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Incorporation of cooling-induced crystallization into a 2-dimensional axisymmetric conduit heat flow model

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Heat flow models can bring new insights into the thermal and rheological evolution of volcanic 3 systems. We shall investigate the thermal processes and timescales in a crystallizing, static 4 magma column, with a heat flow model of Soufriere Hills Volcano (SHV), Montserrat. The latent heat of crystallization is initially computed with MELTS, as a function of pressure and temperature for an andesitic melt (SHV groundmass starting composition). Three fractional crystallization simulations are performed; two with initial pressures of 34MPa (runs 1 & 2) and one of 25MPa (run 3). Decompression rate was varied between 0.1MPa/°C (runs 1 & 3) and 0.2MPa/°C (run 2). Natural and experimental matrix glass compositions are accurately reproduced by all MELTS runs. The cumulative latent heat released for runs 1, 2 and 3 differs by less than 9% (8.69E5 J/kg*K, 9.32E5 J/kg*K, and 9.49E5 J/kg*K respectively). The 2D axisymmetric conductive cooling simulations consider a 30m-diameter conduit that extends from the surface to a depth of 1500m (34MPa). The temporal evolution of temperature is closely tracked at depths of 10m, 750m and 1400m in the centre of the conduit, at the conduit walls, and 20m from the walls into the host rock. Following initial cooling by 7-15^{o}C at 10m depth inside the conduit, the magma temperature rebounds through latent heat release by 32-35^{o}C over 85-123 days to a maximum temperature of 1002-1005^{o}C. At 10m depth, it takes 4.1–9.2 years for the magma column to cool by 108-131^{o}C and crystallize to 75wt%, at which point it cannot be easily remobilized. It takes 11-31.5 years to reach the same crystallinity at 750-1400m depth. We find a wide range in cooling timescales, particularly at depths of 750m or greater, attributed to the initial run pressure and the dominant latent heat producing crystallizing phase, Albite-rich Plagioclase Feldspar. Run 1 is shown to cool fastest and run 3 cool the slowest, with surface emissivity having the strongest cooling influence in the upper tens of meters of the conduit in all runs.