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Imaging the concealed section of the Whakatane fault below Whakatane city, New Zealand, with a shear wave land streamer system

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The Mw 7.1 Darfield Earthquake in September 2010 ruptured the surface along the Greendale Fault that was not known prior to the earthquake. The subsequent Mw 6.3 Christchurch earthquake in February 2011 demonstrated that concealed active faults have a significant risk potential for urban infrastructure and human life in New Zealand if they are located beneath or close to such areas. Mapping exposures and analysis of active faults incorporated into the National Seismic Hazard Model (NSHM) suggests that several thousands of these active structures are yet to be identified and have the potential to generate moderate to large magnitude earthquakes (i.e. magnitudes >5). Geological mapping suggests that active faults pass beneath, or within many urban areas in New Zealand, including Auckland, Blenheim, Christchurch, Hastings/Napier, Nelson, Rotorua, Taupo, Wellington, and Whakatane.

Since no established methodology for routinely locating and assessing the earthquake hazard posed by concealed active faults is available, the principal objective of the presented study was to evaluate the usefulness of high-resolution shear wave seismic reflection profiling using a land streamer to locate buried faults in urban areas of New Zealand. During the survey carried out in the city of Whakatane in February 2015, the method was first tested over a well known surface outcrop of the Edgecumbe Fault 30 km south-west of Whakatane city. This allowed further to investigate the principle shear wave propagation characteristics in the unknown sediments, consisting mainly of effusive rock material of the Taupo volcanic zone mixed with marine transgression units. Subsequently the survey was continued within Whakatane city using night operation time slots to reduce the urban noise.

In total, 11 profiles of 5.7 km length in high data quality were acquired, which clearly show concealed rupture structures of obviously different age in the shallow sediments down to 100 m depth. Subject to depth verification by drillings normal fault displacements of up to 15 m are visible in depths of 20-40 m, deeper rupture structures show displacements of up to 20 m. Furthermore, indications of strike-slip fault activities are visible. The concealed rupture structures found are not aligned along former estimated fault lineaments or main surface structures like the Whakatane river bed. Correlations exist with small topographic variations detected by LIDAR imaging and surface signatures on a historic map of 1867.