Geodynamics Seminar

第358回ジオダイナミクスセミナー

Deformation of olivine and implications for seismic anisotropy in Earth's upper mantle

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主催：愛媛大学地球深部ダイナミクス研究センター
日時：5/31（金）午後 4時30分～
場所：総合研究棟 4F 会議室

Abstract

Crystallographic preferred orientation (CPO) of olivine, which is developed by dislocation creep, controls the seismic anisotropy in the upper mantle. Because olivine is the main constituent in Earth's upper mantle, the seismic anisotropy signatures, such as the direction of shear wave splitting and the V_{SH}/V_{SV} (i.e., ratio of horizontally polarized shear waves and vertically polarized shear waves), are affected not only by flow direction but also by water distribution in the upper mantle. The A-type fabric (developed by the (010)[100] slip system), which is the most commonly observed olivine fabric in natural peridotites, is developed under water-poor conditions (e.g., Zhang et al., 2000). Other olivine fabrics such as the B-type (by the (010)[001] slip system), C-type (by the (100)[001] slip system), and E-type (by the (001)[100] slip system) are formed under wet conditions at 0.5–2 GPa (e.g., Jung and Karato, 2001). However, olivine fabric diagrams obtained at low pressures cannot be applied to high pressures. This is because the easiest slip system changes induced by pressure, which is due to the difference in activation volumes among slip systems (e.g., Raterron et al., 2007).

In order to clarify the variations of olivine fabric in Earth's upper mantle, we have investigated the effects of pressure on the development of olivine fabrics under dry and wet conditions. We conducted simple-shear deformation experiments on olivine with total strains up to 2.1 under deep upper mantle conditions (9.6–12.7 GPa and 1670–1770 K) using a D-DIA apparatus.

C-type olivine fabric was dominantly developed under relatively low-stress (< 550 MPa) and with a wide range of water content (C_{OH} = 49–19242 ppm H/Si). The developments of a B-type olivine fabric and an A-type fabric were observed at relatively high stresses (former: 731 MPa; latter: 384 MPa) under dry and wet conditions, respectively. Because the seismic fast a-axes are perpendicular to the shear plane only for C-type fabric, a positive-negative transition of V_{SH}-V_{SV} (difference in velocity between horizontally and vertically polarized shear waves) inevitably occurs when C-type fabric is developed by a pressure-induced fabric transition. The positive-negative transition of V_{SH}-V_{SV} at ~200 km depth reported in global one-dimensional models is known to be well explained by the horizontal flow of water-poor olivine (water content in olivine: < 500 ppm H/Si). Our results demonstrate that the presence of a moderately high amount of water in olivine (750–2304 ppm H/Si) results in a drastic increase of the boundary depth for the V_{SH}-V_{SV} positive-negative transition (~300 km depth), namely, "wet" olivine flows cannot account for global one-dimensional models, suggesting that the whole upper mantle is mostly occupied by water-poor regions and the distribution of water-rich regions is limited to a small part of the upper mantle.

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
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