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Techniques of Elastic Properties Measurements under Simulated Earth's Mantle Conditions

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The Earth's mantle has a mass of about $4.08 \cdot 10^{21}$ tons and represents 68 % of the total mass of the Earth. It is only accessible by indirect methods, above all seismological studies. 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. The simulation of these in situ conditions require high pressure techniques - diamond anvil cells (DAC), multi-anvil devices (MAD) and mostly synthetical samples. MADs are more limited in pressure, but provide sample volumes 3 to 7 orders of magnitude bigger. They also offer small and even adjustable temperature gradients over the whole sample. The bigger samples make anisotropy and structural effects in complex systems accessible for measurements in principle. The measurement of both elastic wave velocities have also no limits for opaque and encapsulated samples.The ultrasonic interferometry allows the highly precise travel time measurement at a sample enclosed in a high-pressure multi-anvil device. Under high pressure conditions the influence of sample deformation is so important that ultrasonic interferometry requires the exact sample deformation measurement under in situ conditions using synchrotron radiation. There is a promising way to increase the maximum pressure of multi-anvil devices by multi-staging, i.e. implementation of additional sub-anvil set-ups resulting in a better distribution and limitation of the stress inside the anvils. Contrary to the common opinion of overshooting the maximum crushing strength most of the anvils fail in high pressure experiments due to the exceeding of the maximum tensile stress as a result of the lateral deformation. We present recent techniques and results of elastic properties measurements performed at different multi-anvil devices. That comprises standard-free pressure measurements, transient experiments, multi-cycle and multi-staging experiments as well as melt studies.