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Deformation, porosity, and fluid migration within subduction interfaces

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Large earthquakes break the subduction interface to depths of 60 to 80 km. Current models hold that seismic rupture occurs when fluid overpressure builds in link with porosity cycles, an assumption still to be experimentally validated at high pressures. We experimentally determine porosities of subduction zone rocks under pressures equivalent to depths of up to 90 km through a novel experimental technique that uses Raman deuterium-hydrogen mapping of rocks representing a typical cross-section of the subduction interface corresponding to the deep seismogenic zone. We used natural blueschists, antigorite serpentinites, and chlorite-schists that represent, respectively, the metamorphosed oceanic crust corresponding to the footwall of the subduction interface, the hydrated forearc mantle wedge at the hanging wall of the subduction interface, and the sediments or metasomatic rocks near the subduction interface between the subducting plate and the mantle wedge. We find that in serpentinite, and possibly blueschist, porosity increases with deformation, whereas phyllosilicate-rich schists remain impermeable regardless of their deformation history. Such a contrasting behavior explains the observation of over-pressurized oceanic crust and the limited hydration of the forearc mantle wedge. These results provide quantitative evidence that serpentinite, and likely blueschist, may undergo porosity cycles facilitating the downdip propagation of large seismic rupture to great depths.