The record of fluid pressure variations by quartz geochemistry

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Fluid pressure is a key parameter in the brittle, upper portion of the lithosphere, as it controls the stress necessary for faults to slip. In turn, fluid pressure is affected by brittle deformation, as large permeability changes occur during the seismic cycle. The interplay between fluid pressure and deformation is nevertheless mostly a theoretical model, as few data are available regarding the amplitude of fluid pressure at depth and its variations with time.

Quartz veins constitute a potential time record of variations in precipitation conditions, as suggested by microstructures such as crack-seal or growth features. We examine in this work different sets of veins from convergent settings, spanning the seismogenic zone (T<250°C) to its down-dip transition to aseismic slip (T~300-350°C). We focused our analysis on trace element composition of quartz, using a combination of cathodoluminescence, laser ablation coupled to mass spectrometry and electron microprobe.

The veins from the seismogenic zone show large variations in trace element concentration, especially Al and Li, which correlate with variations in cathodoluminescence and fluid inclusion density. Two types of quartz therefore coexist, and we interpret the Al- and Li-rich type as having precipitated by rapid, out-of-equilibrium growth, during stages of fluid pressure drops.

In contrast, this trace element-rich type of quartz is absent, or extremely limited, in higher temperature (T~300-350°C) vein quartz. This absence points to precipitation under constant conditions of fluid pressure, in spite of the presence of crack-seal microstructures, which have been tentatively associated with slow-slip events at the base of the seismogenic zone.

Mots-Clés : Subduction zone, earthquakes, fluid pressure, quartz geochemistry, veins