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Serpentine crack-seal veins: a unique record of fluid conditions during faulting

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Serpentine veins are ubiquitous in hydrated and deformed ultramafic rocks, and have previously been used to track fault kinematics and understand the evolution of environmental conditions during vein formation. However, difficulties in unambiguously identifying and mapping serpentine types at sub-micron to mm scales has limited our understanding of vein precipitation kinetics and growth histories. Using recently developed techniques of Raman spectroscopy mapping, combined with scanning- and transmission-electron microscopy, we describe a new type of mineralogically banded serpentine crack-seal vein in six samples from different settings around the world. In all of the studied samples, individual bands comprise a thin layer (~0.4–2 μm) dominated by chrysotile and a much thicker layer (~0.5–30 μm) dominated by polygonal serpentine/lizardite. Existing field and experimental data suggest that disequilibrium conditions immediately following crack opening may favour rapid precipitation of chrysotile along one of the crack margins. Subsequently, diffusional transport of elements favours slower precipitation of polygonal serpentine/lizardite which leads to crack sealing. The similarities in layer thicknesses and mineralogy exhibited by samples collected from extension and shear veins, dilational jogs, foliation surfaces, and the margins of phacoids, suggest that a common set of processes involving crack opening and sealing are active in a range of different structural sites within serpentinite-dominated shear zones, potentially associated with frequent and repetitive stress drops such as those recorded during episodic tremor and slow slip.