Hands-on Activity

Predicting Eruptions on Montserrat

Predicting Eruptions

No one can predict exactly when a volcano might explode. There are, however, common clues to look for to let people know that the danger is increasing:

- **Land Deformation (Dome Height)**. Near the volcanic vent, as magma pushes up from below, the land on top of and surrounding the vent may start to deform, and grow larger. In many cases this deformation creates a dome of volcanic debris. As the dome grows in size, it becomes more unstable, and ultimately it will collapse and produce pyroclastic flows or lava flows. Increasing dome size indicates a growing danger.

- **Ash Clouds**. Large ash clouds are evidence of increasing volcanic activity. On the island of Montserrat scientists have found that during dangerous times, ash clouds occur in a cycle of 4 to 30 hours apart. What causes an ash cloud? In an active volcano, the vent may become plugged by rocky materials. This plug causes the pressure from the rising magma to build until eventually the plug is blasted apart in a flurry of explosive activity. The released pressure creates an ash cloud, shooting volcanic debris high into the air. Once an ash cloud is produced, the vent may become plugged again and the cycle may repeat. If a plugged volcano does not release its pressure, then scientists become concerned that a massive explosion is imminent. As long as the ash clouds keep appearing regularly, then there is less concern.

- **Tremors**. Flowing magma, trying to make room for itself, causes tremors on the surface. Tremors are measured both for their magnitude and the length of time between vibrations, or rate. On the island of Montserrat, scientists study two kinds of seismic data: Volcanic Tremors (VTs) and Rockfall (RF). The number of tremors or falling rocks which exceed a predetermined critical value are counted by the seismometer (see illustration). The more of these "events" the greater the level of the seismic activity. The rate of tremors is determined by charting the number of events per hour. An increase in the number of events can be an indication of possible eruption.

Predictions Require Evidence

Volcanologists use different tools and techniques to analyze and interpret data. Down below there are two different kinds of data. Table 1 shows one kind of data, which is a list of numbers. These numbers represent the amount of seismic activity in a day. Table 2 shows another kind of data, which is observations. An observation can be just as important as the numbers for predicting volcanic eruptions. For instance, if lava flows are observed as especially "bubbly", then a scientist can infer that the lava contains a high level of dissolved gases and can be explosive.

To be able to predict the volcanic activity during the mission on Sept. 4, you must study what has been occurring in July and August. The numerical and observational data should be considered "evidence". You will want to use all the evidence to develop an explanation of the patterns you see. Using the patterns you will be able to make more scientific predictions than someone who has not studied the patterns.

> Others may have different explanations and predictions. To determine which prediction is most scientific, you must use your best communication skills to point out the relationship between the evidence and the prediction.

How to Study the Evidence

Table 1 gives the total seismic activity for each day from July 1 through September 2. This data has been plotted in Graph 1 below. Use the graph, and the observation data in Table 2 to follow the steps below. By answering the questions you should start to see a pattern concerning the relationship between dome height, ash production, seismic activity and the production of volcanic flows.

1) **Compare Volcanic Flow to the Graph**. Use the final column in Table 2, labeled, “Volcanic Flows”. Begin with the first week, July 1-7. Now look at the relationship between the observations and the dates on the graph. The observations say, “None reported.” On your graph, above 1-Jul and 8-Jul, write the words, “No flows”. Continue to write notes on your graph according to what the table says. For the next week, on July 11 on the graph, note the small “spike” reaching up to about 200 seismic events. In the table there is a report that “Some small pyroclastic flows went into the Mosquito Ghaut area”. On your graph, write “small pyroclastic flows” above the spike. Keep making notes like this for each week and big event. The big events are July 21, Aug. 6, and Aug. 13-14.

2) **Relationship between Dome Height and Volcanic Flows**. In Table 1, note the column labeled, ”Dome Height”. Read each week and compare it to the column labeled, “Volcanic Flows” and to your graph with the notes on it. Answer this question: How are Volcanic Flows related to changes in Dome Height? Write down two pieces of evidence which support your conclusion.

3) **Relationship between Ash Production and Volcanic Flows**. In Table 1, note the column labeled, “Ash Production”. Read each week and compare it to the column labeled, “Volcanic Flows” and to your graph with the notes on it. Answer this question: How are Volcanic Flows related to Ash Production? Write down two pieces of evidence which support your conclusion.

4) **Relationship between Seismic Activity and Volcanic Flows**. In Table 1, note the column labeled, ”Seismic Activity”. Read each week and compare it to the column labeled, “Volcanic Flows” and to your graph with the notes on it. Answer this question: How are Volcanic Flows related to Seismic Activity? Write down two pieces of evidence which support your conclusion.

5) **Design an Invention**. Use the back of this paper to complete this step. Volcanologists try and find new ways to make the connection between evidence and predictions. Be creative for a minute. What is something an engineer could invent that would help us to make better predictions? What do you call your invention? Draw a picture if that would be helpful.

Table 1: Total Daily Seismic Activity

Date	Total Number of Events (VT + RF)
1-Jul	82
2-Jul	84
3-Jul	64
4-Jul	82
5-Jul	55
6-Jul	26
7-Jul	42
8-Jul	1
9-Jul	16
10-Jul	110
11-Jul	198
12-Jul	34
13-Jul	45
14-Jul	49
15-Jul	40
16-Jul	44
17-Jul	46
18-Jul	45
19-Jul	47
20-Jul	29
21-Jul	681
22-Jul	395

Date	Total Number of Events (VT + RF)
23-Jul	140
24-Jul	25
25-Jul	150
26-Jul	220
27-Jul	56
28-Jul	5
29-Jul	0
30-Jul	115
31-Jul	359
1-Aug	388
2-Aug	329
3-Aug	441
4-Aug	No Data Available
5-Aug	508
6-Aug	629
7-Aug	497
8-Aug	407
9-Aug	315
10-Aug	364
11-Aug	166
12-Aug	550
13-Aug	438

Date	Total Number of Events (VT + RF)
14-Aug	389
15-Aug	302
16-Aug	342
17-Aug	365
18-Aug	100
19-Aug	158
20-Aug	225
21-Aug	170
22-Aug	173
23-Aug	58
24-Aug	29
25-Aug	65
26-Aug	107
27-Aug	162
28-Aug	312
29-Aug	407
30-Aug	468
31-Aug	625
1-Sep	660
2-Sep	810

Graph 1

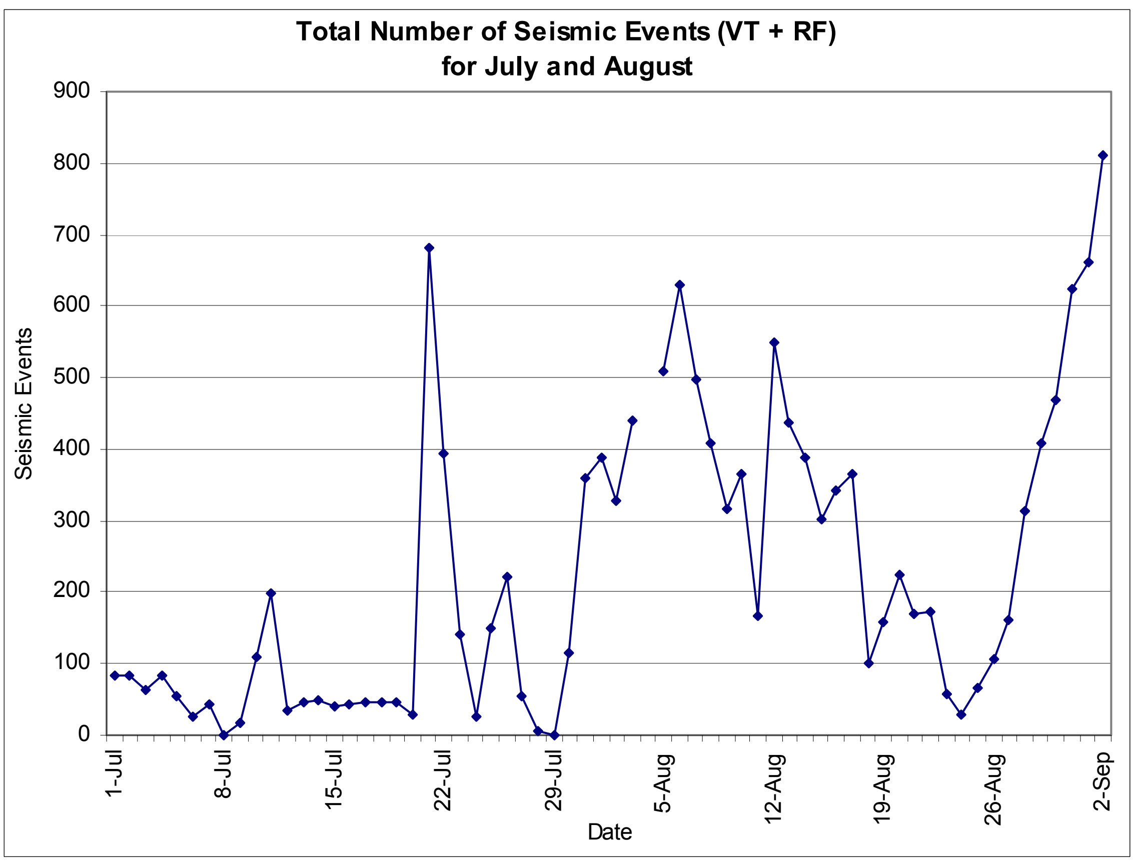

Table2: Observations: July 1- Sep. 2. - Montserrat Volcano Observatory

Dates	Dome Height	Ash Production	Seismic Activity (daily VT & RF data may be found in a separate table)	Volcanic Flows
July 1-7	939 m. Excellent viewing conditions confirmed that the dome was growing, mainly in the south section of the crater. Although the dome does not appear to be growing, new rocky material was seen in the center of the dome.	Mild to moderate levels of ash produced. One small ash cloud noted (less than 0.1 km high).	Seismicity remained low. Daily occurrences of intermittent tremors lasted from a few minutes to several hours.	None reported.
July 8-15	A brief period of good visibility revealed a second peak on the dome. That day the elevation at the top of the dome was measured as 940 meters. Volcanologists say dome hieight has not changed significantly since early May.	A fine ashfall was reported in areas north of Plymouth and out to sea. Production less than 0.1 km high.	The seismic signals became longer and stronger. On July 12, helicopter inspections found that a large amount of rocky material had come down the north and south sides of Castle Peak. The fresh material was still steaming.	July 11 Some small pyroclastic flows went into the Mosquito Ghaut area.
July 16-22	Brief glimpses of the dome revealed vigorous steaming, at times tainted with bluish vapor. Maximum height reached at 963 meters on July 20th.	Ash cloud on July 20th reaches 2.3 km.	Dome collapses on July 21. The occurrence of 681 seismic events (VT & RF) marked a sharp increase in activity.	July 21-22 Eight moderately-sized pyroclastic flows in areas such as the Tar River valley, Tuitt's Ghaut, White's Ghaut and the Belham River valley. One flow reached the coast in Farm Bay.
July 23-29	Dome measured at 929 meters.	Low levels of ashfall reported around Broderick's Estate. Some moderately-sized ash clouds produced light ashfall towards the west.	Observers noted that most of the rockfall activity was on the southwest side of the dome.	Small pyroclastic flows from the east and northeast parts of the dome occurred daily into gulleys around White's Ghaut until they filled the entire valley area. Most of the local vegetation was set on fire by these flows.

July 30-Aug 5	Dome measured at 935 meters.	Data shows that new ash clouds are being produced every 4 to 30 hours. Height of clouds range from 0.1 to 1.5 km. As long as ash clouds occur in regular cycles like this, scientists predict that it is unlikely to develop into an explosive situation.	A field party working at Farrell's Yard heard frequent rockfall activity and observed one rockfall descending the northeast side of the dome.	Small pyroclastic flows reported.
Aug 6- 12	Dome height reached 952 meters before collapsing on Aug. 6. The new dome has almost filled the collapsed structure and some parts of it appear unstable.	Aug 13. Ash cloud reported between 10-13 km and was associated with thunder and lightning and significant ash fall.	Periods of near-continuous rockfalls reported. Most of the rockfalls were channeled down the northeast gully.	Several small-to moderately-sized pyroclastic flows reported daily. Aug. 6 many pyroclastic flows were reported.
Aug 13-19	Dome unstable. Aug 13-14 dome collapses. Maximum dome height reached was 945 meters.	Cycles of ash clouds continue every 4 to 30 hours. Cloud heights range from 5 to 10 km. Satellite imagery and aircraft reports show a band of very light ash in the atmosphere extending from Montserrat almost to Puerto Rico.	The most significant events were small-to-moderate rockfalls from the growing south side of the lava dome. The largest rockfalls produced small dust storms of ash.	Aug 13-14 intense pyroclastic flow activity. Runny lava flow to Farm Bay shows low levels of silica and moderate levels of dissolved gases.
Aug 20-26	The highest point on the dome was measured from Chance's Peak and yielded an elevation of 963 meters.	Cycles of ash clouds continue every 4 to 30 hours. Cloud heights range from 5 to 10 km.	Seismic activity has decreased compared to the last five weeks.	Pyroclastic flow and lava flow production is decreasing. Scientists are concerned it could be due to blockages in the volcanic vent.
Aug 27-Sep 2	980 meters. Good visibility showed that the east part of the dome was very unstable, and the observed rockfalls generally originated from this area.	Ash cloud production is becoming less frequent, but stronger. Three ash clouds sighted ranging from 10-20 km.	Rate and strength of tremors is increasing. In April, seismic levels reached 900 just before the eruption. Seismic levels this week have reached 810.	Pyroclastic flow and lava flow production continues to decrease. Scientists are concerned about increasing pressure in the volcanic vents.