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Natural Hazards and Earth System Sciences Discussions

Interactive comment on "Processes culminating in the 2015 phreatic explosion at Lascar volcano, Chile, monitored by multiparametric data" *by* Ayleen Gaete et al.

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Please find below the comments raised by the reviewer 2 followed by our reply. We have structured the response according to the following sequence: (1) comments from Referees, (2) author's response , (3) author's changes in manuscript.

Main general comments (G1-G3): G1. I found the manuscript very interesting. The authors report a multidisciplinary dataset characterizing the phreatic explosion at Lascar occurred in 2015. They observe long-term changes in LP seismic activity preceding the eruption, with a rapid increase in the LP activity about one year before the eruption and a drop in the LP activity 3-6months before. The decrease of the LP activity is ac-

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Discussion paper

companied with a decrease of the persistent thermal anomaly observed in the crater floor. Two heavy snow events are reported few months before the eruption, not leading to detectable changes at the volcano. However, a heavy rain event about ten days before the eruption is considered by the authors a precursory of the explosion.

Reply G1: We appreciate these comments

G2. The correlation between the rain and the phreatic explosion occurred in 2015 is explained as the heating of the percolated water inside the carapaces of a pre-existing and still hot (?) lava dome in the crater zone. However, a less clear effect of the lava dome is introduced in section "5.4 Conceptual model", were the lava dome has also the effect of blocking the path of the deep fluid sand inducing a long-lasting gradual pressure build-up. 2. This last interpretation is associated to the increase of LP events starting one year before the explosion. I think that the authors should better describe the inter-relationship between pressure increase due to arrival of deep fluids, degassing and the observed subsidence of the crater zone.

Reply G2: We will include the following more detailed explanation already in the introductory paragraph of the discussion section (5) in order to make clearer the interaction between the pressure and the blocking of the degassing path:

Lines 344-354: The steam-driven explosive eruption of Lascar on October 30, 2015, was the first that was densely monitored. The eruption was studied by utilizing different data streams, the results of which suggest that (i) no magma movements within a shallow magma reservoir were identifiable immediately prior to the explosion though significant changes in degassing activity were observed and (ii) the spontaneous steam-driven explosion was directly associated with a brief degassing pulse and the development of a fractured dome-shaped feature on the crater floor. We ascertained that the volcano was in an elevated stage of activity, as the steam explosion was preceded by ∼1 year of enhanced LP seismic activity thus favouring a potential gradual pressure build-up within the shallow volcanic system. However, as the seismic activity gradually declined approximately 4 months prior to the explosion (Figure 2a), a direct and causal relationship is debatable. Nevertheless, similar long-term trends in LP activity were observed prior to eruptions of Mt. Etna, which modulation was associated to replenishment with gas-rich magma (Patanè et al., 2008). If that was the case also at Lascar, this would imply a considerable input of deep gas/fluid into the system which release may eventually have been obstructed by reduction of permeability of the degassing path in response to the precipitation (Heap et al., 2019), increasing the pressure in the volcanic system. We noticed that this decline in seismic activity was accompanied by a reduction in the persistent high-temperature anomaly located inside the active crater (Figure 3a-c), which likely was associated with a general decline in fumarole activity. Similar decreases in the area and intensity of hot spots have previously been observed preceding, e.g., the eruptions that occurred in the periods 1992-1995 and 2000-2004 (See Table 1), which likely have been associated to a sealing of the degassing path probably due to crater subsidence (González et al., 2015; Wooster and Rothery, 1997). The details of our findings, limitations and interpretations as well as a conceptual model will be discussed in the following.

G3. Considering a possible seasonal effect on the occurrence of the phreatic explosions at Lascar, and the possible role of the rain, it would be interesting to know, if possible, whether previous phreatic explosions, such as that occurred on 18 April 2006 (ie: after the emplacement of the dome) were preceded by events of heavy rain. In general, I think that the information contained in the paper can help to better under-stand the processes leading to the conditions for phreatic explosions.

Reply G3: We appreciate this comment and started investigating, but we note that retrieving such potentially archived data is rather challenging: Unfortunately we neither have precipitation data from 2006, which would enable us to answer this question, nor it is indicated in eruption records, whether the 2006 eruption was preceded by a rainfall event. However we emphasize that based on the eruption history (Table 1), we are able to show that 50% of the documented eruptions occurred in springtime only.

A similar seasonality effect of volcano eruptions was also inferred at Iceland, where most large eruptions occur during spring and summer periods (Albino et al., 2010). To understand the occurrence of phreatic eruptions, future monitoring networks should include hydrometeor stations capable of recording rain, hail and snowfall.

We thus propose to insert the following:

Line 366-368: Likewise, the October 2015 eruption falls within this period and occurred only a few days after a precipitation episode, which possibly led to the observed eruption. A similar seasonality effect of volcano eruptions was also inferred at Iceland, where most large eruptions occur during spring and summer periods (Albino et al., 2010).

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