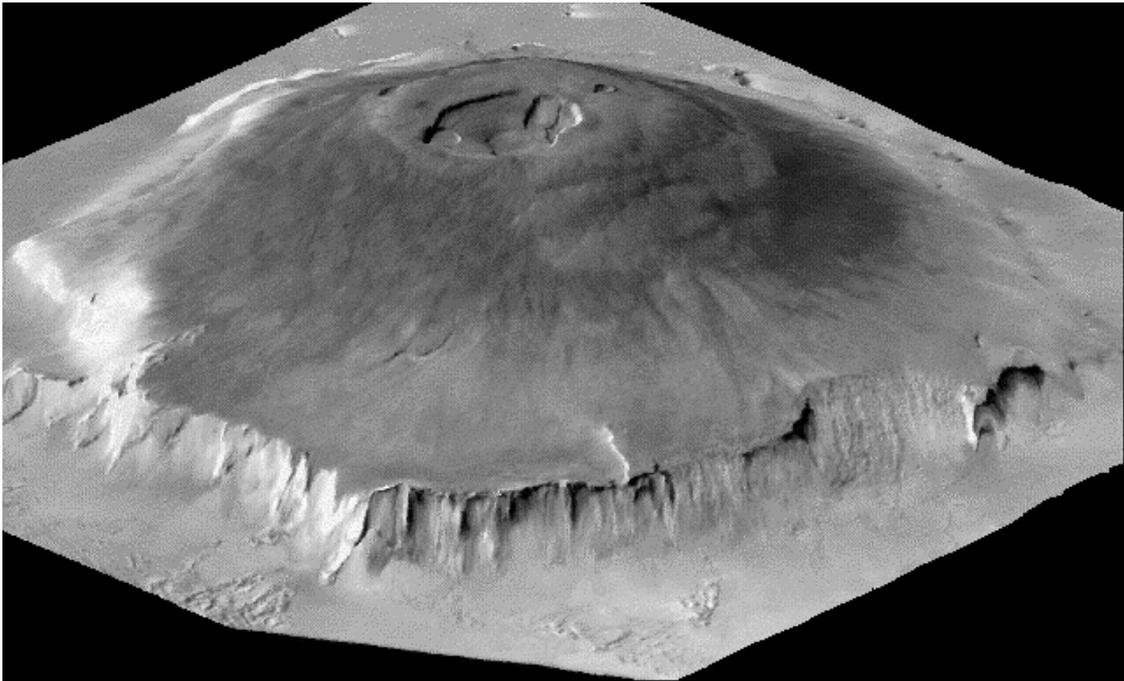




Playdoh Volcanoes



PLAYDOH VOLCANOES – TEACHER NOTES AND HANDY HINTS

The Playdoh Volcano module is composed of two 'hands-on' practicals, one to construct a volcano and a second to analyse a volcano. Both practicals require a full hour each to complete, but either can also be run on their own (although the analysis section will require the students to be given a pre-constructed volcano). Depending on the time available, equipment, and the nature of the students, the lesson could also be entirely non-practical, with the teacher leading a discussion and encouraging participation from the students. In the latter case, it is strongly recommended to use several images such as slides and internet pictures to illustrate the talk and place the topics into a context the students can understand more readily.

Activity sheet - aims and benefits

This activity has been adapted from the 'Lava Layering' experiment run by the Hawai'i Space Grant College who should be acknowledged if your results are placed in public access areas (i.e. displays, web pages etc). They also have many more classroom activities that you can try (see http://imina.soest.hawaii.edu/SPACEGRANT/class_acts/ for details).

This experiment has been designed for students working in small groups. In its full form, the experiment demands good analytical skills from a student. Pupils should be made to carefully consider and discuss the placement of their drill cores during analyses in order to draw out as much information as possible about the history of the volcano. They will soon find that five cores are not enough to fully analyse a volcano, and this will be highlighted further by their river valley and cross section. In order to get a good result from these analyses, students must be able to:

- a) work methodically
- b) record information accurately in sketch form
- c) demonstrate good analytical skills and develop an awareness of the third dimension when studying the model

Throughout the practical, the teacher should stress that the problems facing the students are also limitations when studying real volcanoes, where we are of course unable to drill as deeply as they are on their models, and certainly can't take cross sections etc. Make certain that the information they are gathering is placed in context with the real situation, particularly if you are running the whole *Mars in the Classroom* project.

Hints

1. This practical can be extremely messy and smelly (with the vinegar) - ensure that precautions are taken! Some commercial playdoh can stain when mixed with vinegar, so aprons are strongly recommended during the construction of the volcanoes. It is possible to produce your own playdoh using simple cooking ingredients. See the recipes at the end of these teacher notes for details.
2. If students are constructing and analysing volcanoes themselves, *make sure they don't tell each other about their volcanoes!* This is perhaps one of the most difficult

aspects of this practical from a teaching perspective!! However, it is important for the analysis that each group is faced with a volcano they know nothing about.

3. During construction, if a four sided dice is not available to randomly generate the number of flows, tell each group how many flows their volcano should have – a number between 4 and 7 is fine, and it is good to vary the amount between groups. You should give each group only enough different coloured playdoh to make sure that at least two of the flows will be the same colour. For example, if a group has to produce a volcano with just 4 flows, you should give them a maximum of 3 different colours for playdoh, so that at least two of their flows will be the same colour.
4. Encourage the students to make their flows of a differing thickness and extent, but be aware of a typical preference for the larger scale flows!
5. Make certain that each group is producing careful sketches of their volcano after each flow, as these will be used to compare with the history inferred by another group during analyses.
6. After construction, ***label each volcano with group names before you pass them around so as you know which group is analysing which volcano.***
7. During analyses, encourage the groups to discuss the location of each drill core carefully. Ask them what they hope to learn about the volcano by placing their drill core in a given place. Once the core is taken, ask if they have learned what they wanted. If not, did they learn anything unexpected? Make sure all of the cores are sketched, and located on their diagrams.
8. For the river valley and cross section, use these to illustrate the limitations of the drill cores they took. The cross section might show a completely different history to the one they inferred from the drill cores alone.
9. At the end of the experiment, compare the oldest, youngest and total number of flows measured by the group doing analyses with the corresponding numbers from the group that constructed the volcano. Discuss the differences with the class and ask where they think the problems lie and what they think they could do to improve the measurements. Take more drill cores? Be more careful about the placement of drill cores? Is it possible to be any more accurate with the limitations that are inherent to this experiment? How would these measurements equate with measuring a real volcano?

Answers to questions from the background information sheet and the “Results and questions” sheet

1. Volcanoes can teach us about the thermal history of a planet. The lavas and magmas are of course produced from deep within the planet, so how they develop and move to the surface over time will tell us about how a planet’s thermal regime alters over time.

2. Heat is an important energy resource for potential life. Students may wish to use the search for life (ancient or otherwise) as a scientific goal for their mission, so these areas are important.
3. To see the older buried flows we will have to dig. This can be achieved to a small degree using robotics, but on the scale we are looking at here, it is better by far to send humans. Another point you may wish to discuss here is that not all of the ancient flows will be completely buried. Some may still be partially visible, similar to those in the volcanoes they will make, and these can be used to tell us a little about the feature without the need to land on the surface. If you are completing the Remote Sensing experiment as well, then this can lead on to a discussion of how we can see things such as this from orbiting spacecraft and will provide a useful link between the two experiments.

Results and questions sheet notes

1. Compare these values to the correct ones from the group that constructed the volcano (see Hint number 9)
2. Flow direction should be influenced by the topography of previous flows and by the 'speed' of the flow being produced (i.e. how fast the vinegar is poured onto the soda). In reality, many things can affect flow direction, including older flows and natural channels (or manmade ones such as streets!). The speed and 'effusivity' of the flow (i.e. how quickly it erupts) is also important as it will govern the amount of energy a flow has to pass obstacles, so the speed with which vinegar is poured onto the soda is a good analogy to this.
3. Decreasing the number of colours of playdoh would mean more of the flows would be the same colour, making it more difficult to distinguish between successive flows. In reality, lava flows will appear very similar and it can be difficult to tell them apart without going there in person and analysing the rocks in-situ.
4. Also see point 9 in the 'Hints' above. It will be difficult to draw criteria to satisfy all of the volcanoes, but there are certain common scenarios where it is useful to take a core. For example:
 - a) Every flow will be present at some point around the vent (candleholder) as they were all sourced from there. Taking cores from that area will give you a good idea as to the total number of flows, but you will need to take several cores from all around the vent to be certain you have sampled all the flows. In addition, this will not tell you about the *extent* of the flows.
 - b) Taking cores in two separate sites where a buried flow of similar colour is visible may help to find out whether or not they are the same flow by looking at them in sequence with the other flows.
 - c) Some drill cores should be taken to try and measure the extent of the flows. This is difficult to do reliably, but will often entail sampling near the edge of a volcano or visible flow (e.g. sites 2 and 5 on the example sheet).There may be others depending on the nature of the volcanoes and level of the students, but these are the main points to try and get across.

5. Students often find this question difficult to answer, so it should be approached as a discussion. From photographs and images, scientists are faced with a picture similar to the students before the drill cores, valley and section were taken. It is of course possible to learn a small amount about a volcano's history from these studies, but their analyses should tell the students that it is far better to work in-situ if possible. More advanced groups may wish to briefly discuss Remote Sensing (especially if the Reflectance Spectrometer experiment is to be carried out) as a means for looking at different compositions remotely. These methods can help us unravel more of the volcanic history of an area without the need to land, but are still restricted to the upper layers.
6. Hopefully, students will by now realise the importance and advantages of having a Manned presence on a planet during analyses such as this! Drill cores and in-situ sampling of rocks for studies in a laboratory would be the ideal way to study volcanoes on Mars.

RECIPES - from the Hawai'i Space Grant Consortium's Lava Layering teacher web page. See http://imina.soest.hawaii.edu/SPACEGRANT/class_acts/LavaLayTe.html for details of their experiment.

Play Dough (stove-top recipe) - best texture and lasts for months when refrigerated in an air tight container.

2 cups flour
1/3 cup oil, scant
1 cup salt
2 cups cold water
4 teaspoons cream of tartar
food colourings (20 drops more or less)

Make this large batch one colour or divide ingredients in half to make 2 colours etc. Combine ingredients and cook mixture in a large saucepan, stirring constantly, until the dough forms a ball. Turn dough out onto a floured surface to cool. Then kneed until smooth and elastic. Cool completely; refrigerate in air tight containers.

Play Dough (no-cooking recipe)

2 cups flour
2 Tablespoons oil
1 cup salt
1 cup cold water
6 teaspoons alum or cream of tartar
food colourings (as above)

Make this large batch one colour or divide ingredients in half to make 2 colours etc. Mix ingredients and kneed until smooth and elastic. Store in air tight containers.

PLAYDOH VOLCANOES – STUDENT NOTES

In this activity, you will make your own volcano out of playdoh and find out what you can learn about the history of a volcano by looking at its **stratigraphy** or layering.

What is a volcano?

On Earth, volcanoes are caused by **magma** rising beneath the **crust**, forcing it to bulge up as a mountain and eventually break open and erupt **lava**. There are many types of volcano on the Earth, generally governed by the amount of water or **volatiles** that are present in a **magma**.

Question 1: What do you think we can learn about by looking at volcanoes on other planets? *Hint: think about where the magma and lava come from.*

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Why are volcanoes important?

Volcanoes or evidence of volcanic activity are present on all of the rocky bodies in the inner Solar System: Mercury, Venus, Earth, the Moon, and Mars. **Active** and **dormant volcanoes** are a natural source of heat, so **extinct volcanoes** tell you that there was once a lot of heat in that area.

Question 2: Why is a source of heat important, particularly on Mars? *Hint: Think about what you could be looking for with your Manned mission.*

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Volcanoes have played a large role in shaping the surfaces of these planets. For example, about one third of the nearside of the Moon (the side permanently turned towards the Earth) is covered by the maria, dark lava flows that have flooded large basins.

What about volcanoes on Mars?

On Mars, the whole northern hemisphere is covered by lava rock from a series of very large **shield volcanoes**. One of these is the largest known volcano in the Solar System: Olympus Mons. This volcano is around 24 km (78,000 ft.) tall; that's more than 2.5 times as tall as Mount Everest. Including the surrounding flooded plains, Olympus Mons is similar in size to Spain!! It is large enough in volume to contain about 100 of the biggest volcano on the Earth! Alongside Olympus Mons lies a huge bulge in the

surface known as Tharsis, on top of which lie three more massive volcanoes: Arsia Mons, Pavonis Mons and Ascræus Mons.

On Mars, the volcanoes grew as lava flow after lava flow built up on top of one another. As the volcanoes are so large, this means that there was a source of heat under each volcano for an extremely long time. What we don't know is how the **composition** of the lava changed over time and whether the volcanoes produced more or less lava in earlier flows than in later ones.

Question 3: To answer these questions, we need to look at the old lavas and compare them to the recent flows. How can we do this if the old flows have all been buried by the more recent ones?

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Missions to Mars have to date found no evidence of current volcanic activity, but it is difficult to be certain or to place accurate dates on the duration of Martian volcanic activity without directly sampling a number of volcanic rocks from the surface.

GLOSSARY

ACTIVE VOLCANO – a volcano that is currently erupting lava.

COMPOSITION – what something is made (i.e. *composed*) of.

CRUST – the outermost layer of rock of a solid planet.

DORMANT VOLCANO – a volcano that is not currently erupting, but is not yet extinct.

EXTINCT VOLCANO – a volcano that no longer erupts at all.

LAVA – molten rock that has been released from a volcano across the surface of a planet.

MAGMA – molten rock within a planet, building up beneath a volcano before it erupts

SHIELD VOLCANO – a type of volcano common on Mars, with very broad and shallow slopes formed as flow after flow gradually build up on top of one another.

STRATIGRAPHY – the layering of the rocks.

VOLATILES – these materials cause the build up of pressure in a volcano causing violent or 'volatile' eruptions. Water is a common volatile on the Earth, but there are many others.

VOLCANO – a mountain formed from the build up of magma beneath a planet's crust.

PLAYDOH VOLCANOES – ACTIVITY SHEETS

This experiment has been modified from the ‘Lava Layering’ experiment designed by the Hawai’i Space Grant College. More information about the original experiment can be found on their web pages:

(see http://imina.soest.hawaii.edu/SPACEGRANT/class_acts/VolcanologyDoc.html for a link to the different ‘Lava Layering’ pages).

Aims and objectives

In this experiment, you will be constructing a volcano out of playdoh, and trying to learn about the history of a volcano produced by another group. *It is important that you don’t tell the other groups about how you construct your volcano and don’t ask other groups about theirs!!*

Activity 1 – Constructing your volcano

Your volcano will consist of several flows of lava (represented by the playdoh). Each colour of playdoh represents a different texture or composition for the lava. The teacher will tell you how many colours of playdoh to use when you have found out the total number of flows your volcano will have (see steps 4 and 5 in the Procedure, below).

Apparatus (for each group)

candle holder,	foil,
paper cups,	tray,
teaspoon,	baking soda (bicarbonate of soda),
white vinegar,	paper towels.
playdoh or clay in up to 4 colours (see steps 4 and 5 in the Procedure),	

Experiment procedure

1. Cover your tray with foil, making sure there are no gaps for vinegar to leak through.
2. Secure a candle holder to the centre of the tray. (You may use a small loop of tape). This is your eruption source (or volcanic vent), and the tray is the surface of the planet.
3. Place one teaspoon of baking soda in the candle holder.
4. Roll a 4-sided dice provided (the number on the bottom of the pyramid is the value). Add 3 to this number. This is the number of flows your volcano will have. If no dice is available, your teacher will tell you how many flows your volcano should have.
5. Set aside small balls of playdoh, one of each colour provided by your teacher.
6. Fill some paper cups with white vinegar.
7. You are now ready for your first ‘eruption’ to produce a lava flow. Pour some vinegar onto the baking soda in the candle holder. The mixture will fizz and overflow onto the tray. This represents your flow of lava. Remember, the size of your eruption depends on the amount of vinegar used. Real eruptions vary greatly in size, so try changing it a little (but don’t use too much or you will run out of room on your tray!).
8. Mark out the edge of this flow using a pen and mop up the vinegar with paper towels.

9. As best you can, use a single colour of playdoh to cover the areas where the vinegar (lava) flowed.
10. On the sheets provided, carefully sketch the extent of the flow and the appearance of the volcano, taking note of the colour of each flow, as shown in the example sketches. The history of your volcano will be used later, so make sure you note this down carefully. Some example sketches for a volcano with 8 flows are provided to show you what is expected.
11. Repeat steps 7, 8, 9 and 10 until you reach the total number of flows for your volcano, using all the colours of playdoh provided by your teacher. You may add fresh baking soda to the source cup or spoon out excess vinegar from the source cup as needed. Once you have used all the colours of playdoh, begin the cycle again until your volcano has the same number of flows given in step 4.

Before handing your volcano on to the next group:

- a) sketch the final appearance of the structure.
- b) Choose **five** areas that you think it would be best to locate drill cores if you had to find out about your volcano. Note these down on your sketch, and explain what you would learn from these in the space provided.

Hint: Try to locate the areas that would show the most complete history of the volcano, like the total number of flows and the thickness or extent of different flows.

Now your teacher will pass your volcano on to another group and will give you a volcano to try and study.

Sheets for noting the construction of your volcano

Name

Sketch of volcano after first flow

Sketch of volcano after second flow

Name

Sketch of volcano after third flow

Sketch of volcano after fourth flow

Name

Sketch of volcano after fifth flow

Sketch of volcano after sixth flow

Name

Sketch of volcano after seventh flow

Sketch of final volcano and chosen sites for drill cores

Name

Explain why you have chosen each location for the five drill cores on your volcano (i.e. what you would learn about the flows in the volcano by taking a core there).

Drill Core 1:

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Drill Core 2:

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Drill Core 3:

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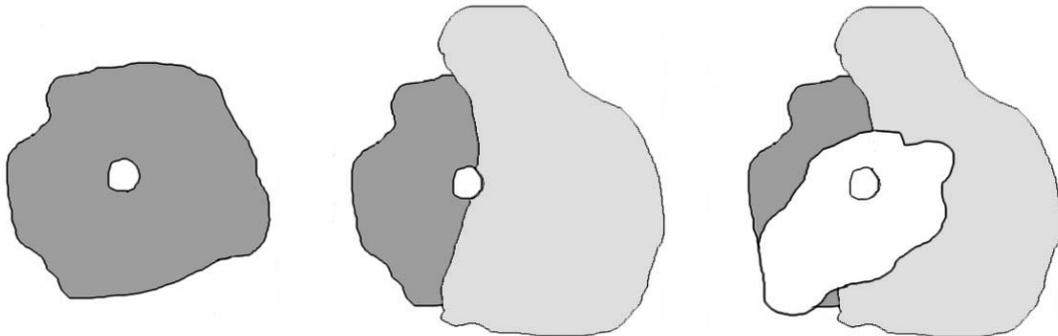
Drill Core 4:

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Drill Core 5:

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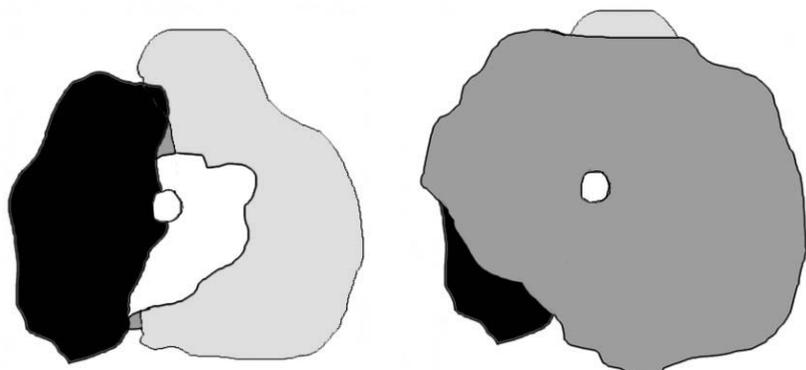
EXAMPLE SHEET (Remember, your pictures should be larger, and can use colour!)



Flow 1

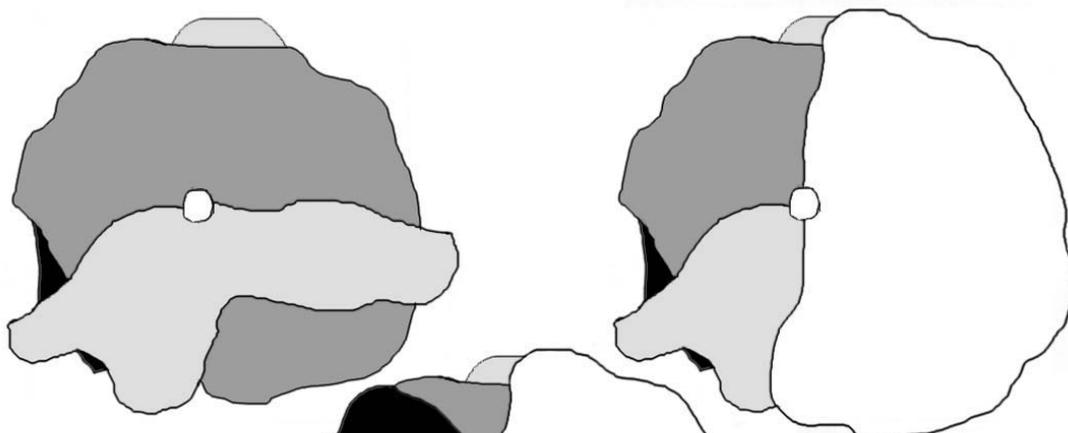
Flow 2

Flow 3



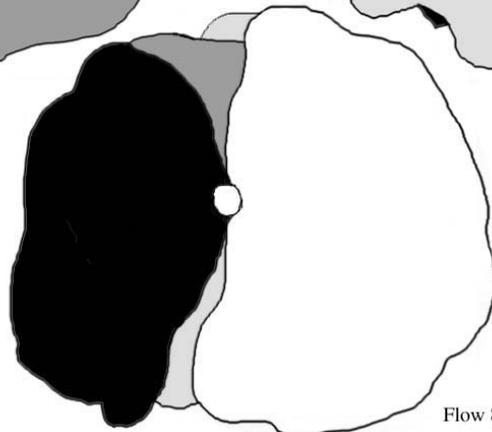
Flow 4

Flow 5

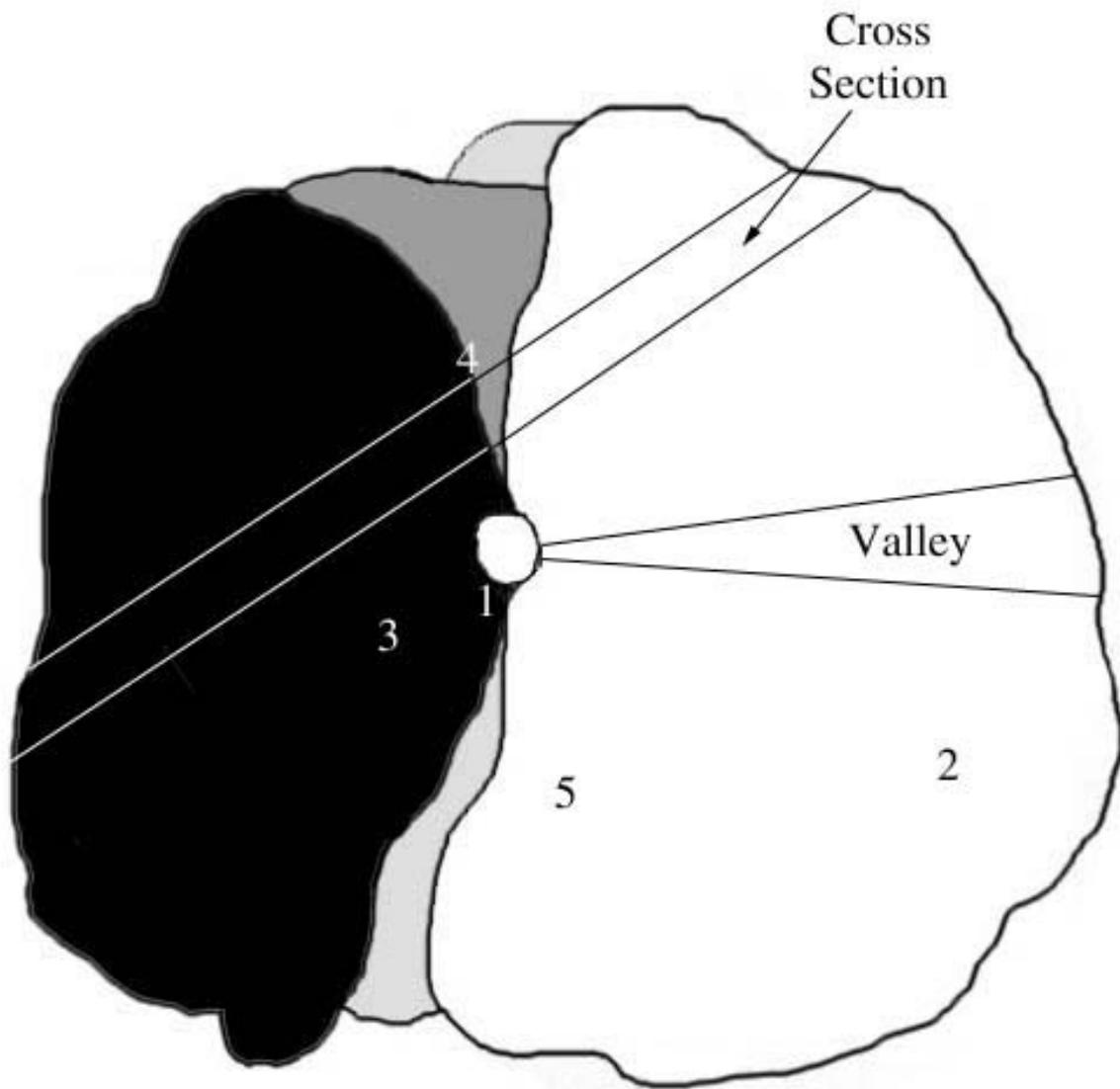


Flow 6

Flow 7



Flow 8



Final Volcano with chosen sites for the five drill cores, river valley and cross section.

Activity 2 – Analysing your volcano

After you have constructed your volcano, you will be given another example made by a different group and asked to analyse it as best you can. When doing this, you are not only looking to find out the number of flows in the volcano, but you should also try to look at their extent and thickness. Bear this in mind when taking your measurements. In order to help you with this, you will be allowed to take **up to five** 'drill cores' using the straws provided. You may then cut **one** 'river valley' and finally, **one** 'cross section' can be taken.

When studying the volcano, try to remember what you did to construct your volcano and use that information to guide you in locating the best places to take your measurements.

Apparatus (for each group)

straws cut into ~ 4 cm lengths toothpicks
a craft knife coloured pencils

Experiment procedure

Step 1 - Initial Impressions

Take a careful look at the complete volcano. This is what geologists are first faced with when analysing volcanoes on Earth. For volcanoes on other planets such as Mars, we are currently restricted to photographs and images taken by spacecraft, so we must learn as much as possible from views similar to those that you now have. Sketch the volcano on the sheet provided and try to answer the following questions:

Question: How many flows are visible?

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Question: What is the *stratigraphy* or layering telling you about the ages of the flows? Try to place the flows you can see in their correct age order:

Colour Of Oldest Flow:

Colour of Youngest Flow:

List of Flows (oldest to youngest):

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Step 2 - Drill Cores

Think very carefully about where you take each of your drill cores, using the information from *Step 1* to guide you in choosing the best positions to "drill", and noting the criteria you use to locate each drill site. In real life, drilling is a difficult and expensive procedure, and you would be restricted in the depth to which you can probe. However, to make things easier for you in this experiment, each of your cores will reach the base of the volcano (so you will see all of the flows at each drill site). You may use **up to five**

drill cores to analyse your volcano. For each core, the following procedure should be followed:

1. Take a cut straw and push it into your volcano at your chosen site. You won't have to push hard before you reach the tray.
2. When it reaches the tray, twist the straw to make sure the bottom layer is free, and carefully pull the straw back up.
3. Poke a toothpick into the top of your core and pull the playdoh from the straw – the layers of the volcano at that site should be visible in your core.
4. Carefully note the location of each drill core taken on your original sketch of the volcano, and sketch the cores in the boxes provided. Take care to note the number of flows of each colour, and the stratigraphy (layering) seen at each site.

Step 3 – 'River Valley'

To help with your analysis, we will say that through the millennia after your volcano formed, water ran through part of the flank, forming a valley and revealing the layering of different flows. As creating a valley in your playdoh volcano with water would be rather messy, use a craft knife to cut a wedge from the flank (side of the volcano) of your choice instead. In reality, we would be very fortunate indeed if a valley cut through any more than the uppermost layers of a volcano, but to make your study easier, you can cut to the tray and reveal all of the layers. Once again, be very careful when locating your valley and note the criteria you use to choose its position. When the valley is cut, carefully note its location on your initial sketch, and draw it in the box provided, noting the different layers and age relations for each.

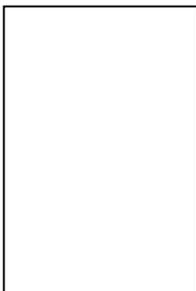
Step 4 – Cross Section

As a final aid to your analysis, you may take a cross section of your volcano. There is no natural process that is likely to produce such a feature in a real volcano; this is simply to help you in your study, and help you test the results you have gained from the valley and drill cores. As with the river valley, the cross section should be cut with a craft knife, its position sketched onto your original diagram of the volcano, and the results carefully noted in the space provided on the sheet.

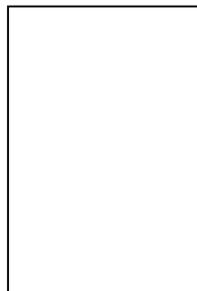
Sheets for analysis of a volcano

Name

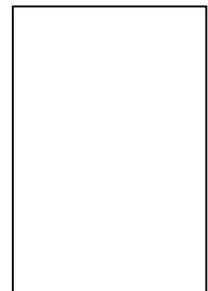
Initial sketch of volcano and chosen sites for drill cores



Drill Core 1



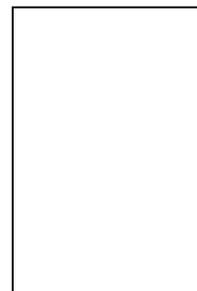
Drill Core 2



Drill Core 3



Drill Core 4



Drill Core 5

Sketch of the layers in the drill cores

Name

Sketch of river valley section from volcano

Sketch of cross section from volcano

Results and questions

Once all of the measurements are taken, try to answer the following questions using the information you have gained through both your analysis and your experience in constructing a volcano. During this, you will be shown the real history of the volcano you were analysing by the group that constructed it. Similarly, your group will be asked to show the history of the volcano you constructed to the group that analysed it

1. On the volcano you have analysed:
 - a) How many flows are there in total?
 - b) What colour is the oldest flow?
 - c) What colour is the youngest flow?

2. What influenced the flow direction during the construction of your volcano? Did the previous flows have any effect? Is there anything else in real life that would affect the flow of real lava?

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3. You were told how many colours of playdoh to use in your volcano. What would have been the effect if you had increased or decreased the number of colours? Would it be easier or harder to determine the flow history? Explain your answer. Which is the most realistic scenario?

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4. Compare the drill core locations you chose on the volcano you constructed with those taken by the group that took the samples. Are they similar? What criteria did you use in selecting the sampling stations? Discuss with your classmates whether you can produce a set of rules that could be used to locate drill sites on all of the volcanoes constructed.

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5. From your initial analysis, do you think there is any way we can identify lava layers on Mars from images and photographs?

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6. If part of your mission plan is to explore the volcanic history of the Mars, what would be your recommended method of analysis and why? Remember that you will be sending people to Mars, not just robots. This will be discussed in class and could form an important part of your final mission plan, so make your arguments clear.

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