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Processes culminating in the 2015 phreatic explosion at Lascar volcano, Chile, evidenced by multiparametric data

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Small steam-driven volcanic explosions are common at volcanoes worldwide but are rarely documented or monitored; therefore, these events still put residents and tourists at risk every year. Steam-driven explosions also occur frequently (once every 2-5 years on average) at Lascar volcano, Chile, where they are often spontaneous and lack any identifiable precursor activity. Here, for the first time at Lascar, we describe the processes culminating in such a sudden volcanic explosion that occurred on October 30, 2015, which was thoroughly monitored by cameras, a seismic network, and gas and temperature sensors.

Prior to the eruption, we retrospectively identified unrest manifesting as a gradual increase in the number of long-period (LP) seismic events in 2014, indicating an enhanced level of activity at the volcano. Additionally, sulfur dioxide (SO_2) flux and thermal anomalies were detected before the eruption. Then, our weather station reported a precipitation event, followed by increase of steaming and a sudden volcanic explosion. The multidisciplinary data exhibited short-term variations associated with the explosion, including (1) an abrupt eruption onset that was seismically identified in the 1-10 Hz frequency band, (2) the detection of a 1.7 km high white-gray eruption column in camera images, and (3) a pronounced spike in SO_2 emission rates reaching 55 kg s^{-1} during the main pulse of the eruption as measured by a mini-Differential Optical Absorption Spectroscopy (DOAS) scanner. Continuous carbon dioxide (CO_2) and temperature measurements conducted at a fumarole on the southern rim of the Lascar crater revealed a pronounced change in the trend of the relationship between the CO_2 mixing ratio and the gas outlet temperature; we speculate that this change was associated with the prior precipitation event. An increased thermal anomaly inside the active crater as observed in Sentinel-2 images and drone overflights performed after the steam-driven explosion revealed the presence of a ~50 meters long fracture truncating the floor of the active crater, which coincides well with the location of the thermal anomaly. This study presents the chronology of events culminating in a steam-driven explosion but also demonstrates that phreatic explosions are difficult to predict, even if the volcano is thoroughly monitored; these findings emphasize why ascending to the summits of Lascar and similar volcanoes is hazardous, particularly after considerable precipitation.

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