SOME OBSERVATIONS AND THOUGHTS REGARDING ANTARCTIC CRYOGENIC WEATHERING

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Studies that either directly or indirectly deal with weathering in cold regions generally assume mechanical processes dominate, that the prime process is freeze-thaw and that the resultant products are angular. Recent observations regarding weathering in the Antarctic question these assumptions and the application of rock fracture mechanics indicates that curvilinear, rather than sharply angular, fracture patterns need not be unusual. Rock temperature data collected at one-minute intervals indicate that thermal stress/shock can play a major role in rock breakdown and the steep temperature gradients in the outer few centimetres of the rock would be conducive to spalling. The aridity of the present study area (Alexander Island, Antarctica) argues against freeze-thaw weathering except in very site-specific locations easily identified by visible water. Detailed rock temperature data, including for a significant part of two winters, clearly show an absence of snow (and hence moisture), the occurrence of $\Delta T/t$ values that exceed the threshold for thermal shock, a marked, but varying, aspect influence and steep thermal gradients with significant subsurface fluctuations (Hall, 1997 a & b, 1998).

Classic Griffith fracture theory expresses that a certain combination of excess pressure and crack length (or diameter) is required to keep a crack open or to increase its dimensions. Linear elastic fracture mechanics (LEFM) show very clearly that cracks may curve during propagation in response to a changing stress field; microfissures in the rock can also greatly influence crack direction. In fact, curvilinear (mixed-mode) crack propagation is common in rock mechanics as a crack will propagate in the direction the tensile stress in the crack tip vicinity is maximum. However, LEFM approaches assume that stress-intensity is decreasing with increasing crack length and that cracks may influence each other's stability and trajectory. In essence, there is no reason why curvilinear cracks may not occur as a result of stresses induced by mechanical and/or chemical weathering (particularly as in stress corrosion crack tip propagation). Non-cubic rock forming minerals show thermal expansion anisotropy. When the total linear thermal expansion of a mass becomes equal to the critical crack opening displacement, $\Delta t = \Delta c$ (where $\Delta t$ is linear thermal expansion and $\Delta c$ is critical crack opening displacement), the centre of the mass originally subjected to a compressive stress will now be subjected to uniform tension. When those initial stresses are very high so the shape will be selected to minimize stress concentrations. As cyclic variation in temperature induces alternating tensile and compressive stresses, particularly along the boundaries of inhomogeneities, there is no reason why the resultant fractures should not be curvilinear. That being so, why should the assumption be that mechanical weathering will only produce angular forms?

Evidence from the weathering of sandstones on Alexander Island (Antarctica) clearly demonstrates the production of rounded forms and debris as a result of mechanical processes, mainly thought to be thermal stress fatigue. This concept of thermal stress fatigue being the cause of breakdown fits well with the available temperature data plus LEFM theory (e.g., Rossmanith, 1983) and results from artificial weathering studies that investigated physically-induced stress-fatigue microcracking (Blaga and Yamasaki, 1973). Further, despite the frequent association of mechanical weathering processes with taffoni development, it seems never to have been questioned that taffoni are rounded forms. Data collected from the same area on taffoni size and Schmidt hammer rebound values for different aspects show that there is an aspect influence on weathering. It is concluded that, in this area of Antarctica, mechanical processes other than freeze-thaw dominate, that forms other than angular can be produced, and that taffoni development shows a distinct aspect influence.
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REFERENCES


