NOVA

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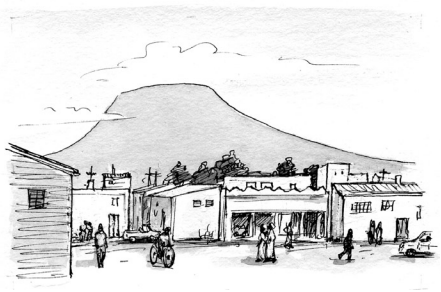
Volcano Under the City

PROGRAM OVERVIEW



NOVA investigates the dangers of Nyiragongo volcano, located in a densely populated valley in the heart of Africa.

The program:

- recounts Nyiragongo's 2002 eruption, which left more than 100 people dead and another 100,000 homeless.
- describes two main types of volcanic eruptions: explosive, as seen at Mt. Saint Helens where lava shot up 25 kilometers, and effusive, as seen in Hawaii, where lava is very fluid and erupts wherever it can.
- notes that Nyiragongo is an effusive volcano characterized by an extensive network of fissures—which now extend beneath the city of Goma—that can fill with magma and erupt.
- points out that the volcano contains lava that has been clocked at speeds of almost 100 kilometers per hour, making it the fastest-moving lava on Earth.
- outlines how scientists forecast volcanic eruptions through the use of seismology, land deformation, and geochemistry, which they measure with seismology readings, satellite imagery, and gas fume sampling.
- relates another threat facing Goma—concentrations of deadly carbon dioxide gas at the bottom of Lake Kivu that could be released through earthquake or lava eruption from Nyiragongo.
- shows people building homes in the path of a potential lava flow because they are unafraid of the volcano's dangers or unable to go elsewhere.
- follows volcanologists as they descend into the volcano's crater to collect gas and lava samples.
- describes the dangers scientists face as volcano walls begin to collapse, forcing the team to abandon its efforts.
- follows the team as it returns to the crater to attempt a new lava collection method.
- details how scientists examine gas and lava samples to gain information about the volcano's current state.
- summarizes evidence showing a very active volcanic system that could quickly erupt stored magma, flood the city with lava in minutes, and release toxic gases from the nearby lake—all of which could lead to a catastrophic natural disaster.

BEFORE WATCHING

1 Have students list and then share what they know about volcanoes. Where are volcanoes found? How are they formed? Do all volcanoes give off the same type of material? *(Volcanoes emit lava, tephra or rock fragments, and gases; these differ according to volcano type.)*

2 Organize students into three groups. As students watch the program, have each group take notes on one of the following areas: what scientists are trying to measure and the instruments they used, the challenges and dangers researchers faced, and past volcanic eruptions and the damage caused by each.

AFTER WATCHING

1 Have students share their notes. Make a chart on the board that includes what scientists measured, what kind of technology they used, and what they learned from their tests. *(Scientists used seismographs to detect earthquake distribution, employed satellite imaging to measure changes in land deformation, took gas measurements to determine gas content and levels, and obtained lava samples to better understand the dynamics of the volcano's magma.)* Include in the discussion the challenges and dangers researchers faced, and the nature of earlier Nyiragongo eruptions.

2 Ask students how they would feel living near Nyiragongo. Why would they stay? Why would they leave? What other forces of nature make some areas unsafe? Have students compare the risk of living in an area where natural disasters might occur and cause devastation and death versus taking risks such as smoking or speeding in a car.

CLASSROOM ACTIVITY (CONT.)

Activity Summary

Students will experiment with three different liquids to determine the relative viscosity and flow rate of each liquid.

Materials for Each Team

- copy of "Thick and Thin" student handout
- copy of "Data Sheet" student handout
- three 25 ml test tubes
- 25 ml each of water, cooking oil, and light corn syrup
- 5 ml each of water, cooking oil, and light corn syrup in separate paper cups
- masking tape
- small metal paper clips of identical size and mass
- stopwatch/timer
- small wood block about 4 cm in height
- non-stick cookie sheet or pan, at least 25 cm long
- ruler or measuring tape
- 3 plastic spoons
- paper towels
- graph paper
- calculator

Background

Magma is molten rock below Earth's surface. Magma rises in volcanic vents; when it reaches the surface it is called lava. The three common types of lava—basaltic, andesitic, and rhyolitic—contain different amounts of silica (SiO_2) and dissolved gases. They have different viscosities based on the amount of silica they contain. Low-silica lavas are less viscous and travel faster than higher-silica lavas, which are more viscous and travel slower. Viscous lavas sometimes cool before they travel very far, which is why they are often less hazardous. When magma or lava cools and solidifies, it forms igneous rock. (Basalt, andesite, and rhyolite are all igneous rocks.) The following chart lists common lava types and their flow rates. Note that lava flows pass through a range of viscosities as they cool and solidify; as lava loses heat, its viscosity increases.

Lava Type	Silica Content	Viscosity	Approximate Flow Rate
basaltic	least	least	30–60 km/hr
andesitic	in between	in between	10 km/hr
rhyolitic	most	most	1 km/hr

LEARNING OBJECTIVES

Students will be able to:

- compare and measure the relative flow rates of different liquids.
- state that different kinds of lava differ in their viscosity.
- understand that a lava's viscosity influences how quickly it flows.

KEY TERMS

flow rate: Determined by distance/time.

lava: Magma that has erupted from a volcano and flowed to the Earth's surface or the ocean floor.

silica: A common mineral composed of silicon and oxygen. Silica makes up almost 75 percent of Earth's crust.

tephra: Air fall material, such as ash, produced by a volcanic eruption.

viscosity: The resistance of a fluid's (gas or liquid) flow on a parallel plane.

Video is required for this activity.

CLASSROOM ACTIVITY (CONT.)

Mount Nyiragongo is a volcano in the Democratic Republic of the Congo, 18 kilometers from Goma near the Rwandan border. The area surrounding the mountain is highly populated. The volcano has very fluid basaltic lava with an unusually low silica content, which moves quickly. During the 1977 eruption, the initial speed of the lava flow was estimated at 100 kilometers per hour. When Nyiragongo erupted in January 2002, more than 250,000 people were temporarily displaced when the lava, flowing at speeds of about 60 kilometers per hour, overran the town of Goma.

Procedure

1. Prepare the test tubes and cups for each team prior to the experiment. Pour 25 milliliters of each liquid into separate test tubes. Make sure each tube contains the same amount of liquid.
2. Discuss the concept of viscosity with students. Point out that viscosity is a fluid's resistance to flow. The viscosity of lava differs depending on the amount of silica in each type of lava. Discuss some possible reasons why scientists might want to study lava viscosity.
3. Organize students into teams and provide a set of materials to each team. Explain to students that the different liquids model different types of lava. Tell students that they will be experimenting with how liquids differ in their viscosity and how liquid viscosity and rate of flow are related.
4. Before having students conduct the paper clip dropping experiment, tell them that one way to test the viscosity of a liquid is to drop an object into the liquid and find how long it takes the object to sink. Discuss buoyancy and density and talk about why the same object must be used for each liquid.
5. Have students conduct the experiments according to the instructions on their handouts. Try to have students set up their ramps at about the same angles (if ramp angles are not the same, results will be relative). When students have completed the activity, record average results for each student team (for both experiments) on the board. Discuss the experiments and results. What did students observe about the three liquids? What is the relationship between viscosity and flow rate? Can students think of some examples of everyday items in which viscosity plays an important role? *(Some items include car engines that need oil to run well and food items like syrup that need to pour readily.)*
6. As an extension, have students determine how temperature affects the viscosity of a liquid. Cool the liquids by placing a jar containing the liquid in a refrigerator. Then ask students to repeat the activity to determine whether cooling the liquid affects viscosity and how quickly the liquid moves.

STANDARDS CONNECTIONS

The "Thick and Thin" activity aligns with the following National Science Education Standards (see **books.nap.edu/html/nses**).

GRADES K–4
Science Standard D
Earth and Space Science
Changes in Earth and sky

GRADES 5–8
Science Standard D
Earth and Space Science
Structure of the Earth system

Classroom Activity Author
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ACTIVITY ANSWER

Sample Paper Clip Dropping Data*

The experiment reveals a relationship between viscosity and flow rate. Students' bar graphs should reflect the fact that water is the least viscous of the three liquids and flows the fastest, while corn syrup is the most viscous and flows the slowest.

	Corn syrup	Oil	Water
Trial 1	30 sec	>1<2 sec	less than 1 sec
Trial 2	24 sec	2 seconds	less than 1 sec
Trial 3	27	2 seconds	less than 1 sec
Average Result	27 sec	about 1.8 sec	less than 1 sec
Viscosity Rating (1–3)	3	2	1

*test tube with 25 ml of liquid

Sample Rate of Flow Data*

	Corn syrup	Oil	Water
Trial 1	3 min. 10 sec	44 sec	3 sec
Trial 2	2 min. 56 sec	42 sec	2 sec
Trial 3	3 min. 4 sec.	43 sec.	2 sec
Average Result	3 min. 4 sec (184 seconds)	43 sec	2.3 sec
Distance	25 cm	25 cm	25 cm
Flow Rate (distance/time)	25 cm/184 sec =.1 cm/sec	25 cm/43 sec =.6 cm/sec	25 cm/2.3 sec = 11 cm/sec

*ramp resting on end of wood block 3.8 cm high, flow distance = 25 cm

Student Handout Questions

1. Compare the relative viscosities of the liquids to the speeds with which the liquids moved during your ramp tests. Based on your data, how does the viscosity of the liquid influence the rate at which the liquid flows? *More viscous liquids flow slower than less viscous liquids.*
2. Nyiragongo is said to have lava that flows "like water." Based on your investigation, describe the viscosity of the lava produced by Nyiragongo. *Nyiragongo volcano lava is not very viscous and flows quickly.*
3. How might the viscosity of lava from a volcanic eruption affect the outcome of an evacuation? *More people and animals might be at risk if the lava is less viscous and flows more quickly.*

LINKS AND BOOKS

Links

NOVA—Volcano Under the City
www.pbs.org/nova/volcanocity
Learn whether volcanic eruptions can be predicted, discover what it was like to film in a volcanic crater, explore Nyiragongo's main features, and read historic accounts of the some of the worst volcanic disasters of the past 400 years.

Natural Hazards
earthobservatory.nasa.gov/NaturalHazards/natural_hazards_v2.php3?img_id=1608
Describes the Nyiragongo volcanic eruption that occurred January 17, 2002.

Volcanoes
www.learner.org/exhibits/volcanoes/entry.html
Discusses volcanic eruptions and includes information on lava flow rate and viscosity.

Books

Earthquakes and Volcanoes
by Fiona Watt.
Usborne Ltd., 1994.
Provides diagrams, illustrations, and photographs to explain earthquakes and volcanoes.

The Visual Dictionary of the Earth
by Charles Wills, editor.
Dorling Kindersley, 1993.
Includes a section on different types of volcanoes and how they erupt.

Volcanoes and Earthquakes
by Susanna Van Rose.
Dorling Kindersley, 1993.
Presents a visual display of volcanoes and how they occur.

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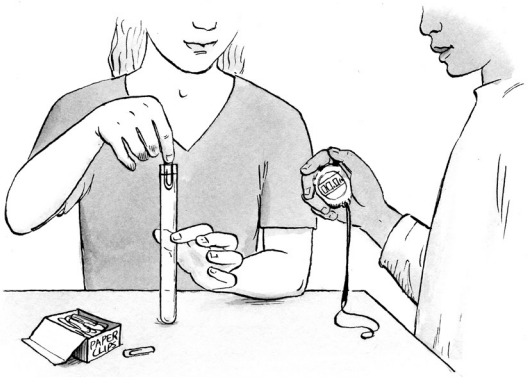
NOVA

Thick and Thin

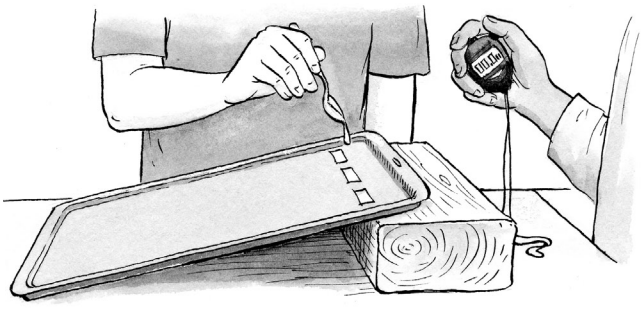
Different types of lava have different viscosities (viscosity is the resistance of a fluid to flow). In this activity, you will use different liquids to investigate viscosity and how viscosity affects the speed at which the liquid flows.

Procedure

1. Gently swirl and observe the liquids in the three test tubes. Which seems to be the thickest (most viscous)? Which seems to be the least thick (least viscous)? On your "Data Sheet" handout, predict which liquid is the most viscous, which is the least, and which is in between.
2. Drop your paper clip into the liquid and time how long it takes for it to fall. Have one member of your group hold the paper clip at the surface of the liquid and release the paper clip. When it is completely below the surface, have another person start timing. The stopwatch should be stopped as soon as the paper clip tip touches the tube bottom.
3. On your "Data Sheet" handout, record how long it takes for a paper clip to fall through each liquid.
4. Do two more trials for each liquid. (You may leave the first paper clip in the liquid.) Average your results.
5. Assign a value of 1 (least viscous) to 3 (most viscous) to the three liquids. Record the values.
6. Make a ramp by balancing a cookie sheet on the edge of the wooden block. Use your masking tape to create three starting lines at the 25-centimeter mark (the bottom of the masking tape should be 25 centimeters from the end of the ramp). Record this distance on the "Rate of Flow Results" table on your "Data Sheet" handout.
7. Predict how the viscosity of each liquid will affect the speed with which the liquid flows down the ramp. Which liquid will have the fastest speed down the ramp? Which will have the slowest? Record your predictions on your "Data Sheet" handout.



8. Pour one plastic teaspoonful of one of the liquids just before the top of the masking tape and start timing as soon as the liquid passes the bottom of the tape and touches the ramp surface. Stop the timer when the liquid reaches the bottom of the ramp. Record the results. Clean the ramp and repeat the test two more times, using a new starting line each time. Average your results.
9. Calculate the flow rate by dividing the distance of the ramp by the average time it took the liquid to cover that distance. Record the flow rate or speed in your data table.
10. Repeat steps 8 and 9 for the other two liquids.
11. Display your flow rate results for the three liquids in a bar graph. Label the *x*-axis "Liquid" and the *y*-axis "Rate of Flow (cm/sec)".



Data Sheet

Paper Clip Dropping Results
Prediction:

	Corn syrup	Oil	Water
Trial 1			
Trial 2			
Trial 3			
Average Result			
Viscosity Rating (1–3)			

Rate of Flow Results
Prediction:

	Corn syrup	Oil	Water
Trial 1			
Trial 2			
Trial 3			
Average Result			
Distance			
Flow Rate (distance/time)			

Questions
Write your answers on a separate piece of paper.

1. Compare the relative viscosities of the liquids to the speeds with which the liquids moved during your ramp tests. Based on your data, how does the viscosity of the liquid influence the rate at which the liquid flows?
2. Nyiragongo is said to have lava that flows "like water." Based on your investigation, describe the viscosity (extremely viscous or not very viscous) of the lava produced by Nyiragongo.
3. How might the viscosity of lava from a volcanic eruption affect the outcome of an evacuation?