Olivine Lattice Preferred Orientation Patterns of the Higashi-akaishi Peridotite Body.

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Olivine lattice preferred orientation (LPO) due to ductile deformation is one of the main causes of mechanical anisotropy in the upper mantle. Knowledge of the type of patterns that develop under different physical conditions combined with measurements of seismic anisotropy can be used to infer the direction of mantle flow in various tectonic settings. Recent deformation experiments have revealed the existence of a 'B-type' LPO with a flow-normal a-axis maximum. This type of fabric is developed under high shear stress and water-present conditions such as expected for water-rich mantle located immediately above a subducting slab. The widespread presence of this type of fabric in the wedge mantle above a subduction zone could reconcile the expectation that mantle flow is driven by and, therefore, parallel to plate motion and the measured seismic anisotropy.

The Higashi-akaishi peridotite body, SW Japan is a rare example of a kilometer scale unit with widespread occurrence of B-type LPO. Structural studies define four deformational phases in this body (D1-D4) that are related to the tectonic evolution in the Cretaceous subduction zone at the Eurasian margin. The main deformational stage, D2, is associated with dynamic recrystallization of olivine to form a porphyroclastic microstructure consisting of clear olivine neoblasts and porphyroclasts with abundant micro-inclusions. Parallel alignment of olivine neoblasts defines a stretching lineation (L2) and tectonic foliation (S2) and the D2 olivine LPO is identified as the B-type fabric with a-axes normal to L2, b-axes normal to S2 and c-axes parallel to L2

Petrological methods can be used to estimate the physical conditions under which the B-type LPO formed, but this is not possible unless a suitable range of minerals is present that also show microstructures related to deformation. Careful study of the Higashi-akaishi unit has revealed the presence of such rocks. Garnet-orthopyroxene geothermobarometry applied to the D2 garnet peridotite shows the B-type LPO formed during a period of almost isothermal burial from depths of ~65 km to greater than 100 km and at temperatures around 700-800 degree C. In addition micro-Raman spectroscopic analyses reveal that syn-D2 micro-inclusions include hydrous minerals, such as serpentine, indicating water-rich conditions for the D2 deformation. The recrystallized grain size can be used to estimate a deviatoric stress of around 100 MPa. These D2 physical conditions in which the B-type LPO was formed are compatible with those expected for mantle wedge near subduction boundaries and the extrapolated results of experimental studies.

It has been known for several decades that the olivine LPO patterns of parts of the Higashi-akaishi unit showed concentrations of all three axes. However, this type of distribution is compatible with several distinct types of LPO patterns. This study shows the need to carry out field-work to identify the associated stretching direction in order to identify these fabrics as B-type. In addition, to relate the development of B-type fabrics to temperature and pressure requires a combination of microstructural and petrological methods. Without this information neither the type of LPO nor the depth of formation can be constrained.

The Higashi-akaishi confirms the presence of B-type olivine LPO in mantle rocks at depths of around 100 km in the Cretaceous subduction zone of SW Japan. This result supports the suggestion initially made from experimental work that mantle flow above subduction zones is parallel to plate motion and simpler than previously proposed. However, the origin of the Higashi-akaishi body is still disputed; does it represent a sliver of mantle wedge or a unit subducted with the downgoing oceanic slab? It is important to resolve this issue to understand better the distribution of B-type fabrics in the convergent margins.