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Deep Magma Transport beneath Soufriere Hills Volcano, Montserrat, WI: 1995-2007

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Magma melting and transport produces a complex architecture of connected magmatic systems present beneath many arc volcanoes. Although melt supplied by subduction may be considered constant over very long timescales (>Ma), rates of magma transport and eruptive episodes are episodic at timescales encompassing millennia and centuries to hours. A variety of mechanisms act at these various timescales; in general longer periodicities imply controlling processes rooted at greater depth and involving reservoirs of increasing volumes. Here we use histories of magma efflux and surface deformation to quantitatively constrain magma transfer into and within the deep (>12 km) crustal plumbing of the Soufrière Hills volcano over a 12-year eruptive cycle of active effusion punctuated by discrete pauses. For three cycles of effusion followed by pause, with a periodicity of 4-6 years, deep supply to the system is continuous and never drops below ∼0.5-1 m3/s; this minimum supply is similar in magnitude to both the mean measured eruptive efflux (including pauses) (∼0.7 m3/s) and the mass accumulation due to crustal convergence (∼0.6 m3/s). Deep fluxes rise synchronously from this background magnitude in times of active eruption (∼1-5 m3/s), are augmented by deflation (∼1-2 m3/s) of a reservoir centered at ∼12 km, and pass through an upper magmatic reservoir. An eruptive pause is marked by a decrease in supply from the deep crust, fully accommodated as the deep reservoir switches to reinflate, and with no resulting supply to the shallow crust. For a two-reservoir model, these observations implicate the deep system in controlling short-term (∼3-5 yr) eruptive periodicity. They are consistent with a model involving the continuous supply of magma from the deep crust/mantle into a voluminous and compliant deep reservoir, episodically-valved below the shallow reservoir.