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Plasticity under pressure: static experiments and models

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Over the last few years, we developed new methods for the study of plastic properties of materials under high pressures and temperatures. These include a broad range of experimental techniques, such as radial diffraction in the diamond anvil cell (DAC), usage of the D-DIA deformation apparatus and, more recently, 3D x-ray diffraction in the DAC. Overall, we can now study the behavior of materials up to 300 GPa at ambient temperature, 70 GPa and 1500 K in the DAC and 20 GPa and 2500 K in the D-DIA. In most experiments, in-situ x-ray diffraction in used to extract quantitative texture information and elastic strains within the sample. The experimental data is then combined with self-consistent plasticity numerical models in order to understand the behavior of the material. In this presentation, I will show results on the hcp phase of Co deformed at 300 K between 0 and 42 GPa and results on the hcp phase of Fe deformed at pressures and temperatures reaching 19 GPa and 600 K. I will highlight how the combination of x-ray diffraction and EPSC modeling can be used to infer important information, such as the average stress within the sample, identify and constrain the plastic deformation mechanisms that were activated, and evaluate stress heterogeneity with the sample. In the last part of the talk, I will introduce techniques based on 3D x-ray diffraction and show how they can be used to constrain grain to grain stress heterogeneities and identify dislocations, in-situ, within a sample under high pressure. In the future, a combination of 3D methods and average techniques of the radial diffraction combined with self-consistent models will offer great opportunities to understand and model plastic behavior under pressure.