SUPPLEMENTARY MATERIAL VOLCANICA

Supplementary Material for: Hybrid rhyolitic eruption at Big Glass Mountain, CA, USA

Jonathan M. Castro*, Sebastian Walter
Johannes Gutenberg-Universität Mainz, Mainz, Germany.

This supplementary material accompanies the article:

Castro, J. M. and Walter, S. (2021) "Hybrid rhyolitic eruption at Big Glass Mountain, CA, USA", *Volcanica*, 4(2), pp. 257 – 277. DOI: 10.30909/vol.04.02.257277.

Castro & Walter (2021) should be cited if this material is used independently of the article.

1 Field evidence for hybrid volcanism at Cordón Caulle, Chile

As the eruption of Big Glass Mountain (BGM) was not observed, parallels must be drawn with observed rhyolitic events (e.g. Cordón Caulle, 2011) that behaved in an hybrid manner in order to interpret the deposits at BGM (Figure S1, Figure S2). In this Supplementary section, we present photographic and observational evidence for hybrid activity at the eruption of Cordón Caulle (2011), Chile. This data is especially relevant to understand the hybrid eruption processes responsible for forming pyroclastic depositional features in the lava flow facies at Big Glass Mountain.

The physical hallmark of hybrid activity is mixed pyroclastic and effusive units (Figure S1, Figure S2). These mixed facies take on many different forms, the most telling of which, is concordant air fall tephra deposited on flowing lava surfaces (Figure S2). The origin of these relations can be seen in the eruption photos of Cordón Caulle, taken during the onset of hybrid activity (Figure S1), but also approximately eight months after the eruptions onset when activity declined (Figure S1). In particular, in Figure S1, the lava flow front is the only barely visible (black vertical face) and the surface of the flow is obscured by thick proximal airfall tephra. Very little of this fall deposit remains on the Cordón Caulle flow. Later in the eruption, the vigor of pyroclastic venting was much reduced and consequently, little if any ash remained on the lava's surface.

Remnants of the fall deposit, which ranges from completely unconsolidated to thoroughly well welded at its contact with lava, can be observed at the northernmost flow margins as 1–10 m^2 outcrops of markedly white material resting on coherent black rhyolite (Figure S2). Such exposures of pyroclastic mantles at the edges Cordón Caulle's lavas were observed to form in early films of that eruption (e.g. from Reuters). During early hybrid activity, the deposition rate of air fall tephra on top of the lava was very high, leading to preservation of incipiently welded pyroclast mantles that were then rafted away with effusion (e.g. Figure S2).

2 VolcDeGas models

The conditions for each `VolcDeGas` simulations included: the starting H_2O concentration, initial melt δD and hydrous speciation [e.g. see Walter and Castro 2020], and nature of degassing system (e.g. open system), along with degassing step size—the fractional amount of H_2O loss calculated with respect to an initial budget—in each successive degassing pulse. In order to achieve a statistical best fit of the model to data—determined by its R^2 and RMSE optimization—`VolcDeGas` iteratively employs variably sized steps until the optimum fit is achieved. `VolcDeGas` also calculates hydrous speciation variation (i.e. relative OH and H_2O in the melt) as degassing progresses, based on independent FTIR measurements of hydrous speciation in the obsidians.

Walter and Castro [2020] show that use of real, hydrous speciation data yields the most accurate reproduction of natural δD-H_2O trends, even though in the absence of such data, `VolcDeGas` can also implement a T- and melt-composition-dependent model to determine the progressive variation in speciation and therefore the H-fractionation factors [alphas: Walter and Castro 2020]. In this study we exclusively applied FTIR-based measurements of BGM hydrous speciation for all `VolcDeGas` model runs.

*Corresponding author: castroj@uni-mainz.de

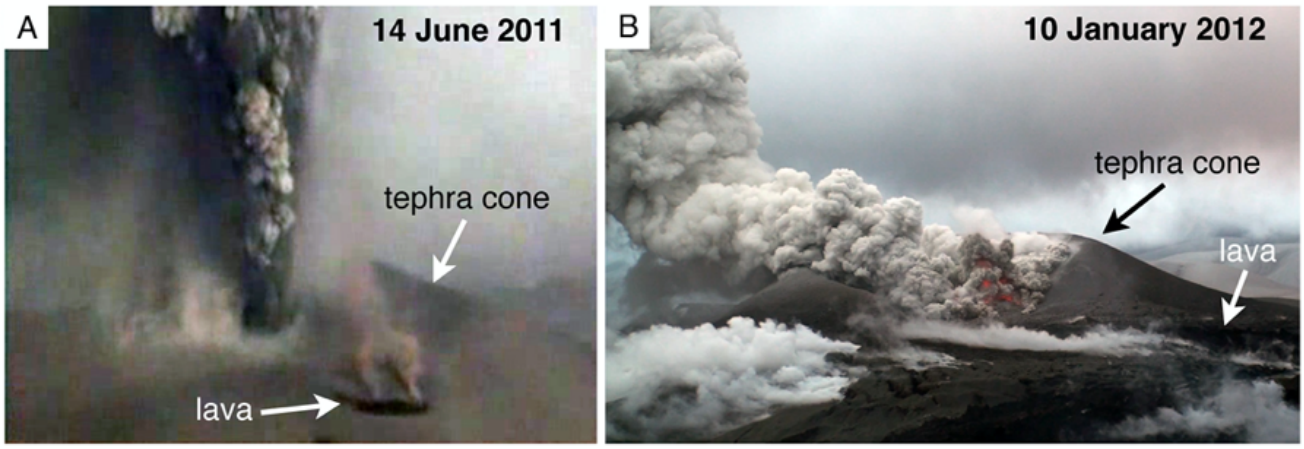

Figure S1: [A] Close up view of the Cordón Caulle vent in the throes of vigorous hybrid activity (collected from Reuters eruption footage on 14 June, 2011). This frame captures the nascent lava flow emerging from a vent simultaneously fueling sub-Plinian eruptive activity. The top of this lava is covered in tephra (tan upper layer) that would later become ingested by flow advance. Remnants of this pyroclastic layer are preserved in the present-day flow margin edge. The image on the right hand side represents a view of the eruption about eight months later exhibiting continued, albeit diminished hybrid activity.

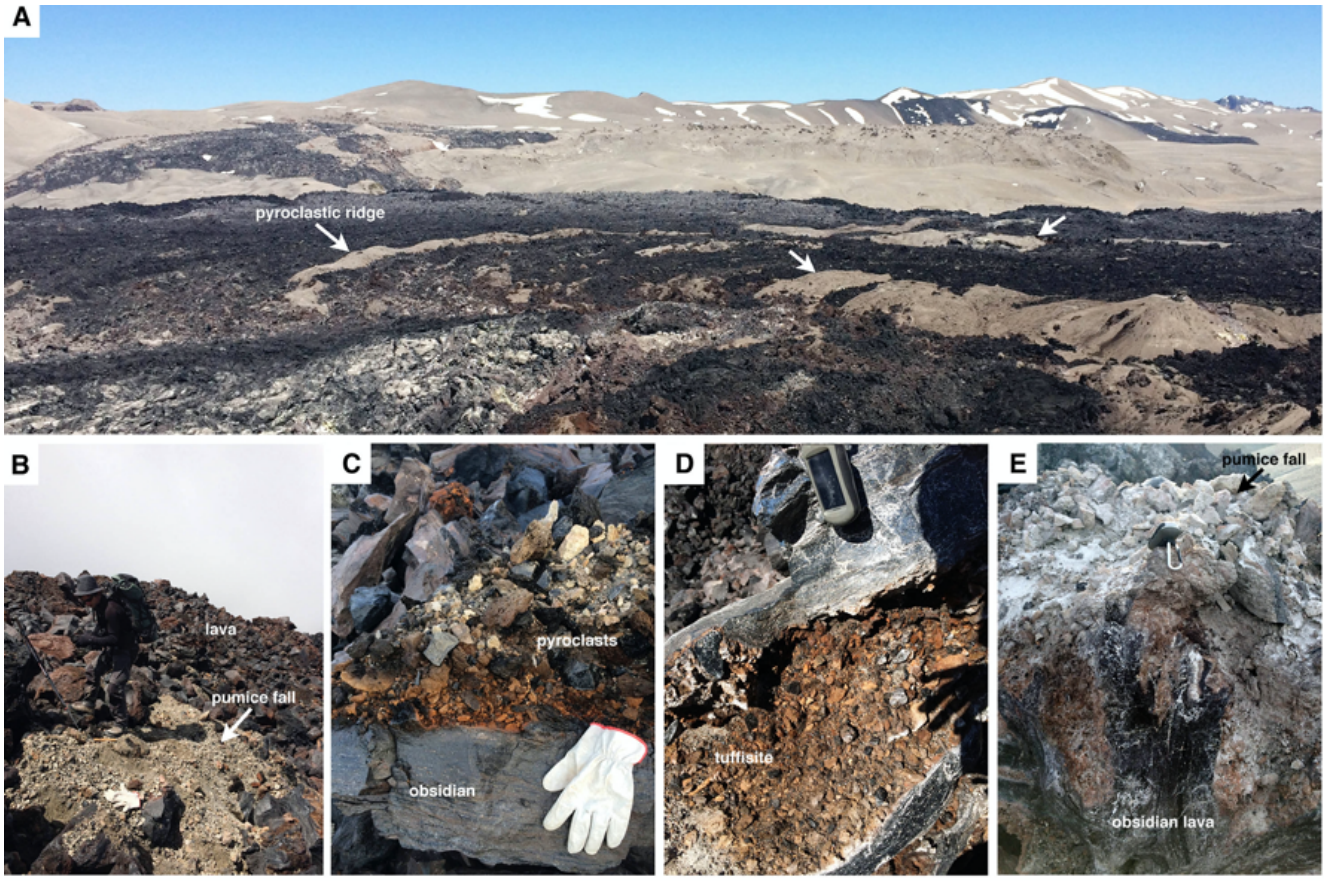

Figure S2: Collage of field images displaying relations indicative of hybrid explosive-effusive activity at Cordón Caulle, including, rafting of pyroclastic cone material, (frame [A]), and superposed pyroclastic fall sequences on lava (frames [B]–[E]). The photo in frame [A] was taken from the pyroclastic vent, and faces to the northwest. This broad, approximately 2.5-km-wide field of view) shows vast dark lava interspersed with with tan pyroclastic mounds and ridges (indicated with white arrows). This series of rafted tephra cone segments become progressively more arcuate and deformed with distance from the vent, eventually attaining forms like those seen at Big Glass Mountain. Pyroclastic ridges such as these were observed to form over a course of several months of hybrid activity, likely in response to the vent shifts and consequent lava flow direction changes that occurred over several months in 2011 [e.g. Schipper et al. 2013]. In addition to rafted pyroclastic cones, Cordón Caulle lava hosts pyroclastic fall deposits in various states of preservation. Image [B] shows a geologist (Hugh Tuffen) standing on a vent proximal pumice raft, laying conformably on lava. Frames [C]–[D] show similar pyclastic-lava mixtures, including incipiently welded pyroclastic falls [C], a pyroclastic channel ([D]; tuffisite), and an unconsolidated pumice fall deposit, all encountered on the northernmost edge of the Cordón Caulle lava field.

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