A TOUR OF CARBONATE LITHOLOGIES IN HUYGENS BASIN, MARS. A. M. Zastrow[1] and T. D. Glotch[1], [1]Stony Brook University, Stony Brook, NY, USA, 11794 (allison.zastrow@stonybrook.edu)

Introduction: Huygens Basin is an ~450 km diameter basin just to the northwest of Hellas Basin that largely contains exposed Noachian-aged rocks (Figure 1). Analysis of multispectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) has identified olivine, high-Ca pyroxene, and low-Ca pyroxene units, as well as aqueously altered regions (largely identified as phyllosilicates) [1, 2]. Carbonates, specifically Fe/Ca carbonates (typically grouped together due to shared absorptions at 2.33 and 2.53 μm), have been detected using CRSIM hyperspectral data in various places throughout the basin [3], often appearing to have been exhumed by crater-forming events.

We have built a quantitative map of mineral abundances across Huygens, analyzing 21 different hyperspectral near-infrared CRISM images (half of which cover Prao crater in the northeast floor of the basin). Many, but not all, of these images contained positive or possible detections of carbonates by [3]. We use a radiative transfer-based atmospheric correction (as described in [4]) that allows for a more direct comparison between CRISM images regardless of differences in collection time of day/year, viewing geometries, and atmospheric conditions (to some interesting results in overlapping regions in Huygens). The standard CRISM I/F spectra are converted to single scattering albedo (SSA), allowing us to use a linear unmixing model to analyze the spectra.

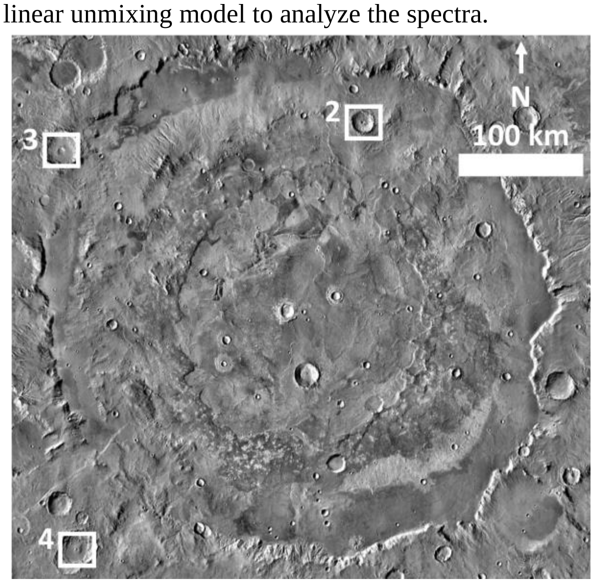

Figure 1. THEMIS Day IR image of Huygens Basin. CRISM images are largely located around the perimeter of the basin. The rest of the figures show close-ups of inside the craters with white boxes.

Mapping Results: Overall, carbonate abundance values in Huygens are not particularly high, compared to other regions such as in Jezero crater [5]. Average areal total carbonate abundances per image range from ~5-10% per pixel. Abundances are generally highest around craters, suggesting they may have been exhumed upon impact, but the carbonates are not always directly associated with a crater.

One of the advantages to using a spectral unmixing model to quantitatively analyze these images is the ability to discern between Fe- and Ca-carbonates. As such, our models indicate that the carbonates in Huygens are predominately Ca-bearing carbonates. There are only a couple of places where Fe-bearing carbonates appear in any significant abundance. [3] identified a broad spectral curvature from 1 to ~1.8 μm that would be consistent with Fe-bearing carbonate (among other minerals), but our modeling indicates that the spectral feature is largely not due to Fe-carbonates.

Prao crater. The highest total carbonate abundances are found inside Prao crater, an ~20 km diameter crater with a central pit on the northeast floor of the basin (Figure 2). These carbonates (up to ~15% per pixel) are particularly associated with a darker-toned, slightly raised, outcrop on the floor of the crater. Additionally, this is one of the two regions where Fe-bearing carbonates are identified by our model. Due to their geologic setting, we posit that these carbonates were formed in a post-impact, aqueous environment.

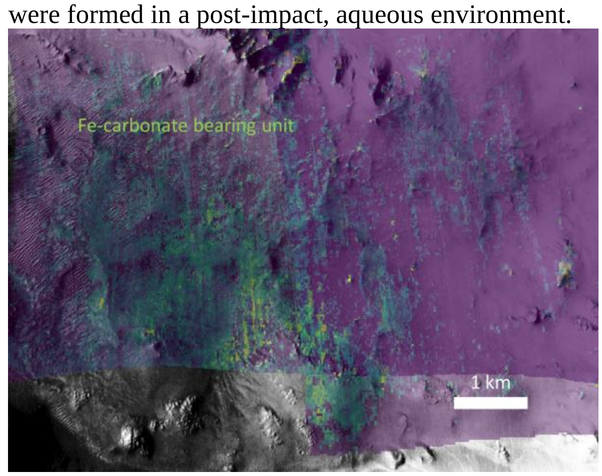

Figure 2. Inside view of Prao crater (CTX overlain by CRISM siderite abundance map). The dark-toned and slightly raised regions are higher in Fe-carbonate.

Lucaya crater. [3] identified the carbonates inside this central-pit crater (found superimposed on the northwest rim of Huygens) as having the most diagnostic carbonate signature in the basin. Our modeling only finds abundances up to ~10%; however, these carbonates are the most strongly associated with a geologic landform of all the carbonates in Huygens. Unlike in Prao, these solely Ca-carbonates are associated with a light-toned, somewhat blocky unit found along the central pit of the crater (Figure 3). In addition to carbonate, this feature also contains high abundances of phyllosilicates (up to ~70%), moderate abundances of feldspar (up to ~30%), and lower, but significant, abundances of ferrihydrite (up to ~7%). Unlike the majority of the carbonates in Huygens, it seems likely that these carbonates formed in an environment post-impact as opposed to being exhumed by Lucaya's forming event.

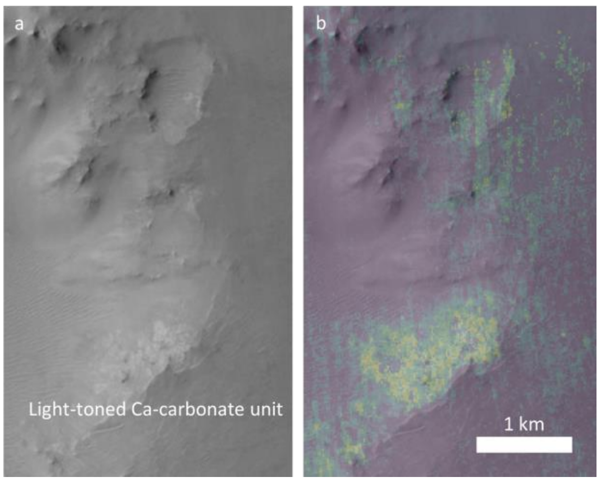

Figure 3. Close-up view of Lucaya crater's central pit. a) CTX alone and b) overlain by the carbonate abundance map. Abundance map goes from 0 to 15% area per pixel.

The effect of dust in spectral modeling. Overall, our modeling finds some high dust abundances (generally ranging from ~60-80% per pixel). These high abundances can have a few effects on our modeling results. If an area has more dust covering the ground, it can artificially lower the derived abundances (of all minerals) that we see from orbital imagery. High surface dust abundances may also potentially obscure a mineral from being modeled all. We can see the effects of variable dust in an unnamed crater just outside the rim to the southwest of the basin.

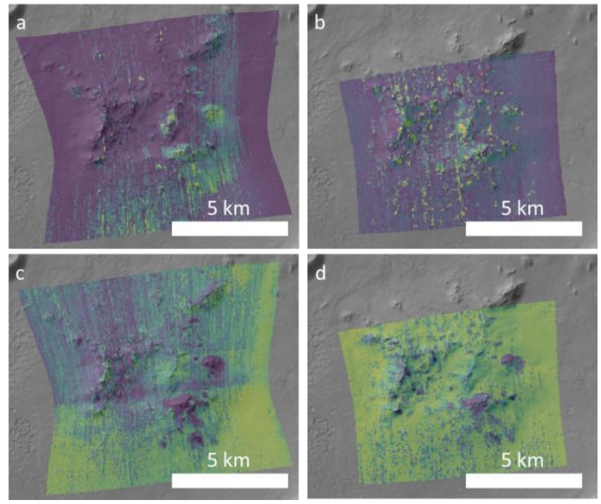

Figure 4. Unnamed crater southwest of Huygens basin. a) FRT1FD79 carbonate abundance map, b) HRS19650 carbonate abundance map, c) FRT1FD79 dust abundance map, and d) HRS19650 dust abundance map. Carbonate abundance maps go from 0 to 10% area per pixel, dust abundance maps go from 0 to 100% area per pixel.

The crater (Figure 4) has a central pit and has clearly been filled since its formation. We analyzed two CRISM images covering the crater's pit. The two images were taken at opposite times of the year and display similar carbonate abundance values, but the locations of those carbonates differ. Based on the dust abundance maps, we see these are semi-correlated to where carbonate does and does not appear in the images.

Conclusions: Carbonates in Huygens Basin likely appear in one of two ways: either revealed by exhumation in crater-forming events or formed at the surface post-impact in likely aqueous environments. Further spectral analysis will hopefully help tease out the differences between these two carbonate occurrences.

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References: [1] Ackiss S. E. et al. (2014) *8th Mars*, Abstract #1038. [2] Seelos K. D. et al. (2010) *LPSC XLI*, Abstract # 2400. [3] Wray J. J. et al. (2015) *JGR Planets, 121:4*, 652-677. [4] Liu Y. et al. (2016) *JGR Planets, 121:10*, 2004-2036. [5] Zastrow A. M. and Glotch T. D. (2020), *GRL*, in review.