Geophysical Research Abstracts
Vol. 13, EGU2011-10190, 2011
EGU General Assembly 2011

Seismicity triggered by the olivine-spinel transition: New insights from combined XRD and acoustic emission monitoring during deformation experiments in Mg2GeO4

Alexandre Schubnel (1), Nadège Hilairet (2), Julien Gasc (1), Eva Héripré (3), Fabrice Brunet (4), and Yanbin Wang (5)

(1) ENS Paris - CNRS, Laboratoire de Geologie, Paris, France (aschubnel@geologie.ens.fr), (2) UMET/CNRS, Université Lille 1, Lille France, (3) LMS, Laboratoire Polytechnique, Palaiseau France, (4) LGCA/ISTER/CNRS, Université Joseph Fourier, Grenoble France, (5) GSECARS, University of Chicago, USA

Polycrystalline Mg_2GeO_4-olivine has been deformed (strain rates from $2.10^{-4}/s$ to $10^{-5}/s$) in the deformation-DIA in 13-BM-D at GSECARS (Advanced Photon Source) at ca. 2 GPa confining pressure for temperatures between 973 and 1573 K (i.e., in the Mg_2GeO_4-ringwoodite field). Stress, advancement of transformation, and strain were measured in-situ using X-ray diffraction (XRD) and imaging, and acoustic emissions (AE) full waveform were recorded simultaneously. When differential stress is applied (ca. 1- to 2 GPa GPa) and temperature is increased, the very beginning of the transformation to the ringwoodite structure (as evidenced by in situ XRD) is accompanied by AE bursts which locate within the sample. At high strain rates ($> 10^{-4}/s$) and low temperatures (800-900 degrees C), the number of AEs is comparable, if not larger, to that observed during the cold compression of quartz grains. The largest events always occur at a temperature slightly below that of appearance of the ringwoodite-structure phase on the XRD images patterns. This suggests that AEs are generated while the transition is still nucleation controlled (pseudo-martensitic stage). During stress-relaxation periods, the rate of AE triggering decreases, but does not completely vanish. The AE production rate increases again as soon as deformation is started again. Importantly, we still observed very large AEs at strain rates as low as approx. $10^{-5}/s$. At these early stages of the transformation, the samples did not show any macroscopic rheological weakening.

Focal mechanism analysis of the largest AEs showed that they are all of shear type, some being even pure double couple. They radiate about the same amount of energy as typically recorded during fast crack propagation in amorphous glass material. This suggests that they cannot only originate from the martensintic nucleation of oriented spinel-lamellae within a single germanium olivine crystal. Microstructural analysis (SEM, EBSD and TEM) highlights the presence of thin transformation bands made of incoherent spinel micro-grains which, possibly, run across germanium-olivine grain boundaries. These bands are all oriented near perpendicular to the principal compressive stress.

Our observations point out that under high deviatoric stress, the olivine – spinel transition is a source of instability which produces micro-seismicity (no AEs are were recorded when in a similar experiment are performed hydrostatically). These instabilities might eventually be precursor to brittle fracturing as observed by Burnley et al. (1990) in their deformation experiments on very similar samples. Both types of study emphasize the potential of phase transitions (with negative volume variations?) in radiating acoustic energy and triggering brittle failure. Obviously, this has important consequences for the understanding of deep-focus earthquakes occurring in cold and metastable olivine within the transition zone.