EXTENSIONAL FEATURES AT EAST SERENITATIS WRINKLE RIDGE-LOBATE SCARP TRANSITION INDICATE RECENT TECTONIC ACTIVITY J. D. Clark[1], H. Bernhardt[1], and M. S. Robinson[1], [1] School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, (jclark@ser.asu.edu).

Introduction: The Moon exhibits globally dispersed tectonic landforms due to thermal contraction, solid-body tides, and loading of the crust. Wrinkle ridges and lobate scarps are both formed as a result of compressional stresses, however, their appearance and formation mechanisms are different [1-5]. Wrinkle ridges are interpreted as blind thrust faults, where horizontal shortening is accommodated by a fault that does not reach the surface. These faults are suggested to extend to depths between 100's of meters to several kilometers [6-8]. It is thought that wrinkle ridges formed 0.1-0.65 Ga after basalt emplacement as a result of basin subsidence [6-11]. Lobate scarps on the other hand are among some of the youngest landforms on the Moon, with derived model ages < 700 Ma [12-16]. The faults that created the scarps are thought to have offset only the upper kilometer of the crust and are found mainly in the anorthositic highlands [15-16]. While wrinkle ridges and lobate scarps are typically not co-located, global mapping revealed at least nine cases where wrinkle ridges transition to lobate scarps at a mare-highland boundary [5,16-18]. These transitions are of interest as they are complex examples of recent tectonism [18-20].

The ridge-scarp transition in eastern Mare Serenitatis (21.7°N, 28.9°E) ruptures the surface at a contact between mare basalts and dark mantle deposits, approximately 70 km NW of the Apollo 17 landing site. The ridge is part of the southern section of the Dorsa Aldrovandi wrinkle ridge system. CSFD based model ages for the mare units range from ~3 – 3.8 Ga [21], while the ridge-scarp transition has been active in the last 100 Ma [18]. Detailed mapping around both the wrinkle ridge and lobate scarp revealed a large network of small-scale graben. To better understand the relationship between the small extensional features and the compressional landforms, a geomorphologic map was produced as a first order investigation.

Data and Methods: We used NAC (Narrow Angle Camera; 1 m/pixel) image data from the Lunar Reconnaissance Orbiter Camera (LROC) with incidence angles of 60-75° for detailed geomorphological mapping [22]. NAC data were calibrated and map projected using the Integrated Software for Imagers and Spectrometers (ISIS3) [23]. The geomorphologic units and landforms were mapped on the basis of their morphology and albedo (Fig. 1). Wrinkle ridges, lobate scarps and small-scale graben are the tectonic landforms that were mapped as well as two volcanic units: dark mantle pyroclastic deposits and mare deposits. Impact craters were not included into the geomorphologic map.

Geologic Interpretations (Fig 1.): The wrinkle ridges (dark brown lines) exhibit typical sinuous and braided morphology [10]. Many ridge sections are discontinuous with some segments as short as 1-2 km in length. The summit of the wider ridge segments occasionally host small-graben that are oriented along strike. Where the ridge crosses the mare-pyroclastic boundary the fault transforms into lobate scarp morphology, likely

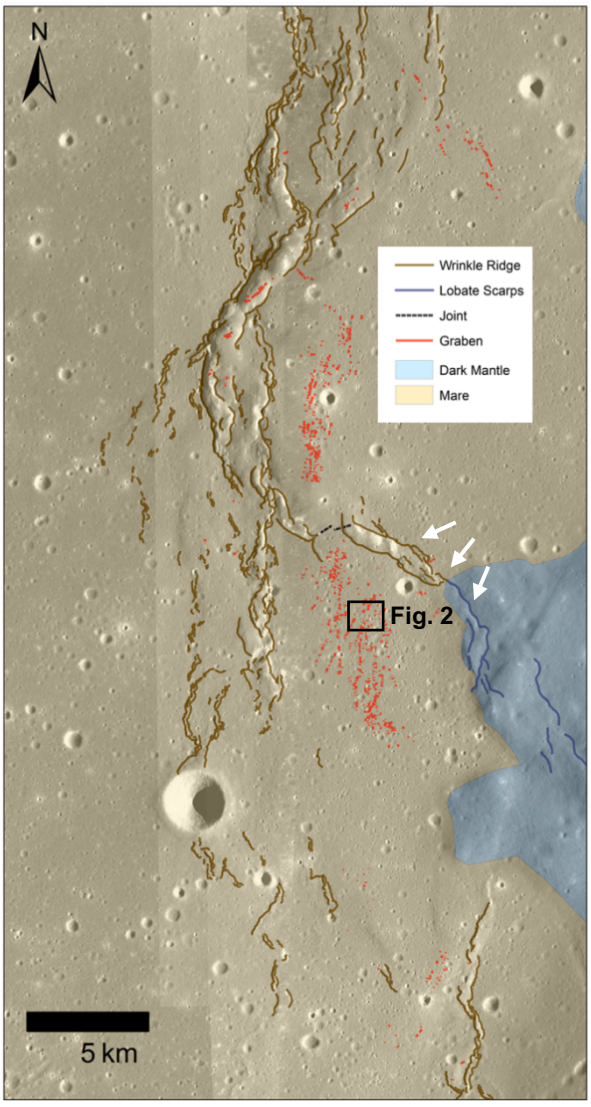

Figure 1: Geomorphologic map of the wrinkle ridge-lobate scarp transition (white arrows) in eastern Mare Serenitatis (21.7°N, 28.9°E) on NAC image data. Brown lines are wrinkle ridge compound scarps, lobate scarps are mapped with blue lines, and small-scale graben are shown with red lines, dashed black lines are joints. Tan color represents the mare, while the light blue areas are dark mantle deposit.

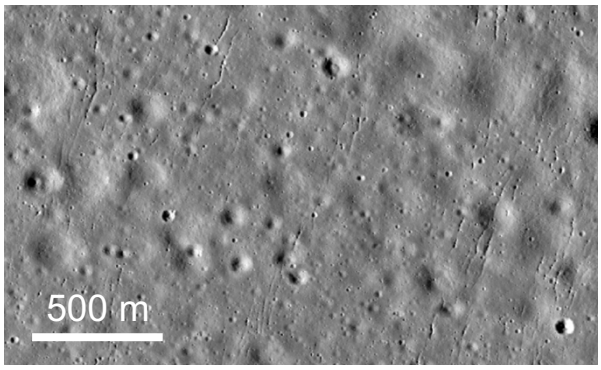

Figure 2: Small-scale graben (21.7º, 28.7º) just south of the ridge section of the transition are approximately perpendicular to the fault.

due to differences in substrate strength and or fault structure. Here, the scarps are simple, curvilinear landforms. The small graben (Fig. 2) are contained within the mare and are mostly tens of meters in length (Fig. 3) Graben widths are only a few meters wide and either exhibit typical flat-floors bounded by an escarpment on both sides or v-shaped troughs with irregular edges.

A possible small wrinkle ridge, which we tentatively mapped as a joint, traverses the gap (relay ramp) between two segments of the main wrinkle ridge complex. This smaller ridge is perpendicular to the main wrinkle complex.

Discussion: Located around the compressional landforms are small-scale graben (*Fig. 2*). These graben are often found in other locations across the Moon and have been suggested to be the result of localized flexural bending or dilation from recent fault movement at compressional landforms and are typically found in clusters of ≤20 [24, 25]. However, the graben here occur as a

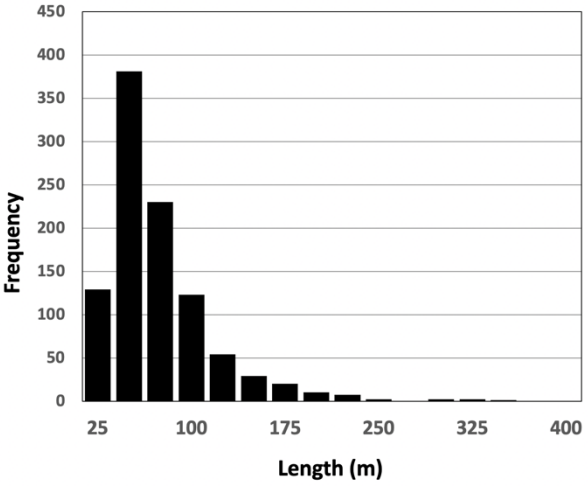

Figure 4: Distribution of graben length: Mean= 61m, standard deviation=44m, median = 49m, and mode= 25m. Lengths are binned at every 25 m.

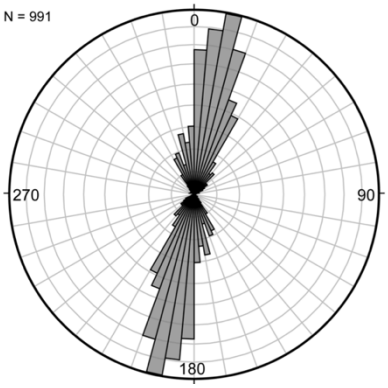

Figure 4: Rose plot for all 991 graben mapped showing a strong SSW-NNE orientation.

relatively large network (n=991, Fig. 4) that spans over ~25 km and they likely formed as a secondary effect (extension) of recent tectonism in the ridges and scarps. These graben have a strong SSW-NNE orientation (Fig 4), which is roughly perpendicular to the section of the wrinkle ridge that transitions into a lobate scarp and parallel to the main Dorsa Aldrovandi wrinkle ridge. Graben are also observed on the crests of the wrinkle ridges due to extension on the ridge and lateral extrusion of wedge material.

Conclusion: In addition to the late-Copernican AMAs determined for the wrinkle ridge-lobate scarp transition, the discovery of small-scale graben additionally suggests recent tectonism at the compressional landforms. This supports the hypothesis of a tectonically active Moon [5, 13, 19, 20, 25] that produces not just compressive, but also extensional landforms.

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