FOLDING CHARACTERISTICS OF BARÉ MONTES, PLUTO.

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Introduction: Sputnik Planitia (SP) is a large, elongated region on Pluto thought to still be geologically young [1-2] to within 10 My, mainly due to lack of craters [3]. SP also has small glaciers, suggesting stresses on the outer edges of SP to pull apart the surrounding crust. Initial findings of SP show convection processes underlying the polygonal structures observed on the surface [2, 4]. A large glacier, named Baré Montes, has a distinct folding pattern unrelated to the surrounding jagged glaciers bordering SP. Our objective is to study the folding mechanism of this glacier and determine the age of the folding.

Baré Montes is located at 13.81°N, 157.59°E on Pluto, approximately 130 kilometers in width, the tip barely in contact with the eastern edge of Cthulhu Regio (Figures 1, 2). From the latest DEM measurements, the glacier averages at about -0.85 km in elevation [2, 5], showing slight relief above SP. However, the folding structures are too small for DEM measurements, so calculations are approximate. The northeastern part of the glacier has chaotic terrain, matching similar terrains on surrounding glaciers outlining SP. The darker material suggests an older relation to SP, but we are mainly concerned about the folding, which is not seen on other glacier formations. Folding of such ice structures could give us insight to Plutonian crust mechanics and associated stresses. This motivates us to measure the dominant wavelength of these folds. The dominant wavelength, along with other parameters, would be used for a folding stress relationship [6-7].

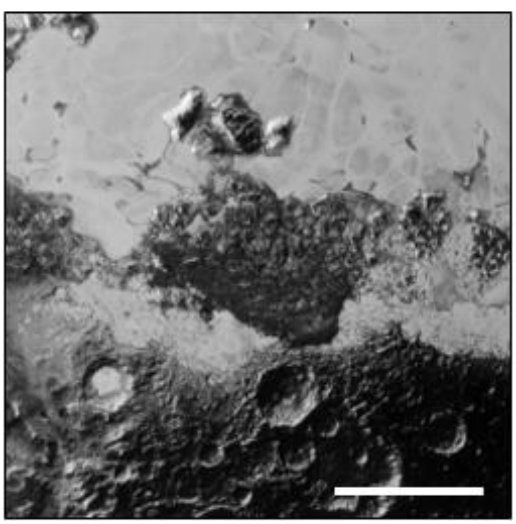

Figure 1: LORRI image of Baré Montes. Scale bar equals 100 km.

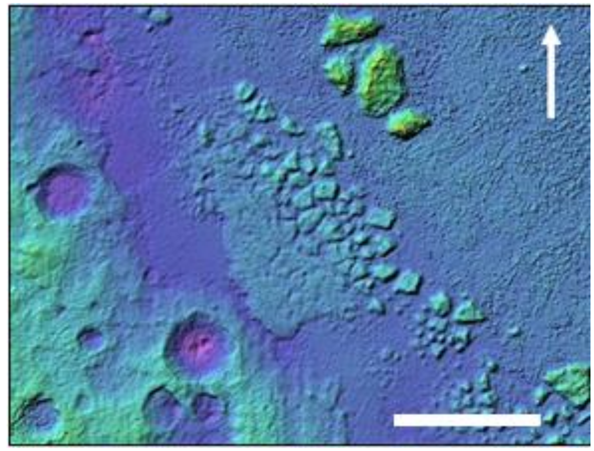

Figure 2: DEM of Baré Montes using JMARS. Arrow pointing North. Scale bar 100 km.

The primary datasets used to evaluate the geologic observations surrounding SP were from the Ralph payload, mainly the Long Range Reconnaissance Imager (LORRI): a visible camera instrument onboard the New Horizons probe. Additional data products used for the manipulation of the images and measurements was JMARS [5] and the SAOImage DS9 imaging software produced by the Smithsonian Astrophysical Observatory.

Folding Observations: The trends of the folds are elongated to the NS, bending slightly at the ends (Figure 3). This bending and folding is analogous to folded mountain belts, such as the Appalachian Mountains ridge and valley system (Figure 4).

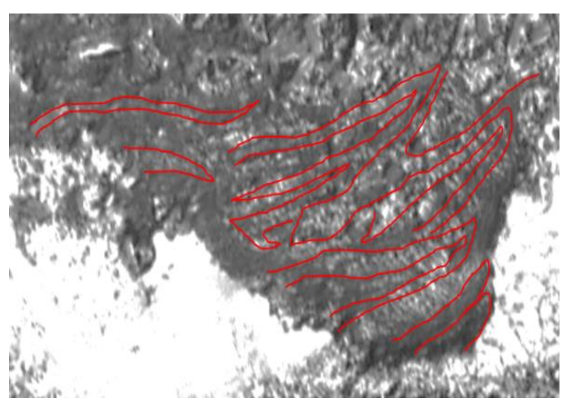

Figure 3: LORRI image with preliminary dominant folding structures as mapped on SAOImage DS9 for measurement purposes.

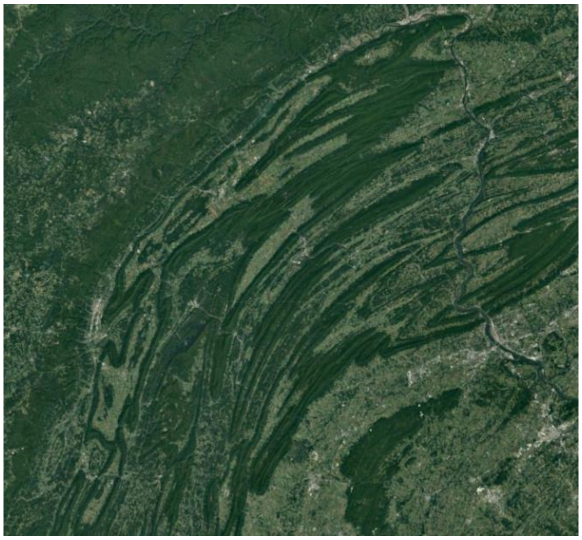

Figure 4: Google Earth image of the Appalachian ridge and valley system showing analogous folding of differing layers.

Results: We measure the dominant wavelength and the Fink [7] folding model to infer properties of the folding stresses and the strain rate associated with deformation. Although Figure 3 shows the bending structures observed, more measurements were taken to observe the dominant wavelength to be 3.95 km. The simplest folding model by Fink 1980 represents a folding process as a two-layer problem [7]. The folded surface has a layer thickness H, in which surface viscosity decreases with depth. However, the viscosity of both layers is assumed to be Newtonian, so viscosity in this measurement is independent of stress. We assume the surface viscosity (n_0) to be $\geq 10^{20}$ Pa·s at Plutonian conditions [7, 9] due to the relatively thin crust of Baré Montes at H = 3.4 km. Such a structure is consistent with a folding structure on top of a thick convecting ice shell with a weak upper surface [10-11], such as SP.

For folding to occur, the ratio between the driving stress and gravitational stress is expressed by $S \leq 0.02$ [7]. With Pluto's approximate ice density to be $\rho = 920$ kg/m^3 and gravity $g = 0.62$ m/s^2 [9], the driving stress is calculated to be 999.7 kPa. If $n_0 = 10^{20}$ Pa·s, the strain rate can be calculated to be 9.99×10^{-15} s^{-1}. Translating this to a time frame, or the inverse of strain rate, gives us an approximate timing of the folding to be 3.17×10^6 years, or 3.17 My. It has to be kept in mind that this is the approximate time of the folding age, not the entirety of the glacier.

Discussion: Constructs of folding on Baré Montes and the Appalachian Mountains were hypothesized to have the following common characteristics: 1) differential erosion; 2) slow collision; 3) horizontal stress between two bodies [8]. This work can expand to the mechanics of glacier building and movement of the Sputnik Planitia region.

Conclusions: This approximate age is consistent with the approximate age of SP to be < 10 My. However, the placement of this glacier does not necessarily constrain a uniform movement of SP convection, but rather a localized stress mechanism for moving and ultimately folding the Baré Montes glacier. Uncertainties in the yield stress and depth of brittle versus ductile ice layering would be useful for a more complex rheological study.

Comparing the folding mechanisms and formulating a folding stress relationship gives us insight into the past movement of this glacier on SP. With an approximate age of the folding being younger than SP verifies the young, geologically active processes of SP to move and collide the glacier. Further insight into this process would include the types of ice phases involved, possible layering of ices, and the erosion or sublimation of ices in the folding.

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