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Flow dynamics of dacite lava flow - AMS, microstructure and porosity case study

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Pyroclastic flows derived from flow frontal collapse of highly viscous "block lavas" formed by andesite or dacite belong to the most serious volcano-related hazards for surrounding populations. The threat results from abrupt transition of lava flow from ductile flow to gravitational failure of the front, which exposes their overpressurized interior and triggers devastating pyroclastic flows. The goal of the study is to quantify the microfabrics and dynamic porosity in a lava flow to constrain the cavitation process (development and coalescence of dynamic porosity).
Pleistocene dacite flow body situated on the slope of Middle Sister Volcano (OR, USA) was studied by means of field-based structural analysis, anisotropy of magnetic susceptibility (AMS), microstructural analysis and mercury injection porosimetry (MIP). The $\sim$500 m exposure of the flow is associated with a vertical feeding dyke at the beginning of the flow, 40 m upslope. The flow shows occasional layers, 5–15 cm thick, marked by evenly spaced and up to 10 cm long, lenticular to sigmoidal cracks often developed in the vicinity of the clasts/phenocrysts. These cracks frequently dip against the slope of the flow and show 15–50° difference with the layering. At the feeding dyke, highly oblate magnetic fabric shows subvertical foliations with horizontal lineations oriented parallel to the dyke walls. Middle part of the flow revealed highly prolate fabrics with subhorizontal magnetic foliations and lineations parallel to the flow direction. At the downslope limit of the flow, magnetic foliations are perpendicular to the flow direction.
The dynamic porosity was studied in detail on larger sample from the central part of the flow. The sample contains three layers with different density of porosity and average crack length. All the cracks were oriented about 45° to the layer boundaries and alignment of the groundmass crystals. MIP data revealed total connected porosities between 11 and 15 %. Throat-size distribution corresponds to four distinct intervals reflected by: (I) distributed porosity in matrix (0.02–0.1 μm), (II) microcracks in matrix and microfractures in the phenocrysts (0.4–2 μm), (III) larger microcracks in matrix that likely represent coalesced microcracks (3–10 μm) and (IV) large microcracks (10–300 μm), including the macroscopic, irregular openings in the matrix and in the vicinity of the clasts/phenocrysts. The highest porosity characterizes the layer C which, unlike the other layers, features important porosity (up to 5 %) accessible by large (10–300 μm) pore throats corresponding to class IV. Results of the MIP measurements of the bulk and the mineralogical densities suggest that an important part (40%) of the total porosity is isolated and becomes progressively connected with the increasing volume of microcracks.
Data suggests that the abundant shear fractures oriented at high angles to shear planes developed as mechanical instabilities during the flow, propagated in distinct layers and were modified to sigmoidal fractures. The dilatancy provides the „shear thickening rheology" and likely plays a significant role in frontal collapse of crystal-rich lava flows.