Comparison of three geothermal fields in the Taupo Volcanic Zone using magnetotellurics and seismicity

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SUMMARY

Since 2009, nearly 1500 broadband magnetotelluric (MT) measurements (at 2 km site spacing) have been acquired in the central part of the Taupo Volcanic Zone (TVZ), New Zealand. The TVZ is an actively rifting volcanic arc, with a central segment that represents the largest rhyolitic volcanic system on Earth (since ~340 ka) and hosts 23 high-temperature geothermal fields that collectively discharge ~4.2 GW of heat.

Previous results, using subsets of these data, provided the first-ever images of the connections between the shallow parts of the geothermal fields and their underlying magmatic heat sources. Variations observed between the sub-basement roots of the geothermal fields demonstrate a strong correlation between the tectonic and volcanic structure of the TVZ. Together with estimates of the thickness of the brittle crust, based on the D90 depth from seismicity, our results support a conceptual model of heat transport in the brittle crust that involves episodic intrusion, modulating an overarching system of convective heat transport.

Recent 3-D resistivity inversion models of TVZ MT data have used FEMTIC (https://github.com/yoshiya-usui/femtic), which allows topography to be included in the modelling. In comparison to previous inversion modelling that did not include topography, the FEMTIC models provide better resolution of the shallow resistivity structure and a more reliable context for comparison with seismicity. Inversion models of MT data from the south-eastern part of TVZ containing the Wairakei-Tauhara, Rotokawa and Ngā Tamariki geothermal fields, all of which lie adjacent to each other separated by ~8 km, show that the resistivity structure at depth is heterogenous. The heterogeneity seems to reflect the distinct volcanic history of each of the geothermal fields, with the shallowest D90 estimate and most conductive body beneath Rotokawa, the field with the highest recorded temperature and where 8 hydrothermal eruptions have occurred in the past 20 ka.

Keywords: Magnetotellurics, FEMTIC, Geothermal, Magma, Taupo Volcanic Zone