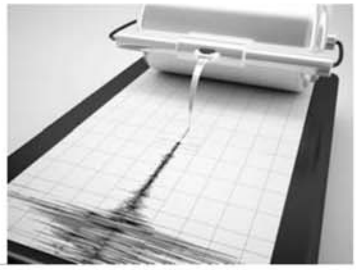
Shed Light to Earth Seismicity

Texture of olivine studied under high pressures help to understand Earth's mantle tectonic properties

The mineral olivine dominates the composition of the Earth's upper mantle and hence controls its mechanical behaviour and seismic anisotropy. Experiments at high temperature and moderate pressure, and extensive data on naturally deformed mantle rocks, have led to the conclusion that olivine at upper-mantle conditions deforms essentially by dislocation creep with dominant [100] slip. The resulting crystal preferred orientation has been used extensively to explain the strong seismic anisotropy observed down to 250 km depth.It has been shown that this high-pressure dislocation creep produces crystal preferred orientations resulting in extremely low seismic anisotropy, consistent with seismological observations below 250 km depth.

Earthquake, Santiago, Chile, 27 October 2010

These results raise new questions about the mechanical state of the lower part of the upper mantle and its coupling with layers both above and below. In order to study the structural modifications /textures of olivine at pressures that exist at depths of 200-300 km below the surface the DIA deformation equipment coupled at Synchrotron X-Ray source was used .

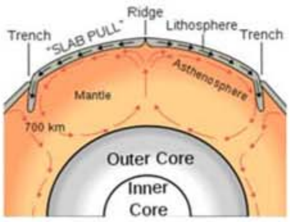


Seismograph

As olivine is stable at ambient conditions, a post-mortem (after application of strong e.g 40 % deformation at 1373 K and 3 GPa) analysis with ASTAR in TEM has been performed in order to reveal the texture at nanoscale size.

The sample studied was a forsterite ; in fact , olivine is actually a name for a series between two end members, fayalite and forsterite.Fayalite is the iron rich member with a pure formula of Fe_2SiO_4. Forsterite is the magnesium rich member with a pure formula of Mg_2SiO_4. The two minerals form a series where the iron and magnesium are substituted for each other without much effect on the crystal structure. Besides the high number of defects formed during DIA deformation cycles, it has been perfectly possibly to study in detail with ASTAR the texture of the deformed sample at nm level scale.

The challenge:	Identify texture and structural defects at nm scale of olivine mineral applied at very high pressures (3 Gpa)
Solution:	ASTAR technique coupled with precession electron diffraction



Experimental Data

TEM type: Jeol 3010
Map resolution: <10 nm
Scanned area: 5 x 5 µm

Crystal Structure

Olivine (Forsterite) Mg_2SiO_4:
Orthorhombic, Pbnm
a= 4.76 Å, b=10.27 Å, c= 5.98 Å

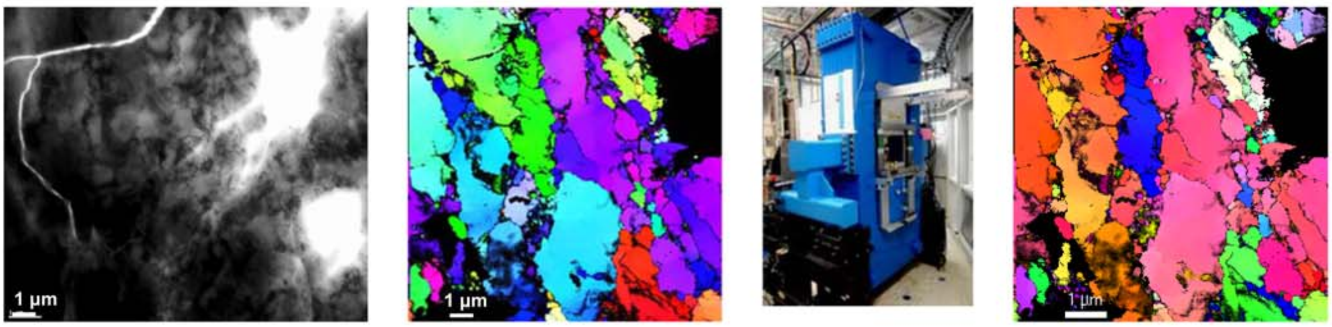


figure 1 ASTAR orientation olivine map with high number of defects (a) BF image (b) along x direction (c) Multi-Anvil Cell X-ray (X17 MAC) facility at the National Synchrotron Light Source Brookhaven USA (d) ASTAR orientation map along z direction

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