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Lattice preferred orientation of talc and implications for seismic anisotropy in subduction zones

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Since hydrous phases such as talc and serpentine are elastically very anisotropic, the lattice preferred orientation (LPO) of both minerals when formed in the mantle wedge or the subducting slab can cause large seismic anisotropies in subduction zones. Although, fabric studies of talc-associated phases (e.g., serpentine, amphibole) have been reported, up to now no quantitative measurements of the talc LPO have been conducted. In order to examine the LPO of talc, SEM/EBSD analyses were performed on highly deformed garnet-chloritoid-talc schists from the Makbal UHP terrane in the Tianshan orogen (Kazakhstan). These rocks underwent subduction-related eclogite-facies metamorphism corresponding to a burial depth of ca. 92 km (P ≅ 2.9 GPa). The samples contain between 20 and 40 vol. % talc. The LPO results showed that talc has a strong alignment of [001] axes subnormal to the foliation and, in addition, the [100] and [010] axes display a weak concentration with a girdle subparallel to the foliation. The seismic anisotropy of the polycrystalline talc was calculated using the obtained LPO and the pressure-dependent elastic constants of single-crystal talc. The magnitude of the seismic anisotropy of talc due to its LPO was 68–69 % for P-waves and 21–23 % for S-waves under the ambient pressure. The seismic anisotropies of talc decreased to 36–37 % for P-waves and 13–17 % for S-waves under high pressure (2.9 GPa), however they still remained high. The polarization direction of vertically propagating fast S-waves of the talc was trench–parallel and it was influenced by the strength of talc LPO of both [100] and [010] axes, pressure, and the dipping angle of the subducting slab. Our results indicate that the presence of strong LPO of talc in the hydrated mantle can contribute significantly to the trench–parallel seismic anisotropy and long delay time of S-waves observed in many subduction zones.