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# Paleostress and fault inversions along the southern Alpine Fault, New Zealand

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The Alpine Fault comes on-shore to the north of Milford Sound in southwestern New Zealand, and is the regional expression of the transpressional Australia-Pacific plate boundary. Fault-slip data, paleostress solutions, and structural observations indicate that brittle structures preserved in rock units located southeast of the Alpine Fault record several distinct stress states. Field observations and the fault patterns indicate that the region within 10 km of the plate boundary records a structural evolution and a rheology that are different than the region 30 km to the south of the Alpine Fault, despite pervasive brittle faulting in both zones. Approximately 30 km to the south of the Alpine Fault, there is no indication of retrogression, ductile deformation, or hydrothermal alteration of dioritic and metasedimentary lithologies. In this distal region, plutonic rocks record mostly brittle behavior and widely-spaced faults, consistent with a relatively viscous rheology. Brittle faults in this domain include dextral strike-slip, oblique strike-slip, and normal faults. The deviatoric stress tensor that satisfies the majority of the faults shows a gently plunging, northeast-trending (035º-045º) axis of maximum compression ($\sigma_1$), and a southeast trending (125º-135º) axis of minimum compression ($\sigma_3$). In contrast, diorite in the region close to (within 10 km) the Alpine Fault records evidence of pervasive fluid flow, distributed ductile deformation, recrystallization, and retrogression. Faults at this proximal location include dextral, sinistral, and oblique strike-slip, and thrust faults. These faults do not combine well into one deviatoric stress solution, suggesting an evolving stress field. However, the stress solution that satisfies the largest number of faults has a nearly horizontal west-northwest trending (285º-295º) axis of maximum compression ($\sigma_1$). This solution is distinct from the modeled solution for the distal sites, and agrees well with published $\sigma_1$ axes from paleostress data along the central (126º $\pm$ 10º) and northern (290º-300º)

parts of the Alpine Fault. In addition, this $\sigma_1$ orientation is congruent with published P-axes determined from earthquakes in southwestern New Zealand. Cross-cutting relationships and the good agreement between the proximal stress state and P-axes suggest that the west-northwest trending $\sigma_1$ orientation represents a stress state similar to the modern stress field. We interpret the differences in structure, paleostress states, and rheologic behavior of the crust adjacent to the Alpine Fault zone to reflect a progressive weakening of the crust due to increased fluid flow and exhumation within 10 km of the plate boundary.