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Experimental simulation of Earth's mantle conditions by multi-anvil techniques

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Understanding processes at deep interior of the Earth is a huge challenge for recent geoscience. In-situ studies are a very successful tool to investigate ongoing mineral reactions and non-quenchable phases within the laboratory as key factors and driving forces for geodynamic processes. The Earth's mantle represents the biggest volume fraction of our home planet. It is well-known from seismic studies since many years that the transition zone - extending from about 410 to 660 km and separating the upper and lower mantle - is a critical region for subduction, convection and pluming, i.e. fundamental material and energy fluxes. During the early 80's of the last century geoscientists worldwide realized synchrotron radiation as a highly valuable tool for in situ experiments, i.e. experiments under simulated Earth's mantle conditions.

The interpretation of seismic data from the Earth's deep interior requires measurements of the physical properties of Earth materials under experimental simulated mantle conditions. Elastic wave velocity measurement by ultrasonic interferometry is an important tool for the determination of the elastic properties in high-pressure devices. Interferometrical ultrasonic techniques including the data transfer function method for single-stage (MAX80) and double-stage (MAX200x) multi-anvil devices are described. Ultrasonic interferometry requires the exact sample length measurement under in situ conditions, because the critical interval between the frequencies of destructive and constructive interference do not only depends on wave velocity but also on sample length. X-ray imaging using brillant synchrotron radiation, called X-radiography, produces grey-scale images of the sample under in situ conditions by converting the X-ray image to an optical one by a CE-YAG-crystal. Saving the optical

image by a CCD-camera after redirection by a mirrow, also requires only few seconds. To derive the sample length, the images are evaluated by image processing. Because X-radiography requires a much larger beam diameter than XRD, adjustable 4-blade high precision slits systems are required.

Parallel to the installation of the new double-stage MAX200x some innovative experiments were carried out to improve the potentials of multi-anvil apparatus in terms of maximum pressure and limitation of stress inside the sample and the anvils. Some recent results on the non-quenchable high-P - low-P clinoenstatite transition, to the quartz-coesite transition as well as to the standard-free pressure measurement are given to discuss the recent and future potentials of high-pressure mineral physics in conjunction with synchrotron radiation.

Mueller et al., 2002. Eur. J. Mineral. 14, 581-589. Mueller et al., 2003. Eur. J. Mineral. 15, 865-873. Mueller et al., 2005a. In: Advances in High Pressure Technology for Geophysical Application, chapter 4, Elsevier B.V., pp. 67-94. Mueller et al., 2005b. In: Advances in High Pressure Technology for Geophysical Application, chapter 21, Elsevier B.V., pp. 427-449.