TOPOGRAPHIC ANALYSIS OF THE BEETHOVEN BASIN OF MERCURY USING MESSENGER STEREO IMAGING DATA. S. L. André, Planetary Science Institute, 1700 East Lowell Road, Suite 106, Tucson, Arizona 85719, andre@psi.edu.

Introduction: Beethoven basin is a 630 km diameter impact basin located at 20°S, 124°W within the Beethoven Quadrangle on Mercury (Figure 1). Images of the Beethoven Quadrangle were acquired by Mariner 10 under high sun angles, making it difficult to observe morphology of features within the images [1]. Mariner 10 images showed Beethoven was an ancient, degraded basin with a subdued rim, no interior rings, and few structural features interior to the basin [2,3,4].

Andre et al. [5,6] analyzed the long wavelength topography of Beethoven basin using digital elevation models (DEMs) generated from Mariner 10 stereo images [7,8] in an effort to characterize the interior structure of the basin. Topographic profiles indicated that it was a relatively shallow basin with a broad interior topographic rise near the northwest margin, about 200 km from the center of the basin. The MErcury Surface, Space, ENvironment, GEochemistry, and Ranging (MESSENGER) mission made three flybys of Mercury and orbited the planet in 2011 [e.g. 9,10], acquiring high-resolution images with varying sun angles. Now, with higher-resolution images and topographic data acquired from the MESSENGER mission to Mercury, basin topography and tectonic features of the Beethoven region can be examined in more detail, providing an update to the original work of [5,6].

Background: Deformation of Mercury's crust is observed in the presence of landforms such as lobate scarps, high-relief ridges, and wrinkle ridges [i.e. 11]. Previous studies of Beethoven's topography [5,6] indicated an interior trough (1 km deep) inside the northwestern basin rim. Beyond the margin, interior to the basin, a broad topographic rise was identified [5,6]. A series of smaller impact craters obscure the southeastern rim of the basin, making it difficult to determine if the topographic rise would be symmetric with the other side of the basin [6].

Scientific Objectives: The primary objective is to examine the topography of the Beethoven region. The topography will be used to assess the tectonism in and around the basin, including the spatial and temporal relationships among the geologic units and tectonic structures.

Data: Orbital stereo imagery obtained from the Mercury Dual Imaging System (MDIS) [10], including a combination of Narrow Angle Camera (NAC) and Wide-Angle Camera (WAC) stereo images, were used to generate digital elevation models of Mercury's surface [12]. The DEMs were produced using stereophotogrammetric processing, including bundle block adjustment, multi-image matching, and surface point triangulation [12,13,14]. The DEM produced for the Beethoven region (Figure 2) has a lateral spacing of 221.7 meters/pixel (192 pixels per degree) and vertical accuracy of ~30 meters [12]. The USGS also produced DEMs from a combination of MESSENGER NAC and WAC stereo images, at 64 pixels/degree, 665 meters/pixel resolution [15].

Both sets of DEMs [12,15] are ideal for performing quantitative geomorphologic analysis, such as impact basin morphology and tectonic analyses. MESSENGER's laser altimeter topographic products were not utilized, as they did not cover most of the southern hemisphere of Mercury. MESSENGER global MDIS grayscale mosaics derived from orbital images and NAC high-resolution images were utilized to analyze features within the basin.

Preliminary Work: The major topographic features associated with the Beethoven basin identified in previous studies [5,6], such as the basin-edge scarp and interior broad topographic rise, are clearly delineated in the MESSENGER DEMs of this region [12]. Higher-resolution MESSENGER images have confirmed that what appeared as a trough was a lobate scarp located inside the northwestern margin of the basin, now named Duyfken Rupes.

Recent studies of mercurian lobate scarps have observed that several lobate scarps are located at the margins of ancient buried basins [16,17,18,19,20]. Rothery and Massironi [19] demonstrated that there are several examples of mercurian basins where basin deformation is limited to portions of the interface between basin-fill and basin-rim [19,21].

Duyfken Rupes, a ~500 km lobate scarp, has been identified in recent studies [i.e. 22,23,24]. A series of topographic profiles along Duyfken Rupes indicate some variation in relief; the average relief is 900 m. Massironi et al. [25] studied the western rim of Beethoven basin and Duyfken Rupes as part of a detailed structural study of the lobate scarp, which they interpret as a series of en echelon folds that indicate a right-lateral component of slip [25]. Masseroni et al. also observed that the south western margin of Beethoven is characterized by segmented faults that they infer to be indicative of sinistral strike-slip kinematics [25].

While few basin-interior wrinkle ridges were observed in the Mariner 10 image data [1,2,3,4], more sets of wrinkle ridges are observed within the basin interior

in the MESSENGER image data. The topographic rise identified within the Mariner 10-derived DEMs corresponds to sets of basin-concentric wrinkle ridges located in the interior of the basin. The overall topographic rise is ~100 km in width and exhibits an average of ~600 m of relief between the basin interior near the margin and the basin interior near the basin center.

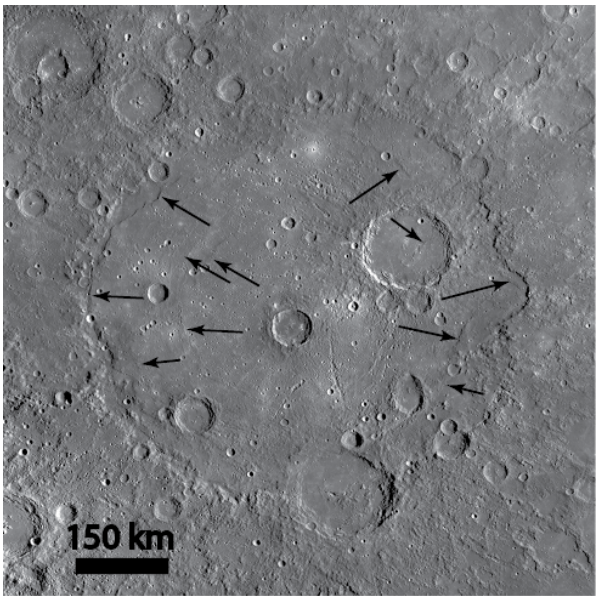

Figure 1. Beethoven basin, a 630 km diameter degraded impact basin located at 20°S and 124°W in Mercury's southern hemisphere. Monochrome mosaic of the Beethoven basin obtained by the MDIS cameras. Arrows show examples of tectonic features located within the basin, including Duyfken Rupes along the western rim and basin-interior wrinkle ridges.

Future Work: The formation of the Beethoven basin likely resulted in significant impact damage to crustal materials within and outside the basin. The topographic analysis will help develop an understanding of how the stress fields and rheology of the lithosphere in the Beethoven region affected the subsequent formation of the tectonic features.

References:

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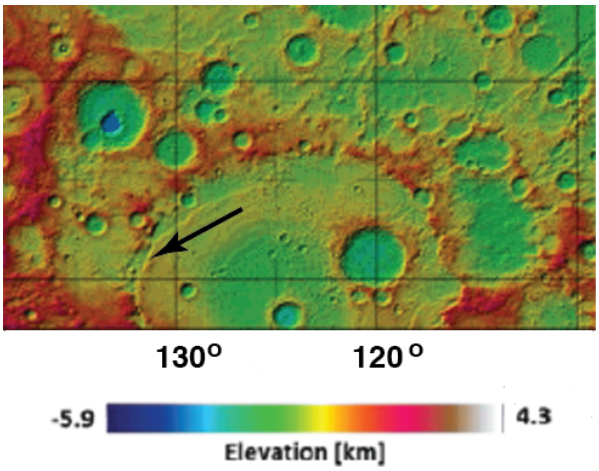

Figure 2. Example DEM adapted from [12], showing the northern half of Beethoven basin. The black arrow indicates the location of Duyfken Rupes along the western interior edge of Beethoven's rim. The topographic rise corresponds to sets of basin-concentric wrinkle ridges. The 130 km diameter crater Bello is located in the north-east region, obscuring the topographic rise observed on the north-west region of the basin interior. Elevations are relative to a sphere of radius 2440 km.