



## MUSICA OTL Lesson: Properties of Magma and Volcanic Hazards

Author Name: Stephanie Anderson

### PART 1a. Lesson Overview

|                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Grade and Subject</b><br>Middle School or High School | <b>Instructional Time Required (Minutes)</b><br>300 minutes (5 hours)<br>Four 75-minute class periods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Unit Title (Topic)</b>                                | <b>Properties of Magma and Volcanic Hazards</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b><u>Anchoring Phenomenon</u></b>                       | <p><b>Phenomenon:</b> How chemical and physical properties of magma affect volcano eruption styles</p> <p><b>Driving Questions:</b></p> <ol style="list-style-type: none"><li>1. How does the fractionalization of magma affect the composition of the magma as it moves towards the surface?</li><li>2. How does the viscosity of magma affect the type of volcanic eruption?</li><li>3. Where are the different types of volcanoes found?</li></ol> <p><b>Curriculum Spark:</b><br/>In Parts 1 and 2, students will look at photographs relating to the content. They will be instructed to write down what "I Notice and I Wonder." This strategy helps students make observations and formulate questions and it provides an opportunity to gauge student engagement and determine prior knowledge.</p> |
| <b>Learning Goals/ Lesson Topics (for 2-3 lessons)</b>   | <p><b>Students will be able to:</b></p> <ul style="list-style-type: none"><li>• identify and describe the evidence necessary for constructing an explanation of rapid catastrophic events (e.g., earthquakes, volcanoes, meteor impacts). (MS-ESS2-2)</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <ul style="list-style-type: none"> <li>• identify the corresponding timescales for each identified geoscience process. (MS-ESS2-2)</li> <li>• use multiple valid and reliable sources, which may include students' own investigations, evidence from data, and observations from conceptual models used to represent changes that occur on very large or small spatial and/or temporal scales. (MS-ESS2-2)</li> <li>• describe how catastrophic changes can modify or create surface features over a very short period of time compared to other geoscience processes, and the results of those catastrophic changes are subject to further changes over time by processes that act on longer time scales (e.g., erosion of a meteor crater) and that surface features will continue to change in the future as geoscience processes continue to occur. (MS-ESS2-2)</li> <li>• analyze data to identify patterns (i.e., similarities and differences), including ( the changes in physical and chemical properties of each substance before and after the interaction. (MS-PS1-2)</li> <li>• analyze data to identify and describe patterns in the datasets, including: i. The location of natural hazard events relative to geographic and/or geologic features. ii. Frequency of natural hazard events. iii. Severity of natural hazard events. iv. Types of damage caused by natural hazard events. v. Location or timing of features and phenomena (e.g., aftershocks, flash floods) associated with natural hazard events. (MS-ESS3-2)</li> <li>• use the analyzed data to describe: i. Areas that are susceptible to the natural hazard events, including areas designated as at the greatest and least risk for severe events. ii. How frequently areas, including areas experiencing the highest and lowest frequency of events, are at risk. iii. What type of damage each area is at risk of during a given natural hazard event. iv. What features, if any, occur before a given natural hazard event that can be used to predict the occurrence of the natural hazard event and when and where they can be observed. (MS-ESS3-2)</li> <li>• make a forecast for the potential of a natural hazard event to affect an area in the future, including information on frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event. (MS-ESS3-2)</li> </ul> |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



|                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Select grade level NGSS <a href="#">Performance Expectations</a> (PEs)</b> | <p><b>Select grade level NGSS <a href="#">Performance Expectations</a> (PEs) that support student learning goals.</b> For the NGSS, the PE color coding reflects its 3-dimensional learning components. Search the <a href="#">Evidence Statements</a> for details on what students should know and be able to do after they complete the lessons that comprise the unit.</p> <p><b>Science and Engineering Practices (SEP)</b><br/> <b>Disciplinary Core Ideas (DCI)</b><br/> <b>Cross Cutting Concepts (CCC)</b></p> <p><b>MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.</b></p> <p><b>MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.</b></p> <p><b>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.</b></p> <p><b>MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.</b></p> |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## PART 1b. Standards

|                                                                                                                                                                                                                                                                                                                                        |                                                |                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------|
| <b>Unpack the <a href="#">3-D learning components</a> of the NGSS Performance Expectations or your state's standards (Texas TEKS) in the table below.</b> For NGSS guidance, see the <a href="#">NGSS Topic Arrangements</a> and <a href="#">NGSS DCI Arrangements</a> (NSTA). Use tools to <a href="#">unpack</a> each PE separately. |                                                |                                               |
| <a href="#">Science and Engineering Practices (SEP)</a>                                                                                                                                                                                                                                                                                | <a href="#">Disciplinary Core Ideas (DCIs)</a> | <a href="#">Cross-cutting Concepts (CCCs)</a> |
| <b>MS-ESS2-2</b>                                                                                                                                                                                                                                                                                                                       |                                                |                                               |



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Constructing Explanations and Designing Solutions</b></p> <p>Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.</p> <ul style="list-style-type: none"> <li>Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.</li> </ul> | <p><b>ESS2.A: Earth's Materials and Systems</b></p> <ul style="list-style-type: none"> <li>The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.</li> </ul> <p><b>ESS2.C: The Roles of Water in Earth's Surface Processes</b></p> <ul style="list-style-type: none"> <li>Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.</li> </ul> | <p><b>Scale Proportion and Quantity</b></p> <ul style="list-style-type: none"> <li>Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.</li> </ul>                                                  |
| <b>MS-ESS3-1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                   |
| <p><b>Constructing Explanations and Designing Solutions</b></p> <ul style="list-style-type: none"> <li>Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students'</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p><b>ESS3.A: Natural Resources</b></p> <ul style="list-style-type: none"> <li>Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and</li> </ul>                                                                                                                                                                                                                                                                                                                                                                             | <p><b>Cause and Effect</b></p> <ul style="list-style-type: none"> <li>Cause and effect relationships may be used to predict phenomena in natural or designed systems.</li> </ul> <p><b>Influence of Science, Engineering, and Technology on Society and the Natural World</b></p> |



|                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.                                                                                                                                                                                                                            | many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.                                                                                                   | <ul style="list-style-type: none"> <li>All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                               |
| <b>MS-ESS3-2</b>                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Analyzing and Interpreting Data</b><br>Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. <ul style="list-style-type: none"> <li>Analyze and interpret data to determine similarities and differences in findings.</li> </ul> | <b>ESS3.B: Natural Hazards</b> <ul style="list-style-type: none"> <li>Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.</li> </ul> | <b>Patterns</b> <ul style="list-style-type: none"> <li>Graphs, charts, and images can be used to identify patterns in data.</li> </ul> <b>Influence of Science, Engineering, and Technology on Society and the Natural World</b> <ul style="list-style-type: none"> <li>The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.</li> </ul> |
| <b>MS-PS1-2</b>                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Analyzing and Interpreting Data</b> <ul style="list-style-type: none"> <li>Analyze and interpret data to determine similarities and differences in findings.</li> </ul>                                                                                                                                                                                                                            | <b>PS1.A: Structure and Properties of Matter</b> <ul style="list-style-type: none"> <li>Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given</li> </ul>                                                    | <b>Patterns</b> <ul style="list-style-type: none"> <li>Macroscopic patterns are related to the nature of microscopic and atomic-level structure.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |



|                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                 |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p><b>Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence</b></p> <ul style="list-style-type: none"> <li>Science knowledge is based upon logical and conceptual connections between evidence and explanations.</li> </ul> | <p>conditions) that can be used to identify it.</p> <p><b>PS1.B: Chemical Reactions</b></p> <ul style="list-style-type: none"> <li>Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</li> </ul> |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

## PART 1c. Lesson Background

| Teacher Preparation                                                                                                                                                                                                                                                                                                    |                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Student Misconceptions</b></p> <ul style="list-style-type: none"> <li>The entire mantle is made of magma.</li> <li>Magma has a very low viscosity and flows very fast.</li> <li>All volcanoes have explosive eruptions.</li> <li>Geologic change is slow.</li> </ul>                                             | <p><b>Scientific Terminology</b></p> <ul style="list-style-type: none"> <li>Ultramafic</li> <li>Mafic</li> <li>Felsic</li> <li>Viscosity</li> </ul> |
| Background Reading/Viewing                                                                                                                                                                                                                                                                                             |                                                                                                                                                     |
| <p>For additional teacher resources on the fractional crystallization lab, see:</p> <ol style="list-style-type: none"> <li><a href="#">Videos of fractional crystallization activity implementation</a></li> <li><a href="#">Poster with guidance for and images of fractional crystallization activity</a></li> </ol> |                                                                                                                                                     |

Students should already be familiar with the basics of plate tectonics and plate boundaries. For more reading on plate tectonics, see:

1.

## PART 2. Lesson Plan

### Materials

#### Fractional crystallization lab

- Sandwich bag of colored beads representing a magma chamber, pre-counted according to the initial composition in the [excel sheet](#) (you will need 6 unique colors of beads; you can use perler beads, since they are fairly inexpensive).
- Butcher paper for marking bead progression (1 per group)
- Computers pre-loaded with copies of the Excel file (1 per group)

#### Viscosity Lab

- Hot plate and beaker filled with water (for the teacher to heat corn syrup)
- Refrigerator or ice bath (for the teacher to cool corn syrup)
- Tongs (for the teacher to lift the beaker of corn syrup out of the hot water)
- 1 piece of cardboard (per group)
- 3 sheets of 8.5"x11" paper (per group)
- Something to prop the cardboard up with (per group)
- 1 timer (per group)





- 1 ruler (per group)
- 1 roll of scotch tape (per group, for taping paper onto cardboard)
- Seven 10 mL graduated cylinders (per group; if there aren't enough graduated cylinders for students to have seven for each group, students can wash them out in between each round. However, they must make sure that the cylinders are completely dry before adding new fluids)
- Substances (per group)
  - Round 1:
    - 5 mL of molasses
    - 5 mL of corn syrup:
  - Round 2:
    - 5 mL of cold corn syrup
    - 5 mL of room temperature corn syrup
    - 5 mL of hot corn syrup
  - Round 3:
    - 5 mL of cold corn syrup
    - 5 mL of corn syrup with water (this should be pre-mixed by the teacher. 2:1 ratio of corn syrup to water recommended)

### Instructional Plan

#### Part A (150 minutes) - Fractional Crystallization ([presentation slides](#))

**Warm-up (20 min):** This part of the lesson starts out with an “I Notice/I Wonder” activity (in the presentation [slides](#)), where the teacher shows the class a photo of three different types of rocks—basalt, andesite, and rhyolite—and asks students to record what they notice and what they wonder about. This activity will be followed by a short class discussion.

**Lecture (10 min):** The teacher then gives a short lecture on types of magma and how magma changes composition through fractional crystallization (in the presentation [slides](#)).

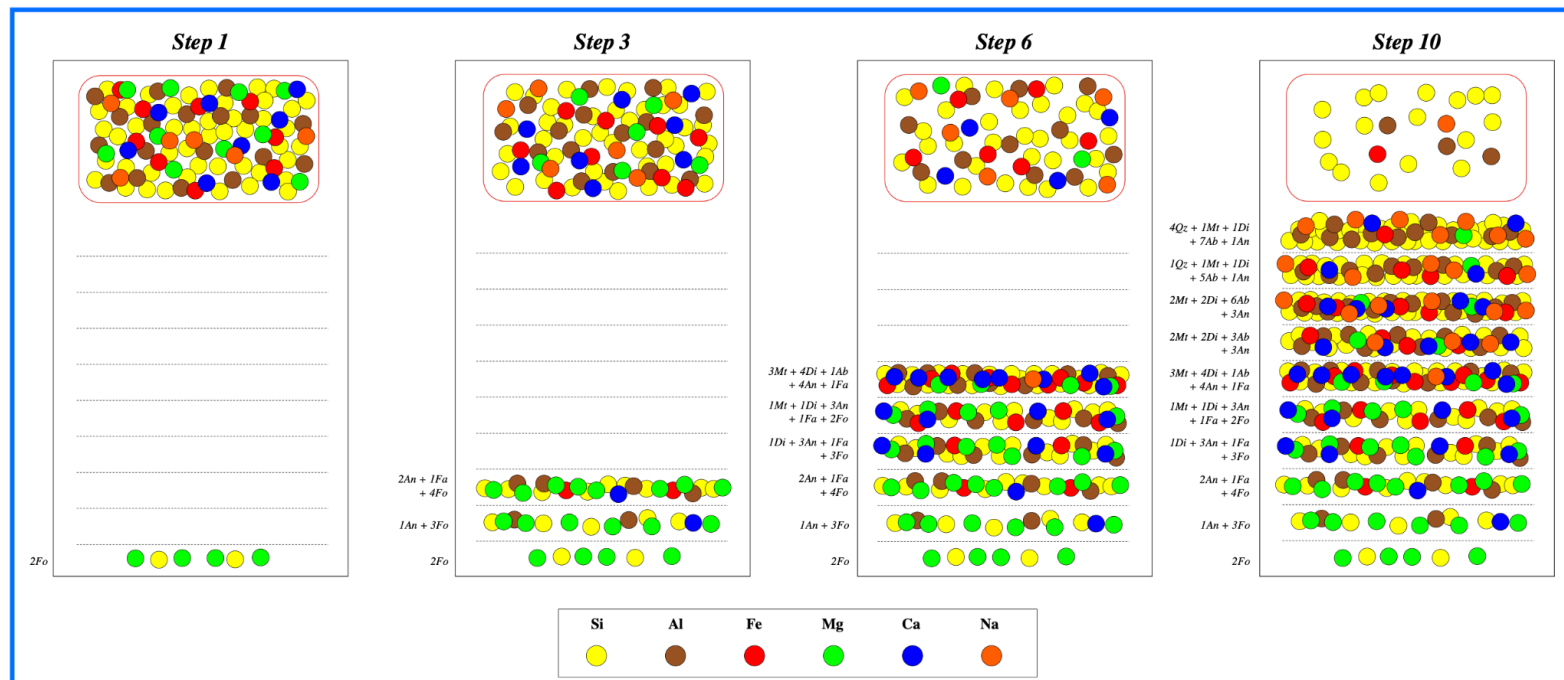
**Lab (120 min):** Students will then work on a fractional crystallization lab, where they simulate minerals crystallizing out of the magma at different temperatures and answer questions about the resulting magma compositions. They should follow the instructions on [the Fractional Crystallization worksheet](#) and use the associated [Excel data sheet](#) for their analyses (the teacher should see the [data sheet answer key](#)).



The teacher should place students into groups of 3-4. Each group will receive a bag of perler beads with a variety of colors that each represent an element found in the magma (the teacher needs to count out beads in the correct proportions in advance).

The teacher should give each group a computer with the Excel data sheet already open on it. The Excel data sheet will have the starting composition of the magma and how much of each mineral should be taken out each time. It will also specify the atomic composition of each mineral. Students will remove a specific amount of each element at each step and place it on their butcher paper, or “phase of magma ascent” (see image below).

They will use the Excel data sheet to record how many atoms of each element are remaining after each phase. The Excel data sheet will automatically record this data on graphs so students can see how the magma’s composition changes over time. The graphs should show that the concentrations of Mg and Fe decrease and Si, Ca, and Na increase as the magma evolves and lower total amounts of magma remain (Notice that the x-axis shows percentage of magma remaining, not time).





**Discussion (15 min):** After doing the lab students will answer analysis questions (on the worksheet) about what they observed during the activity and how the composition of magma would impact volcanic eruptions. Then, the teacher will lead a class discussion, emphasizing how the magma changes from mafic to felsic as the temperature is reduced as the magma moves towards the surface.

**Note:** If you need additional support for this lab, see the links in the “Background Reading/Viewing” section.

### **Part B (75 minutes) - Viscosity ([presentation slides](#))**

**Warm-up (10 min):** This part of the lesson will start out with another “I Notice/I Wonder” activity. Students will look at pictures of different types of common household fluids. They will record their own observations and questions about the pictures. This activity will be followed by a short class discussion.

**Lecture (5 min):** The teacher will define viscosity and ask students about how viscosity would affect the rate of flow of a fluid. As a class or in small groups, students will rank common household fluids in order from lowest to highest viscosities.

**Lab (45 mins):** Students will be placed in their same group of 3-4 as in the previous lesson. Students will be given [a worksheet](#) to guide their experimentation with different household fluids to see which is more viscous (the procedures for this lab are described in the presentation slides). Students will use different temperatures of the same fluid to determine how temperature affects viscosity. Students will then mix water with one of the fluids to determine if/how the added water impacts viscosity. At each round of experimentation, students should be directed to record their predictions and observations in the worksheet. (For a shorter version of this lab, see [this worksheet](#)).

**Discussion (15 mins):** Students will fill in a table with their results. They will answer analysis questions about what they observed during the activity and how this would impact volcanic eruptions. Then the teacher will lead a class discussion (discussion questions are on the presentation slides and on the worksheet).

#### **Notes:**

1. The teacher should reserve at least 20 minutes before class to prepare for this lab.
2. For the hot corn syrup, it is recommended to heat it in a double boiler (in a beaker submerged in hot water). If this is not possible, make sure to not overheat the corn syrup on the hot plate because it will begin to caramelize quickly, making it more (instead of less) viscous. Also, it cools quickly, so students should get it last once they have everything else ready to go, so they can pour it quickly.
3. Trying to pour the cold corn syrup into the small opening of a graduated cylinder is a great way for students to see how very viscous magma could clog up a vent and trap gases resulting in an explosive eruption.



### Part C (75 minutes) - Volcanic Hazard Assessment

In this part of the lesson, students will use maps to determine where different types of volcanic eruptions are most likely to occur based on plate tectonics and their knowledge of magma types, viscosity of different magmas, and fractional crystallization. They will assess the hazards associated with volcanic eruptions in different locations. They will then research a specific volcano and create a hazard assessment for it.

Students will be placed in their same group of 3-4 students from the previous labs. Each group will be given a [plate tectonic map](#). They will determine where they think volcanoes would be located based on their previous knowledge. Each group will then be given a [world map with 9 volcanoes located on it](#). They will determine what type of volcano and eruption style they would predict for each volcano using the [Plate Tectonic Analysis Worksheet](#). They will then assess the possible hazards to nearby communities. Students will then research one active volcano and create a hazard assessment for the nearby communities.

## PART 3. Assessment

### Evidence of Learning

#### "I Notice/I Wonder" Activity Responses:

Observations and questions recorded by students during the "I Notice/I Wonder" activities can provide insight into their initial understanding and curiosity about volcanic processes and magma properties.

#### Class Discussions:

Participation in class discussions following the "I Notice/I Wonder" activities can indicate students' engagement and ability to articulate their observations and questions.

#### Lab Activity Observations:



During the fractional crystallization and viscosity labs, students' ability to follow instructions, make accurate observations, and engage in discussions about their findings will demonstrate their understanding of magma properties and their impact on volcanic eruptions.

Responses to Analysis Questions:

Responses to analysis questions on worksheets related to the lab activities will show students' ability to interpret data and apply their knowledge to real-world volcanic phenomena.

## Resources/ References

Edwards, Ben, Rachel Teasdale & James D. Myers (2006) Active Learning Strategies for Constructing Knowledge of Viscosity Controls on Lava Flow Emplacement, Textures and Volcanic Hazards, Journal of Geoscience Education, 54:5, 603-609, DOI: 10.5408/1089-9995-54.5.603

Wirth, Karl (2011), Using an M&M® Magma Chamber to Illustrate Magmatic Differentiation, NAGT Workshop, presented at the Annual Meeting of Geological Society of America, Sept. 2011, Paper No. 100-18, poster available online at <https://d32ogogmya1dw8.cloudfront.net/files/NAGTWorkshops/gsa03/activities/WirthMM.pdf>, activity implementation available at <https://serc.carleton.edu/NAGTWorkshops/gsa03/activities/2028.html>



This lesson planning template was adapted for the NSF-sponsored MUSICA project by Katherine Ellins and Marlena Jones, using materials that were developed by CIRES Education & Outreach at the University of Colorado Boulder. CIRES teaching materials are available at <https://cires.colorado.edu/outreach/resources/planning-templates>.

The original template is licensed by CIRES under a Creative Commons Attribution 4.0 License <http://creativecommons.org/licenses/by/4.0/>