MONITORING OF VOLCANOGENIC CO_2-INDUCED TREE KILLS WITH AVIRIS IMAGE DATA AT MAMMOTH MOUNTAIN, CALIFORNIA

by
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Elevated cold CO_2 emissions from the flank of Mammoth Mountain volcano on the southwest rim of the Long Valley Caldera, eastern California, have been the cause of over 100 acres of dead trees in that area since 1990. The source of the CO_2 gas is thought to be from one or more magmatic intrusion(s) beneath Mammoth Mountain and is probably related to a period of seismic unrest that began in 1989 (Farrar et al., 1995). The gas rises to the surface probably from depths of a few kilometers, along faults and fracture zones.

The gas is at ambient temperature and diffuses from the soil rather than discharging from distinct vents. Typically, soil gas concentrations in tree-kill areas range from 10% to over 90% CO_2 by volume, as compared to normal background of <1% in healthy forest. The gas composition is predominantly CO_2 mixed with air (sulfur gases are not elevated), and C and He isotopic ratios are consistent with a magmatic origin for the gas (Sorey et al., 1993). The total CO_2 emission has been estimated at 1200 tons/day, comparable to the emissions at Kilauea. Some of the dead trees are as old as 250 years, suggesting that similar anomalous gas discharge has not occurred over the previous few hundred years. The delta C-13/12 ratio in the Mammoth Mtn CO_2 emission averages about -4.5 (PDB standard). This is consistent with a mantle source for the carbon. However, the large volume of the emission suggests that not all of the CO_2 is necessarily being generated from the 1989 intrusion. The voluminous gas could be leaking from a vapor-rich zone, capped by an impermeable layer, that was supplied CO_2 from degassing of many small magma bodies that intruded beneath the mountain over a period of decades or centuries. Earthquakes in 1989 could have fractured the capping layer and provided pathways for the escape of CO_2 to the surface. Alternatively, some of the CO_2 could be derived from contact metamorphism of carbonate rocks intruded by magma. Carbonate-bearing Paleozoic roof pendents crop out in close proximity to Mammoth Mtn. It is possible that similar rocks could occur at depth beneath Mammoth Mtn. and could have contributed CO_2 from thermal decomposition caused from recent intrusions. We hope to determine the C-13/12 ratio of a suite of samples to demonstrate if the carbonate rocks could be the source of at least part of the 1990-97 CO_2 emission.

To better understand the behavior of the CO_2 gas, we have used hyperspectral imagery data of Mammoth Mountain acquired from the Airborne Visual/Infrared Imaging Spectrometer (AVIRIS) to map out areas of dead trees. The areas of tree kill have increased in size from about 50 acres in 1994 to about 100 acres in 1997. Tree kill is the major surface manifestation of the carbon dioxide flux at Mammoth Mountain, is widely dispersed, and has been cursorily mapped by regular field mapping techniques in the area. Initial investigations using airborne digital imagery from the Thematic Mapper Simulator (NS001) and AVIRIS instruments have shown extremely encouraging results for complete delineation of the vegetation anomalies (de Jong, 1996). The most successful maps (when compared with ground truth) were developed using AVIRIS data with spectral angle mapper and matched filter algorithms with a data set that was reduced to maximum variance via the minimum noise fraction transformation. The result of this work is a series of maps that show the tree kill areas occurring in an halo-pattern surrounding the base of Mammoth Mountain. We are applying these same techniques to earlier AVIRIS images of Mammoth Mountain to examine the progression of the tree kill areas over time. Temporal maps of the tree kill areas may assist in constructing a picture of the structure beneath Mammoth Mountain.

References

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