EARTH SCIENCE WESTERN AUSTRALIA

Volcano in the Lab – In-Class Activity

Volcano in the Lab:

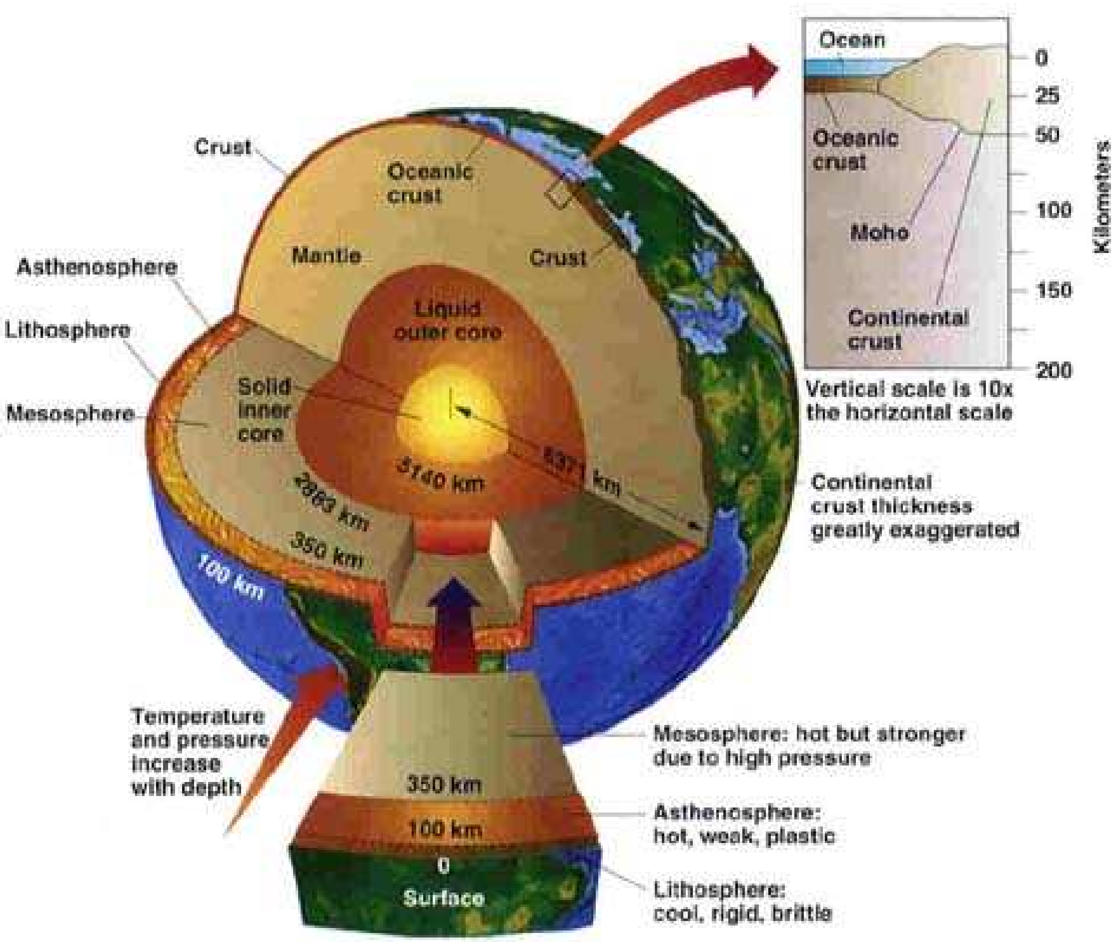
Reference: Earth Science Education Unit

http://www.earthscienceeducation.com/workshops/rock_cycle/volcano.htm

Introduction:

Many people have the misconception that a molten rock layer lies just beneath the Earth's surface. From your recent studies you will be aware that this layer is the mantle and it is in fact solid. Refer to Figure 1.0 below for a quick review on the structure of the Earth.

Figure1.0



Reference:

(http://paos.colorado.edu/~toohey/fig_79.jpg)

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

Aim:
To demonstrate a volcanic eruption in the laboratory and to show different eruption styles, as a result of varying the viscosity of the 'magma'.

Materials:
- 3 x 500ml (or 600ml) glass beakers
- Red candle wax,
- Vegetable oil (to be added to the wax for a less viscous 'magma')
- Washed sand,
- Very cold water to top up the beaker (about three-quarters full)
- Bunsen burner, heat proof mat, tripod and gauze, gas supply (or bottled gas burner etc).
- Safety glasses
- Apron, if available

Pre-activity preparation:
Make up the following beakers:

1. Beaker 1: Melted candle wax poured into the beaker making a 1cm layer at the base of the beaker. Label the Beaker 1. Allow to cool and set.

2. Beaker 2: Melted candle wax and vegetable oil (3:1) poured into the beaker making a 1cm layer at the base of the beaker. Label the Beaker 2. Allow to cool and set.

3. Beaker 3: Melted candle wax and vegetable oil (2:1) poured into the beaker making a 1cm layer at the base of the beaker. Label the Beaker 3. Allow to cool and set.

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

Method 1: **High viscosity wax**

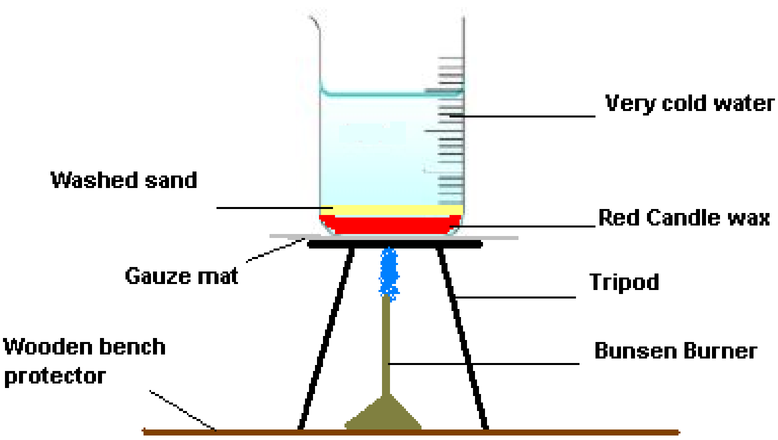


Diagram 1.0

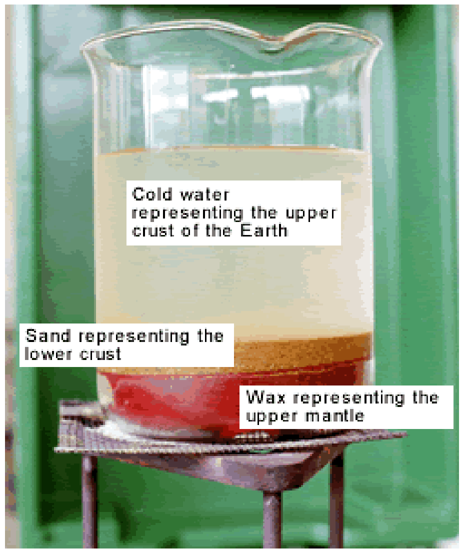


Photo 1.0

- Add the washed sand to beaker number 1 to give about a 1cm layer on top of the wax.
- Gently add very cold water (to approx ¾ full) to the beaker using a stirring rod.
- Set up the apparatus as seen in Diagram 1.0 and Photo 1.0.
- Heat the beaker paying close attention to the wax and sand layers.
- The eruption will not take long…so watch carefully.
- As soon as the eruption is finished, turn off the Bunsen burner and allow the beaker to cool.
- Record your observations as a diagram.

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

Method 2 : **Medium viscosity wax**

- Add the washed sand to beaker number 2 to give about a 1cm layer on top of the wax.
- Gently add very cold water (to approx ¾ full) to the beaker using a stirring rod.
- Set up the apparatus as seen in Diagram 1.0 and Photo 1.0.
- Heat the beaker paying close attention to the wax and sand layers.
- The eruption will not take long…so watch carefully.
- As soon as the eruption is finished, turn off the Bunsen burner and allow the beaker to cool.
- Record your observations as a diagram.

Method 3 : **Low viscosity wax**

- Add the washed sand to beaker number 3 to give about a 1cm layer on top of the wax.
- Gently add very cold water (to approx ¾ full) to the beaker using a stirring rod.
- Set up the apparatus as seen in Diagram 1.0 and Photo 1.0.
- Heat the beaker paying close attention to the wax and sand layers.
- The eruption will not take long…so watch carefully.
- As soon as the eruption is finished, turn off the Bunsen burner and allow the beaker to cool.
- Record your observations as a diagram.

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

Results:

1. **High viscosity wax**

   Draw a labeled diagram illustrating your observations. Note any other information you believe is important in the space provided.

ESWA acknowledges the compilation of this material by Western Australian teachers

2. Medium viscosity wax

Draw a labeled diagram illustrating your observations. Note any other information you believe is important in the space provided.

3. Low viscosity wax

Draw a labeled diagram illustrating your observations. Note any other information you believe is important in the space provided.

Volcano in the Lab – In-Class Activity

Questions:

1. What do the sand and water represent in the beakers?

2. What does the wax layer represent in the beakers?

3. What happens when the wax is heated? Give reasons for this process.

4. What does the melted wax represent as it is heated?

5. What happens to the wax as it reaches the sand/water layer? What is the name given to this magma on the surface?

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

6. Some wax may rise to the surface rapidly through wax tubes avoiding contact with the cold water. Was there evidence of this in your experiments? Explain.

7. You will notice that as some wax reaches the water layer it sets into weird and wonderful shapes. What do these formations represent in the 'real world'?

8. How do your eruptions differ from 'real world' eruptions in respect to the cooling time of the 'surface lava formations' and the 'intrusions'?

9. What do your observations of the different eruptions tell you about the violent nature of eruptions based on magma viscosity? That is, which eruption appeared more violent? Can you explain why?

10. In terms of the surface area covered by an eruption, which magma type (high or low viscosity) would you expect to cover the largest area and why?

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

Extension Work

Read the information below and then answer the questions that follow.

Reference: McConnell, D ;"Volcanic Activity: Magma viscosity"
http://www.mhhe.com/earthsci/geology/mcconnell/vol/magma.htm

Chemical content of magma and viscosity

- Chemical content (**composition**) and **temperature** influence magma viscosity.
- Viscosity increases with increasing silica (silicon + oxygen) content.
- Three types of magma, **basalt**, **andesite**, and **rhyolite**, solidify to form rocks of the same name.

Magma Type	Silica Content (% weight)	Magma Temperature	Viscosity Rank
Basalt	Less than 53	1,100-1,250°C	Low
Andesite	53-68	800-1,100°C	Intermediate
Rhyolite	More than 68	700-850°C	High

- Volcanic **gases** (water vapor, sulfur dioxide, carbon dioxide, hydrogen sulfide) help drive eruptions.
- Low-viscosity magmas allow gases to escape easily whereas gas pressures can build up in high-viscosity magmas, resulting in violent eruptions.

Magma Source vs. Magma Composition

- Volcanic activity is linked to the plate tectonic cycle.
- Mild eruptions occur in plate interiors and along oceanic ridges.
- More violent eruptions are associated with convergent plate boundaries.
- Eruption style and the plate tectonic cycle are governed by the melting process.

- Igneous rocks are composed of a variety of minerals.

- **Silica** (SiO_2) is a key component of these minerals and the silica content of the rocks varies depending upon the constituent minerals.
- High-silica rocks (granite, rhyolite) are dominated by silica-rich minerals such as quartz and feldspar.
- Basalt and gabbro contain minerals with lower silica content (olivine, pyroxene, and amphibole). However, even these rocks contain feldspar and their silica content rarely dips below 50% (by weight).
- The silica-rich minerals have a lower melting temperature than silica-poor minerals.

ESWA acknowledges the compilation of this material by Western Australian teachers

- As a result, when physical conditions favour melting, the first minerals to melt will form a magma that is more silica-rich than the parent rock.
- This limited melting, involving only some minerals, is termed **partial melting** (Fig. 6).

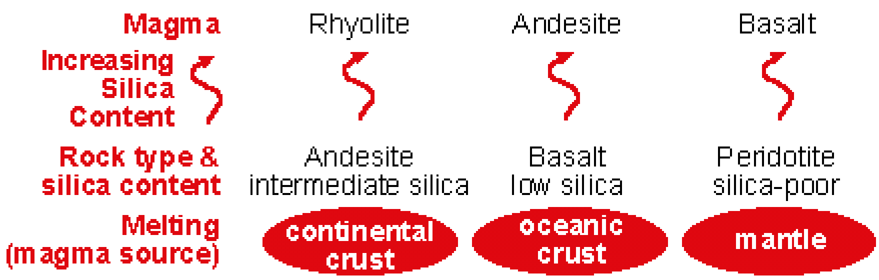


Figure 6. Relationship between parent rock (magma source) and magma type. Note, each magma type contains more silica than its parent.

- The low-silica, low-viscosity **basalt magmas** that are characteristic of the Hawaiian Islands and the oceanic crust are derived from a **mantle source** that is even more deficient in silica (Fig. 7).

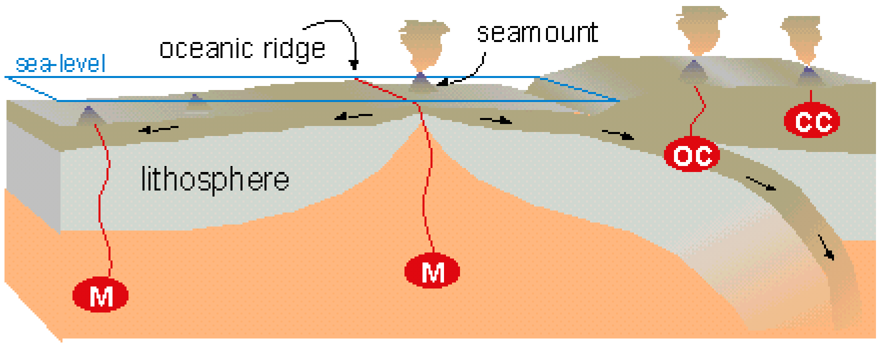


Figure 7. Plate tectonic settings for the formation of different magmas. Basalt is produced from partial melting of the mantle below volcanic islands in the interiors of oceanic plates and oceanic ridges. Andesite is derived from the partial melting of descending oceanic lithosphere. Rhyolite, a rare magma type, is generated by the partial melting of the continental crust. M, mantle source; OC, oceanic crust source; CC, continental crust source.

- **Peridotite**, a common mantle rock, is dominated by olivine and pyroxene, and lacks the feldspar common in basalts.
- Partial melting of peridotite yields a more silica-rich melt that crystallizes to form basalt (olivine, pyroxene, feldspar).
- Basaltic magmas also come to the surface on land where a continent overlies a deep mantle magma source (hot spot) or where a continent is splitting apart along a rift zone (Fig. 7).

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

- Magma is generated along convergent plate boundaries where oceanic lithosphere descends into the hot mantle at **subduction zones** (Fig. 7).
- The descending plate contains **oceanic crust** of basaltic composition but also includes some overlying **sediment mixed with sea water**.
- Partial melting of this mixture generates an **andesitic magma**.
- The increase in silica content results in a more viscous magma and a more violent eruption style.
- Consequently, volcanoes on plates overlying subduction zones (e.g., Mt. St. Helens, Washington; Mt. Pinatubo, Philippines) yield some of the most spectacular and dangerous volcanic eruptions.

- **Rhyolite** is the third, and most silica-rich, magma type but it is also the least common of the three.
- The high-silica content of rhyolite requires the **partial melting of continental crust** that has an average composition similar to andesite.
- The relatively high-silica content results in a highly viscous magma that is relatively immobile and may solidify within the crust to form a plutonic igneous rock (granite).
- Rhyolite is common at Yellowstone National Park, Wyoming, which lies above a hot spot in the mantle (Fig. 7).
- The rising basaltic magma provided the heat source to melt surrounding continental crust and generate rhyolite that is present throughout the park, often in association with basalt.

ESWA acknowledges the compilation of this material by Western Australian teachers

EARTH SCIENCE WESTERN AUSTRALIA

Volcano in the Lab – In-Class Activity

Questions:

1. What two factors affect the viscosity of magma?

2. What is the chemical composition of silica and how does it affect the viscosity of magma?

3. Out of the following magmas, basalt, andesite and rhyolite, which has the highest silica content and therefore, is the most viscous?

4. What relationship exists between magma temperature and the level of viscosity of that magma?

5. Name the volcanic gases.

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

6. Describe the link between the volcanic gases, magma viscosity and the intensity of volcanic eruption?

____
____
____
____
____

7. In reference to the plate tectonic cycle, where do mild eruptions occur? Where do more violent eruptions occur?

____
____
____
____
____

8. What governs the eruption style of volcanoes and the plate tectonic cycle?

____
____
____
____
____

9. Granite and rhyolite are dominated by ______________________________such as ____________________ and _____________________.

10. Basalt and Gabbro contain minerals with lower silica content such as: _____________________, _____________________ and _____________________.

11. Which minerals have the higher melting temperature? (circle the correct answer)

Silica-rich or silica- poor

12. Describe how the magma differs from the parent rock when conditions favour melting.

____
____
____
____

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

13. What is partial melting?

____

____

____

____

____

14. Complete the table below to show the relationship that exists between magma source, parent rock and magma.

Magma	Rhyolite	Andesite	Basalt
Increase in silica	⇧	⇧	⇧
Rock type & silica content			
Melting (magma source)			

15. What magma type comes to the surface on land where a continent overlies a hot spot or where a continent is splitting apart along a rift zone?

____

16. Describe the process and name the magma that is produced along convergent plate boundaries where oceanic lithosphere descends into the hot mantle at subduction zones.

____

____

____

____

ESWA acknowledges the compilation of this material by Western Australian teachers

Volcano in the Lab – In-Class Activity

17. Why do the following volcanoes display some of the most spectacular and dangerous eruptions? Mt. St. Helen, Washington; Mt. Pinatubo, Philippines.

____

____

____

____

18. What is required for the high silica content in rhyolite?

____

____

____

____

19. Describe the viscosity of, and therefore, the mobility of rhyolite magma.

____

____

____

____

20. Give an example of a place where rhyolite is common.

____

____

____

____

ESWA acknowledges the compilation of this material by Western Australian teachers