ACTIVITY 7 — MONITORING ACTIVE VOLCANOES

Background Information

From the most fundamental standpoint, volcanoes develop because large masses of magma produced deep in the Earth, in the upper mantle or lower crust, rise upward buoyantly, being less dense than surrounding rock. Sometimes the magma does not make its way all the way up to the Earth's surface, because it encounters rock that is less dense than the magma, or because the strength of overlying rock arrests its upward movement. The magma then cools slowly at depth, to form coarse-grained intrusive bodies called plutons, rather than being extruded onto the land surface or ejected explosively. Why volcanoes erupt episodically, usually with long time intervals between eruptions, rather than continuously or semicontinuously, is not well understood. Even less well understood is what controls the timing of volcanic eruptions. Intervals between eruptions of some volcanoes are measured in years or decades, but also in centuries or millennia in others. The need for good understanding of the effects that presage a volcanic eruption, and the development of effective techniques for monitoring such effects, is obvious.

Techniques for predicting volcanic eruptions are generally better than those for predicting major earthquakes. Careful monitoring of volcanoes known to have been active in the past can provide a good indication of an impending eruption, although pinning down the occurrence of an eruption is still fraught with uncertainty. The principal effects that volcanologists monitor to aid in predicting volcanic eruptions are seismicity, changes in topography of the land surface, and emission of volcanic gases from fissures and vents.

From: Wright and Pierson, 1992, *Living with Volcanoes*, The U.S. Geological Survey's Volcano Hazards Program: U.S. Geological Survey Circular 1073

Seismicity — Earthquakes commonly provide the earliest warning of volcanic unrest, and earthquake swarms (unusually large numbers of earthquakes in a brief interval of time in some region) immediately precede most volcanic eruptions. Most of theses earthquakes are relatively minor, but they are easily detected on seismograms.

Ground Movements — Geodetic networks are set up to measure the changing shape of the volcano surface caused by the pressure of magma moving underground. Techniques commonly used include electronic distance measurement using a laser light source (EDM); measurement of tilt, both electronically and by repeated leveling of triangular arrays; and standard leveling surveys to obtain elevation changes. Additionally, very simple and inexpensive techniques, like measuring crack openings using a steel tape, or noting changes in water level around a crater lake, have proven useful in certain situations. Upward and outward movement of the ground above a magma storage area commonly occurs before eruption. Localized ground displacement on steep volcanoes may indicate slope instability precursory to mass failure, or cause steep slopes to become unstable and lead to mass

movements like rockfalls or landslides, in which small or large masses of Earth and rock become dislodged and slide or fall downslope.

Geophysical Properties — Changes in electrical conductivity, magnetic field strength, and the force of gravity can also be caused by magma movement. These measurements may respond to magma movement even when no earthquakes or measurable ground deformation occurs.

Gas Geochemistry — Changes in the flow rate or composition of gases emitted from fumaroles (holes or vents on a volcano's surface, out of which volcanic gases are emitted), or in the emission rate of SO_2 and other gases, may be related to variation in magma supply rate, change in magma type, or modifications in the pathways of gas escape induced by magma movement. These latter changes are common precursors to an eruption.

Hydrologic Regime — Changes in groundwater temperature or level, rates of streamflow and transport of stream sediment, lake levels, and snow and ice accumulation are recorded to evaluate (1) the role of groundwater in generating eruptions, (2) the potential hazards when hot, energetic volcanic products interact with snow, ice, and surface streams, and (3) the long-term hazard of infilling of river channels leading to increased flood potential.

- Volcano Monitoring Techniques at USGS web site.
- Volcano Monitoring Techniques at Volcano World.
- Volcano Monitoring Techniques (an excellent site for students to learn more about the types of instruments and methods for their designs).

For further background information about volcano monitoring techniques, visit the *EarthComm* web site to find links to several sites that contain excellent illustrated texts. Visiting these sites and learning more about monitoring techniques will help you to think about the kinds of simple materials you could have available in your classroom for students to use to develop models of instruments. You may want to arrange for your class to have access to the Internet for further research on instrumentation, or print out material for groups to review while doing their work. However, remember that any time you provide information and illustrations to students, you eliminate some of the creativity and thought that they would have put into thinking about the problem and developing an instrument based upon their understanding of the situation.