ERUPTIONS THROUGH CALDERA LAKES IN ALASKA: SURGES, TSUNAMIS, AND CATASTROPHIC FLOODS

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A variety of hazards are associated with eruptions through caldera lakes. New radiocarbon dates indicate that a lake containing 5.8 x 10^9 m^3 of water slowly grew over 1200 years within Okmok caldera following huge eruptions ca. 2050 14C yr BP. Numerous eruptions occurred during this time period, producing tuff cones and emergent lava cones with prominent lava benches. These features record increasing lake levels. About 800 14C yr B.P. explosive eruptions at a tuff cone located near a low point in the caldera rim sent surges more than 10 km downvalley, and large bedforms preserved within the caldera at the top of the lake sequence suggest large waves were generated within the caldera lake. The caldera rim failed at its lowest point, and catastrophic floods eroded a deep gorge and multiple channels on the north flank of the volcano, and built a gravel fan 5 km into the Bering Sea. Paleohydrologic calculations indicate the flood had local peak discharges of ca. 2 x 10^6 m^3/s, making this perhaps the largest flood of the last 10,000 years.

A very similar sequence of events occurred at Fisher Caldera. The caldera formed about 9400 yr B.P. and filled with a large lake. A wave-cut terrace is incised as much as 5 m into colluvial fans and volcaniclastic rocks around the southwest caldera wall, marking the high water level of the lake, and indicates a water depth of ~100 m. The lake drained by cutting a valley through a low-lying part of the southern caldera rim. This event was triggered by a mid-Holocene eruption of Turquoise Cone. A hydromagmatic explosion created a deep crater, dated at 1,500 (+/-50) years. This eruption generated a tsunami wave in the caldera lake that spread away from Turquoise Cone. Dramatic evidence of this wave appears on the southern caldera wall, where rounded cobbles from the wave-cut terrace on the southern wall were transported ~20 m higher by a wave that overtopped the lowest part of the caldera rim. The wave eroded ignimbrite deposits on the flank of the caldera, and the caldera lake drained catastrophically, transporting large boulders (up to 5 m in diameter) of welded tuff several kilometers. Organic-rich soil directly above this flood deposit has a 14C date of 1,500 (+/-50) years, matching the date of the Turquoise Cone explosive eruption.

These two events show that eruptions through caldera lakes can have catastrophic consequences. Hydromagmatic eruptions within caldera lakes can produce surges and large explosions. Tsunami waves as much as 20 m high may be generated by the explosive eruptions. The waves are capable of triggering complete failure of the caldera rims if the waves are high enough to cross over a low point. Once caldera lake failure begins, the stream power and erosive capabilities can produce complete devastation in downstream areas.