PLUTO'S SPUTNIK PLANITIA: SPECTRAL VERSUS GEOLOGICAL SIGNATURE. F. Scipioni[1], O. White[1,2], C.M. Dalle Ore[1,2], D.P. Cruikshank[1], W.M. Grundy[3], R.P. Binzel[4], M.W. Buie[5], J.C. Cook[6], A.M. Earle[4], K. Ennico[1], D.E. Jennings[7], C.J.A. Howett[5], I.E. Linscott[8], A.W. Lunsford[7], J.M. Moore[1], W.B. McKinnon[9], C.B. Olkin[5], A.H. Parker[5], S. Protopapa[10], D.C. Reuter[7], B. Schmitt[11], K.N. Singer[5], J.R. Spencer[5], S.A. Stern[5], H.A. Weaver[6], A.J. Verbiscer[12], L.A. Young[5], and the New Horizons GGI team. [1]NASA Ames Research Center; Moffett Field, CA, 94035 (francesa.scipioni@nasa.gov); [2]SETI Institute, Mountain View, CA; [3]Lowell Observatory, Flagstaff AZ; [4]Massachusetts Institute of Technology, Cambridge MA; [5]Southwest Research Institute, Boulder, CO; [6]Pinhead Institute, Telluride, CO; [7]NASA Goddard Space Flight Center, Greenbelt MD; [8]Stanford University, Stanford CA; [9]Washington University in St. Louis, St. Louis MO; [10]University of Maryland, College Park MD; [11]Université Grenoble Alpes, CNRS, Grenoble, France; [12]University of Virginia, Charlottesville, VA.

Introduction: In 2015 the New Horizons spacecraft encountered Pluto to unveil an icy world with a rich and complex geological history [1,2,3]. The surface of Pluto exhibits several terrain types, the most conspicuous being Sputnik Planitia* (SP). The north and central part of SP is 3-4 km depressed with respect to the surrounding mountains and has a cellular pattern [1,2]. The origin of the cells likely originated from solid-state convection of N_2-ice [4], the primary surface constituent of SP. In the southern part of SP, the cells disappear, and the terrain consists of featureless plains [1,2].

A geological map of Sputnik Planitia has been produced [3] by analyzing New Horizons LOng-Range Reconnaissance Imager (LORRI) [5] observations. The map identifies 15 geological units, plus the undifferentiated Pre-Sputnik Planitia Uplands (*psu*) (Figure 1). The geological units were defined primarily by the texture and albedo that they present at the 386 m/pixel scale of the base map used for classification.

In this work, we consider observations of Sputnik Planitia by New Horizons' near-infrared imaging spectrometer, LEISA [6], and we investigate whether the geological units identified by [3] are defined not only by their geomorphology, but also spectroscopically. The results shown here are still preliminary.

Methodology: From three high spatial resolution (ranging between ~ 6 and ~ 9 km/pixel) LEISA spectral image cubes we produced a mosaic using the Integrated Software for Imagers and Spectrometers (ISIS) routines. We then selected regions of interest on the mosaic corresponding to the Sputnik Planitia geological units identified in [3].

We consider 13 units, excluding the Impact Crater (*ic*), and the Bright, Pitted Uplands (*bpu*) units because they are exterior to SP. The units selected for the analysis are: Bright, Cellular Plains (*bcp*); Dark, Cellular Plains (*dcp*); Dark, Trough-Bounding Plains (*tbp*); Sparsely Pitted Plains (*spp*); Deeply Pitted Plains (*dpp*); Lightly Pitted Plains (*lpp*); Patchy, Pitted, Marginal Plains (*pmp*); Dark-Pitted, Marginal Plains (*dmp*); Chaotic, Angular, Blocky Mountains (*abm*); Chaotic, Inter-Block Material (*ibm*); Scattered Hills (*sh*); Dark, Ridged Terrain (*drt*); Bright, Chaotic Terrain (*bct*). See Table 1 in [3] for a detailed description of the units.

We extract the average spectrum for each of the thirteen units, shown in Figure 2. The spectra are not normalized, or offset. The analysis shown here is qualitative, because the work is preliminary, and not complete. LEISA data were calibrated using

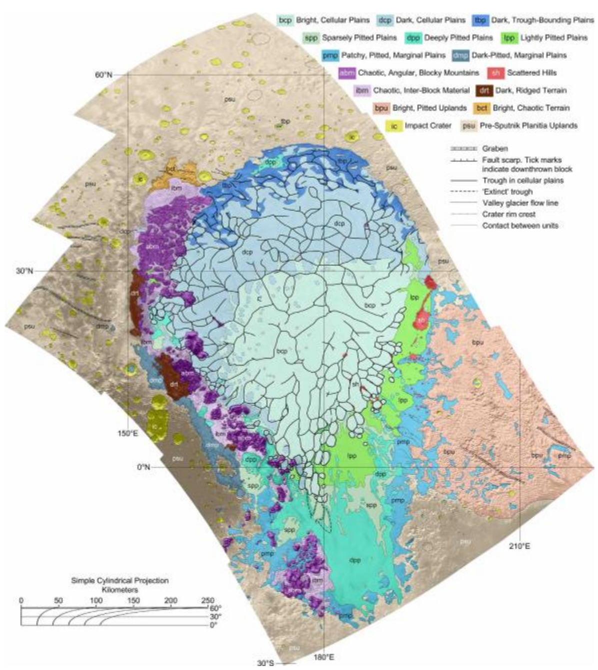

Figure 1: Distribution of geological units on Pluto's Sputnik Planitia [3].

Results: In the region covered by LEISA's low-spectral-resolution segment (1.25-2.5 μm) [6], Sputnik Planitia's spectrum is dominated, on average, by CH_4, N_2, and CO absorptions [7]. CH_4 has four series of broad absorptions in the region between 1.30–1.43 μm, 1.59–1.83 μm, 1.90–2.00 μm, and 2.09–2.48 μm [8]. CO and N_2 absorption bands are centered at 1.58 and

* Some feature names mentioned in this paper are now formalized while others are informal

2.15 μm, respectively. Figure 2 highlights the positions of all the dominant CH_4, N_2 and CO absorptions. All of the geological units we considered show CH_4, N_2, and CO spectral features, although they differ in spectral absorption band depth and slopes.

The unit with the flattest continuum slope is the Bright, Chaotic Terrain (*bct*), which refers to a small portion of terrain located north of al-Idrisi Montes. This mountain range consists of units *ibm* and *abm*, the blocky, mountainous units that extend along the eastern border of Sputnik Planitia and are separated from Cthulhu Macula by the Dark, Ridged Terrain (*drt*) and Dark-Pitted, Marginal Plains (*dmp*) units (Figure 1). Unit *drt* has significantly suppressed CH_4 and N_2 absorption bands, while the CO feature is not present. Absorption features become gradually deeper, and the albedo increases outward from the center of Sputnik Planitia, passing from unit *ibm,* to *abm*, and to *dmp*.

The cellular plains of Sputnik Planitia are split between three units: the northern margin of Sputnik Planitia is occupied by unit Dark, Trough-Bounding Plains (*tbp*); to the south extends unit Dark, Cellular Plains (*dcp*); and the center of Sputnik Planitia contains unit Bright, Cellular Plains (*bcp*). Units *tbp* and *dcp* are spectrally very similar, while *bcp* has slightly shallower CH_4 and N_2, but deeper CO absorption bands.

The average spectrum of the *bcp* unit is remarkably similar to that of the Sparsely Pitted Plains (*spp*), even though the two units occupy portions of Sputnik Planitia that are not adjacent but are separated by the pitted plains units *lpp* and *dpp*.

The same similarity is also shared by units *dmp*, *lpp* and *sh*. The *lpp* and *sh* units occur along the eastern margin of SP, while *dmp* occurs along its western edge.

The similar spectral characteristics of different geological units may be due in some cases to a relatively thin veneer of seasonal or super-seasonal ice.

Discussion: The preliminary analysis of the spectral characteristics of Sputnik Planitia shows that not all mapped geological units exhibit distinct geological and spectral characteristics. Terrains that appear to have different geological ages and evolutionary histories, often spatially separated, show spectra that are strikingly similar, if not almost the same.

References: [1] Stern, S. A. et al. (2015), *Science 350*, aad1815. [2] Moore, J. M. et al. (2016), *Science 351*, 1284-1293. [3] White, O. et al. (2017), *Icarus, 287,* 261-286. [4] McKinnon et al. (2016) Nature, *534*, 82-85 [5] Cheng, A. F. et al. (2008), *Space Sci. Rev. 140,* 189–215. [6] Reuter et al. (2008), *Space Sci. Rev. 140*, 129–154. [7] Grundy W., et al. (2016), *Science, 351*, 1283. [8] Schmitt, B. et al. (2017), *Icarus, 287*, 229–260.

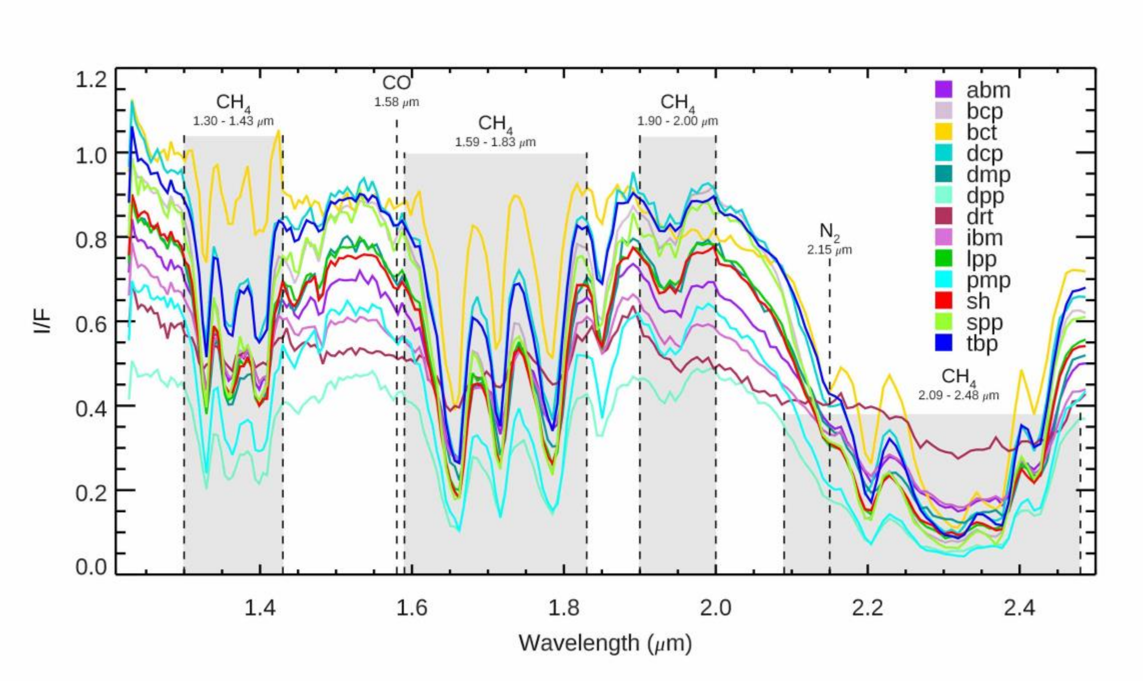

Figure 2: Average spectra for thirteen of the fifteen geological units identified by [3]. Shaded regions and dashed lines show the positions of the main CH_4, N_2 and CO absorption features.