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Imaging magmatic Processes in the Taupo Volcanic Zone (New Zealand) with Magnetotellurics

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The Taupo Volcanic Zone (TVZ) in the North Island of New Zealand is characterised by rapid extension, extremely high heat output and very high rates of rhyolitic magma production. The processes that give rise to these exceptional characteristics have not yet been fully resolved. To maintain the geothermal heat output requires the heat equivalent to magma cooling at rates of about 1-2 m^3 per second. Analysis of volatile inclusions within erupted material suggests that large volumes of magma must have resided in the crust at depths of 4-6 km. Despite these indicators of magma, there is little direct geophysical evidence for shallow magma bodies.

Magnetotelluric (MT) methods, which are capable of measuring the electrical conductivity of the earth to great depths, provide an alternative approach to the search for magma because of their sensitivity to the presence of fluids. From the analysis and inversion of more than 100 MT measurements we have constructed an image of the conductivity structure across the TVZ, extending to depths of about 70 km. Near the surface, basins on the east and west of the TVZ are filled with relatively conductive volcaniclastic material. Beneath the surficial structure, a continuous zone of higher resistivity extending down to about 10 km is interpreted as thinned upper crust. Along the eastern margin of the TVZ, the upper crust is more conductive, possibly indicating more elevated temperatures in this region. A rapid increase in the conductivity occurs at about 10 km depth across the width of the TVZ, about 2km beneath the base of the seismogenic zone and well above the base of the quartzo-feldspathic crust (ca. 16 km) as identified by seismic surveys. The most plausible explanation for the increase of conductivity is the presence of small fraction ($<$4%) of connected melt. This is consistent with both receiver function data and the deduced base of the convectively driven geothermal systems of the TVZ. Lateral variations in the conductance of this zone represent either a greater thickness of the melt or an increase in the melt fraction

slightly to the east of the Taupo Fault Belt. Although the thickness of the conductive zone cannot be resolved accurately it appears to extend across the base of the quartzo-feldspathic crust. It is difficult to reconcile the MT results with the recent interpretation of seismic reflection data which suggests the presence of a layer containing a high ($\sim$6%) melt fraction at 35 km depth. At deeper levels the subducted plate appears as a dipping resistor beneath a conductive mantle wedge.