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The influence of metasomatic reactions on distributed vs. localized slip in ultramafic shear zones

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The Livingstone Fault is a >1000 km long terrane boundary in New Zealand that juxtaposes ultramafic rocks of the Dun Mountain Ophiolite Belt against quartzofeldspathic rocks of the continental Caples Terrane. The fault is characterized by a zone of sheared serpentinite mélange tens to several hundreds of meters wide with a generally well-defined scaly fabric, containing entrained pods of massive serpentinite, volcanic rocks and quartzofeldspathic rocks.

Talc- and tremolite- forming metasomatic reactions occurred frequently within the mélange zone, along the margins of the mélange and at the edges of entrained pods. These reactions were the result of the interaction between the serpentine minerals and silica bearing fluids derived from the quartzofeldspathic Caples Terrane.

In the bulk of the mélange, structures such as distributed scaly fabrics, S-C fabrics, and networks of fibrous serpentine veins suggest a broad delocalization of strain, likely accommodated by pressure-solution mechanisms along the serpentinite- and talc-bearing fabrics.

However, at the margins of the mélange zone and the edges of pods, layers of tremolite tens of centimeters thick are characterized by a highly indurated microstructure consisting of networks of tightly interwoven, acicular tremolite crystals forming a semi-nephritic to nephritic texture. In these metasomatic regions, discrete cataclastic slip zones associated with well-polished slickenlined surfaces are observed at the interfaces of the serpentinite and Caples Terrane quartzofeldspathics.

In the Livingstone Fault, this style of highly-localized slip is uniquely associated withthe development of the indurated nephritic textures. Because tremolite is a frictionally-strong and generally velocity-weakening calc-silicate, we speculate that the tremolite-forming metasomatic reactions may have promoted localized and unstable fault slip within a shear zone that was otherwise deforming by creep. Employing scanning and transmission electron microscopy, and raman spectroscopy, we investigate these metasomatic reactions to determine their progress and possible mechanical effects.