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The interactions of compressive stress and weathering in driving rock fracture.

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Weathering plays an important role in weakening a rock mass before failure. The stresses generated by failure triggering events are often an order of magnitude smaller than those required to fracture rock. The compressive stresses of the slope resulting from gravitational load are also in themselves insufficient to result in fracture. Therefore, the rock must have been weakened prior to failure. Recent studies have shown that local stress concentrations within a slope can determine the effectiveness of weathering events. Currently however, the exact impact of this is not well constrained with few studies undertaken to analyse rock weathering under stress. To address this, we report the results of a laboratory testing programme designed to assess the influence of compressive stress on the effectiveness of weathering, specifically saltwater wetting and drying.

In these laboratory tests, rock cores were placed under a constant 2 MPa uniaxial compressive stress, corresponding to the approximate compressive stresses at the base of a 60 m high, near-vertical rock slope. The cores consist of moderately strong grey Staithes Siltstone (unconfined compressive stress, UCS, range of 20 – 30 MPa), found along the North Yorkshire coastline, United Kingdom. The samples were subjected to saltwater wetting and drying cycles of 6 hours, designed to mimic the submersion of a coastal cliff by the tide. Modified oedometers were used to place the samples under stress as wetting and drying occurred. We tested 4 samples which had been 'preloaded' in unconfined compression to 13.5 MPa (i.e. exceeding the crack initiation threshold but insufficient to cause fracture) to simulate the role of accumulated damage (i.e. creating a population of microcracks) in the rock slope, along with 4 samples which were not 'preloaded', and 8 samples with varying geometries to simulate the role of cliff-face topography in concentrating stress. Each test had a corresponding control sample which was not placed under stress but was subjected to the same weathering cycles. Monitoring of colour, surface texture, surface hardness and axial displacement was undertaken during the experiments, which lasted for 90 days. The samples were then removed and UCS values were obtained at the end of each test. These UCS results were compared with a baseline data-set of UCS tests (n = 10) to determine how strength had changed, if at all, in the samples due to weathering.

Initial results show that samples which were preloaded prior to the tests showed the greatest difference in strength when compared with their corresponding control samples. This suggests that weathering processes are more effective in driving fracture in locations where stress concentrations have created a population of pre-existing microcracks. These microcracks can subsequently be exploited by weathering processes to further weaken the rock. Areas of higher stress in a rock slope may, therefore, form zones of enhanced weathering and greater rock weakening, which may preferentially fail prior to other areas of the rock slope. In turn, the decimetre- to metre-scale topography of the rock slope, an often overlooked component, can play a role in dictating the occurrence of failure on a rock slope.