

Taking the pulse of Yellowstone’s “breathing” volcano: Problem-Based Learning in America’s first national park

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Yellowstone National Park has an aura of magic. When it’s mentioned, people’s faces light up. Who doesn’t treasure a memory of Yellowstone or dream of going there? In this activity you experience its sublime geology, flora, and fauna virtually as you solve a problem: you will use layers of earth science and cultural data to place a research station within the park, somewhere where it will be safe from volcanism, seismicity, and crustal deformation.

Objectives

With classmates, you will:

- identify a good spot to build a scientific research station in Yellowstone National Park;
- interpret historical and real-time scientific data about volcanic activity in the park;
- analyze the data to detect regions of high and low risk for volcanic hazards;
- define criteria for determining when the research station must be evacuated; and
- communicate your findings.

Problem:

Congratulations! You are a private consultant, and you have just been awarded a \$250,000 contract. A research group has preliminary approval to create a research station within Yellowstone National Park. The station is for scientists to live and work as they do research on geological features, flora and fauna, and weather and climate. They will stay at the station for as long as several months. Therefore, the station—or camp—will have

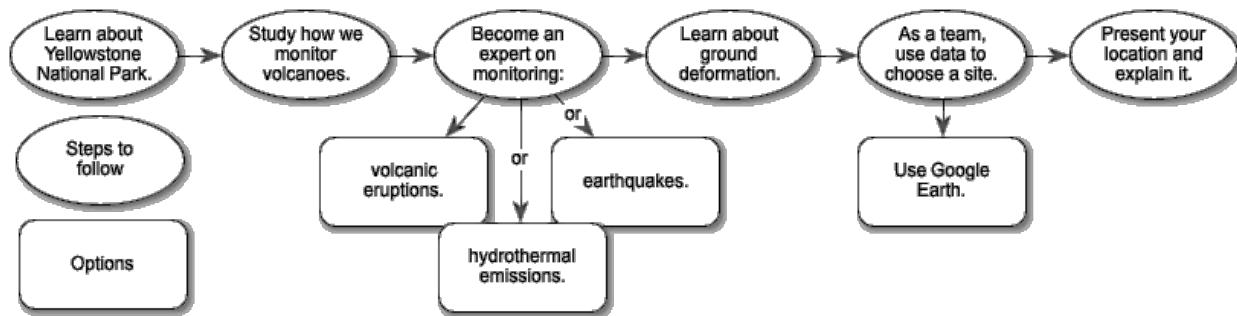
- bedrooms or bunkrooms for about 20 people;
- two laboratories, one for geologists and one for biologists to prepare and examine specimens;
- a kitchen;
- a dining room;
- a living room big enough for all 20 people to relax at the end of the day’s work;
- covered porches;
- and a garage to store snowmobiles.



Figure 1. University of Colorado--Boulder Mountain Research Station. Photographer and date unknown.

Because the park is already in recreation heaven, there will be no need to build recreational facilities like a movie theater. The station needs to be located near an existing road but not visible from the main roads. Assume that the station will cover five to ten acres. How big is ten acres? An acre is about the size of a football field without the end zones. On the map at the end of these instructions, 10 acres would be a square about 0.2 mm on a side. If you made a dot with the sharpest pencil you could find, that dot would be larger than the field station’s area.

Quick Overview of How You Will Tackle the Problem



First, you will decide where the camp should be. Plan for it to exist for at least a century, without disturbing animals or altering the astounding geological features that draw visitors.

To do this, you will learn about Yellowstone National Park and its geological setting—in volcanic calderas. All of you will learn about how we monitor volcanoes, using the 1980 eruption of Mount St. Helens as an example. Then you'll become an expert about volcanic eruptions, hydrothermal activity (and gas emissions), or earthquakes. Finally, all of you will learn about how the ground deforms.

With that knowledge, an expert from each group -- volcanoes, hydrothermal activity, and earthquakes—will join to form a team of three people who combine their expertise to locate the site for the camp. You will use Google Earth or paper maps to analyze your data to find the perfect site.

You will propose a location and explain why it is the best site within the park.

Also, you will develop guidelines to establish when the risk of an eruption is too high for scientists to stay at the camp. They must evacuate—according to your guidelines, or your “Safety Protocol.”

Introduction

In your team of three, or as a whole class, review the presentation, “The Science of Prediction: Monitoring Volcanic Activity.” This presentation shows you how scientists monitor volcanoes. You will see the kinds of measurements scientists made before Mount St. Helens erupted and are making now at volcano observatories in the United States. Yellowstone National Park hosts the Yellowstone Volcano Observatory.

Learning about the Yellowstone Supervolcano

Individually, you will become knowledgeable about Yellowstone's volcanic history or its earthquakes (“seismicity”) or hydrothermal activity and volcanic gases. Each of the topics has a presentation.

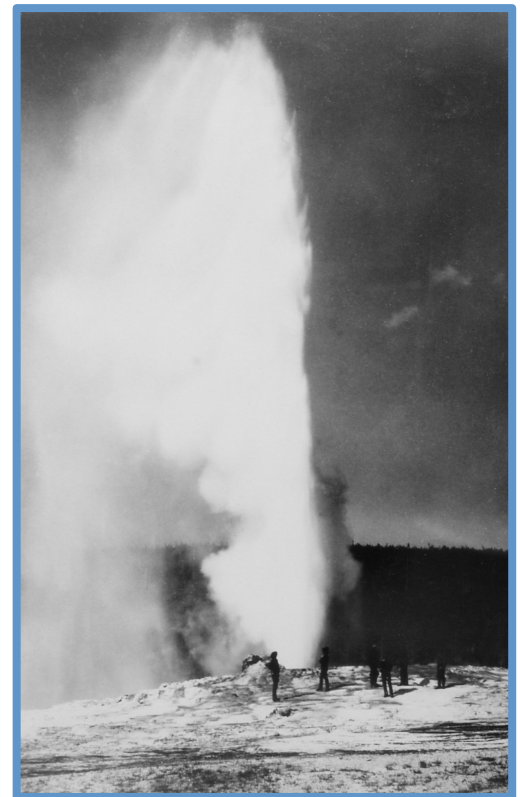


Figure 2. "First" Picture of Old Faithful Eruption. William Henry Jackson, 1872.

Get together with classmates who are learning the same topic.

If you're using paper maps and transparencies, you'll want to record important information by hand. (The information might be where the big earthquakes occurred, for instance.) If you'll be using Google Earth to analyze your data, then pay attention to the slides about Google Earth.

Materials

1. Google Earth and instructions or
2. A map of Yellowstone NP (see last page of this handout: **Yellowstone National Park Base Map**); colored pencils or transparency pens; and transparency sheets
3. Graph paper or Excel/spreadsheets program
4. "Monitoring Yellowstone's Volcanic Activity" presentation on a computer or a printout.
5. Yellowstone GPS data set (Excel file or print version in the slides)
6. (optional) Real-time data (access to Internet or print copies)

Procedure

1. Based on your teacher's instructions, open your presentation,

*Taking the Pulse of Yellowstone's "Breathing" Caldera—Eruptive History; or
Taking the Pulse of Yellowstone's "Breathing" Caldera—Seismic Activity; or
Taking the Pulse of Yellowstone's "Breathing" Caldera—Hydrothermal Activity.*

These presentations describe the current and historical monitoring data at Yellowstone NP. Some slides will ask you to follow links to websites.

2. If you're using paper maps, as you follow along with the presentation, use the Yellowstone National Park Base Map on the last page of this document to record your data. You will need to make a key for your map like those you see on several of the slides. Consider making a draft copy of the map and then dress it up for a final clean copy. Also, discuss the relevant questions in the Analysis section with everyone who is learning the same thing.

3. Now return to your team and learn about GPS and ground deformation. You'll do this by working through another presentation,

"Taking the Pulse of Yellowstone's 'Breathing' Caldera—Ground Deformation."

You will graph the deformation data from four GPS locations. Draw the GPS locations and ID labels on your map.

You might also be graphing data from the "Deformation data--optional" data set, a larger set provided by your teacher. And, you might be exploring ground deformation data with Google Earth.

Data

Your data will be your labeled maps or Google Earth files and your graphs.

Analysis

Now you get to assemble what you've learned and decide where you propose building a research station. Refer to your maps or use Google Earth to look at the data as you think about and discuss with your teammates each of the following questions.

Volcanic eruption data

How often does the Yellowstone hot spot create a new caldera?

What types of volcanic eruptions are associated with Yellowstone?

How are these volcanic eruptions dangerous?

Where are the areas most prone to hazardous eruptions?

In your professional opinion, is there an immediate (next 100 years or so) danger related to volcanic eruptions at Yellowstone?

Hydrothermal activity data

In what way is hydrothermal activity dangerous?

Where would hydrothermal activity keep you from building a research station?

In your professional opinion, is there an immediate (next 100 years or so) danger related to hydrothermal activity at Yellowstone?

Volcanic gases data

What gases are monitored at Yellowstone?

In what way are these gases dangerous?

Where are the areas that are most dangerous?

In your professional opinion, is there an immediate (next 100 years or so) danger related to release of volcanic gases at Yellowstone?

Earthquake activity data

How are earthquakes dangerous?

How many modern day large (greater than magnitude 5) earthquakes have occurred at Yellowstone?

What is the most common magnitude of earthquakes recorded at Yellowstone?

Does the pattern of earthquakes at Yellowstone suggest movement of magma? (Remember the pattern at Mount St Helens.)

Where would earthquakes most likely affect a research station?

In your professional opinion, is there an immediate (next 100 years or so) danger related to earthquakes at Yellowstone?

Ground deformation data

In what way could ground deformation be dangerous?

What patterns do you observe in the data?

Why might leveling data be different from GPS data? (Think about how and when each is measured.)



Figure 3. Castle Geyser, Upper Geyser Basin. Thomas Moran, undated.

Does uplift or subsidence affect some areas more than others? Would this affect where you might put your research station?

In your professional opinion, is there an immediate (next 100 years or so) danger related to ground deformation at Yellowstone?

Conclusions

Read the problem on the first page again. Now, use either your paper maps or Google Earth, and what you've discussed in your group, to agree as a group upon the best place to build a five to ten acre research station.

Prepare Your Recommendations

How you do this depends on what your teacher assigns. For instance, you might make an oral presentation or write a paper or glossy brochure, or some combination of those. No matter what your assigned format is, you will want to:

1. Restate the problem—remind the research group of what they are paying you to do.
2. Summarize your data—they don't have expertise or time. That's why they hired you. Explain to them what data you collected and what it means.
3. Make your recommendations—be specific as to where you think it is appropriate for research station to be.
4. Support your recommendations—explain why the spot you recommend is the best spot. Use specific details from your data. You should also describe any further data collection that you recommend.
5. Make your case in a conclusion by emphasizing the important points.
6. Persuade your classmates that yours is the best site for the research station.



Figure 4. Tourists Wading in Great Fountain. Artist unknown, 1908.

Create guidelines for evacuation: Also, if you've been asked to do this, draft guidelines that will be used to decide if and when scientists (and tourists nearby) must be evacuated in order to keep them safe. How many guidelines and what kind of data you use is up to you. Consider saying something like, "If an earthquake swarm occurs and lasts for x months, then...." Or, if geysers in a geyser basin begin erupting unusually, then...." Or, "If heat values seen on LandSat images exceed x, then...." (The last refers to data visible on Google Earth.)

Image Sources

Figure 1. University of Colorado Mountain Research Station' Wildrose Dining Hall. Photo. Photographer unknown. Date unknown. <http://www.colorado.edu/mrs/setting-facilities> Retrieved 26 March 2012.

Figure 2. William Henry Jackson. "First" Picture of Old Faithful Eruption. Photograph. 1872. Yellowstone Digital Slide File k# 64,176. <http://www.nps.gov/features/yell/slidefile/history/jacksonphotos/Page-2.htm> Retrieved 24 March 2012.

Figure 3. Moran, Thomas. Castle Geyser, Upper Geyser Basin. Watercolor. No Date. Yellowstone Digital Slide File. <http://www.nps.gov/features/yell/slidefile/history/moranandotherart/Page-1.htm> Retrieved 24 March 2012.

Figure 4. Artist unknown. Tourists Wading in Great Fountain. Photograph. 1908. Yellowstone Digital Slide File. http://www.nps.gov/features/yell/slidefile/history/1872_1918/visitoractivities/Page.htm Retrieved 25 March 2012.

Yellowstone National Park Base Map

