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TWO-DIMENSIONAL SIMULATIONS OF MAGMA INTERACTION WITH UNDERGROUND TUNNELS

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A two-dimensional model for magma ascent in a volcanic dike and subsequent flow into a horizontal subsurface tunnel including obstacles is presented. Computational Fluid Dynamics (CFD) analyses were performed to numerically assess magma dynamics inside the horizontal tunnel assuming either transient or steady-state effusive flow of a single-phase magma. For these simulations, the solutions to the full two-dimensional Navier Stokes equations were obtained using an unsteady flow, implicit fluid dynamics approach with the commercial software FLUENT. To calculate the flowfield(s) occupying the dike and horizontal tunnel after intersection, numerical simulations focused primarily on two scenarios: (i) magma entering and eventually filling a tunnel both with and without the presence of obstacles and (ii) a magma filled tunnel including obstacles under conditions of constant magma supply and ascent (steady-state). Simulation results show that magma ascending along a dike that intersects a tunnel will fill the tunnel under the influence of gravity from the base to the top and then continue upwards along the dike or conduit. Counter-rotating vortices adjacent to the dike that extend into the tunnel are driven by viscous coupling between the magma rising in the connected dike and existing magma that filled the tunnel. Computational results also show that magma flow patterns that develop within the tunnel are affected by the location of dike intersection, specifically relative to any obstacles present in the tunnel, where additional secondary vortices can develop adjacent to the primary vortex. The size, shape, and distribution of the vortices are influenced by magma ascent rate through the dike. At higher ascent rate, vertically coupled counter-rotating vortices can develop in the space between the dike and any obstacle present in the tunnel. The computed results show that the complexity of the volcanic plumbing influences the pattern of the circulation developed in the drift. The pattern of circulation is largely influenced by the interplay between the ascending magma and location of the obstacles. This abstract is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the USNRC. The USNRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability of any licensing action that may be under consideration at the US-NRC.