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POWTEX Diffractometer at FRM II - New Perspectives in Geoscientific Neutron Diffraction

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In recent decades neutron diffraction has become a commonly used method in Geoscience for the quantitative analysis of crystallographic preferred orientations (CPOs) and for experimental high-field powder diffraction in respect to pressure, temperature, magnetic and electric fields. Quantitative texture analysis with neutrons is now also a routine tool for the investigation of fabric development in mono- and polyphase rocks, deformation histories and kinematics during mountain building processes and the characterization of flow kinematics in lava flows. Furthermore the quantitative characterization of anisotropic physical properties of both rock and analogue materials by bulk texture measurements can be achieved by neutron diffraction due to the high penetration capabilities of the neutrons.

To cope with the geoscientific needs for increased beam time at neutron diffraction facilities with the corresponding technical characteristics and equipment, POWTEX (POWder and TEXture Diffractometer) at the neutron research reactor FRM II in Garching, Germany is designed as a high-intensity diffractometer by a consortium of groups from the RWTH Aachen, Forschungszentrum Jülich and the University of Göttingen. Complementary to existing neutron diffractometers (SKAT at Dubna, Russia; GEM at ISIS, UK; HIPPO at Los Alamos, USA; D20 at ILL, France; and the local STRESS-SPEC and SPODI at FRM II) the layout of the POWTEX diffractometer is focused on fast measurements for either time-resolved experiments or the measurement of larger sample series as necessary e.g. for the study of large scale geological structures. This is possible due to the simultaneous utilization of a range of neutron wavelengths by means of the time-of-flight technique with a high flux of about 1 x 10^7 n/cm^{2}s and a large detector coverage of 9.8 sr. The detector layout will provide a sufficient angular resolution and pole figure coverage to be able to measure strong recrystallisation textures as well as weak textures of polyphase rocks without the necessity of sample tilting and rotation. This instrument configuration allows large sample environments, which will be implemented at POWTEX allowing *in-situ* time-resolved texture measurements during deformation experiments on rock salt, carbonates, ice and other materials. Furthermore a furnace for 3D-recrystallisation analysis by orientation stereology of the single grains will be built for POWTEX corresponding to the furnace that already exists for fine grained materials at the synchrotron beamline BW5 at HASYLAB, Germany (e.g. Klein et al. 2009 and references therein).

The *in-situ* triaxial deformation apparatus is operated by a uniaxial spindle drive with a maximum axial load of 200 kN, which will be specially designed to minimize shadowing effects between the sample and the neutron detector. The high temperature experiments will be carried out in uniaxial compression or extension at temperatures up to 1200° C and an upgrade to triaxial deformation conditions is envisaged. The load frame can alternatively be used for ice deformation by inserting a cryostat cell for temperatures down to 77 K with a triaxial apparatus allowing also simple shear experiments on ice. The spindle drive will be suitable for strain rates ranging between 10^{-8} and 10^{-3} s^{-1} reaching to at least 50 % axial strain. The furnace for the recrystallization analysis will be a mirror furnace with temperatures up to 1500° C, which will be rotatable around a vertical axis to obtain the required stereologic orientation information. This furnace can also be used as a standard furnace for parametric HT powder diffraction experiments.

References:

Klein, H. (2009). Principles of highly resolved determination of texture and microstructure using high-energy synchrotron radiation. Adv. Eng. Mat. 11, 452-458.