Catastrophic acid crater lake drainage, lahar, and acidic aerosol formation at Mount Chiginagak volcano, Alaska

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An area of snow and ice 400 m wide and 105 m deep began melting at the summit crater of Mount Chiginagak volcano sometime between November 2004 and early May 2005, presumably due to increased heat flux from the hydrothermal system, or possible magma intrusion and degassing. In early May 2005, an estimated 3.8 x 10^6 m^3 of sulfurous, clay-rich debris and acidic water, with an accompanying acidic aerosol component, exited the crater through a tunnel at the base of a glacier that breaches the south crater rim. Over 27 km downstream, the acidic waters of the flood inundated an important salmon spawning drainage, acidifying Mother Goose Lake from surface to depth (approximately 0.5 km^3 in volume with a pH of 2.9 to 3.1), killing all aquatic life, and preventing the annual salmon run. Crater lake water sampled 8 km downstream of the summit outflow after considerable dilution from glacial meltwater was a weak sulfuric acid solution (pH = 3.2, SO_4 = 504 mg/L, Cl = 53.6 mg/L, and F = 7.92 mg/L). The acid flood waters caused severe vegetation damage including plant death and leaf kill along the flood flow path. The flood was accompanied by an ambioructic flow of acidic aerosols that followed the flood flow-path, contributing to defoliation and necrotic leaf damage to vegetation in a 29 km^2 area along and above affected streams, in areas to heights of over 150 m in elevation above the drainage. Moss species killed in the event contained high levels of sulfur indicating an extremely elevated atmospheric sulfur content. The most abundant airborne phytotoxic constituents were likely wet sulfuric acid aerosols in possible combination with dry SO_2 gas that were released during the catastrophic partial crater-lake drainage event. Two mechanisms of acidic aerosol formation are proposed: (1) generation of aerosol mist through turbulent flow of acidic water, and (2) catastrophic gas exsolution. This previously undocumented phenomenon of simultaneous vegetation-damaging acidic aerosols accompanying an acid crater lake drainage has important implications for the study of hazards associated with active volcanic crater lakes.

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