FLOW OF VOLATILE-FREE AND VOLATILE-RICH BASALTIC MAGMAS THROUGH ELASTIC-WALLED DIKES

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Ascent of volatile-poor and volatile-rich basaltic magma through a vertical dike is examined. A two-dimensional model is used in which the flow is averaged across a dike, which is narrow relative to the vertical and the horizontal length scales along the dike. The model only considers flow variations along the dike that are localized. A generalized equation of state is formulated that captures three distinct limits to flow:

i) Volatile-free flow of nearly incompressible magma through a dike of fixed dimensions.

ii) Volatile-free flow of incompressible magma through a dike in which width is assumed to be proportional to the difference in the magmatic pressure and the lithostatic pressure of the surrounding host rock.

iii) Volatile-rich flow of bubbly magma in a dike of fixed dimensions. We use a leading-order approach in which the motion of the bubbles relative to the liquid magma is neglected.

In all cases, the bulk viscous resistance is parameterized. The resulting model consists of momentum equations, a continuity equation, the equation of state, and (for cases ii and iii) the relationship between dike width and the magma and rock pressures. Time-dependent numerical simulations are verified against steady-state solutions that have variations in the vertical dimension only. Finally, the leading-order response to local non uniformities is explored and the model is applied to possible patterns of magma flow through elastic-walled dikes encountering a horizontal tunnel.