

Tectonics of Charon Ross A. Beyer^{1,2}, Francis Nimmo³, William B. McKinnon⁴, Jeffrey Moore², Paul Schenk⁵, Kelsi Singer⁶, John R. Spencer⁶, Hal Weaver⁷, Leslie Young⁶, Kimberly Ennico², Cathy Olkin⁶, Alan Stern⁶, and the New Horizons Science Team. ¹Carl Sagan Center at the SETI Institute, ²NASA Ames Research Center, Moffett Field, CA, USA (Ross.A.Beyer@nasa.gov), ³UCSC, ⁴WUSTL, ⁵LPI, ⁶SwRI, ⁷JHU APL

Charon, Pluto's large companion, has a variety of terrains that exhibit tectonic features. The Pluto-facing hemisphere that New Horizons [1] observed at high resolution has two broad provinces: the relatively smooth plains of the informally named (as are all names in this abstract) Vulcan Planum to the south of the encounter hemisphere, and the zone north of Vulcan Planum. This area is characterized by ridges, graben, and scarps, which are signs of extensional tectonism. The border between these two provinces strikes diagonally across the encounter hemisphere from as far south as -19° latitude in the west to 25° in the east (Figure 1).

The lower-resolution views of the non-encounter hemisphere are also suggestive of other potential large ridges and troughs, indicating that the tectonic expressions we see so well on the encounter hemisphere likely extend around Charon.

Relief exceeding 10 km is seen in limb profiles and stereo topography, presumably the result of the bearing strength of cold water ice and Charon's modest gravity

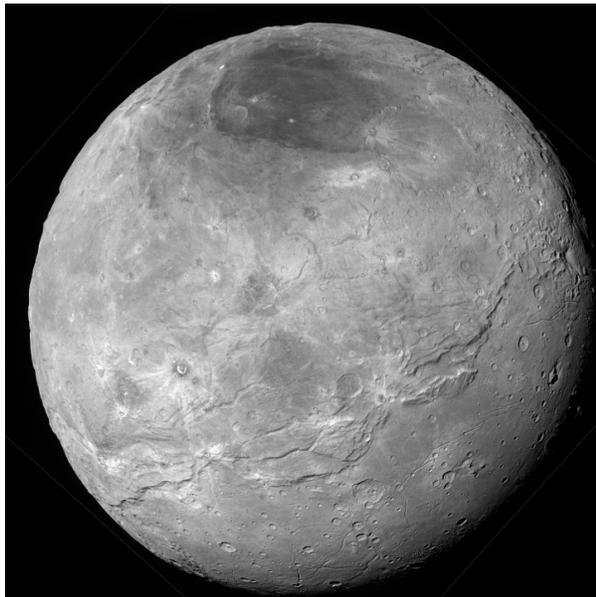


Figure 1: C_LORRI_FULLFRAME observation of Charon showing the smooth southern plains and the tectonized zone north of that, which continues northward as expressed by the irregular northern limb.

(0.288 m s^{-2}). Charon's tectonic terrain is exceptionally rugged and contains a network of fault-bounded troughs and scarps in the equatorial to middle latitudes. This transitions northward and over the pole to the visible limb into an irregular zone where the fault traces are neither so parallel nor so obvious, but which contains irregular depressions (one as deep as 10 km just outside of Mordor Macula) and other large relief variations.

Chasmata: There are a number of chasmata that generally parallel the strike of the northern margin of Vulcan Planum, and we will discuss the largest two here as they have slightly different characters.

Mandjet Chasma (Figure 2) is at least 450 km long and typically 30 km across. It was not identified early on because it does not have a sharp topographic rim, but a gentle slope as its walls transition from the surrounding plains and then plunge 7 km to its floor.

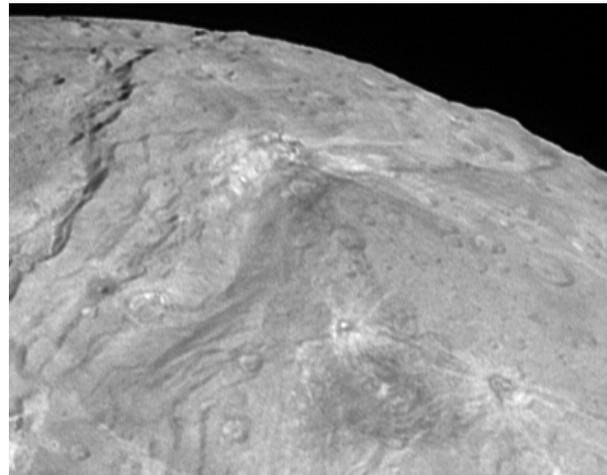


Figure 2: Perspective view of Mandjet Chasma looking westward to the limb, North is to the lower right. Mandjet starts in the lower left of the frame and extends to the limb in the upper right. The scarp along the left side of the frame south of Mandjet bounds Vulcan Planum.

Serenity Chasma (Figure 3) is 40 to 50 km wide rim-to-rim and is almost 200 km long, with a maximum relief upwards of 5 km. At its eastern end where the southern rim terminates against the Vulcan Planum boundary, its northern rim continues another 200 km east as a south-facing scarp and becomes segmented by fault ramps. We

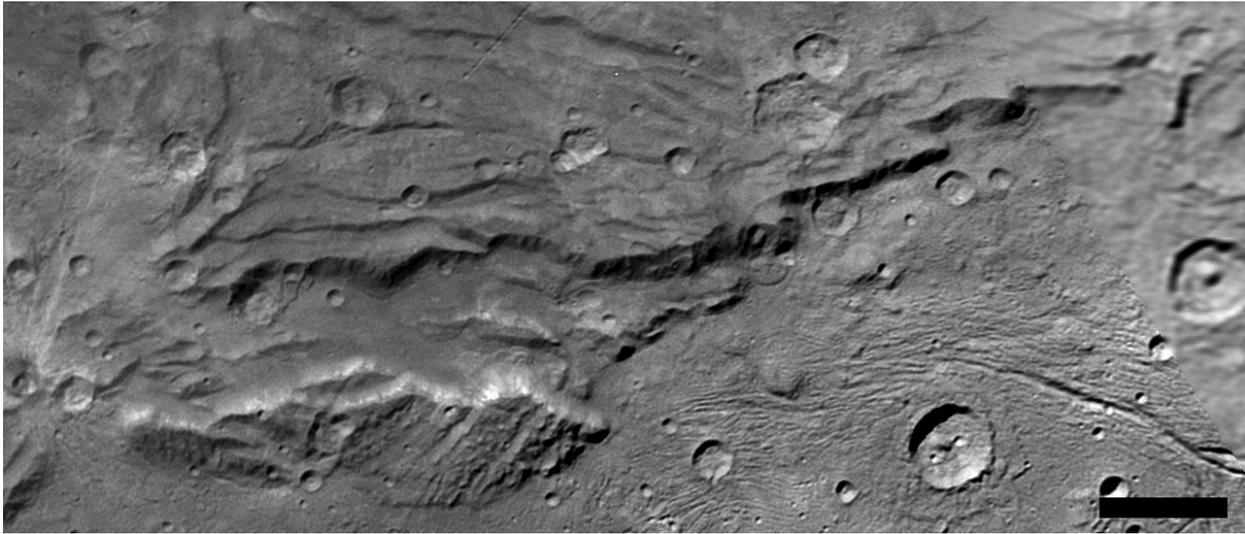


Figure 3: Serenity Chasma. Scale bar is 50 km.

measured topographic profiles across the classic rift valley shape of Serenity and used them to estimate the elastic thickness of the lithosphere at 1.5 to 5 km. This, in turn can be used to estimate the heat flux. However, the resultant number is large compared to any conceivable long-lived radiogenic contribution, indicating that the elastic lithosphere is probably much thicker today, and that the observed flank topography is not a flexural response.

Scarps: There are a number of scarps which appear to be the trace of a single normal fault without a complementary facing normal fault that would make a graben. The zone north of Vulcan Planum has a much larger number of these than graben, with a variety of expressions. There are small relief, parallel structures that are reminiscent of grooved terrain on other icy satellites resulting from bookshelf faulting, as well as large, south-facing scarps with several kilometers of relief that bound Vulcan Planum. There are also some scarps that appear to delineate larger crustal blocks.

Conclusions: We interpret this ensemble of features to be the structural expression of normal faults and graben, representing substantial tectonic extension of Charon's icy crust on the order of 1%. Several large craters are superposed on the chasmata, indicating that this extension is geologically old. Given the horizontal and vertical scale of these structures, steeply dipping normal faults are likely to extend to depths of 10s of kilometers. The tectonic record is consistent with global expansion. The

spatial distribution of tectonic features is not readily reconciled with the kinds of patterns expected from tidal or despinning stresses [2]. Charon may have had an ancient subsurface ocean that subsequently froze, which could have generated this global set of extensional features.

References

- [1] S. A. Stern, et al. The Pluto system: Initial results from its exploration by New Horizons. *Science*, 350(6258), 2015. doi:10.1126/science.aad1815.
- [2] J. M. Moore, et al. Geology before Pluto: Pre-encounter considerations. *Icarus*, 246:65–81, 2015. doi:10.1016/j.icarus.2014.04.028.