HIGH-RESOLUTION TOPOGRAPHY FROM MESSENGER ORBITAL STEREO IMAGING – THE H3 QUADRANGLE „SHAKESPEARE“.

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Introduction: The MErcury Surface, Space ENviorment, GEochemistry, and Ranging (MESSENGER) spacecraft entered orbit about Mercury in March 2011 [1] to carry out a comprehensive topographic mapping of Mercury. Measurements of Mercury’s topography have been made with stereo imaging [2,3], laser altimetry [4,5], limb profiling [6], and radio occultation [7]. We describe the production of a high-resolution digital terrain models (DTM) using stereo photogrammetry [8,9]. In this paper, we describe the H3 quadrangle “Shakespeare” (Fig. 1).

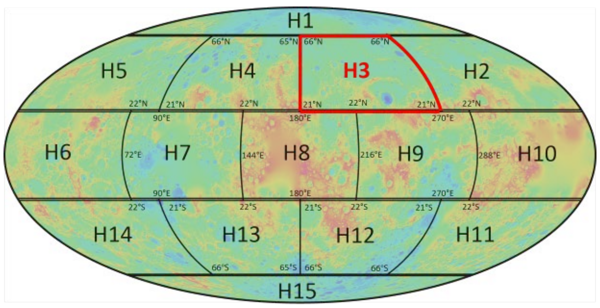

Fig. 1. Mercury’s 15 tiles quadrangle scheme. The selected H3 quadrangle is highlighted in red.

Data: The Mercury Dual Imaging System (MDIS) onboard MESSENGER spacecraft consists of a wide-angle camera (WAC) and a narrow-angle camera (NAC) co-aligned on a pivot platform [10]. In almost 4 years MDIS has acquired more than 200,000 images to map the surface. Owing to MESSENGER’s highly eccentric near-polar orbit, the WAC is primarily used for the northern hemisphere and the NAC to cover the southern hemisphere, respectively.

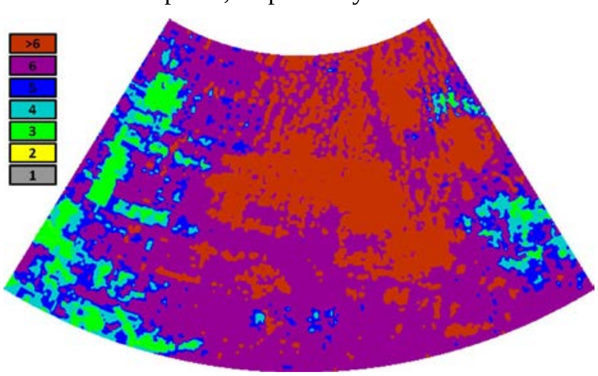

Fig. 2. Stereo coverage of MDIS images having spatial resolutions better than 350 m/pixel. Colors indicate the number of stereo observations.

Those images provide multiple (at least triple) coverage for almost all areas on Mercury at a resolution better than 350 m/pixel.

Stereo Coverage: We have selected about 20,300 images that have resolutions better than 350 m/pixel within the H3 quadrangle area, which extends from 21°N to 66°N and from 180°E to 270.0°E. Subsequently we applied our stereo conditions (Table 1) to compile a stereo coverage map (Fig. 2). From this map we identified about 50,000 stereo image combinations consisting of at least three images each.

Parameters	
Differences in illumination	<10°
Stereo angle	15°-55°
Incidence angle	5°-85°
Emission angle	0°-55°
Phase angle	5°-160°

Table 1. Stereo conditions used for stereo processing

Method: The stereo-photogrammetric processing for Mercury is based on a software suite that has been developed within the last decade and has been applied successfully to several planetary image data sets [11-15]. The suite comprises photogrammetric block adjustment, multi-image matching, surface point triangulation, digital terrain model (DTM) generation, and base map production.

Results: Beginning with nominal navigation (pointing and position) data of the selected stereo images, we have collected ~80,000 tie points for navigation data correction using a photogrammetric block adjustment. This improves the three-dimensional (3D) point accuracy from ±800 m to ±40 m. Then 50,000 individual matching runs were carried out to yield ~5.6 billion object points. The mean ray intersection errors of the ground points were ±45 m. Finally, we generated a DTM with a lateral spacing of 192 pixels per degree (~222 m/pixel) and a vertical accuracy of about 30 m (Fig. 3). The H3 DTM covers 6.8% (5.08×10^6 km^2) of Mercury’s surface and comprises a total height range of 7.6 km. This model highlights three large basins (Fig. 3), the *van Eyck* basin (~250 km diameter), the *Shakespeare* basin (~380 km diameter), and the *Sobkou* basin (~780 km diameter).

Conclusion: The H3 quadrangle DTM will be delivered in begin of March 2017 to the Planetary Data System (PDS). It represents a further element towards a high resolution global shape model of Mercury from stereo-photogrammetry [14].

References: [1] Solomon S .C. et al. (2011) *EPSC-DPS Joint Meeting Abstracts and Program*, Abstract EPSC-DPS2011-430. [2] Oberst J. et al. (2010) *Icarus*, *209*, 230–238. [3] Preusker F. et al. (2011) *Planet. Space Sci.*, *59*, 1910–1917. [4] Zuber, M.T. et al. (2008) *Science*, *321*, 77-79. [5] Zuber, M.T. et al. (2012) *Science*, *336*, 217-220. [6] Elgner S. et al. (2014) *Planet. Space Sci.*, *103*, 299-308. [7] Perry M.E. et al. (2011) *Planet. Space Sci.*, *59*, 1925-1931. [8] Oberst et al. (2017) this issue. [9] Stark et al. (2017) this issue. [10] Hawkins S.E., III, et al. (2007) *Space Sci. Rev.*, *131*, 247-338. [11] Gwinner K. et al. (2009) *Photogram. Engineering Remote Sensing*, *75*, 1127–1142. [12] Gwinner K. et al. (2016) *Planet. Space Sci.*, *126*, 93-138. [13] Preusker F. et al. (2015) *A&A*, *583*, A33. [14] Preusker F. et al. (2017), submitted to *Planet. Space Sci.*. [15] Scholten F. et al. (2012) *JGR*, 117, e00H17.

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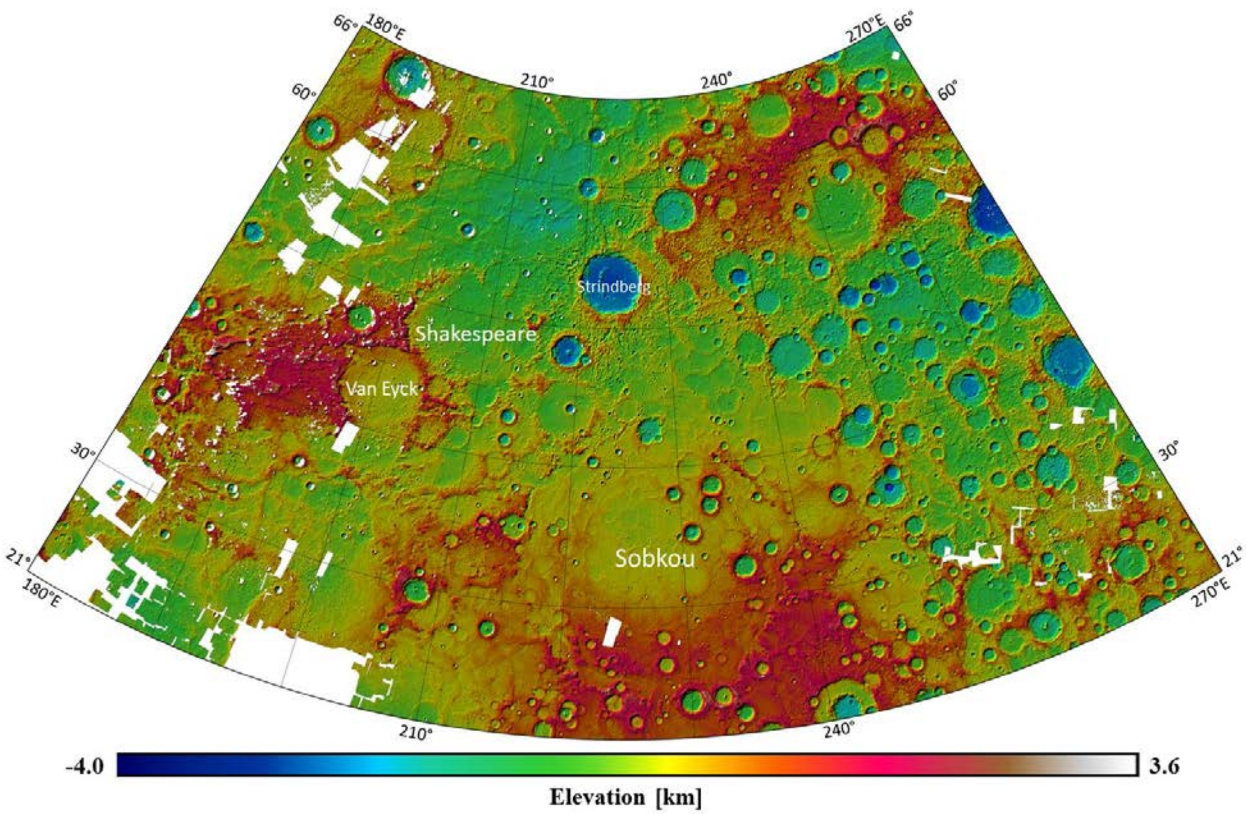

Fig. 3. H3 ("Shakespeare") quadrangle DTM (hill-shaded color-coded heights) with a lateral spacing of 192 pixel per degree (~222 m) in Lambert two-parallel (conformal) projection. White areas are gaps in the current processing stage. Completed version of this model will be available at the time of the conference.