

Chapter 5

Alaska's Volcanoes and You!

Resources

- Alaska Volcano Observatory Preliminary Volcano Hazard Assessments
<http://www.avo.alaska.edu/downloads/classresults.php?pregen=haz> .
 - Begét, J.E., Larsen, J.F., Neal, C.A., Nye, C.J., and Schaefer, J.R., 2005, Preliminary volcano-hazard assessment for Okmok Volcano, Umnak Island, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 2004-3, 32 p., 1 sheet, scale 1:150,000, accessed June 1, 2010, at <http://www.avo.alaska.edu/downloads/classresults.php?citid=4029>.
 - Begét, J.E., Nye, C.J., and Bean, K.W., 2000, Preliminary volcano-hazard assessment for Makushin Volcano, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations RI 2000-4, 22 p., 1 sheet, scale 1:100,000, accessed June 1, 2010, at <http://www.avo.alaska.edu/downloads/classresults.php?citid=656>.
 - Begét, J.E., Nye, C.J., Schaefer, J.R., and Stelling, P.L., 2002, Preliminary volcano-hazard assessment for Shishaldin Volcano, Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 2002-4, 28 p., 1 sheet, scale 1:500,000, accessed June 1, 2010, at <http://www.avo.alaska.edu/downloads/classresults.php?citid=3380>.
 - Coombs, M.L., McGimsey, R.G., and Browne, B.L., 2007, Preliminary volcano-hazard assessment for the Tanaga Volcanic Cluster, Tanaga Island, Alaska: U.S. Geological Survey Scientific Investigations Report 2007-5094, 36 p., 1 sheet. (Also available at <http://pubs.usgs.gov/sir/2007/5094/>.)
 - Coombs, M.L., McGimsey, R.G., and Browne, B.L., 2008, Preliminary volcano-hazard assessment for Gareloi Volcano, Gareloi Island, Alaska: U.S. Geological Survey Scientific Investigations Report 2008-5159, 26 p., 1 sheet. (Also available at <http://pubs.usgs.gov/sir/2008/5159/>.)
 - Fierstein, Judy, and Hildreth, Wes, 2001, Preliminary volcano-hazard assessment for the Katmai volcanic cluster, Alaska: U.S. Geological Survey Open-File Report 00-489, 50 p., 1 plate. (Also available at <http://www.avo.alaska.edu/downloads/classresults.php?citid=660>.)
 - Neal, C.A., McGimsey, R.G., Miller, T.P., Riehle, J.R., and Waythomas, C.F., 2001, Preliminary volcano-hazard assessment for Aniakchak Volcano, Alaska: U.S. Geological Survey Open-File Report 00-519, 35 p., 1 plate. (Also available at <http://www.avo.alaska.edu/downloads/classresults.php?citid=718>.)
 - Waythomas, C.F., Dorava, J.M., Miller, T.P., Neal, C.A., and McGimsey, R.G., 1998, Preliminary volcano-hazard assessment for Redoubt Volcano, Alaska: U.S. Geological Survey Open-File Report 97-857, 40 p., 1 plate, scale unknown. (Also available at <http://www.avo.alaska.edu/downloads/classresults.php?citid=713>.)
 - Waythomas, C.F., and Miller, T.P., 1999, Preliminary volcano-hazard assessment for Iliamna Volcano, Alaska: U.S. Geological Survey Open-File Report 99-373, 31 p., 1 sheet, scale unknown. (Also available at <http://www.avo.alaska.edu/downloads/classresults.php?citid=642>.)

- Waythomas, C.F., and Miller, T.P., 2002, Preliminary volcano-hazard assessment for Hayes Volcano, Alaska: U.S. Geological Survey Open-File Report 02-72, 33 p. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=2935.](http://www.avo.alaska.edu/downloads/classresults.php?citid=2935))
- Waythomas, C.F., Miller, T.P., and Mangan, M.T., 2006, Preliminary volcano hazard assessment for the Emmons Lake Volcanic Center, Alaska: Anchorage, Alaska: U.S. Geological Survey, Scientific Investigations Report 2006-5248, 33 p., 1 sheet. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=4180.](http://www.avo.alaska.edu/downloads/classresults.php?citid=4180))
- Waythomas, C.F., Miller, T.P., and Nye, C.J., 2002, Preliminary volcano-hazard assessment for Kanaga Volcano, Alaska: U.S. Geological Survey Open-File Report 02-397, 27 p., 1 sheet. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=3494.](http://www.avo.alaska.edu/downloads/classresults.php?citid=3494))
- Waythomas, C.F., Miller, T.P., and Nye, C.J., 2003, Preliminary volcano-hazard assessment for Great Sitkin Volcano, Alaska: U.S. Geological Survey Open-File Report 03-112, 25 p., 1 sheet. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=3493.](http://www.avo.alaska.edu/downloads/classresults.php?citid=3493))
- Waythomas, C.F., and Nye, C.J., 2002, Preliminary volcano-hazard assessment for Mount Spurr Volcano, Alaska: U.S. Geological Survey Open-File Report 01-482, 46 p. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=2936.](http://www.avo.alaska.edu/downloads/classresults.php?citid=2936))
- Waythomas, C.F., Power, J.A., Richter, D.H., and McGimsey, R.G., 1998, Preliminary volcano-hazard assessment for Akutan Volcano east-central Aleutian Islands, Alaska: U.S. Geological Survey Open-File Report 98-360, 36 p., 1 plate, scale unknown. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=728.](http://www.avo.alaska.edu/downloads/classresults.php?citid=728))
- Waythomas, C.F., and Waitt, R.B., 1998, Preliminary volcano-hazard assessment for Augustine Volcano, Alaska: U.S. Geological Survey Open-File Report 98-0106, 39 p., 1 plate, scale unknown. (Also available at [http://www.avo.alaska.edu/downloads/classresults.php?citid=701.](http://www.avo.alaska.edu/downloads/classresults.php?citid=701))
- U.S. Geological Survey Volcano Hazards Program Fact Sheets
 - Brantley, S.R., McGimsey, R.G., and Neal, C.A., 2004 [2009], The Alaska Volcano Observatory—Expanded monitoring of volcanoes yields results: U.S. Geological Survey Fact Sheet 2004-3084, 2 p. (Also available at <http://pubs.usgs.gov/fs/2004/3084/> and [http://pubs.usgs.gov/fs/2004/3084/fs2004-3084_v1.1.pdf.](http://pubs.usgs.gov/fs/2004/3084/fs2004-3084_v1.1.pdf))
 - Fierstein, Judy, Hildreth, Wes, Hendley, J.W., and Stauffer, P.H., 1998, Can another great eruption happen in Alaska? U.S. Geological Survey Fact Sheet 075-98, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs075-98/> and [http://pubs.usgs.gov/fs/fs075-98/fs075-98.pdf.](http://pubs.usgs.gov/fs/fs075-98/fs075-98.pdf))
 - Gardner C.A., and Guffanti, M.C., 2006, U.S. Geological Survey's alert notification system for volcanic activity: U.S. Geological Survey Fact Sheet 2006-3139, 4 p. (Also available at [http://pubs.usgs.gov/fs/2006/3139/fs2006-3139.pdf.](http://pubs.usgs.gov/fs/2006/3139/fs2006-3139.pdf))

- Kenedi, C.A., Brantley, S.R., Hendley, J.W., II, and Stauffer, P.H., 2000, Volcanic ash—A "hard rain" of abrasive particles: U.S. Geological Survey Fact Sheet 027-00, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs027-00/> and <http://pubs.usgs.gov/fs/fs027-00/fs027-00.pdf>.)
- Myers, B., Brantley, S.R., Stauffer, P., and Hendley, J.W., II, 1997 [2004], What are volcano hazards: U.S. Geological Survey Fact Sheet 002-97, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs002-97/>, <http://pubs.usgs.gov/fs/fs002-97/fs002-97.pdf>, and Spanish PDF <http://pubs.usgs.gov/fs/fs144-00/fs144-00.pdf>.)
- Neal, C.A., Casadevall, T.J., Miller, T.P., Hendley, J.W., II, and Stauffer, P.H., 1997, Volcanic ash—Danger to aircraft in the north Pacific: U.S. Geological Survey Fact Sheet 030-97, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs030-97/> and <http://pubs.usgs.gov/fs/fs030-97/fs030-97.pdf>.)
- Wallace, K.L., McGimsey, R.G., and Miller, T.P., 2000, Historically active volcanoes in Alaska—A quick reference: U.S. Geological Survey Fact Sheet 118-00, 2 p. (Also available at <http://pubs.usgs.gov/fs/2000/fs118-00/> and <http://pubs.usgs.gov/fs/2000/fs118-00/fs118-00.pdf>.)
- U.S. Geological Survey websites
 - U.S. Geological Survey, 2003, Volcano and hydrologic hazards, features, and terminology: U.S. Geological Survey website. (Available at <http://vulcan.wr.usgs.gov/Glossary/framework.html>.)
 - U.S. Geological Survey, 2009, Volcano Hazards Program—1989–90 eruption of Redoubt Volcano, Alaska, and the first test case of a USGS lahar-detection system: U.S. Geological Survey website. (Available at http://volcanoes.usgs.gov/activity/methods/hydrologic/afm_redoubt.php.)
 - U.S. Geological Survey, 2009, Volcano Hazards Program—Types of Volcano Hazards: U.S. Geological Survey website. (Available at <http://volcanoes.usgs.gov/hazards/>.)
 - U.S. Geological Survey and partners, 2010, Volcanic ash... what it can do and how to prevent damage: U.S. Geological Survey and partners website. (Available at <http://volcanoes.usgs.gov/ash/>.)
 - U.S. Geological Survey, 2010, Volcano Hazards Program—USGS photo glossary of volcanic terms: U.S. Geological Survey website. (Available at <http://volcanoes.usgs.gov/images/pglossary/index.php>.)
 - U.S. Geological Survey, 2009, Volcano Hazards Program—USGS volcanic activity alert-notification system: U.S. Geological Survey website. (Available at <http://volcanoes.usgs.gov/activity/alertsystem/>.)
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 - American Red Cross, [n.d.], Public information—Volcanoes: American Red Cross web page, accessed June 1, 2010, at <http://alaska.redcross.org/media/volcano.pdf>.
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 - Federal Emergency Management Agency and American Red Cross, 2004, Preparing for disaster: Federal Emergency Management Agency and American Red Cross booklet, 14 p., accessed June 1, 2010, at <http://www.redcross.org/images/pdfs/preparedness/A4600.pdf>.
 - Federal Emergency Management Agency, 2009, Are you ready?—Volcanoes: Federal Emergency Management Agency website, accessed June 1, 2010, at <http://www.fema.gov/areyouready/volcanoes.shtm>.
- International Volcanic Health Hazard Network (IVHHN), 2010, Durham University website, accessed June 1, 2010, at <http://ivhhn.org/>.
 - The Health Hazards of Volcanic Ash—A guide for the public PDF http://www.ivhhn.org/index.php?option=com_content&view=article&id=55&Itemid=61
 - Guidelines on Preparedness Before, During and After an Ashfall PDF http://www.ivhhn.org/index.php?option=com_content&view=article&id=55&Itemid=61

- Washington Military Department, Emergency Management Division and U.S. Geological Survey, 1999, Volcanic ashfall—How to be prepared for an ashfall: Washington State Emergency Management Division pamphlet, accessed June 1, 2010, at http://emd.wa.gov/publications/pubed/volcanic_ash_english.pdf.
- Alaska Division of Emergency Services, [n.d.], Ash alert!: Alaska Division of Emergency Services website, accessed June 1, 2010, at http://www.ak-prepared.com/Poster_Contest_Files/Ash_Alert.pdf

Activities

Students will be introduced to several types of volcanic eruption products, all of which are potential hazards, likely to occur in Alaska at least once during their lifetime. Students will generate their own volcanic activity notification systems and compare them to those used by the volcano observatories within the U.S. Students will study and generate safety and community planning documents, plans, and kits to help prepare for a volcanic eruption and will be able to watch as a community becomes affected by falling volcanic ash through hands-on experimentation. Students will synthesize the general background information about volcanoes in Alaska and apply this knowledge to planning and preparing for a volcanic eruption that may affect their own community.

Activity I. We need all the assistance you have...

Activity II. What is the Plan?

Activity III. Volcanic Ash Fall in Your Community

Activity I. We Need All the Assistance You Have...

Grade Level 6–11

Setting Classroom

Time 45–90 minutes

Vocabulary (see Glossary)

acid rain, ash fall, bombs, debris avalanche, eruption cloud, eruption column, fumarole, lahar—volcanic mudflow—volcanic debris flow, landslide, lava flow, pyroclastic flow, tephra

Correlations to Alaska State Department of Education (2006) Performance Standards (Grade Level Expectations)

A1—Science as Inquiry and Process

SA3[6-11] Students develop an understanding that cultural, local knowledge, history, and interactions with the environment contribute to the development of scientific knowledge, and that local applications provide opportunity for understanding scientific concepts and global issues.

D1—Concepts of Earth Science

SD[6-11] Students develop an understanding of the concepts, processes, theories, models, evidence, and systems of earth and space sciences.

SD2[6-11] Students develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth.

E1—Science and Technology

SE[6-11] Students develop an understanding of the relationship among science, technology, and society

SE1[6-11] Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to everyday events.

SE2[6-11] Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits.

Overview

Students will be introduced to several types of volcanic eruption products, all of which are potential hazards, likely to occur in Alaska at least once during their lifetime. Students will also learn about the close encounter of a jet aircraft and a volcanic ash cloud from Redoubt volcano that took place in 1989. This activity will give students the opportunity to develop two systems to describe activity at a volcano and the likely hazards it may pose to local and distant communities and to regional air traffic. The documents prepared in this activity are used to explain likely volcanic eruption products, the hazards they may pose to Alaskans, and how scientists communicate that kind of information. Students will compare their system with the system current used at all U.S. volcano observatories including the Alaska Volcano Observatory.

Background

Alaska is home to about 140 volcanoes and volcanic regions, which have been active within the last 2 million years. Of these volcanoes, about 90 have been active within the last 10,000 years and more than 50 have been active within historical time (since about 1700, for Alaska).

- Alaska Volcano Observatory, [n.d.], About Alaska's volcanoes: Alaska Volcano Observatory website. (Available at <http://www.avo.alaska.edu/volcanoes/about.php>.)

Several types of volcanic activity can endanger the lives of people and property at distances near to and far from the volcano. Most volcanic eruptions in Alaska include explosive ejection or the flow of rock fragments and molten rock in various combinations of hot or cold, wet or dry, fast or slow, and acidic or not. Some hazards are more severe than other hazards depending on the size and extent of the eruption that is taking place and whether people and (or) property are in the way. Although most volcano hazards are triggered directly by an eruption, some may occur even when a volcano is relatively quiet.

The Alaska Volcano Observatory (AVO) assesses the full range of potential hazards at volcanic regions of Alaska in support of planning for public land use, developing emergency response plans, and raising general public awareness about volcanic hazards. This requires researchers to study the style and frequency of past eruptions, and to assess potential effects of future activity. Scientific results are summarized in hazards assessments, and include descriptions of the eruptive history of a given volcano, explanations of likely eruption scenarios, and determinations of probable impact zones for the range of expected hazards. Ultimately, hazards assessments will be published for all seismically monitored volcanoes in Alaska. All of AVOs hazard assessments are posted on the AVO website (<http://www.avo.alaska.edu/downloads/classresults.php?pregen=haz>).

AVO uses an alert-notification system for describing the level of activity (including eruptions) at Alaskan volcanoes. The alert-notification system is useful to people on the ground and in the air. The system has two parts—a four-tiered Volcano Alert Level and a four-tiered Aviation Color Code. AVO scientists determine alert levels for a volcano by using monitoring data and their knowledge of the expected or ongoing hazardous activity and assign the appropriate attributes using this system. The information is then posted to

AVOs website and is faxed and emailed to hundreds of organizations and agencies responsible for the safety of life and property on the ground and in the air. AVO also conducts a call-down to at least a dozen agencies and organizations that are involved in eruption response and have responsibilities to generate their own warning messages, for example air traffic closures, ash fall estimates, and community preparedness planning.

This volcano alert-notification system also is used by the Cascades Volcano Observatory, the Hawaiian Volcano Observatory, the Long Valley Observatory, and the Yellowstone Volcano Observatory.

Materials emphasizing the types of volcanoes and volcanic eruption products are in Chapter 3 of this guidebook.

Objectives

Students will understand the different types of volcanic eruption products and potential hazards in Alaska and the unique aspects of ground-based and aviation volcanic hazards. Students will become familiar with a real Alaskan eruption and the serious hazards posed in the air and on the ground during explosive activity. Students will learn about the difficulties of forming a consensus regarding volcanic activity notifications, specifically those in use by emergency managers. Students will compare their outcomes with notification schemes that are currently used by the U.S. Geological Survey (USGS).

Materials

- *Potential Volcanic Hazards I, Potential Volcanic Hazards II, Potential Volcanic Hazards III, and Volcanic Activity Notifications* worksheets
- *KLM Flight 867, Boeing -747 Communications with Anchorage Center on December 15, 1989* handout

Procedure

A. *Potential Volcanic Hazards I* worksheet

1. Instruct students to label the correct type of potential volcanic hazards portrayed in the *Potential Volcanic Hazards I* worksheet. Suggested resources include
 - U.S. Geological Survey
 - Myers, Bobbie, Brantley, S.R., Stauffer, Peter, and Hendley, J.W., II, 1997 [2004], What are volcano hazards?: U.S. Geological Survey Fact Sheet 002-97, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs002-97/>, <http://pubs.usgs.gov/fs/fs002-97/fs002-97.pdf>, and (Spanish PDF) <http://pubs.usgs.gov/fs/fs144-00/fs144-00.pdf>.)
Note Roughly the worksheet provided in activity
 - U.S. Geological Survey, 2003, Cascades Volcano Observatory—Volcano and hydrologic hazards, features, and terminology: U.S. Geological Survey web pages. (Available at <http://vulcan.wr.usgs.gov/Glossary/framework.html>.)

- U.S. Geological Survey, 2009, Volcano Hazards Program—Types of volcano hazards: U.S. Geological Survey web pages. (Available at <http://volcanoes.usgs.gov/hazards/>.)
Note This web page includes a figure that is roughly equal to a figure on the worksheet provided in activity.
- U.S. Geological Survey, 2010, Volcano Hazards Program—USGS photo glossary of volcanic terms: U.S. Geological Survey website. (Available at <http://volcanoes.usgs.gov/imagespglossary/index.php>.)

B. *Potential Volcano Hazards II* worksheet

1. For each potential volcanic hazard instruct the student to fill in the name and year of a specific volcanic eruption in which the hazard was posed. Have students emphasize Alaskan volcanic eruptions whenever possible. There is space on the worksheet for students to include hazards not already identified in the worksheet. Suitable for this section:
 - Alaska Volcano Observatory, [n.d.], Alaska Volcano Observatory website. (Available at <http://www.avo.alaska.edu>).
 - Alaska Volcano Observatory, [n.d.], Hazard assessments: Alaska Volcano Observatory web page. (Available at <http://www.avo.alaska.edu/downloads/classresults.php?pregen=haz>.)

The AVO website also has an “Impact” tab under the reported Activity timeline for each volcano with available published documentation of impacts. Thus, not all volcanoes or reported activity will have such a tab or information listed at the AVO website. For example:

- Alaska Volcano Observatory, [n.d.], Novarupta reported activity 1912—Impact: Alaska Volcano Observatory website. (Available at <http://www2.avo.alaska.edu/volcanoes/volcact.php?volcname=Novarupta&page=impact&eruptionid=456>.)

C. *Potential Volcano Hazards III* worksheet

1. Discuss with your class the need to categorize and report likely volcanic hazards for emergency planning purposes. Determine if your students can come up with the airborne ash hazard to aircraft. The resources listed in A. above are appropriate for this as well.
2. In discussion, and (or) using the *Potential Volcanic Hazards I* and *II* worksheets, have students segregate the illustrated possible volcanic hazards into two categories approximating proximal and distal (close to the vent and far away, on the flanks of the volcano, and in the air, and so on) and determine which hazards belong in which category. Many hazards may belong in both categories. Have them include any hazards they came up with that were not already on the worksheet.

D. *KLM Flight 867* handout

1. Have students read aloud the *KLM Flight 867, Boeing -747 Communications with Anchorage Center on December 15, 1989* handout.
2. Ask students why volcanic ash is a danger to aircraft. Discuss if airborne ash is a threat only to jet aircraft or to general aviation, as well. Determine if airborne ash in the North Pacific is a problem only for Alaska aviation or if it affects air travel elsewhere. Suggested resources include
 - U.S. Geological Survey Volcano Hazards Program Fact Sheets
 - Brantley, S.R., McGimsey, R.G., and Neal, C.A., 2004 (rev. 2009), The Alaska Volcano Observatory—Expanded monitoring of volcanoes yields results: U.S. Geological Survey Fact Sheet 2004-3084, 2 p. (Also available at <http://pubs.usgs.gov/fs/2004/3084/> and http://pubs.usgs.gov/fs/2004/3084/fs2004-3084_v1.1.pdf.)
 - Fierstein, Judy, Hildreth, Wes, Hendley, J.W., II, and Stauffer, P.H., 1998, Can another great eruption happen in Alaska?: U.S. Geological Survey Fact Sheet 075-98, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs075-98/> and <http://pubs.usgs.gov/fs/fs075-98/fs075-98.pdf>.)
 - Kenedi, C.A., Brantley, S.R., Hendley, J.W., II, and Stauffer, P.H., 2000, Volcanic ash—A "hard rain" of abrasive particles: U.S. Geological Survey Fact Sheet 027-00, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs027-00/> and <http://pubs.usgs.gov/fs/fs027-00/fs027-00.pdf>.)
 - Kienle, J., 1994, Volcanic ash-aircraft incidents in Alaska prior to the Redoubt eruption on 15 December 1989, in Casadevall, T.J., ed., Volcanic ash and aviation safety—Proceedings of the First International Symposium on Volcanic Ash and Aviation Safety: U.S. Geological Survey Bulletin B 2047, p. 119-123. (Also available at <http://www.avo.alaska.edu/downloads/classresults.php?citid=650>.)
 - Neal, C.A., Casadevall, T.J., Miller, T.P., Hendley, J.W., II, and Stauffer, P.H., 1997, Volcanic ash—Danger to aircraft in the north Pacific: U.S. Geological Survey Fact Sheet 030-97, 2 p. (Also available at <http://pubs.usgs.gov/fs/fs030-97/> and <http://pubs.usgs.gov/fs/fs030-97/fs030-97.pdf>.)
3. Ask students what they have heard about the fate of this plane and its passengers. As a homework assignment, assign students to collect oral stories from relatives, friends, and other community members about this event and write a summary of their findings. An e-mail exchange will be all right instead of phone, radio, or in-person communication.
4. Discuss student findings in class. How many different accounts have the students assembled? Compare these summaries, memories of individuals who may have been there or heard of the incident, with the accounts conveyed in contemporary documents and periodicals. Stress the importance of contemporary documentation and its superiority to reliance on human memory. Recommended documents:

- Casadevall, T.J., 1994, The 1989–1990 eruption of Redoubt Volcano, Alaska—Impacts on aircraft operations, *in* Miller, T.P., and Chouet, B.A., eds., The 1989–1990 eruptions of Redoubt Volcano, Alaska: Journal of Volcanology and Geothermal Research, v. 62, no. 1, p. 301-316.
 - Dean, K.G., Whiting Lawrence, and Jiao, Haitao, 1994, An aircraft encounter with a Redoubt ash cloud (a satellite view), *in* Casadevall, T.J., ed., Volcanic ash and aviation safety—Proceedings of the First International Symposium on Volcanic Ash and Aviation Safety: U.S. Geological Survey Bulletin B 2047, p. 333-339. (Also available at http://www.avo.alaska.edu/pdfs/B2047_p333to339.pdf.)
 - McGimsey, Game, 2001, Redoubt volcano and the Alaska Volcano Observatory, 10 years later, *in* Gough, L.P., and Wilson, F.H., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1999: U.S. Geological Survey Professional Paper 1633, p. 5-12. (Also available at <http://pubs.usgs.gov/pp/p1633/>.)
 - Miller, T.P., and Chouet, B.A., 1994, The 1989-1990 eruptions of Redoubt volcano—An introduction, *in* Miller, T.P., and Chouet, B.A., eds., The 1989–1990 eruptions of Redoubt Volcano, Alaska: Journal of Volcanology and Geothermal Research, v. 62, no. 1, p. 1-10.
5. The 1989–90 eruption of Redoubt Volcano generated lahars in the Drift River Valley. The lahars were caused by sudden melting of snow and ice from hot pyroclastic flows and dome collapses that swept down the volcano's north flank. Many of the lahars swept all the way to Cook Inlet (a distance of ~35 km, [~ 22 mi]), and raised concern about the safety of an oil terminal facility built on the bank of Drift River. Discuss this event with your students. Have students conduct research about the response of the USGS. Resources include:
- Alaska Volcano Observatory, [n.d.], Redoubt reported activity—1989 eruption impact: Alaska Volcano Observatory website. Available at <http://www.avo.alaska.edu/volcanoes/volcact.php?volcname=Redoubt&page=impact&eruptionid=442> .
 - Dorava, J.M., and Meyer, D.F., 1994, Hydrologic hazards in the lower Drift River Basin associated with the 1989–1990 eruptions of Redoubt Volcano, Alaska, *in* Miller, T.P., and Chouet, B.A., eds., The 1989–1990 eruptions of Redoubt Volcano, Alaska: Journal of Volcanology and Geothermal Research, v. 62, no. 1, p. 387-407.
 - Tuck, B.H., and Huskey, L., 1994, Economic disruptions by Redoubt volcano: assessment methodology and anecdotal empirical evidence, *in* Casadevall, T.J., ed., Volcanic ash and aviation safety—Proceedings of the First International Symposium on Volcanic Ash and Aviation Safety: U.S. Geological Survey Bulletin B 2047, p. 137-140. (Also available at http://www.avo.alaska.edu/pdfs/B2047_p137to140.pdf.)
 - U.S. Geological Survey, 2009, Volcano Hazards Program—1989–1990 eruption of Redoubt Volcano, Alaska, and the first test case of a USGS lahar-detection system: U.S. Geological Survey website. (Available at http://volcanoes.usgs.gov/activity/methods/hydrologic/afm_recoubt.php.)

E. *Volcanic Activity Notifications* worksheets

1. After completion of parts A–D, students should be able to recognize the distinct potential volcanic hazards facing infrastructure and people on the ground and in the air. Students will now develop a system that categorizes and ranks the level of volcanic activity and the possible hazards that it may pose to people and property.
2. On the *Volcanic Activity Notifications* worksheets, instruct students develop two, four-level activity notification schemes for use by emergency managers. Include one for ground-based hazards, and one for aviation hazards. Direct students to consider how scientists would move from one level of notification to another, “up” or “down.” In other words, on what basis would scientists change the current level of activity to another? You may ignore the worksheet, and tell students to develop their own tables. This works well as a group activity or class activity, with results displayed on the classroom white board.
3. It may be worth showing or discussing examples of similar systems for relaying information about other kinds of natural hazards. A few examples are:
 - National Oceanographic and Atmospheric Administration, 2009, National Weather Service Forecast Office— Baltimore/Washington—Definitions of Weather Watch, Warnings and Advisories: National Oceanic and Atmospheric Administration web page, accessed June 2, 2010, at <http://www.erh.noaa.gov/lwx/Defined/index.htm>.
 - National Oceanographic and Atmospheric Administration, 2010, National Weather Service: National Oceanographic and Atmospheric Administration website, accessed June 2, 2010, at <http://www.weather.gov/>.
 - National Oceanographic and Atmospheric Administration, 2010, National Weather Service Pacific Tsunami Warning Center Messages: National Oceanographic and Atmospheric Administration web page, accessed June 2, 2010, at http://www.prh.noaa.gov/ptwc/about_messages.php.
4. Have students compare their system to those in currently in use by AVO. You can use the current scheme provided in summary or use
 - Gardner, C.A., and Guffanti, M.C., 2006, U.S. Geological Survey's alert notification system for volcanic activity: U.S. Geological Survey Fact Sheet 2006-3139. p. 2-3. (Also available at <http://pubs.usgs.gov/fs/2006/3139/fs2006-3139.pdf>.) [12.14 MB]

Extensions

1. Have students study a particular Alaskan volcano or community and report the volcanic hazards the community faces or those that the volcano may produce in the event on an eruption.
2. Have students interview a relative, friend, or member of the community who can recall local ash fall, the KLM flight 867 Redoubt airborne ash encounter, or other volcanic activity affecting the community.
3. Have students study and report on the positive contributions of volcanic products to the landscape to agriculture, beauty, and so on.

References Cited

- Alaska State Department of Education and Early Development, 2006, Standards and grade level expectations, March 2006: State of Alaska website, accessed October 2009 at <http://www.eed.state.ak.us/tls/assessment/GLEHome.html>.
- Alaska Volcano Observatory, [n.d.], About Alaska's volcanoes: Alaska Volcano Observatory web page. (Available at <http://www.avo.alaska.edu/volcanoes/about.php>.)
- Alaska Volcano Observatory, [n.d.], About AVO: Alaska Volcano Observatory web page. (Available at <http://www.avo.alaska.edu/about/index.php>.)
- U.S. Geological Survey, 2009, Volcano Hazards Program—USGS volcanic activity alert-notification system: U.S. Geological Survey web page. (Available at <http://volcanoes.usgs.gov/activity/alertsystem/>.)

Glossary

Acid rain – The term "acid rain" is commonly used to mean the deposition of acidic components in rain, snow, fog, dew, or dry particles. The more accurate term is "acid precipitation." Distilled water, which contains no carbon dioxide, has a neutral pH of 7. Liquids with a pH less than 7 are acid, and those with a pH greater than 7 are alkaline (or basic). "Clean" or unpolluted rain has a slightly acidic pH of 5.6, because carbon dioxide and water in the air react together to form carbonic acid, a weak acid. Around Washington, D.C., however, the average rain pH is between 4.2 and 4.4.

Ash fall – Volcanic ash consists of fine fragments (less than 2 mm (~ 8/100 of an inch) across) of lava or rock formed in an explosive volcanic eruption. When volcanic ash falls to the ground the deposit typically is called an ash fall (also ashfall) deposit and typically is referred to as an ash fall. Ash falls vary widely in intensity, size of the ash particles, and the degree to which light from the sun is obscured or blocked completely. Because of the unexpected darkness during daylight hours, loud thunder and lightning, and the sometimes-strong smell of sulfur during an ash fall, many people describe the experience as eerie and frightening, disorienting and confusing, or dreadful. In extreme ash fall, for example when ash thickness is more than 5-10 cm (2-4 in.), people may feel stunned and fearful of the conditions, and have difficult time breathing if a well-sealed shelter is not available. If caught outside during low visibility, people may become lost or extremely disoriented.

Bombs – Volcanic bombs are lava fragments that were ejected while viscous (partially molten) and are larger than 64 mm in diameter. Many acquire rounded aerodynamic shapes during their travel through the air. Volcanic bombs include breadcrust bombs, ribbon bombs, spindle bombs (with twisted ends), spheroidal bombs, and “cow-dung” bombs.

Debris avalanche – Debris avalanches are moving masses of rock, soil, and snow that occur when the flank of a mountain or volcano collapses and slides downslope. As the moving debris rushes down a volcano and into river valleys, it incorporates water, snow, trees, bridges, buildings, and anything else in the way. Debris avalanches may travel several kilometers before coming to rest, or they may transform into more water-rich lahars, which travel many tens of kilometers downstream.

Eruption cloud – An eruption cloud is a cloud of tephra and gases that forms downwind of an erupting volcano. The vertical pillar of tephra and gases rising directly above a vent is known as an eruption column. Eruption clouds are often dark colored—brown to gray—but they also can be white, very similar to weather clouds. Eruption clouds may drift downwind for thousands of kilometers and often increasingly spread out over a large area with increasing distance from an erupting vent. Large eruption clouds can circle the Earth within days.

Eruption column – An explosive eruption blasts molten and solid rock fragments (tephra) into the air with tremendous force. The largest fragments (bombs) fall back to the ground near the vent, usually within 2 mi. The smallest rock fragments (ash) continue rising into the air, forming a huge, billowing eruption column. Eruption columns can be enormous in size and grow rapidly, reaching more than 12 mi above a volcano in less than 30 minutes. Once in the air, the volcanic ash and gas form an eruption cloud. Large eruption clouds can travel hundreds of miles downwind from a volcano, resulting in ash fall over enormous areas.

Fumarole – Vents from which volcanic gas escapes into the atmosphere. Fumaroles may occur along tiny cracks or long fissures, in chaotic clusters or fields, and on the surfaces of lava flows and thick deposits of pyroclastic flows. They may persist for decades or centuries if they are above a persistent heat source or disappear within weeks to months if they occur atop a fresh volcanic deposit that quickly cools.

Lahar - Volcanic mudflow - Volcanic debris flow - Lahar is an Indonesian word for a rapidly flowing mixture of rock debris and water that originates on the slopes of a volcano. Lahars are also referred to as volcanic mudflows or debris flows. They form in various ways, chiefly by the rapid melting of snow and ice by pyroclastic flows, intense rainfall on loose volcanic rock deposits, breakout of a lake dammed by volcanic deposits, and as a consequence of debris avalanches.

Landslide – Describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these materials. The materials may move by falling, toppling, sliding, spreading, or flowing.

Lava flow – Streams of molten rock that pours or oozes from an erupting vent. Lava is erupted during either non-explosive activity or explosive lava fountains. Lava flows destroy everything in their path, but most move slowly enough that people can move out of the way. The speed at which lava moves across the ground depends on several factors, including (1) type of lava erupted and its viscosity; (2) steepness of the ground over which it travels; (3) whether the lava flows as a broad sheet, through a confined channel, or down a lava tube; and (4) rate of lava production at the vent.

Pyroclastic flow – A ground-hugging avalanche of hot ash, pumice, rock fragments, and volcanic gas that rushes down the side of a volcano as fast as 100 km/h (~60 mi/h) or more. The temperature within a pyroclastic flow may be greater than 500°C (900°F), sufficient to burn and carbonize wood. Once deposited, the ash, pumice, and rock fragments may deform (flatten) and weld together because of the intense heat and the weight of the overlying material. The emplaced flow is called a deposit.

Tephra – A general term for fragments of volcanic rock and lava regardless of sizes that are blasted into the air by explosions or carried upward by hot gases in eruption columns or lava fountains. Tephra includes large dense blocks and bombs, and small light rock debris such as scoria, pumice, reticulite, and ash.

Source of Glossary Definitions

National Atlas of the United States, 2009, Landslide types and processes: National Atlas of the United States web page, accessed June 2, 2010, at

http://www.nationalatlas.gov/articles/geology/a_landslide.html.

U.S. Geological Survey, 1997, What is acid rain?: U.S. Geological Survey web page.

(Available at <http://pubs.usgs.gov/gip/acidrain/2.html>.)

U.S. Geological Survey, 2006, Cascades Volcano Observatory—Description—volcanic eruptions, blasts, plumes, ballistics, etc.: U.S. Geological Survey web page. (Available at

http://vulcan.wr.usgs.gov/Glossary/VolcanicBlasts/description_volcanic_blasts.html.)

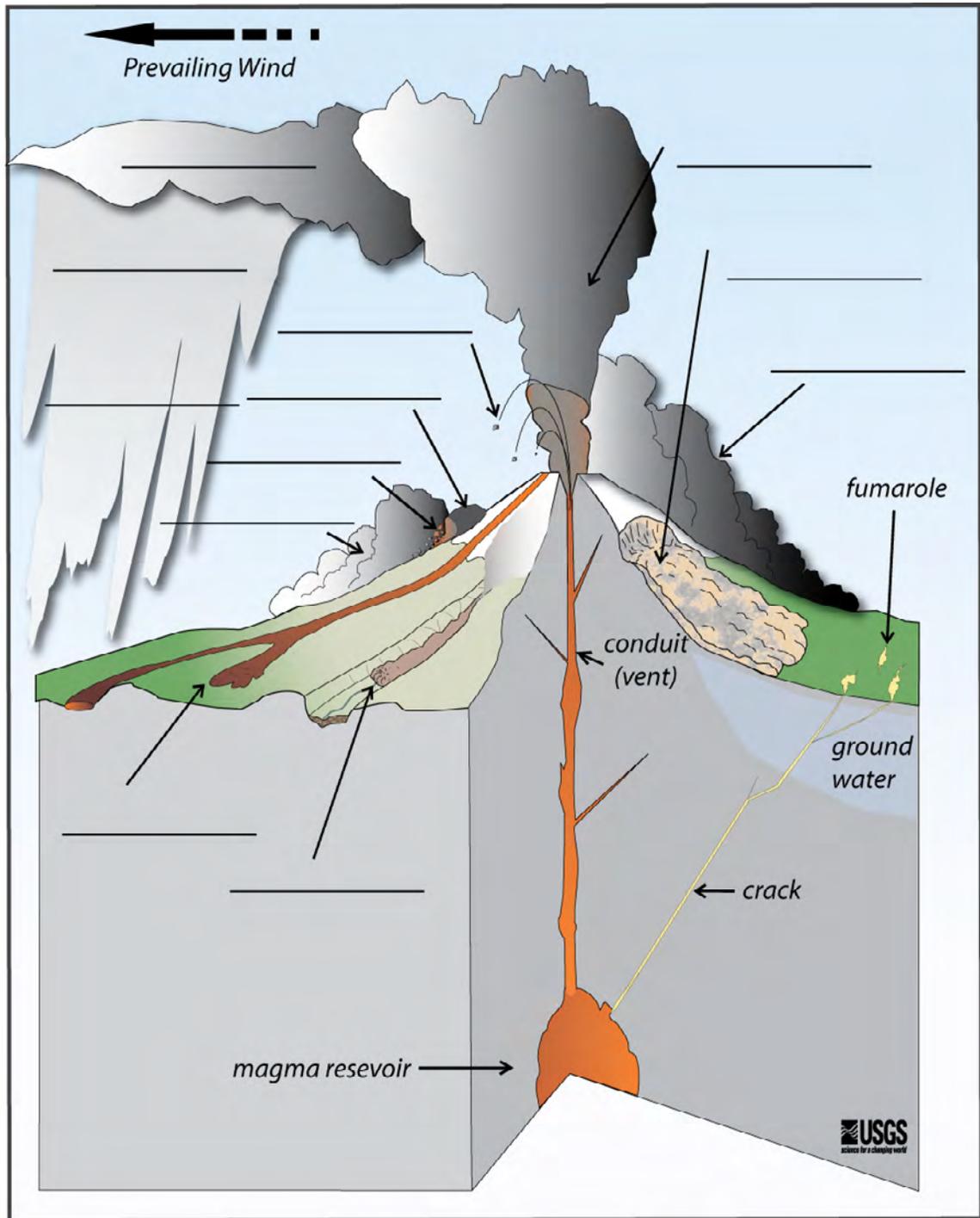
U.S. Geological Survey and partners, 2009, Volcanic ash—Effects and mitigation strategies—What’s it like during an ash fall?: U.S. Geological Survey web page.

(Available at <http://volcanoes.usgs.gov/ash/ashfall.html>.)

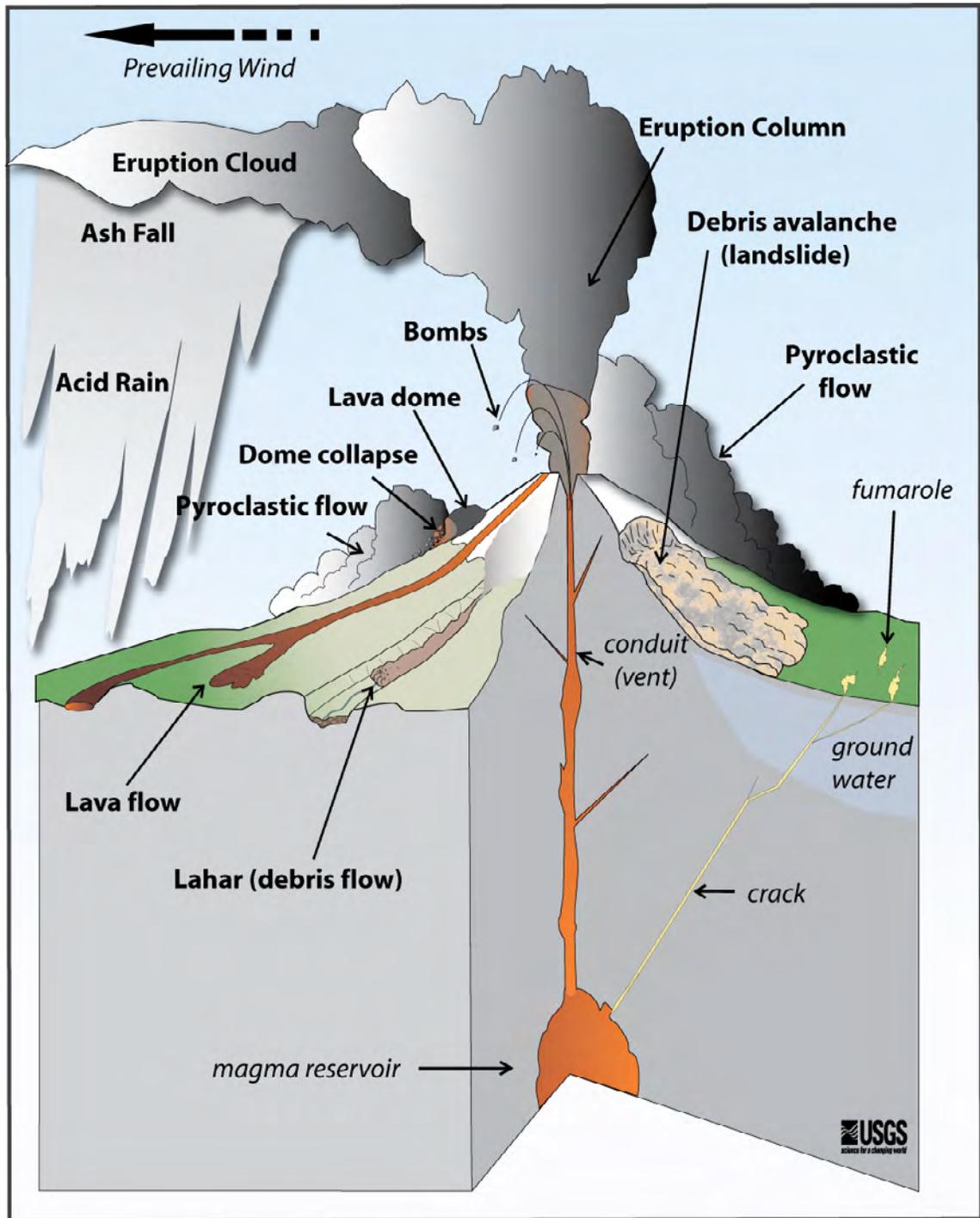
U.S. Geological Survey, 2010, Volcano Hazards Program—USGS photo glossary of volcanic terms: U.S. Geological Survey website. (Available at

<http://volcanoes.usgs.gov/images/pglossary/index.php>.)

Potential Volcanic Hazards I



Potential Volcanic Hazards I Key



Name _____ Date _____ Period _____

Potential Volcanic Hazards II

Use the volcanic hazard terms below to fill in the blanks on the *Volcanic Hazards I* figure using your library, the internet, and other resources available to you. Under each term write an example of a volcano (try to find as many in Alaska as possible!) that has produced this type of hazard and the year of that eruption.

1. Eruption cloud

Volcano _____ Year _____

2. Pyroclastic flow

Volcano _____ Year _____

3. Bombs

Volcano _____ Year _____

4. Lahar

Volcano _____ Year _____

5. Lava flow

Volcano _____ Year _____

6. Ash fall

Volcano _____ Year _____

7. Acid rain

Volcano _____ Year _____

8. Eruption column

Volcano _____ Year _____

9. Debris avalanche

Volcano _____ Year _____

Name _____ Date _____ Period _____

10. Volcanic mudflow

Volcano _____ Year _____

11. Landslide

Volcano _____ Year _____

12. Eruption cloud

Volcano _____ Year _____

Bonus: What are additional hazards not noted on this figure?

Potential Volcanic Hazards II Answer Key

Answers below are examples; there are several answers for each.

1. Eruption cloud

Volcano Redoubt (AK) Year 1989–1990

2. Pyroclastic flow

Volcano Redoubt (AK) Year 1989–1990

3. Bombs

Volcano Pavlof (AK) Year 2007

4. Lahar

Volcano Redoubt (AK) Year 1989–1990

5. Lava flow

Volcano Augustine (AK) Year 2006

6. Ash fall

Volcano Mt. Spurr/ Crater Peak (AK) Year 1992

7. Acid rain

Volcano Kilauea (HI) Year 1983–

8. Eruption column

Volcano Augustine (AK) Year 2006

9. Debris avalanche

Volcano Mt. St. Helen's (WA) Year 1980

10. Volcanic mudflow

Volcano Redoubt (AK) Year 1989–1990

11. Landslide

Volcano Mt. St. Helen's (WA) Year 1980

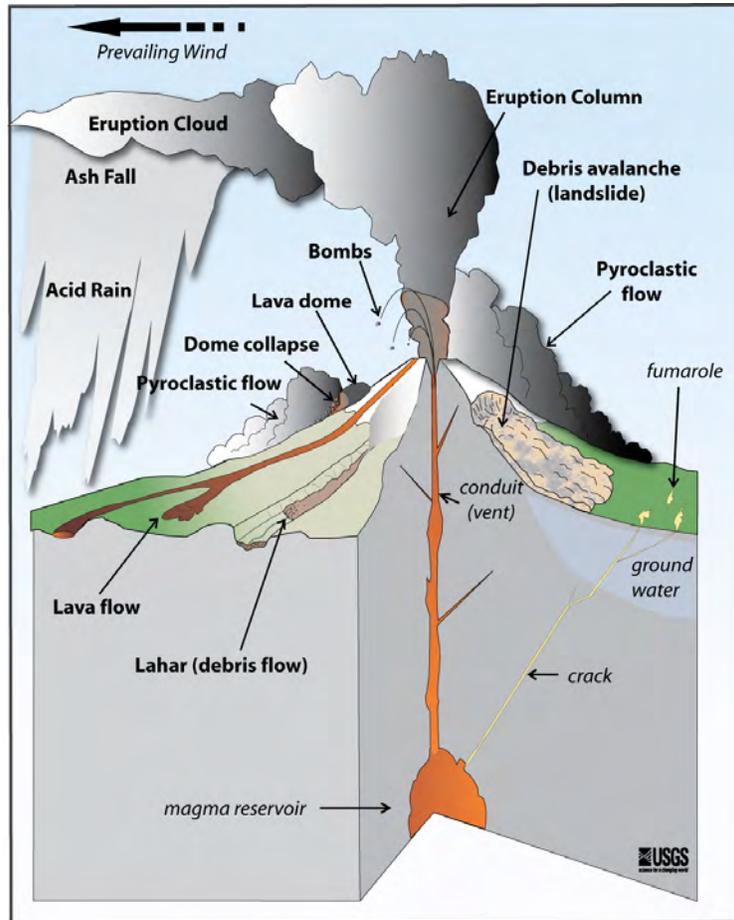
12. Eruption cloud

Volcano Mt. Spurr/ Crater Peak (AK) Year 1992

Bonus: What additional hazards are not noted on this figure?

Earthquakes, tsunamis, lava-seawater explosions

Potential Volcanic Hazards III

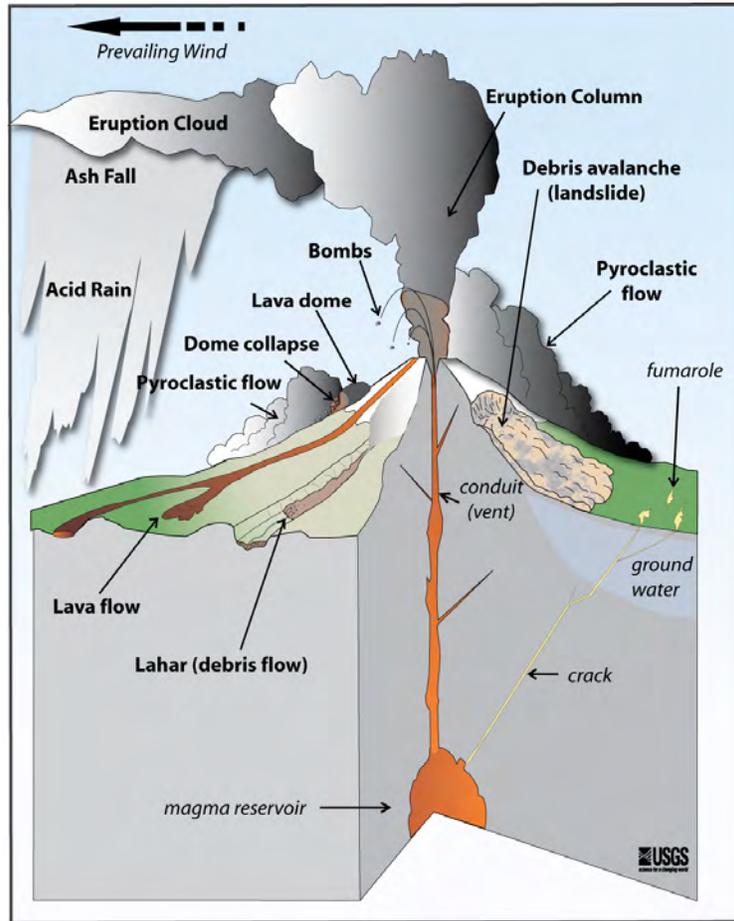


Scientists categorize volcanic hazards into two specific groups in order to generate appropriate response plans. What two groups would you select and which hazards belong in each group? Why? Be sure to include volcanic hazards that may not be in the figure.

1. _____

2. _____

Potential Volcanic Hazards III Key



Scientists categorize volcanic hazards into two specific groups in order to generate appropriate response plans. What two groups would you select and which hazards belong in each group? Why? Be sure to include volcanic hazards that may not be in the figure.

1. Proximal (on flanks, close to...) _____

Eruption column and cloud, Lava flow

Lahar, ash fall, acid rain, gasses

Pyroclastic flow

Dome collapse

Bombs

Debris avalanche, volcanic mudflow

Landslide

2. Distal (airborne, far from...) _____

Eruption cloud

Acid rain

Ash fall

Eruption column and cloud

Volcanic gasses

Tsunami

KLM Flight 867, Boeing-747 Communications with Anchorage Center on December 15, 1989

Background:

On December 14, 1989, at 9:47 AM, Redoubt Volcano began erupting with a major explosion. A Boeing-747 in route from Amsterdam flew into the ash cloud several hours after the eruption, and experienced complete engine failure. What follows is the communication between the pilot and the air traffic controller.

PILOT KLM B-747 – “KLM 867 HEAVY IS REACHING {FLIGHT} LEVEL 250⁺ HEADING 140”

ANCHORAGE CENTER - “OKAY, DO YOU HAVE GOOD SIGHT ON THE ASH PLUME AT THIS TIME?”

PILOT KLM B-747 – “YEA, IT’S JUST CLOUDY IT COULD BE ASHES. IT’S JUST A LITTLE BROWNER THAN THE NORMAL CLOUD.”

PILOT KLM B-747 – “WE HAVE TO GO LEFT NOW... IT’S SMOKY IN THE COCKPIT AT THE MOMENT SIR.”

ANCHORAGE CENTER – “KLM 867 HEAVY, ROGER, LEFT AT YOUR DISCRETION.”

PILOT KLM B-747 – “CLIMBING TO {FLIGHT} LEVEL 390*, WE’RE IN A BLACK CLOUD, HEADING 130.”

PILOT KLM B-747 – “KLM 867 WE HAVE FLAME OUT ALL ENGINES AND WE ARE DESCENDING NOW!”

ANCHORAGE CENTER – “KLM 867 HEAVY ANCHORAGE?”

PILOT KLM B747 – “KLM 867 HEAVY WE ARE DESCENDING NOW ... WE ARE IN A FALL!”

PILOT KLM B-747 – “KLM 867 WE NEED ALL THE ASSISTANCE YOU HAVE SIR. GIVE US RADAR VECTORS PLEASE!”

⁺250 = 25,000 ft above sea level (asl)

*390 = 39,000 ft asl

From: Statement of Captain Terry McVenes, Executive Chairman, Airline Pilots Association, International, Before the Committee on Commerce, Science, and Transportation Subcommittee on Disaster Prevention and Prediction, U.S. Senate March 16, 2006. Volcanic Hazards – Impacts on Aviation.

http://www.alpa.org/portals/alpa/pressroom/testimony/2006/TM_3-16-06.htm

Name _____ Date _____ Period _____

Volcanic Activity Notifications

Aviation Hazard Level	Description / Definition

Ground-based Hazard Level	Description / Definition

USGS Volcano Hazards Alert-Notification System

Volcano Alert Levels Used by USGS Volcano Observatories	
Alert Levels are intended to inform people on the ground about a volcano's status and are issued in conjunction with the Aviation Color Code. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption and about potential or current hazards and likely outcomes.	
Term	Description
NORMAL	Volcano is in typical background, noneruptive state <i>or, after a change from a higher level,</i> volcanic activity has ceased and volcano has returned to noneruptive background state.
ADVISORY	Volcano is exhibiting signs of elevated unrest above known background level <i>or, after a change from a higher level,</i> volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
WATCH	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway but poses limited hazards.
WARNING	Hazardous eruption is imminent, underway, or suspected.

Aviation Color Code Used by USGS Volcano Observatories	
Color codes, which are in accordance with recommended International Civil Aviation Organization (ICAO) procedures, are intended to inform the aviation sector about a volcano's status and are issued in conjunction with an Alert Level. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption, especially in regard to ash-plume information and likely outcomes.	
Color	Description
GREEN	Volcano is in typical background, noneruptive state <i>or, after a change from a higher level,</i> volcanic activity has ceased and volcano has returned to noneruptive background state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background level <i>or, after a change from a higher level,</i> volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, OR eruption is underway with no or minor volcanic-ash emissions [ash-plume height specified, if possible].
RED	Eruption is imminent with significant emission of volcanic ash into the atmosphere likely OR eruption is underway or suspected with significant emission of volcanic ash into the atmosphere [ash-plume height specified, if possible].

Activity II. What is the Plan?

Grade Level 6–11

Setting Classroom

Time 45–90 minutes

Correlations to Alaska State Department of Education (2006) Performance Standards (Grade Level Expectations)

A1—Science as Inquiry and Process

SA3[6-11] Students develop an understanding that cultural and local knowledge, history, and interactions with the environment contribute to the development of scientific knowledge, and that local applications provide opportunity for understanding scientific concepts and global issues.

E1—Science and Technology

SE[6-11] Students develop an understanding of the relationship among science, technology, and society.

SE1[6-11] Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to everyday events.

SE1.1[6] The student demonstrates understanding of how to integrate scientific knowledge and technology to address problems by recognizing that technology cannot always provide successful solutions for problems or fulfill every human need.

SE1.1[9] The student demonstrates an understating of how to integrate scientific knowledge and technology to address problems by recognizing that the value of any given technology may be different for different groups of people and at different points in time (e.g., different uses of snow machines in different regions of Alaska).

SE2[6-11] Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits.

SE2.1[6] The student demonstrates an understating that solving problems by involving different ways of thinking by identifying and designing a solution to a problem.

SE2.1[8] The student demonstrates an understanding that solving problems by identifying, designing, testing, and revising solutions to a local problem.

Overview

Students learn preparedness by planning for volcanic hazards, assembling a preparedness kit, learning how to protect their community, and assessing the likelihood of volcanic hazards, ash fall in particular, in their community.

Background

Federal and state officials and preparedness organizations recommend that communities prepare to “shelter in place,” meaning reliance on stored supplies of food, water, and medicine. Preparedness for volcanic hazards encompasses and instigates preparedness for other natural hazard emergencies as well.

Objectives

Students will describe recommended procedures to plan for volcanic hazards. Students will implement an emergency plan and plan a preparedness kit.

Materials

- Examples of preparedness plans and kits, including those specific to ash
 - Alaska Division of Emergency Services, [n.d.], Ash alert!: Alaska Division of Emergency Services website, accessed June 1, 2010, at http://www.ak-prepared.com/Poster_Contest_Files/Ash_Alert.pdf
 - American Red Cross and Federal Emergency Management Agency (FEMA)
 - American Red Cross, [n.d.], Disaster preparedness for people with disabilities: American Red Cross booklet, 48 p., accessed June 1, 2010, at <http://alaska.redcross.org/media/disability.pdf>.
 - American Red Cross, [n.d.], Public information—Volcanoes: American Red Cross web page, accessed June 1, 2010, at <http://alaska.redcross.org/media/volcano.pdf>.
 - American Red Cross of Alaska, 2010, Be Red Cross ready (in English, Hmong, Russian and Spanish): American Red Cross of Alaska web page, accessed June 1, 2010, at http://alaska.redcross.org/index.php?pr=Safety_Tips.
 - American Red Cross of Alaska, 2010, Volcanoes: American Red Cross of Alaska website, accessed June 1, 2010, at <http://alaska.redcross.org/index.php?pr=Volcanoes>.
 - Federal Emergency Management Agency and American Red Cross, 1991, Your family disaster plan: Federal Emergency Management Agency and American Red cross pamphlet, , accessed June 1, 2010, at <http://alaska.redcross.org/media/disasterplan.pdf>.
 - Federal Emergency Management Agency and American Red Cross, 2004, Preparing for disaster: Federal Emergency Management Agency and American Red Cross booklet, 14 p., accessed June 1, 2010, at <http://www.redcross.org/images/pdfs/preparedness/A4600.pdf>.
 - Federal Emergency Management Agency, 2009, Are you ready?—Volcanoes: Federal Emergency Management Agency website, accessed June 1, 2010, at <http://www.fema.gov/areyouready/volcanoes.shtm>

- Federal Emergency Management Agency, 2010, Ready America: Federal Emergency Management Agency website, accessed June 1, 2010, at <http://www.ready.gov/america/index.html>.
 - Federal Emergency Management Agency, [n.d.], Family emergency plan: Federal Emergency Management Agency website, accessed June 1, 2010, at <http://www.ready.gov/america/downloads/familyemergencyplan.pdf>
 - Department of Homeland Security, [n.d.], Preparing makes sense for people with disabilities and special needs: Department of Homeland Security web page, accessed June 1, 2010, at <http://www.ready.gov/america/downloads/disabilities.pdf>.
- International Volcanic Health Hazard Network (IVHHN), 2010, Durham University website, accessed June 1, 2010, at <http://ivhhn.org/>.
 - The Health Hazards of Volcanic Ash—A guide for the public PDF
http://www.ivhhn.org/index.php?option=com_content&view=article&id=55&itemid=61
 - Guidelines on Preparedness Before, During and After an Ashfall PDF
http://www.ivhhn.org/index.php?option=com_content&view=article&id=55&itemid=61
- Municipality of Anchorage, [n.d.], Emergency Management—Volcanic Ash Preparedness: Municipality of Anchorage website, accessed June 1, 2010, at <http://www.muni.org/Departments/OEM/Prepared/Pages/VolcanicAsh.aspx>.
- U.S. Geological Survey and partners, 2010, Volcanic ash ...What it can do and how to prevent damage: U.S. Geological Survey website. (Available at <http://volcanoes.usgs.gov/ash/>.)
- Washington Military Department, Emergency Management Division and U.S. Geological Survey, 1999, Volcanic ashfall—How to be prepared for an ashfall: Washington State Emergency Management Division pamphlet, accessed June 1, 2010, at http://emd.wa.gov/publications/pubed/volcanic_ash_english.pdf.

Procedure

A. Teacher set-up

1. Download and print different preparedness plans and kit literature from the sites listed. Assemble enough preparedness plans and kit literature for your students to have a wide selection to view.

B. Students review plan materials

1. Give students time to examine the variety of different preparedness plans and kit literature that you made available.

2. Have your class discuss the limitations on transportation into and out of their community and the possible difficulties with communications in the community during ash fall. In many rural communities, radios are used instead of telephones and air travel is very limited. Cell phone service could be hampered during an ash fall or any associated emergencies. Boat travel may be the only way to leave or approach certain marine communities. Some communities may receive emergency warning messages only by marine band radio due to poor or limited television broadcast services. Ask students to remember these concerns as they proceed through the activity.

C. Students generate plans

1. Using the examples as a guide, ask students to identify the necessary components of a preparedness plan for their community. Instruct students to generate an emergency plan for their family and to include all the identified necessary components. Students can incorporate any unique transportation and communications issues into their plans. Advise students to identify special situations that require additional thought and planning, such as care of people with disabilities, the elderly, and pets.
2. Suggest to your students that they carry out their plan as a training exercise with their family. Advise students to test the phone numbers (or radio messages) and other resources that they have gathered and put the phone numbers and other resources in their plans.
3. Using the examples as a guide, students can determine the necessary components of a preparedness kit.

Extensions

1. Have the students list all the available components of preparedness kit and gather all the needed supplies, if possible. One way to do this with limited financial impact is to purchase one item at a time during the family's standard shopping trip or order. Here is an example using this concept:
 - Alaska Division of Homeland Security and Emergency Management, [n.d.], Homeland security and emergency preparedness 7 day survival kit: Alaska Division of Homeland Security and Emergency Management brochure, 4 p., accessed June 2, 2010, at <http://ready.alaska.gov/outreach/DHSEM%207%20Day%20Survival%20Kit.pdf>.
2. Instruct students to develop a plan and kit for their classroom, school and (or) workplace.
3. Have students develop a plan and kit for someone in the community, a business or a local organization.

4. Have students explore opportunities to assist their community's emergency responders in the event of an emergency. Resources include
 - Citizen Corps, [n.d.], About Citizen Corps: Federal Emergency Management Administration website, accessed June 2, 2010, at <http://www.citizencorps.gov/>.
 - Learning for Life, 2005, Exploring (age 14 and completed 8th grade through 20 years old): Learning for Life website, accessed June 2, 2010, at <http://www.learning-for-life.org/exploring/index.html>.

Reference Cited

Alaska State Department of Education and Early Development, 2006, Standards and grade level expectations, March 2006: State of Alaska website, accessed October 2009 at <http://www.eed.state.ak.us/tls/assessment/GLEHome.html>.

Modified from

Driedger, C.L., Doherty, Anne, and Dixon, Cheryll, 2005, Living with a volcano in your backyard—An educator's guide with emphasis on Mount Rainier: U.S. Geological Survey General Interest Product 19; produced in cooperation with the National Park service. (Available at <http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/>.)

- Chapter 3: Don't be scared—Be prepared!
http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_three_dont_be_scared.pdf.

Activity III. Volcanic Ash Fall in Your Community

Grade Level 6—11

Setting Large (non-carpeted) classroom, gym, or outside

Time 90—150 minutes

Correlations to Alaska State Department of Education (2006) Performance Standards (Grade Level Expectations)

D1—Concepts of Earth Science

SD[6-11] Students develop an understanding of the concepts, processes, theories, models, evidence, and systems of earth and space sciences.

SD2[6-11] Students develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth.

SD2.3[6] The student demonstrates an understanding of the forces that shape Earth by describing how the surface can change rapidly as a result of geological activity (e.g., earthquakes, tsunamis, volcanoes, floods, landslides, avalanches).

E1—Science and Technology

SE[6-11] Students develop an understanding of the relationships among science, technology, and society.

SE1[6-11] Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events.

Overview

By simulating an ash-rich volcanic eruption on a model community of their own design, students will learn firsthand about the affects of volcanic ash fall on a community, and how preparedness and planning by a community may lessen the affects of ash fall.

Background

The most common and widespread hazard in the event of a volcanic eruption in Alaska is volcanic ash fall. Volcanic ash is electrically conductive, corrosive, abrasive, and heavy, especially when wet. Airborne volcanic ash can travel hundreds of miles before falling to the ground. Two sources of information are:

- U.S. Geological Survey and partners, 2010, Volcanic ash ...what it can do and how to prevent damage: U.S. Geological Survey and partners website. (Available at
 - Ash properties & dispersal by wind
<http://volcanoes.usgs.gov/ash/properties.html> and
 - What's it like during and ash fall?
<http://volcanoes.usgs.gov/ash/ashfall.html>.)

Objectives

Students will construct a model community and subject it to an ash fall. Students will observe the relation between particle size and distance traveled. Students will evaluate their community and determine changes that should be made when considering the ash fall scenario.

Materials

— *Volcanic Ash Fall in Your Community* worksheets

Simulated ash fall (enough for multiple groups)

- soil, sand, dirt, rice, flour, dry oatmeal—roughly 4 cups (~950 mL) each of four types of dry goods (preferably varying in color and particle size)
- 1/8 of a cup (~30 mL) measuring cups
- fans and (or) blow dryers
- brush or broom, dust pan and brush
- meter sticks or tape measures

Community building (not all materials are necessary, but a good variety is beneficial)

- table cloths, butcher paper, easel paper, or tarps, at least 1.5 x 1.5 m (~5 x 5 ft) to serve as base
- colored markers or paints (and associated brushes and water containers for rinsing)
- newspaper
- shallow plastic bowls
- masking or duct tape
- thimbles
- small measuring cups (like for liquid medicine)
- board game pieces
- spray bottles with water
- board game objects
- tooth pick, popsicle stick or cardboard structures

Procedure

A. Constructing a model community

1. Divide students into manageable groups. Each group will create an Alaskan community using the materials provided. Students must draw a 2.5 x 2.5 cm (1 x 1 in.) grid on their base (or use a checkered picnic/table cloth. Each square represents 1 km² (0.4 mi²) in the simulation and calculations.
2. Students need to have a “volcano” on the perimeter of their region, designated by a 15 cm (~6 in.) radius semicircle on one side (if the base is not square, the volcano should be on one of the two shorter sides).
3. Students can consider making topography (mountains and basins) using wadded up newspaper, plastic bowls (convex or concave), thimbles, or other supplies available. These may be placed on top of or underneath the base for the desired effect.

4. Make sure the base material and structures (tarp, butcher paper, and so on) are taped down (or adhered any other way) to the surface. The goal is for the structures to be affected by the ash fall, not blown away the wind!
5. Students can draw a map view (from the perspective of looking straight down) of their community in the space provided on the *Volcanic Ash Fall in Your Community* worksheet

B. *Eruption! and Ash Fall in Your Community* worksheet

1. Each group can gather their worksheet, wind sources (fan, blow dryer, or other device), markers, meter stick (or tape measure), 1/8 cup (~ 30 mL) measuring cup, and ~ 1 cup (~ 240 mL) each of the four types of dry goods or soil-like substances as ash simulators.
2. Have students place or hold the wind sources at the edge of the “volcano.” Box fans can stand on the ground. Shorter fans or blow dryers should be held at roughly waist level.
3. Have students turn the wind source on, using the lowest setting. Have another student gently sprinkle 1/8 cup (~30 mL) of one ash simulator in front of source of wind to release it into the wind. Make sure students begin with the smallest particle-size ash simulator, then the next smallest, until the last sample used is the one with the largest particle size. *Note* Students need to turn the fan off between the releases of each ingredient. Measurements of each “ash” fall are made while the fan is off. Students can relocate their hand to the same position relative to the fan each time.
4. Students will use a marker to outline the concentrated area of the deposit where most of the “ash” fell.
5. Students will measure the furthest distance traveled by each ingredient. Remind students that the side of each square equals 1 km and to record the results in the space provided on the worksheet.
6. Students will count the number of squares that are covered by each ingredient, determine the area covered, and record the results in the space provided on the *Volcanic Ash Fall in Your Community* worksheet.
7. Have students repeat the steps until all ash simulators have been tried.
8. When students finish the experiment, ask each group to look at the other groups’ communities and answer the questions on the *Volcanic Ash Fall in Your Community* worksheet before clean up.
9. Reassemble the class and review the answers to the questions.

Extensions

1. Have students use AVO's Ash Collection Instructions by simulating ash fall using soil, sand, dirt, rice, flour, and (or) dry oatmeal. If you are using a human food item, please do not do this activity outside because the remaining food items left will become an attractant for wildlife.
 - Alaska Volcano Observatory, [n.d.], Procedures for collecting and returning ash samples from modern volcanic eruptions: Alaska Volcano Observatory web page. (Available at <http://www.avo.alaska.edu/ashfall.php>.)
2. Change the wind direction by setting the fan at an angle to the paper.
3. Add wind shear by using multiple wind sources at different heights above the volcano. Be sure the "ash" falls in front of both sources of wind.

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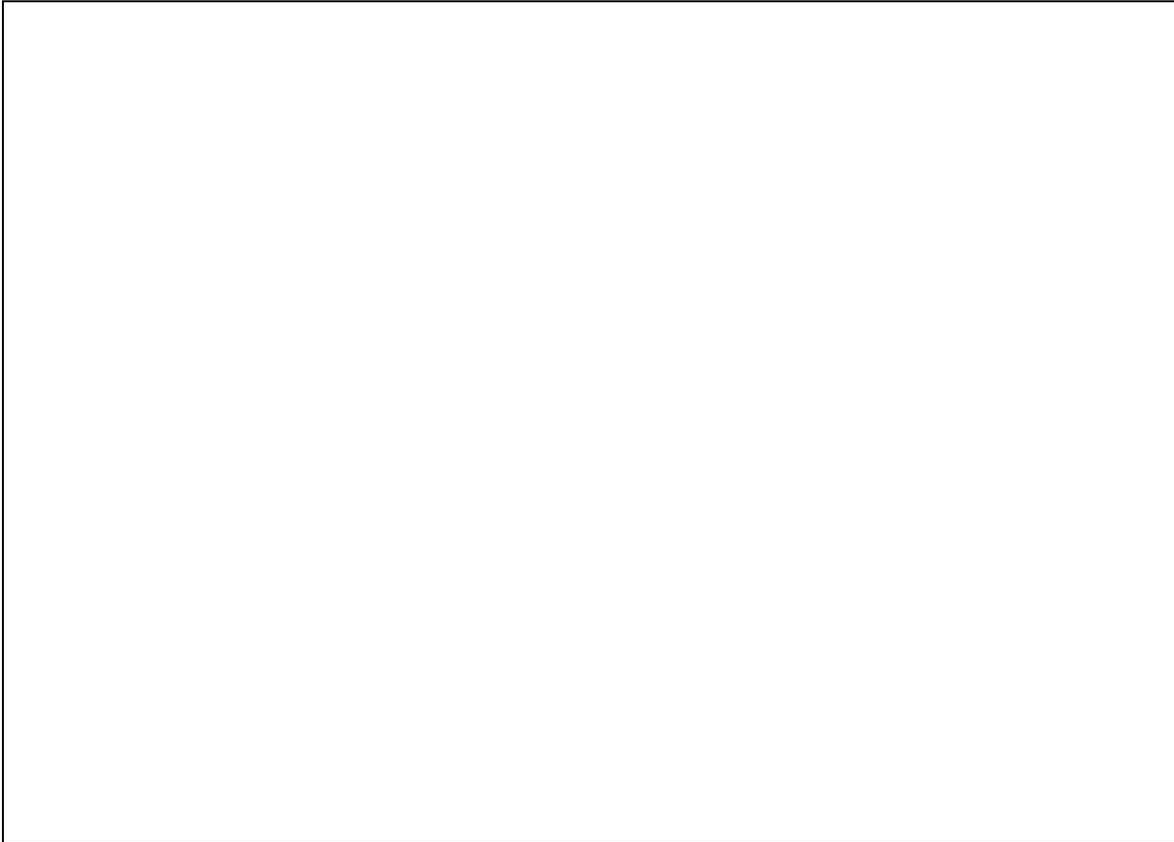
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Name _____ Date _____ Period _____

Volcanic Ash Fall in Your Community

Build Your Community

1. Create an Alaskan community using the materials provided.
2. Draw a 2.5 x 2.5 cm (1 x 1 in.) grid on your base. Each square represents 1 km² (0.4 mi²) in the simulation and calculations.
3. Include a volcano on the perimeter of your community. Designate the volcano by drawing a 15 cm (~6 in.) radius semicircle on one side of your base. If your base is not square, draw the volcano on one of the shorter sides of your base.
4. Make topography (mountains and basins) using wadded up newspaper, plastic bowls (convex or concave), thimbles, or other supplies under or on top of your base. These may be placed on top of or underneath the base for the desired effect.
5. Make sure the base material and all structures are taped or adhered to the surface.
6. Draw a map-view of your community below.



Volcanic Ash Fall in Your Community

Volcanic Ash Fall

1. Gather your wind sources (fan, blow dryer...), markers, meter stick (or tape measure), 1/8 cup (~30 mL) measuring cup and ~ 1 cup (~ 240 mL) each of the four types of dry goods or soil-like substances for ash simulators.
2. Place or hold your wind sources at the edge of the “volcano.” Box fans can stand on the ground. Shorter fans or blow dryers should be held at roughly waist level.
3. Turn on the wind source to low. Gently sprinkle 1/8 cup (~30 mL) of one ash sample in front of source of wind to release it into the wind towards your community. Begin with the smallest particle size sample, then the next smallest, until the last sample used is the one with the largest particle size. Turn off the fan and make the designated measurements between the releases of each ash sample.
4. Use a marker to outline the concentrated area of the deposit where most of the ash fell.
5. Measure the farthest distance traveled by each ash. Remember the side of each square equals 1 km. Record the results in the table below.
6. Count the total number of squares that are covered by each ingredient, determine the area covered, and record in the table below.
7. Relocate your hand to the same position relative to the fan each time. Repeat until all ash samples have been tried.
8. Look at the other groups’ communities before clean up.

Ash sample	Farthest distance traveled km (mi)	Number of squares covered or mostly covered by deposit	Area covered by deposit km ² (mi ²)

