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Induced damage in Carrara Marble as a result of long-term low-magnitude environmental stresses

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Damage of intact rock is commonly driven by the interaction of long-term low-magnitude external environmental stresses in combination with surface chemistry, rather than short-term loading in excess of intact rock strength. In order to determine the contribution of environmental stresses to the propagation of micro- and macroscopic fractures under natural environmental conditions we undertook long-term three-point bending tests on large size Carrara Marble specimens. The interaction of mechanical stresses induced by external loading and corrosive conditions (e.g. the presence of water) at the tip of a pre-existing crack is termed stress corrosion. We investigate stress corrosion below saw cut notches in wet and dry samples of Carrara Marble (M1-5, each 10cm x 10cm x 110cm). These were pre-loaded to about 66% of their assumed ultimate strength (determined by the fracture toughness (Kic) calculated for the crack tip). Two marble beams (M1, M3) were initially loaded to 22% and three (M2, M4, M5) to 55% of Kic. CaC03 saturated water was continuously dripped in the notch of samples –M1-4 to create corrosive conditions, while M5 was kept dry. After a three-week bedding period, loading on sample M1 was increased to 55%, M2 and M5 to 77% and M3 and M4 to 85% of Kic respectively. The tests were interrupted prior to failure of the specimens in order to allow the assessment of the crack-tip structure.

During the testing period we used classical strain gages and acoustic emission sensors to measure strain and elastic stress changes through coda wave interferometry. Temperature and humidity were monitored and the outflowing fluid was collected for future analysis, throughout. The effect of induced damage on residual intrinsic stresses was evaluated using neutron diffraction on the SALSA instrument at the Institute Laue-Langevin (ILL, Grenoble, France), while texture measurements were undertaken using the X-ray goniometer at the Geoscience Center, University Göttingen, and optical microscopy. Here we present first results describing induced damage in calcite rocks as a result of imposed environmental stresses.

We expect, that our test approach will provide insight into the interaction of environmental stresses and material properties, and their effect on degradation of bedrock exposed to natural environmental conditions.