Investigation of structural transformations in high pressure shocked silicates from in-situ x-ray diffraction

A.Ravasio[1], J.-A. Hernandez[1], G. Morard[2], M. Guarguaglini[1], R. Alonso-Mori[3], D. Andrault[4], M. A. Baron[2], A. Benuzzi-Mounaix[1], R. Bolis[1], G. Fiquet[2], E. Galtier[3], G. Garbarino[5], A. E. Gleason[6], S. Glenzer[3], F. Guyot[2], B. Ko[7], H. J. Lee[3], W. L. Mao[6], M. Mezouar[5], B. Nagler[3], N. Ozaki[8], A. K. Schuster[9], S. H. Shim[7], T.

[1]Laboratoire pour l'Utilisation des Lasers Intenses (LULI), Ecole Polytechnique, CNRS, CEA, UPMC, 91128 Palaiseau, France, [2]Sorbonne Université, Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, IMPMC, Museum, National d'Histoire Naturelle, UMR CNRS 7590, IRD, 4 Place Jussieu, 75005 Paris, France,[3]SLAC National Accelerator Laboratory, 2575 Sand Hill Rd., Menlo Park, CA 94025, USA, [4] Université Clermont Auvergne, CNRS, IRD, OPGC, LMV, Clermont-Ferrand, France, [5]European Synchrotron Radiation Facility, ESRF, Grenoble, France, [6]Stanford Institute for Materials and Energy Sciences, SLAC, Menlo Park, CA, 94025, USA, [7]School of Earth and Space Exploration, Arizona State University, Tempe, Arizona, USA, [8]Graduate School of Engineering, Osaka University, Suita, Osaka 565-0871, Japan and Institute of Laser Engineering, Osaka, [9]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, D-01328 Dresden, Germany

alessandra.ravasio@polytechnique.fr

Accurate models of the Earth, of Earth-Type exoplanets and of putative differentiated cores of giants planets require an improved description of the physical properties of silicates. Of overall importance are olivine $(Mg,Fe)_2SiO_4$ and orthopyroxene $(Mg,Fe)SiO_3$ minerals, with enstatite ($MgSiO_3$) and forsterite (Mg_2SiO_4) as the archetypal members. The knowledge of their phase diagram at high pressures and temperatures both in solid and liquid phases is crucial for planetology. Precise measurements in Diamond Anvil Cells allowed to associate the solid-solid phase transitions that olivine undergoes at high pressure to the major seismic discontinuity detected in the Earth's mantle. Establishing the stability of these phases with pressure and temperature is necessary for super Earth studies and meteorites impacts as well as for high pressure physics. Similarly, the knowledge of properties of liquid silicates under high pressure and high temperature are requested for modelling the dynamics and solidification mechanisms of the Magma Ocean in the early Earth, constraining the presence of partial melting at the present day core-mantle boundary. Reaching these extreme temperatures and pressure in DAC is as today a real challenge. Often, $MgSiO_3$ and Mg_2SiO_4 glasses under high pressures are studied as liquid analogs, but this approximation has never been validated. In this context, dynamic compression schemes can help in widening the characterised phase diagram region. This research has so far been impeded by the absence of a structural probe able to directly determine phase transformations along shocked states, but new exciting perspectives are today opened by the advent of extremely brillant and temporally short XFEL x-ray sources allowing in-situ x-ray diffraction (XRD) measurements. In this talk we will present recent results we obtained on in-situ XRD from shock compressed SiO_2, $MgSiO_3$ cristalline and glass samples. The experiment was carried on at the MEC end-station of LCLS, in Stanford. Main shocked induced structural changes will be reported, comprising first observation of shock-induced metastable amorphous phases as well as unexpected high pressure polymorphs. Direct XRD data of liquid states could also be achieved and will also be discussed. A particular attention will be placed in the comparison between melts and high pressure glass we obtained in both static and dynamic compressions.