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Comparing results from neutron tomography and X-ray microtomography on sedimentary and metamorphic rocks with application to structural geology

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New techniques of data acquisition have provoked a rapidly increasing popularity of 3D analysis of geological structures, e.g. 3D seismic reflection on the large scale or tomographic methods on the sample scale. While reflection seismic data are an almost standard method to develop 3D structural subsurface models of sedimentary basins or fold- and thrust belts, the application of 3D tomographic analysis on hand specimen of structural interest is in its beginnings.

We investigated drill cores from (1) a pegmatite mylonite and (2) a deformation band within highly porous limestones with (a) Neutron Tomography (NT) at the Atomic Institute of the Austrian Universities and (b) X-ray microtomography (X-ray CT) at the University of Mainz. Due to the specific setup of the radiation source and detectors, the two methods have different resolution of 200-300 microns (NT) and 10-100 microns (X-ray) CT. While X-ray measurements are mostly sensitive to density variations of the material, NT allows a certain level of chemical analysis, as individual elements show different attenuation of neutrons, in relation to the properties of the atom nucleus. Both methods depict the distribution of pore space within the limestone samples, but while X-ray CT shows clear contrast with simply air-filled pores, the results are of higher quality in the NT measurements if the pores are filled with water during measurements.

On the one hand, the ability of the NT to distinguish between certain chemical elements, e.g. strong neutron scatterers (hydrogen) and neutron absorbers (boron, rare earth elements), may provide a useful tool for determination of 3D mineral shapes and distribution in metamorphic rock samples with well-known chemical composition and clearly distinguishable mineral phases. On the other hand, the high resolution X-ray measurements allows for very precise calculation of porosity and permeability in sedimentary rocks, which might be useful for petrophysical investigations in sedimentary rocks in hydrocarbon reservoirs.