DIFFRACTION LIMITED IMAGES OF THE LUNAR SURFACE WITH KECK ADAPTIVE OPTICS. A. R. Conrad[1], D. Wooden[2], P. Lucey[3], R. D. Campbell[1], R. Goodrich[1], W. J. Merline[4], C. Chapman[4]. [1]W.M. Keck Observatory, 65-1120 Mamalahoa Hwy, Kamuela, HI, 96743, [2]NASA Ames Research Center, Moffett Field, CA 94043, [3]Hawaii Institute of Geophysics and Planetology, University of Hawaii, 2525 Correa Road, Honolulu, Hawaii 96822, [4]Southwest Research Institute, 1050 Walnut Street, Suite 300, Boulder, CO 80302

Introduction: On Oct 30, 2009, we locked the Keck-II adaptive optics (AO) system on a sunlit peak near the Moon's terminator and acquired data at near-infrared wavelengths. For on-axis images taken at M-band, AO correction was at the diffraction limit, but was poorer at shorter wavelengths and when observing off-axis. With this demonstration, observers may now propose for observing time to investigate some of the open questions in lunar science listed here.

Imaging Results: We took data with the near-infrared camera fed by the Keck-II AO system (NIRC2). Figure 1 shows our M-band image of a crater along the flank of mountain M5 located near crater Cabeus [1].

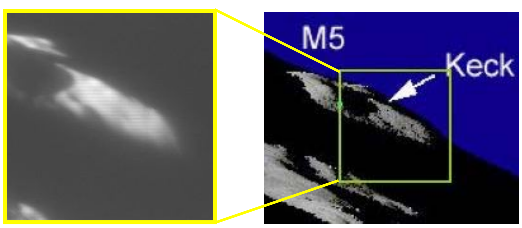

Figure 1. AO corrected image of a crater along the flank of M5 taken with Keck-AO/NIRC2 at M-band (4.55 – 4.79um) 2009 Oct 30 10:15 UT (left), together with a visualization of the area produced from the Kaguya global lunar digital elevation model (right). The right-hand figure was kindly provided by J. Mosher using the Lunar Terminator Visualization Tool (LTVT). The field of view of the AO image on the left is approx. 10x10 arcseconds (17.8 x 17.8 km). Assuming AO correction to approx. 110 milli-arcseconds at this wavelength, details are revealed to approx. 200m resolution.

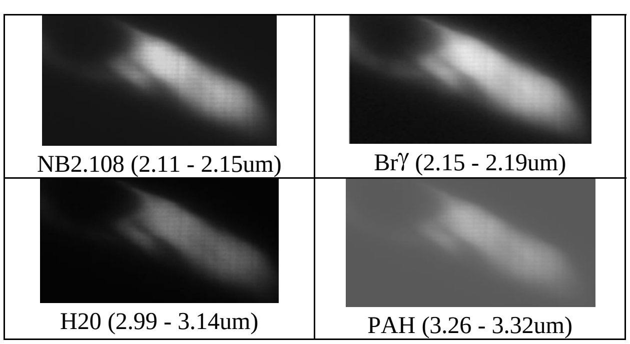

Figure 2. Diffraction limited images of the mountain M5 taken at four different wavelengths via standard filters available within the NIRC2 instrument.

Figure 2 shows a selection of narrow band images taken at this same location, revealing subtle changes in reflected light at different wavelengths (for example, the sunlit knob near the top appears brighter at shorter wavelengths, and appears as two distinct 'knots' at M-band). Future observations, acquired in lunar locations where color variations are expected (e.g., in the maria, or associated with recent fresh, large craters) might be able to apply similar imaging to obtain very low resolution Band-1/Band-2 reflectance spectra. These observations might determine surface composition to a spatial resolution better than 200m on the lunar surface [2].

Acquisition: As noted in previous reports, the Keck-II next generation guider system [3] provides neutral density sufficient to acquire individual features on the lunar surface, as was possible, for example, for the LCROSS impact while working with the seeing-limited spectrograph NIRSPEC on Keck-II. The AO system, however, has not yet been upgraded to this system. We have investigated adding the necessary neutral density filter to the AO system for this purpose [2], but have since learned that it is possible to use NIRC2 itself as the AO acquisition camera (by first calibrating the pixel-location of the AO wave-front sensor on the NIRC2 detector). Then, using a narrow-band filter at the shortest possible wavelength (Jcont – 1.20 – 1.22um) to best approximate the flux seen on the AO wave-font sensor, a visible-light sensitive CCD, we position the 'hot spot' seen on NIRC2 at that pixel location and then close the loops.

Potential Science: At least two open questions in lunar science might be addressed via the current and planned capabilities of NIRC2 with Keck AO.

1. At what level do the bright grains of anorthite, first witnessed by Apollo 11 astronauts in Mare Tranquilatris, occur over the entire lunar surface [4]?

Band-1/Band-2 spectroscopy via multi-color photometry could provide this answer over wide regions of the lunar surface at resolutions down to 200 meters.

2. What is the source of glass deposits found within the Aristarchus Plateau [5]?

A planned upgrade for the NIRC2 instrument (approx. late-2010) to include a Wollaston prism for polarimetry could allow exploration of this question.

Conclusions: Data taken during an October 2009 engineering night demonstrate the feasibility of applying Keck high angular resolution capabilities to the field of lunar science. Images of a crater along the flank of lunar mountain M5 reveal diffraction limited resolution at M-band. Several open questions in lunar science (especially those requiring regular monitoring over wide areas of the lunar surface) lend themselves to ground-based programs of this type.

Acknowledgements: We gratefully acknowledge the assistance of Jim Mosher for correcting the misidentified peak in the abstract distributed on CD. It is correctly identified here as M5, not M4.

The data presented herein were obtained at the W.M. Keck Observatory, which is operated as a scientific partnership among the Cal Tech, Univ. California and NASA. Keck Observatory was made possible by the generous financial support of the W.M. Keck Foundation.

References: [1] Whitaker 1954, JBAA, 64, 234-242. [2] Conrad et al. 2009, LPI, 1483, 28. [3] Kwok et al. 2008, SPIE, 7019, 70190A-70190A-12. [4] Lucey et al. 1995, Science, 268, 5214, 1150-1153. [5] Shkuratov et al. 2008, Icarus, 198, 1-6