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Is localised dehydration and vein generation the tremor-generating mechanism in subduction zones?

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The phenomena of tectonic, non-volcanic, tremor was first discovered at the down-dip end of the seismogenic zone in Japan early this millennium. Now this low amplitude, low frequency, noise-like seismic signal has been observed at and/or below the deep limit of interseismic coupling along most well-instrumented subduction thrust interfaces. Data and models from these examples suggest a link between tremor and areas of elevated fluid pressure, or at least fluid presence. Tremor locations appear to also correlate with margin-specific locations of metamorphic fluid release, determined by composition and thermal structure. We therefore hypothesise that: (i) tremor on the deep subduction thrust interface is related to localised fluid release; and (ii) accretionary complex rocks exhumed from appropriate pressure - temperature conditions should include a record of this process, and allow a test for the hypothesis.

Hydrothermal veins are a record of mineral precipitation at non-equilibrium conditions, commonly caused by fracture, fluid influx, and precipitation of dissolved minerals from this fluid. Quartz veins are ubiquitous in several accretionary complexes, including the Chrystalls Beach Complex, New Zealand, and the Kuiseb Schist of the Namibian Damara Belt. In both locations, representing temperatures of deformation of < 300 and < 600 °C respectively, there are networks of foliation-parallel and oblique veins, which developed incrementally and record a combination of shear and dilation. Required to have formed at differential stresses less than four times the tensile strength, and at fluid pressures exceeding the least compressive stress, these veins are consistent with tremorgenic conditions of low effective stress and mixed-mode deformation kinematically in agreement with shear on the plate interface.

We have analysed the oxygen isotope composition of syntectonic quartz veins in both Chrystalls Beach Complex and Kuiseb Schist accretionary complexes, to unravel the geochemical characteristics of the fluid source potentially required to produce tremor. In the Chrystalls Beach Complex, quartz $\delta^{18}O$ values range from 14.1 ‰ to 17.0 ‰ (n = 18), whereas in the Kuiseb schist, values range from 9.4 ‰ to 17.9 ‰ (n = 30). In the latter, values less than 14.0‰ are associated with long-lived shear zones. Excluding the lower values in the Kuiseb schist, the $\delta^{18}O$ values are consistent with metamorphic fluids in near equilibrium with the host rocks. We thus infer that the veins that developed on the prograde path formed at a small range of temperatures from a local fluid source. This interpretation is consistent with the veins forming in response to a spatially localised metamorphic fluid release. If vein swarms are formed by the mechanism geophysically recorded as tremor, this implies that tremor is, at least in some locations, triggered by metamorphic fluid release and associated hydrofracture and low effective stress shear activation of low permeability shear zone rocks. If this is correct, then a corollary may be that the near-periodic nature of tremor events is related to a regular nature in the build-up and release of fluid pressure.