of the time, steadily oozing lava and hot gas. Others lie dormant for centuries but then erupt suddenly and violently. There are also many more extinct volcanoes, no longer liable to erupt (Fardon 53).

THE MAGMA AND THE ERUPTION PROCESS

The eruption is the sudden emergence of hot material from the Earth's interior. **V**olcanic eruption vary greatly in the amount of material erupted and its effect on the surrounding environment. An eruption takes place when magma stored in the chamber reaches sufficient pressure to overcome the resistance of the rocks that form the roof of the magma chamber. In most cases an eruption will bring to the surface only a portion of the volume of the magma stored in the magma chamber (Rosi 40).

Magma is a complex mixture of liquid (molten rock), solid (suspended crystals and rock fragments), and dissolved gas. Variations in the composition and temperature of the magma determine the different properties of magma, which in turn determine the type of eruptive process, associated hazards, and resulting volcanic landforms (Table 1).

Variables →	**Magma Properties** →	**Effects**
Composition Temperature Crystals and rock fragments Dissolved gas	Density Viscosity Ability to contain dissolved gases	Type of eruption Characteristic of the volcanic deposits Structure of the volcano

Table 1: Variables affecting magmatic properties and resulting effects.

Properties of Magma

Composition

The composition of magma varies greatly depending on the geologic setting in which the magma was generated. The liquid portion of the magma consists almost entirely of eight elements, of which Silicon and Oxygen are the most abundant. The compound formed by the bonding of Silicon and Oxygen (SiO_2) is referred to as Silica. It is possible to distinguish three categories of magma on the basis of the relative silica content within the magma.

- Mafic magmas (low silica content – form at divergent margins)
- Intermediate magmas (intermediate silica content – form at convergent margins)
- Felsic magmas (high silica content – typically form in continental regions)

Density

Magmas low in silica content (e.g. mafic magmas) are rich in iron and magnesium, hence are denser than magmas high in silica content (e.g. felsic magmas). The composition of magma can change through time; in doing so, its density can change as well.

Viscosity

The viscosity of a fluid is a measure of the ease with which a fluid flows. The lower the viscosity, the more "fluid-like" is the liquid. The viscosity of magma significantly affects both the nature of the lava flows as well as the explosivity of the eruption. Two factors that explain explosive volcanic activity are viscosity and gas content.

Viscosity of magma depends mainly on composition, temperature, and gas content.

Chemical composition: the higher the silica content of the magma, the greater the viscosity.

Temperature: the higher the temperature of the magma, the lower the viscosity.

Amount of crystals**:** the more crystals in the magma, the greater the increase in viscosity.

Amount of dissolved gases: the more dissolved gas in the magma, the lower the viscosity. (Rosi 33)

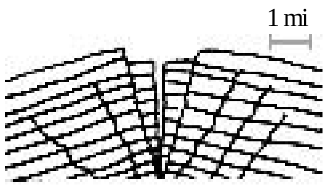
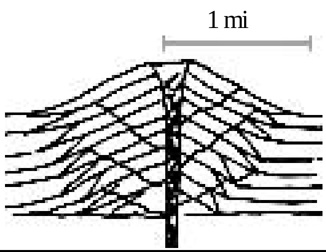
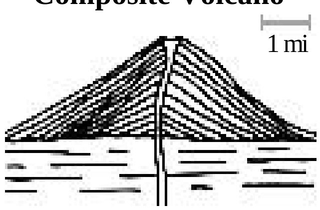
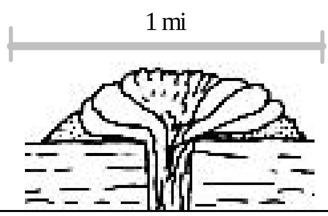
Shield Volcano 	Their overall broad shapes result from the extrusion of very fluid (low viscosity) basalt lava that spreads outward from the summit area, in contrast to the vertical accumulation of air fall tempura around cinder cone vents, and the build-up of viscous lava and tephra around composite.
Cinder Cone 	Cinder cones are the most common type of volcano. They are also the smallest type. They can occur as discrete volcanoes on basaltic lava fields, or as parasitic cones generated by flank eruptions on shield volcanoes and composite. Cinder cones are composed almost wholly of ejected basaltic tephra. The tephra fragments typically contain abundant gas bubbles (vesicles), giving the lapilli and bombs a cindery (or scoriaceous) appearance.
Composite Volcano 	Composites are the most picturesque and most deadly of the volcano types. Their lower slopes are gentle, but they rise steeply near the summit to produce an overall morphology that is concave in an upward direction. The summit area typically contains a surprisingly small summit crater. This classic composite shape is exemplified by many well-known composites, such as Mt. Fuji in Japan, Mt. Mayon in the Philippines, Mt. Agua in Guatemala and Mt. Ranier in US.
Volcanic Dome 	"If highly viscous magma is erupted at a slow enough rate, it may pile up above the vent rather than flow away from it. Leading to the formation of steep-sided mounds of lava known as lava domes. Such effusive activity can go on for many years or even decades" (Rosi 43)

Table 2: Types of Volcanoes (diagrams from USGS)

	Shield Volcano	**Cinder Cone**	**Composite**	**Volcanic Dome**
Composition	Formed mainly of mafic lava	Formed mainly of balsatic pyroclastic material	Alternate pyroclastic deposits and intermediate lava	Formed of viscous felsic lava
Silica content $Si0_2$	Least (~50%)	Least (~50%)	Intermediate (60%)	Most (~70%)
Viscosity	Least	Least	Intermediate	Great
Gas content	Least (~1-2%)	Least (~1-2%)	Intermediate (3 -4 %)	Most (4-6%)
Shape	Gentle sides: ~2 - 10 degrees Very gentle slopes; convex upward	Steep sides: ~30 degrees Straight sides with steep slopes; large summit crater	Gentle lower slopes, but steep upper slopes; concave upward; small summit crater	Steep-sided
Size	Up to 120 Km wide	Relatively small: ~ 1 km wide	Relatively large: ~10-15 km wide	Small: ~100 meters wide
Tendency to form pyroclastics	Least	Least	Intermediate	Great
Life span	Long duration of activity: 10,000 years	Short life: typically a single event	Intermittent eruptions over long time span: 1000 years	

Table 3: Selected characteristics of volcano types (Source: Dr. Dupré, Farndon, and Rosi)

	Eruptive Type
Shield Volcano e.g. Mauna Loa, Mauna Kea	Effusive volcanic activity: Eruptions are usually non-violent. (e.g. Hawaiian). The arrival on the surface of magma that has lost its gas component produces the formation of a lava flow or an accumulation of lava around the vent. The speed at which lava flows and the distance covered are affected by the viscosity, angle of slope and amount of material involved (Rosi 44).
Cinder Cone e.g. Sunset Crater, Capulan Crater, Paricutin	Explosive activity: These eruptions are not highly explosive, and are produces by medium-low viscosity magma with a gas content generally greater that that of effusive activities. (e.g. Strombolian eruptions)
Composite Volcano e.g. Mt. Ranier, Mt. Fuji Mt. St. Helens	Explosive activity: It can lead to the complete destruction of the magma chamber and the discharge into the atmosphere of fragments of magma at high temperature. These eruptions are often highly explosive because magma mixes with substances in the overlying plate, making more viscous or sticky. This magma clogs up the volcano conduct, trapping magma below. Pressure builds up until the magma burst through in a huge explosion. At great depths inside the Earth volcanic gases are dissolved in the magma (e.g. Plinian eruptions)
Volcanic Dome e.g .forming in Mt. St. Helens	Typically effusive activity, however may be associated with explosive eruptions

Table 4: Types of eruptions associated with different types of volcanoes (Dr. Dupré, Farndon, and Rosi)

HOW AND WHERE DO VOLCANOES FORM?

In order to understand where and how volcanoes form, we must first understand how the earth is subdivided into layers (Table 5). Layers based on composition include the crust, mantle, and core. Important layers based on their mechanical properties include the lithosphere and asthenosphere.

- <u>Crust</u>: Earth is known to have a solid upper part called the crust. It has an average thickness of 30 to 40 km under continents, and about 7 km under the oceans. It represents less than 1% of the total mass of the earth.
- <u>Mantle</u>: is nearly 2,900 km thick, and represents about 70% of the Earth's mass. It is composed primarily of rocks in a plastic state that varies from solid to partially melted.
- <u>Core</u>: it is the innermost part of the Earth consisting mainly of Iron with some Nickel. It is subdivided into an outer, liquid layer and an inner, solid layer.
- <u>Lithosphere</u>: the outermost part of the Earth, composed of the crust and part of the mantle, is rigid, meaning that is has the characteristics of a solid. It is broken into several large plates that glide over the underlying asthenosphere.
- <u>Asthenosphere</u>: an area of the mantle immediately below the lithosphere. It begins at a depth of approximately 150 Km. In this area, the conditions of pressure and temperature are such to cause the partial melting of the rocks of the mantle. (Rosi 50).

Based on **Composition**	Based on **Mechanical Properties**
CRUST	LITHOSPHERE (rigid) (plate)
MANTLE	ASTHENOSPHERE (plastic)
	MESOSPHERE (solid)
CORE	OUTER CORE (liquid0
	INNER CORE (solid)

Table 5: Major layers within the Earth

Most volcanoes form along plate boundaries. Plate boundaries are areas where Earth's shifting plates (formed by the lithosphere) collide, pull apart, or slide past one another, usually with violent results (expressed as earthquakes). Earth's outer shell, long thought to be a continuous, unbroken crust is actually a mosaic of pieces of broken lithosphere, or plates.

These enormous blocks of Earth's plates vary in size and shape, and have definite borders that cut through continents and oceans. There are nine large plates and a number of smaller plates. Most plates are comprised of both continental and oceanic crust, the giant Pacific Plate is almost entirely oceanic, and the little Turkish-Aegean Plate is entirely land. Of the nine major plates, six are named for the continents embedded in them: the North American, South American, Eurasian, African, Indo-Australian, and Antarctic. The other three are oceanic plates: the Pacific, Nazca, and Cocos. The boundaries between these plates can be: **convergent** (moving towards each other), **divergent** (moving away from each other), or **transform** (sliding past each others). Volcanoes also occur on **hot spots**, which are rising plumes of hot material that generates magma within the lithosphere.

Convergent Plate Boundaries

Plates that are moving towards one another met at what are called convergent plate boundaries. Where two plates meet, and one typically descends beneath the other in a process called subduction. It is along these subduction zones that the world's strongest earthquakes occur! As the descending plate is forced deeper into the mantle, parts of it begin to partially melt and form intermediate composition magma that rises to the surface, often in explosive eruptions. Convergent margins tend to create large, cone-shaped volcanoes called composite (or strato-) volcanoes, such as Mt. Rainer and Mt. St. Helens in Washington State.

There are 3 types of convergent plate boundaries: Oceanic-Continental, Oceanic-Oceanic and Continental-Continental.

Oceanic-Oceanic (Figure 1)

When two oceanic plates converge, the more dense plate is subducted beneath the less dense plate, and in the process a deep oceanic trench is formed. The Marianas Trench (the deepest place on the bottom of the ocean) is an oceanic trench created as the result of the subduction of the Philippine Plate beneath the Pacific Plate. Oceanic-Oceanic convergence results in the formation of undersea volcanoes. Over millions of years, however, the erupted lava and volcanic debris pile up on the ocean floor until a submarine volcano rises above sea level to form a volcanic island. Such volcanoes are typically strung out in chains, parallel to the oceanic trench, and are called island arcs.

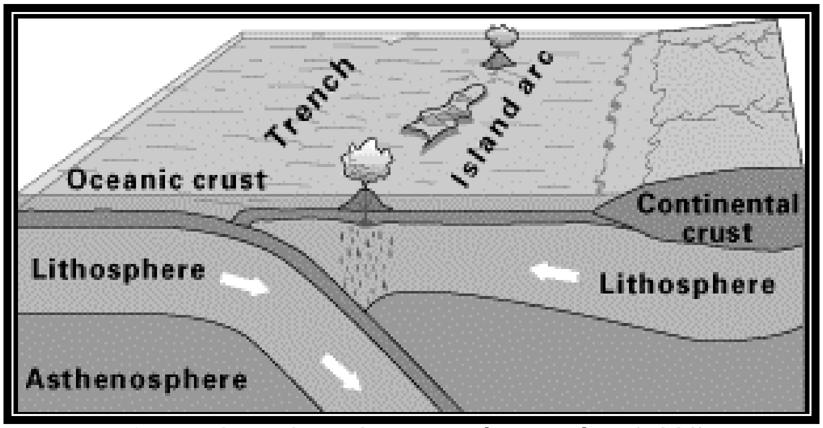


Figure 1: Ocean-Ocean Convergent Plate Boundary (USGS)

Oceanic – Continental (Figure 2)

When an oceanic plate collides with and is subducted beneath a continental plate, the overriding continental plate is lifted up and a mountain range is created. The crests of these mountain chains are lined with a series of composite volcanoes, such as those along the Cascade Range (Washington and Oregon).

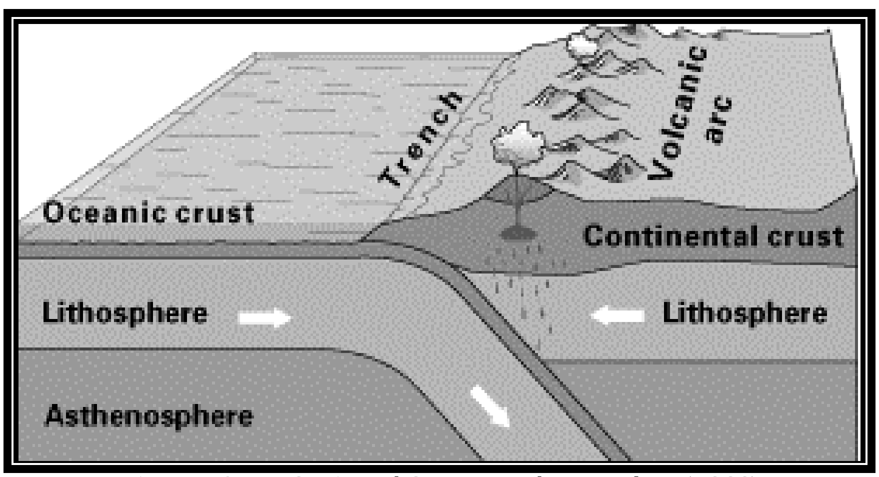


Figure 2: Ocean-Continental Convergent Plate Boundary (USGS)

Continental-Continental (Figure 3)

When two continental plates meet, the crust tends to buckle and be pushed upward and sideways. The collision of India into Asia 50 million years ago caused the Eurasian Plate to crumple up and override the Indian Plate. The slow, continuous convergence of the two plates over millions of years has pushed up the Himalayas and the Tibetan Plateau to their present heights. Composite volcanoes occur in these setting, but are relatively uncommon.

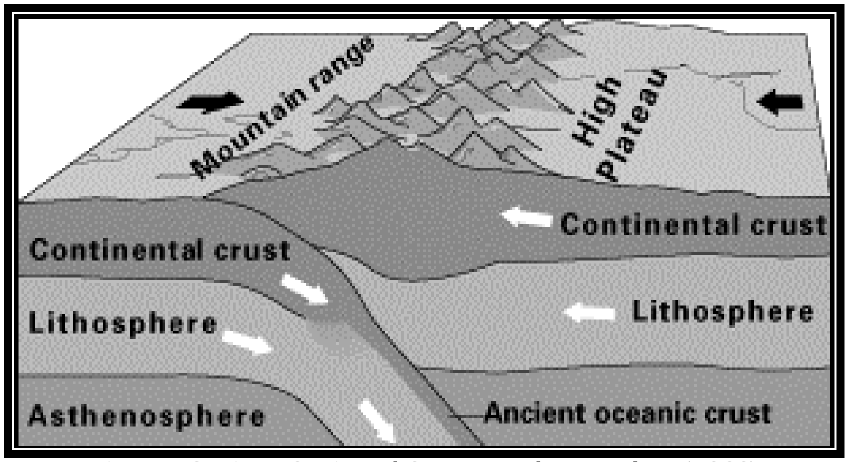


Figure 3: Continent-Continental Convergent Plate Boundary (USGS)

Divergent Plates Boundaries

At divergent plate margins, plates are coming apart and hot, mafic magma rises to fill the gap between the diverging plates. Many divergent plate margins are under the oceans, creating long undersea rift zones that fill with lava to create new oceanic crust. In most eruptions at divergent margins, relatively calm eruptions of mafic lava create volcanoes with gently sloping sides, called shield volcanoes. Cinder cones may also form associated with these shield volcanoes.

Transform Plate Boundaries

Plates that slide past one another form transform plate boundaries. Large earthquakes can and do occur along such boundaries (e.g. the San Andreas Fault in California); however, it is important to note no volcanoes form along these boundaries, as the lateral movement does not allow for the generation of magma!

Hot Spots

Hot spots can also cause volcanoes to form at areas other than plate boundaries. As plates move over hotspots, volcanoes spring up and die down in turn, often creating an island chain. The Hawaiian Islands in the Pacific are shield volcanoes that formed as the result of a hotspot. Hotspots under continental crust may give different type of volcanoes (including lava domes) such as seen in Yellowstone, Wyoming.

SIGNS OF A POSSIBLE ERUPTION

Prior to the actual eruption of a volcano, magma moves into the area beneath the volcano and collects in a magma chamber or reservoir. As it comes closer to the surface, the magma releases gases. These events can offer valuable clues about the likelihood of an eruption. For example, the movement of magma produces small earthquakes and vibrations (seismicity). Magma gathering in a chamber causes swelling or tilting of the volcano's slopes. Gases coming out of solution may make it to the surface.

A number of tools can be used to record these warning signs. Seismographs can detect small earthquakes while tiltmeters and geodimeters can measure the subtle swelling of a volcano. Gases from the volcano can be measured for changes in quantity and makeup. Correlation spectrometers can measure amounts of sulfur dioxide (a telltale gas that is released in increasing quantities before an eruption). Using these and other tools, it's possible to closely monitor activity at an awakening volcano.

Volcanologists are becoming very skilled at predicting the likelihood of an eruption. Still, a number of barriers remain. It's very difficult to pinpoint exactly when an eruption will happen.

Often, moving magma doesn't result in an eruption, but instead cools below the surface. Monitoring potential eruptions is expensive. With many volcanoes erupting only every few hundred or thousand years, it's not possible to monitor every site. However volcanic eruptions don't occur without warning. If monitoring devices are set up, it could be possible not be caught off guard by disastrous eruptions. Scientists can often find clues about past eruptions by studying the deposits left behind.

There is no way to prevent an eruption from occurring. We can, however, reduce the eruption's effects by reinforcing structures (for example, strengthening roofs to support the weight of tephra deposits) or by building protective works (such as walls to deflect lava flows away from developed areas). Such efforts are of limited use in a large-scale eruption.

IMPLEMENTATION STRATEGIES

TAKS (Texas Assessment of Knowledge and Skills) Objective 4

The student will demonstrate an understanding of the earth sciences.

4.6 The student knows that forces cause change.

- B. Identify that the surface of the Earth can be changed by forces such as earthquakes and glaciers.

3.11 The student knows that the natural world includes earth materials and objects in the sky.

- A. Identify and describe the importance of earth materials including rocks, soil, water, and gases of the atmosphere in the local area and classify them as renewable, nonrenewable, or inexhaustible resources.

4.6 The student knows that change can create recognizable patterns.

- A. Identify patterns of change such as in weather, metamorphosis, and objects in the sky.

4.11 The student knows that the natural world includes earth materials and objects in the sky.

- A. Test properties of soils including texture, capacity to retain water, and ability to support life.
- B. Summarize the effects of the oceans on land.
- C. Identify the Sun as the major source of energy for the Earth and understand its role in the growth of plants, in the creation of winds, and in the water cycle.

5.5 The student knows that a system is a collection of cycles, structures, and processes that interact.

- A. Describe some cycles, structures, and processes that are found in a simple system.
- B. Describe some interactions that occur in a simple system.

5.6 The student knows that some change occurs in cycles.

- A. Identify events and describe changes that occur on a regular basis such as in daily, weekly, lunar, and seasonal cycles.
- B. Identify the significance of the water, carbon, and nitrogen cycles.

5.11 The student knows that certain past events affect present and future events.

- A. Identify and observe actions that require time for changes to be measurable, including growth, erosion, dissolving, weathering, and flow.

B. Draw conclusions about "what happened before" using data such as from tree-growth rings and sedimentary rock sequences.
C. Identify past events that led to the formation of the Earth's renewable, non-renewable, and inexhaustible resources.

5.12 The student knows that the natural world includes earth materials and objects in the sky.

A. Interpret how landforms are the result of a combination of constructive and destructive forces such as deposition of sediment and weathering.
C. Identify the physical characteristics of the Earth and compare them to the physical characteristics of the moon.

This unit will be used mainly as part of the science curriculum. Considering that the students are second graders, with the help of a computer and an overhead projector, I will use a lot of photographs and illustrations of different kind of volcanoes found in books and Internet. The use of manipulatives will be essential in the introduction of the lessons. I also plan to use videos and provide books for kids about volcanoes and earthquakes. Likewise, the landform of the three main types of volcanoes will be made and shown in class. Safety regulations will be necessary to be introduced first. Also, the science center will be accordingly arranged with books to help the student with this topic.

I will first use the KWL method: what I know, what I want to know, and what I learned. It will be tremendously beneficial for me and for the student to use the KWL method because it will help me to know how much they know about volcanoes. I will then teach them the information described above in session of 45 minutes, twice a week. We will also read science books with passages that emphasize the development of the reading skills: e.g. cause and effect, sequence, main idea, context clue, and inference. There will also be weekly tests. Additionally, there will be writing (KWL chart) and group work. Geography will be covered as well as Sciences and Social Studies. We will work with maps, and talk about the countries and oceans where volcanoes are located.

GLOSSARY

Crater: A shallow depression at the top of a volcanic cone.

Caldera: a caldera is a large, usually circular depression at the summit of a volcano formed when magma is withdrawn or erupted from a shallow underground magma reservoir. The removal of large volumes of magma may result in loss of structural support for the overlying rock, thereby leading to collapse of the ground and formation of a large depression. Calderas are different from craters, which are smaller, circular depressions created primarily by explosive excavation of rock during eruptions.

Edifice: The volcano's cone-shaped structure, or edifice, is built by the more-or-less symmetrical accumulation of lava and/or pyroclastic material around this central vent system.

Falling Ash: In an explosive eruption, gases escape violently. Magma breaks into pieces and bursts from the volcano in a column of ash and fiery fragments. The cooled fragments that fall back to Earth are called tephra. In a large eruption, tephra can cover vast areas with a thick layer of ash, presenting a much greater hazard than lava flows.

Fumaroles: Fractures can also act as conduits for escaping volcanic gases, which are released at the surface through vent openings called fumaroles.

Gas: Magma contains dissolved gases that are released into the atmosphere during eruptions. Gases are also released from magma that either remains below ground or rises toward the surface. In such cases, gases may escape continuously into the atmosphere from the soil, volcanic vents, fumaroles, and hydrothermal systems. The most common gas released by magma is steam (H_2O), followed by CO_2 (carbon dioxide), SO_2 (sulfur dioxide), (HCl) hydrogen chloride and other compounds.

Glowing Avalanches: Pyroclastic flows are mixtures of very hot gas and tephra that cascade down a volcano's sides at high speeds. They can spread destruction over large areas and move at very high speeds, they are extremely hazardous.

Lava flows: Lava flows are a threat, but they are usually slow enough to people to be able to get out of the way. However, lava flows burn buildings and ruin crops. Lava flows normally don't cover very large areas.

Magma chamber: The central vent is connected at depth to a magma chamber, which is the main storage area for the eruptive material.

Mud and debris flows: Debris flows, fragments of mud and other debris that flow down the sides of a volcano are another serious and little-known hazard. Debris flows often form when part of the volcano collapses, breaking up and flowing downhill. If the collapse is a major one, the large flow that results can travel great distances, often burying everything in its path.

Pyroclast: A fragment from an explosive volcanic eruption

Pyroclastic flow: A flowing avalanche of hot volcanic ash, cinder, and pyroclasts.

Tephra: fragments thrown into the air by a volcanic eruption.

Vent: A volcanic vent is an opening exposed on the earth's surface where volcanic material is emitted.

Volcanic Explosivity Index: or VEI, was proposed in 1982 as a way to describe the relative size or magnitude of explosive volcanic eruptions. It is a 0-to-8 index of increasing explosivity. Each increase in number represents an increase around a factor of ten. The VEI uses several factors to assign a number, including volume of erupted pyroclastic material (for example, ashfall, pyroclastic flows, and others), height of eruption column, duration in hours, and qualitative descriptive terms.

Lesson Planning Form 1

Grade/Subject: SECOND GRADE Time: 2 sessions of 45 minutes each
Topic: Volcanoes: Introduction

LESSON CYCLE	**TAKS/Project CLEAR**	**Material**	**Description**
Focus: A short opening "attention getter"	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.	Photographs of real volcanoes	Students will identify the volcanoes that they see in the photographs
Objective(s)	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.		
Explanation Modeling Monitoring Guided Practice	KWL: volcanoes	Construction paper	In groups of four, students will be instructed to share all the information they know about volcanoes. After that, the board will be divided in three parts. In the first part the students will say all they know about volcanoes. In the second part, they will say all they want to know about volcanoes. I will write the sentences they tell me, and also will make the necessary corrections to their sentences repeating them but using the new terms they will learn.
Independent Practice Enrichment	KWL: volcanoes		Once finished, they will copy all that in their construction paper. Once they finish copying, I will tell then what we are going to learn the followings days: definition of a volcano, the magma and the eruption process, type of volcanoes, plate tectonics, how volcanoes form, parts of a volcano, and the effects of the eruption of a volcano.
Closing: An opportunity for the students to restate what they have learned or for the teacher to tie together facets of the lesson.	KWL: volcanoes		Students will restate what the class knows and what the class wants to know. I will also tell them again what we are going to do during the following classes. They will write on their word book the new words they are learning.

Lesson Planning Form 2

Grade/Subject: SECOND GRADE   Time: 3 sessions of 45 minutes each
Topic: Volcanoes: Magma and the eruption process

LESSON CYCLE	TAKS/Project Clear	Material	Description
Focus: A short opening "attention getter"	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.	Overhead projector, computer and photographs of real volcanoes. Videos of volcanoes erupting.	Students will re-state all that we did the previous class. I will tell them what we are going to do: The magma and the eruption process. First they will watch a video of an erupting volcano
Objective(s):	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.		
Explanation Modeling Monitoring			They will write on their word book the new words they are learning. The new words are: magma, lava, eruption, viscosity, shield volcano, cinder cone, composite, basalt, andesite, rhyolite, silica, and effusive and explosive activity. I will define each word while I explain what is magma, lava, and the eruption process. They will see other videos where I will explain and they will see the different between an effusive eruption and an explosive eruption. In another session I will show them pictures of the type of volcanoes. I will explain the characteristics of each one. Likewise, they also will see a scale comparison of these volcanoes to understand how big is one of them (shield volcano) and small is another one (cinder cone). In another session the topic will be to explain the different eruption processes and the type of volcanoes. We will study magma, composition, properties and effects. They will learn that some very important components (like silica) make the magma more viscous, and viscosity (together with other properties and components) explains the type of eruption and type

LESSON CYCLE	TAKS/Project Clear	Material	Description
			of volcano.
Guided Practice -Assessment mastery -Re-teaching: if needed			I will summarize all the relationships among compositions of magma, properties and effects in a chart presented to the students, so they will understand, for example (in a simplified way), that silica content explain a property of magma named viscosity, and viscosity is related to explosivity in volcanic eruptions. Also, we will place volcanoes around the world using maps. So the students will know the there are volcanoes almost in every part of the world. As a test, there will be a group activity: The students will write a report about the type of erupting processes and the type of volcanoes. The second part of the report will be to explain the following relationships: viscosity vs. type of volcano and viscosity vs. explosivity of volcanic activities.
Independent Practice Enrichment			As an independent practice and enrichment, in groups, the students will develop a list of procedures to follow (by the city, government and the people) in the case of a volcanic eruption. These procedures will be presented and discussed in class.
Closing: An opportunity for the students to restate what they have learned or for the teacher to tie together facets of the lesson.			The students and I will restate what the class has learned. This time, in groups of four, they will complete the third part of the KWL chart, that they started the first session of this unit about volcanoes: “What I Learned” I will write in the board all what they tell me they have learned during all the sessions. One at a time. I will make necessary corrections trying to use proper terms and grammar. Once it is all done, they will write it all on their KWL chart they made with construction paper.

Lesson Planning Form 3

Grade/Subject: SECOND GRADE Time: 3 sessions of 45 minutes each

Topic: Volcanoes: How do volcanoes form?

LESSON CYCLE	TAKS/Project Clear	Material	Description
Focus: A short opening "attention getter"	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.	Overhead projector, computer and photographs of real volcanoes and plates, and boiled eggs.	Students will re-state all what we did the previous class. I will tell them what we are going to do: plate tectonics and the formation of volcanoes.
Objective(s)	TAKS Objective 4 The student will demonstrate an understanding of the earth sciences.		To know plate tectonics is very important to understand earthquakes and volcanoes.
Explanation Modeling Monitoring			I will show them the globe with the continents and the oceans. They will identify the continents, countries and some cities. I will explain that the continents, islands, and water cover the surface of our planet. Then, I will ask if they know what is under the oceans and continents. After listening to their different answers, I will show them a picture of the planet, but cut in half, so they can see what is underneath. I will explain that those layers are (the crust, the mantle and the core) and what are they made of. Next, I will use boiled eggs to explain again the different layers. One egg will be referred as the earth and other eggs cut in half will show them what would be the core, the mantle and the crust.
Guided Practice -Assessment mastery -Re-teaching: if needed		Overhead projector to show the earth's layers, illustration of plates and about convergent plates and divergent plates.	I will tell them that the shell of the egg represents the Earth's outer shell. Then I will explain that the crust is broken and actually a mosaic of many irregular rigid segments, called plates. There are nine large plates and a number of smaller plates. These plates have borders that cut through continents and oceans. I will explain that when these plates move they cause earthquakes and volcanoes. They will see and touch representations of plates through the use of clay, and convergent and divergent plates through the use of illustrations. They will see what happen

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			when these blocks of rock mo ve under the ocean and when are continental blocks that come together. The part that is subducted under the other is forced deeper into the mantle, part of it begins to melt and form magma that rises to the surface, often in explosive eruptions.
Independent Practice Enrichment			Using clay, and watching the pictures that are projected on the board, the students in pairs will made plates that come together. This way they will understand how mountains appear, earthquakes and the formation of volcanoes. Each group is going to explain using the clay how volcanoes form. This activity will be graded. Group work, question: How do you think that mountains appear on the Earth?
Closing: An opportunity for the students to restate what they have learned or for the teacher to tie together facets of the lesson.			The students and I will restate what the class has learned. This time, in groups of four, they will complete the third part of the KWL chart, that they started the first session of this unit about volcanoes: "What I Learned" I will write in the board all what they tell me they have learned during all the sessions. One at a time, I will make necessary corrections trying to use proper terms and grammar. Once it is all done, they will write it all on their KWL chart they made with construction paper.

ANNOTATED BIBLIOGRAPHY

Works Cited

Dupré, William. Houston Teachers Institute Seminar Leader. "Living with Geologic Hazards." Spring 2005.

Farndon, John. *Dictionary of the Earth*. New York: Dorling Kindersley Publishing Inc., 1994.
This book has more than 2000 definitions arraigned by sub-subjects, and is fully illustrated.

Rosi, Mauro, Paolo Papale, Luca Lupi, and Marco Stoppato. *Volcanoes.* New York: Firefly Books, 2002.
This book is fully illustrated and, after giving basic information about volcanoes, it describes the main characteristics of 100 volcanoes.

U.S. Department of the Interior, U.S. Geological Survey. Menlo Park, CA. 8 March 2005.
<http://volcanoes.usgs.gov/Products/Pglossary/pglossary.html>.
This source contains a photo glossary of volcanic terminology.

Supplemental Resources

De Boer, Jelle Zeiliga, and Donald Theodore Sanders. *Volcanoes in Human history: The Far Reaching Effects of Major Eruptions.* Princeton: Princeton UP, 2002.
This book is about the events of nine volcanoes and the influence of these events in human history. It is a book with photographs, stories and illustrations.

Kunhardt, Edith, and Eagle, Michael. *Pompeii… Buried Alive!* New York: Random House, 1987.
This book is designed to help to develop reading comprehension for second graders through the story of Pompeii, before, during and after the eruption of Vesuvius.

Levy, Matthys and Mario Salvadori. *Why the Earth Quakes: The Story of Earthquakes and Volcanoes.* New York: W.W. Norton & Company, 1995.
This book explains origins of earthquakes and volcanoes through the stories of the worst natural disasters of all time, from Lisbon (1977) to Kobe (1995).

Mathews, Rupert. *The Eruption of Krakatoa*. New York: The Bookwright Press, 1989.
This fully illustrated elementary book presents the story of Krakatoa, before, during and after the big eruption of 1883. It gives us information of the prosperous population in the island by 1883, the aftermath of the big eruption and Krakatoa today.

Weisel, Dorian, and Johnson, Carl. *Fire on the Mountain: The Nature of Volcanoes.* San Francisco: Chronicle Books, 1994.
This book compiles more than 100 photographs of volcanoes. These are accompanied by comprehensive information about the nature of volcanoes.

Videos

The Eruptions of Mt. St. Helens. Director Otter Sieber. Holiday Video Library.
An offer, in 30 minutes, the eruption of the volcano, since its initial blast sequence and it also shows the effects caused over 150 square miles of forest.

Born of Fire. Producers Dennis B. Kane, Thomas Skinner. National Geographic, 1983.
Five case studies of volcanic eruptions.

The Eruption of Mount St. Helens. Director George V. Casey. Sling Shot Entertainment, 1990.
Present the events of Mount St. Helens eruption of 1980.

Web Resources

Alaska Volcano Observatory. http://www.avo.alaska.edu/
This site contains information and a photo archive on over 40 active volcanoes in the Alaskan region.

Ask-a-Geologist. http://geology.usgs.gov/ask-a-geo.html
If you can't find an answer anywhere else, try asking a USGS geologist.

Cascades Volcano Observatory. http://vulcan.wr.usgs.gov/

The Electronic Volcano. http://www.dartmouth.edu/~volcano/
Dartmouth University's extensive collection of volcanology resources.

Eruptions of Hawaiian Volcanoes: Past, Present, and Future. http://pubs.usgs.gov/gip/hawaii/

Eruptions of Mt. St. Helens: Past, Present, and Future. http://pubs.usgs.gov/publications/msh/

Global Volcanism Program, Smithsonian Institution. http://www.nmnh.si.edu/gvp/index.htm
A wealth of up-to-date volcano information, including the monthly Bulletin of the Global Volcanism Network.

How Volcanoes Work. http://www.geology.sdsu.edu
This site has basic information about volcanoes

Monitoring Active Volcanoes. http://pubs.usgs.gov/gip/monitor/

MTU Volcanoes Page. http://www.geo.mtu.edu/volcanoes/
Maps, terms, current volcanic events, and more can be found at Michigan Tech's site.

Plate Tectonics. http://www.platetectonics.com

U.S. Geological Survey (USGS) Volcano Hazards Program. <http://volcanoes.usgs.gov>.
An essential resource on volcanic hazards, this site includes a FAQ, photo glossary, and more.
Volcanoes. http://pubs.usgs.gov

Volcanoes of the United States. http://pubs.usgs.gov/gip/volcus/

Volcano Resources for Educators. http://volcanoes.usgs.gov/educators.html.

Volcano World. http://volcano.und.nodak.edu/
Excellent resource designed for younger audiences but fun for all ages. Don't miss their "Ask a Volcanologist" feature.

Volcano World's Email Forums. http://volcano.und.nodak.edu/vwdocs/mailing_lists/
Get email notices when volcanoes erupt around the world.