Geophysical Research Abstracts
Vol. 19, EGU2017-8385, 2017
EGU General Assembly 2017

Gas exsolution and bubbles nucleation from the 1669 lava flow of Mount Etna (Italy): evidences from phase-contrast synchrotron X-ray microtomography

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Bubbles are usually present in lavas, often showing an increase in their size and number from bottom to the top of vertical profile of the flows. Their presence is commonly interpreted as the final phase of the degassing processes starting and massively occurring at depth, before the eruption. In this work we present the results of a detailed study of size, shape and volumetric distribution of bubbles in lavas from the 1669 eruption of Mount Etna (Italy), one of the most voluminous and destructive historic events of this volcano. The lava field produced during this event extends up to 18 km from the craters, and the massive presence of bubbles in lavas sampled many kilometres away from the emission point is in contrast with the models predicting their almost total exsolution from the magma before the eruption, at depth of several kilometres beneath the volcano edifice.
Sampling of the 1669 lava field has been performed along the longitudinal profile of the field at increasing distance from the vent. Collected rocks have been analysed by X-ray fluorescence and phase-contrast synchrotron X-ray computed microtomography in order to extract three-dimensional (3D) qualitative and quantitative information on the bubbles network. The use of synchrotron light permitted to investigate small portions of the samples at high spatial and contrast resolution and allowed us to obtain the 3D morphology and distribution of the micro-bubbles present in the lava, avoiding the limitations of the traditional two-dimensional analysis on thin sections. Results indicate that bubbles in lavas are present in various abundance, constituting up to 18% of the rocks volume, and are randomly distributed, with no regards for the distance from the vent. Their casual abundance, morphological characteristics and spatial distribution indicate large nucleation from syn- to post-eruptive stage, during the lava flowing and probably after it halted its run. These observations are in contrast with the general view that considers the magma completely (or largely) degassed and the volcanic gas species (mostly H_2O, CO_2, SO_2) as largely exsolved when magma reaches the surface. On the contrary, results indicate that the exsolution of bubble-forming volcanic gases can occur far from the emission vent and right before the complete solidification of the lava. Finally, this process could easily explain, for the case of 1669 eruption, the impressive fluidity of the lavas, which display pahoehoe morphology 16 km away from the emission vent.