MARS LANDING SITES IN PHYLLOSILICATE, CARBONATE, AND ANCIENT WET NOACHIAN TERRAINS OF LIBYA MONTES.. L. Crumpler[1] and Athena Science Team. [1]New Mexico Museum of Natural History & Science, 1801 Mountain Rd NW Albuquerque, NM, 87104,USA, larry.crumpler@state.nm.us,

Introduction: Landing sites within the lower elevations of Libya Montes offer access to potential outcrops of carbonates [*1,2,3*], phyllosilicates [*4*], and ancient crustal rocks [*5, 6*], as well as volcanic rocks of intermediate Martian geologic age. Several preliminary landing ellipses (~15 km diameter) are proposed in this pilot study (with potential for improved locations with more data) ranging from ellipses with access to known phyllosilicates within 5-10 km to sites with immediate access to volcanic rocks and/or sediments shed off of the steep local massifs. Given the near ubiquity of phyllosilicate signatures in CRISM data, there is a high probability of access to phyllosilicates and related carbonates within shorter traverses, including within the immediate area of a lander.

Mission Description: Important goals of the proposed mission are to provide both materials bearing hydrous mineral phases as required for current Mars exploration goals and to provide a diverse range of ancient crustal rocks and younger volcanic rocks. The inclusion of additional rock types provides not only the potential for other *in situ* discoveries, but broadens the relevance of the mission to other areas of potential rewarding Mars science investigation, such as volcanic petrology, landscape evolution, and stratigraphy.

The goal of the mission is to land a rover with traverse capabilities of greater than a few kilometers on one of the intermontane areas, and to traverse to sites within the landing ellipse to sample outcrops of phyllosilicates and possible carbonates (***Fig. 1***). The rover would include instruments capable of *in situ* analysis and proximal remote sensing oriented toward a campaign of reconnaissance geologic mapping and sampling.

Science Merit Related to Mission Objectives: The proposed site lies on the lower reaches of the Libya Montes where the surface grades to the Isidis plains, and where substantial valley networks and channels have deposited materials from the surrounding massifs. Recent work with MRO/CRISM data [*1,2,3,4*] has identified many sites of phyllosilicates and carbonates within the proposed region. Based on the fact that many sites too of important hydrous mineralogy have been encountered by Spirit in the Columbia Hills that are too small to be detected in CRISM data, the apparent abundance of large areas of important targets in CRISM data for the Libya Montes bodes well for the availability of phyllosilicates and carbonates within relatively short traverse by a rover.

The Libya Montes have been mapped in the course of previous landing site studies [*6*] prior to the latest results of MRO. New data confirms that this is a geologically complex

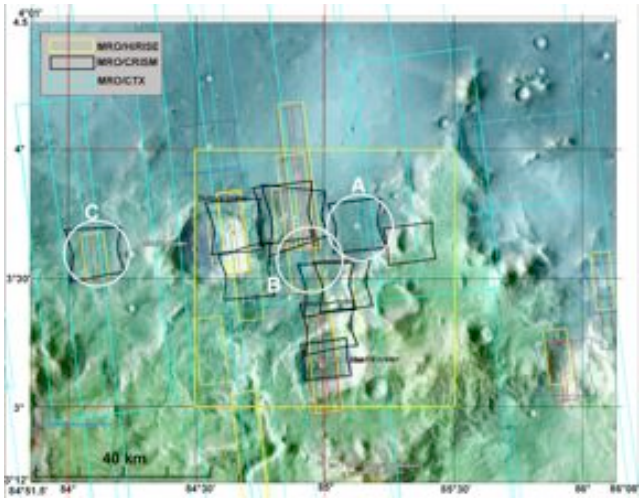

Figure 1: *Composite of the Libya Montes in MOLA color elevation on THEMIS Day IR. Three pilot study ellipses are centered at (A) 3° 41.5'N/85°37'E, (B) 3°34.5'N/84°26.5'E. and (C) 3°34.5'N/84°6.5'E at an elevation between -2.5 km and -3.3 km with respect to the geoid in MOLA planetocentric coordinates. The prime science* targets within the ellipses are phyllosilicates, likely carbonates [*1*], and some of the oldest terrain on Mars. Black, red, and light blue lines show the footprints of MRO/CTX, HiRISE, and CRISM data products respectively.

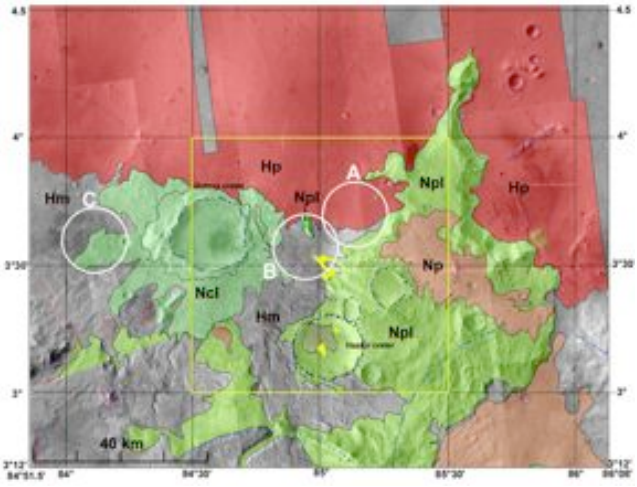

Figure 2: *generalized geologic map based on MRO/CTX mosaic base supplemented with MRO/HiRISE images. Small yellow areas near center of map within " target B" are identified carbonates (MRO/CRISM, [1]).Extremely eroded and valley network-rich Noachian highland terrains (Npl) are sites of most identified phyllosilicates (MRO/CRISM). Other units: Hp- Hesperian Isidis plains (two units, upper and lower identified, onlap Npl); Ncl- Noachian late crater material units; Hm-late Hesperian valley floors.*

area, that there are multiple lithologies present, and that clear stratigraphic relations may be observed implying a very long and varied geologic history. Substantial ancient "bedrock" is present in the form of mountainous terrains that are placed at the lowest stratigraphic level in Martian geologic history [7] and possibly sampling the events in the formation of the Isidis Basin. The intermontane areas are filled with a variety of younger materials ranging from layered materials, materials exhibiting fluid flow characteristics, either mass flow or lavas, and numerous valley networks (Hm). Impact craters cut across many of these lithologies, and the breached rims have provided access for inflow of later materials. In at least one available CRISM image a lobate-shaped tabular material, possibly lavas, occurs within a crater adjacent to valley networks. Impact craters cut across many of these lithologies, and the breached rims have provided access for inflow of later materials. In at least one available CRISM image a lobate-shaped tabular material, possibly lavas, occurs within a crater adjacent to the lowland plains. Based on high spatial resolution mapping (***Fig 2***) this unit overlies and is in sharp contact with materials bearing phyllosilicates on the crater floor. The above sample of summary points indicates significant potential for encountering materials of diverse origin and age, and that these materials may be placed in both a regional and global stratigraphic context. Even the volcanic materials would be significant in that they likely represent distal outliers of Syrtis Major Planum lavas, which are of intermediate geologic age, a prime candidate for sample return for volcanic rocks in general. In summary, this site offers the potential to sample a wide range of Martian geologic history while also satisfying the desire for materials bearing hydrous mineralogies.

Table 1: *The location of Libya Montes sites and their principal target characteristics. Three pilot ellipses are included initially. Further study will be used to restrict the pro-*

Center Coordinates Lat/Long	3° 41.5' N 85° 37'E	3° 34.5' N 84° 26.5'E	3° 35.5' N 84° 6.5'E
Elevation	-3.11 km wrt MOLA	-2.54 km wrt MOLA	-3.29 km wrt MOLA
Ellipse Size	15 km by 15 km	15 km by 15 km	15 km by 15 km
Prime Science Targets	carbonates, phyllosilicates [Highest Priority]; Syrtis basalts [Lowest Priority]	carbonates, phyllosilicates [Highest Priority; Syrtis basalts [Lowest Priority]	carbonates, phyllosilicates [Highest Priority]; Syrtis basalts [Lowest Priority]
Distance of Science Targets from Ellipse Center	Carbonates – ? km; phyllosilicates, 6 km, Basalt, 0 km(?)	Carbonates – ? km; phyllosilicates, 2 km, Basalt, 0 km(?)	Carbonates – ? km; phyllosilicates, 6 km

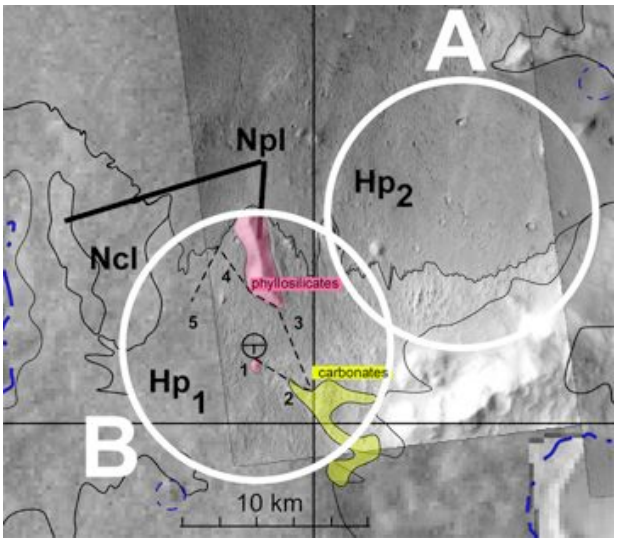

Figure 3: *Simple traverse from the target center encompassing both phyllosilicate and carbonate-rich areas. The Traverse (1-4) visits ancient Noachian materials and crosses the unconformity with overlying Hesperian plains units. This includes both upper and lower Isidis basin plains (Hp2 and Hp1). The traverse then continues south (5) into the Hesperian valley floor units (unit Hm, see Fig 2).*

Landing Ellipse: Three pilot study ellipses are shown on ***Figure 1 and 2*** for purposes of discussion, assuming a 15 km-diameter landing ellipse based on EDL design architecture similar to current technology. Several areas of relatively low-lyng to flat relief are identified that lie near or within known areas of phyllosilicate and/or carbonates. An hypothetical traverse as shown in ***Figure 3*** for ellipse **B** is capable of sampling several lithologies within a few kilometers and phyllosilicate areas all lay within less than 6 km at most. The traverse would start in valley floor material, and would proceed to local outcrops of either the ancient massif material or phyllosilicates, whichever is closer. Given the evidence for carbonates in the Libya Montes, it is also possible that local materials will enable early detection and analysis of carbonates. Beyond the ellipse, the geologic complexity is such that numerous additional targets of significant value in understanding the regional stratigraphy and geologic history will be available.

References: [1] B. Ehlmann et al, Science, 2008. DOI: 10.1126/science.1164759, [2] Bishop et al. (2010) LPSC, #2147, [3] Bishop et al. (2010) LPSC,#2605, [4] Bishop, J. L., et al. (2007) 7th Int'l Mars Conf, [5] Crumpler, L. S., and K. L. Tanaka (2003) J. Geophys. Res., 108, DOI: 8010.1029 /2002JE002040. [6] R. Jaumann et al (2009) EPSL, doi:10.1016/j.epsl.2009.09.026, [7] R. Greeley and J. Guest (1987) Geol Map Eastern Eq. Region, Mars, USGS I-1802-B