THE 2010 M_w7.1 DARFIELD EARTHQUAKE RUPTURE AND REGIONAL STRESS IN THE NORTHERN SOUTH ISLAND

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E.M. Anderson (1905) proposed that where σ_2 is vertical, wrench faults should initiate on vertical planes at c. 30° to horizontal maximum compressive stress in accordance with the Coulomb shear failure criterion. This relationship may not hold for strike-slip faults with large finite displacements (because of block rotations about vertical axes), but appears to hold for low-displacement structures. Available data on regional stress in the northern South Island are sparse, but a reasonably consistent picture is emerging of a horizontal maximum compressive stress (σ_1) oriented WNW-ESE from inversion of focal mechanisms, geological structures, and wellbore breakouts. A compilation of such data suggests σ_1 oriented 115±5°. However, the vertical component of the stress tensor is less well constrained, given the spatial and temporal coexistence of steep reverse faults striking 000-020°, and sub-vertical right-lateral strike-slip faults trending 080-095°. Derivation of the regional stress regime is complicated by: (i) extensive reactivation of inherited normal faults; (ii) reactivation of terrane boundary discontinuities; and, (iii) comparative paucity of young slip vector data from exposed fault surfaces.

Long-period focal mechanisms for the 2010 M7.1 Darfield earthquake yield a subvertical fault striking 086-099° in good agreement with the mapped surface trace which trends 085-090°. The subvertical fault thus lies at 25-35° to the inferred regional σ_1, close to that expected for an ideal 'Andersonian' dextral wrench fault. This implies either that the structure is comparatively new-formed in the contemporary stress field, or that there has been preferential reactivation of an unknown, pre-existing fault that is optimally oriented in the stress field. The inferred orientation of maximum compressive stress is also compatible with reverse faulting along the eastern range front of the Southern Alps. Improved definition of the regional stress field will facilitate hazard assessment from both recognised and unrecognised active faults through slip tendency analysis.