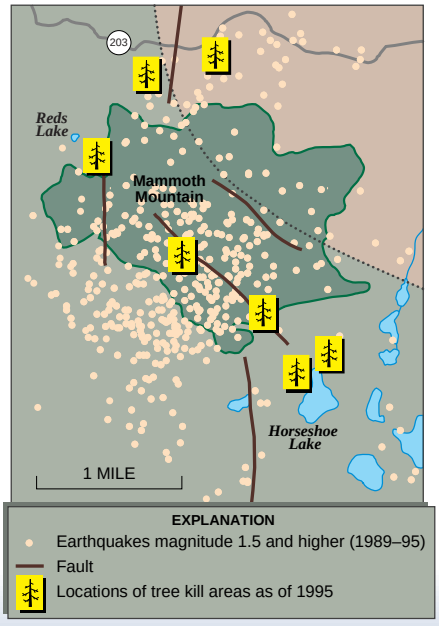
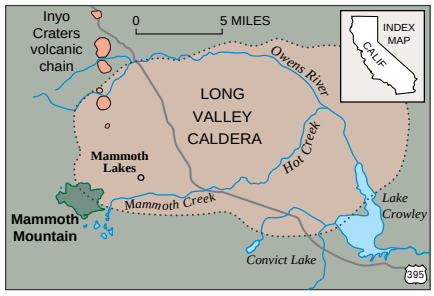
# Invisible $CO_2$ Gas Killing Trees at Mammoth Mountain, California

***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, a young volcano in eastern California, rises above the floor of a large volcanic depression known as Long Valley Caldera. The scenic Long Valley area, popular with skiers, hikers, and campers, has been volcanically active for about 4 million years. High concentrations of $CO_2$ gas have been detected in the soil on Mammoth Mountain. This invisible gas, seeping from beneath the volcano, is killing trees on the sides of the mountain.*

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.

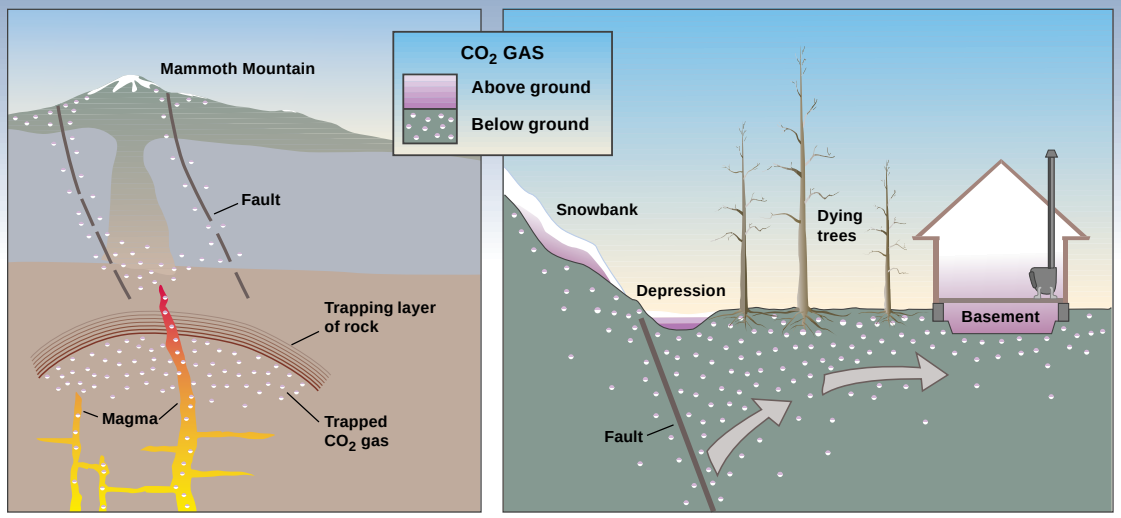



*Areas of dead and dying trees at Mammoth Mountain volcano in eastern California total more than 100 acres. In 1990, the year after a persistent swarm of small earthquakes occurred beneath the volcano, U.S. Forest Service rangers first noticed areas of tree kill. When U.S. Geological Survey scientists investigated, they discovered that the roots of the trees are being killed by high concentrations of $CO_2$ gas in the soil. The seepage of this $CO_2$ gas from below Mammoth Mountain and the continued occurrence of local earthquakes are signs of the ongoing geologic unrest in the area. The upper part of the 11,027-ft-high volcano (above 9,500 ft) is shown in dark green.*

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




*$CO_2$ gas seeping from the ground at Mammoth Mountain likely was derived from magma (molten rock) beneath the volcano. In 1989, rising magma may have opened cracks, allowing large amounts of trapped $CO_2$ gas to leak upward along faults. High concentrations of $CO_2$ in soil can kill the roots of trees. $CO_2$ gas is heavier than air, and when it leaks from the soil it can collect in snowbanks, depressions, and poorly ventilated enclosures, such as cabins and tents, posing a potential danger to people.*

gas content of the soil; soil gas normally contains 1% or less $CO_2$.

When $CO_2$ from soil leaves the ground, it normally mixes with the air and dissipates rapidly. $CO_2$ 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% $CO_2$ can very quickly cause unconsciousness and death. Therefore, poorly ventilated areas above and below ground can be dangerous in areas of $CO_2$ seepage. Where thick snowpacks accumulate in winter, the $CO_2$ can be trapped within and beneath the snow. Dangerous levels of $CO_2$ have been measured in pits dug in the snowpack in tree-kill areas on Mammoth Mountain, and snow-cave camping in such areas is not advised.

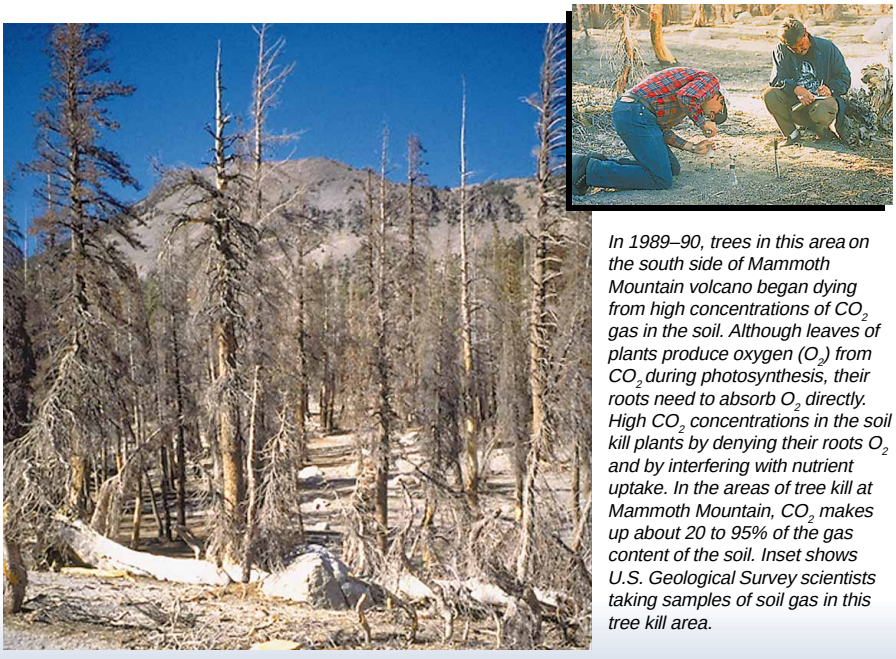
Geologists have detected $CO_2$ emissions, like those at Mammoth Mountain, on the flanks of other volcanoes, including Kilauea in Hawaii and Mount Etna in Sicily. Measuring the rate of such gas emissions on the flanks of volcanoes or within calderas is difficult and labor intensive. Readings must be made at many locations using small gas-collection instruments placed on the soil.

A preliminary estimate of the current rate of $CO_2$ gas emission at Mammoth Mountain is 1,600 tons per day. Similar rates of $CO_2$ 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 $CO_2$ emissions. Scientists think that the current episode of high $CO_2$ 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 $CO_2$ 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 $CO_2$ 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 $CO_2$ 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.



*In 1989–90, trees in this area on the south side of Mammoth Mountain volcano began dying from high concentrations of $CO_2$ gas in the soil. Although leaves of plants produce oxygen ($O_2$) from $CO_2$ during photosynthesis, their roots need to absorb $O_2$ directly. High $CO_2$ concentrations in the soil kill plants by denying their roots $O_2$ and by interfering with nutrient uptake. In the areas of tree kill at Mammoth Mountain, $CO_2$ makes up about 20 to 95% of the gas content of the soil. Inset shows U.S. Geological Survey scientists taking samples of soil gas in this tree kill area.*

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http://quake.wr.usgs.gov/VOLCANOES/LongValley/

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

*U.S. Geological Survey Fact Sheet-172-96*
*1996*