THE GEOLOGY OF PLUTO AND CHARON REVEALED BY NEW HORIZONS.

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Introduction: The New Horizons spacecraft flew past the Pluto system on July 14th 2015, and provided our first view of the geology of Pluto and Charon by obtaining hundreds of images, including extensive stereo, with hemispheric coverage at best resolution 0.47 km/pixel and regional coverage at resolutions down to 80 meters/pixel on Pluto (Fig. 1). The best imaging covered the anti-Charon hemisphere of Pluto and the Pluto-facing hemisphere of Charon, but global context was provided by approach imaging of all longitudes at resolutions of 20 km/pixel or better. Regions south of 38° S were in permanent darkness, though illumination by Pluto's haze extended useful imaging several 100 km into the dark regions on the encounter hemisphere. Almost all high-resolution imaging has now been returned to Earth. Preliminary geological results are published [1] or in review [2], and additional details are provided in many other abstracts by the New Horizons team at this conference, including #s 1089, 1636, 2276, 2310, and 2479.

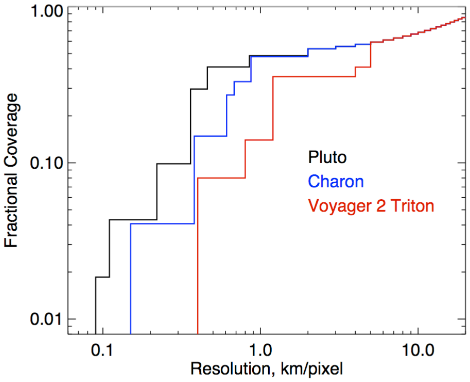

Figure 1 *Resolution and approximate fractional global coverage of New Horizons imaging of Pluto and Charon, compared to Voyager 2 imaging of Triton*

Pluto: Pluto shows astonishing geological variety (Fig. 2). Much of its surface is ancient and relatively heavily cratered (Fig. 2A), with craters up to 250 km in diameter and one possible 900 km impact basin (below). However most of the cratered terrains have been heavily modified. Mantles up to a few km thick partially cover much of the northern hemisphere, and are bounded by complex scarps. Craters and mantles are locally heavily eroded by processes that form fluted slopes and interconnected, sometimes dendritic, valleys (Fig. 2B). The nature of the mantling and erosion is mysterious, particularly given Pluto's current low atmospheric pressure of ~10 μbars which limits the effectiveness of aeolian erosion and sediment transport: perhaps glacial or sub-glacial processes are involved. The mantles are unlikely to be primarily composed of N_2 condensed from the atmosphere, which could not support the observed topography [3]. Tectonism on the encounter hemisphere is limited to sparsely distributed extensional graben.

The encounter hemisphere is dominated by a 3 – 4 km deep basin of possible impact origin, containing an ~900-km diameter plain of smooth bright material, Sputnik Planum (SP) (all feature names here are informal). The surface of SP (Fig. 2C) has no detectable impact craters and is thus extremely young, probably < 10 Ma old [2, 4]. The northern two-thirds of SP is dominated by a network of polygons resembling convection cells, and shows obvious flow features along its margins, while the southern part is punctuated by vast swarms of aligned km-scale pits. We interpret SP to be a deep, convecting, deposit of low-viscosity volatile ices, probably dominated by N_2 (consistent with its surface composition [5]), that has accumulated within the basin.

On the western margin of SP is an intermittent chain of rugged mountains composed of jumbled blocks up to 5 km high (Fig. 2C), which in many places resemble Europan chaos and appear to have formed by disruption and transport of pre-existing crust, perhaps due to undermining by volatile ices from SP. The height and steepness of the mountains, and their NIR spectra [5] imply a water ice composition. Elsewhere, SP is surrounded by even more baffling features. These include a 3 – 4 km high possible cryovolcano (Wright Mons, Fig. 2D), elongated hills covered in aligned 300-m high blade-like features (Tartarus Dorsa), and extensive pitted terrain cut by what appear to be active glaciers flowing into SP.

Charon: Charon is also geologically varied, though all terrains are heavily cratered and most appear to be roughly 4 Ga old. The northern portion of the encounter hemisphere is extremely rugged (Fig. 2E), with craters up to 240 km in diameter and a polygonal network of broad troughs up to 10 km deep. A series of parallel graben and tilted blocks separate the northern terrain from much smoother plains to the south (Fig 2F). Convex marginal scarps, 1 – 2 km high, some of which form moats around isolated mountains, suggest that the material that surfaced the plains was a viscous fluid, perhaps an ammonia/water mixture. Many young craters show conspicuous light and dark rays, suggesting subsurface inhomogeneities.

Implications: Despite extensive recent activity around SP, much of the Pluto's surface is ancient, having undergone only surficial modification over the past 4 Ga. This is in striking contrast to Triton where ongoing activity appears to have erased large craters globally [6]. Triton's much younger mean surface age suggests that its activity is powered by additional heat sources not available to Pluto, probably heating by obliquity tides [7]. Pluto's radiogenic and residual primordial heat is nevertheless able to maintain recent and ongoing activity in SP and its environs, perhaps due to the lower heat flow necessary to mobilize N_2 and other volatile ices compared to water ice. The age and nature of Charon's activity is comparable to that of similar-sized giant planet moons such as Ariel [8], and likely postdates any likely tidal heating from post-giant-impact orbital evolution [9]. This suggests that tidal heating may not be necessary to produce similar ancient activity seen on many icy moons.

References:

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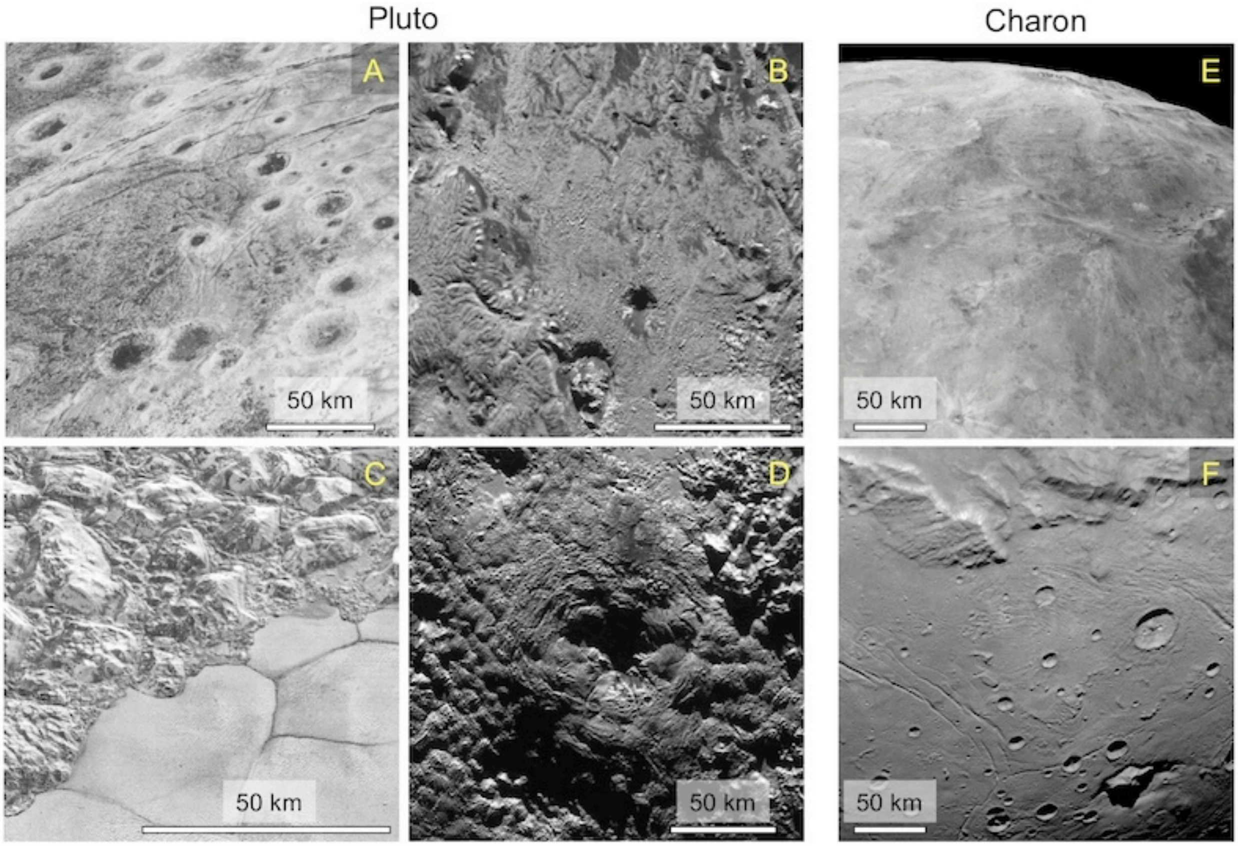

Figure 2 *Sample terrain types on Pluto and Charon. A: Ancient cratered terrain on Pluto, cut by graben (95 E, 40 N). B: Eroded channelled terrain (160 E, 20 S). C: Chaotic mountains (al-Idrisi Montes), bordering the apparent convection cells of north-west Sputnik Planum (160 E, 40 N). D: Wright Mons, a possible cryovolcano with concentric textures surrounding a large central depression (170 E, 20 S). E: Rugged highlands on Charon, with deep troughs, ridges, and ray craters. F: Smooth plains (Vulcan Planum) on Charon, with complex surface textures and convex margins surrounding isolated mountains, bordered by graben and tilted blocks (top).*