ON THE CONTRIBUTION OF NANOMECHANICAL TESTING TO THE STUDY OF EARTH MANTLE DEFORMATIONS

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Nanogeodynamics is based on the belief that some answers concerning the dynamic evolution of our planet find their origin and their explanation in microscopic mechanisms within rocks and their constituent minerals. The particularity of these deformations is that they develop over time scales that exceed those accessible to humans. Building constitutive equations necessary for the modeling of terrestrial deformations must be based on very rigorous physics. Nanomechanical tests offer the possibility to isolate elementary mechanisms and to quantify their efficiency. We present examples that focus on a magnesium-iron silicate: olivine. This mineral is the most abundant (> 60 % in volume) and weakest phase in the Earth's upper mantle of which it controls the rheology. The lithospheric mantle (where plate tectonics couples with mantle convection) can be subject to temperatures as low as 500 °C. Experimental deformation of mantle rocks at such low temperatures is a major challenge in mineral and rock physics, since the strain rates necessary to achieve steady state dislocation creep are too low to be performed in the laboratory with standard techniques. The use of small-scale specimens shifts the brittle ductile transition and allows to activate ductile mechanisms which can be quantitatively studied *in situ* in a transmission electron microscope (TEM). In this presentation, we will present two studies on two different deformation mechanisms of olivine. One is dislocation glide which can be activated and followed *in situ* in the TEM . The quantification of dislocation velocities provides a new approach to evaluate the low-temperature rheology of olivine. The second one is grain boundary sliding resulting from stress-induced amorphization. Nanomechanical testing sheds light on the stress-induced amorphization mechanisms. It also provides a unique opportunity to study the mechanical properties of amorphous olivine which shear deformation controls grain boundary sliding.