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Modes of magma degassing at active basaltic volcanoes by synchrotron X-ray computed microtomography of volcanic products

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Characterization of volcanic products from explosive and effusive eruptions has proved to be an important approach complementary to field, laboratory and theoretical studies in constraining processes related to volcanic systems. In particular, quantification of vesicle size, shape, distribution and degree of interconnectivity provides textural parameters strictly linked to modes of magma exsolution (volatile release from the melt), degassing (volatile separation from the melt), and development of magmatic permeability, which are crucial in the development of degassing models, and hence in the interpretation of the whole eruption dynamics. Techniques conventionally used to image and quantify clast morphology and texture include optical and scanning electron microscopy of thin sections, and/or direct measurements of the physical properties of volcanic rocks in the laboratory. Yet these methods are destructive, extremely time-consuming and do not easily allow a real 3D reconstruction of the sample. Here we present the preliminary results of a study using synchrotron X-ray computed microtomography to obtain 2D and 3D images of volcanic specimens. This approach, novel in the volcanological field, has been applied to investigate the degassing pathways at two persistently degassing basaltic volcanoes, Stromboli (Aeolian Islands, Italy) and Villarrica (Chile), through the full 3D reconstruction of the erupted products. Microtomography experiments have been performed at the SYRMEP beamline of the ELETTRA synchrotron radiation facility in Trieste (Italy). Samples of pumice and scoria have been studied and the resulting 2D slices (270 for each sample) have been transformed into volume renderings via specific tomographic software. The use of a third generation synchrotron radiation facility allowed optimal visualization of vesicle and crystal geometry in the reconstructed volume where conventional X-ray

methods are strongly limited. Networks of differently interconnected vesicles have been easily identified and attributed to different modes of magma degassing and eruptive styles. In addition, the Blob3D software package has been used to accomplish quantitative descriptions of vesicle textures in terms of true size, shape, and distribution. These textural parameters provide snapshots of vesicle growth and coalescence at different time steps of an eruption history, and will be used to constrain pathways of magmatic exsolution, degassing, development of permeability and fragmentation in the numerical modeling of conduit magma ascent. Finally, a better knowledge of the flow-dynamics of magmatic gases along the volcanic conduit will provide the framework for a direct comparison with monitoring of gas emissions by remote sensing at active volcanoes, with the final aim of achieving more reliable eruption predictions for a better assessment of the volcanic hazard.