Michigan Technological University GK12 Global Watershed Program

Schoolyard Volcanoes
Earth Science 8th grade

Unit Summary: *This unit builds on students' knowledge of geology and looks more closely at the processes, energy and morphology involved in volcanic eruptions and development. Lesson 1 focusses on the composition of magma and its various viscosities and the influence on the eruption style and shape of different volcanoes. Lesson two uses an analogue model of a volcano to demonstrate the forces involved in a eruption and potential hazards. Students will think critically about the factors that affect hazards and risk as well as the variables (such as topography) that affect the eruption and the hazard. Lesson 3 uses Google Earth to take a virtual field trip to a volcano in Central America. In this lesson the students will examine changes in the landscape over time to and other evidence of volcanic activity to make interpretations about the volcano. Lesson 4 returns to the analogue model but this time collects data from the explosion to interpret the energy release and the speed of the pressure wave.*

Next Generation Science Standards

- **MS-ESS3-2.** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- **MS-ESS2-2.** Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact of the environment.
- **Crosscutting Concept 4: Systems and system models.**

Michigan Standards:

- **E3.4 Earthquakes and volcanoes**: …the intensity of volcanic eruptions is controlled by the chemistry and properties of the magma.
- **E.3.4C** Describe the effects of earthquakes and volcanic eruptions on humans.

Key Words: Volcanoes, eruptions, magma composition, viscosity, hazards, monitoring, models, Google Earth

Table of Lessons:

Lesson Title- Brief Description	Learning Objectives	Materials
Volcanoes, Hazards and the Stuff Inside. A volcano and volcanic eruption can produce a variety of hazards. The composition and viscosity of magma are the driving forces of volcanic eruptions and influence eruptive activity. Not only that but it is these factors that create the two principle volcano types: shield and composite. This lesson which is ada pted from The University of Arizona Geosciences outreach program. This lesson has the students follow the scientific method to understand the variables of magma properties that influence volcanic eruptions. Students will make hypotheses, run experiments, and test predictions to	• Explain how volcanic eruptions vary due to variables related to the chemistry and physical properties of the magma and volcano morphology. • Define the term viscosity. • Explain how gasses trapped in magma are influenced by viscosity and eruptive properties. • Identify fluids in order of increasing or decreasing viscosity. • Identify the properties of magma based on information about the volcano. • Explain why we use models to study volcanic processes.	• *Student sheets* o Viscosity Experiment worksheet o Viscosity Quick Quiz o Google Earth Scavenger Hunt • *Volcanoes PowerPoint Presentation* • *Computer with internet and Google Earth.* • *Teacher Demos* o *Clear, see-through bottle of shampoo* o *Clear, see-through bottle of hair gel* o *Any fluids that can be used to demonstrate how gas (air bubbles) moves through a viscous medium. If they are in a clear, see-through bottle it is best.* o *Shaving cream* o *Bottle or can of soda* o *2 Graduated cylinders* • *Student experiment 1* o *Materials of varying viscosity (honey, ketchup, mustard, peanut butter, etc…)* o *Cutting boards* o *Catch tray* • *Student experiment 2* o *Pudding cups, one for each student* o *Dixie cups, one-two for each*

determine what kind of eruption type and associated hazards might be expected given various magmas. Using Google Earth, students will take a tour of different volcanoes around the world and using the knowledge gained in this lesson, identify the type of volcano, the properties of its magma/lava, and likely eruption styles.		*student* ○ *Straws, one-two for each student* ○ *Spoons (for eating the pudding after)* ***Optional Demo Materials*** • *Lava lamp* • *Intrusive Volcanism* *wordpress.up.edu/totle/2012/09/gelatin-model-of-magma-intrusion-lesson-plan/* ○ *Jell-O mold* ○ *Chocolate syrup* ○ *Injector/syringe* ○ *Flat surface* • *Volcanic Gasses* *wordpress.up.edu/totle/2012/09/co2-and-candles-lesson/* ○ *Metal mixing bowl* ○ *Three small candles of variable heights* ○ *Beaker* ○ *Baking soda* ○ *Vinegar*
Where is Safe? The Schoolyard Volcano This lesson uses an analogue model of an erupting volcano to a show students how variables in the eruption can influence the degree of exposure and the spatial extent of the hazard. The driving	• Create a hazard map based on empirical evidence • Use evidence from previous events to predict where a hazards is likely to occur • Critique the trash can volcano model for its ability to simulate a volcanic eruption	• *Heavy-duty, round, plastic trashcan* ○ *Metal trash cans are inappropriate for this demonstration because they will rupture along the welded seam. A Rubbermaid "Brute" series container is recommended.* • *http://www.rubbermaidcommercial.com/rcp/products/detail.jsp?categoryCode=waste&subCategoryCode=waste_brute_utilit*

force of the model (the expansive properties of CO_2 and N_2 are analogous to the driving forces of a volcanic eruption. CO_2 expands 850 times its volume during sublimation, while N_2 expands 750 times when boiling. Discussions in this lesson will revolve around the spatial extents and hazards to humans. Students will also gain a greater appreciation and understanding for the use of models in the study natural hazards, volcanology and science in general.	• Explain how and why models are used to study natural hazards. • Use evidence based reasoning to explain how changes in volcanic eruptions result in changes to the hazard area	*y&rcpNum=1867531* • *Water outlet* • *Sandbag* • *Soda bottles of various sizes: 2 liter bottles are the best but you are welcome to experiment. Also the bottle integrity must be sound. There should be no nicks, cracks or greases in the plastic. The bottle cap and threads must also be in good condition.* • *Duct Tape* • *Liquid Nitrogen* • *Funnel* • *Various sized Ping-Pong balls and whiffle balls* • *Student worksheets* ○ *Trash Can Volcano: Student Worksheet* ○ *Trash Can Volcano: Student Hazard Maps* • *Tape measure* • *Colored pencils* • *3-4 pieces of paper labeled "Village A," "Village B," etc.* • *PowerPoint Presentation* ○ *Lesson_2_volcanic_hazards* ○ *Images of volcanoes and embedded video* http://youtu.be/jJO1QEmcZGs http://youtu.be/6J6X9PsAR5w
Virtual Volcanology This lesson takes the students on a virtual field trip to an active	• Identify evidence of past eruptions • Evaluate spatial extent of past eruptions	• *Computer with internet* • *Google Earth* • *Zip file "Files"* ○ *KMZ files:*

volcano. While there they will collect data and information to investigate recent eruptions and hazards. They will look for changes in the landscape over time as well as technical data. They will use higher order logic to make interpretations regarding geologic features, changes in the landscape as well as volcanic behavior.	• Describe how volcanic processes affect the surrounding landscape over time • Interpret a graph to explain changes in volcanic activity • Identify a volcano in Central America using Google Earth • Explain how volcanologists study volcanoes	▪ *Virtual volcanology demo tour* ▪ *Pacaya virtual volcanology* ○ *Associated JPEG's* • *Students worksheets: Virtual Volcanology Field Guide*
Volcano Monitoring: The Schoolyard Volcano. This lesson using scientific instrumentation to record the energy released during the modeled volcanic eruption described in lesson 2 "Where is Safe." Students will come to understand that volcanologists require high tech instruments to record wave energy to what happens during a volcanic eruption. They will look at data,	• Use appropriate scientific instruments to collect geophysical data • Explain the value in using scientific models • Tabulate data • Analyze data • Graph data • Interpret data and make predictions about the future • Explain how more energetic explosions emit higher amplitude waves • Describe how scientists use seismology/wave-forms to carry out	*Lesson 2 "Where is Safe"* • *Trash Can Volcano Demonstration* • *Accompanying demo and safety materials* *Student worksheet* • *Volcano monitoring student sheet* *Slinky (optional)* *Tape measure* *Colored pencils* *Accelerometer and software from Quake Catcher Network* • *http://qcn.stanford.edu/join-qcn/request-a-sensor* • *QCNLive http://qcn.stanford.edu/join-qcn/download*

make calculations, analyses and conclusions about the energy released and the speed of sound from the modeled eruption. This lesson requires that you have at least one of the two instruments described in the body of this lesson (accelerometer and/or micro-barometer). Accelerometers can be obtained for free from the company website listed above. If you have a well-equipped and capable physics department you might obtain micro-barometers from them. This lesson can also be accomplished in one of two ways; you as the teacher must decide which is most feasible and works best for you. Option 1: If you have the time and resources you will repeat the volcanic eruption model that was demonstrated in lesson 2 “Where is Safe.” Option 2: If you	investigations	*Microbarometer data* • *Excel sheet - micro_barometer_data* • *If you have micro barameters:* ○ *Excel sheet – Trash_Can_Volcano_Plotter* ○ *Trash_Can_Volcano_Plotter_Instructions* *Computer with Excel*

don't have the time you can integrate the instrumentation and monitoring of this lesson into the demo of lesson 2 and then come back to the data later to complete the exercises and student worksheets from this lesson.		

Safety Considerations:

- http://engineering.dartmouth.edu/microeng/ln2.html
- http://www.uvic.ca/science/stores/assets/docs/LIQUID%20NITROGEN%20SAFETY.pdf
- https://labsafety.tamu.edu/training/labsafety/PDF/12_LN2Cylinders-color.pdf
- http://www.chem.purdue.edu/chemsafety/chem/ln2.htm
- http://rgs.usu.edu/ehs/htm/programs-and-services/laboratory-safety/liquid-nitrogen-guidelines

Cryogens are substances that are used to produce temperatures below -153°C (-243°F). Liquid Nitrogen (LN_2) has a boiling point of -196°C (-321°F). Solid carbon dioxide (from here to referred to as dry ice) is not a cryogen but sublimates (converts directly to CO_2 gas) at -78°C (-109°F).

- LN_2 should only be transported in a **Dewar flask**. This is a non-pressurized cylinder with a safety release valve.
- LN_2 should only be transported in an upright position.
- LN_2 and CO_2 gas released in a confined space can displace sufficient oxygen to make the atmosphere incapable of sustaining life and cause asphyxiation without warning.

OSHA safety concerns for Dry Ice or LN_2

- Avoid eye or skin contact with these substances.
- Never handle dry ice or LN_2 with bare hands.
- Use loose-fitting, cryogenic, or heavy work-gloves. They must be loose so that they can be quickly removed incase LN_2 splashes or a piece of dry ice falls into them.
- Always use appropriate eye protection.

- **DO NOT** use or store dry ice or LN_2 in confined areas, walk-in refrigerators, environmental chambers or rooms without ventilation. A leak in such an area could cause an oxygen-deficient atmosphere
- Never place a cryogen on tile or laminated counters because the adhesive will be destroyed.
- Never dip a hollow tube into liquid nitrogen; it may spurt liquid.
- **NEVER** store a cryogen in a sealed, airtight container at temperature above the boiling point of the cryogen; the resulting pressure from the production of gaseous CO_2 or LN_2 may lead to an explosion.

First Aid

- In case of exposure to cryogens or dry ice, remove any clothing that is not frozen to the skin. **DO NOT** rub frozen body parts because tissue damage may result. Obtain medical assistance as soon as possible.
- Place the affected part of the body in warm water bath not above (40°C). **NEVER** use dry heat.

Safety Measures:

- In the event of a large spill, evacuate the area. There may be an oxygen deficiency in the area of the spill.
- In the event that the soda bottle is miss threaded, do not approach the bottle. Allow it to degas over the next 15-20 minutes.
- In the event that the soda bottle becomes detached from the sandbag or weights, DO NOT approach the bottle or trashcan. Cover your ears and have all the audience/observers cover their ears.

Safety procedure:

Either of these substances can be hazardous to humans if not handled properly. Either one should only be handled by adults using appropriate safety precautions, gear, gloves and eye protection. When using liquid nitrogen for this demonstration a minimum of two adults are required. One person should hold the bottle and funnel while the other pours the liquid N_2. Both chemicals, when sealed in the soda bottles will eventually build up a critical pressure and result in an explosion. Students should stand a minimum of 50 feet away at all times. The liquid N_2 will over pressurize in roughly 30 seconds after sealing the bottle. It is important that adults evacuate the area as soon as the bottle is submerged. After the explosion the students will want to approach the trashcan to examine it. It is necessary that the Dewar-flask be kept under supervision of one of the adult scientists.

It is important to keep the students at least 10 meters away from the demonstration. Other teachers or adults must help keep the students back at all times. If feasible it is advised to rope off an area that students cannot pass.

Evaluation Plan: Indicates the formative and summative assessment tools that will be used and the purpose of each tool.

Formative:

- Students will fill in worksheets during each lesson and answer questions related to each activity to assess their comprehension of the material.
- At the end of each lesson students will be asked to write a sentence or two identifying the main points of the lesson.

Summative:

- Student worksheets and lesson quizzes will be assigned a grade.

Resources (websites):

- http://wordpress.up.edu/totle/2012/09/gelatin-model-of-magma-intrusion-lesson-plan/ - Gelatin model of magma intrusion.
- http://wordpress.up.edu/totle/2012/09/co2-and-candles-lesson/ - CO2 and Candles, heavy gasses model.
- http://www.geo.arizona.edu/sites/www.geo.arizona.edu/files/Volcanoes%20and%20Viscosity.pdf – Volcano viscosity lesson plan from the University of Arizona.
- http://www.geo.arizona.edu/node/267 - University of Arizona Geoscience Resources for teachers.
- http://www.rubbermaidcommercial.com/rcp/products/detail.jsp?categoryCode=waste&subCategoryCode=waste_brute_utility&rcpNum=1867531 – Rubbermaid Commercial products; heavy duty trashcan

Liquid Nitrogen Safety

- http://engineering.dartmouth.edu/microeng/ln2.html - Dartmouth Engineering, Liquid Nitrogen Safety.
- http://www.uvic.ca/science/stores/assets/docs/LIQUID%20NITROGEN%20SAFETY.pdf – UW Madison, liquid nitrogen safety training PDF
- https://labsafety.tamu.edu/training/labsafety/PDF/12_LN2Cylinders-color.pdf – Texas A&M Engineering; liquid nitrogen safety training PDF
- http://www.chem.purdue.edu/chemsafety/chem/ln2.htm – liquid nitrogen safety; Purdue University
- http://rgs.usu.edu/ehs/htm/programs-and-services/laboratory-safety/liquid-nitrogen-guidelines – Utah State University; liquid nitrogen safety guidlines
- OSHA safety concerns for Dry Ice or LN_2 – OSHA Safety concerns for liquid nitrogen

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Google Earth training and support – These Google support sites will help you learn how to navigate through Google Earth.

- https://support.google.com/earth/answer/176674?hl=en
- https://support.google.com/earth/answer/176682?hl=en
- http://www.google.com/earth/outreach/tutorials/index.html
- http://www.google.com/earth/learn/beginner.html

Quake Catcher Network (QCN) – These sites from Stanford University are where you can go to request the instruments necessary for lesson 4 of this unit.

- http://qcn.stanford.edu/join-qcn/request-a-sensor
- http://qcn.stanford.edu/join-qcn/download

Information on wave energy and acceleration- this pages provide information that can be useful in explaining some of the geophysical concepts found in lesson 4.

- http://en.wikipedia.org/wiki/Accelerometer – Wikipedia accelerometer
- https://www.dimensionengineering.com/info/accelerometers - A beginner's guide to accelerometers
- http://web.ics.purdue.edu/~braile/edumod/slinky/slinky4.htm - Purdue University, seismic waves and the slinky.

Youtube videos – these videos show clips of volcanic hazards. Most of them demonstrate how volcanic hazards are constrained, controlled by gravity and flow down existing river channels

- http://youtu.be/jJO1QEmcZGs - Iceland Eyjafjallajökull Volcano eruption, volcanic bombs
- http://youtu.be/6J6X9PsAR5w – lava flow, Hawaii
- http://www.youtube.com/watch?v=WEAfXO7q8Xs – Lahar, Indonesia
- http://www.youtube.com/watch?v=kznwnpNTB6k – Lahars, Japan
- http://www.youtube.com/watch?v=N4H0KrMPEyw – Pyroclastic flow, Paluweh
- http://www.youtube.com/watch?v=Cvjwt9nnwXY – Dome collapse at Unzen.
- http://www.youtube.com/watch?v=tJfU3ylydYc – Tephra Fall, Mt. Etna
- http://www.youtube.com/watch?v=bEOhPeeUJws – The sound of ashfall, Etna

Volcanoes, seismic and wave animations

- http://web.ics.purdue.edu/~braile/edumod/waves/Pwave.htm P-wave animation, Purdue
- http://web.ics.purdue.edu/~braile/edumod/waves/Swave.htmb S-wave animation, Purdue
- http://www.mediacollege.com/audio/01/sound-waves.html Sound wave animation
- https://www.youtube.com/watch?v=QG9MJJeNJ9Y – Volcanic rocks fracture to create seismic signals.
- https://www.youtube.com/watch?v=nlo-2JoNHrw – Magma intrusion forces expansion and fracturing of rock to cause seismic signals.

The field of natural hazards is dedicated to understanding the physics and natural processes and triggering agents that can lead to disastrous events. This is done in an effort so that people can be better informed of potential or impending risk. Effective science-communication skills are essential to disseminate information related to the nature, location, probability, methodology and risk involved in hazard/disaster scenarios.

My research is directly related to the study of natural hazards, specifically volcanic hazards with the goal to better understand the processes involved before, during and after volcanic eruptions in order to communicate the risk to people living within range of any potential threat. I have found that this task becomes less onerous if I can clearly and effectively communicate the science behind volcanic processes and hazards before communicating the risk.

During the process of developing this unit, I discovered new and engaging explorative activities and lessons that can be used to do just that – communicate the science of volcanology. Through the use of classroom demonstrations, analogue models and virtual field explorations students gain a more intimate understanding of the factors that influence hazards, risk and volcanic eruptions. While the students gain a greater appreciation for using models to represent earth processes, methodologies for interpreting and explaining evidence as well as the scientific methods used in investigating hazards; I added to my tool kit the ability to communicate the science of volcanic hazards to kids in fun and exciting ways.