Since 1980, scientists have monitored geologic unrest in Long Valley Caldera and at adjacent Mammoth Mountain, California. After a persistent swarm of earthquakes beneath Mammoth Mountain in 1989, earth scientists discovered that large volumes of carbon dioxide (CO$_2$) gas were seeping from beneath this volcano. This gas is killing trees on the mountain and also can be a danger to people. The USGS continues to study the CO$_2$ emissions to help protect the public from this invisible potential hazard.

Mammoth Mountain is a young volcano on the southwestern rim of Long Valley Caldera, a large volcanic depression in eastern California. The Long Valley area, well known for its superb skiing, hiking, and camping, has been volcanically active for about 4 million years. The most recent volcanic eruptions in the region occurred about 200 years ago, and earthquakes frequently shake the area. Because of this, the U.S. Geological Survey (USGS) operates an extensive network of instruments to monitor the continuing unrest in the Long Valley area.

Numerous small earthquakes occurred beneath Mammoth Mountain from May to November 1989. Data collected from monitoring instruments during those months indicated that a small body of magma (molten rock) was rising through a fissure beneath the mountain. In the following year, U.S. Forest Service rangers noticed areas of dead and dying trees on the mountain. After drought and insect infestations were eliminated as causes, a geologic explanation was suspected. USGS scientists then made measurements and discovered that the roots of the trees are being killed by exceptionally high concentrations of CO$_2$ gas in the soil. Today areas of dead and dying trees at Mammoth Mountain total more than 100 acres. The town of Mammoth Lakes, just east of this volcano, has not been affected.

Although leaves of plants produce oxygen (O$_2$) from CO$_2$ during photosynthesis, their roots need to absorb O$_2$ directly. The high CO$_2$ concentrations in the soil on Mammoth Mountain are killing trees by denying their roots O$_2$ and by interfering with nutrient uptake. In the areas of tree kill, CO$_2$ makes up about 20 to 95% of the...
Therefore, poorly ventilated areas above and gas content of the soil; soil gas normally contains 1% or less CO₂.

When CO₂ from soil leaves the ground, it normally mixes with the air and dissipates rapidly. CO₂ is heavier than air, however, and it can collect at high concentrations in the lower parts of depressions and enclosures, posing a potential danger to people. Breathing air with more than 30% CO₂ can very quickly cause unconsciousness and death.

Measuring the rate of such gas emissions on the flanks of volcanoes or within calderas is difficult and labor intensive. Readings must be made at many locations using small gas-collection instruments placed on the soil.

A preliminary estimate of the current rate of CO₂ gas emission at Mammoth Mountain is 1,300 tons per day. Similar rates of CO₂ emission have been measured from the craters of Mt. St. Helens (Washington) and Kilauea (Hawaii) volcanoes during periods of low-level eruptive activity. Past eruptions at Mammoth Mountain, such as the phreatic (steam-blast) eruptions that occurred about 600 years ago on the volcano's north flank, may have been accompanied by CO₂ emissions. Scientists think that the current episode of high CO₂ emission is the first large-scale release of the gas on the mountain for at least 250 years, because the oldest trees in the active tree-kill areas are about that age.

The characteristics of CO₂ and other gases seeping from Mammoth Mountain indicate that they were originally derived from magma. Large amounts of these gases probably were trapped beneath the volcano until 1989. In that year the magma rising through a fault may have opened cracks, allowing the gases to leak upward. Although infrequent small earthquakes continue to occur below the mountain, there is no evidence of current magma movement.

Earthquakes and CO₂ seepage beneath Mammoth Mountain are only two signs of volcanic unrest in the Long Valley area. Mammoth Mountain is the southernmost volcano in the Mono-Inyo Craters volcanic chain, and over the past 4,000 years, small eruptions have occurred somewhere along this chain every few hundred years.

Scientists with the USGS Volcano Hazards Program are closely monitoring CO₂ emissions and other geologic hazards at Mammoth Mountain. Their continued studies in the Long Valley area of eastern California and in other volcanic regions of the United States, including Hawaii, the Pacific Northwest, Wyoming, and Alaska, are helping to protect the citizens of our Nation from geologic hazards.

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See also Living With a Restless Caldera—Long Valley, California (USGS Fact Sheet 108-96).