Microstructural evolution during mid-crustal shear zone thickening and thinning, Mount Irene detachment zone, Fiordland, New Zealand

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Recent work has shown that ductile shear zones experience cyclic variations in stress and strain rate due to, for example, elastic loading from earthquake slip on brittle faults or the presence of rigid particles and asperities within the shear zone. Such *non-steady state* flow conditions can promote microstructural changes including a decrease in grain sizes followed by a switch in the main deformation mechanisms. Understanding the microstructural changes that occur during non steady-state deformation is therefore critical in evaluating shear zone rheology.

The Mount Irene shear zone formed during Cretaceous extension in the middle crust and was active at temperatures of ~ 600°C and pressures of ~ 6 kbar. The shear zone localized in a basal calcite marble layer typically 3-5 m thick containing hundreds of thin (mm-cm) calc-silicate bands that are now parallel to the shear zone boundaries. The lower boundary of the shear zone preserves meter-scale undulations that cause the shear zone to be squeezed in to regions that are <1.5 m thick. The calc-silicate bands act as "flow markers" and allow individual shear zone layers to be traced continuously through thick and thin regions, implying that the mylonites experienced cyclic variations in stress and strain rate. Calc-mylonite samples collected from the same layer close to the base of the shear zone reveal that layer thinning was accompanied by progressive microstructural changes including intense twinning, stretching and flattening of large calcite porphyroclasts as well as the development of interconnected networks of recrystallized calcite aggregates. EBSD analysis shows that the recrystallized aggregates contain polygonal calcite grains with microstructures (e.g. grain quadruple junctions) similar to those reported for neighbor-switching processes associated with grain boundary sliding and superplasticity. Ongoing and future work will utilize samples from across the full thickness of the shear zone to determine key microstructural changes and deformation mechanisms that accommodated shear zone thinning and thickening during non-steady state deformation.