CRATERS ON PLUTO AND CHARON – SURFACE AGES AND IMPACTOR POPULATIONS. K. N. Singer[1], W. B. McKinnon[2], S. J. Robbins[1], P. M. Schenk[3], S. Greenstreet[4], B. Gladman[5], A. H. Parker[1], S. A. Stern[1], V. J. Bray[6], H. A. Weaver[7], R. A. Beyer[8], L. A. Young[1], J. R. Spencer[1], J. M. Moore[8], C. B. Olkin[1], K. Ennico[8], R. P. Binzel[9], W. M. Grundy[10], The New Horizons Geology, Geophysics and Imaging Science Theme Team, The New Horizons Surface Composition Science Theme Team, The New Horizons MVIC and LORRI Teams. [1]Southwest Research Inst., Boulder, CO (ksinger@boulder.swri.edu), [2]Washington U. in St. Louis, [3]Lunar and Planetary Inst., [4]LCOGT, [5]U. British Columbia, [6]U. Arizona, [7]JHU Appl. Phys. Lab, [8]NASA Ames, [9]MIT, [10]Lowell Observatory.

Overview: The craters observed during the New Horizons flyby of the Pluto system currently provide the most extensive empirical constraints on the size-frequency distribution of smaller impactors in the outer solar system. These craters also help us understand the surface ages and geologic evolution of the Pluto system bodies. Pluto's terrains display a diversity of crater retention ages, indicating ongoing geologic activity and various styles of resurfacing (both exogenic and endogenic). Charon's informally named Vulcan Planum did experience resurfacing, but crater densities suggest this is also a relatively ancient surface. We do not observe large numbers of small craters despite adequate resolution to do so; thus the Pluto system craters are inconsistent with Kuiper belt and solar system evolution models producing large numbers of small impactors.

Image dataset: Creation of a consensus crater catalog from both the LORRI (LOng Range Reconnaissance Imager) and Ralph/MVIC (Multispectral Visual Imaging Camera) data is underway [1]. Here we present results from the initial mapping of the two LORRI mosaics covering Pluto and Charon at a more-or-less consistent resolution across their encounter hemispheres (~900 m px^{-1}). All feature names in this abstract are informal.

Crater Populations and Surface Ages:

Pluto. Sputnik Planum displays no obvious craters, in either the ~320 m px^{-1} MVIC mosaic covering the entirety of the feature, or the higher resolution strips crossing it (down to 80 m px^{-1}). This implies a surface model age of less than 10 Ma, and likely much younger; viscous relaxation would proceed quickly in N_2 ice even at Pluto temperatures [2], and much of the planum is likely convecting [2-3]. Examples of intermediate-age terrains include the eastern part of Pluto's "heart", east Tombaugh Regio (see Fig. 1 for R-plot compared to model ages), and the putative cryovolcanic construct Wright Mons, which only displays one possible crater (see additional discussion in [4]). East Tombaugh Reggio is likely resurfaced by an ongoing combination of volatile sublimation and deposition, while Wright Mons appears to be constructed of younger crust.

Cthulhu, and the mid- and northern latitudes to the north and west of Sputnik Planum [4,6], are relatively

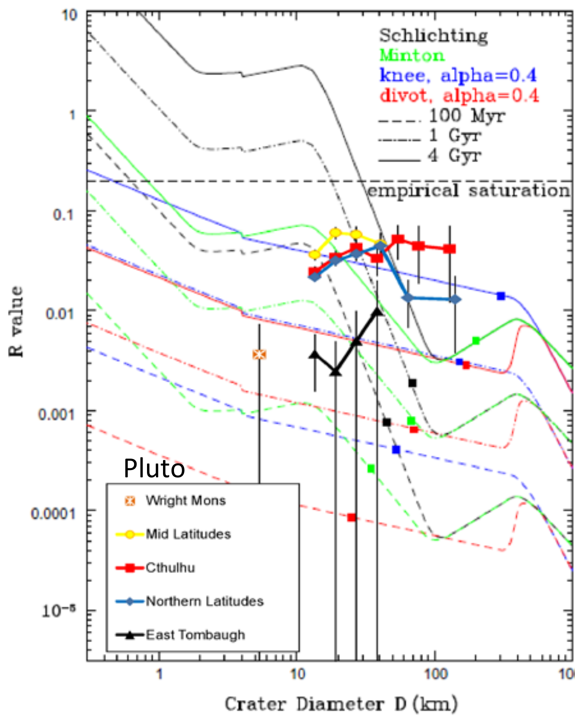

Figure 1. R-plot of mapped regional Pluto crater populations compared with crater density predictions from four model impactor fluxes, and for three surface ages [8].

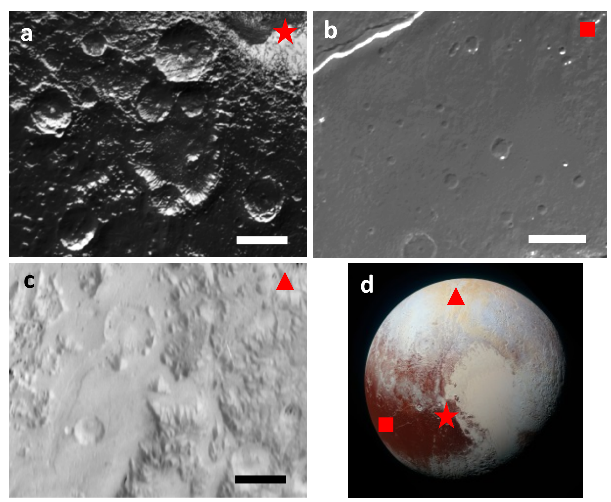

Figure 2. a) The only region on Pluto appearing ~saturated with craters, b) relatively smooth, lightly-cratered region in the informally named Cthulhu, c) partially buried craters in the north polar mantled terrains, and d) location of insets a-c. All scale bars are 40 km, and images are ~300 m px^{-1}.

highly cratered over all, yielding ages of ~4 Ga. The active geology on Pluto has left pockets of higher and lower crater density even across these older regions. One region on the eastern edge of Cthulhu appears quite heavily cratered (Fig. 2a), but Cthulhu also contains relatively smooth, lightly cratered areas (Fig. 2b). The northern plains are also variably cratered. The smooth surfaces of partially-filled craters near the North Pole (Fig. 2c) attest to burial by atmospheric transport and deposition or potentially cryovolcanic or glacial flow, later mantled. There are no obvious secondary craters on Pluto.

Charon. Charon's northern and southern regions are divided by a large extensional tectonic belt [7], and all regions appear relatively old (~4 Ga or older; Fig. 3a) based on crater statistics. The lighting and viewing geometry of the northern cratered plains precludes confident identification of smaller craters. Here we report on craters with D > 50 km for the north. The smoother surface of Vulcan Planum and the enigmatic ropy/wrinkly features found at several scales suggest past cryovolcanic resurfacing. Vulcan Planum contains less large craters than the North, but a high crater density overall, indicating the resurfacing occurred early in Charon's history. Smaller craters (D < 10 km) are noticeably scarce relative to their larger counterparts (Fig. 3b). The tectonic belt is also overprinted by many craters, but a few examples of craters likely cut by faults can be found. Charon displays some possible secondary crater features, but none on Vulcan Planum.

Implications for Outer Solar System Impactor Populations: Observational limitations and active geology make seeing a true production function on Pluto difficult, but we can still put constraints on the impactor flux (post-dating any LHB-like events if they occurred in the outer Solar System).

We compared the initial crater size-frequency distributions (SFD) from Pluto and Charon to a variety of impactor flux models. Preliminary analysis indicates the shape of the crater distributions best matches a broken power-law size distribution expressed as the "knee" model in Greenstreet et al. [8]. This model uses observational constraints to set the SFD slope for Kuiper belt objects larger than ~100 km, and bends to a shallower slope below that size [e.g., 9-10]. The shape of the Pluto and Charon SFDs are inconsistent with estimates based on some solar system accretion models [11], or those derived from saturnian satellites [12]. Other published models [13-14] provide a good match in terms of crater densities (for an ~4 Ga surface), but have slightly different slopes that fit the data less well at the large or small crater sizes.

It is notable, given the paucity of small craters, that the Pluto and Charon data are more consistent with scenarios of solar system formation where planetesimals grow rapidly to ~100-km-size and experience less collisional erosion, leaving behind fewer small impactors [e.g., 15-16, 2].

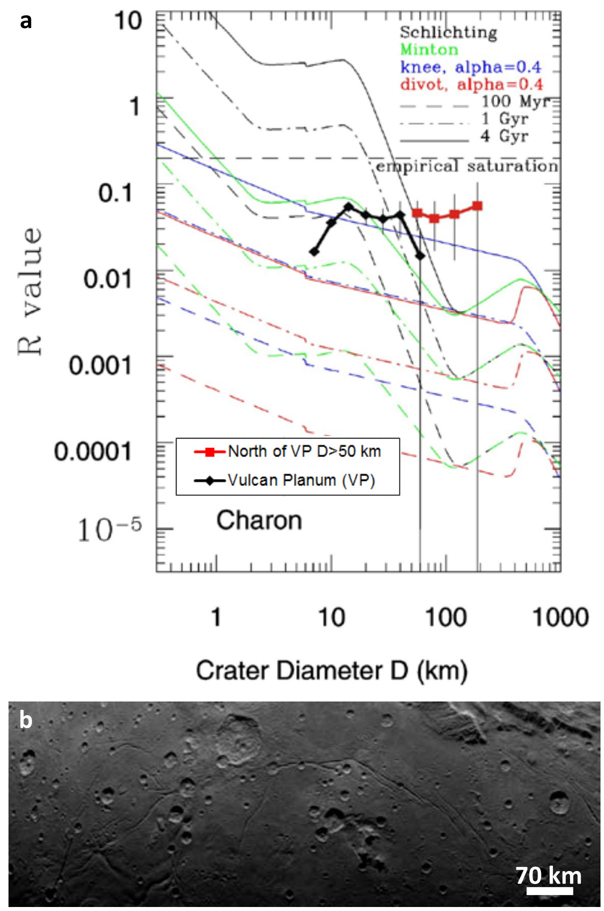

Figure 3. a) R-plot of mapped regions on Charon, compared with crater density predictions from four model impactor fluxes, and for three surfaces ages [8], b) View of Charon's Vulcan Planum at ~630 m px^{-1}.

References:
[1] Robbins S.J. et al. (2016) this conference #1756. [2] Stern S.A. et al. (2015a) *Icarus* 250, 287-293. [3] Stern S.A. et al. (2015b) *Science* 350, 6258. [4] Singer K.N. et al. (2016) this conference #2276. [5] Moore J.M. et al. (2016) *Science*, submitted. [6] Spencer J.R. et al. (2016) this conference, #2440. [7] Beyer R.A. et al. (2016) this conference. [8] Greenstreet S. et al. (2015) *Icarus* 258**,** 267-288. (erratum available on www.phas.ubc.ca/~sarahg) [9] Bernstein G.M. et al. (2004) *AJ* 128, 1364–1390. [10] Fraser W.C. et al. (2014) *AJ* 782, 100. [11] Schlichting et al. (2013) *AJ* 146**,** 36. [12] Minton D.A. et al. (2012) *ACM abs* #6348. [13] Zahnle K. et al. (2003) *Icarus* 163, 263-289. [14] Bierhaus E.B. and Dones L. (2015) *Icarus* 246, 165-182. [15] Chiang E. and Youdin A. (2010) *AREP* 38, 493. [16] Nesvorný D. et al. (2010) *AJ* 140, 785–793.