Flow fabrics and dynamic porosity in Pleistocene dacite lava flows from Three Sisters volcanoes (Cascades, OR, USA)

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The statistics show that pyroclastic flows derived from the flow frontal collapse of highly viscous "block lavas" formed by andesite to dacite caused the most (70 %) of all volcano-related casualties in 1900–1982 (Blong, 1984). These flows can advance on large distances, because the blocky cover of the advancing flow effectively insulates the interior of the flows, which remains molten and mobile (Harris et al., 2002). Their insidious threat to surrounding populations is that these flows show abrupt transition from ductile flow to gravitational failure of the front, which exposes their overpressured interior and triggers devastating pyroclastic flows (e.g. Sigurdsson et al., 2000). Textural evidence in exposed parts of such collapsed flows revealed that the lava is affected by cavities that form due to the ductile tearing of the magma at high strain rates (Smith et al., 2001). In order to constrain critical conditions that can trigger frontal collapse of such flows, two Pleistocene dacite flows on the eastern slope of Middle Sister Volcano in Cascades (OR, USA) were studied by means of field survey and microstructural analysis. The basal slope of both flows is approximately 30°. Both flows were sampled along 230, resp. 360 m long glacial erosion scarps trending in ENE direction. Both flows reveal blocky upper parts and fabrics inclined downslope or upslope along the axis of the flow with magnetic lineations either parallel or perpendicular to the flow axis. Both flows reveal up to 10 cm long lenticular to sigmoidal shaped pores distributed along distinct layers 5–15 cm thick. These cracks frequently dip against the slope of the flow and show 15–50° angular difference with the macroscopic flow induced fabric in the lava. Cavities with diffuse edges and low aspect ratio mark the "pressure shadows" – edges of lithic fragments that are also locally distributed in layers parallel with the flow fabrics. Our preliminary interpretation of the field and AMS (anisotropy of magnetic susceptibility) fabric data suggest that the described porosity represents a result of mechanical failure of the dacite glass and/or failure induced by dilatancy of the groundmass rich in plagioclase lath shaped crystals. The progression of this brittle-ductile failure can disrupt the lava into distinct angular to spherical fragments that start to roll in the surrounding and still viscous lava. Further microstructural work will aim to constrain the timing, conditions and growth rate of the dynamic porosity in different parts of the flows. These parameters should be in the future incorporated into numerical models simulating stability of lava flows for mitigation of associated volcanic hazards.

References

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