EVIDENCE FOR A LISTRIC EXTENSIONAL FAULT SYSTEM BOUNDING ARDEN CORONA ON URANUS' MOON MIRANDA. C. B. Beddingfield[1], D. M. Burr[1], J. P. Emery, [1]Earth and Planetary Sciences Department, University of Tennessee, Knoxville, TN, USA (cbeddin1@utk.edu).

Introduction: Distinct albedo contrasts highlight plan view geometries of an assemblage of structures that riddle the surface of Uranus' tiny icy satellite Miranda [1,2,3]. Although Miranda is only ~472 km in mean diameter, the surface dispalys a unique and enigmatic arrangement of features whose oddness ranks above many imaged satellites of larger diameters.

Three highly deformed regions consisting of bright, banded, and ridged terrain [1] are termed 'coronae'. The coronae are bounded by a series of ridges and troughs, and possess sharp contacts with Miranda's more extensive cratered terrain [2]. Arden Corona is located on Miranda's leading hemisphere and extends from the equatorial region to about -60º latitude.

The boundary surrounding Arden Corona [Fig.1] consists of extensional normal faults [3]. Fault scarps were identified through methods including mapping of inferred slickenlines. Ridges and troughs were interpreted as blocks shifted from normal faulting [3].

Scarp dips of ~40º and ~25º were found by [3]. Due to the decrease in dip away from the corona interior, these authors suggested that further studies may indicate the presence of a listric fault geometry. A listric geometry, in turn, would indicate the presence of a detachment layer in the subsurface likely due to a brittle-ductile transition zone [4].

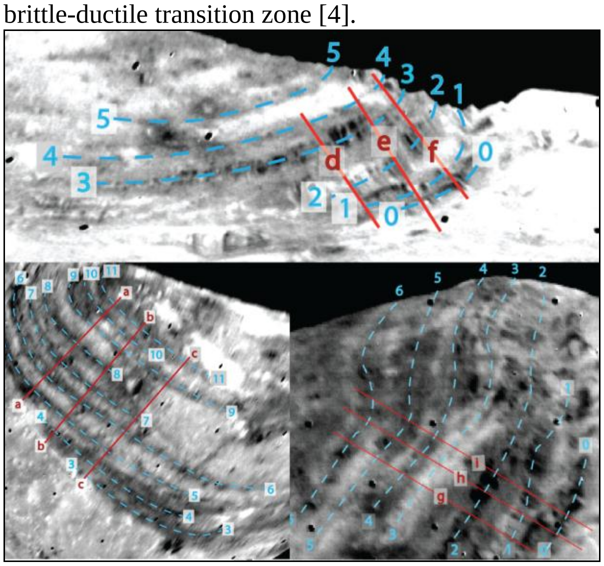

Figure 1: Top: Image 2684608. Bottom left: Image 2684611. Bottom right: Image 2684608. The locations of the nine profile lines (red) used for measurements of scarps 0 through 11 (blue) are shown.

Hypothesis: Here we further explore the geometry of the normal fault system bounding Arden Corona. We test the hypothesis of listric normal faults bounding the corona with four lines of investigation. If the faults are listric, then the curvature of the faults would result in scarp dips progressively decreasing towards the corona boundary. In addition, the rotation of the fault blocks along the hypothesized listric fault surface would cause slopes of back-tilted faces to increase with distance outward, i.e., towards the boundary [5].

The amount of throw (vertical displacement) and heave (horizontal displacement) are directly correlated for a listric fault [6]. Because the throw of a listric fault scarp decreases with decreasing curvature of the fault surface [6], the maximum heave of each scarp measured here should decrease toward Arden Corona's boundary, where the curvature decreases.

Rollover structures occur in listric fault systems due to geometry space problems. These features slope in the opposite direction of the fault dip direction [7]. For a listric fault bounding Arden Corona, a rollover structure should exist and slope inward. The lack of corrugations on an inward dipping slope and convex topography of a corona-ward sloping feature would support the interpretation of a rollover structure.

Data and Methods: Voyager 2 images 2684626 (~250 m/px), 2684608 (~330 m/px), and 2684611 (~310 m/px) were used in this study. These images were processed, reprojected, and measured using the Integrated Software for Imagers and Spectrometers (ISIS; [8-10]). Several measurements of heave were taken in plan view for each of the 12 scarps [Fig.1] along discernible corrugations, which allowed for easier identification of the top and bottom of each scarp. In addition, four dip measurements of scarp faces as well as four slope measurements of the back-tilted faces along Miranda's limb were taken [see Fig. 2 for measurement locations] with ImageJ software.

Analysis and Discussion: A plot of our data shows that the dips of the fault scarps progressively decrease towards the boundary of Arden Corona, while the slopes of the back-tilted faces progressively increase toward the boundary [Fig.3]. However, the amount of change of each parameter is not the same. Over a distance of ~35 km, the change in fault scarp dip is ~28º and the change in back-tilted face slope is ~10º. This variation may be due to internal deformation within the hanging wall material as displacement occurred.

Heave along each fault scarp bounding the corona varies along strike. Heave of each scarp tends to decrease toward the boundary of the corona [Fig.4]. The maximum heave of the multiple measurements taken for each scarp is shown in Fig.5. A trend of increasing heave is obvious with the exception of three outliers on scarps two, three, and six. Across ~120 km, the change in heave is ~6 km.

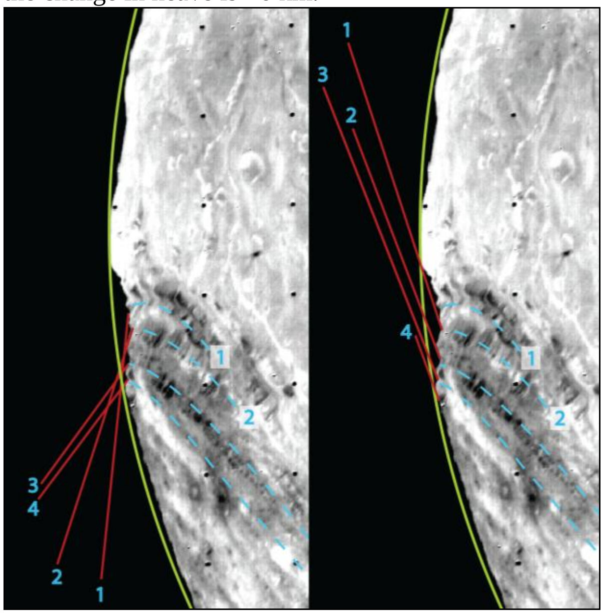

Figure 2: (Above) Image 2684626. The lines used to measure dip angles (left) and back-tilted face slopes (right) of scarps 1-4 (blue) are shown in red. The angles of these lines are measured relative to a line fit to Miranda's circumference (yellow).

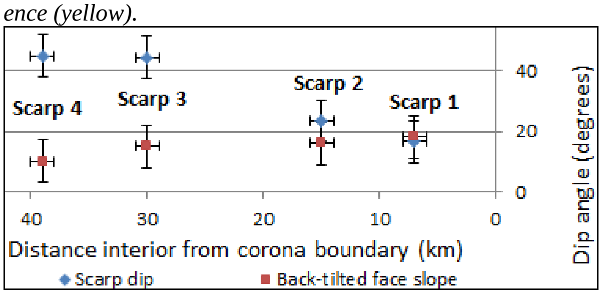

Figure 3: (Above) The angles of dips and back-tilted faces.

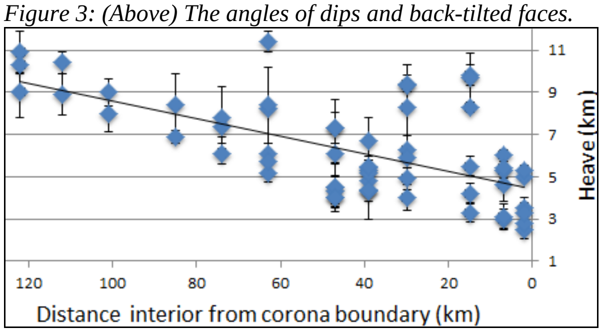

Figure 4: Heave measurements across profile lines a-i.

Because the entire boundary of Arden Corona is not observable, the maximum heave observed along each scarp may not represent the actual maximum heave present. Alternatively, these outliers could indicate a more complex subsurface fault geometry, or multiple events involving fault reactivation episodes.

A feature sloping in the opposite direction of the scarps is observed [Fig.1] and inspected for evidence supporting formation as a rollover structure. This feature does not show the characteristic corrugations present on the oppositely dipping fault scarps, which is consistent with interpretation as a rollover structure.

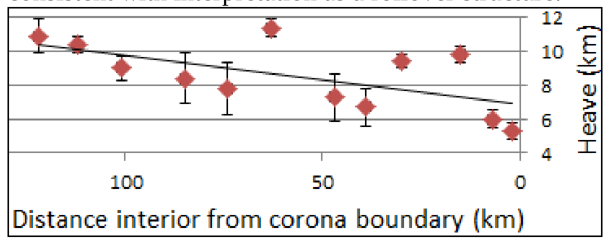

Figure 5: The maximum heave of each scarp is shown.

Conclusion: The progressive decrease in fault scarp dip as well as the progressive increase in back-tilted face slope is indicative of a listric fault geometry bounding Arden Corona. The increase in heave toward the boundary and the presence of a feature with an opposite slope direction that lacks corrugations is also indicative of this type of geometry. These four lines of evidence all support the interpretation of a listric extensional fault system, although heave outliers and the variation in the change of dip and slope require further investigation.

Implications: We used the method of [11,12] to estimate a depth to a detachment layer that was present during the formation of Arden Corona. This depth can be found by dividing the area in profile view dropped below the regional elevation (yellow line in Fig.2) by the heave of the rollover anticline, calculated as the sum of the horizontal distance between the base of the inward sloping feature and the top of outward dipping scarp 1 and the heave of scarps 2, 3, and 4. The approximate depth to the detachment is thereby estimated as ~15 ±5 km. This depth is thick relative to estimates for icy satellites with recent tectonic activity such as Enceladus, but comparable to the brittle-ductile transition zone depth of ~12 km estimated for Tethys [13].

References: [1] Strobell and Masursky (1987) Abstr. 18th *LPS 964-965*. [2] Smith et al. (1986) *Science, 233, 43-64*. [3] Pappalardo et al. (1997) *JGR, 102, 13369-13379*. [4] Bally (1981) *Oceanologica Acta, Proc. 26th Intern. Geol. Cong., Paris 87-101*. [5] Wernicke and Burchfiel (1982) *J. Str. Geol. 2, 105-115*. [6] Ellis and McClay (1988) *Basin Research, 1, 55-70*. [7] Bruce (1973) *Bull. Am. Assoc. Petrol. Geol. 57, 878-886*. [8] Gaddis et al. (1997) *LPS XXVIII, 387*. [9] Torson and Becker (1997) *LPS XXVIII, 1443*. [10] Anderson et al. (2004) *LPS XXXV, 2039*. [11] Chamberlin (1910) *J. Geology, 18, 228-251*. [12] Gibbs (1983) *J. Struct. Geol., 5, 153-160*. [13] Giese et al. (2007) *Geophys. Res. Lett. 34, 21203*.