VOLCANO HAZARDS FACT SHEET

U.S. Department of the Interior
U. S. Geological Survey

Volcanic Gas

In Roman mythology, Vulcan, the god of fire, was said to have made tools and weapons for the other gods in his workshop at Olympus. Throughout history, volcanoes have frequently been identified with Vulcan and other mythological figures. Scientists now know that the "smoke" from volcanoes, once attributed by poets to be from Vulcan's forge, is actually volcanic gas naturally released from both active and many inactive volcanoes.

The molten rock, or magma, that lies beneath volcanoes and fuels eruptions, contains abundant gases that are released to the surface before, during, and after eruptions. These gases range from relatively benign low-temperature steam to thick hot clouds of choking sulfurous fume jetting from the earth.

Water vapor is typically the most abundant volcanic gas, followed by carbon dioxide and sulfur dioxide. Other volcanic gases are hydrogen sulfide, hydrochloric acid, hydrogen, carbon monoxide, hydrofluoric acid, and other trace gases and volatile metals. The concentrations of these gas species can vary considerably from one volcano to the next.

WHY STUDY VOLCANIC GAS?

A famous Japanese geochemist, Sadao Matsuo, once said that "Volcanic gas is a telegram from the earth's interior." By studying volcanic gases, volcanologists hope to recognize changes in abundance or composition that might signal reawakening of a dormant volcano or portend an imminent eruption at an already restless volcano.

Another significant component of volcanic gas research involves measuring the quantities of gas that volcanoes release to the atmosphere. Huge amounts of volcanic gas, aerosol droplets, and ash are injected into the stratosphere during major explosive eruptions. Some gases, such as carbon dioxide, contribute to global warming, while others, like sulfur dioxide, can cause global cooling and ozone destruction. Studies of volcanic emissions will allow scientists to compare volcanic gas output to emissions from man-made sources and to assess the effects of both past and future eruptions on Earth's climate.

IS VOLCANIC GAS HAZARDOUS?

Yes, volcanic gas can be harmful to humans, animals, plants, agricultural crops, and property. Usually, the hazards from volcanic gases are restricted to the areas immediately surrounding volcanic vents and fumaroles and to low spots on the flanks of volcanoes. But these hazards sometimes persist for long distances downwind from a volcano.

Health hazards can range from minor to life threatening. Exposure to acid gases such as sulfur dioxide, hydrogen sulfide, and hydrochloric acid can damage eyes and mucous membranes along with the respiratory system and, under extreme conditions, can lead to death. The toxicity of carbon monoxide is well

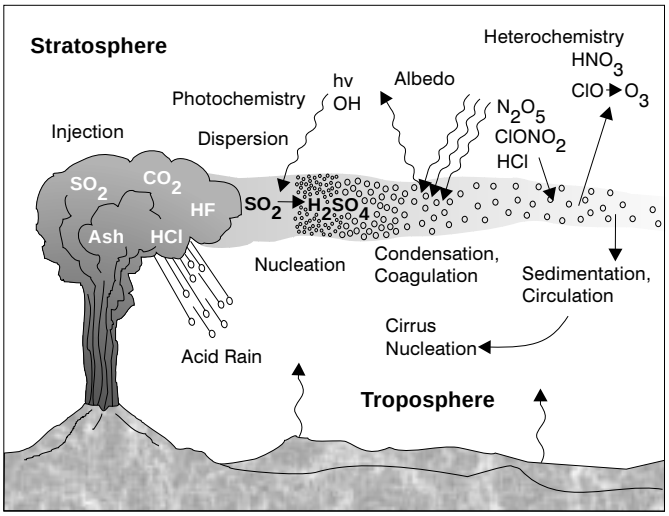

Figure 1. Large volcanic eruptions inject water vapor (H_2O), carbon dioxide (CO_2), sulfur dioxide (SO_2), hydrochloric acid (HCl), hydrofluoric acid (HF) and ash (pulverized rock and pumice) into the stratosphere. CO_2 is a greenhouse gas and contributes to global warming. HCl and HF can dissolve in water and fall to the earth as acid rain. Most of the SO_2 is slowly converted to sulfuric acid (H_2SO_4) which condenses into a mist of fine particles. These sulfate aerosols reflect radiation from the Sun, cooling the troposphere; they also absorb the Earth's heat, warming the stratosphere. The aerosols also promote ozone destruction by altering chlorine and nitrogen chemical species in the stratosphere. As the aerosols settle down into the upper troposphere, they can serve as nuclei for cirrus clouds, further affecting the Earth's radiation balance. (figure modified from Richard Turco in American Geophysical Union Special Report: Volcanism and Climate Change, May 1992).

Figure 2. U.S. Geological Survey geochemists sampling gases from the dome at Mount St. Helens.

known, although it is rarely abundant enough to cause serious problems. One of the most serious hazards occurs when volcanoes emit large quantities of carbon dioxide. Carbon dioxide is heavier than air and collects in low spots, displacing air in these locations. Hundreds of people have died of carbon dioxide asphyxiation near volcanoes in the past two decades, most of them in Cameroon, Africa, and in Indonesia.

Volcanic gases can also severely damage vegetation. Direct exposure to concentrated volcanic gas or long-term exposure to dilute volcanic gas has a lethal effect on most types of foliage.

Fume clouds from volcanoes also contain water droplets in which acid gases have dissolved. These droplets eventually fall to earth as acid rain. Utility lines, farm equipment, cars, and other metal objects corrode when exposed to volcanic gases or acid rain. Persistent acid rain causes galvanized nails or lead solder in water catchment systems to deteriorate and release heavy metals into drinking water. Hydrofluoric acid gas emitted from a volcano can attach itself to ash particles. When these particles fall to earth, there can be serious consequences if ingested by grazing animals.

HOW ARE VOLCANIC GASES STUDIED?

Customarily, gases are collected directly from volcanic fumaroles (vents), then transported to an analytical laboratory for detailed chemical analysis.

A new approach involves installing chemical sensors in or near volcanic vents and linking them to radio telemetry devices to provide a continuous readout on one or more gases. This method can detect significant short-term releases of gas that will usually be missed by occasional sampling.

Finally, emissions of certain gases can be measured in the plume discharging from a volcano. Scientists use an optical spectrometer mounted in an airplane and flown through or beneath a volcanic plume or in a satellite measuring the plume from space. This equipment provides a measure of the total output of one or more gases and is useful in understanding how much volcanic gas is released into the atmosphere.

WHAT HAVE WE LEARNED?

Studies by scientists at the U.S. Geological Survey (USGS) have revealed the compositions and amounts of gases released from several active volcanoes in the U.S. (Alaska, Cascades, Hawaii). As an example, USGS scientists studying the gases of Mount St. Helens have determined that about 2 million tons of sulfur dioxide were emitted between 1980 and 1988. Sensors aboard a satellite detected about 1 million tons of sulfur dioxide injected into the stratosphere during the main eruption on May 18, 1980. Another half-million tons of sulfur dioxide was dissolved in water droplets attached to ash particles that eventually fell to earth. The remaining half-million tons was emitted from the volcano during the eight years following the initial eruption. These measurements allow important comparisons with sulfur dioxide emissions from power plants and other man-made sources.

Careful study of Mount St. Helens' gases using chemical sensors installed on the dome along with airborne measurements of sulfur dioxide revealed periods of increased gas emission prior to four dome-building eruptions during 1984-86. This observation is an important first step in developing the ability to predict eruptions by monitoring gases.

In summary, the study of volcanic gases contributes important new information related to global climate change and may lead to the development of an effective tool for predicting volcanic eruptions.

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