Deformation of antigorite serpentinite in the base of the shallow wedge mantle and relationship to slow earthquakes

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Slow slip events (SSE) in SW Japan detected by geodetic and seismic studies develop at depths of 30–40 km. This domain is thought to consist of serpentinite with antigorite as the dominant serpentine mineral. The physical properties of antigorite and serpentinite, and in particular the anisotropic properties of foliated serpentinite, have been highlighted as important in controlling the nature of fluid flow, the times scales for relaxation after slip, and the seismic anisotropy in the plate boundary domain. The properties of foliated serpentinite are closely linked to the crystallographic preferred orientation (CPO) patterns and the most commonly recognized natural examples of antigorite CPO have c-axis maxima perpendicular to the foliation, thought to be roughly parallel to the subduction boundary, and b-axis maxima parallel to the extension direction, which approximates the subduction direction. However, the antigorite CPO of natural examples may not preserve the conditions at the depth because some antigorite may recrystallize and/or deform during exhumation of the serpentinite to the earth’ s surface.

Here we report on the kilometer-scale Shiragayama serpentinite body derived from the mantle wedge and exposed in the subduction-type Sanbagawa belt of Shikoku. Previous work has shown that there is an extensive antigorite shear zone in the base of this serpentinite body parallel to the boundary with slab-derived subducted metapelite units. This shear zone is potentially an important source of information on the state of the subduction boundary beneath the mantle wedge. However, it remains to be shown that this shear zone was present at depth or if it developed during exhumation. Previous petrological studies have shown that most of the Shiragayama serpentinite body originally consisted of both antigorite and up to 20 vol% of brucite. In addition, shortly before the onset of exhumation there was a regional rise in temperature that resulted in the reaction of brucite with adjacent antigorite to form olivine. All the observed olivine is metamorphic in origin. The growth of the olivine took place without deformation at peak pressure and this olivine can be used as a marker to look for evidence of post-olivine, exhumation-related growth and deformation of antigorite. Our microstructural observations show that aligned antigorite is locally overgrown by olivine. The CPO characteristics of this antigorite are indistinguishable from those of the shear zone. These features show that the foliated antigorite domain reflects features formed at depth in the subduction zone. A second line of evidence in favour of this interpretation comes from observations of a separate serpentinite body in the Sanbagawa belt, the Kamabuseyama body. The Kamabuseyama body consist dominantly of antigorite serpentinite and the outermost boundary is strongly deformed. However, the foliated serpentinite domain is largely defined by the presence of aligned chrysotile, which is the a low-T type of serpentine. A similar development of a foliation defined by chrysotile is not observed in the Shiragayama area supporting the idea that the antigorite shear zone reflects the state of the subduction boundary at depths of 30–40 km.

Keywords: Antigorite serpentinite, Slow slip event, Crystallographic preferred orientation, Sambagawa metamorphic belt

