**Rheological behaviors of the subducting oceanic crust: Evidences from naturally and experimentally deformed blueschists**

**(沈み込む海洋地殻のレオロジー：天然と実験により変形した青色片岩からの制約)**

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**ABSTRACT**

Subduction zone could generate strong stresses especially within subducting slab and also it makes special high pressure and low temperature environments. Ergo study on blueschist is important to understand active stresses in subduction zone and in addition to reveal geofluid circulations owing to abundant hydrous phases in it. Fabric analyses of naturally and experimentally deformed blueschists were investigated to delineate its implications for seismic anisotropy and source of seismicity in subducting oceanic crust.

The first subproject dealt rheological contrast of glaucophane and lawsonite in natural blueschist from the New Idria serpentinite body, Diablo Range, California. Anhedral to subhedral glaucophane shows strong crystal-preferred orientations (CPOs) with small grain size, irregular grain boundary, and high aspect ratio, indicating recovery and dynamic recrystallization possibly accommodated by dislocation creep. Euhedral to subhedral lawsonite deforms by rigid body rotation due to angular or straight grain boundary. Glaucophane-rich layer contains higher aspect ratio, lower angle to foliation, stronger CPOs, and higher seismic anisotropy of glaucophane and lawsonite than those in lawsonite-rich layer, suggesting the strain localization into the glaucophane-rich layer. On the other hand, glaucophane has higher aspect ratio, lower angle to foliation, stronger CPOs, and higher seismic anisotropy than lawsonite,

supporting the strain localization into the glaucophane rather than lawsonite. All the results of the study therefore imply the dominant roles of glaucophane rather than lawsonite for rheological behaviors of subducting oceanic crust.

Seismic anisotropy of lawsonite and epidote blueschists from the Diablo Range and Franciscan Complex in California, and the Hida Mountains in Japan was investigated for the second subproject. Glaucophane is characterized by very fine grains aligned along the foliation, high aspect ratio, and strong CPOs identified by a (100)[001] system. These results with a bimodal distribution of grain size in some specimens probably suggest recovery and dynamic recrystallization of glaucophane. Though lawsonite and epidote have high aspect ratio and strong CPOs of (100)[010], straight grain boundary and euhedral crystal shape indicate rigid body rotation as predominant deformation mechanism. Seismicity calculations of glaucophane from CPOs show the fastest propagation of P-waves along the lineation, and the S-wave polarization parallel to the foliation ($AV_P$ = 20.4%, $AV_S$ = 11.48%), implying possible generation of a trench-parallel seismic anisotropy due to the slowest $V_S$ polarization being normal to the subducting slab. Lawsonite has the fast propagation of P-waves subnormal to the foliation lawsonite and S-wave polarization subnormal to the [001] maxima ($AV_P$ = 9.6%, $AV_S$ = 19.88%), indicating probable occurrence of a trench-normal anisotropy. Epidote displays similar patterns of seismic anisotropy with glaucophane nevertheless intensity is relatively low ($AV_P$ = 9.0%, $AV_S$ = 8.04%). The $AV_S$ of lawsonite blueschist (5.6%–9.2%) therefore is weaker than that of epidote blueschist (8.4%–11.1%), in consistent to the occurrence of strong trench-parallel anisotropy beneath Ryukyu arc and weak trench-parallel anisotropy beneath NE Japan. Intensity of seismic anisotropy suggests that glaucophane and lawsonite can satisfactorily cause trench-parallel seismic anisotropy beneath NE Japan. The results consequently demonstrate that trench-parallel seismic anisotropy in forearc beneath NE Japan could be attributed to the combination of glaucophane and lawsonite, and also that trench-normal anisotropy in backarc could possibly be generated by seismic anisotropy of lawsonite.

Thirdly deformation mechanisms of glaucophane and lawsonite in experimentally deformed blueschists were conducted using a Griggs-type solid-medium apparatus housed at Hiroshima University. Mechanical data of pure-shear experiments at 500 °C and 0.5–2 GPa display pressure-sensitive increase of shear stress at low confining pressure and pressure-insensitive increase of stress at high pressure, probably influenced by a change of deformation mechanism of blueschist. Brittle deformation features in simple-shear experiments investigated at 400–500 °C and 1–2.5 GPa are dominant at 1–2 GPa experiments, in contrast to abundant strain-localized area at 2.5 GPa. Glaucophane has a systematic decrease of *J*-index with an increase of shear strain and confining pressure, and angular change of slip plane to shear direction is similar to that of strain ellipsoid at >2 GPa. These results might be attributed to the change of deformation behaviors of glaucophane from brittle failure to brittle-ductile transition at ~2 GPa. On the other hand, though lawsonite exhibits angle of slip plane to shear direction is comparable to that of strain ellipsoid at 2.5 GPa, relatively abundant relict phases in specimens deformed at 2.5 GPa, and weak relation among *J*-index, shear strain, and confining pressure indicate no change of deformation mechanism within the experimental conditions. The results of the study therefore imply brittle or semi-brittle behaviors of glaucophane as a source of observed seismicity in subducting oceanic crust beneath NE Japan. However additional experiments at higher pressure are needed to reveal the upper limit of brittle-ductile transition.