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Charon tectonics

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ABSTRACT

New Horizons images of Pluto's companion Charon show a variety of terrains that display extensional tectonic features, with relief surprising for this relatively small world. These features suggest a global extensional areal strain of order 1% early in Charon's history. Such extension is consistent with the presence of an ancient global ocean, now frozen.

1. Introduction

Charon, Pluto's large companion, has a variety of terrains that exhibit tectonic features. We present observations of them here from New Horizons' Long-Range Reconnaissance Imager (LORRI, Cheng et al., 2008) and the Multi-spectral Visible Imaging Camera (MVIC) on the Ralph instrument (Reuter et al., 2008). This work analyzes these observations and measures tectonic strike, estimates elastic thickness, compares these features to those seen on Pluto, and concludes that Charon has undergone global extension.

The Pluto-facing hemisphere that New Horizons (Stern et al., 2015) observed at high resolution has two broad provinces: the relatively smooth plains of Vulcan Planum[1] in the southern part of the encounter hemisphere (Spencer et al., 2016; Moore et al., 2016a), and the zone north of Vulcan Planum, which we describe here, and informally named Oz Terra. This latter zone is characterized by grooves, graben, and scarps, which are signs of extensional tectonism (Fig. 1). The border between these two provinces strikes diagonally across the encounter hemisphere from as far south as –19° latitude in the west (~285° E longitude) to 26° in the east (~30° E longitude). We define longitude and latitude on Charon according to the right hand rule and follow the recommendations of Zangari (2015). Charon's north pole points in the direction of the angular momentum vector and longitudes increase to the east. Charon's prime meridian is the sub-Pluto longitude. Pluto's pole is defined by Archinal et al. (2011a, 2011b).

North of the Vulcan Planum boundary with Oz Terra, the terrain is exceptionally rugged (Fig. 2) and contains a network of fault-bounded troughs and scarps in the equatorial to middle latitudes (Moore et al., 2016a). 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 and other large relief variations (Fig. 3).

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[1] All names in this work are informal, and follow the informal names in Moore et al. (2016a).

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Fig. 1. This is the last LORRI image that captures the whole disk of Charon and what is referred to as the New Horizons encounter hemisphere, roughly centered at 350° longitude, 40° latitude. Informal names of some features are provided, for more informal named features see Moore et al. (2016a). This is the C_LORRI_FULLFRAME_1 observation (LOR_029914776, ~2.4 km/pixel) which has been deconvolved to bring out features.

The lower-resolution views of the non-encounter hemisphere (Fig. 10) 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.

2. Observations

There is a visually obvious belt of fractures just above the Vulcan Planum boundary that are highlighted by the solar illumination angle at these middle latitudes. The fault structures continue northwards from this zone, but are less obvious due to the decreasing illumination angle and changing style of tectonic deformation. We define three different zones in Oz Terra: low-latitude scarps and chasmata, mid-latitude scarps and crustal blocks, and high-latitude depressions and ridges. Although it is unknown if the tectonic features observed in Oz Terra are limited to the encounter hemisphere or if they extend around Charon and represent global latitudinal tectonic zones, there does seem to be some evidence for tectonic features on the non-encounter hemisphere (Fig. 10). There is no information on structures southward of −30°; due to the inclination of the Pluto system to its orbit about the Sun, all of that territory was in darkness during the New Horizons flyby.

New Horizons obtained extensive stereo coverage of the encounter hemisphere, and we used tested stereogrammetric methods after Schenk et al. (2004) to derive terrain from these images. The best global terrain data was generated from the PELR_C_LORRI and PEMV_C_COLOR_2 observations (Figs. 2 and 3) upon which our topographic interpretations are based. This terrain model has an approximate ground scale of 4.4 km/pixel, and an expected vertical precision of 1.2 km. We also used a terrain model created from the PEMV_C_COLOR_2 and PEMV_C_MVIC_LORRI_CA observations (Fig. 8). This terrain model also has an approximate resolution of 4.4 km/pixel but has an improved expected vertical precision of 0.3 km due to better parallax angle of the two images with each other.

Most of the highest-resolution images presented here were obtained with the New Horizons LORRI camera. The LORRI point spread function has a full width at half maximum (FWHM) of ~2 pixels, which meets its specifications (Cheng et al., 2008), but can cause noticeable blurring. This can be improved through (Lucy, 1974; Richardson, 1972) deconvolution, and the images for which this has been applied are noted.

2.1. Low-latitude scarps and chasmata

In the low-latitude zone of Oz Terra, there are a number of scarps and chasmata that generally parallel the strike of the northern margin of Vulcan Planum (Figs. 4 and 5).

The chasmata appear to be fault-bounded depressions, or graben, resulting from extension of the crust. In this region there are far more scarps that appear to be the trace of a single normal fault rather than a graben set, and these have a variety of expressions.

There are small relief, parallel structures (Fig. 6) that are reminiscent of grooved terrain on other icy satellites (Pappalardo et al., 1998), which result from extensional instabilities and bookshelf faulting (Bland and McKinnon, 2015).

The largest scarps, with several kilometers of relief, face south and delineate the border with Vulcan Planum.