CHARON'S SURFACE COMPOSITION J. C. Cook[1], S. Protopapa[2], D. P .Cruikshank[3], C. M. Dalle Ore[3,4], W. M. Grundy[5]. [1]Pinhead Institute, Telluride, CO., [2]Southwest Research Institute, Boulder, CO, [3]NASA Ames Research Center, Moffett Field, CA, [4]SETI Institute, Mountain View, CA, [5]Lowell Observatory, Flagstaff, AZ. (jasoncampbellcook@gmail.com)

Introduction: From its 1978 discovery [1] to the weeks prior to *New Horizons'* July 2015 encounter [2], our understanding of Charon's composition was limited. From 1985-1990, Pluto and Charon underwent a season of mutual events, one eclipsing the other, every few days as viewed from the Earth. Ground-based observations were able to obtain color and low-resolution near-infrared spectra that were composed of a few spectral points for each object. These data were sufficient to show that Charon's eclipsed hemisphere was distinctly bluer than Pluto and nearly neutral in color with respect to the Sun [3] and covered in H_2O-ice [4, 5]. [6] used Keck to obtain a more detailed spectrum of Charon that was separate from Pluto, when Pluto and Charon were at maximum angular separation ($\sim 0.9''$) and seeing was extremely favorable. These observations determined the H_2O-ice present on Charon was in the crystalline phase. They also found evidence for an absorption band at 2.21 μm which they suggested was $NH_3 \cdot H_2O$. Shortly after, [7] and [8] reported similar findings with *Hubble Space Telescope*/NICMOS spectra taken over multiple longitudes.

The detection of the absorption band at 2.21 μm and its identification as $NH_3 \cdot H_2O$ relied on two to four spectral points at low signal-to-noise. In order to examine the issue more thoroughly, [9] used the adaptive optics system on Gemini North to obtain spatially resolved spectra of Pluto and Charon. The higher spectral resolution and higher signal-to-noise data showed that the absorption at 2.21 μm was indeed real and it appeared on the anti- and sub-Pluto hemispheres of Charon. Observations by [10] showed the absorption band was present at other longitudes as well. [11] provided a comprehensive examination of the band position and depth with longitude using all known data up to that point.

Observations of Charon separated from Pluto from 2.5 to 4 μm were obtained using the NACO instrument at the 8.2-, Very Large Telescope. These data confirmed the presence of H_2O-ice on the surface of Charon and enabled the characterization of a continuum featureless absorber on its surface [12].

Observations: In this invited talk, we review the composition of Charon as determined by data from *New Horizons* obtained during its approach and encounter with the Pluto system on July 14, 2015. Using the Ralph [13] instrument, *New Horizons* successfully obtained images and spectra necessary to map the distribution of ices on the surface of Charon. Ralph is a dual channel instrument with MVIC (Multi-spectral Visible Imaging Camera), the visible color imager, and LEISA (Linear Etalon Imaging Spectral Array), the near-infrared spectrograph. LEISA covers the spectral range 1.25 to 2.50 μm at a resolving power ($\lambda/\Delta\lambda$) of 240, and 2.10 to 2.25 μm at a resolving power of 560. While *New Horizons* did obtain several scans across the disk of Charon while it was spatially resolved, only the highest spatial resolution observation of Charon has been published [14]. These data were obtained at a distance of $\sim$81,000 km and a spatial resolution of $\sim$5 km/pix. In order to provide a thorough review of Charon's surface composition, we will include analysis of data from the two prior scans taken on approach to the Pluto system. These observations were taken at distances of 136,000 and 483,000 km, and have spatial resolutions of 9 and 30 km/pix, respectively.

Results: In their examination of the highest spatial resolution data, [14] applied statistical clustering to identify spectrally distinct regions and radiative transfer models to interpret the variation in the 2.0 μm H_2O-ice band across Charon's surface. Using this, they map the distribution of H_2O-ice and NH_3 products. They concluded that H_2O-ice is largely found in the crystalline phase, with enhanced fractions of amorphous H_2O-ice in low-albedo regions. High albedo regions, particularly bright rays from craters, are characterized by larger H_2O-ice grains and are presumably younger than the surrounding terrain.

$NH_3 \cdot H_2O$ has at least two distinct bands within our spectral range. The strongest is centered near 2.21 μm, and a second, weaker band is centered near 1.99 μm. [15] examined lab spectra to show how these bands change for different concentrations of NH_3 in H_2O and temperatures. [14] found two behaviors of the 2.21 μm band on Charon. First, they found the 2.21 μm band is present in more terrain in the northern hemisphere than the other $NH_3 \cdot H_2O$ band. Second, they found both bands are present in bright crater rays, but not present in all craters. Since the 2.21 μm band is present on Nix and Hydra [16] with little evidence for the weaker band, [14] concluded that there are multiple forms of NH_3 products on Charon. One known NH_3 product that produces a band at 2.21 μm, but not one at 1.99 μm is NH_4Cl [17]. In their analysis of Pluto's small satellites, [16] suggested NH_4NO_3 and $(NH_4)_2CO_3$ may also explain the spectrum. While these two ammoniated salts have absorption near 2.21 μm, no information is available at wavelengths shorter than 2.05 μm to know whether or not the weak band is present in these

species, nor are these spectra obtained at Charon-like temperatures. More lab work is needed covering the 1.25-2.5 μm range and appropriate temperatures ($\sim$40-50 K) of these and other ammoniated species in order to best understand what is present on Chaorn, Nix and Hydra.

At the meeting, we will present the latest compositional maps of Charon. We will compare the findings of [14] to pixel-by-pixel Hapke modeling of Charon and discuss their differences and similarities. We will examine the distribution of crystalline and amorphous H_2O-ice and the 2.21 μm band in further detail.

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