Boiling River Research Guide

Topic: Hydrothermal Systems of Yellowstone National Park

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the big book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "Hydrothermal Systems" and answer the following questions with several sentences in YOUR OWN WORDS.

Why was a water rights compact and controlled-groundwater area established by the National Park Service and the state of Montana?
What does the park's hydrothermal system need in order to exist?
How is the superheated water (with temperatures exceeding 400ºF) formed? Hint: It has to do with the water cycle and percolation.
Describe the natural "plumbing" system of the park's hydrothermal features.
What role does silica play in the park's "plumbing" system?

ARIZONA GEOGRAPHIC ALLIANCE

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Describe the 5 main hydrothermal features of Yellowstone National Park and how they work.

Hot Springs:

Geysers:

Mudpots:

Travertine Terraces:

Fumaroles:

3. How does Yellowstone's boiling river work?

4. Why is Yellowstone's boiling river closed in spring and early summer?

5. What types of deaths/injuries have occurred as a result of Yellowstone's hydrothermal system? How frequent are deaths and injuries?

6. What types of organisms can live in Yellowstone's boiling river? Can they cause any infections? Are there any invasive species?

7. One thing not included in this research guide that you would like to include on your page of the book.

Works Cited Page: What sources did you use to find the above information?

Cite your sources **using MLA format**. Use www.easybib.com to help you! You need **at least 3** credible sources!
1. 2. 3.

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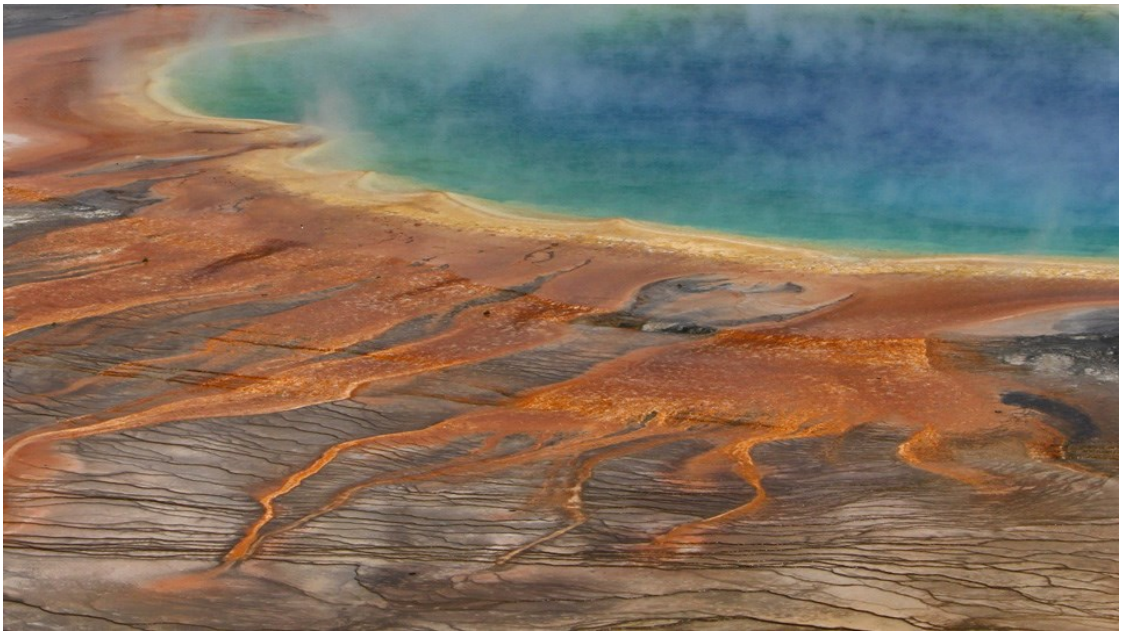
Hydrothermal Systems

Adapted from National Park Service

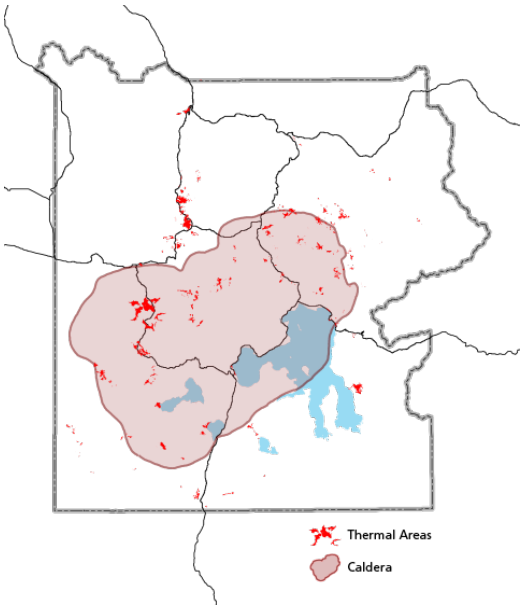
https://www.nps.gov/yell/learn/nature/hydrothermal-systems.htm



Grand Prismatic Spring is one of more than 10,000 thermal features in Yellowstone. Research on heat-resistant microbes in the park's thermal areas has led to medical, forensic, and commercial uses.

Yellowstone was set aside as the world's first national park because of its hydrothermal wonders. The park contains more than 10,000 thermal features, including the world's greatest concentration of geysers as well as hot springs, mudpots, and steam vents. Research on heat-resistant microbes in the park's thermal areas has led to medical, forensic, and commercial uses. Oil, gas, and groundwater development near the park, and drilling in "Known Geothermal Resources Areas" identified by the US Geological Survey in Island Park, Idaho, and Corwin Springs, Montana, could alter the functioning of hydrothermal systems in the park. So, in 1994, the National Park Service and State of Montana established a water rights compact and controlled-groundwater area to protect those areas from development.

The park's hydrothermal system is the visible expression of the immense Yellowstone volcano. It would not exist without the underlying partially molten magma body that releases tremendous heat. The system also requires water such as ground water from the mountains surrounding the Yellowstone Plateau. There, snow and rain slowly percolate through layers of permeable rock riddled with cracks. Some of this cold water meets hot brine directly heated by the shallow magma body. The water's temperature rises well above the boiling point, but the water remains in a liquid state due to the great pressure and weight of the overlying water. The result is superheated water with temperatures exceeding 400°F.



The superheated water is less dense than the colder, heavier water sinking around it. This creates convection currents that allow the lighter, more buoyant, superheated water to begin its journey back to the surface following the cracks and weak areas through rhyolitic lava flows. This upward path is the natural "plumbing" system of the park's hydrothermal features.

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As hot water travels through this rock, it dissolves some silica in the rhyolite. This silica can precipitate in the cracks, increasing the system's ability to withstand the great pressure needed to produce a geyser.

At the surface, silica precipitates to form siliceous sinter, creating the scalloped edges of hot springs and the seemingly barren landscape of hydrothermal basins. The siliceous sinter deposits, with bulbous or cauliflower-like surfaces, are known as geyserite.

Boiling River Research Guide

Topic: Extremophiles

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "Life in Extreme Heat" and answer the following questions with several sentences in YOUR OWN WORDS.

What are thermophiles?
How do thermophiles look? What conditions do thermophiles thrive in?
What is an extremophile?
Describe the revised tree of life that microbial research led to.
What are hyperthermophiles? Where do they fit into the revised tree of life?

ARIZONA GEOGRAPHIC ALLIANCE

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Who is Rosa Vásquez Espinoza? Where does she go to school? What does she research?

3. What types of organisms live in Peru's boiling river? Why can't the organisms that live in Peru's boiling river be compared to those that live in the Yellowstone boiling river?

4. What is Rosa Vásquez Espinoza doing to better understand the unique ecosystem of the boiling river? How is she studying the microorganisms that live in the river? How does she hope this will contribute to medicine?

5. What did Andrés Ruzo do with the help of Spencer Wells and Jonathan Eisen?

6. Can organisms who don't normally live in extreme temperatures and conditions adapt to live in the conditions of the boiling river?

7. One thing not included in this research guide that you would like to include on your page of the book.

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Life in Extreme Heat

Adapted from National Park Service

https://www.nps.gov/yell/learn/nature/life-in-extreme-heat.htm

The hydrothermal features of Yellowstone are magnificent evidence of Earth's volcanic activity. Amazingly, they are also habitats in which microscopic organisms called thermophiles—"thermo" for heat, "phile" for lover—survive and thrive.

Grand Prismatic Spring at Midway Geyser Basin is an outstanding example of this dual characteristic. Visitors marvel at its size and brilliant colors. The boardwalk crosses a vast habitat for thermophiles. Nourished by energy and chemical building blocks available in the hot springs, microbes construct vividly colored communities. Living with these microscopic life forms are larger examples of life in extreme environments such as mites, flies, spiders, and plants.

For thousands of years, people have likely wondered about these extreme habitats. The color of Yellowstone's superheated environments certainly caused geologist Walter Harvey Weed to pause, think, and even question scientists who preceded him. In 1889, he wrote:

> "There is good reason to believe that the existence of algae of other colors, particularly the pink, yellow and red forms so common in the Yellowstone waters, have been overlooked or mistaken for deposits of purely mineral matter."

Species, unseen to the human eye, thrive in waters as acidic as the liquid in your car battery and hot enough to blister your skin. Some create layers that look like molten wax on the surface of steaming alkaline pools. Still others, apparent to us through the odors they create, exist only in murky, sulfuric caldrons that stink worse than rotten eggs.

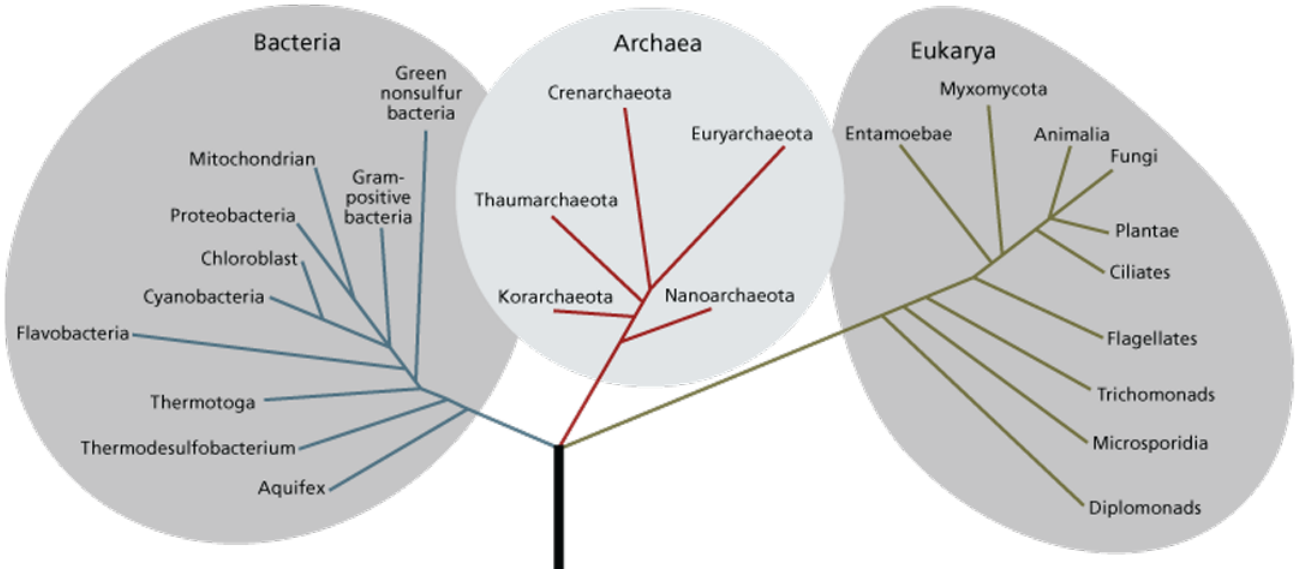
Today, many scientists study Yellowstone's thermophiles. Some of these microbes are similar to the first life forms capable of photosynthesis—the process of using sunlight to convert water and carbon dioxide to oxygen, sugars, and other by-products. These life forms, called cyanobacteria, began to create an atmosphere that would eventually support human life. Cyanobacteria are found in some of the colorful mats and streamers of Yellowstone's hot springs.

Thermophiles, or heat-loving microscopic organisms, are nourished by the extreme habitat at hydrothermal features in Yellowstone National Park. They also color hydrothermal features shown here at Firehole Spring.

Words to Know

- Extremophile: a microorganism living in extreme conditions such as heat and acid, that cannot survive without these conditions
- Thermophile: heat-loving extremophile
- Microorganism: single- or multi-celled organism of microscopic or submicroscopic size--also called a microbe.

- Microbes in Yellowstone: Millions of other microbes thrive in Yellowstone's soils, streams, rivers, lakes, vegetation, and animals.
- Bacteria (Bacterium): single-celled microorganisms without nuclei, varying in shape, metabolism, and ability to move
- Archaea (Archaeon): single-celled microorganisms without nuclei and with membranes different from all other organisms--once thought to be bacteria
- Viruses: non-living parasitic microorganisms consisting of a piece of DNA or RNA coated by protein
- Eukarya (Eukaryote): single- or multi-celled organisms whose cells contain a distinct membrane-bound nucleus



Yellowstone's hot springs contain species from the circled groups on this Tree of Life.

In the last few decades, microbial research has led to a revised tree of life, far different from the one taught before. The new tree combines animal, plant, and fungi in one branch. The other two branches consist solely of microorganisms, including an entire branch of microorganisms not known until the 1970s—the Archaea.

Dr. Carl Woese first proposed this "tree" in the 1970s. He also proposed the new branch, Archaea, which includes many microorganisms formerly considered bacteria. The ancestor of the Bacteria, Archaea, and Eukarya is inferred to be where the blue, red, and green lines connect. Organisms that branch closest to this ancestor are hyperthermophiles, which thrive in water above 176°F (80°C), indicating life may have arisen in hot environments on the young Earth.

Boiling River Research Guide

Topic: The Shaman, Culture, and Legends

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "Shamans of Peru: Healing diseases with the power of the Earth" and answer the following questions with several sentences in YOUR OWN WORDS.

Explain the significance and meaning of Mayantuyacu.
Who is Maestro Juan?
What are shamans? What do they do?
How does someone become a shaman?
Describe the significance and role of shamans to the Peruvian people.

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Describe the historical significance of the Spanish conquest of “El Dorado.”

3. What does Shanay-Timpishka translate to? What does this tell us about the indigenous people?

4. Explain the significance of “Yacumama.” What does it mean? What does the legend say?

5. Did the legend of “Yacumama” turn out to be true? Explain.

6. How did the shaman respond to Andrés’ request to study the river? What was the shaman’s condition?

7. One thing not included in this research guide that you would like to include on your page of the book.

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Shamans of Peru: Healing diseases with the power of the Earth

Adapted from Jungle Experiences

https://www.junglexperiences.com/blog/shamans-of-peru-healing-diseases-with-the-power-of-the-earth/

Maestro Juan at the Boiling River

https://www.telegraph.co.uk/travel/destinations/south-america/peru/articles/peru-mysterious-boiling-river-that-can-burn-you-to-death/

On the Boiling River there are two shamanic, Amazonian communities. The one Andrés Ruzzo primarily works with is called Mayantuyacu. Mayantu is a jungle spirit, with the head of a frog, the body of a lizard, and the arms and legs of a turtle. He's one of the benevolent jungle spirits. Yacu means water. According to oral traditions, the Boiling River is a place of tremendous spiritual power, a home to very powerful jungle spirits, where only the most powerful shamans could go because other people were afraid of the spirits. Maestro Juan comes from a long line of Ashánika curanderos (healers) and runs the Mayantuyacu Healing Center. He explained that every site on the river is home to a unique jungle spirit, like Yacumama, a very large, serpent spirit that gives birth to hot and cold waters.

Shamans are native doctors who have ancient knowledge of medicinal plants to cure people of various ills and are essential figures of the Amazonian cultures of Peru. The shamans are wise people who are considered the link between the spirits and nature. It is to these shamans that the native communities owe, to a great extent, their survival.

For Peruvians, being a shaman is not a role that is chosen by the individual. It is God who grants the gift of healing to the right people - a special capacity that manifests itself through the spirit of the plants. The role of the shaman is essential for their community. Shamans are the ones who protect and guide the people who live in their villages. Shamans are beings with a higher level of consciousness that have learned to connect with the spirits of nature. It is this connection, which is usually transmitted from generation to generation, that allows the shamans to heal and access the deepest part of the people who come to them to free themselves from their ailments. Using native plants, the shaman detoxifies his patient and accesses his subconscious.

The shaman becomes the guide of his people through his own experience. To do this, one must be willing to commit and demonstrate their resistance. The first step should be to go into isolation in the jungle, where one will follow a strict diet based on fishing and gathering. The shaman needs health, freedom, and serenity. These three elements he achieves during his period of isolation in the jungle and contact with nature

If there is a corner in the world that embraces all the magic and mysticism among its vegetation, it is the Peruvian Amazon. In the communities, deep in the jungle, the spirits of nature take on an unprecedented relevance. Shamanism becomes an unequivocal sign of the identity of the Amazonian cultures of Peru. It is, in fact, thanks to the figure of the shaman that the communities advance, grow and survive especially in communities that, historically, have not had access to conventional medicine.

Boiling River Research Guide

Topic: Andrés Ruzo

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "This River Kills Everything That Falls Into It" and answer the following questions with several sentences in YOUR OWN WORDS.

How did Ruzo first hear about the boiling river? What did he learn from his family?
What were the experts' thoughts on the idea of a boiling river? How did they react to Ruzo's questions about the river?
What work was Ruzo doing that caused him to revisit the idea that the river could be real?
How did Ruzo get to the river?
Describe the differences in temperature Ruzo initially observed.

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Describe Ruzo's childhood. Where did he grow up? What did he do as a child?

3. Where did Ruzo go to school? What did he study?

4. Ruzo is the Founder and Director of the Boiling River Project. What is the Boiling River Project?

5. How does Ruzo describe the significance of the boiling river? *Revisit the TED Talk if you need help.*

6. How is Ruzo trying to protect the river from development and deforestation?

7. One thing not included in this research guide that you would like to include on your page of the book.

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1. 2. 3.

This River Kills Everything That Falls into It

Adapted from National Geographic

https://www.nationalgeographic.com/adventure/article/160313-boiling-river-amazon-geothermal-science-conservation-ngbooktalk

It sounds like a Jules Verne tale: a boiling river that seems to flow from the center of the earth and kills anything that falls into it. Andrés Ruzo, a National Geographic Young Explorer, first heard about it from his Peruvian grandfather, who shared a legend with him when he was a kid about the Lost City of Gold in Peru. “One of the details of the story was a ‘river that boils,’” Ruzo recalls. According to the story, Spanish soldiers looking for other peoples to conquer were told to go to Amazon where there is a city of gold called El Dorado. The soldiers who managed to return came back with tales of shamans, gigantic trees, man-eating snakes and "a river that boiled."

Twelve years later, when Ruzo was studying at Southern Methodist University in Texas to become a geophysicist, he asked colleagues and other experts if they knew anything about a large river that boiled in the Peruvian Amazon. No one had; some scoffed at the inquiry. While thermal rivers do occur on earth, they’re generally tied to active volcanic or magmatic systems—neither of which were known to exist in the Amazon jungle, they said.

Ruzo gave up on the idea that the river was real. But then he happened to mention his frustration at a family dinner, when his aunt interrupted and said, “‘No, Andrés, I’ve been there,’” Ruzo recalls. “I didn’t believe her initially.” But his aunt insisted. The river supposedly had healing powers, and shamans would make medicines from its scalding waters. But only those with the shaman’s permission could access the river. Ruzo’s aunt tried to connect him with the shaman of a healing center. When the healing center didn’t return his correspondence, she offered to personally take him, so they traveled to Peru in November 2011.

After they reached the healing center in the shamanic town of Mayantuyacu, the duo received permission to visit the river. Guided by the shaman’s apprentice, they embarked into the jungle, eventually arriving at their destination.
Almost seven hundred kilometers away from the nearest volcanic center, he started hiking, and as he went deeper into the region, he started noticing some vapor coming from some of the trees. He went deeper until he stopped, stunned by what was in front of him. He ran into what seemed to be a shaman almost fully surrounded by vapor. He took his thermometer, and the average temperature of the river was 86 degrees Celsius. After talking with this man for a while, he discovers that the man was the shaman’s apprentice. He was told that the shaman was in charge of protecting the river and that the place where he was standing was the land of the “Yacumama,” a giant snake spirit that was the mother of waters. It was a snake who creates hot and cold streams. Surprisingly, the point where the hot and cold streams mix is underneath one big rock formation that has the shape of a snake’s head, covered with moss and surrounded by vegetation.

From there, we took a peke-peke (motorized canoe) upriver for about 30 minutes to the mouth of the Boiling River. It's called a peke-peke because the motor goes pekepekepekepekepekepeke.

As we approached the confluence of the two rivers, the shaman's apprentice, who was at the prow, said, Stick your hand in! So we put our hands into the cold waters of the Pachitea. As the boat glided into this olive-green plume that was the mouth of the Boiling River, immediately the temperature went up. But there was no steam, and the temperature was only like hot bath water.

It was a bit of an anti-climax. I had just broken the piggy bank to get here. We were moving from Peru back to the United States. I had left my wife in Lima to handle all of the logistics while I want gallivanting into the jungle for two days to look for this thing.

Some questions answered by Ruzo in an interview.

The Boiling River hovers on the boundary between scientific fact and myth—what drew you to the story?

I first heard the story of the Boiling River as a boy in Lima from my grandfather as part of a legend of a lost city of gold in the Amazon. Much later, when I was working on my PhD in geophysics, I started looking at this detail from a scientific viewpoint. The focus of my dissertation was to create the first detailed heat flow map of Peru in order to identify areas of potential geothermal energy.

When looking at the heat of the earth, naturally hot springs, fumaroles, and volcanoes caught my attention. One day, my colleagues from the Peruvian government called me in to look at this map they were about to publish. I took a look at it and saw there were some hot springs in the Amazon, and some of them were really quite hot. So I asked them: Hey, do you guys remember that detail in the legend about a river that boils deep in the Amazon?

You write, "This river challenges what we think we know." Explain that.
There are two levels to that. On one side, it's the personal expectations you might have for what is possible—and what is impossible. We rely on experts, and it becomes very easy to outsource your thinking, so to speak. In a way, that's what happened to me. I asked a bunch of experts for their thoughts about the Boiling River. Most said it's just a legend. One professor even told me, Stop asking stupid questions; it's making you look bad. [Laughs] But what do we really know? I think that that's a very interesting question now more than ever. If you go online, you hear so many opinions, some that are qualified, others that are not. Wondering what you really know is a very positive exercise that we can all do.

Where is this mysterious river? Take us through your journey.
The Boiling River is in the central Peruvian Amazon, in the middle of low jungle. From Lima it's about an hour flight to the city of Pucallpa, the largest city in the central Peruvian Amazon. From Pucallpa, it was a two-hour drive mostly on red dirt roads to the Pachitea River, a tributary of the Amazon over 300 meters wide.

Boiling River Research Guide

Topic: Hypotheses for how the river works

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "The Search for Peru's Boiling River" and answer the following questions with several sentences in YOUR OWN WORDS.

What 3 things do you need to create a large geothermal system?
1. 2. 3.
Describe the 3 hypotheses for how the river works.
1. 2. 3.
How did Ruzo rule out the first hypothesis?
How did Ruzo rule out the third hypothesis?
What was Ruzo able to gather some data about?

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. What makes Peru's boiling river a geothermal phenomenon?

3. How does a hydrothermal system work?

4. Describe the layers of Earth and how the temperature changes across layers. Include a diagram.

5. Calistoga's Old Faithful Geyser works because of a previous volcanic feature. Explain how the geyser works.

6. Why are oil field accidents so serious? Provide examples.

7. One thing not included in this research guide that you would like to include on your page of the book.

Works Cited Page: What sources did you use to find the above information?

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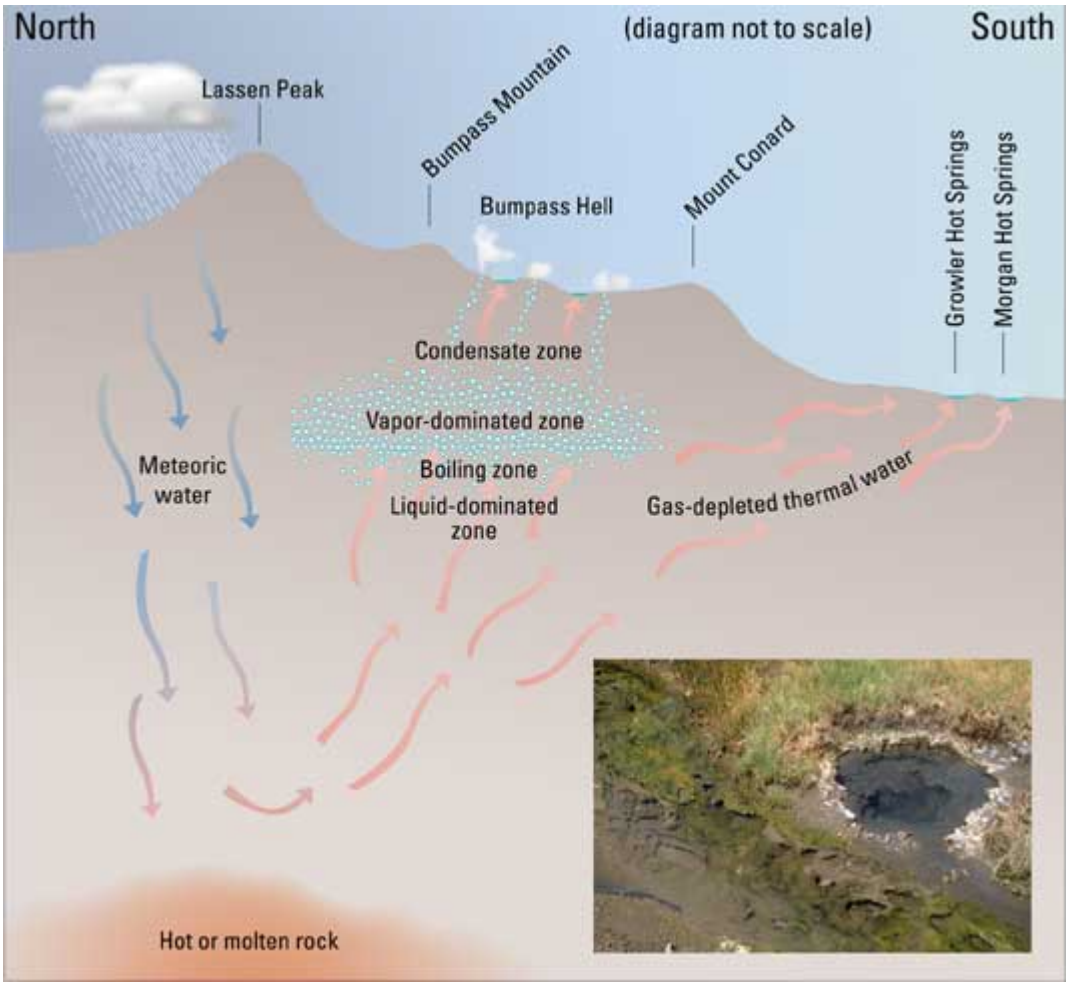
ARIZONA GEOGRAPHIC ALLIANCE

The Search for Peru's Boiling River

Adapted from Science Friday

https://www.sciencefriday.com/articles/the-search-for-perus-boiling-river/



Model of a hydrothermal system

https://commons.wikimedia.org/wiki/File:Lassen_hydrothermal_system.jpg

Ruzo's three main scientific hypotheses for the existence of the river:

When Andrés Ruzo first got to the river, his biggest concern was whether it was natural or not. To create a large geothermal system like this, you need three things: a tremendous source of heat, a large volume of water, and a plumbing system that will take this hot water from depth all the way up to the surface.

One hypothesis was that this was a volcanic feature, a magmatic system that the scientists had missed.

A second hypothesis was that it could also have been a non-volcanic feature, i.e. hot water flowing out of the earth at an anomalously high rate. Water seeps into the Earth, heats up, then rises back up. The deeper we go into the earth the hotter it gets. That's called the geothermal gradient. At these temperatures the water would have to be coming up from pretty deep down and at very fast rates.

The final theory was that this place was not natural at all but the result of an oil field accident. The river is only 2-3 kilometers from the oldest active oil field in the Peruvian Amazon. If there was an oil and gas flow that only produces hot water but no hydrocarbons or gas, they might just have abandoned it. Another possibility is that an oil and gas company

accidentally drilled into a geothermal system. The biggest and most frightening example of this is the Lusi mud volcano on Java. Over 40,000 people were displaced, and it is still erupting.

Over the course of several research trips, Ruzo narrowed down his hypotheses. He ruled out the first idea—geochemical testing of the water indicated that it wasn't volcanic or magmatic.

The third hypothesis—an oil drilling accident—worried Ruzo. He learned that there was indeed an oil well more than a mile away, but the company that operated it was forthcoming with their activities, which didn't affect the river. Stories told by the local shamans also suggested the river had been around for generations far before the oil company. And finally, Ruzo found mention of a thermal river in historical archives that documented the area before any oil development.

"The only remaining option is it's just a 'normal' hydrothermal feature where waters are seeping deep into the earth, heating up, and then coming back up quickly," Ruzo says.

After discovering one of the largest thermal rivers in the world, Ruzo published his findings, and he is now credited for making more widely known the existence of this phenomenon. With the help from his colleagues from National Geographic, Dr. Spencer Wells, and from UC Davis, Dr. Jon Eisen, he discovered new lifeforms, new species living inside the river. Apart from that, he also gathered some data indicating the presence of a large hydrothermal system (the deeper into the earth, the hotter), but he still needs more research in order to discover the exact reason for its temperatures. Since the discovery is recent, there's not much information about the new species.

Boiling River Research Guide

Topic: How Does Peru's Boiling River Work?

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

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Pre-Research Questions: Read the article "The Search for Peru's Boiling River" and answer the following questions with several sentences in YOUR OWN WORDS.

Describe the 3 hypotheses for how the river works.
1. 2. 3.
How did Ruzo rule out the first and third hypotheses?
What did Ruzo discover with the help of Dr. Spencer Wells and Dr. Jon Eisen?
What did Richards hypothesize?
What is Ruzo's next step in research?

ARIZONA GEOGRAPHIC ALLIANCE

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Define and explain what Earth's geothermal gradient is.

3. What does Ruzo know so far about how the boiling river works?

4. What is the average temperature of the river? What is the highest temperature that Ruzo measured? What does this mean for animals that fall in? What about people who touch the water?

5. Where does the water come from? How can the water in the river potentially come from so far away?

6. Provide a detailed explanation for how the river is heated.

7. One thing not included in this research guide that you would like to include on your page of the book.

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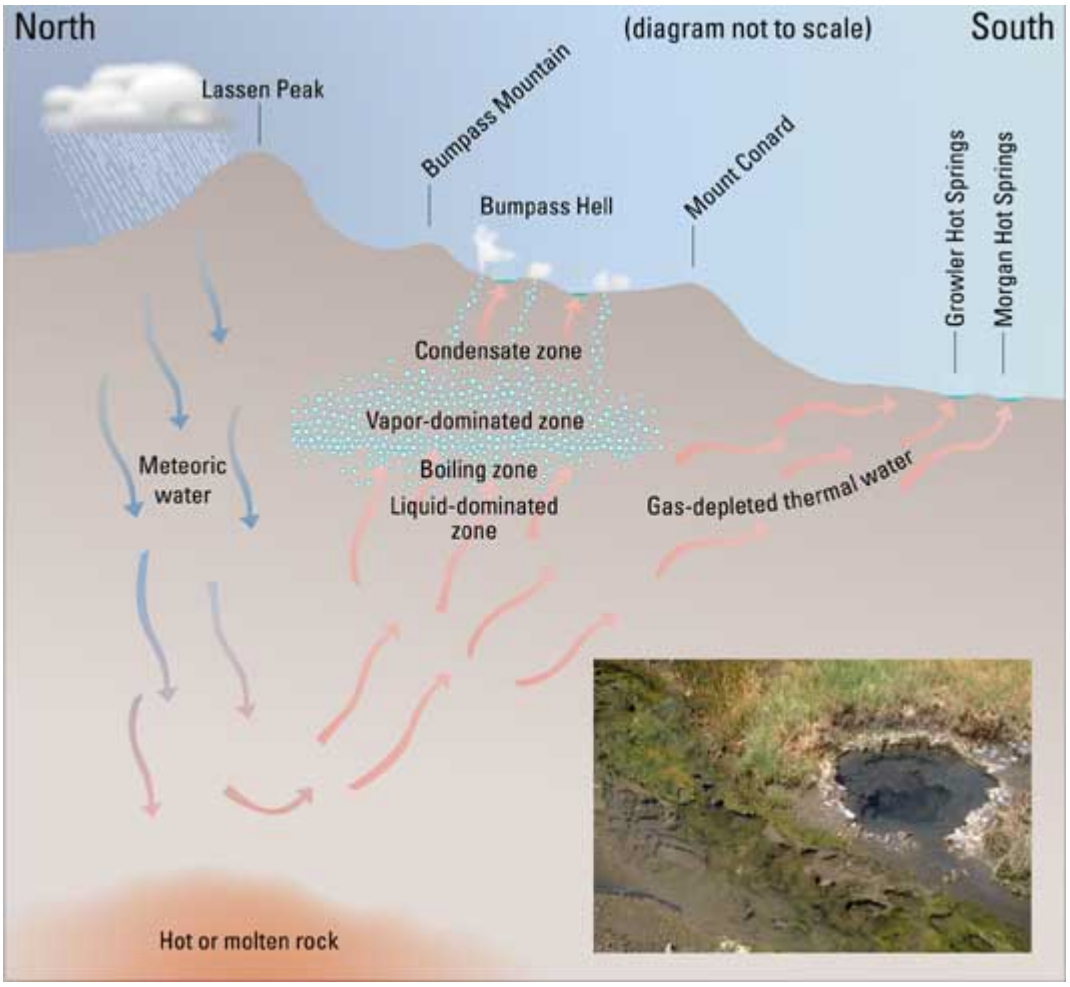
The Search for Peru's Boiling River

Adapted from Science Friday

https://www.sciencefriday.com/articles/the-search-for-perus-boiling-river/



Model of a hydrothermal system

https://commons.wikimedia.org/wiki/File:Lassen_hydrothermal_system.jpg

Ruzo's three main scientific hypotheses for the existence of the river:

When Andrés Ruzo first got to the river, his biggest concern was whether it was natural or not. To create a large geothermal system like this, you need three things: a tremendous source of heat, a large volume of water, and a plumbing system that will take this hot water from depth all the way up to the surface.

One hypothesis was that this was a volcanic feature, a magmatic system that the scientists had missed.

A second hypothesis was that it could also have been a non-volcanic feature, i.e. hot water flowing out of the earth at an anomalously high rate. Water seeps into the Earth, heats up, then rises back up. The deeper we go into the earth the hotter it gets. That's called the geothermal gradient. At these temperatures the water would have to be coming up from pretty deep down and at very fast rates.

The final theory was that this place was not natural at all but the result of an oil field accident. The river is only 2-3 kilometers from the oldest active oil field in the Peruvian Amazon. If there was an oil and gas flow that only produces hot water but no hydrocarbons or gas, they might just have abandoned it. Another possibility is that an oil and gas company

accidentally drilled into a geothermal system. The biggest and most frightening example of this is the Lusi mud volcano on Java. Over 40,000 people were displaced, and it is still erupting.

Over the course of several research trips, Ruzo narrowed down his hypotheses. He ruled out the first idea—geochemical testing of the water indicated that it wasn't volcanic or magmatic.

The third hypothesis—an oil drilling accident—worried Ruzo. He learned that there was indeed an oil well more than a mile away, but the company that operated it was forthcoming with their activities, which didn't affect the river. Stories told by the local shamans also suggested the river had been around for generations far before the oil company. And finally, Ruzo found mention of a thermal river in historical archives that documented the area before any oil development.

"The only remaining option is it's just a 'normal' hydrothermal feature where waters are seeping deep into the earth, heating up, and then coming back up quickly," Ruzo says.

After discovering one of the largest thermal rivers in the world, Ruzo published his findings, and he is now credited for making more widely known the existence of this phenomenon. With the help from his colleagues from National Geographic, Dr. Spencer Wells, and from UC Davis, Dr. Jon Eisen, he discovered new lifeforms, new species living inside the river. Apart from that, he also gathered some data indicating the presence of a large hydrothermal system (the deeper into the earth, the hotter), but he still needs more research in order to discover the exact reason for its temperatures. Since the discovery is recent, there's not much information about the new species.

Boiling River Research Guide

Topic: Tourism

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

Student's First and Last Name	Color Font
	Purple
	Blue
	Dark Green
	Orange

Pre-Research Questions: Read the article "Visiting the Legendary Boiling River in Peru" and answer the following questions with several sentences in YOUR OWN WORDS.

How do the native Asháninka view the river? What do they use it for?
How is deforestation affecting the river and its surroundings?
What does Mayantuyacu mean? What significance does it hold for the local people?
Who is Maestro Juan Flores? What practices do visitors engage in with him?
How should the river be visited? Explain.

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. Can tourists swim in the river? Explain. (Can humans swim in the entire river? Will the river burn you if you swim in it? When is it best to swim in the river?)

3. How can you get to the river? Make sure to include all modes of travel and estimated travel times.

4. Can you get hurt visiting the river? How common are accidents? How far is the nearest hospital?

5. Why did being bilingual allow Andrés Ruzo to study the river?

6. Research how to schedule a Boiling River tour and explain how someone can visit the river.

7. One thing not included in this research guide that you would like to include on your page of the book.

Works Cited Page: What sources did you use to find the above information?

Cite your sources **<u>using MLA format</u>**. Use www.easybib.com to help you! You need **at least 3** credible sources!
1. 2. 3.

Visiting the Legendary Boiling River in Peru

Adapted from Cusco Native

https://www.cusconative.com/boiling-river-in-peru/

Hidden deep in a remote area of Peru's central jungle, you'll find an incredible natural wonder which is still not fully understood by scientists. The Boiling River in Peru was once thought to be merely legend, and only a handful of local people had visited it or were even aware of its existence. Nowadays, its existence has been verified and scientists are currently studying the Boiling River in Peru to learn more about the source of its intense heat.

Geoscientist Andrés Ruzo had grown up hearing stories of the boiling river in Peru from his grandfather, who had grown up nearby. Ruzo's scientific training made him skeptical about the possibility of such a thing, but nevertheless he set out looking for answers. After consulting other members of his family, he was able to pinpoint the location of the boiling river in Peru and took a trip into the jungle to try to see it for himself. What he discovered was something straight out of legend: a real river of boiling water, a place so hot that any unfortunate animal which falls in is instantly cooked alive.

As it turns out, the Boiling River in Peru has long been considered a sacred place by the native Asháninka people who live in the area. When Ruzo arrived, there was already a local shaman who lived at the site and used it as a base for conducting healing ceremonies. The river had not, however, been studied at all by scientists up to this point. Ruzo worked on establishing good relationships with the local people of the area, who allowed him to begin scientific studies of the river which are still ongoing.

The traditional name for this river is Shanay-Timpishka, which translates literally as "boiled with the heat of the sun" in the Asháninka Language. The temperature of the water has been measured at just below 100°C–not enough to actually boil but certainly hot enough to kill any creature that ventures in. Further downstream, as Shanay-Timpishka combines with other, colder streams, the water becomes a much more reasonable temperature and it's actually possible to climb in and enjoy a bath. Just make sure you're extremely careful, as you can severely injure yourself if you enter at a point where the water is still too hot.

Unfortunately, much of this part of the central jungle in Peru has suffered from intense deforestation due to logging and other resource extraction. While the part of the forest directly surrounding the river is relatively pristine (and, in fact, deforestation nearby has probably driven even more wildlife into what forest remains), the sanctity of this unique ecosystem is still very much at risk. The hope is that, with scientists and local citizens working together to protect the site, the rainforest surrounding this incredible natural wonder will remain intact for future generations to enjoy.

According to local people, the Boiling River has always been considered a place of great power and spiritual significance. It is said that in the past, the people were afraid to enter the area for fear of evil spirits and man-eating jaguars. Only the most powerful shamans would dare to enter. Nowadays, the Boiling River is home to a small handful of spiritual healing centers, the oldest and most famous of which is called Mayantuyacu ("the water and the air").

Maestro Juan Flores, the shaman of Mayantuyacu, is a member of the Asháninka tribe and descends from a long line of traditional curanderos (healers). Many visitors every year make the journey deep into the forest to Mayantuyacu to learn about ancient healing techniques. These practices include drinking the potent hallucinogenic tea known as ayahuasca, as well as taking tobacco and other plant medicines.

The Boiling River is located in the extreme eastern part of Peru's Huánuco region, near its border with the Ucayali Region. Shanay-Timpishka, as the river is known locally, is a small tributary of the Pachitea River. The Pachitea is itself a tributary of the massive Ucayali River, one of the Amazon River's primary sources. Boats traveling to the Boiling River's trailhead usually leave from the small frontier town of Honoria, which is about 3 hours by car from Pucallpa, the closest major city.

Those wishing to visit the Boiling River should do so with a knowledgeable guide, since the area is quite remote and inaccessible. Tours and hikes to the area will usually leave from the city of Pucallpa. It is possible to take part in a traditional healing ceremony at Mayantuyacu or another retreat center.

Boiling River Research Guide

Topic: Conservation

Directions: Each group member picks a different color font to use (purple, blue, orange, or dark green). Answer the following questions/prompts in your font color so your team knows who contributed to answering the questions/prompts. Answer these questions **IN YOUR OWN WORDS--NO QUOTES!!!** You will use your answers from these questions to create your page of the book. Make sure to answer all questions in complete sentences.

Student's First and Last Name	Color Font
	Purple
	Blue
	Dark Green
	Orange

Pre-Research Questions: Read the article "A Legendary Boiling River Flows Through the Amazon. Can It Be Saved?" and answer the following questions with several sentences in YOUR OWN WORDS.

Explain the following quote: "The greatest threat to the jungle are the 'natives' who have forgotten they are natives."
How have some oil and gas companies been helpful in protecting the river?
What is causing 99% of the deforestation?
Why is the goal to have the area declared a Peruvian national monument?
What is so special about the boiling river?

ARIZONA GEOGRAPHIC ALLIANCE

Research Questions: Use the internet to answer the following questions. Cite your sources in MLA format.

1. What topic is your group researching?

2. What is deforestation? Describe the positive and negative impacts it can bring.

3. What impacts does deforestation have on the river and locals?

4. How does Rosa Vásquez Espinoza's work on the boiling river support the protection of the river and its diverse ecosystem?

5. What is the aim of the Boiling River Project?

6. Provide a local example of deforestation. Explain the impacts it has on the environment.

7. One thing not included in this research guide that you would like to include on your page of the book.

Works Cited Page: What sources did you use to find the above information?

Cite your sources **using MLA format**. Use www.easybib.com to help you! You need **at least 3** credible sources!
1. 2. 3.

ARIZONA GEOGRAPHIC ALLIANCE

A Legendary Boiling River Flows Through the Amazon. Can It Be Saved?

Adapted from National Geographic

https://www.nationalgeographic.com/adventure/article/this-mythical-river-in-peru-is-boiling-and-one-young-scientist-is-on-a-quest-to-protect-it#:~:text=Ultimately%2C%20it's%20about%20saving%20the,it%20a%20Peruvian%20national%20monument.&text=better%20understand...-,Please%20be%20respectful%20of,Unauthorized%20use%20is%20prohibited.

Comments from Andres Ruzo

A Shaman once said that "the greatest threat to the jungle are the 'natives' who have forgotten they are natives." The Amazon basin is 90 percent the size of the United States, and it's very easy to generalize that everything's the same down there. But that's not true. There is a wealth of different cultures and languages, ethnicities, flora and fauna, and problems. In some parts of the Amazon, illegal mining is a major issue. In others, it is illegal logging or narco-trafficking. In this part of the central Peruvian Amazon, the threat to the jungle comes from development. Pucallpa is a very large city, a center of modernity and logistics, and it keeps expanding. There's a narrative that's grossly oversimplified these days—all big companies, bad; all indigenous groups, good. Unfortunately, this oversimplification does not do a good job of addressing the real problems in the Amazon.

Some oil and gas companies have really predatory practices. But there are some responsible companies that are doing really good work. The same holds true with the indigenous people. You have some people who have forgotten the ancient traditions and ways of treating the jungle and are just interested in private gain. Even in the Amazon, everyone wants iPhones these days; everyone is on Facebook.

Surprisingly, an oil company is doing a great job protecting the Boiling River. For the Boiling River area, all you have to do is go to Google Earth. If you look at this area on Google Earth, you will see that the area protected by the oil and gas company Maple Energy is the only pristine jungle left. One of the reasons for that is that oil and gas companies can get whacked with huge fines for not complying on environmental issues and can even lose their concession.

Ninety-nine percent of deforestation around the Boiling River is caused by locals coming in and chopping down the large expensive trees, then clear burning the rest. They dump gasoline on the jungle, light it up a couple times, then turn loose cattle on it. Obviously, if you have gas lines in the area, that creates a big issue. The companies are protecting the jungle out of self-interest. But there are many people [at the oil companies] who do sincerely care about the jungle. Even the shamans have said they've been good neighbors.

We're working with the two shamanic communities on the Boiling River in order to help the Mayantuyacu community and preserve the river. The goal is to have the area declared a Peruvian national monument and rezone the jungle in that area. Currently, the jungle is legally considered exploitable jungle, so it is basically open to clear-cutting. We want it rezoned so that it's only open for eco-friendly activities.

I think we are making good headway so far, led by scientific studies that have been underway since 2011. We're also working with some major conservation groups, both in Peru and internationally. This is such a special area, not only because of the geologic aspect, but also culturally. It's a key location for traditional knowledge. The area around the Boiling River not protected by the oil field or by the shamans has been totally clear-cut. As a result, all the fauna and flora that would normally be present across the entire area has been concentrated in this one small oasis of remaining jungle. So it's now of great biological significance, as well. It's this bastion of Amazonia in a sea of deforestation.