Exploring Earth's Volcanic Environments
Lava Flow Eruptions

FIELD NOTEBOOK

NAME(S) ______________________

CLASS ______________________

INSTRUCTOR(S) ______________________

DATE ______________________

UNIVERSITY OF Rhode Island
NATIONAL SCIENCE FOUNDATION

Introduction

The eruption of magma to form lava flows is the most common volcanic process on Earth. Lava flows occur both under the sea and on land. In this web exercise you will learn about the processes of lava flow eruptions in both the marine and terrestrial environments. Part of the exercise will focus on the great 1783 Laki fissure eruption in southeast Iceland, the largest lava flow eruption in historic times. The Laki fissure eruption had significant local and global environmental impacts. You will take a virtual fieldtrip to Iceland and Hawaii to observe lava flow eruptions and their products.

The project was conceived and developed by Professors Steven Carey and Haraldur Sigurdsson of the University of Rhode Island. Support was provided by a grant from the Undergraduate Education Division of the National Science Foundation (DUE-0716952).

How to Proceed

The tasks that you will find in this notebook and the website can be completed individually or as a team of up to 3 students. The average time to complete the exercises is about 2 hours. You may stop and return to the exercise at another time if needed. All of your work is recorded in your field notebook. Please note that the tasks should be completed sequentially. Each task is designed to give you a base of understanding to complete the following tasks. It is to your benefit to finish each task before moving on.

There are 10 tasks to be completed during the exercise. This notebook contains specific questions and areas for each of the tasks as you move through the website. You will be asked to record observations, draw diagrams, formulate hypotheses, and plot graphs in your notebook when you see this field book icon on the webpage.

Task

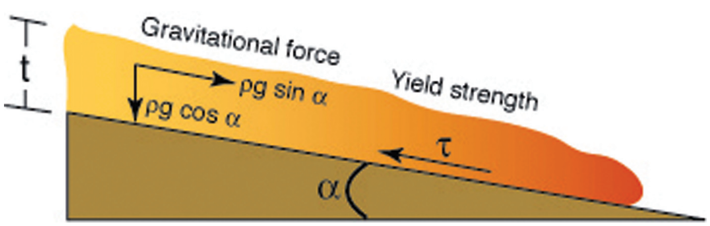
Look for this icon to complete a task!

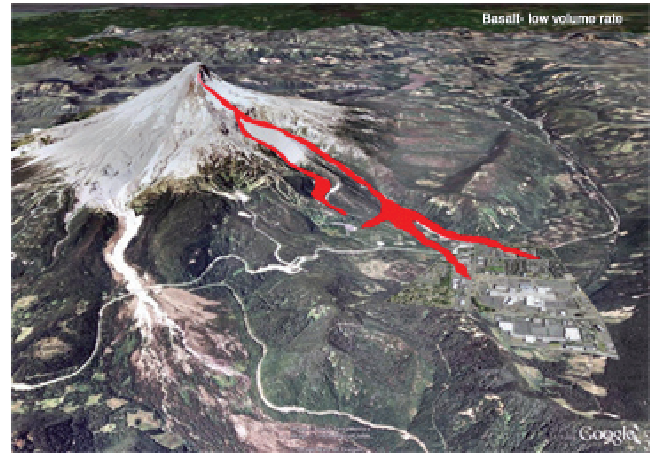
Lava Flow Behavior

The behavior of lava flows depends on many factors. Some of the most important include the magma viscosity volume discharge rate at the vent, and the slope of the surrounding terrain.

In this part of the exercise you will look at the effect of magma viscosity and volume discharge rate on the extent of lava flows from a series of hypothetical eruptions. The simulations allows you to change the parameters and observe the effects on the resulting flows.

Using the lava flow simulation, evaluate the behavior of different types of lava flows (basalt, andesite and rhyolite) as you vary the volume discharge rate.





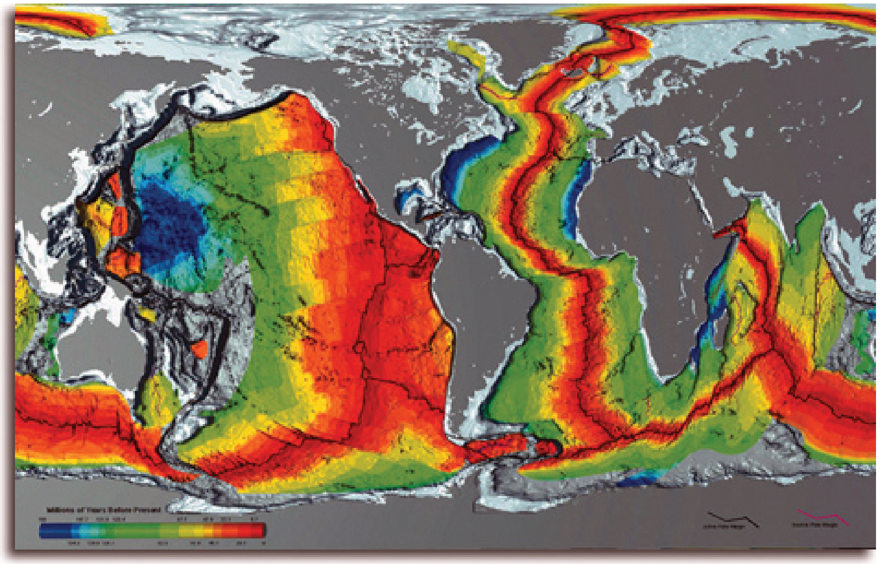
How does magma viscosity affect the total distance that lava flows travel?

How does the volume discharge rate affect how far a given type of lava flow (e.g. basalt) travels?

Which type of lava flow poses the most serious threat to the town at the base of the volcano shown in the figure above?

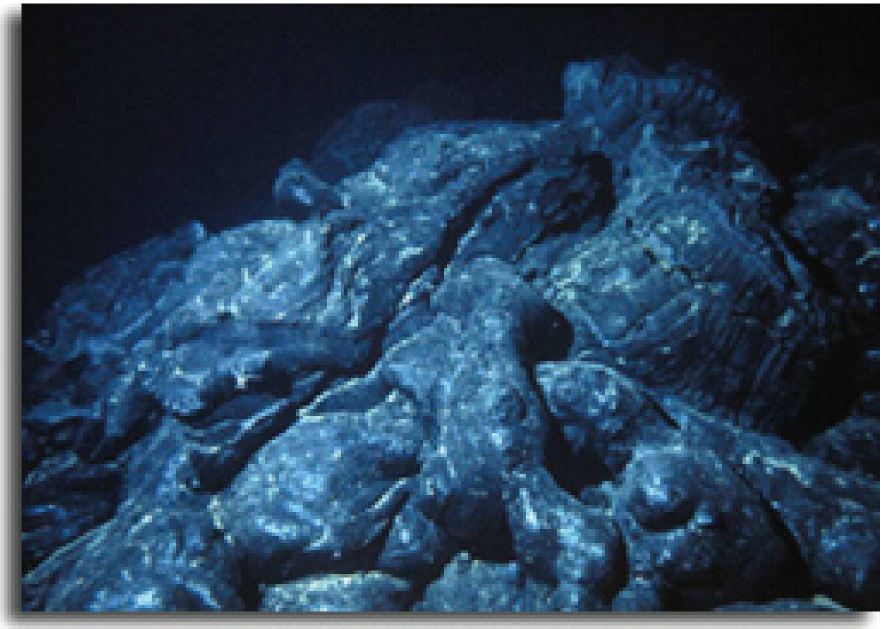
Observing Submarine Flows

Most of the volcanic activity on Earth occurs out of sight in the deep ocean. At the mid-ocean ridges, submarine lava flows contribute to the formation of new oceanic crust. Submarine lava flows form a very distinctive type of lava rock that you will observe and describe during this task.



Describe the formation of submarine lava flows from **Eruption 1**

An important aspect of the formation of submarine lava flows is the tremendous cooling power of water as compared to air. As you watch the video of a submarine flow think about how the cooling rates differ between submarine and subaerial lava flows.



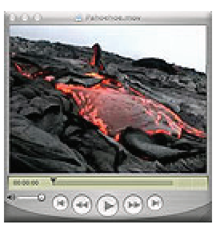
Describe the general shape, texture, and color of the submarine lava flows from **Eruption 1** shown in the pictures

Observing Subaerial Flows

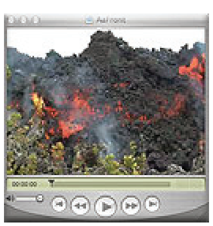
In this section you will watch videos of three examples of subaerial lava flows and examine the type of volcanic rocks that they produce. The video clips are from eruptions of Kilauea volcano in Hawaii and all involve basaltic magma of relatively low viscosity.

Watch the videos on the website and describe each eruption in your own words

Eruption 2



Eruption 3

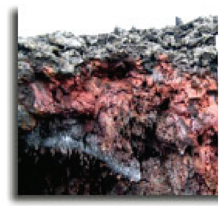


Eruption 4

Once a lava flow cools the magma solidifies to form a volcanic rock. There is a wide variety of shapes, textures and colors produced by different types of lava flow eruptions. Now that you viewed videos of Eruptions 2, 3 and 4 it is now time to observe the types of volcanic rocks that they produce. Each type of eruption results in characteristic features that help volcanologists interpret eruptive processes from the study of ancient lava flows.

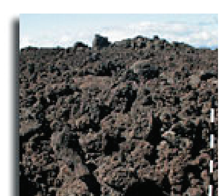
Describe the characteristics, such as shape, texture, and color of the products of eruptions 2, 3, 4

Eruption 2 Products



Eruption 3 Products

Eruption 4 Products



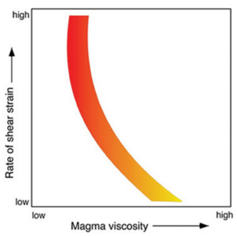
Aa and Pahoehoe Flows

You've seen that the textures and morphology of aa and pahoehoe flows are very different, but what causes such differences? In many cases the magmas have similar compositions.

Use the interactive figure on the website to examine the effects of rate of shear strain (amount of force applied to make the flow move) and magma viscosity on the type of flow that is produced.

Aa

Pahoehoe



What type of flow is produced if the lava flow has a high viscosity and a high rate of shear strain?

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What type of flow is produced if the lava flow has a low viscosity and a low rate of shear strain?

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What might cause a pahoehoe flow to change to an aa flow?

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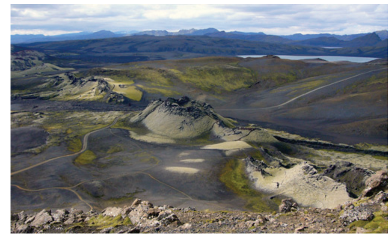
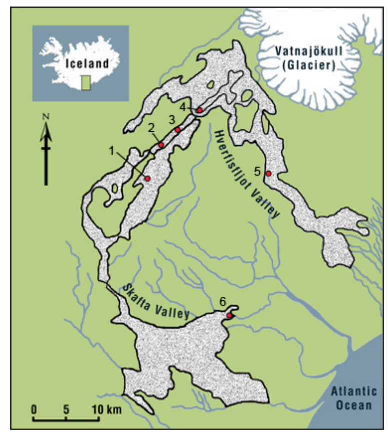
Fieldwork

In this part of the exercise you will visit a number of sites on the Laki 1783 fissure and its lava flows in Iceland and try to determine which sites are in the vent areas and which ones are out in the lava flow fields. Use what you've learned about vents and lava flow characteristics from the earlier part of the web exercise to help guide you in your interpretations.



What type of eruptive activity (Eruptions 2, 3, or 4) do you think produced the volcanic rocks at:



Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

Which sites do you think represent the source vents for the Laki 1783 lava flows and why do you think so?

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Laki 1783 Lava Advance

In this part of the exercise you will use a Flash animation module to measure the advance of the southwest and northeast lobes of the 1783 Laki lava flows.

Go to the Flash animation to explore the geology and morphology of the Laki area. In the section on the **Laki volcanic field** you will carry out measurements of the Laki lava flow advance using the movable measuring tool. Measure the distance between the labeled points along the lava flow between different days. You can use the controller to advance or rewind between different days. Fill in the appropriate values in the table below and calculate the speed of the flow lobes in the two different areas.

Southwest lobe

Distance Between Points	Kms	Meters (kms x 1000)	Date	Hours	Speed (meters/hours)
1 and 2			June 12–June 16	96	
2 and 3			June 16–June 18	48	
3 and 4			June 18–June 21	72	
4 and 5			June 21–July 20	696	

Northeast lobe

Distance Between Points	Kms	Meters (kms x 1000)	Date	Hours	Speed (meters/hours)
1 and 2			August 12–Sept. 16	768	

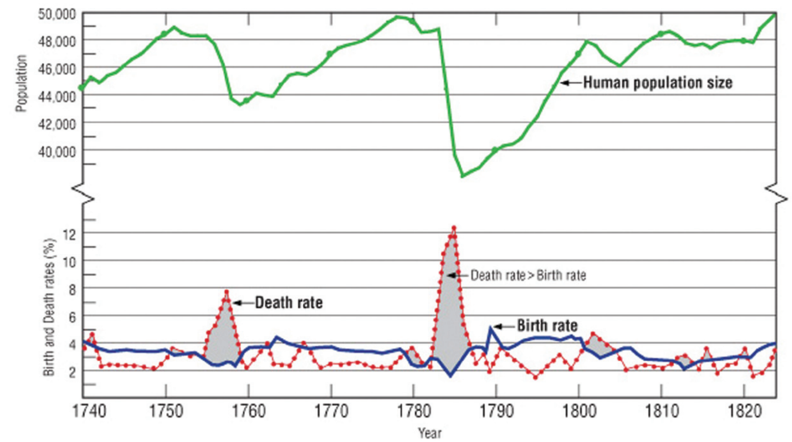
Which flow lobe had the highest speed and during what period (dates) did it occur?

How did the advance of the Southwest lava lobe change over the period from June 12 to July 20?

Do you think the advance of the lava flow would have been dangerous to the people living in areas of the southwest and northeast lava flow lobes? Explain why.

Eruption Impacts

The 1783 Laki fissure eruption was one of the worst natural disasters for the country of Iceland. In this part of the exercise you will think about the impact of the eruption and how the lava flows and in particular, the gases that were discharged into the atmosphere, might had led to the terrible loss of livestock and human life.

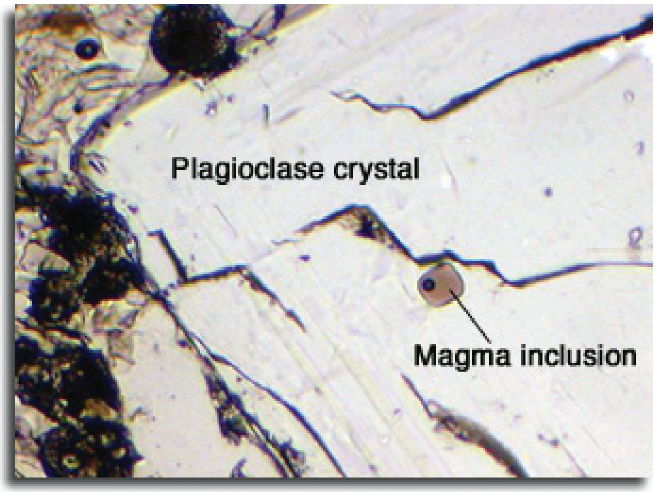


What do you think caused the rapid decline in the total population of sheep, horses, and cattle as a result of the eruption?

What do you think caused the marked population decline and the spike in the human death rate? Is it related to your answer to the first question?

Sulfur Discharge from Laki

You will now collect data on the sulfur content of magma inclusions from two samples collected from the 1783 Laki lava flows. The data will be provided by a virtual electron microprobe. Place your mouse cursor over the inclusions in the analyzer window for each sample and note the results below.



Sample 1

Sulfur content (ppm)

Magma Inclusion 1 ______________

Magma Inclusion 2 ______________

Calculate the average content of the 2 inclusions ______________

Sample 2

Magma Inclusion 1 ______________

Magma Inclusion 2 ______________

Magma Inclusion 3 ______________

Magma Inclusion 4 ______________

Calculate the average content of the 4 inclusions ______________

Calculate the average content of the 6 inclusions from both samples ______________

Is there a significant difference in the averages of the 2 samples? ______________

Now that you've carried out analyses of magma inclusions from the 1783 Laki samples, you can calculate the total amount of sulfur that was discharged during the eruption. To do the calculation you will use the equation shown below.

Mass of eruption x Sulfur concentration x 0.9 = Sulfur release

The factor 0.9 in the equation above just takes into account the degree of degassing that occurred during the Laki eruption.

Mass of the eruption is equal to 4.2×10^{13} kg

Sulfur concentration equals ______________________ $/1 \times 10^{6}$ = ______________
(ave. Sulfur conc. of 6 inclusions from prev. page)

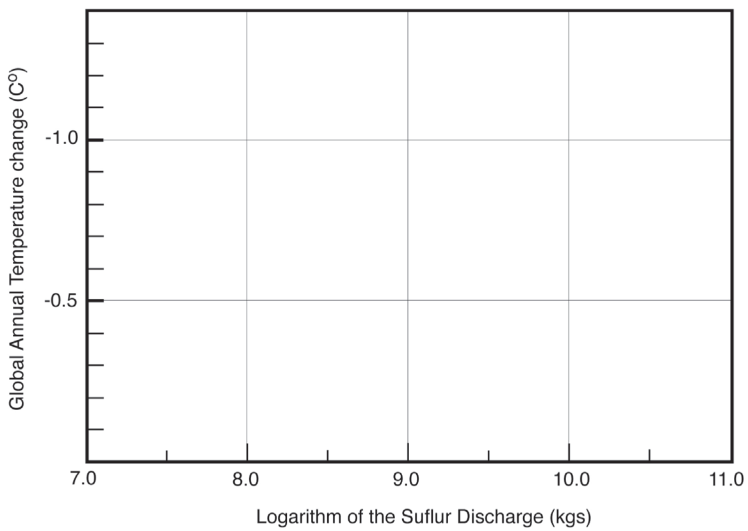
Calculate the Sulfur release in kilograms:

4.2×10^{13} kg x ______________ **x 0.9 =** ______________
(Sulfur concentration) (Sulfur release in kg)

Laki Climate Effects

More information is becoming available about the impacts of volcanic eruptions on the Earth's climate. Volcanologists and atmospheric scientists now believe that the amount of sulfur injected into the atmosphere by an eruption is a key factor in determining the extent of climate impact. In this section you will look at some available data along with the sulfur discharge that you calculated for the Laki 1783 eruption and see for yourself whether this hypothesis is supported by the observations.

On the graph below plot the values of logarithm of sulfur discharge versus global temperature change presented in the web exercise. Include the value that you calculated for the 1783 Laki fissure eruption on the previous page (you will need to determine the logarithm of the value in order to plot it).



Is there a correlation between the sulfur discharge and global annual temperature change, and what is the relationship?

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How do you suppose the discharge of sulfur to the atmosphere caused global cooling at the surface? (Think about what the presence of aerosols would do in the atmosphere.)

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