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Application of neutron diffraction techniques for the observation of residual stress changes due to brittle fracture in intact rock

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Residual stresses play a fundamental role in the determination of both elastic, and brittle behavior of bedrock. These inter- and intragranular stresses result from the formation of bedrock under confined conditions and surrounding crustal stress field. They are present as compressive and tensile stresses in the intact rock. In sedimentary rocks residual stresses are evident as inhomogeneous elastic strains, which develop as grains recrystallized and deformed during metamorphosis interlock and expand as the rock exhumes. While the resulting ‘locked-in’ residual stresses are assumed to be negligible at the depth of rock formation and metamorphosis, they may increase to magnitudes approaching that of macroscopic rock strength (i.e. observed during short-term laboratory tests) by the time rock reaches the Earth’s surface. These residual stresses determine the external loading required to break intergranular bonds, and therefore the macroscopic strength of intact rock. Residual stress magnitudes will therefore both influence, and be influenced by, brittle fracture processes, and the observation of residual stress offers key insights into the mechanics of rock fracture.

Here, we describe a novel experiment designed to quantify the magnitude and distribution of residual stress changes in response to induced tensile fracturing during standard ‘Brazilian’ tests performed on pure marble (>95% $CaCO_3$) and quartzite (>95% SiO_2) samples. Changes in residual strain as a result of mechanical loading will be monitored using neutron diffraction. This is a technique which allows to investigate polycrystalline materials in the cm-scale using the Bragg law to detect the Bragg peak position and width in order to estimate the intra-crystalline strain. Due to the fast acquisition of the diffraction patterns at the EPSILON instrument at Frank Laboratory of Neutron Physics in Dubna (Russia), we expect to be able to compare strain observations prior to, and during, specified stages of the mechanical loading process. These observations will be supplemented by texture and initial micro-crack distributions analysis, micro-acoustic emissions, and macroscopic strain measurements.