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Lattice preferred orientation of olivine found in diamond-bearing garnet peridotites in Finsch, South Africa and implications for seismic anisotropy

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Seismic anisotropy in the upper mantle provides important constraints on mantle dynamics, continental evolution and global tectonics and is believed to be produced by the flow-induced lattice-preferred orientation (LPO) of olivine. Recent experimental studies at high pressure and temperature have suggested that the LPO of olivine is affected by pressure in addition to water and stress. However, there has been no report yet for the pressure-induced LPO of natural olivine because samples from the deep upper mantle are rare and often unsuitable for study due to ambiguous foliation and lineation. Here we show evidence of the pressure-induced LPO of natural olivine in diamond-bearing garnet peridotites from Finsch, South Africa. We found that the [010] axes of olivine are aligned subnormal to foliation and that the [001] axes are aligned subparallel to lineation, which is known as B-type LPO of olivine. The equilibrium pressure of the samples, as estimated using geobarometer, was greater than 4 GPa, indicating that the samples originated from a depth greater than $\sim$120 km. In addition, FTIR spectroscopy of the olivine showed that the samples are dry, with a water content of less than 90$\pm$20 ppm H/Si (5.5$\pm$1.2 ppm wt. H_2O). These data suggest that the samples are the first natural examples of olivine displaying B-type LPOs produced due to high pressure under dry condition. Our data indicate that the trench-parallel seismic anisotropy observed in many subduction zones in and below subducting slabs at depths greater than $\sim$90 km under dry condition may be attributed to the pressure-induced olivine fabrics (B-type LPO) and may be interpreted as the entrainment of the sub-lithospheric mantle in the direction of subduction rather than anomalous trench-parallel flow.