Linking geodesy and petrology - The influence of cooling, crystallisation and re-melting on the interpretation of geodetic signals

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Deformation of volcanic edifices is typically attributed to the movement of magma within the volcanic plumbing system but a wide range of magmatic processes are capable of produce significant volume variations. In order to understand the evolution of magmatic systems prior to eruption and properly interpret monitoring signals, it is necessary to quantify the patterns and timescales of surface deformation that processes such as crystallisation and degassing can produce. We show how the combination of petrology and thermal modelling can be applied to geodetic observations to identify the processes occurring in magmatic reservoir during volcanic unrest.

Thermal modelling in combination with petrology was used to determine the timescales and volumetric variations associated to cooling, crystallization and gas exsolution. These calculations can be performed rapidly and highlight the most likely processes responsible for the variation of a set of monitoring parameters.

This modelling was applied to a time series of geodetic data spanning the period between the 1997 and 2008 eruptions of Okmok volcano, Aleutians, examining scenarios involving crystallisation, degassing and re-melting of a crystallizing shallow magmatic body. The geodetic observations are consistent with the injection of a water-saturated basalt, followed by minor crystallization and degassing, while other scenarios are not compatible either with the magnitude or rate of the deformation signals.