Geodynamics Seminar

第294回ジオダイナミクスセミナー

Deformation of olivine and implicationsfor the dynamics of Earth's upper mantle

Speaker:Tomohiro Ohuchi
(Postdoctral Fellow, GRC)

主催：愛媛大学地球深部ダイナミクス研究センター
日時：4/22（金）午後 4時30分～
場所：総合研究棟4F　共通会議室

Abstract

Crystallographic preferred orientation (CPO) of olivine, which is developed by dislocation creep, controls the seismic anisotropy in the upper mantle. One of the remarkable observations on the upper mantle near subduction zones is a striking rotation of fast direction of shear-wave splitting across an arc. Trench-normal fast directions are observed in the back-arc side, but trench-parallel ones are observed in the fore-arc side (e.g, Smith et al., 2001; Nakajima and Hasegawa, 2004). The rotation of fast direction of shear-wave splitting has been attributed to the transition of mantle-flow direction from trench-normal flow (in the back-arc side) to trench-parallel flow (in the fore-arc side) under the assumption that the A-type olivine fabric (developed by the (010)[100] slip system), which has a seismic fast-axis orientation subparallel to the shear direction, is assumed to be the unique cause of seismic anisotropy (e.g., Russo and Silver, 1994). However, this model is not fully supported by other observations such as geodetic observations.

Recent laboratory results have shown that the flow-parallel shear wave splitting is caused not only by A-type olivine fabric but also by C- (developed by the (100)[001] slip system) and E-type (by the (001)[100] slip system) olivine fabrics (Jung and Karato, 2001; Katayama et al., 2004). Moreover, flow-perpendicular shear wave splitting is also found to be caused by the B-type olivine fabric (developed by the (010)[001] slip system) (Jung and Karato, 2001). All of newly found olivine fabrics are developed under wet conditions. Based on the seismological properties of various olivine fabrics, it has been proposed that the trench-parallel shear wave splitting and trench-normal shear wave splitting are caused by trench-normal flow associated with B-type olivine fabric (in fore-arc side) and with C- (or E-) type olivine fabrics (in back-arc side), respectively (Karato, 2003; Kneller et al., 2005). However, it has recently been reported that the CPO patterns of anhydrous olivine depend on pressure (Jung et al., 2009; Ohuchi et al., 2011), suggesting the possibility that the fabric boundaries determined at low pressures (0.5–2 GPa: Jung and Karato, 2001; Katayama et al., 2004) cannot be applicable to the asthenospheric mantle wedges (> 60 km depth).

In order to explore the effect of water on CPO of minerals at high pressures, we developed a new cell assembly for the multi-anvil assembly 6-6 (MA6-6) system combined with a deformation-DIA apparatus (Ohuchi et al. 2010). We have initiated a series of experimental studies on the effect of water on the CPO of olivine under the upper mantle conditions. We conducted the experiments of the simple-shear deformation of hydrous olivine at P = 2-7 GPa and T = 1400-1670 K for a range of shear strain rate 1E-5 to 1E-4 /s. Our experimental results showed that the A-type olivine fabric was the dominant under dry and moderately wet conditions. In contrast, B-type-like olivine fabrics were developed under wet conditions. These observations suggest that water content is one of the most important parameter controlling the fabric transition of olivine not only in the lithosphere but also in the asthenosphere. The water-induced fabric transition can be the cause of the rotation of fast direction of shear-wave splitting across an arc.

詳細は当センターホームページ: http://www.ehime-u.ac.jp/~grc/をご覧ください
問い合わせ先：桑山靖弘（TEL:089-927-8408,e-mail:kuwayama@sci.ehime-u.ac.jp）

Geodynamics Seminar

第294回ジオダイナミクスセミナー

Flow and Seismic Anisotropy in the Mantle Transition Zone: Shear Deformation Experiments on Wadsleyite

Speaker:Takaaki Kawazoe
(Postdoctral Fellow, GRC)

主催：愛媛大学地球深部ダイナミクス研究センター
日時：4/22（金）午後 4時30分～
場所：総合研究棟4F　共通会議室

Abstract

Convection in the mantle transition zone plays a key role to connect convections in the upper and lower mantles and can be mapped by interpreting seismic anisotropy based on relationship between crystallographic preferred orientation (CPO) of wadsleyite and deformation geometry. Wadsleyite is the most plausible mineral to generate the seismic anisotropy in the mantle transition zone, however, there have been very few studies and no definitive result for the wadsleyite CPO due to limitation of experimental technique. I investigated the relationship between the wadsleyite CPO and deformation geometry by shear deformation experiments on polycrystalline wadsleyite at pressure-temperature conditions (18 GPa and 1800-1900 K) of the mantle transition zone using a deformation-DIA apparatus with a multi-anvil 6-6 system. I found the wadsleyite CPO, where the [001] axis is subparallel to the shear direction and the (010) plane is subparallel to the shear plane, and calculated seismic anisotropy produced by the CPO to compare with the seismological observations. Based on the comparison, the seismic anisotropy observed in the mantle transition zone can be attributed to wadsleyite aggregate preferentially-oriented by mantle flow, and horizontal component of the mantle flow in the mantle transition zone is dominantly parallel to the direction of the plate motion.

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問い合わせ先：桑山靖弘（TEL:089-927-8408,e-mail:kuwayama@sci.ehime-u.ac.jp）