LESSON 6:
PREDICTING ERUPTIONS

GRADE LEVEL 6-8

VOLCANOES EDUCATOR GUIDE

An SK Films Release

DIGITAL CROSSING FILMS

Volcanoes Educator Guide

LESSON 6:
PREDICTING ERUPTIONS

GRADE LEVEL 6-8
(1) 15 MINUTE PREP LESSON
(2) 45 MINUTE OR (1) 90 MINUTE LESSON(S)

LESSON OVERVIEW:

In this lesson, students form a plan for warning towns near volcanoes of imminent eruptions. First, students begin by studying several case studies of different volcanoes that have erupted in the past. Students will identify patterns in the data and decide on the best predictors of volcanic eruptions. Finally, students will participate in a simulation of being a geologist.

SCIENCE STANDARDS:

- MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

SCIENCE AND ENGINEERING PRACTICES:

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

FROM THE FILM:

The film ***Volcanoes*** speaks about the difficulties of predicting volcanic eruptions. There are many different tools we use to track volcanic activity, and our technology is ever-evolving. This lesson challenges students to evaluate our technologies and create a plan for those that live near volcanoes.

MATERIALS:

- Blank paper
- Rulers
- Pens or pencils

LESSON 6:
PREDICTING ERUPTIONS

TEACHER PREP:

DAY 1:

Students will be sending "tweets" during this lesson. It is up to the teacher to decide how they would like to structure this activity. Students can write down their "tweets" on white boards and hold them above their head. Alternatively, there are many online and school friendly platforms that allow students to post ideas or answer questions. *Socrative.com* is an excellent example. Before you begin, decide on which platform you will use, create an account, and test to ensure it is working properly.

TO DO:

BEFORE VIEWING THE FILM:

1. Tell students that soon, they are going to watch the film ***Volcanoes***. This film follows photographers and scientists as they get up close to active volcano sites around the world. Give each student a sticky note. Have students put their name on the top of the sticky note. Tell students that you are going to ask them some questions and have them form a hypothesis (educated guess) for what the answer might be. They should record their guesses on their sticky note.

Questions:

"How many active volcanoes do you think there are on the planet right now?"

"How many people do you think live near an active volcano?"

"How many people have die from volcanoes a year (on average)?"

2. Have students place their sticky note on an anchor chart for you to revisit after watching the film.

DAY 1:

1. Have students collect their stick notes and bring them back to their desk. As a warm up, review the answers to the four questions:

Questions:

"How many active volcanoes do you think there are on the planet right now?" 1,500!

"How many people around the world do you think live near active volcanoes?" 500 million

"How many people are killed by volcanoes each year (on average)?" 540

2. Remind students that the film says predicting eruptions can be very difficult. There are multiple tools and instruments scientists have developed to monitor volcanic activity and predict imminent large eruptions. Over the next two days, students will investigate ways that we predict the eruptions of volcanic activity, their reliability, and develop a plan to help towns warn their citizens of upcoming eruptions.

3. Begin by defining an active volcano and dormant volcano. An active volcano is one that is having present moment lava, magma, or pyroclastic (rock) eruptions. A dormant volcano is a volcano that is not currently erupting but still could. A volcano is labeled as extinct if it has not erupted in more than 10,000 years.

LESSON 6:
PREDICTING ERUPTIONS

DAY 1 CONTINUED:

4. In order to learn about warning signs that a dormant volcano is about to be active, students will conduct a case study of different volcanic eruptions. Group students into reading pairs. Give each reading pair one of the volcano case studies. Instruct students to read the passage, and underline two things: dates and geologic events the happened before the volcano exploded. Afterwards, they should create a timeline on a blank sheet of paper that includes the dates and events that happened before and during the volcanic eruption.

5. Give each pair of students a piece of tape and instruct them to tape it on the wall of the classroom. Give students 5 minutes to do a gallery walk. Students should visit each timeline and note patterns that they observe. *What geologic events appear to happen at all of the volcanoes?*

6. If students have not already made the connection, illustrate that the common events can be used as good warning signs that a volcano might erupt. Review the current tools that we use to measure and track these geologic warning events:

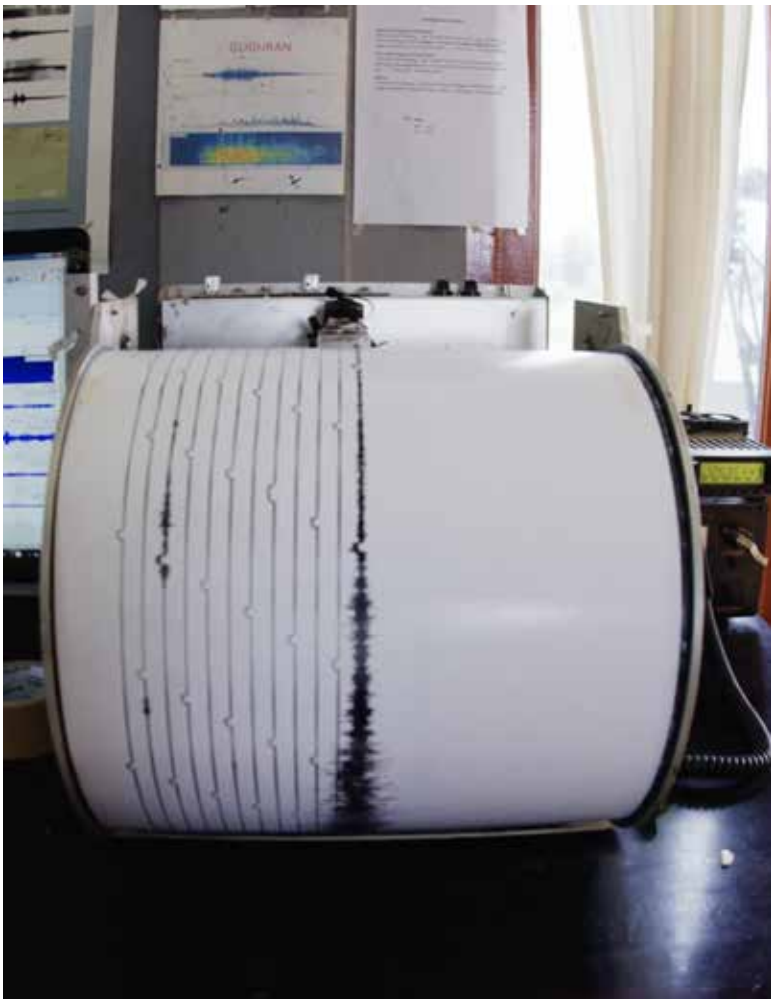
- Seismometer: This instrument is used to measure the presence and strength of earthquakes around a volcano. Though earthquakes are common even around dormant volcanoes, an increase and/or peak in seismic activity can indicate an upcoming eruption. Scientists look for an increase in earthquakes to at least 10 quakes a day for warnings that a volcanic eruption is imminent.
- Tiltmeter: This instrument allows scientists to measure to slope of the volcano. Before a volcano erupts, it is common for a lava dome to swell underneath the volcano surface. This causes the slopes of the volcano to increase in angle. Geologists name this warning sign a "ground deformation." A tiltmeter measures the angle or slope of the volcanic sides to detect swelling lava domes.
- Photography: Scientists often use video and photographs to track changes of volcanoes over time. These images are incredible important in recording the presence and frequency of steam ejections, called phreatic eruptions.

7. To conclude, ask students *"Do all of these warning signals appear to work equally well in predicting eruptions?"* Allow students to offer their ideas. Review the case of Nevado del Ruiz, who was not evacuated because the earthquakes appeared to end. Shortly after, however, the volcano erupted and killed thousands of people living near by.

DAY 2:

1. As a warm up, give students the three tools/warning sign pairs and ask them to rank them in order of "most reliable" to "least reliable" warning signs: Earthquakes and seismographs; tiltmeters and ground deformation; photography and phreatic eruptions.

A seismometer (or seisomograph) like this one in Indonesia, measures the motion of the ground caused by events like earthquakes and volcanic eruptions.



LESSON 6:
PREDICTING ERUPTIONS

DAY 2 CONTINUED:

2. After allowing several students to share their ranking, remind students that alone, no one of these warning signals is perfect. Geologists study warning signals as a group and must make decisions about when to warn towns to evacuate. Ask students:

"Why is it important to evacuate neighboring towns before the eruption begins?"

"What do you think are the consequences of evacuating a town too early or causing a false alarm?"

3. If students have not already identified the reasons why accurate evacuation predictions are important, review the two major concerns: trust and economy. It is important to get evacuation predictions correct because too many false evacuations will cause the towns to lose trust in you as a scientist. Like the boy who cried wolf, people may stop believing in your predictions and then stay on the volcano when it actually erupts. Likewise, scientists must be mindful that evacuations cause a large stress on the economy. Not only does it shut down all business in the town (people cannot make money), it also forces people to spend money to stay in hotels and accommodations in other locations.

4. To explore the role of geologists in predicting eruptions and calling for evacuations, students will assume the role of a geologist monitoring a volcano. Each day, geologists must send out a "tweet" for the town telling them if an eruption is likely and if they should prepare to evacuate or evacuate immediately.

5. To begin, give each student a copy of the "Predicting Eruptions" activity page(s). Assign one of the five volcanoes to each student. Inform students that you will give them five days of data (from the Teacher Slides: Volcano Data page(s)) for them to graph on the "Predicting Eruptions" activity page(s). They should create a point plot and connect each point with a line. After each set of five days, they must indicate how likely an eruption will occur. Finally, they must send out a "tweet" to the town that follows the following format:

To the people living near [Volcano name], a volcanic eruption is [how likely they think an eruption is about to occur], the geologic station recommends that you [student recommendation of continue normal activity, prepare to evacuate, evacuate immediately, etc].

- There are many different online platforms for students to display the false tweets without actually using twitter. One recommended site is *socrative.com*. It is recommended that you create a teacher account before the class begins.

6. After each round of tweets, reveal to students the state of the volcano (from the Teacher Slides: Volcano Data page(s)).

7. At the end, ask students to raise their hands if they were able to evacuate the town before the eruption but not as a false alarm. Remind students that in the film ***Volcanoes***, the scientists indicated that it is still very difficult to predict eruptions. Because of this, we still have hundreds of deaths from volcanic eruptions each year. Ask students to conclude with a brainstorm: "*How might they be able to more accurately warn citizens of erupting volcanoes and help evacuate towns?*"

The lava lake inside Marum crater, Vanuatu.

Mount St. Helens

Case Study:

For 123 years, Mount St. Helens remained dormant. The large sleeping volcano was a favorite spot for hikers and outdoor enthusiasts. Thousands of people of visited the national park to fish, camp, and play.

On March 16th, 1980, three small earthquakes were measured at the park ranger station. The earthquakes were so small most visitors did not notice them. Each day after that, the number of earthquakes steadily increased. By the week of March 26th, an average of 10 earthquakes were occurring daily.

On March 27th a helicopter tourist company flew a group around the crater of the still dormant volcano. During flight, the group observed a small steam explosion blow a 15 meter hole in the top of the mountain. The group took pictures and passed them to the United States Geological Service when they returned. For the next two weeks, small spots of steam could be seen shooting out of the top of the volcano. By April 22nd, however, all steam activity ceased. Because there were no small steam eruptions, the park rangers believed the volcano was returning to dormancy and did not issue an evacuation.

Geologists, however, started to notice a bulge forming in part of the mountain. Like the mountain was growing fatter, they could see part of it growing in size. By May 17th, the bulge was growing at 2 meters per day. Finally, on May 18th, a final earthquake occurred followed by the immediate eruption of the volcano. The blast from the volcano was so large the ash cloud circled the Earth for 15 days. 57 people died.

Mount St. Helens

Before eruption, 1980.

After eruption, 1982.

Mount Pinatubo

Case Study:

Mount Pinatubo is found on an island of the Philippines. The island is densely populated with large towns and tourist sites. Mount Pinatubo had not erupted in 500 years. For the past 500 years, small bursts of steam would shoot from a hot spring on the volcano. On July 16th, 1990, a magnitude 7.8 quake shook the volcano. This earthquake was followed by a series of smaller earthquakes and increase in steam activity for one week. After the week, however, the volcano appeared to return to dormancy.

In March and April 1991, earthquakes returned and steam activity increased again. The steam explosions created three craters towards the top of the volcano. For the next three months, steam explosions continued to increase in frequency. On June 7th, the first magma explosion erupted. Though the eruption was weak, geologists decided to evacuate the area. On June 15th, a large explosive eruption demolished the area, resulting in one of the largest volcanic eruptions in history.

Before eruption, 1991.

After eruption, 2008.

Nevado Del Ruiz

Case Study:

Nevado Del Ruiz is a volcano located in the Andes Mountains. In November 1985, the volcano began to experience earthquakes. For the next two months, geologists recorded 10 earthquakes per day. Scientists observed small spouts of steam shot from the top of the volcano each day. Scientists feared that a major eruption would come soon. By February 1985, however, the earthquakes and steam ejections stopped. Geologists still feared an eruption, but town politicians refused to evacuate. They believed that the volcano would not erupt because the earthquakes stopped.

The volcano stayed silent for several more months. On October 1985, one year after earthquakes began, a large eruption shook the volcano. The volcano exploded in a major and sudden eruption. The eruption was so strong, people could not evacuate. In the end, 25,000 people had died.

Before eruption, 1985.

After eruption, 2007.

Predicting Eruptions

Directions:

You will be given a set of data from a volcano. Graph the data over time on the graphs below. After each day, send out a "tweet" to the town warning them of any likely volcanic eruptions. Obtain the actual results of your volcano from your teacher and add or subtract "credibility points" to your score

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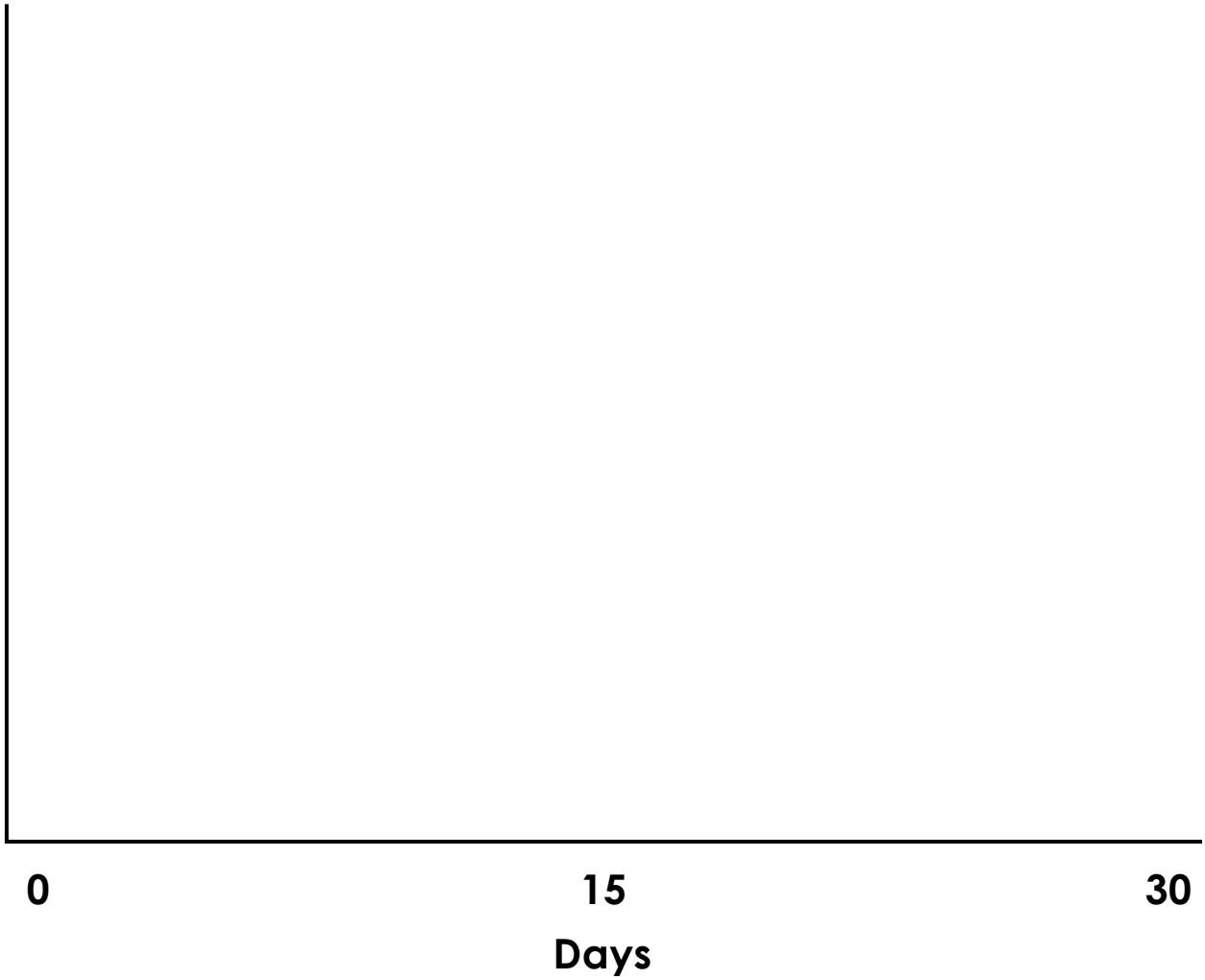
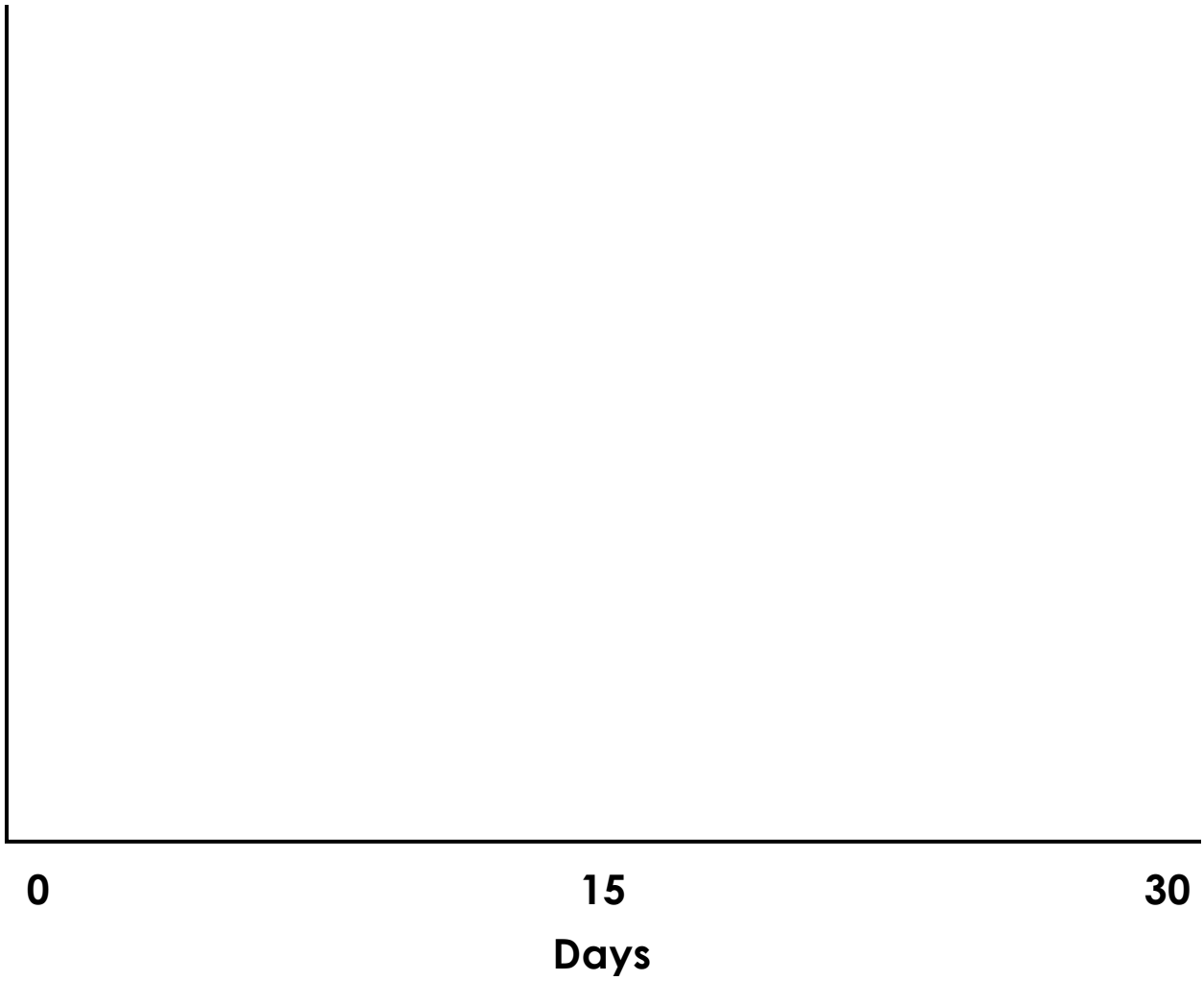
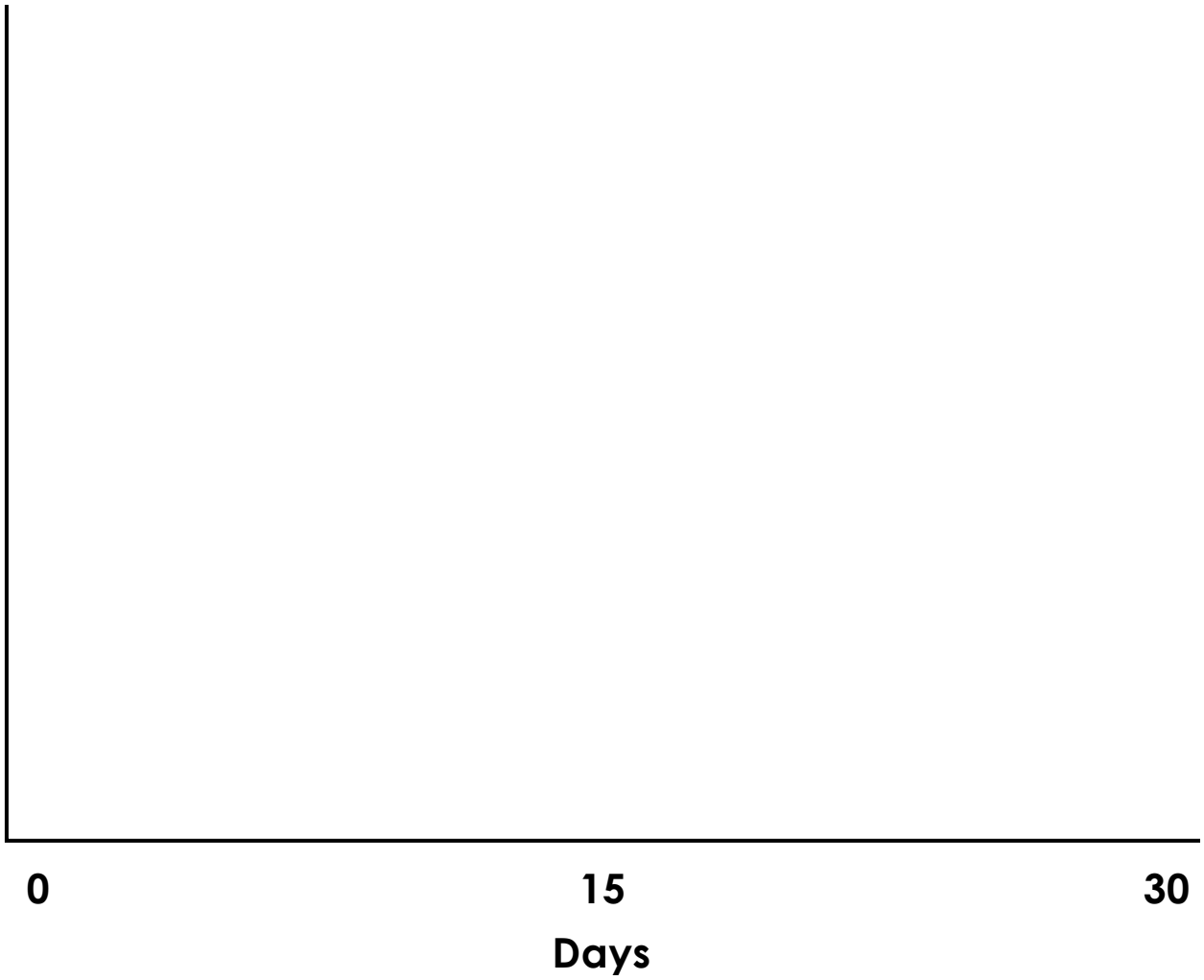
Number of Earthquakes



Tiltmeter: Angle of Volcanic Slope



Number of Phreatic Ejections



Results:

After each five days, send a "tweet" in the following format:

**To the people living near [Volcano name],
a volcanic eruption is [how likely they think an eruption is about to occur],
the geologic station recommends that you [student recommendation
to continue normal activity, prepare to evacuate, evacuate immediately, etc].**

Day 5 Tweet:

Credibility Points: _____

Day 10 Tweet:

Credibility Points: _____

Day 15 Tweet:

Credibility Points: _____

Results:

After each five days, send a "tweet" in the following format:

To the people living near [Volcano name],
a volcanic eruption is [how likely they think an eruption is about to occur],
the geologic station recommends that you [student recommendation
to continue normal activity, prepare to evacuate, evacuate immediately, etc].

Day 20 Tweet:

Credibility Points: _____

Day 25 Tweet:

Credibility Points: _____

Day 30 Tweet:

Credibility Points: _____

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TEACHER SLIDES: VOLCANO DATA

Show students slides one at a time. Allow students time to graph data and then send out a geologist tweet. After they have sent out a tweet for each data slide, show them the status of the volcanoes. Students should compare their status to the warning they give people living near the volcano. If they evacuated people early, they should subtract 10 credibility points. If they did not evacuate people on time, they should subtract 100 credibility points.

DATA:

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	1	22	2
2	1	22	2
3	2	22	2
4	1	22	2
5	1	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	2	15	6
2	1	15	6
3	2	14	6
4	0	15	6
5	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	0	30	2
2	0	30	2
3	0	30	2
4	1	31	2
5	2	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	3	33	3
2	2	33	3
3	3	33	3
4	3	33	3
5	3	33	3

RESULTS:

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	1	22	2
2	1	22	2
3	2	22	2
4	1	22	2
5	1	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	2	15	6
2	1	15	6
3	2	14	6
4	0	15	6
5	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	0	30	2
2	0	30	2
3	0	30	2
4	1	31	2
5	2	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	3	33	3
2	2	33	3
3	3	33	3
4	3	33	3
5	3	33	3

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	0	22	2
7	1	22	2
8	2	22	2
9	2	22	2
10	2	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	0	15	6
7	0	15	6
8	1	14	6
9	0	15	6
10	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	2	31	4
7	2	31	2
8	2	31	2
9	2	31	2
10	3	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	3	33	3
7	3	33	3
8	3	33	3
9	3	33	3
10	3	34	4

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	2	22	4
12	2	23	6
13	2	24	6
14	3	25	4
15	3	26	4

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	2	15	6
12	3	15	6
13	4	14	6
14	5	15	6
15	6	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	4	32	5
12	6	32	6
13	8	33	0
14	7	33	0
15	10	33	0

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	3	33	4
12	4	35	6
13	5	36	6
14	6	38	6
15	8	38	6

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	4	26	6
17	5	26	5
18	6	26	6
19	7	27	6
20	7	27	6

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	5	15	6
17	4	15	6
18	3	15	6
19	2	15	6
20	1	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	10	34	0
17	11	34	0
18	12	35	0
19	10	35	0
20	11	36	0

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	8	38	6
17	9	38	8
18	8	38	8
19	9	38	8
20	8	38	4

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	9	27	6
22	8	27	6
23	9	27	10
24	11	27	10
25	10	27	10

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	2	15	6
22	2	15	6
23	3	15	6
24	4	15	6
25	2	15	6

Mount Shasta

	ACTIVE

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	9	38	12
22	11	38	10
23	15	38	9
24	16	38	12
25	15	38	10

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
26	12	27	11
27	15	27	12
28	16	27	15
29	17	27	15
30	18	27	15

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
26	1	15	6
27	2	15	6
28	5	15	6
29	2	15	6
30	1	15	6

Mount Shasta

ACTIVE

Mount Cleveland

ACTIVE

Mount Hood Oregon

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points