Messengers from the deep: Fossil wadsleyite-chromite microstructures from the Mantle Transition Zone

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Investigations of the Mantle Transition Zone (MTZ; 410-660 km deep) by deformation experiments and geophysical methods suggest that the MTZ has distinct rheological properties, but their exact cause is still unclear due to the lack of natural samples. Here we present the first direct evidence for crystal-plastic deformation by dislocation creep in the MTZ using a chromitite from the Luobusa peridotite (E. Tibet). Chromite grains show exsolution of diopside and SiO_2, suggesting previous equilibration in the MTZ. Electron backscattered diffraction (EBSD) analysis reveals that olivine grains co-existing with exsolved phases inside chromite grains and occurring on chromite grain boundaries have a single pronounced crystallographic preferred orientation (CPO). This suggests that olivine preserves the CPO of a high-pressure polymorph (wadsleyite) before the high-pressure polymorph of chromite began to invert and exsolve. Chromite also shows a significant CPO. Thus, the fine-grained high-pressure phases were deformed by dislocation creep in the MTZ. Grain growth in inverted chromite produced an equilibrated microstructure during exhumation to the surface, masking at first sight its MTZ deformation history. These unique observations provide a window into the deep Earth, and constraints for interpreting geophysical signals and their geodynamic implications in a geologically robust context.

Keywords: Mantle transition zone, chromitite, olivine, CPO, EBSD, microstructure

