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Direct evidence for upper mantle structure in the NW Pacific Plate: microstructural analysis of a petit-spot peridotite

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Petit-spots are the late Miocene alkali basaltic volcanoes on the Early Cretaceous NW Pacific Plate, originate at the base of the lithosphere. Petrological studies reveal that the alkali basaltic volcanoes have their roots at the base of the NW Pacific lithosphere (Hirano et al., 2006, 2008), and that essentially unaltered pieces of oceanic lithosphere (tholeiitic basalt, dolerite, gabbro, and mantle peridotite) were caught up in the ascending magma as mafic and ultramafic xenoliths (Abe et al., 2006; Hirano et al., 2004; Yamamoto et al., 2009). Therefore, the petit-spots provide a unique window into the entire section of subducting oceanic lithosphere. We present here the first direct observations on the deep structure of the Pacific lithosphere using microstructural analyses of a petit-spot peridotite xenolith. The petit-spot peridotite xenolith (6K880R2O) which was obtained during the cruise YK05-06, R/V Yokosuka and the submersible Shinkai 6500 from a dive site 6K#880 at the eastern fault escarpment of a petit-spot volcano in the Japan Trench is a lherzolite that consists mainly of coarse- and medium-grained olivine, orthopyroxene, and clinopyroxene, as well as fine-grained aggregates of spinel and orthopyroxene. The bulk trace-element patterns of the aggregates are similar to those of pyrope-rich garnet and the associated clinopyroxene shows a signature typically seen in those equilibrated under conditions of the garnet-lherzolite stability field (Abe et al., 2006). The equilibrium conditions of this sample applied to a two-pyroxene geothermometer (Wells, 1977) and a univariant curve for the garnet-spinel facies transition (O'Neill, 1981; Klemme and O'Neill, 2000), indicating that was determined to be 1100+-50 oC at a pressure of 16-20 kbar as reported by Abe et al. (2006) and Yamamoto et al. (2009). This conditions correspond to a depth of ˜60 km below the seafloor (Abe et al., 2006; Yamamoto et al., 2009). A strong deformational fabric is marked by a parallel alignment of millimeter-sized elongate minerals and their crystallographic preferred orientation. The olivine displays a [010] fiber pattern with a girdle of [100] axes and a maximum of [010] perpendicular to the foliation, a pattern which is consistent with a transpressional deformation in high temperature conditions at the base of oceanic lithosphere. Our microstructural observations and seismic data indicate that the lower part of the NW Pacific lithosphere possess an early stage structure of mantle flow at the asthenosphere. A discrepancy between the weak anisotropy in the petit-spot peridotite and the strong azimuthal anisotropy from the seismic data in the NW Pacific plate implies the existence of a highly anisotropic component in the deep oceanic lithosphere.