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Hidden earthquakes unveil the dynamic evolution of a large-scale explosive eruption

Ricardo Garza-Giron[1], Emily Brodsky[1], Zack Spica[2], and Matt Haney[3]
[1]University of California, Santa Cruz, Earth and Planetary Sciences, Santa Cruz, United States of America (rgarzagi@ucsc.edu)
[2]University of Michigan, Earth and Environmental Sciences, Ann Arbor, MI, United States of America
[3]United States Geological Survey, Alaska Volcano Observatory, Anchorage, AK, United States of America

Volcanic eruptions progress by co-evolving the fluid and solid systems. The fluid mechanics can be observed through the evolution of plumes and ejecta. How does the solid evolve? When does the conduit open? When does it close? Seismology can potentially tell us about these processes by measuring the failure of the solid rock. However, such inferences require detection of earthquakes during an explosive eruption. Standard earthquake detection methods often fail during this time as the eruption itself produces seismic noise that obscures the earthquakes. In this work, we address this problem by applying both a supervised and unsupervised search techniques to the existing catalog of the 2008 Okmok Caldera eruption to find brittle failure signals during the continuous eruptive sequence. We were able to detect >4500 new earthquakes using the 419 events previously located by the Alaska Volcano Observatory (AVO). A spatiotemporal analysis of the occurrence of earthquakes during the eruption reveal interesting observations: Seismic bursts during the eruption are not synchronized with the exhalation of large ash and steam plumes, suggesting that the dynamics of the eruption are controlled by a clog-and-crack mechanism; most of the Caldera co-eruptive seismicity that is not located at the focus of the eruption occurs under the intra-Caldera cones, showing the activation of their hydrological system due to a system-wide pressurization; the end of the eruption is marked by a large burst of small, deep earthquakes trending SW-NE, possibly related to a propagating lateral dike similar to those observed in other basaltic calderas; the magnitude distribution of seismicity through time shows that the largest earthquakes in the bursts do not happen at the beginning of the sequence like in typical mainshock-aftershock sequences. Furthermore, high precision earthquake relocations highlight a ring-fault structure inside of Okmok Caldera which is thought to be acting as the pathway for fluids to the surface.