Geophysical Research Abstracts
Vol. 12, EGU2010-5637, 2010
EGU General Assembly 2010

Numerical Calculation of LP Seismic Signals Modeling the Fluid-Rock Interaction in Simulated Volcanic Conduits

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We present an investigation of the fluid-solid dynamic interaction of a fluid-driven cylindrical conduit embedded within an infinite, homogeneous elastic space with physical properties similar to those encountered in volcanic environments.
In our model, a pressure transient is applied at the bottom of the conduit, which perturbs the steady flow of incompressible viscous fluid, driven by a pressure gradient. The model includes radial variation of a cylindrical fluid-filled conduit driven by changes in the flow velocity of a Newtonian fluid and a pressure gradient. Both fluid and solid are dynamically coupled by the continuity of radial velocities and shear and radial stresses at the conduit wall. The conduit dynamics are governed by three ordinary non-linear differential equations of second order, which are solved numerically by applying a fifth-order Runge-Kutta scheme. Our model allows for any number of pipe segments of different sizes coupled in series, thus representing an extended source region, which closely mimics the geometry of realistic volcanic conduits. Various examples of fluid-filled pipe-systems, starting from the simplest penny-shape geometries up to conduits of hundreds of meters in length, are presented. The values assumed for the fluid density and viscosity are in the mean range of basaltic and andesitic composition. Far-field velocity synthetics radiated by the motion of the conduit and fluid flows ascending to the surface display characteristic waveforms and frequency contents that closely resemble those of long-period (LP) signals observed at active volcanoes.