

EFFECTS OF DIURNAL TEMPERATURE VARIATIONS ON LUNAR ROCKS;

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Diurnal temperature variations can significantly change the fracture content of rocks residing on the lunar surface. Temperatures vary from approximately -100°C to $+100^{\circ}\text{C}$ at the surface in the course of a lunar day. Lunar rocks will have initial fracture porosities due to shock events and other causes when the rocks are brought to the surface. The thermal cycling can both increase the initial porosities and modify the fracture characteristics. In addition, those physical properties of the rocks which are dependent on the fracture parameters will be drastically affected.

Samples of terrestrial rocks were thermally cycled with a technique described by Simmons and Cooper (1) between 30°C and 230°C to simulate lunar surface conditions. The temperature was varied at a rate less than one degree per minute to prevent thermal gradient effects (see 2). The samples consisted of cubes 2.5 cm wide of Westerly (RI) granite and both virgin Frederick (MD) diabase and samples of this diabase heated to 700°C . The samples were prepared in a glovebox and heated in closed containers under a constant flow of dry nitrogen to prevent water vapor from entering any newly created cracks. Samples were removed from the oven after exposure to a logarithmically increasing number of cycles. The fracture porosities and characteristics were measured with differential strain analysis to 2500 bars. This high precision strain technique is described in detail by Simmons *et al.* (3) and Siegfried and Simmons (4).

The fracture contents of both the Westerly granite and the preheated Frederick diabase were drastically modified by the thermal cycling (see figure 1). Westerly granite was chosen for its abundance of natural rough and irregular fractures. The fracture porosity ζ increases with the number of cycles N according to the equation $\Delta\zeta/\Delta\log_{10}N = .003$. See figure 1. The initial porosity doubles after about 500 cycles (approximately 40 years). The thermal stresses open new cracks or extend pre-existing cracks. Frederick diabase more closely resembles the composition of lunar samples. The virgin diabase has no measurable fracture porosity. After 100 cycles, only a very small fracture porosity has appeared. Hence, thermal cycling tends to modify pre-existing cracks rather than creating new ones. Several samples of the diabase were preheated to 700°C before cycling to introduce fresh, artificial cracks. The fracture porosity of the preheated diabase decreased with cycling. The scatter in the data is too great to determine whether the porosity will continue to decrease or whether it has reached a steady value. This decrease in porosity is not surprising. The high preheating temperature opens cracks to relieve stresses and prevent further fracturing precisely at the locations where thermal stresses would have opened cracks at the lower cycling temperatures. The tendency is to close cracks perhaps by shifting the grains to fit closer together, crushing material propping cracks open, or possibly some annealing.

The crack spectra, or closure rate as a function of pressure, did not appear to be modified by the cycling for any of the samples. Lunar samples have spectra much broader than terrestrial rocks, including shocked specimens (5). Perhaps with further cycling, the spectra of our analogue samples will broaden significantly.

Many important physical properties will also change as the fracture

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porosities of lunar rocks change with cycling. Such properties as seismic velocity and dielectric constants may be altered substantially and have little relation to the initial properties of the lunar rock. Hence, measurements of such properties on surface samples may not be valid for estimating properties at depth. Even if the estimated *in situ* conditions are duplicated, the modification of the fracture contents and characteristics can make such property measurements invalid.

References

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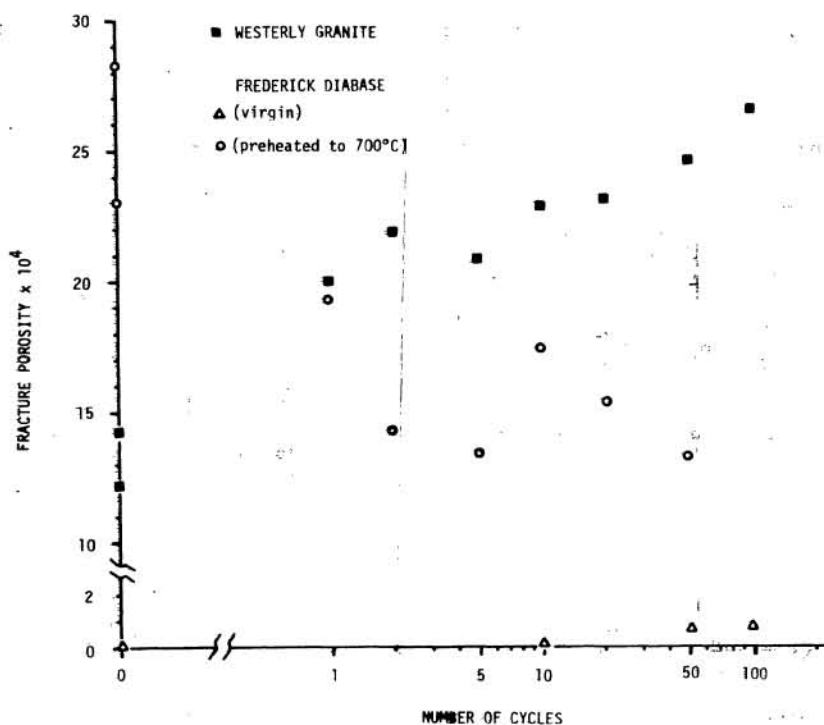


Figure 1.

Effect of thermal cycling on the fracture porosity of rock. (Note breaks in scale.)