

Stress-induced amorphization triggers deformation in the lithospheric mantle

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The boundary between the lithosphere and the asthenosphere is a major mechanical discontinuity of the globe. This thermal boundary layer is characterised by a five-order drop in viscosity generally associated with the 1300-1400 K isotherm. It is the key to the coupling between the dynamics of mantle convection and those of the lithospheric plates, yet its origin is still uncertain. A new study carried out within the framework of the ERC-funded TimeMan project addresses this question from the perspective of the mechanical properties of olivine, the most abundant mineral in the lithospheric mantle.

Although olivine is the subject of numerous studies, the way in which this mineral can deform in nature is still poorly understood. Indeed, the crystallographic structure of olivine does not have sufficient intracrystalline deformation mechanisms to allow the deformation of a rock without inducing damage and causing failure. Recent studies have suggested that the boundaries between the olivine grains could localise deformation without the mechanisms involved being clearly established. In this study, the authors carried out extensive transmission electron microscopy investigations of deformed samples under high stresses. They observed that under these conditions, the boundaries between the grains present a thin amorphous layer resulting from the mechanical collapse of the crystal structure. This observation sheds new light on the mechanical properties of the rock because glass has very specific mechanical properties, in particular a sudden drop in viscosity near a characteristic temperature called the glass transition temperature. The authors therefore propose that the softening of this thin intergranular layer would be the trigger for the rheological transition between the lithosphere and the asthenosphere.