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Lawsonite petrofabric as a gauge of high-pressure kinematics

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Lawsonite is a common mineral at depth in subduction zones, but it is not commonly preserved during exhumation. In exhumed high-pressure (HP) rocks that contain pristine lawsonite, lawsonite behaves rigidly and shape and lattice preferred orientation can be used to document kinematic vorticity (Wk, relative components of coaxial vs. noncoaxial strain) at HP conditions, using the same principles of vorticity analyses that are based on rigid feldspar grains in granitic rocks. The deformation of rocks under HP conditions is poorly documented, and therefore lawsonite, where preserved, provides a remarkable opportunity to use a major HP mineral to test conflicting ideas about the mechanisms of deformation and exhumation in a subduction channel. In the Sivrihisar Massif, Turkey, the exceptional preservation of lawsonite in eclogite, blueschist, and phengite-quartz schist allows evaluation of the mechanisms and conditions of deformation at HP. The orientation and aspect ratio of 200-1000 lawsonite crystals were measured in each of 10 samples collected along a traverse perpendicular to the structural grain of the HP terrain. Most samples were cut perpendicular to foliation and parallel to lineation, but we also analyzed a lineation-perpendicular face of one sample. Some samples were collected from map-scale layers of lawsonite blueschist; others are from the margins of meter-scale pods rimmed by blueschist and cored by eclogite. Crystallographic orientation of lawsonite was determined by electron backscattered diffraction (EBSD); shape characteristics were determined petrographically and by image analysis. Determination of the lawsonite critical aspect ratio above which rigid grain rotation is significantly reduced allows a quantitative assessment of kinematic vorticity Wk. Lawsonite analyzed from blueschist layers record a major component of pure shear (Wk = 0.44-0.50) or similar amounts of pure and simple shear (Wk = 0.70-0.80). Analyses from eclogite pod margins record distributions consistent with dominant simple shear (Wk closer to 1.00) and likely relate to the rigid rotation of subspherical eclogite pods. The variations in crystallographic preferred orientation of lawsonite correlate well with the variations in vorticity, suggesting that 2D vorticity results are applicable to 3D flow. The lawsonite textures reflect deformation during a HP part of the exhumation path, suggesting that pure shear was an essential component of exhumation kinematics. Squeezing and rapid upward extrusion of the subduction channel would likely result in pure-shear dominated kinematics while relatively low-T conditions are maintained, explaining the preservation of lawsonite.