GEOLOGIC MAPPING OF WESTERN LIBYA MONTES AND NORTHERN TYRRHENA TERRA. A. E. Huff and J. A. Skinner, Jr. Astrogeology Science Center, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ, 86001 (ahuff@usgs.gov).

Introduction: Libya Montes is a series of topographic promontories located south of Isidis Planitia, southeast of Syrtis Major, and north of Tyrrhena Terra. This region covers the highland-lowland boundary and records a sequence of Noachian- and Hesperian-aged rocks that are critical to our comprehension of the global geology and evolution of impact basin massifs, inter-massif plains and erosional sequences, and lava provenance. Broad-scale geologic and stratigraphic characteristics have been established by contextual geologic maps at global scales using *Viking* and post-*Viking* data sets [1-2]. These maps have been expanded and refined by several topical-science maps and associated investigations [3-5], which leverage specific data sets to test and/or alter geologic hypotheses, and if necessary develop new hypotheses based on the mapped observations. Contextual and topical geologic maps work in tandem to form and refine local, regional, and global geologic frameworks. To assist, we are filling a scale-based gap in the understanding of our study area by compiling a 1:1M scale geologic map to bridge global and local maps and provide context for future investigations.

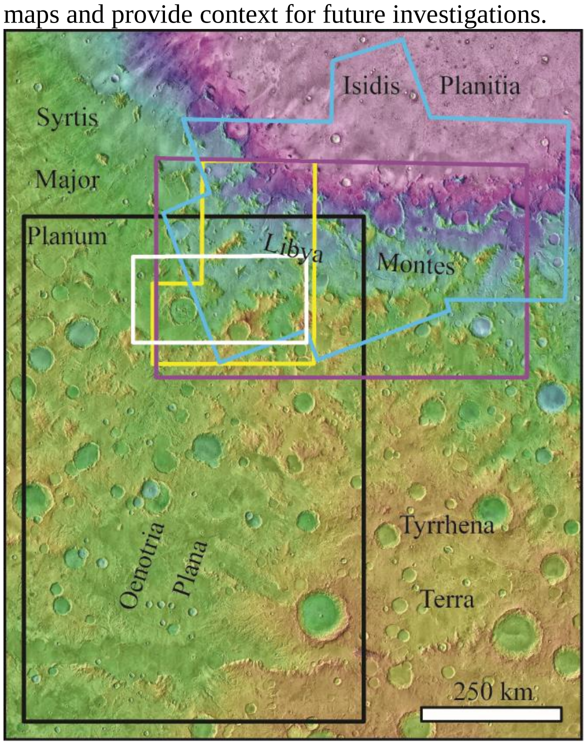

Figure 1: Our study area (black) with geographic features and other map boundaries: [3] (blue), [4] (yellow), [5] (purple). White inset is **Fig. 2 A**. (THEMIS daytime IR base with MOLA overlay: purple is -3876 km and red is 4140 km).

The first geologic map to cover Libya Montes, the *Viking*-based geologic map of southern Isidis Planitia, defined the eastern, middle, and western valley systems (WVS) of Libya Montes [3]. The WVS falls within our mapping area and its geology is complex (**Fig. 1**). As we mapped, we referred to several topical-science maps and noted mapping variances of the WVS both when comparing those maps to each other and to our own [3-5]. Herein, we show the mapping evolution of the WVS and discuss our results (**Fig. 2**).

Geologic Setting: The global-scale geologic framework for the study area has been established by USGS-published geologic maps. *Viking*-based geologic mapping at 1:15M scale [1] identified six major units in and around Libya Montes, including mountainous material (unit Nm), plateau materials (hilly (Nplh), dissected (Npld), and smooth (Hpl3) units), ridged plains (Hr), and Syrtis Major units (Hs). For the same area, post-*Viking* global geologic mapping at 1:20M scale [2] identified three major unit groups including highlands (eNh, mNh, and lNh), massifs (mNhm), and volcanics (eHv). Both of these maps established similar histories composed of Middle Noachian Isidis-related massifs, Middle Noachian erosion and inter-massif deposition by various processes, subsequent Middle and Late Noachian fluvial (and other) erosion, and partial burial by Hesperian-age lava flows from Syrtis Major. There are no intermediate-scale, USGS published maps for our study area, but there are three maps in peer review articles detailing topical studies of Libya Montes [3-5].

The three maps that overlap our study area are noteworthy due to the use of both *Viking* and post-*Viking* data [3], crater density analyses [4], and mineralogical analyses [5] (**Fig. 2**). [3] used a *Viking* mosaic (230 m/pix) augmented with MGS MOC images to identify massifs (Nm), fluvially-modified terrain (NHf), dissected plains (Hd), intermontane plains (Hi), and Syrtis Major lava flows (Hv). [4] used HRSC images (~10 m/pix) and subsequent crater size frequency analyses to identify a geologic sequence of massif material (Nm), fluted and dissected terrain (NHf), three valley deposits (vd), dissected plains (Hd), intermountain plains and highlands (Hi), and eight Syrtis Major lava flows (sm). [5] used HRSC images (12.5 m/pix) with supplemental CRISM data and OMEGA mineral maps to identify massifs (Nm), fluted and dissected terrains (NHf), eroded materials (HAe), volcanic deposits (HAvod), and valley deposits (NHAvd). All three topical maps have geologic histories for their study areas which parallel the history summarized above, but they provide a more detailed record of the style and timing of local geologic processes.

Results: We mapped at 1:250,000 on a THEMIS daytime IR controlled mosaic base map [6, 7]. We have identified four unit groups: massifs (m1 and m2), terra (t1, t2, and td), plains (p1, p2, p3, and p4), and craters (c1, c2, c3, and differentiated). We have not yet integrated crater counts into relative and absolute model ages.

Within this area, we divided the Libya Montes highlands into massifs with the greatest relief and pronounced valley-and-spur morphology (m1), and shallow (t1) or flat (t2) terra units. Infilling these topographic highs are two plains units: fluvial-altered plains (p3) and lava flows (p4). A supplemental characteristic for identifying p4 is bright albedo in THEMIS nighttime IR images, confirmed by the albedo of Syrtis Major flows to the west of Lipany Crater (**Fig. 2 A**). With this, we mapped a lava flow within a channel northeast of Lipany Crater. Comparing cross-cutting relationships, we infer p3 incised the channel that p4 later infilled. There are places along the infilled channel where the lava embayed existing fluvial junctions implying the stream system was well established before the volcanic event. However, for the scale and data sets we are using, we only identify one lava unit instead of multiple volcanic events. We restricted the lava to the incised channel as opposed to including the channel floodplain due to THEMIS nighttime IR observations. Additionally, there is a trough within the lava flow that may be a collapsed lava channel or a fluvial event. Consequently, we have not established an order for geologic events past the channel lava infill.

Discussion: Each new geologic map draws upon results presented in preceding maps and topical science investigations. **Fig. 2 B-E** shows a chronological progression of how the headwaters for the western branch of the WVS of Libya Montes were mapped. [3] was the first to map this area for the purpose of posing geologic questions about early Martian climatic conditions as reasoning for a MER target site, and identified the incised valley north of an intermontane plain. [4] followed by using comprehensive model absolute ages to place temporal constraints on local fluvial activity. These workers identified the intermontane plain as a distal Syrtis Major lava flow along with various volcanic events within the dissected valley. [5] also studied local fluvial activity by examining mineralogical data for chemical alterations, resulting in mapped valley deposits for the incised channel and dissected lavas for its floodplain. With the aid of these previous maps paired with the additional context provided by the larger map area and THEMIS and CTX data sets, we have mapped the continuous lava flow within the incised channel that bisects the fluvial plains. We acknowledge the possible presence of lava within the floodplain, but based on our unit descriptions and cross cutting relationships we have mapped it as p3.

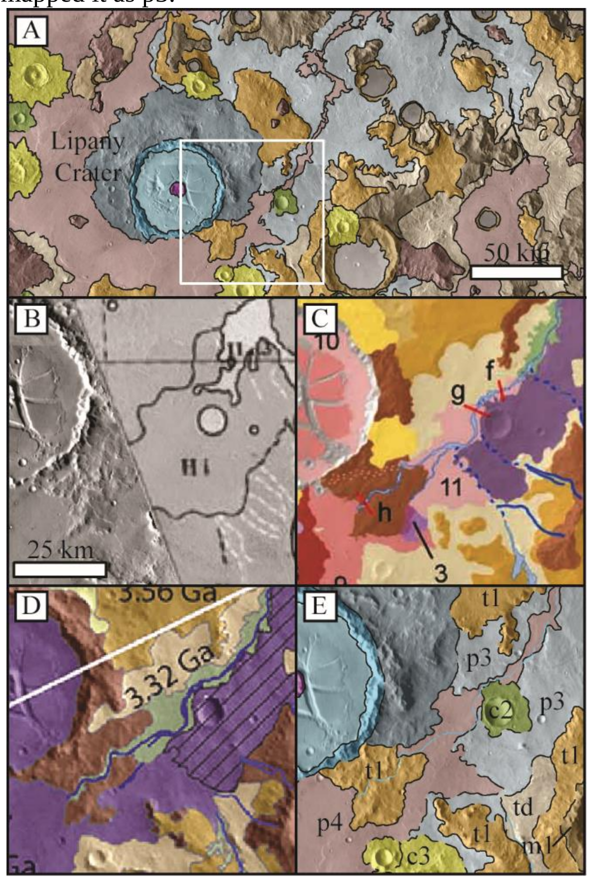

Figure 2: A – Overview of our mapping from **Fig. 1**. B-E (white inset of A) are used for comparing mapping evolution of the western headwaters of the WVS: B – [3]. C – [4]. D – [5]. E – our mapping. B scale applies to C – E.

References: [1] Greeley R. and Guest J. E. (1987) *USGS I-1802-B*, 1:15M scale. [2] Tanaka, K. L. et al. (2014) *USGS SIM 3292*, 1:20M scale. [3] Crumpler L. S. and Tanaka K. L. (2003) *JGR*, *108*. [4] Jaumann R. et al. (2010) *EPSL*, *294*, 212-290. [5] Bishop J. L. et al. (2013) *JGR*, *118*, 487-513. [6] Christensen P. R. et al. (2004) *Space Sci. Rev.*, *110*, 85-130. [7] Fergason R. L. et al. (2013) *LPS XLIV*, Abstract #1642.

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