MULTISPECTRAL THERMAL IMAGER OBSERVATIONS OF THE MOON DURING TOTAL ECLIPSE. S. L. Lawson[1], A. P. Rodger[1], B. G. Henderson[1], S. C. Bender[1], and P. G. Lucey[2]. [1]Los Alamos National Laboratory, Los Alamos, NM 87545; [2]University of Hawai'i at Manoa, Honolulu, HI 96822. (stefs@lanl.gov)

Introduction: Lunar eclipse temperature measurements are sensitive to rock populations because surfaces with abundant exposed rock have much higher mean thermal inertias than surfaces dominated by fine powders. When the Moon passes into the Earth's shadow, the abrupt reduction in insolation causes surface elements to cool at rates which are functions of their thermal inertia. The rock population is a function of the exposure of a surface unit, originally composed of solid igneous rock or impact melt, to the impact flux of modest sized projectiles. With time, a competent surface such as a lava flow field or an impact melt sheet will be comminuted by the impact flux reducing the ratio of coarse to fine particles. In principle, thermal measurements taken during lunar eclipse can be used as a measure of the relative age of surface units.

During their series of visible and infrared imaging observations of the Moon, J. M. Saari and R. W. Shorthill [1, 2] observed the lunar eclipse of 19 December 1964 and produced a data set intended to reflect relative thermal inertias. Ground-based telescopic infrared scanner measurements, normalized to initial temperature and time of observation, showed numerous thermal anomalies which often correlated with stratigraphic ages of craters and crater count ages of individual maria [2, 3]. The Apollo 17 Infrared Scanning Radiometer collected high quality temperature data for portions of both the night and day side of the Moon [4]. These data revealed nighttime temperature anomalies and observed that they often correlated with geologic features. The experiment showed that areas with high thermal inertia (indicated by high nighttime temperatures) also had higher frequencies of exposed rock.

Observations: The Multispectral Thermal Imager (MTI) satellite was launched on 12 March 2000 with the mission objective of demonstrating the effectiveness of highly accurate multispectral imaging for passive characterization of industrial areas and sites of environmental interest [5]. Figure 1 shows MTI's fifteen spectral bands which include three visible bands, five near infrared bands, two short-wave infrared bands, two mid-wave infrared bands, and three long-wave infrared bands. The last five MTI bands are particularly useful for studies focused on Earth-based (land and water) temperature and emissivity problems. In addition to Earth-based observations, MTI routinely images the Moon.

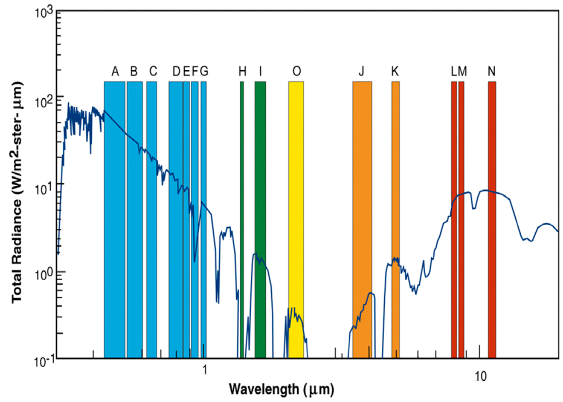

Figure 1. MTI spectral bands overlaid on a modeled Earth-looking spectrum.

During the total lunar eclipse of 9 January 2001 (mid-eclipse 20:21 UT), MTI imaged the Moon while it was in partial and full eclipse. Figure 2 shows two MTI images of the lunar surface. The left image was taken on 9 February 2001 in band E (0.86-0.89 μm) and is shown for lunar feature reference. The right image in Figure 2 was taken during totality (20:38 UT) on 9 January 2001 in band M (8.42-8.83 μm) and shows the variation in relative brightness temperature across the lunar surface. In the MTI infrared bands, the Moon spans approximately 260 pixels. Figure 3 shows crater Tycho (85 km diameter) from the band M relative brightness temperature totality image; note the different scale of this figure.

Discussion: The relative brightness temperature image of Figure 2 shows numerous hot spots. The highest relative temperatures are from young craters, for example Tycho and Copernicus, which have strewn large blocks on the lunar surface. Maria Serenitatis, Tranquillitatis, and Nubium show large anomalously hot areas, while Mare Humorum is much warmer than its surroundings. The relative temperature maps of Figures 2 and 3 are in excellent agreement with the 19 December 1964 eclipse results of Saari, Shorthill, and Deaton [2]. The hot central peak of Tycho, which is poor in fine particulates, is apparent in Figure 3.

In examining the variety of data available, it is evident that at least in part the eclipse temperature of a surface is a function of the age of that surface. However, even cursory examination of Figure 2 shows that major exceptions exist which indicate controls on this parameter other than age. For example, the extensive bright ejecta of Tycho crater does not appear anomalous against the ancient highland upon which it is draped, despite its youth (~100 My). It is the interior of Tycho which is "eclipse hot" and the difference in eclipse temperature between Tycho interior and ejecta is due to the differences in rock population. The ejecta of a crater is dominated by pulverized rock, especially outside one crater diameter from the rim, while for large craters such as Tycho, the floor is initially lined by a thick impact melt sheet which is physically equivalent to a solid lava flow. With exposure this melt sheet will gradually be broken into smaller blocks and its thermal inertia will decrease. This discussion suggests that if a lunar geologic unit begins its existence as a thick layer of competent rock, and is not blanketed by thick pulverized ejecta from a large crater, then its eclipse temperature can be used to estimate the age of that surface.

References: [1] Shorthill, R. W. and J. M. Saari (1965) *Science*, **150**, 210-212. [2] Saari, J. M. *et al.* (1966) *Icarus*, **5**, 635-659. [3] Fudali, R. F. (1966) *Icarus*, **5**, 534-544. [4] Mendell, W. W. and F. J. Low (1975) *Proc. Lunar Planet. Sci Conf. 6th*, 2711-2719. [5] Weber, P. G. *et al.* (1999) *Proc. SPIE*, **3753**, 394-402.

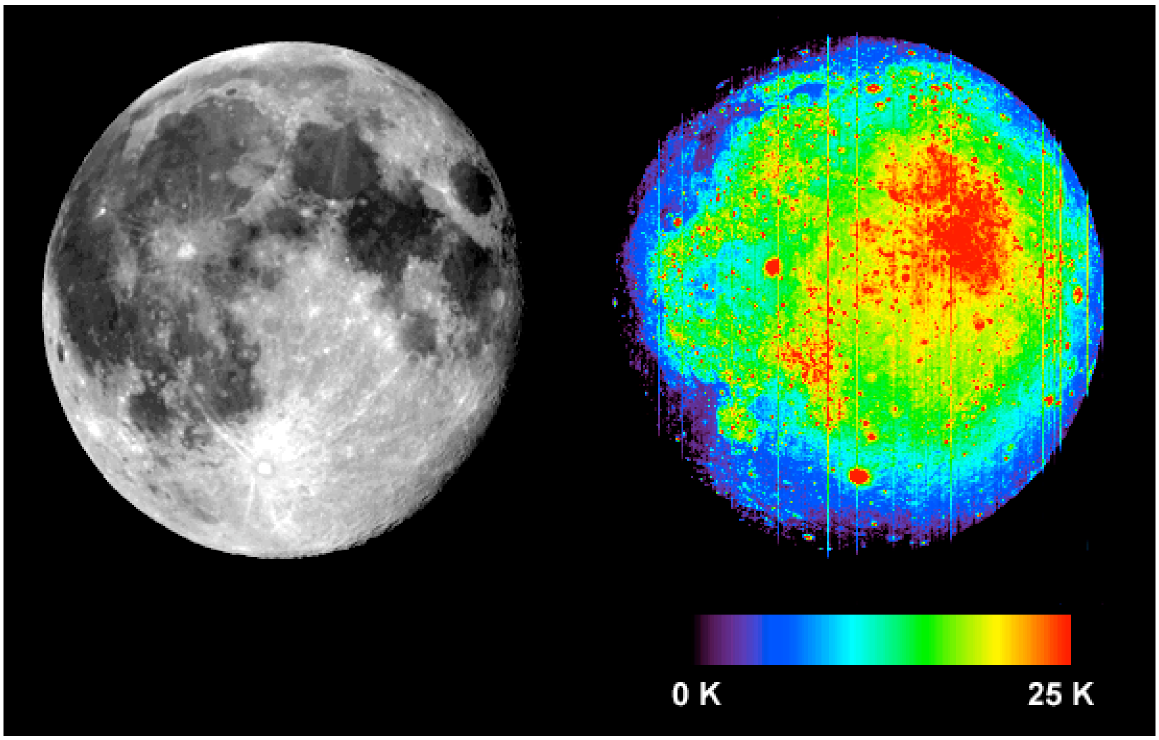

Figure 2. MTI 0.88 m image (left) and relative 8.6 m brightness temperature map of the lunar surface during total eclipse (right).

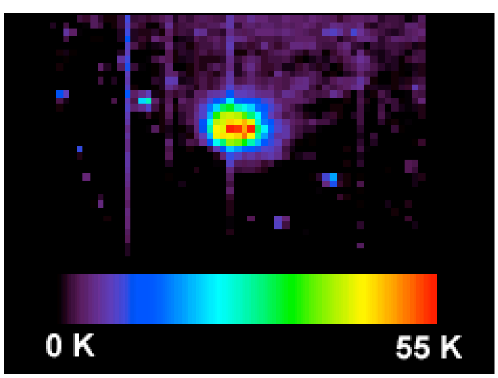

Figure 3. MTI relative 8.6 m brightness temperature map of crater Tycho during total eclipse.