OUTFLOW CHANNELS OF MARS: FORMATION PROCESS AND TIMING OF WAIKATO VALLIS-MORPHEOS BASIN-REULL VALLIS –FLUVIAL SYSTEM IN THE EASTERN HELLAS RIM REGION.

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Introduction: Although majority of the large scale outflow channels of Hellas basin that are characteristic to its eastern rim region are located in the large scale topographic trough connecting Hesperia Planum and Hellas [1,2], the most far-reaching of them, Reull Vallis is located to the S-SE of this trough, cutting Promethei Terra. Reull and the general geology of the region have been studied in the past [i.e., 3,4], but recent high resolution data enables to analyze the implicating details of fluvial history within the features and the region as a whole. Mapping and crater counting utilizing CTX, HiRISE and HRSC give new insights and constraints to timing of the events, features, and episodes.

This study yielded more detailed age constraints compared to the previous results from Viking images [3]. The calculations and the geological study of the WMR system (Waikato Vallis – Morpheos basin – Reull Vallis) region and southern Hesperia Planum enabled to estimate more exact time-frame of the Morpheos reservoir and also the formation time of the upper Reull Vallis and Waikato Vallis outflow channels. The fluvial system was formed in the period of 3.67-3.52 Ga. The results also define the size (to be confined below the 500-550 m contour level) of the previously identified Morpheos basin reservoir, which may have been an open-basin lake [5,6] for a period of time.

Key regions and features: The studied WMR-system is located in the southern part of Hesperia Planum. These, mostly volcanic plains form the general setting of the region for the pre-WMR geology. The plains are cut by the emerging first part of the system. As portrayed also by the earlier studies of this region, this former Segment 1 of the Reull Vallis, now named Waikato Vallis has a complex history. It is different from the other outflow channels of the Hellas rim region by showing features more related to riverine activity [4]. More importantly, it does not have a single theater-head style beginning; in fact there are three to four separate points of origins that all have fed into the same general channel system. Mapping in CTX resolution showed evidence of at least three levels of flooding events.

It was previously suggested [3] that the concentrated erosion of the crater 1 (Cr 1) and the crater 2 (Cr 2) rims in the N-NE part and the missing connection between the previously named [4] two uppermost Reull segments (1 and 2) may hold some indications where the flows from the Waikato Vallis may have continued. In CTX resolution this is even more obvious (Fig.1), as the large ejecta field to the east gently connects to the embaying unit within the crater 1. Also, there are three subdued craters (Fig. 1) of which only part of the rim (Cr3a) or just indication of crater topography (Cr3b and Cr3c) is remaining. This is in contrast to the quite well preserved rim of the crater 1 (Cr1) and the adjoining crater 2 (Cr2) to the south.

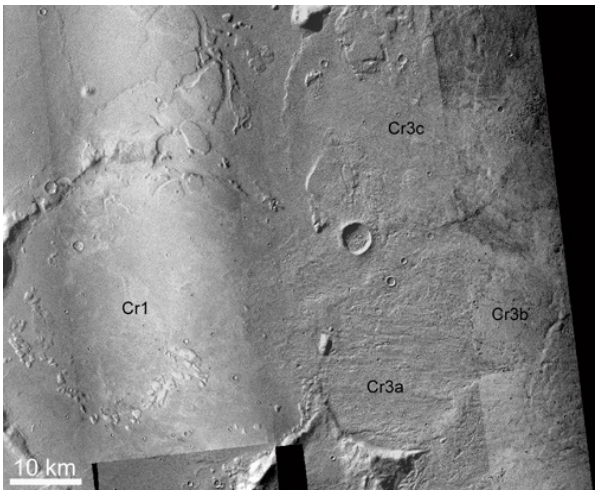

Figure 1. CTX image of the connection of Waikato Vallis and the crater cluster to the north of Morpheos basin.

Second part of the WMR-system, Morpheos basin is a large topographic depression between Waikato and Reull Vallis segments. It has been suggested to have been filled by the flows from Waikato before the formation of Reull Vallis proper (Segment 2) [i.e., 3]. Studies of the basin region have resulted to some propositions of the basin size limits [3,6].

Reull Vallis, the part of the WMR system that was previously known as Segment 2 begins as a full-sized feature directly from the Morpheos basin. As the exact formation history of the lower part of Reull is somewhat debatable [cf., 3], we refer to this part of the WMR system as upper Reull Vallis which continues as a single continuous structure until it connects to the Teviot Vallis associated part of the larger Vallis system. The upper Reull floor shows abundant evidence of flows, channeling and cutting of the basin and valley floor. More importantly, there are terraces that are seen on the walls of the channel implying more than one event of flows from the source region (Fig. 2). Details

on the channel floor also suggest multitude of flow events and diminishing flow activity.

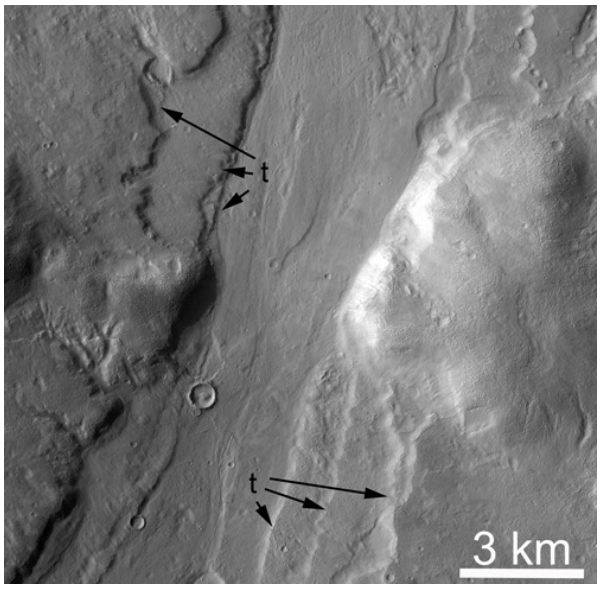

Figure 2. Detail image of the Reull Vallis showing the terraces (t) in the walls of the channel as well as remnants of the crater rim which was cut by the flow.

Timing of the WMR: According to our hypothesis, the Morpheos basin served as a place of accumulation from Waikato Vallis. This kind of resurfacing effect should appear on the cumulative crater frequency plots. To test our hypothesis, the crater counts were performed both above (in Hesperia Planum) and below the expected 500 m contour level of the basin. We noted that due to a far reaching secondary field of the impact crater 4 (D~33 km, 35.5°S, 115.5°E) on the north-eastern Morpheos basin, the suitable counting areas were limited. But because of the embaying of the Morpheos basin, the ejecta deposit of this crater is in fact a useful stratigraphic marker in the region and therefore a proper area for crater counting.

Combined counts from Hesperia Planum volcanic plains gave an age for the formation of Hesperia Planum lava plains. This age of ~3.67 Ga represents the lower deadline for the formation of Waikato Vallis as the valley structures cut the lava plains.

We also measured the cratering model age for the impact ejecta of the noted crater 4 (35.5°S, 115.5°E). Because it embays the structures of Waikato Vallis and Morpheos basin, it gives us the second needed stratigraphic marker for the WMR-system. The age of the impact deposit was estimated to be ~3.52 Ga. This is the higher deadline for the filling of the reservoir by the effluents of Waikato Vallis, and thus the higher deadline for the formation of the Waikato Vallis. These two markers confine time-wisely the formation of the WMR system and formation of these regional outflow channels to the period between 3.52-3.67 Ga. This period is presented as phases B and C in the formation scheme (Fig. 3).

Conclusions: The existence of the previously suggested on-surface reservoir of Morpheos basin between Waikato and Reull Valles was confirmed. Also, necessary information for a refined evolution scheme for the presented WMR fluvial system was found. The system was formed and was subject to several flow episodes rather than just one phase of activity during a limited period of time between 3.52-3.67 Ga. This is seen as the complexity of Waikato Vallis and Morpheos basin, and as the multitude of channels and other observed implications of flow activity, and from the details of the Reull Vallis channel structure. Age of the formation of WMR (Waikato Vallis–Morpheos basin–Reull Vallis) was determined based on two stratigraphic units, 1) the Hesperia Planum lava plains cut by the formation of the WMR structures, and 2) the widely spread and easily identifiable ejecta blanket from the impact event in coordinates 35.5°S, 115.5°E.

The analysis of the study region also revealed a more exact size for Morpheos basin. Geological mapping supported by the crater counts imply that the basin was filled up to the ~500-550 m contour line. This result supports the study of Capitoli and Mest [7], in which this limit was also suggested due to the measured volumes of the segments of Reull Vallis.

References: [1] Ivanov, M.A. et al. (2005) *JGR*, 110, E12S21. [2] Kostama, V.-P. et al. (2010) *EPSL*, 294, 321-331. [3] Kostama, V.-P. et al. (2007) *JGR*, 112, E11001. [4] Mest, S.C. and Crown, D.A. (2001) *Icarus*. 153, 89-110. [5] Cabrol, N.A and Grin, E.A. (1999) *Icarus*, 142, 160-172. [6] Fassett, C. and Head, J.W. (2008) *Icarus*, 198, 37-56. [7] Capitoli, E.J. and Mest, S.C. (2010) *First Int. Conf. on Mars Sedimentology and Stratigraphy*, 1547, 12.

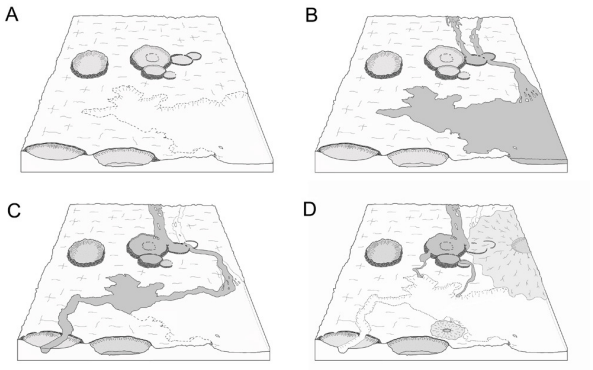

Figure 3. Evolution scheme of the Waikato Vallis – Morpheos basin – Reull Vallis (WMR) system.