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Porosity and permeability relationships of edifice-forming andesites: A combined field and laboratory study

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In volcanic settings, permeability is a key parameter controlling eruptive style and magnitude of eruptive activity by influencing the capacity for a volcano to outgas. The relative ease by which these volatiles can outgas depends on the connectivity and mobility of bubbles within the conduit and the permeability of the edifice. To explore the permeability and porosity of edifice-forming rocks, a field campaign was undertaken in May/June 2014 at Volcán de Colima, an active and currently erupting stratovolcano in Mexico. The density (used to infer porosity) and permeability of around 600 rock samples, collected from several debris-flow tracks, were measured using a field Archimedean double-weight method and a portable field permeameter, respectively. Permeability was found to range between 7.6 x 10-16 to 6.5 x 10-11 m2 across a porosity range of 2.5 to 73%. The permeability data are notably scattered, with up to four orders of magnitude difference in permeability observable for rocks of similar porosity. Scatter in the data is attributed to the wide variety in rock microstructure (due to variable vesiculation and deformation during emplacement, as well as pre- or post-emplacement alteration). Our density measurements highlight that the proportion of dense rocks increases with distance from the active dome. To complement these field data, a subset of samples (spanning the range of porosity) were brought back to the laboratory for gas permeability and porosity measurements, as well as further properties such as specific surface. Statistical analysis of the laboratory permeability-porosity data suggests a critical porosity threshold may exist, above which increased connectivity yields more efficient fluid transport. Finally, we also collected a suite of field samples containing subplanar deformation bands and tuffisites, features common to many of the rocks comprising the edifice. Laboratory permeability analysis demonstrates that some features act as conduits while others serve as barriers to fluid flow, suggesting fundamentally different feature geneses or modes of deformation. Our combined field and laboratory study hopes to shed light on porosity-permeability trends at active andesitic stratovolcanoes, as well as help constrain models of magma degassing and emplacement processes.