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Investigation of fault structures from microseismicity in the Wairakei geothermal field, New Zealand

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The Wairakei geothermal field is located in the centre of a NNE-trending rifting arc, called the Taupo Volcanic Zone (TVZ), New Zealand. In 1958, commercial production of electricity started at the Wairakei field, which currently holds the largest installed capacity of the TVZ ($\sim$375 MWe). For some operational reasons, large scale infield re-injection started in the mid 1990's (Otupu area; east of Wairakei) and further extended to the south (Karapiti area) in August 2011. Small scale re-injection trials have been also being conducted since 2012 (West of Wairakei).

In total, 13 borehole seismometers have been installed in the Wairakei geothermal field since 2009 to support reservoir management and drilling strategies, and observe the reservoir response to production and injection. The range of installation depths is 65 m to 1,200 m. About 97% of the 7049 events recorded have magnitude $\leq$2, in the so-called micro-earthquake range, and locate above 6 km depth. The micro-seismicity distribution tends to be diffuse. Although some correlation with geological units and faults can be made, identification of distinct fractures is challenging.

In this study, we investigate active fault structures from micro-seismic events occurring in the geothermal field between March 2009 and June 2013 using focal mechanism, clustering and double-difference relocation methods.

We firstly calculate double-couple focal mechanism solutions from the micro-seismic data set using HASH. To reduce uncertainty of focal mechanism parameters, P-wave first motion polarities from 12 GeoNet stations installed in the vicinity of the Wairakei were combined with those of 13 Wairakei stations within the field. In total, 21 focal mechanisms with more than eight P-wave polarities have been computed. Most focal mechanisms are consistent in showing a NNE-trending nodal plane, and have normal or strike-slip mechanisms, coinciding well with the overall extensional tectonic regime and mapped active faults in the TVZ.

As focal mechanism solutions are rare in the injection fields, where fault geometries are of particular interest, the spatio-temporal micro-seismic distribution was analysed using an event clustering method, CURATE. It determines event sequences by comparing observed event rates to an average event rate. We have obtained 35 event clusters, which will now be further analysed using a hypocentre relocation double-difference method (HypoDD). Waveform correlation between the events in each swarm will be used to refine fault structures.