Tectonic stress and fault rock fabrics in the vicinity of the Alpine Fault inferred from DFDP-2 borehole televiewer (BHTV)imagery

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The Alpine Fault is the primary structure accommodating Australia-Pacific plate motion in South Island, New Zealand. Paleoseismic studies have revealed that the fault is late in its seismic cycle. One of the aims of the Alpine Fault, Deep Fault Drilling Project (DFDP) is to reveal the ambient conditions before an earthquake. Stress around the fault is one of the targeted measurements.

Previous stress estimates based on focal mechanism analysis of the principal stress orientations at seismogenic depths reveal a regional axis of maximum horizontal compressive stress trending approximately 115°. However, seismicity adjacent to the Alpine Fault is sparse and does not constrain the stress field close to the fault.

The analysis of planar features revealed in BHTV logs collected during DFDP-2B drilling provides an opportunity to examine stresses in the hanging-wall of the Alpine Fault. 2244 planar features were detected in BHTV logs, and 1680 of them are classified as fractures. Here we present the results of stress analysis utilizing detected fractures.

We compute stress parameters using the Hough transform method, which enables us to make use of faults even if they do not contain slip directions. For this analysis, we assume that all fractures used in the calculation are representing reverse fault motion in response to a single homogeneous stress tensor, and that factures with similar geometries to the Alpine Fault accommodated similar top to the west shear.

The analysis of the dataset as a whole yields orientations (trend/plunge) for the maximum and minimum compressive stress axes S_1 and S_3 of 124/30 and 023/19 (±30°), respectively and a stress ratio of $(S_2-S_3)/(S_1-S_3)= 0.288$. The maximum compressive stress axis, S_1 is slightly different from that estimated by focal mechanism analysis. The orientations are compatible with geologically determined horizontal shortening from analysis of small scale fractures within a few km of the fault trace.

Stress tensors were also determined for groups of fractures within 20 m depth intervals. In most of these groups, the results are similar to the solution for all depths. However, in depth intervals 720-740 m and 780-860 m, the calculated S_1 and S_3 orientations have respectively smaller and larger plunges, and stress ratios are larger.

The thermal profile of DFDP-2B has been measured by Distributed temperature sensing (DTS) using a fiber-optic cable. A thermal gradient changes at ~720 m depth. This depth corresponds to that where results of stress analysis are changed. [N1] Shear and normal stresses for the stress calculated from fractures across the entire depth range were plotted on 3-D Mohr diagram for fractures. In depth intervals 720-740 m and 780-860 m, many fractures oriented such that low shear stresses would be resolved on them.

Slug tests suggest higher fluid pressure in depth interval 780-860 m. It is known that unfavorably oriented faults can slip under high fluid pressure. There is a possibility that high fluid pressure causes the changing of the distribution pattern of fractures which results in the different

solutions of stress tensor inversion and different thermal gradient at the depths deeper than 720 m. To confirm the hypothesis that high Pf facilitates slip on unfavourably oriented faults at depth, we need to acquire complete fault slip data including the orientations of fault planes and slip directions from drill core samples.

Keywords: the Alpine Fault, borehole televiewer imagery, fault rock fabrics, Stress tensor

