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Progressive fracture in quartzite samples as a result of chemo-mechanical interactions

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Stress corrosion cracking reduces brittle fracture strength through the interaction of chemical and mechanical processes. In order to better understand the coupling of these processes in natural rock samples, we set up a long-term test in which six Alta-Quartzite samples (AQ 1-6, 300 x 30 x 70 mm) were brought to failure in stepped single edge notch bending (SENB) creep tests. Distilled water was introduced to the notch in four of these samples (AQ 1-2, 4-5), while reference samples remained dry. Samples were pre-loaded to 60% of their intact strength, as determined from preliminary short-term tests, to generate sharp initial cracks at the end of the saw-cut notch. They were then unloaded, before being re-loaded in steps of 5-10 % of the intact flexural strength starting at 0% for AQ1-3 and at 50% for AQ4-6. Strains were measured using electrical resistivity strain gages 2 mm below the notch.
For comparable loading paths, measured strains were up to an order of magnitude higher in samples which had water introduced, and approached tertiary creep at 70-80% of the dry maximum load. Scanning electron microscopy of the fracture path of the 'wet notch' quartzite samples revealed various alterations in conformity with the stress field. Observations include etch pits aligned parallel to the principal stress direction, terrace dissolution in the plane of the principal tensile stress, as well as stress direction dependent contrast of highly to not corroded surface, following microstructural, e.g. foliation planes. These fracture features indicate the importance of coupled chemical and mechanical processes, particularly along grain boundaries, crystal planes and microstructural interfaces.
Chemo-mechanical interactions are likely to facilitate progressive fracture of surface bedrocks in natural setting. Stress corrosion cracking is thus an important control on the promotion of rock slope failure, bedrock incision and building material damage.