Dynamics of rhyolitic obsidian flow evolution at Cordón Caulle, Chile

Hugh Tuffen[1], Mike R. James[1], Jonathan M. Castro[2], C. Ian Schipper[3], Ashley G. Davies[4], Magda Dabrowska[1], James Farquharson[1]

[1]Lancaster University, UK, [2]University of Mainz, Germany, [3]University of Wellington, New Zealand, [4]Jet Propulsion Laboratory, USA

E-mail: h.tuffen@lancaster.ac.uk

The 2011-2012 rhyolitic eruption of Cordón Caulle (Chile) has provided an unprecedented opportunity to observe an evolving obsidian lava flow. The eruption began explosively on June 4th 2011, with lava first reported on June 15th 2011. By January 2013 the lava had reached >6 km^2 area and >0.3 km^3 volume, and continued to locally advance, despite effusion at the vent halting in April 2012.

We present observations, images and samples of the lava flow carried out in January 2012 and January 2013, plus satellite imagery. The flow field comprises two major branches (NW and SE), each 2 km long, 1 km wide, 35 m thick and emplaced onto shallow topography. These branches exhibit 500-700 m-wide central channels of blocky lava with distinctive surface folding (ogives), bound by near-linear, nested levees. The outer portion of the flow consists of many dozens of breakout lava lobes, typically 50-100 m across, which originate from the outermost levees and create an indented flow margin. By contrast, there is a third, minor flow branch that extends down steep slopes 2 km to the NE. This is considerably narrower (100-300 m), thinner (20 m) and morphologically simpler. Blocky lava facies dominate the lava flow surfaces, comprising metre-scale blocks of vesicle-poor, glassy lava, with local coarsely vesicular pumice. By contrast, lava breakouts consist of darker, more continuous lava spines and slab tens of metres across, with abundant crease structures and highly deformed vesicles.

An automated photo-reconstruction technique (SfM-MVS, a combination of structure from motion and multi-view stereo algorithms) was used to create 3D models of portions of the lava flow front on repeated visits, allowing precise quantification of morphological changes over timescales of 3 hours, 6 days and 1 year. Evolution of the margin of the NW flow branch over 6 days in 2012 involved spreading of 1-2 m/day of blocky lava facies, perpendicular to the channel axis, with more rapid advance of breakout lava (3 m/day) in a discrete, non-perpendicular direction. Zones of rapid advance correspond with the loci of most frequent rockfall events, which occurred from active breakouts at 1-10 minute intervals in both 2012 and 2013.

Our observations reveal the striking similarity between the dynamics of the Cordón Caulle rhyolite and far better-understood compound basaltic flow fields, whose late-stage evolution involves the breakout of lava lobes from stalled lava margins. We emphasise the importance of bedrock slope on controlling lava structure and evolution. The localized persistence of lava advance eight months after ceased vent supply indicates efficient thermal insulation, which serves to significantly prolong the duration of hazardous activity. Finally, endogenous growth can clearly play a major role in obsidian lava flow advance, which demands the reappraisal of the architecture, longevity, and emplacement mechanisms of rhyolitic lavas.