FINSEN AND ALDER: A COMPOSITIONAL STUDY OF LUNAR CENTRAL PEAK CRATERS IN THE SOUTH POLE-AITKEN BASIN. D. P. Moriarty[1], C. M. Pieters[1], J. Nettles[1], P. J. Isaacson[1], L. Cheek[1], J. W. Head[1], S. Tompkins[2], and N. Petro[3] [1]Dept. Geological Sciences, Brown Univ., Providence RI, 02912 [Daniel_Moriarty@Brown.edu], [2]DARPA, [3]NASA GSFC.

Introduction: Here, we present our first look at the mineralogy of Finsen and Alder, two lunar central peak craters, using Moon Mineralogy Mapper (M^3) data. Finsen and Alder are located near the center of the South Pole-Aitken basin (SPA) on the farside of the Moon and have similar diameters. SPA is one of the largest impact structures in the solar system and may have formed a thick, homogenous melt sheet [1,2]. Preliminary analysis shows that Alder displays significant diversity in composition and an unusual morphology. Finsen displays two distinct mafic lithologies associated with the central peak and crater wall.

Background: Central peaks are an extremely useful resource for remote sensing studies of the lunar surface. Typical central peaks in craters between 40 and 150 km in diameter excavate material from between 5 and 30 km in depth [3]. Many central peaks have steep walls that prevent the accumulation of a space-weathered regolith layer, preserving optical immaturity [2].

Geophysical calculations suggest a compositionally derived division in the crust at 20 km depth [4]. Calculations also show that crust within lunar basins is approximately 20 km thinner than highlands crust [5]. Therefore, craters with central peaks located within basins should sample the lower crust. However, many SPA central peaks have been shown to be compositionally homogenous and may only sample the potentially thick melt sheet associated with basin formation [1,2]. Previous studies have shown that central peaks within many basins contain more mafic lithologies than peaks in the lunar highlands, which are dominated by plagioclase [2]. This suggests that the lower crust (and any sampled melt sheet) is more mafic than the upper crust [2]. We anticipate the targeted peaks in this region to exhibit strong mafic absorptions.

Data and Methods: We use data from the Moon Mineralogy Mapper to analyze the mineralogy of Alder and Finsen craters. The M^3 flew as a guest instrument on the Indian Space Research Organization's Chandrayaan-1 spacecraft and completed its mission in 2009 [6]. The instrument is a pushbroom imaging spectrometer with unprecedented spatial and spectral resolution, allowing mineralogical analysis in spatial context. M^3 data for Finsen and Alder is available at 280x140 m per pixel spatial resolution. Most M^3 data was collected in long strips as the spacecraft orbited

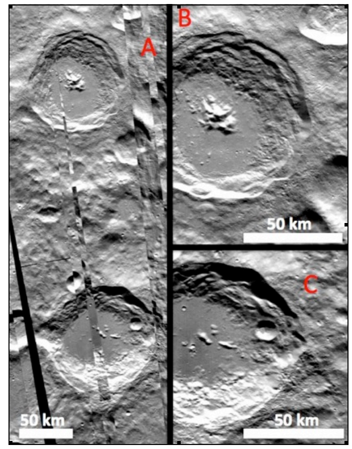

Fig. 1: M^3 data brightness at 2936 nm. (A) A mosaic showing Finsen (north) and Alder (south). The craters are located in close proximity in the South Pole-Aitken Basin. Misalignment of some strips is being corrected in current selenolocation work. Figures 1B and 1C are single strips showing Finsen and Alder, respectively.

the Moon in a polar orbit. Images are 300 pixels across and can be tens of thousands of pixels long. The instrument is sensitive from 430 to 3000 nanometers and the spectral resolution is split between 20 and 40 nm [7].

Finsen is directly north of Alder, so their central peaks generally fall in the same M^3 strips. However, the craters are wider than individual strips, so strips must be combined in a mosaic to obtain full geographic context (Fig. 1A).

To explore mafic mineralogy, we made parameter maps of the 1- and 2-μm integrated band depths (Fig. 2A, Fig. 3C). The integrated band depth calculates the total area between a continuum and the absorption band of interest for each spectrum (pixel). Mapping the integrated band depths across a scene allows us to observe the strength of mafic absorptions in spatial context and identify associations with geologic features. We then obtain spectra from areas of interest and can compare to laboratory spectra and results from previous missions.

Results:

Finsen. Finsen (42.38° S, 177.96° W, D=73km, Fig. 1B) [8] has a prominent central peak that clearly displays a more mafic composition than the surrounding area, as indicated by its brightness in the integrated 2-μm band depth map (Fig. 2A). The map also shows a mafic component present in the crater wall and floor.

Spectra were collected from the peak, floor, and wall (Fig. 2B). The peak (spectrum #1) exhibits strong mafic absorptions, indicating optical immaturity and the presence of low-Ca pyroxene (LCP). This M^3 data confirms the character of the 1μm band as measured by Spectral Profiler [1], expanding the spectral analysis to include the 2 μm band and spatial context. Spectra from Finsen's crater wall exhibit absorption band centers at longer wavelengths (spectra #2, 4). This suggests the presence of a higher-calcium pyroxene (HCP). This component is present around much of the wall.

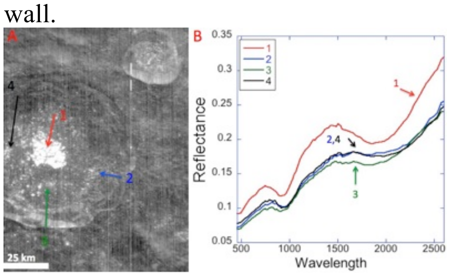

Fig. 2: (A) A parameter map of the integrated 2-micron band depth for Finsen. Mafic absorptions are prevalent in the central peak and areas of the floor and walls. (B) Spectra corresponding to areas in (A) indicated by numbered arrows. Spectra are derived from a 2x2 pixel average.

Alder. Alder (48.62° S, 177.68° W, D=82 km, Fig. 1C) [8] displays more diversity in both mineralogy and morphology than Finsen (Fig. 3). The two small central mounds appear similar in shape and size yet display very different mineralogy. The western mound displays strong mafic absorptions (spectrum #1), while a significant part of the eastern mound has a very flat spectrum (#2), suggesting the presence of plagioclase without an abundant mafic component. Relatively pure plagioclase appears prominently in an area on the southern wall (#5). Additional strong mafic absorptions appear in and around smaller, fresh craters on Alder's floor and eastern wall.

Discussion: There are two major lithologies in Finsen. The central peak displays a spectrum consistent with Mg-rich LCP, while the crater wall includes a component that is more Fe- or Ca-rich. Since central peaks sample deeper material than crater walls [3], it is seen that the deeper material is compositionally distinct from the shallower material. Both the central peak and crater wall appear to sample layers of material that are homogenous at the scale sampled by the impact event.

Alder's two central mounds appear similar in albedo and morphology. Those facts suggest that they formed from the same process and sample the same depth. However, their spectra appear quite different. The western mound displays strong mafic absorptions, while the eastern mound contains areas with a very flat spectrum consistent with pure plagioclase. The southern wall also exhibits this distinctive lack of mafic absorptions, indicated by black areas in Fig. 3C. The presence of nearly pure plagioclase in Alder is unusual within the South Pole-Aitken basin [9].

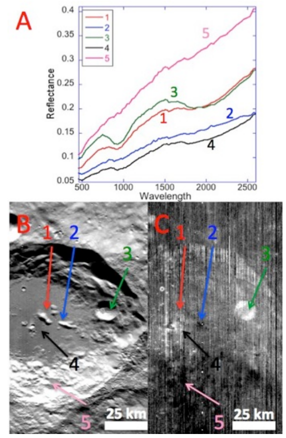

Fig. 3: [A] Spectra taken from points in Alder corresponding to the points shown in [B] the 2936 nm reflectance image and [C] the integrated 1-micron band depth parameter image. Spectra are derived from 2x2 pixel averages.

Summary and Future Work: Although Finsen and Alder are similar in size and location, they show significant differences in morphology and mineralogy. Finsen appears to have excavated homogenous, distinct layers, while Alder has excavated heterogeneous material whose layers are intermixed.

Future work will continue to interpret the mafic absorption bands in spectra from each crater to better characterize mineralogy. The presence and implications of anorthosite in Alder will be further investigated, along with its central peak's unusual morphology. We will evaluate consistency with previous and ongoing studies of central peaks and crustal stratigraphy [9, 10, 11].

Acknowledgments: M^3 science validation is supported through NASA contract #NNM05AB26C. M^3 is supported as a NASA Discovery Program mission of opportunity. The M^3 team is grateful to ISRO for the opportunity to fly as a guest instrument on Chandrayaan-1.

References: [1] Nakamura, R. et al. (2009) *GRL*, **36** L2202. [2] Tompkins, S. and Pieters, C.M. (1999) *MAPS*, **34**, 25-41. [3] Cintala, M.J. and Grieve R.A.F. (1994) *Large Meteorite Impacts and Planetary Evolution*, *GSA* **293**, 51-59. [4] Wieczorek, M.A. and Phillips, R.J. (1997) *JGR*, **102,** 10,933-10,943. [5] Neumann, G.A. (1996) *JGR,* **101,** 16,841-16,843. [6] Pieters, C.M. et al. (2009) *Current Science*, **96**, 500-505. [7] Green, R. et al. (2010) *JGR*, submitted. [8] Schulz, R. et al. (2010) *USGS Gazetteer of Planetary Nomenclature* [9] Pieters, et al. (2001) *JGR* **106,** E11, 28,001-28,022. [10] Isaacson et al. (2011) these volumes. [11] Pieters et al. (2011) these volumes.