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High-resolution seismic reflection and ground-penetrating radar investigations of seismically active faults on the South Island of New Zealand

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New Zealand is located along the plate boundary between the Australian and Pacific plates. Although numerous fault zones associated with the plate boundary setting have not ruptured during the nearly 200 years of European settlement, paleoseismology provides clear evidence of relatively recent activity on many of them. Knowledge of the shallow structure and other characteristics of these fault zones is important for understanding the related seismic hazard and seismic risk. Critical physical properties of faults that produce infrequent large earthquakes are usually determined or inferred from paleoseismological investigations based on surface outcrops, geomorphology, boreholes and/or trenches. In an attempt to improve our knowledge of active faults beyond the reach of conventional paleoseismological methods (i.e. deeper than a few metres), we have acquired and processed high-resolution seismic reflection and ground-penetrating radar (GPR) data across three major fault systems located on the South Island: northern parts of the transpressive Alpine Fault Zone, a portion of the reverse Ostler Fault Zone in the south-central part of the Island, and a number of faults hidden beneath the very young sediments of the Canterbury Plains. After subjecting our data to a wide variety of processing schemes, the resultant seismic and GPR sections provide vivid images of all target structures. We see the principal strand of the Alpine Fault dipping steeply through Quaternary sediments and offsetting the basement. Furthermore, a significant subsidiary fault strand and associated deformation is observed $\tilde{3}$0 m from the principal fault trace. Our images of the Ostler Fault Zone reveal a $\tilde{5}$0° west-dipping primary fault strand with multiple subsidiary fault splays and complex folds on either side of it. Finally, our Canterbury Plains seismic sections display a complex pattern of relatively major faults, folds and tilting beneath a thin veneer of nearly flat lying sediments.