

## Pluto dark refractory material: a close look at composition and origin

**Cristina M. Dalle Ore** (1,2), Dale P. Cruikshank (2), Silvia Protopapa (3), Will M. Grundy (4), Kim Ennico (2), Cathy B. Olkin (3), S. Alan Stern (3), Hal A. Weaver (5), Leslie A. Young (3), and the New Horizons Composition Team

(1) SETI Institute, Mountain View, CA; (2) NASA Ames, Moffett Field, CA, (cmdalleore@gmail.com); (3) Southwest Research Institute, Boulder, CO; (4) Lowell Observatory, Flagstaff, AZ, (5) Johns Hopkins University Applied Physics Laboratory, Laurel, MD.

### Abstract

We examine a few regions of interest (ROIs) from the high spatial resolution scan obtained with the Linear Etalon Imaging Spectral Array (LEISA) during the July 2015 New Horizons Pluto flyby. We focus on the dark material that distinguishes the equatorial region known as Cthulhu and compare and contrast its signature as the H<sub>2</sub>O component varies in either abundance or grain size. Our goal is to trace the origin of the material and constrain its mechanisms of formation.

### 1. Introduction

The variety of terrains on Pluto surface has provided us with an opportunity to investigate a bounty of data on processes and conditions that before the New Horizons flyby where unsuspected [1]. One particular region has attracted a lot of attention, Cthulhu, with its dark coloration and location on the equatorial belt, which on the encounter hemisphere, is interrupted only by the bright and icy Sputnik Planitia. Cthulhu is otherwise a region deprived of volatile ices, with the possible exception of protected valleys and mountain peaks showing presence of CH<sub>4</sub> ice [2], [3]. However, careful analysis of the spectral signature of selected regions shows presence of H<sub>2</sub>O ice, the main component of the bedrock layer that lies under the volatile ices [2]. It is in some of these regions that ammonia and its products have been detected [4]. The presence of ammoniated product in H<sub>2</sub>O prompted an investigation that led to the uncovering of evidence of cryovolcanism [5]. We present results of further analysis of these areas, stripped of volatile ices and composed mainly of dark material and H<sub>2</sub>O laced with ammoniated products.

### 2. Data Analysis

The goal of our study has been to extract the purest possible signature of the dark constituent(s) covering Cthulhu making use of data from LEISA (Linear Etalon Imaging Spectral Array) and corresponding MVIC (Multi-spectral Visible Imaging Camera) [6]. We have analyzed several Regions of Interest (ROIs) spread over the strip (P\_LEISA\_HIRES) covered at the highest spatial resolution of 2.7 km/px by New Horizons during the July 2015 flyby, from a mean range of 45,000 km and with a mean phase angle of 33°.

Making use of a ‘recursive’ clustering technique we have isolated those pixels that are not contaminated by CH<sub>4</sub> but still show the presence of H<sub>2</sub>O in varied amounts.

We compare the spectral signature of those CH<sub>4</sub> free pixels across areas of the strip that have different amounts of H<sub>2</sub>O contamination in an effort to study the behavior of the dark material and its constituents as well as the presence of ammoniated products present in the H<sub>2</sub>O.

### 3. Preliminary results

The very first region to be investigated was the trough running west from Elliott Crater known as Virgil Fossae. It was studying this region that we uncovered evidence of ammoniated products laced into the H<sub>2</sub>O spectral signature [4].

Using the same approach we then investigated a few other ROIs, deemed geographically interesting because of their location with respect to areas where H<sub>2</sub>O had been previously detected. Figure 1 shows

the geographical distribution of pixels with different degrees of  $\text{H}_2\text{O}$  and ammoniated products contamination in the region north of Virgil Fossae, near Inanna Fossae. The blue pixels are those with the largest amount of  $\text{H}_2\text{O}$  as shown in Figure 2 where the average spectra corresponding to each cluster are shown. The blue trace shows the deepest bands at 1.5 and 2.0  $\mu\text{m}$  an indication of  $\text{H}_2\text{O}$  being present in this area. The spectra in color are germane to the different pixels in the map shown in Figure 2, the grey trace instead belongs to the cluster average of the pixels falling on Virgil Fossae.

We will compare and contrast the signature of a few ROIs across Cthulhu, and we will present the results and preliminary interpretation with the ultimate goal of tracing the origin and evolution of the material(s).

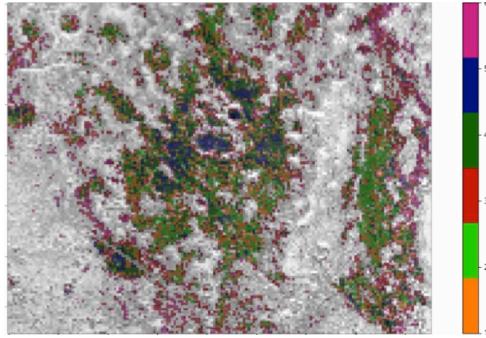


Figure 1: Map of part of Inanna Fossae, north east of Virgil Fossae showing regions with different amounts of  $\text{H}_2\text{O}$  laced with ammoniated products.

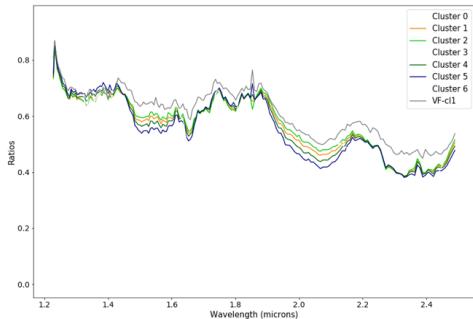


Figure 2: Spectral averages corresponding to the different clusters shown in Figure 1. Cluster 5 appears the most  $\text{H}_2\text{O}$  rich based on the depth of the 1.5 and 2.0  $\mu\text{m}$  bands. The grey trace belongs to the

spectral average of pixels located on and near Virgil Fossae.

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