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Effect of thermal shock on the decomposition of rocks under controlled laboratory conditions

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The major factor determining the rate of weathering of a given rock are the climatic conditions of the surrounding environment, most notably type and amount of precipitation and temperature. For the latter, average annual temperature and where applicable, the frequency of freezing and thawing are often considered to be relevant for weathering. The rate of temperature change is mostly ignored. However, a rapid change in temperature, referred to as thermal shock could have more severe consequences of rock deterioration then gradual heating and cooling of rocks is gradual. Thermal shock induces a stress of such a magnitude that the material is unable to adjust fast enough and so it breaks down.

The aim of this study is to examine the importance of mechanical decomposition of rocks when treated with thermal shock by freezing. The rate of decomposition of rocks of various sizes was measured based on their weight loss. In addition, they were immersed in water after freezing and the electrical conductivity and pH of the water were measured as an index for thermal-shock induced micro-fracturing.

Samples of three rock types were chosen for the experiment: limestone, tuffaceous rock and basalt. Samples were examined in two separate cycles: (i) 24h immersion in ultra-clean water followed by 24h drying at 30o and (ii) 24h immersion, 24h temperature shock by freezing at -20°C and 6h thawing. Each cycle was repeated approximately 20 times. In each cycle three different sizes of rock were examined: <16mm, 16-8mm and 8-5mm.

Limestone mass decreased for both cycles, although more distinctly after repeated thermal shocks. Furthermore, the rate of decay decreased with increasing rock size. Tuffaceous rock exposed to cycle (i) also showed a significant weight loss. Somewhat surprisingly, the mass of the tuffaceous rock exposed to thermal shock increased by about 13% in all sample size groups. It is possible that pore volume increased during experiment and that the rocks became capable of absorbing more water, but the rock was elastic enough not to break under stress. On the basalt, as expected, the rate of weight loss was the smallest. Cylce (ii) samples also showed more intensive mass reduction. Electrical conductivity and pH of the immersion water were constant throughout the experiment and did not change with the number of cycles. This implies that no significant chemical disintegration occurred.

The results show that thermal shock can have a rock type-specific effect on physical weathering. The lacking effect on chemical weathering is expected due to the design of the experiment. Under natural conditions, with non-pH neutral water, the declining rock stability, indicated by the loss of mass, especially of the limestone, will mostly likely also enhance leaching and thus chemical weathering.