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Possible lateral variation of seismic anisotropies in the oceanic lithosphere due to an active mantle flow

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Crystal-preferred orientation (CPO) is a common feature of peridotites and is developed during intense homogeneous plastic deformation of peridotitic minerals with a dominant slip system. Whereas an olivine CPO classification (A, B, C, D and E types) has been proposed by Karato and co-workers to illustrate the roles of stress and water content as controlling factors of olivine slip systems (e.g., Karato et al., 2008 Annu. Rev. Earth Planet. Sci.), an additional CPO type (AG) has also been proposed in recognition of its common occurrence in nature (Mainprice, 2007 Treatise on Geophysics). AG-type has been experimentally formed in sheared partially-molten samples, in which a-axes of olivine grains are aligned predominantly normal to the shear direction, rather than parallel to it (Kohlstedt & Holtzman, 2008 Annu. Rev. Earth Planet. Sci.). Thus, we can expect the development of AG-type olivine fabrics to be related to the occurrence of melt during deformation, most likely in the vicinity of mid-ocean ridges, where strong upflow is related to active mantle ascent (Nicolas et al., 2000 Marine Geophysical Researches; Michibayashi et al., 2000 MGR). Results from our analysis of peridotites from the Hilti mantle section of the Oman ophiolite show that olivine in that section is dominated more commonly by AG-Type than A-type CPO. This section preserves subhorizontal uppermost mantle lithosphere (Michibayashi & Mainprice, 2004 Jour. Petrology; Onoue & Michibayashi, 2013 JpGU abstract). Since olivine contains intrinsic elastic anisotropies, the development of CPO within peridotite during plastic deformation at mid-ocean ridges gives rise to seismic anisotropy in the upper mantle. Seismic properties of AG-type olivine fabrics reveal that whereas Vp velocity is maximum parallel to the flow direction (X) and minimum normal to the flow plane (Z), the intermediate direction (Y) has relatively higher Vp velocity than the median velocity. This feature of AG-type fabric is different from that of A-type, which occurs commonly under melt-free conditions, resulting in the different degrees of seismic anisotropies between AG-type and A-type. Thus, we propose, based on our results for the Oman ophiolite, that the intensity distribution of seismic anisotropy in the uppermost mantle could vary laterally depending on various strength of mantle ascent along a given segment of mid-ocean ridges in conjunction with various degree of melt impregnation.

Keywords: Olivine farics, Seismic anisotropy, melt, segment center, mid-ocean ridge