**INVESTIGATING LUNAR CENTRAL PEAK COMPOSITIONS USING LRO DIVINER THERMAL INFRARED MEASUREMENTS.** E. Song[1], J.L. Bandfield[1], T.D. Glotch[2], P.G. Lucey[3], B.T. Greenhagen[4], D.A. Paige[5], [1]University of Washington, Seattle (eugsong at uw.edu), [2]Stony Brook University, [3]University of Hawaii at Manoa, [4]Jet Propulsion Laboratory, [5]University of California, Los Angeles

**Introduction:** Crater central peaks on the lunar surface are composed of material uplifted from varying levels within the crust. The composition of this material may be distinct from the surrounding terrain, which may provide detailed information about the crust's vertical heterogeneity. Compositional analysis of the central peaks of large craters has been performed using existing data sets, including telescopic spectra and Clementine visible and NIR images [e.g. 1-3]. We are continuing the investigation of central peak composition by using thermal infrared data from the Diviner Lunar Radiometer.

The thermal IR spectra are largely sensitive to bulk compositions. Craters listed by Tompkins et al [1] and Cahill et al [2] are of particular interest to this study due to their highly contrasting composition relative to the dominant lithologies in the surrounding terrain. For this investigation, the central peaks of craters Finsen and White are analyzed.

**Background:** Diviner is a 7 channel thermal infrared radiometer with 3 spectral filters near 8 microns (bands 3-5). Four additional bandpasses cover the 13-400 micron wavelength region. The 8 micron channels (centered near 7.8µm, 8.25µm, 8.55µm) are designed to characterize the Christiansen feature (CF) [4]. The wavelength position of the CF is generally correlated with the bulk silica content of the surface material. The CF location can be affected by the thermal gradients in a vacuum environment, however the relative differences between compositions are preserved [5,6].

**Method:** Diviner data acquired at local times from early to late afternoon were extracted and binned at 128 pixels per degree. The brightness temperature data was overlaid onto Clementine multispectral reflectance data. The ratio of 750nm / 950nm Clementine data is used to highlight regions with prominent $Fe^{2+}$ absorptions [1]. With the reflectance data as a spatial reference, select areas of diviner radiance data were converted to emissivity. Temperature differences can result in spectral data variability unrelated to composition. This was avoided by sampling areas of similar temperatures (within ~5K).

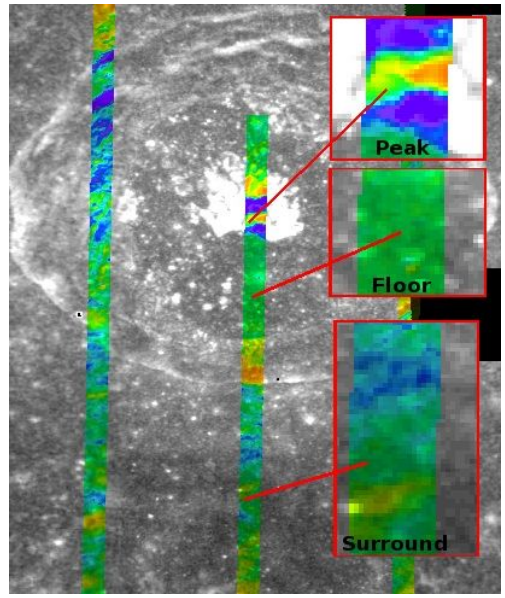


*Figure 1. Clementine ratio image of Finsen crater with Diviner temperature overlay. Sampled regions are highlighted – temperatures are all ~360K.*

This initial analysis is limited to investigating qualitative relationships between surfaces. However, significant changes in bulk composition will cause measurable differences in the Diviner spectral data. For example, a central peak with significant mafic compo-

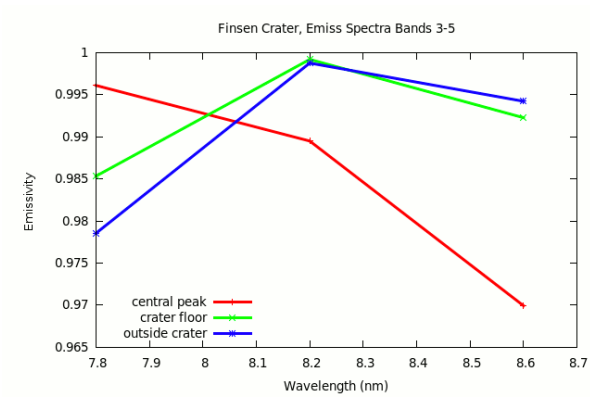


*Figure 2. Bands 3-5 spectra, Finsen crater.*

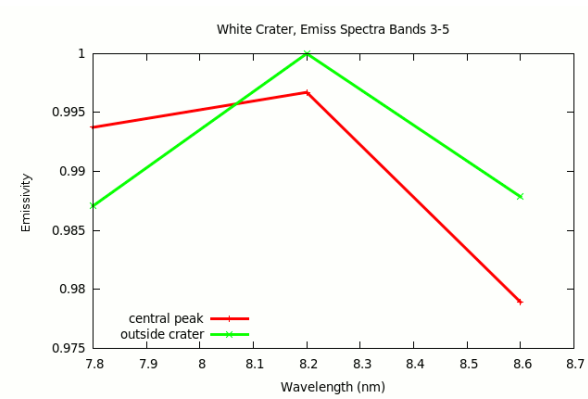


*Figure 3. Bands 3-5 spectra, White crater.*

nents surrounded by anorthositic highland materials may show a distinguishable shift in the CF towards longer wavelengths.

**Results:** Figure 1 shows Diviner temperature data as a colorized overlay on a Clementine ratio image of Finsen crater (near -42N,181E). The central peak of Finsen is reported to contain approximately the same amount of mafic material as the surrounding mare terrain [2]. The spectra [Figure 2] show that the central peak region has a noticeably shorter wavelength CF than both the crater floor adjacent to the peak and the dark lunar plains outside of the crater rim. The peak has more prominent $Fe^{2+}$ absorptions than the surrounding terrain in the Clementine ratio image.

White crater, located in the highlands, is reported to contain significant quantities of olivine with a Mafics/Plagioclase ratio of 8.5 [2]. The spectra in Figure 3 shows a similar spectral relationship between the central peak and outer highlands as shown in the Finsen crater example [Fig.2] – the central peak appears to have an emissivity maximum between bands 3 and 4, while the highlands region has a maximum near the center of band 4.

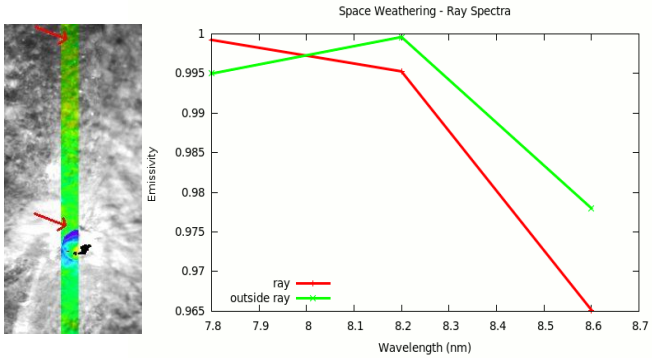


*Figure 4. Example of the effects of space weathering on bands 3-5. Samples taken from bright crater ray area and dark surrounding area.*

**Discussion:** These and other craters analyzed show shorter CFs at their central peaks than in the surrounding terrain, despite the fairly diverse sampling of craters representing varying geographical locations, previously reported composition, and crater sizes.

In the case of White crater, a longer wavelength CF was expected due to the presence of large amounts of mafic materials in the central peak relative to the largely anorthositic highlands. However, the Diviner data shows the opposite effect – the wavelength of the CF is significantly shorter at the central peak than in the surrounding terrain. Similar effects were observed at Finsen crater.

It is apparent that factors other than bulk composition are influencing the thermal IR spectral data. For example, the effects of space weathering have also been shown to have a significant influence on emissivity [7]. An example of the effects of space weathering on Diviner data is shown in Figure 4. The bright unweathered ray surrounding a small crater has a shorter wavelength CF than the surrounding area. Based on the size of the impact crater, the material within the ray is assumed to be otherwise compositionally consistent with the outside material. This shift towards a shorter wavelength CF is similar to that seen with the larger craters discussed above, leading to the conclusion that the CFs are biased towards the shorter wavelengths in our specific regions of interest. The high surface slopes of the central peaks of craters will maintain a less weathered surface than the surrounding plains. This is likely to make space weathering a source of spectral variability associated with the central peaks.

Another possible source of this spectral variability is the presence of different thermal gradients in the topmost layers of the lunar soil due to factors such as particle size distributions. A change in the thermal gradient in the upper tens of microns in the lunar soil can cause a large enough shift in the CF location to affect the Diviner spectral data [5,6].

**Conclusion:** Diviner thermal IR spectral data clearly reflect compositional variations on the lunar surface [8-10]. However, lunar thermal IR spectral data is also influenced by several factors, including space weathering and temperature. In order to interpret lunar surface compositions with Diviner data, it is necessary to separate the contributions due to these effects. More extensive analysis of craters of interest will be possible with the increasing coverage of the lunar surface with the Diviner instrument.

**References:**

[1] Tompkins, S. and Pieters, C.M. (1999) *Meteoritics & Planet. Sci., 34,* 25-41.

[2] Cahill*, J.T.S., Lucey, P.G.; Wieczorek, M.A. (2009) J. Geophys. Res.* 10.1029/2008JE003282, 2009.

[3] Pieters, C.M. (1982) *Science,* 10.1126/science.215.4528.59.

[4] Paige, D.A. et al. (2009) *Space Sci. Rev.* 10.1007/s11214-009-9529-2.

[5] Henderson, B.G. et al. (1996) *J. Geophys. Res, 101(E6),* 14,969-14,975.

[6] Henderson, B.G. and Jakosky, B.M. (1994) *J. Geophys. Res., 99(E9),* 19,063-109,073.

[7] Lucey, P.G. et al. (2009) *LPSC XLI, 41.*

[8] Glotch, T.D et al. (2009) *LPSC XLI, 41.*

[9] Greenhagen, B.A. et al. (2009) *LPSC XLI, 41.*

[10] Salisbury, J.W. et al. (1995) *Icarus 115*, 181-190.