

Lake of Fire

By Stephen Fraser

What happened when a U.S. geologist ventured into the mouth of a seething volcano?

The wicked heat, the ear-pounding noise, the stinging air—the assault on Ken Sims’s senses was almost unbearable. At any moment, a shower of molten rock could have reduced him to cinders.

Sims had never known such fear—or such exhilaration. The object of his scientific curiosity lay just above him. If he could just keep his footing for a few more feet, something no other human had seen awaited him on the other side.



Olivier Grunewald
climbing into Nyiragongo’s crater

Ken Sims is a volcanologist. For most of the year, he teaches and works in a lab at the University of Wyoming. His field studies take him far away, though, to some of the most treacherous spots in the world.

Few places are more treacherous than the Democratic Republic of the Congo (DRC) in Africa. For two decades, near-steady warfare has claimed millions of lives in the area.



Olivier Grunewald

Red-hot lava spills over the lip of the lava lake inside the crater

The DRC is also the site of Lake Kivu. Its cold depths hold a huge concentration of dissolved methane and carbon dioxide. A geologic disturbance, such as an earthquake or a volcanic eruption, could stir up the lake. The cold water could rise, releasing the dissolved gas from solution. Like a shaken can of Coke, the lake could unleash the gas in a swarm of bubbles, endangering the people who live on Kivu's shores. (When the human body breathes too much carbon dioxide, its fluids become acidic and fatal carbon dioxide poisoning can occur.) The results of such an event could be disastrous because more than 1 million people live in the shoreline city of Goma.

An earthquake or volcanic eruption is a real possibility in Goma. Nyiragongo, an active volcano, looms over the city. It was to Goma and the volcano that Sims traveled last year. Accompanying him were an Italian volcanologist, Dario Tedesco; a team of younger scientists; and a posse of bodyguards.



Olivier Grunewald

Molten rock that flows

through channels in Nyiragongo surfaces in a lake at the bottom of its crater.

Nyiragongo is a *stratovolcano*—conical in shape, built up by layers of hardened *lava* (molten rock). Stratovolcanoes are characterized by *Plinian eruptions*—violent explosions that vault columns of gas and ash into the stratosphere. “Nyiragongo could, and most likely will, erupt again that way someday, jeopardizing the lives of everyone in Goma,” Sims told *Current Science*. The scientific expedition to Nyiragongo was conducted to gather clues about when the next outburst might occur.

Although Nyiragongo hasn’t blown its top in recent memory, it has split its sides. In 1977 and 2002, lava broke through *fissures* (cracks) on the flanks of the volcano and tore downhill. Thousands of homes in Goma were torched, and several hundred residents were killed.

Gas Leaks

A veteran mountaineer, Sims led his colleagues to Nyiragongo’s summit. The climb was arduous. Reaching the top, they lowered themselves and their equipment into the giant *caldera* (crater) and set up camp on a ledge. The ground was warm and covered in volcanic ash and filaments of volcanic glass.

Even when Nyiragongo is between eruptions, the movement of *magma* (molten underground rock) through its internal plumbing regularly shakes the mountain. Magma also contains gases, such as carbon dioxide and methane, which Nyiragongo is steadily releasing into the air. It was those gases that Sims, Tedesco, and their research team measured on the ledge.



Olivier Grunewald

Nyiragongo towers over the city of Goma.

The scientists often had to wear gas masks while they were on the ledge. Magma also emits *sulfur dioxide*, a colorless gas with the pungent odor of a just-struck match. Sulfur dioxide is highly acidic and can irritate the skin, the eyes, and the tissues of the *respiratory* (breathing) system. “The air was so acidic inside the crater that our equipment began to corrode,” says Sims.

The gases that a volcano discharges hint at what’s happening in its depths. The scientists hope that return trips to Nyiragongo will establish a long-term profile of its gaseous output. Changes in that output could signal an upcoming Plinian eruption. If the signal is caught in time, says Sims, the residents of Goma might escape catastrophe.

Hot Pot

Nyiragongo attracted Sims for another reason. It’s one of the few volcanoes known to harbor a molten lava lake. Lava is magma that has reached Earth’s surface. He had already seen one lava lake on Mount Erebus in Antarctica. “It looked like boiling honey,” he recalls.



Olivier Grunewald
smoke and lava burst through the
black crust on the lake

From the center of Nyiragongo’s crater rises a low, steep-sided, volcanic cauldron—a *spatter cone*. Inside it lies the fiery orange lava lake, heaving and spewing geysers of melted rock.

Sims refused to let his colleagues approach the cauldron. He wouldn’t risk any loss of life—except his own. “I felt like a moth drawn to a flame,” says Sims.

Donning a rigid, heat-protective suit, Sims chugged across the crater floor, the black cauldron towering above him. At any moment, molten rock could have spilled over its lip like overheated soup, instantly incinerating him. Undaunted, he struggled up the 15-meter (50-foot) cauldron wall. Partway

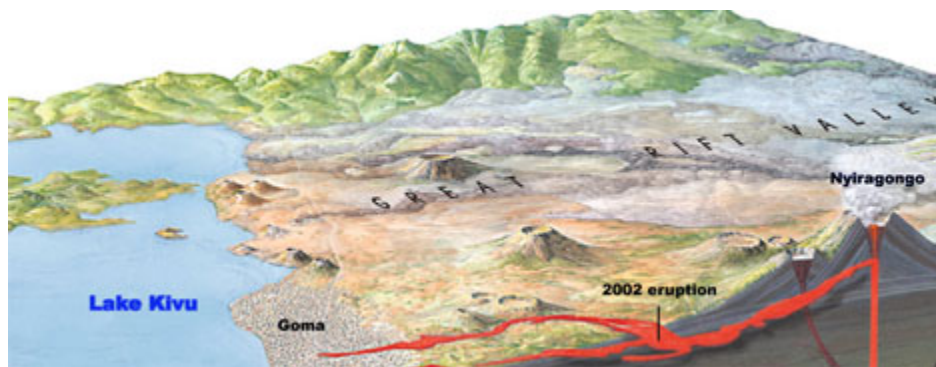
up, a hot rock melted one of his shoes. With one last heave, he rose high enough to peer over the rim. What lay before him was “mesmerizing,” he says. The seething lake roared like a jetliner. Great chunks of black, hardened lava banged against one another on the surface. He recalls thinking, *I will never encounter anything like it again.*

Sims could chance that view for only a moment. On his way back down the cauldron wall, he chipped off a chunk of gleaming, newly hardened lava and carried it with him out of the caldera. Examining its composition back in Wyoming might offer another clue to when Nyiragongo will roar to life again.

“While the adventure is great,” says Sims, “equally important is the careful, scientific analysis back in the labs. In addition to getting a rush from working in the field—looking right in the face of a dangerous volcano—you have to be willing to go home to do the work.”

Hazard Zone

The residents of the city of Goma inhabit one of the most perilous places on Earth. On one side is Lake Kivu, bloated with deadly gases. On the other side is Nyiragongo, an active volcano. This drawing traces the destructive paths that rivers of red-hot lava took when they poured out of the volcano in 2002.



William E. McNulty & Lisa R. Ritter/NGM Staff

Name: _____ Date: _____

1. What causes Nyiragongo to shake even when the volcano is between eruptions?
 - A sulfur dioxide, which is very acidic and can eat away at the rock
 - B the release of methane and carbon dioxide into the air
 - C the movement of magma through the inside of the mountain
 - D the boiling lava lake located in the center of the volcano's crater

2. Which of the following best captures how the author describes Sims' work?
 - A Sims has an exciting and dangerous job, but he would rather spend all of his time in the lab, analyzing data from volcanoes.
 - B Sims gets to climb mountains for a living, risking his life in order to glimpse parts of volcanoes no person has ever seen.
 - C Sims travels to foreign countries to understand the culture and experiences of people living near volcanoes by seeing how volcanoes impact their lives.
 - D Sims studies samples and data gathered from his exploration of volcanoes in order to predict future eruptions.

3. In the opening two paragraphs, the author describes a moment when Sims is exploring Nyiragongo. Based on evidence later in the passage, which specific part of Nyiragongo is the author most likely describing?
 - A the crater
 - B the summit
 - C the caldera
 - D the lava lake

4. Read the following sentences and answer the question below: "What lay before him was 'mesmerizing,' he says. The seething lake roared like a jetliner. Great chunks of black, hardened lava banged against one another on the surface. He recalls thinking, *I will never encounter anything like it again.*"

What does the word **mesmerizing** mean?

 - A horrifying
 - B boring
 - C spell-binding
 - D beautiful

5. The author's purpose of this passage is to
 - A persuade politicians to provide support to the city of Goma in preparation for a volcanic eruption
 - B describe the exploration of a famous volcanologist and the workings of an active volcano
 - C warn the people of Goma of a possible nearby volcanic eruption so they can relocate as soon as possible
 - D argue for the importance of scientific exploration to better predict and prevent natural disasters

6. List two reasons why the author considers the Democratic Republic of Congo to be one of the most treacherous places on Earth.

7. Why would Sims travel to Goma with bodyguards?

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

_____ the adventure of exploring the volcano is fun, a volcanologist must also be willing to work a lot back at the office.

- A Because
- B Although
- C So
- D Instead

9. Answer the following questions based on the sentence below.

The residents of Goma inhabit one of the most dangerous places on Earth.

Who? the residents

(do) What? _____

Where? _____

10. Read the vocabulary word and definition below and complete questions 10a, 10b, and 11.

Vocabulary Word: arduous (ar · du · ous): difficult and tiring or challenging to overcome.

10a. Read the sentences below and underline the word **arduous**.

1. The construction workers had the arduous task of repairing the roads in the hot sun in the middle of the summer afternoon.
2. Before heading off for the war in Iraq, U.S. soldiers had to endure arduous training to prepare them for the challenging tasks they would face in during wartime.
3. Walking had become an arduous activity for Ryan after his car accident because his legs were always in pain.
4. The doctor found it arduous to take care of all the sick people in the village by himself without enough medicine.
5. The runner ran 26 miles in the marathon which was very arduous and difficult to do, especially since he was not in the best physical shape.

10b. Which image shows something that would be more arduous to climb?



11. Which task would be more arduous: watching television or cooking a dinner for 50 people? Why?

Teacher Guide & Answers

Passage Reading Level: Lexile 1000

Featured Text Structure: Descriptive – the writer explains, defines or illustrates a concept or topic

Passage Summary: In “Lake of Fire,” the author describes the work of volcanologist Ken Sims as he explores a volcano in the Democratic Republic of Congo in order to predict when the volcano might erupt. A volcanic eruption could threaten the lives of more than one million people who live in the nearby city of Goma.

1. What causes Nyiragongo to shake even when the volcano is between eruptions?
 - A sulfur dioxide, which is very acidic and can eat away at the rock
 - B the release of methane and carbon dioxide into the air
 - C the movement of magma through the inside of the mountain**
 - D the boiling lava lake located in the center of the volcano’s crater
2. Which of the following best captures how the author describes Sims’ work?
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3. In the opening two paragraphs, the author describes a moment when Sims is exploring Nyiragongo. Based on evidence later in the passage, which specific part of Nyiragongo is the author most likely describing?
 - A the crater
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4. Read the following sentences and answer the question below: “What lay before him was ‘mesmerizing,’ he says. The seething lake roared like a jetliner. Great chunks of black, hardened lava banged against one another on the surface. He recalls thinking, *I will never encounter anything like it again.*”

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6. List two reasons why the author considers the Democratic Republic of Congo to be one of the most treacherous places on Earth.

Suggested answer: For two decades, near-steady warfare has claimed millions of lives in the area. Additionally, Lake Kivu is in the DRC and contains a big mass of dissolved methane and carbon dioxide. Lastly, the DRC is home to Nyiragongo, a very active volcano. [paragraphs #4 and #5]

7. Why would Sims travel to Goma with bodyguards?

Suggested answer: Because the DRC was undergoing a Civil War and the violence might put Sims' life in danger, thus warranting body guards for protection. [paragraph #2]

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

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- A Because
- B Although**
- C So
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9. Answer the following questions based on the sentence below.

The residents of Goma inhabit one of the most dangerous places on Earth.

Who? the residents

(do) What? **inhabit one of the most dangerous places on the Earth**

Where? **Goma**

10. ReadWorks recommends that you teach this vocabulary word to the whole class out loud using the four steps listed below.

Vocabulary Word: arduous

Step 1: Introduce the word

- a. Teacher writes the word on the board and divides it into syllables: (ar · du · ous)

Teacher says: "This word is arduous. What is the word?" [All students reply together out loud: "arduous."]

Step 2: Provide a child-friendly definition

- a. Teacher says: "Arduous means difficult and tiring or challenging to overcome. Something that is arduous requires hard work or continuous physical effort."
- b. Teacher says: "In the text, the climb to the summit of Nyiragongo was very arduous as Sims and his colleagues had to navigate dangerous terrain with heavy equipment, meaning this was a very difficult process."
- c. Teacher says: "What is the word?" [All students reply together out loud: "arduous."]

Step 3: Practice the word

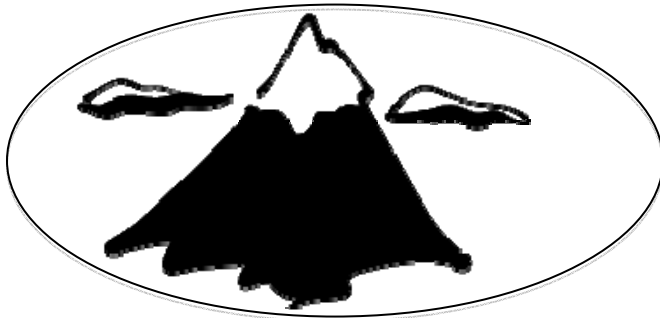
Teacher provides examples and additional opportunities to repeat the word. Read the first sentence out loud to your students. Begin reading it again and when you come to the vocabulary word prompt students to say the vocabulary word out loud. Then, finish reading the sentence out loud to your students.

- 10a.**
1. The construction workers had the arduous task of repairing the roads in the hot sun in the middle of the summer afternoon.
 2. Before heading off for the war in Iraq, U.S. soldiers had to endure arduous training to prepare them for the challenging tasks they would face during wartime.
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 4. The doctor found it arduous to take care of all the sick people in town by himself without enough medicine.
 5. The runner ran 26 miles in the marathon which was very arduous and difficult to do, especially since he was not in the best physical shape.

Step 4: Check for student understanding

This step can be completed as a whole class activity or as an independent practice.

- 10b.** Which image shows something that would be more arduous to climb?



- 11.** Which task would be more arduous: watching television or cooking a dinner for 50 people? Why?

Suggested answer: It would be more arduous to cook a dinner for 50 people because it would be more difficult and tiring than watching television.

Suggested Additional Vocabulary: unbearable, exhilaration, treacherous, disastrous, incinerating, undaunted, mesmerizing