東京大学工学系研究科総合研究機構
結晶界面工学セミナー

“Shear induced amorphization of olivine and the rheology of amorphous olivine”

Prof. Patrick CORDIER

University of Lille, Lille, France & Institut Universitaire de France, Paris, France

The dynamics of the deep interior of the Earth results into one of the most fundamental features of our planet: plate tectonics. The large-scale convection motions taking place in the asthenosphere are mechanically coupled, but only partially, to the atop lithospheric tectonic plates, which then move mostly horizontally. Interestingly, no major difference in chemical, mineralogical or petrological composition is known to easily explain the difference in mechanical behavior at the horizontal interface between the two layers called the lithosphere-asthenosphere boundary (LAB). To date this important mechanical problem is still not fully understood and actively debated. The relatively rigid lithospheric plate is mainly composed of upper mantle (90%) and its main mineralogical constituent is therefore olivine, a silicate with the composition $(Mg, Fe)_2SiO_4$. As olivine dominates the modal composition of the Earth's mantle down to a depth of 410 km and is the only interconnected phase, it controls the rheological properties of the upper mantle. Recent observations have highlighted a new deformation mechanism in olivine involving sliding along previously amorphized grain boundaries (Samae et al., 2021). This mechanism, which could account for the rheological transition at the LAB, is described in the first part of the presentation. One of the consequences of this mechanism is to give an important role to the rheology of olivine glass, whose properties were previously virtually unknown. The second part of this presentation describes the experimental program set up to study the rheology of olivine glass. As olivine glass is only available in thin-film form, these experiments mainly involve micromechanical testing. We show how, in particular, the application of these techniques enables us to reach extremely slow strain rates, close to those found in nature.

V. Samae, P. Cordier, S. Demouchy, C. Bollinger, J. Gasc, S. Koizumi, A. Mussi, D. Schryvers & H. Idrissi (2021) Stress-induced amorphization triggers deformation in the lithospheric mantle. Nature 591, 82–86. https://doi.org/10.1038/s41586-021-03238-3

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