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Field evidence for fluid facilitated fracturing and Dissolution-Precipitaion creep explains observed off-fault tremor and continuous deformation: Field examples from the Alpine Fault, New Zealand

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Geophysical observations show that the Alpine Fault in New Zealand is characterised by mid-crustal off-fault recurring tremor events and off-fault regions of continuous deformation. While geodesy indicates that deformation is distributed across the South Island, evidence from the rock record shows deformation accommodated in a region within several km from the fault. This zone is characterized by a 100-300 m wide mylonitised central fault zone and an approximately 8--10km, wide deformation region marked by the presence of Alpine foliation. Magnetotelluric surveys of the Southern Alps indicate a mid-crustal, high signal area coinciding with the location of the recurring tremors.

While the mylonites and their associated mechanisms have been extensively studied in the field area, the wider off-fault deformation region has not had the same scrutiny. In the latter region, we observe frequent layer parallel, folded and crosscutting quartz veins. Quartz vein orientation and geometries are consistent with fracturing in the presence of fluid within an overall tectonic stress regime. The observed overprinting of older veins by younger vein generations, as well as their successive reorientations, indicate recurring fracturing within a continuously deforming region. Quantitative analysis of vein geometries including their width and displacement shows that vein formation may trigger the observed mid-crustal tremor signal. Microstructural signatures within the host rock are consistent with dissolution-precipitation creep as the main deformation mechanism in the host rock and pre-existing veins.

In summary, according to field evidence both geophysically observed transient and continuous deformation take place in the presence of fluid and occur contemporaneously. This implies that strain accommodation in the host rock facilitated by dissolution-precipitation creep is insufficient; consequently, stress is build-up over time triggering intermittent fracturing.