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New insights into magma fragmentation during silicic explosive eruptions from X-ray microtomography: the case of the Minoan eruption, Santorini, Greece

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Magma fragmentation during explosive eruptions remains incompletely understood. In our work, X-ray microtomography was used to study textures of rhyodacitic pumices from the 3.6 ka Minoan Santorini eruption. X-ray microtomography offers the opportunity to study the internal structure of pumices in a non-destructive manner by 2D and 3D imaging. Textural characteristics of pumices record their physical state during magma fragmentation, and thus can help constrain fragmentation models. Based on qualitative observations of the microtomography images, a conceptual magma fragmentation model for the Minoan eruption was developed.

Outer surfaces (which possess an incomplete chill margin) of Minoan pumices are knobbly, indicating ductile fragmentation. The heterogeneous distribution of vesicle sizes and shapes in pumices, and the co-existence of regular pumice and tube pumice, suggest that gas concentration in the fragmenting foam is highly heterogeneous. In addition, microtomography images reveal insights into the control of phenocrysts and microlites on vesicle shape (spherical vs. stretched) and density. Relatively large phenocrysts (sometimes together with microlites) tend to be surrounded by large pockets of spherical vesicles, whereas microlites are also seen distributed randomly in between stretched vesicles.

We propose a two-step fragmentation model with ductile fragmentation as the main mechanism to form pumices during the Minoan eruption, followed by brittle fragmen-

tation to produce ash. The development of an incomplete chill margin on pumices is consistent with enhanced permeability development during ductile fragmentation, gas loss and rheological change bringing the locally more degassed melt at the pumice margins to the glass transition immediately after fragmentation. Thus whereas pumice production occurs in the ductile regime, any further fragmentation to produce the volumetrically dominant ash occurs in the brittle regime.