**COMPARISON OF DIVINER CHRISTIANSEN FEATURE POSITION AND VISIBLE ALBEDO: COMPOSITION AND SPACE WEATHERING IMPLICATIONS.** Paul G. Lucey[1], David A Paige[2], Benjamin T Greenhagen[3], Joshua L Bandfield[4], Timothy D Glotch[5], [1.] Hawaii Inst Geophys & Planetology, 1680 East-West Road, University of Hawaii, Honolulu, HI, USA, lucey@higp.hawaii.edu; [2]. University of California, Los Angeles, Los Angeles, CA, USA.; [3.] Jet Propulsion Laboratory , Pasadena, CA, USA.;[4.] University of Washington, Seattle, WA, USA; [5.] Stony Brook University, Stony Brook, NY, USA.

**Introduction:** The Diviner multispectral radiometer carried by LRO features 3 wavelengths near 8 microns to characterize an infrared emissivity maximum called the Christiansen Feature (CF) [1]. The position of this spectral feature has been established as compositional indicator in laboratory experiments that show that the CF is related to silicate polymerization, occurring at shorter wavelengths for feldspathic minerals and longer wavelengths for mafic minerals[2]. Early laboratory experiments regarding the effect of space weathering on this feature suggested that there should be little observed affect by space weathering[3]. However, this work only examined the effect of vitrification and did not address the host of other physical and compositional effects of space weathering.

**Observations:** The Diviner Lunar Radiometer Experiment data suggest that the Christiansen Feature is detectably influenced by space weathering. Our first expectation was that the CF would inversely correlate with global FeO measurements because the principal hosts of iron in lunar materials are the mafic minerals pyroxene and olivine (with the rare ilmenite-rich maria being the chief exception), so the CF wavelength position should be proportional to mafic mineral abundance relative to plagioclase. We expected deviations from this correlation would be due to variations in mineral chemistry, olivine-pyroxene ratio, and possibly, space weathering effects. What we observed in comparing Lunar Prospector and Clementine FeO estimates with global CF images is that residuals showed marked anomalies associated with young, large, fresh craters, notably Tycho and Jackson. Direct inspection of the CF image explains this: The CF image, stretched from high to low wavelengths and viewed in black and white, appears strikingly like an image of visual albedo, with known fresh craters showing distinct anomalies (Figure 1).

The full range of values of the Christiansen Frequency in the data presented (here binned at 12 km resolution) is about 7.8 to 8.3 microns. Assuming Tycho's ejecta is not compositionally anomalous--supported by no apparent anomaly in LP and Clementine iron images--the shift from the very immature Tycho interior to background mature highlands is about 0.1 microns, or about 20% of the full range of the data (dominated by mature surfaces at this scale). At least in this case, space weathering appears to systematically shift the CF toward longer wavelengths with increasing maturity. Thus composition dominates the Christiansen feature position, but space weathering has a significant effect that should be taken into account in detailed analysis.

**Origin of space weathering effects:** Soil maturation, the result of lunar materials exposure to the space environment, is accompanied by a host of physical effects. With increasing space weathering, grain size distributions evolve, composition fractionates among grain size fractions, agglutinates (aggregates of rock and mineral fragments welded by impact melt glass) accumulate, grains acquire vapor deposited coatings rich in nanophase iron among the many effects. The effects of maturity in the optical and near-IR is dominated by the abundance of nanophase iron that causes darkening, reddening, and loss of spectral contrast with space exposure.

There are several potential causes for the apparent Christiansen feature position sensitivity to space weathering. The position of this feature is strongly dependent on the thermal structure of the optically active surface as demonstrated by its variation between observations in air and vacuum. Space weathering may affect this structure either with physical evolution of the microstructure of the surface, or by changing the average albedo and hence the optical penetration depth, and then the thermal gradient. Composition evolves with soil maturity in the form of conversion of minerals to glass, and changes in the composition of different grain size fractions. Vitrification experiments seem to indicate that this process does not affect the Christiansen feature position [3]. If grain size fraction compositional evolution dominates, this would suggest that the Christiansen feature position is more sensitive to the coarse fractions that become more mafic with maturity owing to the loss of relatively fragile plagioclase[5]. This is a fertile area for laboratory experiments.

The position shift could also be caused by the effects of nanophase iron, as in the visible and near-IR. The effect of nanophase iron is due to the extremely efficient absorption properties of absorbing subwavelength particles; at thermal wavelengths this fact has not changed. Near 8 and 9 microns iron is still spectrally red and will have some influence on the spectrum in its nanophase form; how large this influence is and

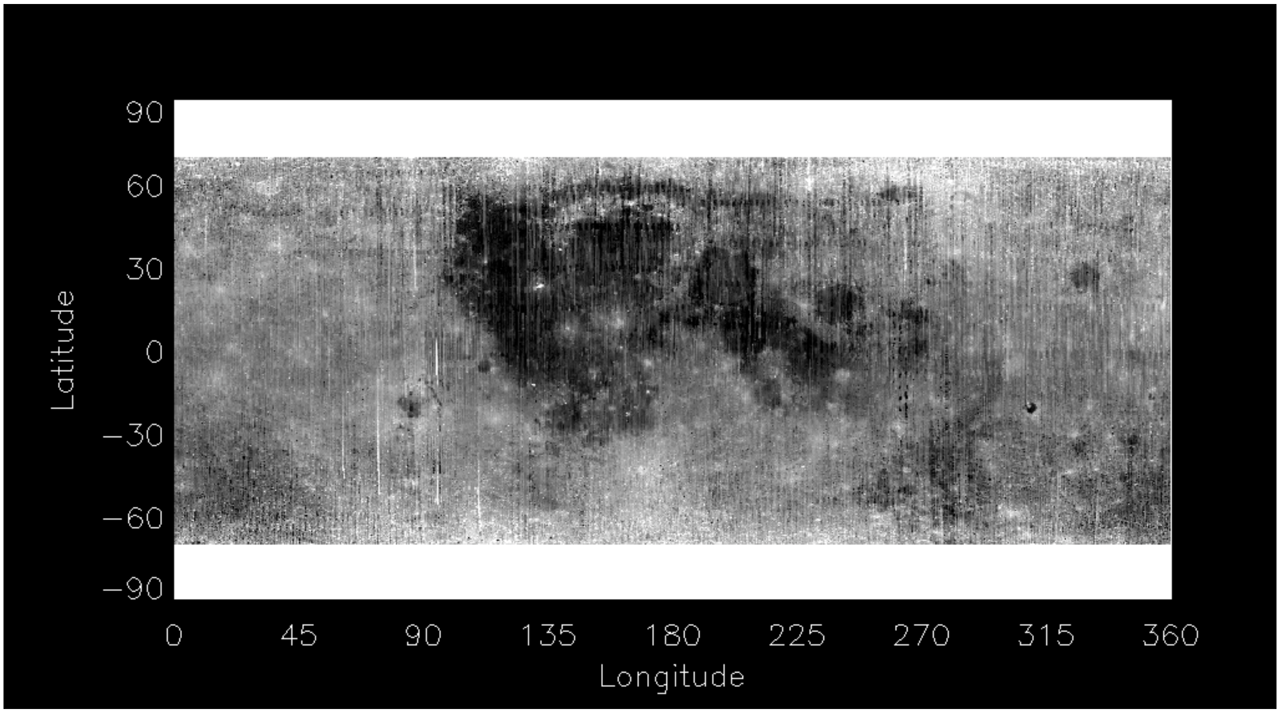


*Figure 1. Christiansen Feature image of the Moon, latitude ranges from +/- 60 degrees latitude. The data are stretched from 7.8 to 8.4 micrrons, where white is the shorter wavelength and black is the longer. Note the similarity to visual albedo.*

whether it has the proper sign is the subject of radiative transfer modeling.

**Decorrelation of CF and albedo**: To search for differences between the visible and infrared data that might be due to compositional or space weathering anomalies we regressed the 750 nm Clementine alboed on the CF image shown in Figure 1. We then predicted the CF image from the 750 nm reflectance and subtracted the CF and CF-predicted images. The residual image, with a one sigma deviation of 0.15 microns, is largely dominated by orbit-orbit striping in the evolving Diviner calibration, with possible local and region anomalies near the noise in the image. Some structure appears at high latitudes where the Clementine data become dominated by topographic shading.

**Conclusion**: The similarity of the CF and visible albedo data suggests first that variations in Mg-number are relative modest, or at least that Mg-number correlates with albedo. If major regional variations in Mg-number of mafic minerals were present, the correlation between the iron dominated visual reflectance, and pyroxene/olivine dominated CF would show greater variation. This is consistent with the result of [6] who did not detect substantial variation in Mg-number except for mare highland differences.

**References:**

[1] D. Paige, *et al.* , *Space Science Reviews, Online First.* [2] Logan, L.M., G.R. Hunt, J.W. Salisbury, and S.R. Balsame, *J. Geophys. Res*., 78, 4983-5003, 1973. [3] Nash, D. B., and J. W. Salisbury 1991, *Geophys. Res. Lett* . 18, 1151-1154. [4] G.Y. Kramer, B R. Hawke, T A. Giguere, G Heitman, and T B. McCord, *LPSC XXXX* (2009), abstract #2369. [5] Taylor et al, JGR 105 E11, 27985, 2001. Prettyman, T. H. et al. (2007), *JGR*, *111*, E1, doi:10.1029/2005JE002656

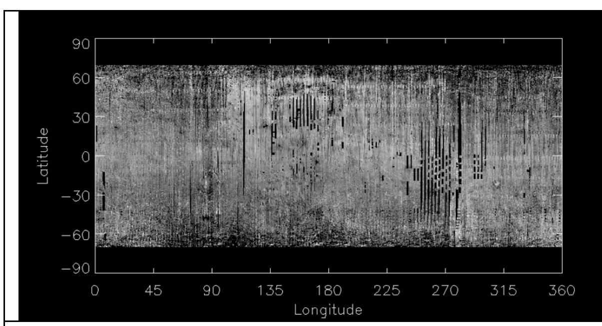


*Figure 2. Difference between CF (Figure 1) and Clementine 750 nm reflectance regressed on the CF data. Anomalies may be present, but are on the order of artifacts in the data due to orbit-orbit striping in the evolving Diviner CF calibration, and at high latitudes, the influence of topographic shading in the Clementine data.*