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Rheological Implications of Peridotite Serpentinization Reactions and Orogenic Serpentinite Emplacement by "Cold" Intrusion under Hydrothermal Conditions (T < 550°C) in the California Coast Ranges: Insights from Dissolution and Growth Microstructures

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The natural system represented by a simplified serpentinization and dehydration reaction:

olivine + water <-> serpentine + associated minerals

has unusual properties from the standpoint of rheology and flow. In the absence of free water, the layer-silicate serpentine at T < 500°C is moderately strong, with a coefficient of friction of 0.6 over the range that it is stable, poor (001) cleavage, conchoidal fracture, high plastic yield strength, consequent to its difficult intracrystalline slip owing to its difficult basal slip that require breaking the Mg-O and Mg-OH bonds in the Mg interlayer and lack of easy slip on non-basal glide planes. The serpentinite-forming reaction involves a large mass uptake of water and volume increase. In excess of the amount of water to complete the reaction, serpentinites in orogens generally show abundant evidence of deformation under hydrothermal conditions, such as vein filling and deformation-induced dissolution and growth processes. Recent petrographic studies of serpentinite block-and-matrix samples collected from the San Francisco Bay Area of California by Uno and Kirby (EPSL Submitted, 2017), Lewis and Kirby (2015 AGU Poster Abstract) verify the importance of this deformation mechanism in those rocks. Finally, dozens of geologic papers published from 1935 to 1999 on these same serpentinite bodies, including those based geologic mapping on surface and underground mercury mine workings, concluded that they are cold intrusions injected as plugs, sills, dikes and fault fillings as enabled by the rheological effects of hydrothermal fluids as described above (Kellner and Kirby, 2016 AGU Poster Abstract). Some of these bodies may have been driven upward as diapirs and/or by volume expansion while being serpentinized during ascent through the crust. Evidence for these reactions has been found in thin sections found in nearly several hundred thin sections cut from block samples from 21 such bodies (Uno and Kirby, 2017; Madeline Lewis and Caroline Kellner, unpublished, 2015-2016). Finally, we discuss a model that gives insight into the possible source of water, the source of the ultramafic rocks, and metamorphic rocks entrained in them (Kirby, Wang, and Brocher, EPS 2014).