Estimating the distribution of melt beneath the Okataina Caldera, New Zealand: an integrated approach using geodesy, seismology and magnetotellurics.

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Abstract

The inversion of geodetic data to estimate the position and depth of a magmatic body is inherently non-unique. To help constrain a model's geometry, a priori information is often used to fix the depth and position to make the inversion problem more tractable. This is commonly done based on independent information from other datasets such as Magnetotellurics (MT) and seismology which is able to provide an image of the subsurface structure. Here we use geodetic (InSAR and GPS), seismological and MT data acquired over the Okataina Caldera, New Zealand, and perform a joint inversion whereby information from MT and seismology are directly included in the inversion of surface deformation data. Both InSAR and GPS indicate subsidence of up to 2 cm/yr over much of the Okataina Caldera. To model the deformation, we assume that all of the subsidence is a result of the cooling and contraction of a magma at depth. We build a model consisting of a stack of sills at 1 km intervals and use the MT resistivity model along with relocated seismicity to constrain the inversion. Assuming that regions with minimal or no partial melt are more resistive, the addition of the MT resistivity acts as a penalty function where areas with high resistivity are penalised causing the inversion to preferentially put contraction in regions where it can satisfy both the displacement data and MT results. The inversion suggests that most of the deformation can be explained by a source located at between 5 and 6 kms depth with lesser amounts of contraction above 4 km. This is consistent with independent geochemical data which suggests that most of the silicic magmas are stored between 5 and 8 km depth. At 6 km, the model suggests a broad region of contraction of _˜2 cm/yr located SW of Lake Tarawera consistent with the spatial pattern of seismicity and location of a large conductor. The extent of the deeper source reduces at 5 km depth but a region to the north of the lake shows a focussed zone of contraction coinciding with a cluster of seismicity at a similar depth.

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