Towards *in situ* petrology of the Earth's deep interior

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Recent developments in high-pressure and high-temperature instrumentation and the coupling of these tools with synchrotron X-ray diffraction have greatly advanced our understanding of the deep Earth.

The laser heated diamond anvil cell is a unique tool to explore phase diagrams in the extremes P-T conditions of the lower mantle. For example, the phase transformations of natural mid-ocean ridge basalt were determined from 28 to 89 GPa and 1600 to 2700 K. Refinement of *in situ* X-ray patterns provided information on the nature of the crystalline phases, their unit-cell volumes and proportions. Combining these data with chemical composition of phases obtained by TEM or NanoSIMS, the density of basalt in the lower mantle was calculated. This density profile reveals that the dynamics of subducted slabs in the deep mantle may be strongly dependent on their thermal state.

Time-resolved X-ray diffraction in the large volume Paris-Edinburgh press is now a mature technique to study the kinetics of mineral reactions. As an instance, the kinetics of antigorite (serpentine mineral) dehydration will be presented. The transformation-time data acquired in the 1-5.5 GPa, 300-700 °C range were analyzed within Avrami's model of nucleation and growth to determine the mechanism of reaction and transformation rates. The breakdown of antigorite under low H_2O activity conditions resulted in a fluid discharge rate of the order of 3.10^{-6} to 3.10^{-8} $m^3_{fluid}.m^{-3}_{rock}.s^{-1}$. This is faster than the viscous relaxation of serpentinites, and could lead to brittle failure or weakening of pre-existing faults. The dehydration of antigorite could thus provide an explanation for the seismicity of subduction zones.

Further experimental improvements should focus on the combination of X-ray diffraction with measurements of the mechanical and transport properties of geomaterials. In this respect, the development of an X-ray imaging system for the Paris-Edinburgh press will allow, among others, viscosity measurements on melts by falling spheres experiments; increasing our knowledge of magmatic processes that occur inside the Earth.