WESTERN PROMETHEI TERRA, MARS: PRELIMINARY VIEW OF THE GEOLOGICAL HISTORY.

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Introduction: The westernmost edge of Promethei Terra around the major channels of Harmakhis and Reull Valles is an area of smooth plains where massifs of ancient cratered terrains are rare [1-9]. The Noachian cratered terrains surround this territory from the N, E, and S. The plains bear numerous fluvial features (e.g. small channels) that occur on both sides of the lower portion of Reull Vallis but are especially widespread in the area between Reull and Harmakhis Valles. This area also displays a set of features that does not occur elsewhere on the eastern side of the Hellas basin.

In the earlier works we studied in detail the fluvial history of Hesperia Planitia [10] and evolution of the fluvial system of Reull Vallis [11]. The western Promethei Terra includes the lowermost portion of the Reull Vallis and may provide additional information on the evolution of this system. We studied this territory in order to establish the major episodes of its geologic history and see if they relate to the evolution of the Reull Vallis system or not. We used a variety of available data (MOLA gridded altimetry, MOC and THEMIS (IR & VIS) data, and HRSC images). Here we present the preliminary results of our investigation.

Regional topography: The studied area (35-45°S, 90-110°E) is ~600 km across and occurs within the elevation range from ~-0 to -5.0 km. The regional topographic profile from the E to the W shows that the study area consists of two distinct parts. The eastern side of the territory (from ~104 to ~97°E) is practically horizontal (mean regional slope is ~0.07^o). A break of slope occurs at ~97°E and the area to the W of it is on significantly steeper regional slope (~0.88^o). V-shaped narrow (several km wide) topographic depressions oriented preferentially in the E-W direction characterise this zone of the enhanced topographic gradient. The S-N topographic profile shows that the surface is steady lowering from ~-1 km at the southern edge of the smooth plains (at ~49°S) to ~-2 km near the lower portion of Reull Vallis (at ~40°S). The mean regional slope is ~0.18^o.

Background terrain types: Two major types of terrain characterise the western portion of Promethei Terra. 1) *The Noachian-aged cratered materials with rough and rugged surface*. Massifs of this terrain are usually high (several km) and preferentially occur on the northern side of Reull Vallis. To the south Reull, there is only a few such massifs. Just to the S of the end of Reull Vallis, small and low massifs arranged in a circle ~100 km in diameter and probably represent remnants of heavily eroded rim of a large crater [12,13]. 2) *The smooth plains which occupy the low areas between the massifs*. The plains occur on both sides of Reull and Harmakhis Valles and are more abundant in the area between Reull and Harmakhis. Their multi-layered nature is seen on the walls of the canyons that cut the plains. The mean thickness of the layers is estimated to be ~40-50 m and total thickness of the stack of the layers is at least 1-1.5 km. In many places, narrow wrinkle ridges deform the surface of the plains. WR mostly occur in the eastern portion of the area near Reull and Teviot Valles but some of them are seen near Harmakhis Vallis in the west. WR appear to avoid the area of the steeper topographic gradient. The multi-layered structure and WR are the typical features of vast lava plateaus (e.g. Hesperia Planum and Lunae Planum) on Mars [e.g. 14]). Thus, we interpret the smooth plains to be the surface of thick stacks of lava flows. In places, very narrow (<1 km), low (10s m), and long (10s km) straight and curvilinear ridges are seen on the surface of the plains. Usually, they occur in groups (swarms) oriented preferentially in NE direction and the regional topography does not appear to control the distribution of the ridges. The morphologic characteristics of the ridges, their areal distribution, and close association with the lava plains are consistent with and suggest that the ridges may represent exhumed dikes [15] that served as feeders for the lava plains. The crater retention age of the smooth plains on both sides of the lower portion of Reull Vallis appears to be noticeably different. The plains to the north were determined to be of Hesperian age [16] while the area to the south of Reull corresponds to the transition from Hesperian to lower Amazonian [11,16].

Features related to modification of the major terrain types: The background terrain types were modified subsequently to their emplacement by late secondary processes, the most effective of which appears to have been fluvial activity. The most pronounced and most recent features of this kind are flow-like debris aprons that surround almost all massifs of the Noachian terrain [17]. The close association of the flows with the Noachian massifs is resulted in virtual lack of the flows in the region between Reull and Harmakhis Valles where the massifs are almost absent. Instead of lobate flows, other types of features manifest fluvial activity in the western portion of Promethei Terra. <u>*Sinuous channels:*</u> The most prominent features there are narrow (100s m up to a few km wide) and sinuous to meandering channels that usually inserted within V- or U-shaped valleys. There are several tens of these channels in the area of our study and each of them has no obvious sources. The channels and the valleys preferentially occur and are more prominent in the area of the higher topographic gradient where the valleys are wider and deeper than elsewhere. At the high resolution of the HRSC and THEMIS-VIS images a braided pattern is seen where the channels get broader. The channels have either no or only a few tributaries and do not form the den-

dritic pattern of integrated features that occur, for example, in the cratered terrain around Hesperia Planum [18,19]. *Mesas:* Flat-topped and low (10s m to a few 100s m high) mesa-like hills are scattered throughout the plains to the south of the lower Reull. They have irregular shape and vary in size from tens to hundreds of km. Although the mesas preferentially occur to the east of ~95°E in the area of the shallow regional slope, some of them are also seen on the steeper inner wall of Hellas. The pattern of distribution of the mesas suggests that they represent isolated fragments of a deposit that was more widespread and contiguous in the past. Typically, the mesas have very sinuous to scalloped edges are surrounded by low ridges at the base. Sometimes, mesas display broad terraces that may indicate rough layering of the mesa bodies. The number of terraces is usually 2-3 that may correspond to the mean thickness of the layers to be 50-75 m. The sinuous channels either run around the mesas or appear to begin within broad and shallow depressions on top of mesas. These relationships suggest that formation of the channels and mesas was roughly synchronous. For additional information on the mesas, see also [20].

Ridges: Three types of ridges occur on the southern side of the lower Reull. These ridges are not abundant and usually presented by low structures (a few 10s m high) that are a few kilometers wide and several kilometers long. The ridges do not display a preferential orientation and do not correlate with the local relief. They appear as either very sinuous or bent features and, in places, consist of chains of shorter segments with rounded edges. The short ridges are very different from both wrinkle ridges and long straight ridges that likely related to emplacement and deformation of the background lava plains. The sinuosity, segmentation, and relationships with local topography of the short ridges suggest that they may be features akin to the terrestrial eskers.

Discussion: Five important features of the western part of Promethei Terra are the keys to understanding the geologic history of this region. 1) In the circum-Hellas topographic profile this area represents a large depression that is ~2 km deeper than the rest of the Hellas basin rim [10]. 2) Within this region, massifs of the Noachian cratered terrain are rare or absent. 3) The large portion of this area is covered by a thick sequence of lava flows, the cross-section of which is seen on the walls of Reull, Teviot, and Harmakhis Valles. 4) The sinuous channels, mesas, and esker-like features are preferentially concentrated in the area between the low Reull and Harmakhis Valles. 5) The crater retention age of the area to the north of Reull Vallis corresponds to Hesperian time while the surface to the south of Reull is younger and displays Hesperian-Amazonian ages [7,16].

These features could be integrated into a geologic history consisting of three major episodes. **1)** Phase of massive erosion erased most of the Noachian terrain in the broad region to the south of Reull Vallis. The erosion could be induced by intrusion of hot magma into the ice-saturated regolith. This mechanism was proposed for the vast volcanic plains in Hesperia Planum [21]. **2)** Large volume of lava filled the eroded area at the second episode that occurred, according to the crater statistics [22,23,7,10], during Hesperian time. **3)** The abundant fluvial-related features and the younger age of terrains to the south of Reull suggest that there was a episode in the geologic history that was related to relatively late resurfacing. The presence of the channels requires a source of water. The channels are sinuous to meandering and typically inserted into the V- or box-shaped valleys. This implies that the channels were cut by a sustained flow or by repeating flows along the same path. The channels have a few tributaries and do not form an integrated pattern. This suggests the presence of localised individual source for each channel and, thus, is poorly consistent with the precipitation and run-off. The presence of a possible subsurface aquifer that fed the channels has little support because such features as sagged or collapsed depressions or pits, are absent near the beginning of the channels. On the other hand, the general topographic configuration of the western Promethei Terra shows no evidence for possible large or small closed topographic depressions that may have served as transient basins that stored and released water. Thus, either precipitation and run-off or subsurface aquifer(s) or open lake(s) as the sources for the channels have little observational support.

The other possibility that may explain both the channel formation and the resurfacing episode is the presence of a glacier in the western Promethei Terra. The basal melting [24] may explain the meandering, low number of tributaries, and localised sources of the channels. The melting on the surface would be consistent with the alignment of most of the channels about along the same line that may mark the edge of the glacier. The problem with the surface melting, however, is that if the Martian atmosphere during the glaciation was as thin as at the present it would strongly favor sublimation over melting. In the framework of the glacier model, the mesas (see also [20]) may represent a lag deposit of a low-strength material and the short and segmented ridges may be interpreted as eskers.

References: [1] Potter (1976) *USGS I-941*; [2] King (1978) *USGS I-1073*; [3] Scott & Carr (1978) *USGS I-1083*; [4] Scott &. Tanaka (1986) *USGS I-1802-A*; [5] Greeley & Guest (1987) *USGS I-1802-B*; [6] Crown et al. (1992) *Icarus*; [7] Price (1998) *USGS I-2557*; [8] Mest & Crown (2002) *USGS I-2730*; [9] Mest & Crown (2002) *USGS I-2763*; [10] Ivanov et al. (2005) *JGR*; [11] Kostama et al. (2006) *LPSC37*; [12] Tanaka & Leonard (1995) *JGR*; [13] Leonard & Tanaka (2001) *USGS I-2694*; [14] Greeley & Spudis (1981) *RGSP*; [15] Head et al. (2006) *Geology*; [16] Mest & Crown (2001) *Icarus*; [17] Head et al. (2005) *Nature*; [18] Carr (1995) *JGR*; [19] Carr & Chuang (1997) *JGR*; [20] Korteniemi et al. (2007) *this conf.*; [21] Tanaka et al. (2002) *GRL*; [22] Tanaka (1986) *JGR*; [23] Tanaka et al. (1992) *in: Mars, UAP*; [24] Carr & Head (2003) *GRL*.