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Using volumetric strain data to elucidate the shallow crustal mechanics of Soufrière Hills Volcano

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Volumetric strain data from the July 29th 2008 Vulcanian explosion of the Soufrière Hills Volcano provide an excellent opportunity to explore the mechanical properties of the shallow crust beneath Montserrat. We find that simple models neglecting topography and medium mechanical heterogeneities may be substantially underestimating conduit pressure drops. We use Finite Element Analysis to model sub-domains representing i) a mechanically compliant rock halo around the conduit and ii) a mechanically compliant edifice and shallow crust to obtain geologically and mechanically acceptable pressures to fit the volumetric strain signal. Our results from both forward and inverse models indicate a conduit radius of $\sim$40m and a length of 1500m, much larger conduit dimensions than have been suggested previously.In order to fit the syn-eruptive volumetric strain data at a conduit pressure drop of <10 MPa, the conduit needs to be surrounded by a $\sim$300m wide halo of mechanically compliant rock material with a Young's modulus of $\sim$1 GPa. Our best-fit inverse model indicates that the conduit radially contracted by a maximum of 0.24m during the eruption with a corresponding conduit volume loss of $\sim$0.1 Mm3. In contrast, field data suggest an eruptive volume of 0.2-1.4Mm3 which implies only partial emptying of the conduit upon the explosion. Our study demonstrates the critical role of mechanical heterogeneities in the edifice and shallow crust for strain partitioning on Montserrat.