HIGHLAND DRAINAGE BASINS AND VALLEY NETWORKS IN THE EASTERN HELLAS REGION OF MARS.

Scott C. Mest, David A. Crown, and William Harbert, Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260, Email: scmst25@pitt.edu.

Introduction: Geologic mapping of the Reull Vallis region (27.5° to 47.5°S, 245° to 270°W) of Mars at the 1:2M [1,2] and 1:500K scales [3,4] has revealed the influence of fluvial activity on the highlands east of the Hellas basin [1-9]. Some of the most intriguing features identified are numerous well-developed valley networks situated in the rugged highlands. Valley networks are found predominantly within a sedimentary unit among massifs of ancient cratered highland materials. This Late Noachian- to Early Hesperian-aged unit, called intermontane basin fill [3,4], consists of smooth to hummocky deposits and is interpreted to consist of materials eroded and/or mass wasted from surrounding highland massifs. This study characterizes drainage basins and valley networks in the eastern Hellas region of Mars in order to better understand their process(es) of formation and the role of water in highland degradation.

Geology of the Eastern Hellas Region: Ancient cratered highland materials within Mars Transverse Mercator Quadrangles -40252, -40257, -45252, and -45257 [3,4] occur as a large tract of rugged terrain in the northern part of the study area. Here, fluvial and mass wasting processes have degraded highland materials depositing intermontane basin fill in low-lying regions. Highland materials are surrounded by a Hesperian-aged smooth plains unit, which embays the highlands and is interpreted to have formed by flooding of Reull Vallis and/or by highland erosion. Further highland degradation is preserved as Amazonian- and Hesperian-aged channeled and dissected plains, where heavily scoured surfaces indicate fluids eroded and remobilized overlying plains materials. Finally, Amazonian-aged debris flows demonstrate that mass-wasting dominates the youngest stage of highland degradation.

Drainage Basin Morphology: Rugged highland topography along with the distinctive characteristics of intermontane basin fill and the well-developed valley networks allow individual drainage basins to be identified. Drainage basins are currently defined by the areal extents of intermontane basin fill, which in most cases extends to the bases of basin-bounding massifs (Fig. 1). Mars Orbiter Laser Altimeter (MOLA) data are also being used to more precisely delineate basin divides. Twelve drainage basins were identified in the mapped area: four basins appear isolated by adjacent highland massifs; the remaining eight basins occur within connected exposures of intermontane basin fill. For these areas, basin divides are difficult to approximate; however, these basins are considered separate drainage basins as valley networks within them do not merge but radiate away from each other.

Drainage basins tend to be irregular in shape, due to the shapes of adjacent highland massifs, and are generally two to three times longer than they are wide. Basin lengths range from 6 to 75 km and widths from 2 to 39 km. After georeferencing and rectification of MTMs -40252, -40257, -45252, and -45257, basin areas for the four isolated basins in the study area were measured using ArcInfo (v. 8.0.2). Basin areas range from 110 km^2 to 712 km^2. Dissection of the basins varies with size; smaller basins tend to be more densely dissected (Fig. 1) whereas larger basins usually contain more areas of undissected terrain.

MOLA topographic data were used to estimate the upper and lower limits of the drainage basins in the study area. For this analysis drainage basins were not restricted to the edges of the intermontane basin fill, but included the adjacent topographic highs that would naturally define the basin. Each of the twelve basins identified contained at least one MOLA track; some basins contained multiple tracks with various orientations (two basins contained two tracks, one basin contained three tracks, one basin contained four tracks, and one basin contained six tracks). In all, twenty-three elevation measurements were taken with eleven tracks oriented roughly parallel to the basins and twelve tracks oriented roughly perpendicular. Track orientations were defined relative to the basin length – parallel tracks are aligned with basin long axes and perpendicular tracks cross this trend at high angles. Maximum basin elevations, defined as the highest basin-bounding elevation observed in a MOLA track, and minimum basin elevations, defined as the lowest elevation observed in a MOLA track within a basin, were found to be 3337 m and -945 m, respectively (mean ≈ 998 m). Basin relief ranges from a minimum of 385 m to a maximum of 3410 m (mean ≈ 1244 m). The upper surface of intermontane basin fill was found to occupy an elevation range of -945 m to 1341 m (mean ≈ 396 m). MOLA tracks oriented parallel to three basins show a scarp bounding intermontane basin fill at the contact with a younger smooth plains unit. Here estimates of basin fill thickness were made: two of the basins show deposits ~25 m thick, whereas the third basin showed a thickness of ~400 m.

Valley Network Morphology: All of the drainage basins identified in the study area contain valley forms. Valley network patterns include parallel, rectilinear, rectangular, and dendritic morphologies and can vary within a given basin, especially for larger basins. Dendritic and rectangular patterns tend to occur in some of the larger basins whereas parallel and rectilinear patterns are found in smaller basins as well as basins (and subbasins) with higher basin length to width ratios. Using the Strahler stream ordering system, networks in the study area range from first- to fourth-order, consistent with the Mars global average [10] and networks in Margaritifer Sinus [11,12].

Many of the larger basins display extensive areas of undissected terrain; many of the valleys in these larger basins do not extend to the basin divide (i.e., the edge of exposures of intermontane basin fill). Most valleys in intermontane basin fill appear to terminate at the surrounding highland massifs but some valleys extend headward from intermontane basin fill into the adjacent basin-rim unit, and some valleys extend downstream onto plains surfaces. Valleys found in the basin rim unit that terminate at intermontane basin fill margins generally form first- to second-order networks. Drainage densities calculated for the four isolated basins in the study area range from 0.19 to 0.50 km^{-1}. This is consistent with values for pristine and degraded martian networks (0.2-0.3 km^{-1}) [13], higher than Martian global average values (0.001-0.01 km^{-1}) [10] and those for Margaritifer Sinus (0.03-0.07 km^{-1}) [11,12], but significantly lower than terrestrial values (>2 km^{-1}) [14-18].

Conclusions: Well-developed valley networks and associated drainage basins found east of the Hellas basin form predominantly in deposits of intermontane basin fill located among massifs of ancient highland materials. Intermontane basin fill, forms irregularly shaped basins which surround and embay adjacent highland massifs. Analysis of Viking Orbiter images show a variety of valley network patterns. Dissection of drainage basins is found to vary with basin size: smaller basins are more densely dissected by networks with parallel and rectilinear patterns, whereas larger basins are less densely dissected and contain networks with dendritic and rectangular patterns. MOLA topographic data are being used to delineate basin divides, constrain elevations where intermontane basin fill occurs, and estimate the thickness of basin fill deposits. MOLA profiles show that drainage basins occur at a wide range of elevations and that intermontane basin fill forms 25 to 400 m thick deposits. Further analysis of MOLA topographic data and incorporation of ArcInfo GRID and NETWORK analyses will help constrain basin and network morphometries as well as processes of formation.

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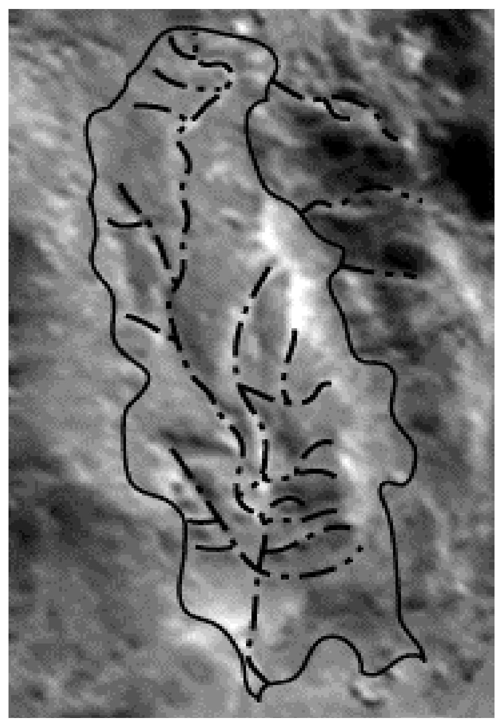

Figure 1. Drainage basin centered at 40.5°S, 253°W. Parallel network of valleys (dashed lines) dissects deposit of intermontane basin fill (solid line), bounded to the north, east, and west by basin-rim unit, opens to south into smooth plains unit. Viking Orbiter image 411S20; north is to the top.