LUNAR SURFACE PROPERTIES FROM NEW DIVINER ECLIPSE OBSERVATIONS. D. A. Paige[1], P. O. Hayne[2], B. T. Greenhagen[3], J. L. Bandfield[4], M. A. Siegler[2,5], and P. G. Lucey[6], [1]University of California, Los Angeles (dap@moon.ucla.edu), [2]NASA-Jet Propulsion Laboratory, California Institute of Technology (Paul.O.Hayne@jpl.nasa.gov), [3]Applied Physics Laboratory, Johns Hopkins University, [4]Space Science Institute, [5]Planetary Science Institute, [6]University of Hawaii, Manoa

Introduction: The thermal behavior of planetary bodies can reveal information about fundamental processes shaping their surfaces and interiors. Diviner [1] has been mapping the Moon's diurnal temperatures since the Lunar Reconnaissance Orbiter (LRO) arrived in 2009, yielding new insights into regolith formation [2, 3], the distribution of volatiles [4, 5], lunar volcanism [6, 7, 8], and impact processes [9]. The Moon's cooling during eclipse provides complementary information on the physical properties of the uppermost surface layer, which can be used to further investigate these and other processes.

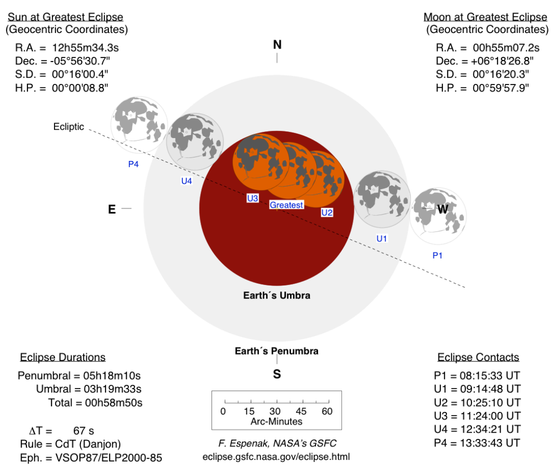

Fig. 1: The Oct. 8, 2014 total lunar eclipse. *Credit: NASA/GSFC*

Background: Although Diviner had previously acquired observations of the Moon's cooling during eclipse [10], these measurements were made with undesirable geometry as LRO remained near the lunar terminator throughout the eclipse. This meant that the surface temperature distribution prior to the eclipse was highly complex, and that subsurface temperature gradients were strong. However, during the total lunar eclipse of October 8, 2014 (Fig. 1), the LRO orbit was only ~30° from the sub-solar point, such that the surface was initially very warm prior to eclipse, and temperature heterogeneity was much less severe. Diviner's October 8, 2014 measurements therefore provide the best opportunity so far to quantify and map the thermal inertia of the Moon's uppermost surface layer.

Observations: We used data from Diviner's seven thermal infrared spectral channels to measure surface temperatures before, during and after the Oct. 8 eclipse. In its standard nadir-pushbroom mode, Diviner maps surface temperatures in a ~6-km swath with a spatial resolution of ~250 m. Using Diviner's independent scanning capability [11], we also targeted two regions of interest on sequential orbits to create a time series of thermal observations: 1) Kepler crater (-38°E, 8°N) and 2) an unnamed nighttime "cold spot" (-33.3°E, 3°N). Pre-eclipse surface temperatures in these regions were ~380 K. As a relatively young Copernican-aged impact crater, Kepler was selected to investigate the abundance and size distribution of rocks in the ejecta and interior. Lunar nighttime "cold spots" are anomalous features around very young impact craters, extending for up to hundreds of crater radii, notable for their low temperatures in the Diviner nighttime data [9]. Although their origins are not fully explained, they are likely the result of in-situ disruption and deconsolidation of regolith during the impact process. The selected cold spot (one of hundreds or even thousands on the lunar surface) was located with good viewing geometry from LRO, and had a diameter of ~10 km surrounding a crater < 1 km in diameter.

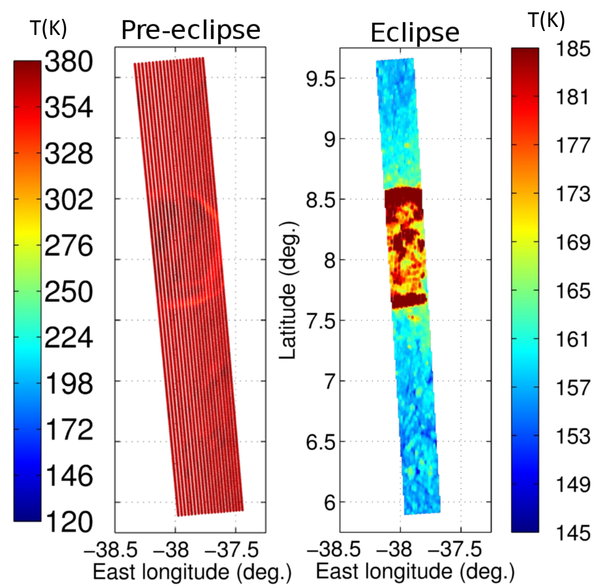

Fig. 2: Diviner Channel 7 eclipse observations at Kepler crater.

Kepler Crater Results. At Kepler crater, we observed dramatic differences in the amount of cooling related to the presence of blocky ejecta material (Fig. 2). Comparisons of the rock abundance derived from the eclipse measurements can be made to those derived from the standard Diviner diurnal data [2] in order to constrain the rock size distribution.

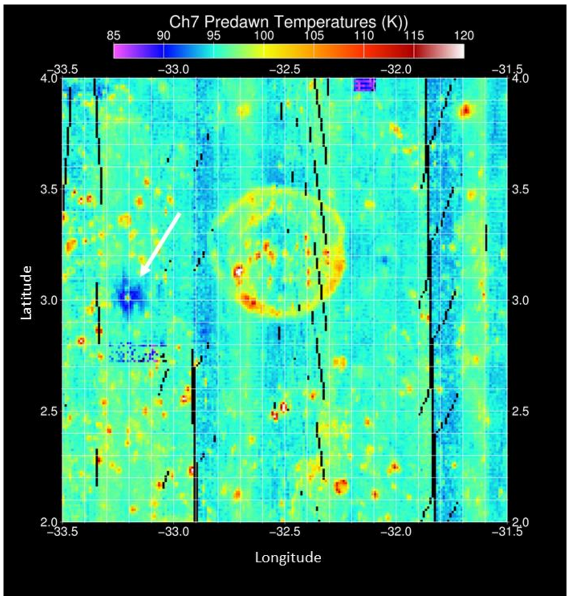

Fig. 3. Diviner pre-dawn Channel 7 brightness temperature map showing the location of a small nighttime cold spot (white arrow) that was targeted for eclipse observations.

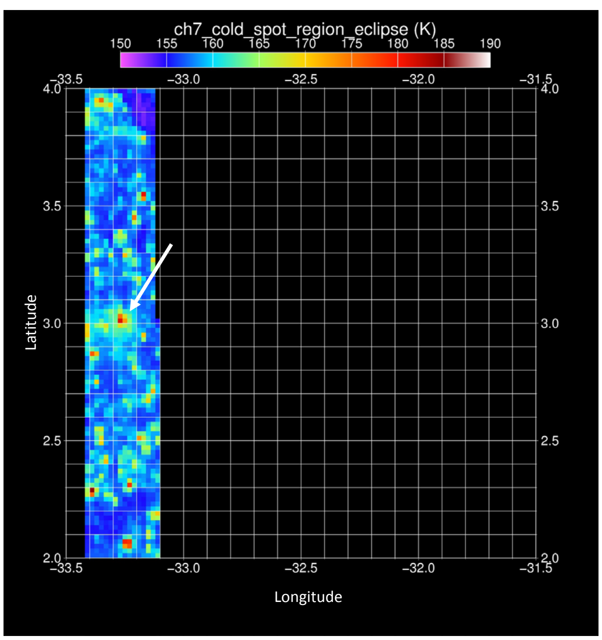

Fig. 4: Diviner Channel 7 brightness temperature map obtained during the eclipse showing elevated temperatures at the location of the small nighttime cold spot.

Nighttime Cold Spot Results. At a small nighttime cold spot (Fig. 3), we observed brightness temperatures during the eclipse that were more than 10K higher than those observed in surrounding non-cold-spot regions (Fig. 4). This somewhat paradoxical result implies that the vertical stratigraphy of the Moon's near-surface regolith may be more complex than has been previously appreciated. We are in the process of evaluating several possible explanations for this phenomenon quantitatively.

References: [1] Paige D. A., et al. (2010) *Space Sci. Rev.* 150, 125-160. [2] Bandfield J. L., et al. (2011) *J. Geophys. Res.*, *116,* E12. [3] Ghent R. R., et al. (2014) *Geology*, *42* (12), 1059-1062. [4] Paige D. A., et al. (2010) S*cience, 330*, 479-482. [5] Hayne P. O., et al. (2015) *Icarus*, submitted. [6] Greenhagen B. T., et al. (2010) *Science, 329*, 1507-1509. [7] Glotch T. D., et al. (2010) *Science, 329*, 1510-1513. [8] Allen C. C., et al. (2012) *J. Geophys. Res., 117*, E12. [9] Bandfield J. L., et al. (2014) *Icarus, 231*, 221-231. [10] Hayne P. O., et al. (2011) *AGU Fall Meeting Abstracts*, p. 1712. [11] Hayne P. O., et al. (2010) *Science, 330*, 477-479.

Acknowledgement: Part of this work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.