Deformation of olivine under conditions of the lower part of the mantle transition zone: the role of olivine transition on deep-focus earthquakes

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1. deep-focus earthquake
2. olivine transition
3. weak gouge

The mechanism of deep-focus earthquakes, which occur at depths of greater than 300 km, has been enigmatic because faulting should be inhibited under such high-pressure conditions due to the positive pressure dependency of frictional strength (i.e., Byerlee's rule). The 'transformational faulting' model (e.g., Green and Burnley, 1989), in which earthquakes are assumed to be triggered by pressure-induced olivine transition, has been widely accepted by many researchers. However, most of experimental studies have been conducted using analogue materials such as germinate olivine at 1-2 GPa (Wang et al., 2017) and fayalite at 4-9 GPa (Officer and Secco, 2020). Thus, deformation experiments using mantle olivine under the conditions of mantle transition zone are needed. We performed in situ uniaxial deformation experiments on olivine aggregates at pressures of 16-20 GPa and temperatures of 970-1120 K with a constant strain rate using a D-DIA apparatus at BL04B1/SPring-8. Pressure, stress, and strain were determined by using x-ray diffraction patterns and r adiographs. Acoustic emissions were also recorded by using six sensors, and the hypocenters were determined. We also conducted some off-line shear deformation experiments on olivine single-crystal at a pressure of 14.5 GPa and temperatures of 1020-1220 K. We observed the formation of fault associating a gouge filled with nano-grains of olivine and platinum blobs (products of melting of the strain marker), indicating the occurrence of adiabatic shear heating along the weak layer. Shear deformation experiments demonstrated nucleation of nanocrystalline wadsleyite lamellae parallel to the shear direction, which would be explained by martensitic olivine transition. Our results suggest that 'weak' gouge layers inducing shear localization (i.e., faulting) could be formed via the olivine transition occurring at the surface of the metastable olivine wedge in the subducted slab.