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Evidence for magmatic vapor deposition of anhydrite prior to the 1991 climactic eruption of Mount Pinatubo, Philippines

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ABSTRACT

Anhydrite ($CaSO_4$) phenocrysts from Mount Pinatubo pumices show evidence of having responded dynamically to changing conditions prior to the June 15, 1991 climactic eruption. Micrometer-sized and smaller pyramidal surface growth features and lesser numbers of etch pits on anhydrite surfaces are documented by scanning electron microscopy. Chemical analyses indicate that the pyramids are a $CaSO_4$ polymorph and electron backscatter diffraction patterns show conclusively that the pyramids are indeed orthorhombic anhydrite and not another Ca-sulfate phase. Unit-cell measurements of volcanic anhydrite are identical with evaporitic anhydrite, as determined from single-crystal X-ray diffraction patterns.

The computer program SOLVGAS was used to identify conditions under which the pyramids may have precipitated. Thermodynamic modeling of a cooling magmatic gas (H_2O-CO_2-SO_2) at 500 bars (maximum model pressure) and NNO +1.7 was performed. Assuming that the gas contained $>10^{-9}$ mol% Ca and 4 mol% SO_2, the program indicates that anhydrite will precipitate homogeneously at approximately 780 °C, whereas an isothermal drop in pressure would likely lead to dissolution. Pyramids located between a phenocryst and adjacent glass provide physical evidence that at least a portion of the pyramids nucleated and grew before the melt quenched.

We propose a mechanism to account for these previously unrecognized surface growths, which is that the anhydrite pyramids precipitated from a fluid or vapor phase that had separated from the magma at depth. At least a portion of the Pinatubo anhydrite phenocrysts provided substrates for nucleation and epitaxial growth of anhydrite. Because the anhydrite pyramids resemble products of chemical vapor deposition of metals and ceramics, we propose that this previously unrecognized process be termed magmatic vapor deposition. Evidence of high-temperature, magmatic vapor deposition of anhydrite could be used as an indicator that a pre-eruptive gas phase was accumulating or stored at depth, especially at arc volcanoes where excess amounts of sulfur are vented into the atmosphere.