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Microstructural controls on Ti concentration in an extensional shear zone

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The application of Ti-in-quartz thermobarometry for reconstructing P-T conditions in deformed rocks is a potentially powerful tool to track tectonic events recorded in crustal shear zones. This is particularly true for extensional shear zones because they record decompression, cooling, and changes in chemical environment during their activity. In this study of the Columbia River detachment shear zone (Shuswap core complex, British Columbia), we compare Ti-in-quartz concentrations from different microstructural sites in the recrystallized quartzite mylonite to determine a possible P-T history.

Samples collected for this study are from a 1-km thick section of continuous quartzite mylonite that records a strain gradient from coarse-grained micaceous quartzite in the deepest levels of the footwall to quartzite mylonite directly beneath the hangingwall. The Ti concentration of quartz has been analyzed from six samples using an ion microprobe to detect Ti concentrations at trace levels with high spatial resolution sampling of micron-scale quartz textures in thin section. Results show that quartz grains in the protolith of the mylonite preserve a higher, uniformly-distributed Ti concentration (39.2 $\pm$ 3.0 ppm), whereas deformed samples with recrystallized quartz record considerably lower and more variable concentrations. Within each deformed sample there exist three distinct populations of quartz, each preserving a distinct Ti concentration with textures that can be distinguished based on microstructural setting, CL intensity, and crystallographic fabric orientation. For example, one sample collected near the top of the section contains quartz ribbons with a high Ti core (18.6 $\pm$ 3.1 ppm), a recrystallized rim with lower and more variable values (11.8 $\pm$ 5.9 ppm), and neocrystallized quartz precipitated within pressure shadows of feldspar porphyroclasts that have the lowest, most uniform Ti concentration (1.2 $\pm$ 0.6 ppm). These results show that the protolith T was $\sim$620°C (for P= 8 kbar), a likely T for the footwall prior to shear zone activation. The progressively lower Ti values are interpreted in the context of an assumed decompression path for the shear zone rocks. Using the calibration of Thomas et al. (2010), T derived from quartz cores and rims and neocrystallized quartz grains decrease progressively from $\sim$525 to $\sim$290°C. This T range is consistent with T obtained from published oxygen isotope ratios of mineral pairs and corresponds well with the rheological evolution of the shear zone during exhumation (high-T/low to low-T/high stress microstructures).