To All Aspiring Volcanologists!

We need your feedback on these do-it-yourself instructions. If you build the "exploding" flour volcano and let us know how it went (and any improvements in the instructions or design) by July 31, 2012, we will add your name and your class or school's name to the acknowledgements section of this Open File Report.

Thank you!

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An Erupting Flour Volcano: Step-by-Step Instructions to Create an Engaging Demonstration Model of Volcanic Processes

By Liz Westby, Dina Venezky, Joel Robinson, and Carolyn Driedger

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An Erupting Flour Volcano: Step-by-Step Instructions to Create an Engaging Demonstration Model of Volcanic Processes

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Introduction

Magmatic gases drive explosive volcanic eruptions. Below the Earth's surface, the weight of overlying rock (or pressure) keeps gases dissolved in magma. As magma begins to rise, the pressure is reduced and gases expand. The expanding gases in the magma have enough force to crack the surrounding wall rocks that provides magma with a pathway to the surface. When a gas-rich volcanic explosion occurs, rocks are blown apart and a dense cloud of pyroclastic fragments including fine ash particles, shoots into the air. Larger, more dense fragments typically fall to the ground accumulating near the volcanic vent. The fine particles are driven upward into the volcanic plume's umbrella region, where the density of the plume equals the density of the surrounding air. The plume can be pushed by the prevailing wind direction and particles may travel a great distance from the volcano.

By examining volcanic deposits -- the size of fragments and how far they traveled from the vent, volcanologists gain a greater understanding of the eruption dynamics, even for volcanoes that have erupted in the past. This knowledge aids in the assessment of the different types of hazards for people and communities located near volcanoes.

Inventors Dina Venezky and Joel Robinson created the "erupting flour volcano" to demonstrate explosive volcanic processes. After filling the demonstration model with a mixture of fine and coarse material, a bicycle pump is used to increase the gas pressure within the system through compression. By turning a lever, kinetic energy sends the eruptive products skyward. At the height of the erupting ash column (the umbrella region of the of the volcanic plume), kinetic energy derived from the gas thrust is converted to potential energy as particles reach their maximum height. The material then begins to fall to the ground, converting the potential energy to kinetic energy (Figure 1).

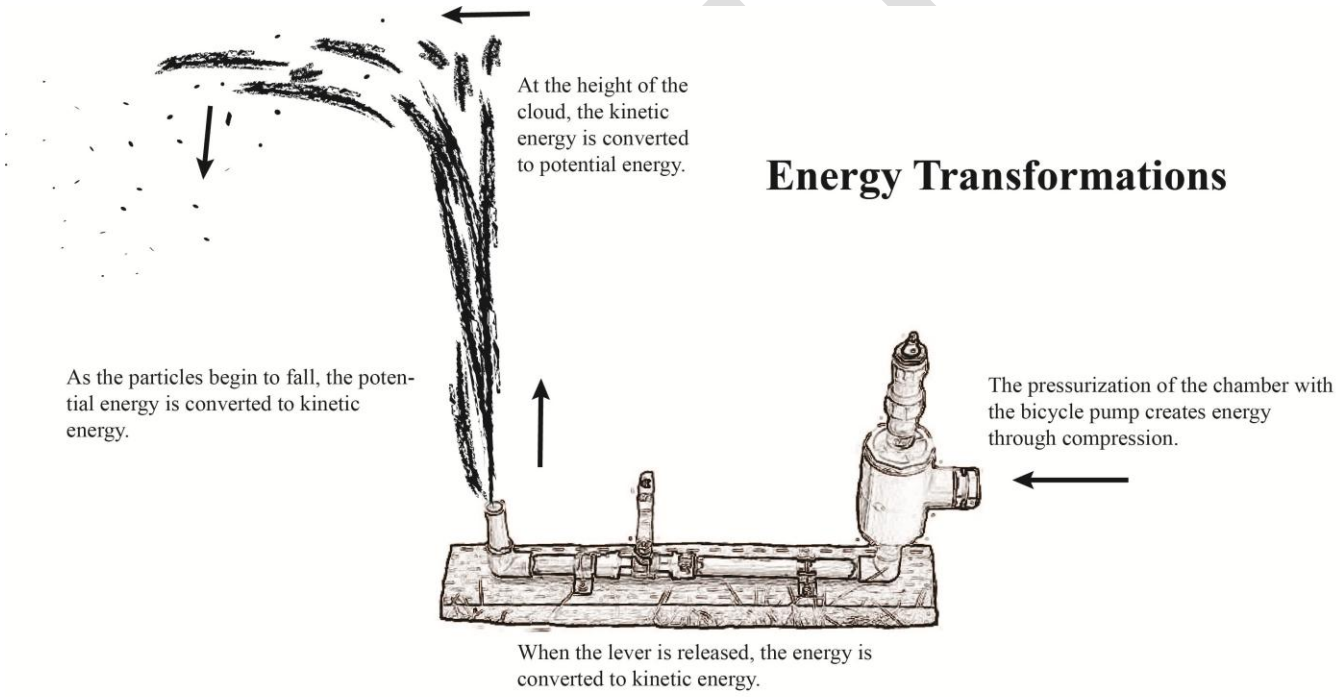

Figure 1. The model demonstrates how energy is transformed during the course of an explosive eruption.

Coupled with an interactive discussion, this demonstration model has been successfully used in school groups and adult settings to demonstrate:

- Magmatic gases drive explosive eruptions;
- The sudden release of pressure produces an explosive eruption;
- Energy is transformed during an explosive eruption;

- Coarse material will fall to the ground before fine-grained material and volcanic deposits will be progressively thinner and finer-grained with increasing distance from the volcanic vent;
- Wind influences the dispersion pattern of eruptive material; and
- The most recent eruptive material covers older deposits.

Instructions for Creating a Demonstration Model

Materials to Assemble

These simple instructions show how to construct a model of a subsurface volcanic system and vent as shown in 0.

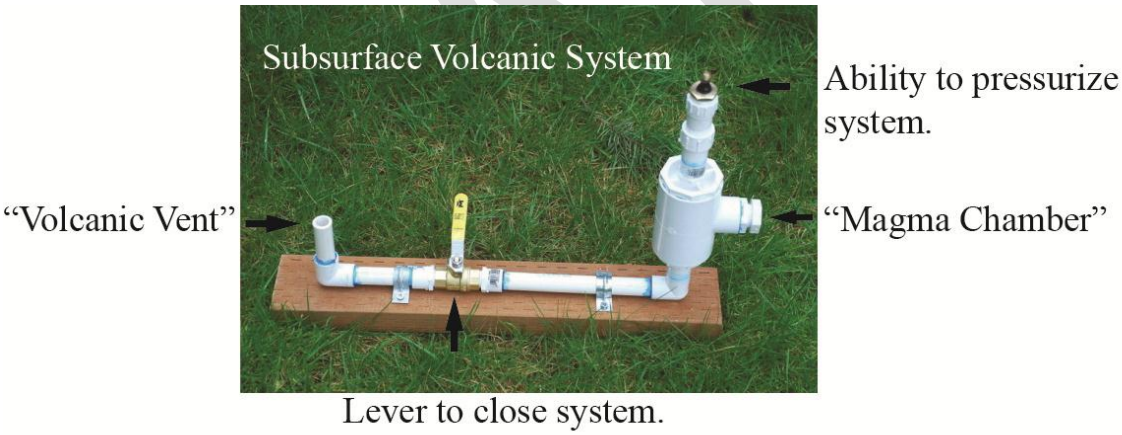

Figure 2.The simple, step-by-step instructions show how to construct this demonstration model illustrating how a pressuring magmatic system can produce an explosive eruption with far-ranging volcanic deposits.

The materials and supplies to construct this demonstration model are listed in Table 1. The supplies are generally available at plumbing, hardware, or home improvement stores. Substitutions may be made for the parts with satisfactory results; consult local plumbing or home improvement store representative for

more information. Once the materials are acquired, it will take approximately two- to four-hours to build the model.

Table 1. Materials and supplies required to construct the exploding flour volcano demonstration model.

Quantity	Size	Description	Photo (Not to Scale)
18.5 inches (total)	½ inch nominal pipe size (Schedule 40)	PVC pipe, cut into 5 smaller segments of 1.5, 1.5, 3, 4, and 8.5 inches.	
3	½ inch	PVC Male Adapters	
1		RV Blow Out Plug	
1	¾ x ¾ inch	PVC Swivel Connector [for Garden Hose]	
1	¾ x ½ inch	PVC Female Adapter	
1	2 x ½ inch	PVC Reducer Bushing	
1	2 x 2 x 1 inch	PVC Slip T	
1	1 x ¾ inch	Reducer Bushing	
1	¾ inch	Threaded PVC Plug	
1	2 x ¾ inch	PVC Reducer Bushing	
1	¾ x ½ inch	Reducer Bushing	
2	½ inch	90° "Ell" Joints	
1	½ inch	Threaded Ball Valve	
2	½ inch	Galvanized Straps	
4	#10 x 1 ¼	Wood Screws	

Table 1. Materials and supplies required to construct the exploding flour volcano demonstration model.

Quantity	Size	Description	Photo (Not to Scale)
1	20 inches	2x4 Lumber	
1	Container	PVC Cement (PVC Primer may be required. Follow instructions on PVC cement label.).	
1 roll	½ inch	Plumber's Pipe Tape	

Also required for the demonstration is a bicycle pump with an air pressure gauge, crescent wrench, and approximately one cup of dry "eruptive product," such as 2/3 cup flour and 1/3 cup small birdseed, or other combination of both fine and slightly coarse materials.

Step-by-Step Directions

The demonstration model can be constructed on a medium-size table top. The assembly area should be well lit and well ventilated. Use proper safety equipment when cutting the PVC pipe segments and always follow safety instructions listed on the PVC product labels.

1. Prepare the pieces.

   Cut the ½-inch PVC pipe into the following 5 pieces:

   - 1 segment 3-inches in length;
   - 1 segment 4-inches in length;
   - 1 segment 8.5-inches in length;
   - 2 segments 1.5-inches in length.

Remove any dirt and file down burrs from both ends of the PVC pipe segments to make it easier to cement into the fittings (0).

Figure 3. Clean and gently file the ends of the five PVC pipe segments to remove dirt and burrs, making it easier to cement into the fittings.

2. Lay out the pieces.

After cutting and preparing the PVC pipe segments, lay the pieces on a flat surface in the way they will be assembled. This will ensure that you have all of the pieces required to construct the demonstration model (0).

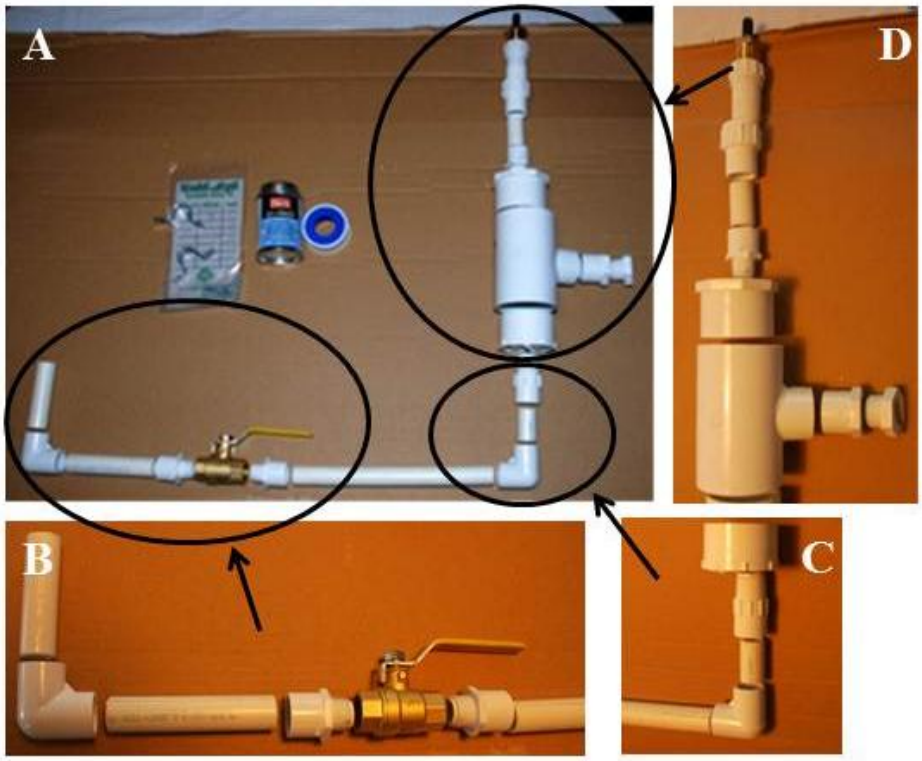

Figure 4. On a flat surface, lay out the pieces as they will be assembled (A). Photographs (B), (C) and (D) provide greater detail for the sections in the encircled areas.

Beginning with the left side of the demonstration model (0 (B)), lay out the 3-inch PVC pipe segment, the 90° Ell Joint, the 4-inch PVC pipe segment, the PVC Male Adaptor, the Threaded Ball Valve, the second PVC Male Adaptor, and the 8.5-inch PVC pipe segment. Continue the assembly process (0 (C)) by laying out the second 90° Ell Joint, a 1.5-inch PVC pipe segment, the third Male Adaptor, the 2 x ½ inch Reducer Bushing, and T Slip. To the right of the T Slip, lay out the 1 x ¾ Reducer Bushing and PVC Plug (0 (D)). At the top of the T Slip, lay out the 2 x ¾ Reducer Bushing, Male Adaptor and 1.5-inch PVC pipe segment, the PVC Female Adapter, PVC Swivel Connector and RV Blow Out Valve. At this point, all the pieces are assembled and ready to be cemented into place.

3. Cement the pieces.

Read and follow the instructions and safety recommendations on the PVC cement container and use only in a well-ventilated area. For a better hold and longer lasting seal, first apply a light coat of

PVC primer to soften the pipe surface. Apply the cement to the pipe and fittings while the primer is still wet in order to achieve maximum bonding strength. Note that the cement dries quickly so work with one segment of PVC pipe and one fitting at a time. Most manufacturers recommend that their cements be applied in temperatures between about 40 degrees and 90 degrees Fahrenheit.

Begin with the left side of the demonstration model (as shown in 0 (B)), the 3-inch PVC pipe segment and the 90° Ell Joint. Apply primer, if required or desired. Using the round ball applicator, apply cement to the inside of the fitting, about ½-inch from the end, covering the area completely but avoiding over-application and puddling inside the fitting. Set the fitting aside. Using this same technique, apply a coat to the PVC pipe segment (0). Assemble the two pieces QUICKLY, while the cement is still wet. Push the PVC pipe into the Ell Joint, using a quarter-turning motion until the pipe can no longer be inserted. Hold the PVC pipe and fitting together for 30 seconds and then wipe off any excess cement outside the fitting.

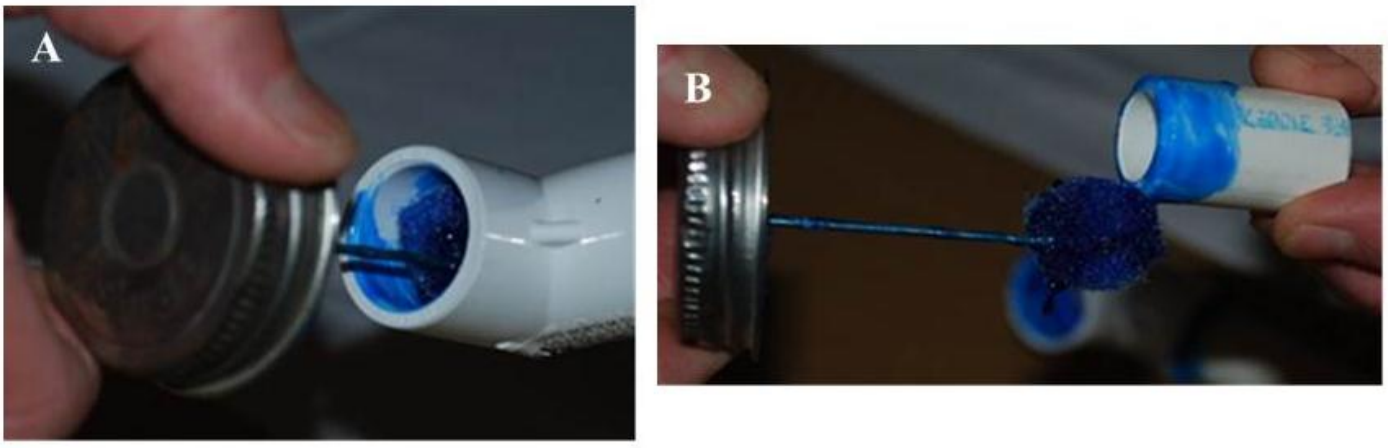

Figure 5. Using the ball applicator, apply the PVC primer (if required) and then apply cement to the inside of the fitting and pipe segment about ½-inch from the end. Apply an even coat and avoid puddling or over application. Assemble quickly. While firmly holding the pipe and fitting, wipe off the excess cement with a paper towel.

Working systematically from left to right on the demonstration model shown in 0, continue the same cementing procedures to attach the remaining pieces. Specifically, apply PVC primer and then cement to the two pieces just joined with the 4-inch PVC pipe segment. Cement this assembly to the

PVC Male Adaptor. Do NOT apply cement to the threads of the Male Adaptor or the Threaded Ball Valve. These pieces will be screwed together later. Set this assembly aside.

Continue the same cementing procedures to cement the second PVC Male Adaptor and the 8.5-inch PVC pipe segment (0(C)). Cement this assembly to the second 90° Ell Joint. Cement this assembly to the 1.5-inch PVC pipe segment. Cement this assembly to the third Male Adaptor. Cement this assembly to the 2 x ½ inch Reducer Bushing. Cement this assembly to the T-Slip.

At this point, cement the T-Slip and 1 x ¾ Reducer Bushing (0).

Figure 6. Cement the T-Slip and threaded 1 x ¾ Reducer Bushing.

Cement the T-slip to the third Male Adaptor. Cement this assembly to the 1.5 inch PVC pipe segment. Cement this assembly to the PVC Female Adapter.

The cementing of the PVC pipe and fittings for the demonstration model should now be completed. Curing times for the newly cemented pieces will vary by the cement manufacturer and by climate. Most recommend a minimum of 10 minutes. For this model, the cemented joints were allowed to set for 24-hours before the demonstration test.

4. Wrap and join the threaded sections.

Using the Plumber's Pipe Tape, wrap all of the threaded sections. Firmly hold the end of the tape on the fitting to get it started. Applying a light tugging tension, wrap in the direction that the threads will turn when connecting the pieces, typically clockwise (0(A)). Cover the threads with a single wrap of tape. Firm the tape with each wrap it so it goes into the threads (0(B)). The tape will help to seal the threaded sections tightly and maintain pressure within the system.

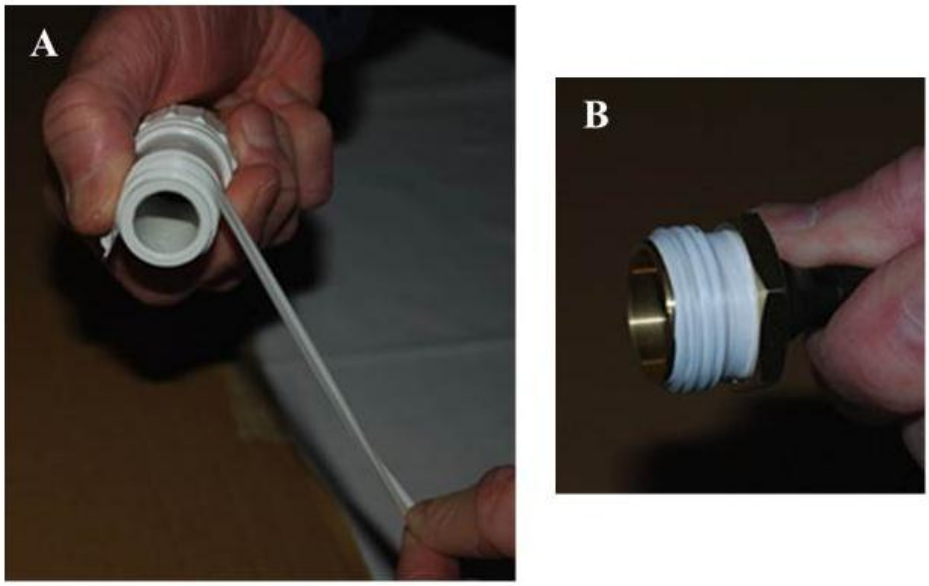

Figure 7. While holding one end firmly to the fitting and applying a light tension, wrap the Plumber's Pipe Tape in a clockwise direction (A), firming the tape with each wrap (B).

After wrapping the threads of the Blow Out Valve, screw the valve into the PVC Swivel Connector. After wrapping the threads of the PVC Swivel Connector, screw it onto the PVC Female Adaptor. After wrapping the threads the PVC Male Adaptor, screw it onto the T Slip.

Wrap the remaining two PVC Male Adaptors and screw it into the Threaded Ball Valve (0). A crescent or pipe wrench may be used to make the Threaded Ball Valve fitting tight. Take care not to overstress the glued joints. Make sure that the entire assembly looks like the one in the original photo (0) and that the pieces have not been over-rotated during the cementation or threading process. At this point, everything should be connected.

Figure 8. After wrapping the threads of the PVC Male Adaptor (left), screw into the Threaded Ball Valve (right). A wrench may be used to tighten the fitting. Avoid overstressing the glued joints or over-rotating the assembly.

5. Securely mount the volcano on the 2 x 4 lumber.

Align the assembled volcano on the centerline of the 2 x 4 lumber. The galvanized straps should be placed approximately 3- to 4-inches from each end of the volcano to hold down the PVC pipe segments. Screw the straps to the lumber (0).

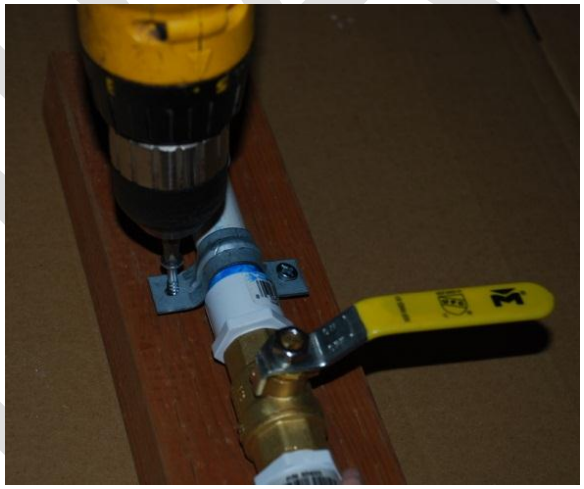

Figure 9. Use screws to securely mount the volcano onto the 2 x 4 lumber using the galvanized straps.

Using the Demonstration Model

The demonstration will result in a plume of eruptive products that bursts from the PVC pipe and rises as much as 4-meters (12-feet) into the air with the fine material spreading over a wide area. Do not

do this activity indoors. Ask observers to keep a safe distance during the eruption; eye protection is recommended.

To demonstrate, close the lever on the Threaded Ball Valve. The closed position will be with the handle of the Threaded Ball Valve perpendicular to the PVC pipe (0 shows a closed valve with the handle in the correct position). Tilt the volcano on its side. Using a funnel or other device, loosely fill the T-Slip with a mixture of fine and coarse dry material. It is not necessary to pack the material into the T-Slip. In 0, the T-Slip is filled with a mixture of 2/3 flour and 1/3 small birdseed.

Figure 10. Tilt the volcano on its side and loosely fill the T Slip with eruptive products, such as a mixture of 2/3 cup flour and 1/3 cup birdseed.

Screw the ¾-inch Threaded PVC Plug into the T Slip. A crescent or pipe wrench is useful to maintain a tight seal (0). Do not over tighten.

Figure 11. Tighten the Threaded PVC Plug to the T Slip with a crescent or pipe wrench.

Attach the bicycle pump to the RV Blow-Out Plug (0) and pressurize the system to 60 psi. **Do not over pressurize** as the cemented joints may begin to fail and the system will develop leaks.

Figure 12. Attach the bicycle pump to the RV Blow Out Plug and pump up the system to 60 psi. **Do not over pressurize** or the cemented joints may develop leaks. Before conducting the demonstration remind onlookers to stand back 4-meters (12-feet) and warn them to watch out for airborne particles.

The volcano is now ready. To release the pressure and observe the eruption, turn the lever on the Threaded Ball Valve so that it is in-line with the PVC pipe. The fine and coarse material will immediately burst from the end of the PVC pipe segment and rise into the air (0). The coarse, heavier material (birdseed) will fall quickly near the volcano. The fine material (flour) will drift in the same direction as the wind. Once the eruption is complete, it is possible to create a map of the deposits by locating the boundaries of where the flour and birdseed fell. This area can be measured with a tape measure and plotted on graph paper to compare how far the birdseed traveled to how far the flour traveled. Wind direction and speed should also be noted because they will affect the outcome.

Some of the fine and course material will not erupt on the first attempt. By pumping up the system again, it is generally possible to conduct the demonstration several times before re-filling the chamber. Remember, always conduct the demonstration in a safe manner.

Figure 13. The erupting flour volcano will produce an eruption rising as much as 4-meters into the air, demonstrating how gases drive explosive volcanic eruptions.

Acknowledgements

Special thanks to the following for their assistance in preparing these step-by-step instructions:

Clinton Stellfox, Pacific Science Center, Seattle, Washington

Arron Steiner, Instructor, Portland State University

Appendix

For more information on volcanoes, plus additional activities and experiments for students, see General Information Publication 19, *Living with a Volcano in Your Backyard,* available at http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/.

More information regarding volcanic gases and their effects is available at the U.S. Geological Survey Volcano Hazards Program, *http://volcanoes.usgs.gov/hazards/gas/index.php*.