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# Testing the role of climate-dependent subcritical cracking in rock weathering and erosion.

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Mechanical weathering both drives and limits a multitude of Earth processes ranging from carbon sequestration to formation of the soils and sediment that host life. Ample attention has been focused on individual stresses that may set the pace for mechanical weathering, but little effort has been made to identify the mechanisms by which the mechanical properties of rock modulate the impact of those stresses over timespans longer than those of human observation. Here we begin to test the newly proposed hypothesis that all mechanical weathering proceeds by subcritical cracking, whose rates are predicated on climate - separate from the influence that climate has on stress-loading. To first test the role of subcritical cracking parameters on long-term weathering and erosion, we measured 10Be-derived erosion rates of 20 outcrops comprised of four rock types in the Blue Ridge Mountains, VA USA. These rates ranged from $\sim$1 to $\sim$30 m/my. The chosen outcrops were interpreted to have had similar stress-loading histories. We also measured subcrticial cracking parameters of samples from four of the same outcrops. Bivariate correlations between averages of the erosion rates with those of the measured Subcritical Cracking Index (exponent n of Charles' Law), Charles' law constant A, and fracture toughness of the four rocks are strong (R2>0.85; P-value <0.05 for all). We found no statistical correlation between erosion rate and the critical rock parameter, compressive strength, measured on the outcrops with a Schmidt hammer.

Then, to test the role of climate on subcritical cracking, we examine a three year record of subcritical cracking rate as measured by acoustic emission energy (AE) on a natural boulder set in full sun in the desert environment of New Mexico, USA. A full suite of per-minute meteorological data accompanied the cracking data. We find no statistical correlation between AE and commonly hypothesized stress-loading environmental variables – like diurnal temperature range. We attribute this finding to the non-linear nature of subcritical cracking acceleration as cracks increase in length, even as stresses remain relatively stable. We find a correlation between vapor pressure and subcritical cracking rate. Vapor pressure is known to strongly influence the rates of crack-tip, chemo-physical processes that constitute subcritical cracking. These datasets, together, begin to build a compelling case that mechanical weathering proceeds by climate-driven subcritical cracking. This conclusion encompasses broad implications for the interpretation of climate- and weathering-related datasets across the spectrum of Earth sciences.