Numerical Investigation of Subaqueous Volcanic Explosions

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We present results from a numerical investigation of volcanic eruptions through a crater lake using the computer code SAGE. In our investigation, we model the interaction between the erupting volcanic fluid and fluids that occupy the crater lake. Sage is a numerical model developed by the Thermonuclear Division at Los Alamos National Laboratory to simulate submarine nuclear tests. It is a 2D/3D Cartesian, multi-material fluid dynamic finite difference code with automatic adaptive mesh refinement capabilities. The calculations are governed by first principle physics and the Navier Stokes equations. The fluids are treated as compressible and viscosity is considered by a weak tensor viscosity term. The code solves the governing equations in terms of spatio-temporal components of fluid pressure, density , flow velocity, and internal energy .

We apply SAGE to the 1995-1996 eruption at Ruapehu volcano in New Zealand using data collected during the eruption by the Ruapehu Surveillance Group. The early phases of this eruption were characterised by explosive eruptions that passed through a crater lake. During this time, a microphone was operating and recorded the acoustic signals associated with these subaqueous eruptions. We compare these pressure measurements with those calculated by the model to estimate the initial conditions of each eruption and study the exchange of energy between the erupting fluid and the crater lake. These simulations are set up such that the volcanic fluid is situated in a conduit at lithostatic pressure with the vent located at the base of a crater lake. The volcanic fluid is comprised mainly of steam, the crater lake is comprised of pure water with surface and bottom temperatures of 48^{o} C and 170^{o} C, respectively, with a layer of molten sulfur located at the interface with the vent.