IN VERY TIGHT PLACES! – STRUCTURAL TRANSFORMATIONS OF MINERALS UNDER EXTREME CONDITIONS

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Extremes of pressure and temperature shape our planets and extraterrestrial bodies, turn everyday gases and liquids within the interior of gas giants into condensed solids, form unexpected compounds, and densify any matter (including our Earth's geomaterials) exposed to that kind of non-ambient conditions. Densification of crystalline solids follows the given freedom as determined by simple geometry aspects in stereochemistry, changes in electronic structures and chemical bonding, but also as controlled by symmetry and energetics related to the long-range order of the crystal structure. In many cases structural transformations in the sense of rapid transitions between long-lived structural states are the consequence of dynamically changed conditions.

Mineral transformations are in the focus of interest for mineral physics, as they control e.g. geochemical element distribution, considering the formation of new host phases, or account for anomalies in seismic wave propagation, seismic discontinuities, and related geophysical heterogeneities at our planets deep interior. Our current knowledge about mineral transformations is the result of experimental and computational advances of the past decades. In particular in-situ techniques, such as the diamond-anvil cell, nowadays allow to directly probe materials exposed to pressure, temperature, to electric and magnetic fields, radiation, and combinations of them.

Access to advanced in-situ characterization tools, including diffraction, scattering, spectroscopy, microscopy, and imaging is provided through dedicated large-scale facilities. In this context the newest technical developments including the advances made for in-situ high-pressure high-temperature experiments will be demonstrated, and an outlook for upcoming technical developments will be provided. A particular focus is dedicated to single-crystal techniques, which most currently started to experience a renaissance owing to the demand for very small sample sizes on approaching multi-megabar pressures at temperatures relevant to the Earth interior. Examples of selected mineral transformation are supposed to illustrate the recent activities in experimental crystallography and extreme-condition research, the application if developed techniques, and the efforts to use synchrotron radiation for in-situ investigations. Case studies encompass investigations of geologically relevant transitions in carbonate phases (transformation of calcite polymorphs, the pressure-induced transformation in dolomite-type norsethite).