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Garnet deformation structures in ultra-high pressure upper mantle rocks from the Western Gneiss Region (Norway)

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The deformation behaviour of minerals in upper mantle rocks plays an important role in controlling the dynamics of the Earth. The garnet peridotite bodies on the island of Otrøy in the Western Gneiss Region of Norway originate from extreme depth (up to 390 km). The deformation structures in those garnet peridotite bodies will therefore provide a unique opportunity to study the dynamics of the deeper parts of the upper mantle.
This study focuses on the various types of deformation microstructures present in the garnet grains of the deformed garnet peridotites. Depending on the grain size, the garnet grains have been deformed by different deformation mechanisms. Some of the megacryst garnet grains (up to 10 cm) in size are elongated and form trails of recrystallised smaller garnets on both sides of the garnet grain parallel to the layering. Microstructural analyses using EBSD show that the larger garnet grains in the peridotite body deformed by dislocation creep mechanisms. The trails are formed due to dynamic recrystallisation of those large megacryst garnet grains. In some areas fine-grained garnet-clinopyroxene layers occur. The garnet grains have sizes less than 1 mm. The equant shapes of the grains, the absence of a strong crystallographic preferred orientation and the absence of any internal deformation features (e.g. dislocation) indicate that the finer-grained garnets were deformed by diffusion creep mechanisms. The different garnet deformation microstructures shed light on the different deformation events of the ultra-high pressure garnet peridotite body during its exhumation history. During asthenospheric upwelling and subsequent cooling of the lithosphere in Proterozoic times the large garnet grains deformed by dislocation creep and dynamic recrystallisation, whereas only later on (either during or before the Caledonian subduction event) the fine-grained garnet aggregates deformed by diffusive processes.