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Fluid-Rock Dynamic Interaction in Magmatic Conduits: Modelling Transients Using an Analytical Solution

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We compute transients fluid-rock dynamic interaction in a fluid driven axisymmetric conduit embedded in an infinite, homogeneous elastic space. Both fluid and solid are dynamically coupled fulfilling continuity of velocities and radial stresses at the conduit's wall. The calculation model considers the viscosity as a key parameter leading to non-linear scheme. A pressure transient at a point of the conduit, that perturbs a steady flow of incompressible viscous fluid, produces the interaction between the fluid and motion at the conduit's walls. The fluid motion induces the elastic response of the conduit forcing it to oscillate radially. The fluid-filled conduit dynamics is governed by three second-order, ordinary non-linear differential equations, which are solved numerically by applying a fifth-order Runge-Kutta scheme. Boundary conditions satisfy the Bernoulli's principle allowing coupling several pipe segments which may present smooth variation in fluid properties. The nature of the source involves different pressure excitations functions including those measuring during simulations of gas burst and fragmentation of volcanic rocks under controlled laboratory conditions. Far-field velocity synthetics radiated by motion of the conduit's walls and fluid flows ascending to the surface, display characteristic waveforms and frequency content that are similar to those of long-period signals and tremor observed at active volcanoes. Results suggest that transient fluid flow induced oscillations may explain long-period and tremor signals. Advantages and limitations of this approach are discussed.