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A tool for computing time-dependent permeability reduction of fractured volcanic conduit margins.

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Laterally-oriented fractures within volcanic conduit margins are thought to play an important role in tempering eruption explosivity by allowing magmatic volatiles to outgas. The permeability of a fractured conduit margin—the equivalent permeability—can be modelled as the sum of permeability contributions of the edifice host rock and the fracture(s) within it. We present here a flexible MATLAB® tool which computes the time-dependent equivalent permeability of a volcanic conduit margin containing ash-filled fractures. The tool is designed so that the end-user can define a wide range of input parameters to yield equivalent permeability estimates for their application. The time-dependence of the equivalent permeability is incorporated by considering permeability decrease as a function of porosity loss in the ash-filled fractures due to viscous sintering (after Russell and Quane, 2005), which is in turn dependent on the depth and temperature of each fracture and the crystal-content of the magma (all user-defined variables). The initial viscosity of the granular material filling the fracture is dependent on the water content (Hess and Dingwell, 1996), which is computed assuming equilibrium depth-dependent water content (Liu et al., 2005). Crystallinity is subsequently accounted for by employing the particle-suspension rheological model of Mueller et al. (2010). The user then defines the number of fractures, their widths, and their depths, and the lengthscale of interest (e.g. the length of the conduit).

Using these data, the combined influence of transient fractures on the equivalent permeability of the conduit margin is then calculated by adapting a parallel-plate flow model (developed by Baud et al., 2012 for porous sandstones), for host rock permeabilities from 10^{-11} to 10^{-22} m^2. The calculated values of porosity and equivalent permeability with time for each host rock permeability is then output in text and worksheet file formats. We introduce two dimensionless scale limits: the first to determine the applicability of the compaction model over the width of each fracture, and the second to indicate whether the fracture can outgas (or if pore pressure within the fracture will increase). The computational tool warns the user when the scale limits are violated.

We outline applications of our tool: both independently and in concert with larger-scale models of volcanic outgassing. For example, in testing the tool, results suggest that fractures in a highly permeable edifice have marginal—if any—influence on the overall permeability of a volcanic system. On the other hand, in low permeability systems, even narrow fractures can allow significant outgassing to occur. Similarly, shallow fractures will serve to increase outgassing capability relative to deep fractures that heal more rapidly. We highlight the eminent flexibility of our tool, which enables it to be adapted to a wide range of specific user-defined requirements and scenarios.