Crystallographic preferred orientation of talc determined by an improved EBSD procedure for sheet silicates: Implications for anisotropy at the slab–mantle interface due to Si-metasomatism

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Abstract
Talc is widely distributed over the Earth’s surface and is predicted to be formed in various tectonic settings. Talc is a very soft and anisotropic sheet silicate showing very low friction behavior. Therefore, the formation of talc is expected to weaken the strength of talc-bearing rocks and may be associated with the initiation of subduction, and with a decrease in the coupling coefficient resulting in aseismic movements along faults and shear zones within subduction zones. For these reasons, understanding the crystallographic preferred orientation (CPO) of talc is important to quantify the anisotropy and physical properties of the host rock. However, it is difficult to measure a significant number of talc crystal orientations and to evaluate the accuracy of the measurements using electron-backscattered diffraction (EBSD). Therefore, talc CPO has not been reported, and there is uncertainty regarding the estimation of the strength of deformed talc-bearing rocks. Using methods developed for antigorite, we report the first successful EBSD measurements of talc CPO from a talc schist formed due to Si-metasomatism of ultramafic rocks by subduction zone fluids. We used a combination of W-SEM and FE-SEM measurements to examine domains of various grain sizes of talc. In addition, we used TEM measurements to evaluate the accuracy of the EBSD measurements and discuss the results of talc CPO analysis. Talc CPO in the present study shows a strong concentration of the pole to the (001) plane normal to the foliation. The strongest concentration of the [100] direction is parallel to the lineation. The talc schist produces similar S-wave splitting and P- and S-wave anisotropy as antigorite schist in deeper domains, thus identifying talc-rich layers in subduction zones may require a combination of geophysical surveys, seismic observations, and anisotropy modeling. The presence of strong talc CPO in rocks comprising the slab–mantle interface boundary may promote spatial expansion of the slip area during earthquakes along the base of the mantle wedge.

Keywords: Talc, crystallographic preferred orientation (CPO), electron-backscatter diffraction (EBSD), Si-metasomatism, anisotropy, sheet silicates, seismic observations, aseismicity

INTRODUCTION
Talc is a common mineral found in ultramafic igneous and metamorphic rocks and can be formed by alteration (e.g., hydration of dolomite or carbonation of serpentine) and dehydration of serpentine. In addition, talc is thought to be formed at the slab–mantle interface in subduction zones due to metasomatism of the wedge by SiO2-rich aqueous fluids derived from the subducting slab (e.g., Platt 1975; Brown et al. 1982; Peacock 1987; Sorensen 1988; Grove and Bebout 1995; Peacock and Hyndman 1999; Och et al. 2003; Fitzherbert et al. 2004; Maekawa et al. 2004; Fotoohi Rad et al. 2005; King et al. 2006; Miller et al. 2009; Escudér-Viruete et al. 2011; Pabst et al. 2012; Bebout and Penniston-Dorland 2016). Talc-rich rock can also be formed due to Si-metasomatism during seafloor alteration of mantle rocks (e.g., Lupton 1979; Lonsdale et al. 1980; Allen and Seyfried 2003; Escartín et al. 2003; D’Orazio et al. 2004; Morishita et al. 2009; Marchesi et al. 2013). Talc is stable even at relatively high temperatures when compared to related clay minerals such as smectite (e.g., Moore and Rymer 2007). The dehydration breakdown of talc to enstatite and quartz is predicted to occur at up to ~780–830 °C (e.g., Bose and Ganguly 1995; Spear 1995) meaning that in subduction zones talc schist will, in general, be stable for most of the depth range covered by the slab-mantle boundary present in the forearc region (e.g., Escartín et al. 2008). Talc is also predicted to exhibit a low frictional behavior related to the weak bonding in the c-axis direction (Moore...