Variation of the brittle-ductile transition beneath New Zealand's geothermal systems: Imaging using 3-D passive seismic attenuation

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We image seismic properties Vp, Vs and Qp in the Taupo Volcanic Zone (TVZ), New Zealand, across a region encompassing the Wairakei, Rotokawa, and Waimangu high-temperature geothermal systems, as part of a multi-disciplinary research programme to investigate untapped deep geothermal resource. The TVZ contains more than 20 high-temperature geothermal systems, which together discharge ~4.2 GW of heat at the surface. This study of seismic properties is complementary to a magnetotelluric study investigating electrical conductivity in the same region (Bertrand et al., GRL 2012 and JVGR 2015).
Seismic data used for the imaging include data from a 38-site broadband seismic array deployed across the region between 2009 and 2011, as well as from an 11-site broadband array deployed since 2015. We supplement these new data with legacy seismic data recorded by previous arrays, including the “TVZ95” array, the 2001 “CNIPSE” array, as well as by data recorded by the national GeoNet seismometer network.
We have inverted these data to derive the spatial and depth variation of seismic properties Vp, Vs, and Q (1/attenuation), especially focusing on resolving the properties in the 2-8 km depth range. Our derived 3-D Vp, Vp/Vs, and Q volumes show heterogeneity at a range of length scales, with strong lateral changes, especially for Q. The revised 3D velocity model has also enabled us to relocate all seismicity in the area, providing the best dataset to date of earthquake locations in the TVZ; we observe some areas where the inferred brittle-ductile transition appears to be shallower than 6 km, while seismicity locally extends down to ~10 km beneath the Wairakei and Te Mihi systems.

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