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Thermal and mechanical controls on magma supply and volcanic deformation

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Ground deformation often precedes volcanic eruptions, and results from complex interactions between source processes and the thermomechanical behaviour of surrounding rock. Geodetic models aimed at constraining source processes consequently require the implementation of realistic mechanical and thermal rock properties. However, most generic models ignore this requirement and employ oversimplified mechanical assumptions without regard for thermal effects. Here we show how spatio-temporal deformation and magma reservoir evolution are fundamentally controlled by three-dimensional thermomechanical heterogeneity. Using the example of continued inflation at Aira caldera, Japan, we demonstrate that despite on-going eruptions magma is accumulating faster than it can be ejected, and the current uplift is approaching the level inferred prior to the 1914 Plinian eruption. Our results from inverse and forward numerical models are consistent with petrological constraints and highlight how the location, volume, and rate of magma supply, 0.014 km^3/yr, are thermomechanically controlled. Magma storage conditions coincide with estimates for the caldera-forming reservoir ~29,000 years ago, and the inferred magma supply rate indicates a ~130-year timeframe to amass enough magma to feed a future 1914-sized eruption. These new inferences are important for eruption forecasting and risk mitigation, and have significant implications for the interpretations of volcanic deformation worldwide.