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Where is serpentine in subduction? ... And where it is not.

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Water is recycled to the Earth's interior at subduction zones. Serpentinisation is caused by the release of large amounts of hydrous fluids in the cold mantle wedge above the dehydrating subducting plate. Low seismic velocities in the wedge give an image of extensive hydration and serpentinisation within the stability of serpentine below 700°C.

Double Wadati-Benioff seismic zones (DSZ) with two parallel planes of seismicity separated by 15-30 km are a global feature of subduction zones in the 50-200 km depth range. Upper plane seismicity is generally attributed to dehydration of the oceanic crust but the origin of the lower seismicity plane is debated. Serpentine or hydrous-phase dehydration embrittlement is a commonly advocated mechanism that implies significant slab mantle hydration.

Interpreting of seismic data in terms of serpentinisation relies on the knowledge of single-crystal elastic properties of serpentine. The elastic constants of antigorite, the dominant serpentine at high pressure in subduction zones, were measured using Brillouin spectroscopy under ambient conditions1. We extended the range of measurements up to pressures of 8.8 GPa covering the whole stability range. These results are used to obtain the isotropic and anisotropic properties of serpentinites by combining with antigorite lattice preferred orientations (LPO) EBSD measurements.

Antigorite and deformed serpentinites have a very high seismic anisotropy and remarkably low velocities along particular directions. VP and VS anisotropies of serpentinites can reach 40 and 50%, respectively. The VP/VS ratio and shear-wave splitting also vary with orientation. Deformed serpentinites can present seismic velocities similar to peridotites for wave propagation parallel to the foliation or lower than crustal rocks for wave propagation perpendicular to the foliation. These properties can be used to detect serpentinite, quantify the amount of serpentinization, and to discuss relationships between seismic anisotropy and deformation in the mantle wedge. We find that the mantle wedge is generally very serpentinised (50-100%) down to 60 km in hot subductions.

High-resolution seismic tomography reveals low seismic velocities in the lower seismicity plane2 that are better explained by seismic anisotropy of anhydrous deformed peridotites than by serpentinisation3. Earthquakes correlate with anisotropic planar shear zones and favour a shear instability mechanism as the cause of lower plane seismicity without requiring the presence of water in the centre of subducting slabs. The contribution of the subducted lithospheric mantle to the water budget of subduction zones is thus likely limited to the first 2-3 kilometres beneath oceanic crust.

1Bezacier, L., Reynard, B., Bass, J.D., Sanchez-Valle, C., & Van de Moortele, B.V., Elasticity of antigorite, seismic detection of serpentinites, and anisotropy in subduction zones. Earth and Planetary Science Letters 289, 198-208 (2010).

2Nakajima, J., Tsuji, Y., & Hasegawa, A., Seismic evidence for thermally-controlled dehydration reaction in subducting oceanic crust. Geophysical Research Letters 36 (2009).

3Reynard, B., Nakajima, J., & Kawakatsu, H., Earthquakes and plastic deformation of anhydrous slab mantle in double Wadati[U+2010]Benioff zones. Geophysical Research Letters 37, LXXXXX, doi:10.1029/2010GL045494 (2010).