HELLAS OUTFLOW CHANNEL STUDY: FORMATION AND TIMING OF WAIKATO AND REULL VALLES, MARS

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1. Introduction

The outflow channels of the Hellas basin are characteristic to its eastern rim region (Fig. 1). Although majority of the Valles are located in the large scale topographic trough connecting Hesperia Planum and Hellas basin [1], the most far-reaching of them, Reull Vallis is situated to the S-SE of this trough cutting through Promethei Terra. Mapping, using the newly available data and extensive crater counting utilizing CTX, HiRISE and HRSC provided new insights to the timing of the regional events and episodes associated with Reull Vallis.

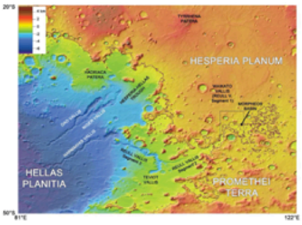


Fig. 1. MOLA DEM of Hellas rim region. Morpheos basin is located between the previously identified two segments of the upper Reull Vallis system [2,3]. The outline of the basin shown is roughly based on the 500 m contour line.

The study resulted in more detailed age constraints compared to the previous results from Viking images [2]. Calculations and the geological study of the upper WMR system (Waikato Vallis – Morpheos basin – Reull Vallis) region and southern Hesperia Planum enabled us to estimate the time-frame of the formation of this reservoir which is also the formation time of the upper Reull Vallis and Waikato Vallis outflow channels. The study also aimed to more explicitly define the size of the previously identified Morpheos basin (confined to the 500-550 m contour lines).

We present a geological analysis of the upper parts of WMR system, and using the observations and calculations, present an updated view of the evolution of the system and associated region.

3. Age of the WMR formation

Morpheos basin resurfacing effect should appear on the cumulative crater frequency plot as a step in the distribution between two segments that have different tangential isochrones [e.g. 5,6]. However, previous crater counts based on the Viking data [2] showed an indistinguishable age difference between the Morpheos basin and surrounding Hesperia Planum.

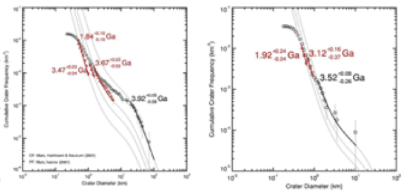


Fig. 9: Results of the crater counts: A) Hesperia Planum surfaces. Formation of the plains ~3.67 Ga. B) Ejecta of the eastern crater 4 (35.5°S, 115.5°E). Impact event that formed crater 4 occurred at ~3.52 Ga.

To test our hypothesis, the crater counts were performed both above and below the expected 500 m contour level of the Morpheos basin. For combined counts from Hesperia Planum volcanic plains, an average age of 3.67 Ga was obtained for the formation of Hesperia Planum lava plains and younger model ages for the Morpheos basin floor units. We also measured the cratering model age for the impact ejecta (unit e in Fig. 3) of the crater 4 (35.5°S, 115.5°E). Because it embays Waikato Vallis and units on Morpheos basin, the ejecta deposit is a stratigraphic marker within the studied region.

The age of the impact deposit was estimated to be 3.52 Ga. This should therefore be the higher deadline for the filling of the reservoir by the effluents of Waikato Vallis, and thus the higher deadline for the formation of units Hbv2 and Hbv3, and formation of the Waikato Vallis.

4. Updated sequence of events of formation of Reull Vallis

Two major stratigraphic markers were found. These two markers confine time-wisely the formation of the WMR system and formation of the regional outflow channels to the ~150 Ma period between 3.52-3.67 Ga. This period is presented as phases B and C in the formation scheme (Fig. 10).

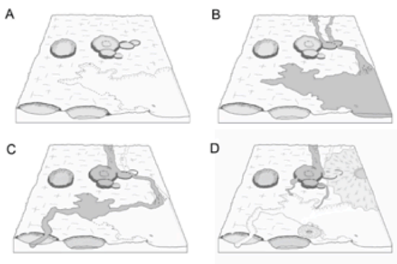


Fig. 10. Evolution of the Waikato Vallis – Morpheos basin – Reull Vallis (WMR) system. Mapping, observations and crater counts were used to analyze in detail the regional evolution. The formation scheme of the WMR system is presented in four phases.

A) Placement of the regional Hesperia Planum lava flows, and formation of the larger impact structures (Fitzroy, Gregg and Cr1-3). Morpheos basin is a local topographic low.

B) First activity of Waikato Vallis initiates channel formation, erodes the crater rims of Cr3a-c and cuts through the southern Hesperia Planum. The flows connect and empty to the existing Morpheos basin depression filling it partly with transported material.

C) Continued activity from the source regions of Waikato Vallis breach the rim of Cr1, and fill the crater (at least partly). The already formed channels to the east are favored and Cr3a-c are even more eroded. Previously partly filled Morpheos basin depression to the south is filled in the deepest parts to the west until the flows breach the neck in the west thus forming the Reull Vallis.

D) The large impact to the east is formed and the extensive ejecta blanket covers majority of the previous signs of activity. Some remains of the first activity phases can still be seen (eroded crater rims, tear drop shaped islands and flow fans). Later activity from Waikato Vallis fill the large crater and adjoining smaller crater in the crater cluster and in places overflow the SW-S-SE rims. The deposits left from these flows are later eroded, as is the floor of the now empty Morpheos basin reservoir. Latest activities in the region are the viscous flows on the rims of the craters and channel walls and floors.

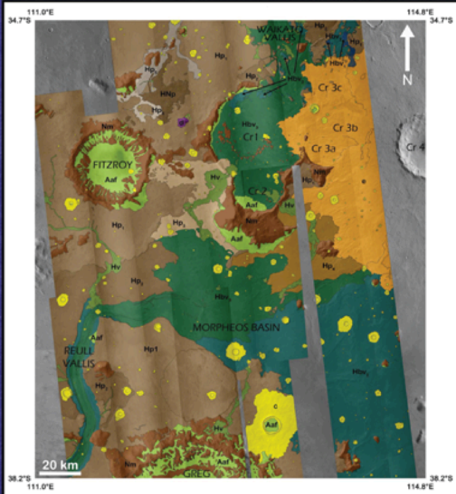


Fig. 3. The available CTX coverage of the studied Waikato Vallis-Morpheos basin-Reull Vallis system was used in mapping of the system, Fig. 3a (up). Data from HRSC images is included to show the Cr 4 to the east of the mosaic. Map shows the three major suites within the region (basement and plains, valley and basin materials, and impact related units). Stratigraphic relation of the units is shown in Fig. 3b (right).

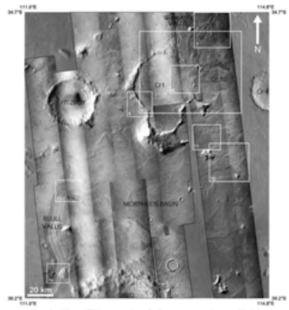
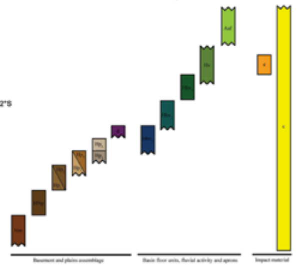


Fig. 2. The CTX mosaic of the currently available images of the WMR study region shown on the background of HRSC images. Image shows the locations of the detail images.



2. Geology of the WMR system

Reull Vallis and its surrounding regions have been studied extensively in the past [i.e., 1-4]. These studies have been mostly based on the existing data (i.e. Viking, HRSC, and THEMIS) and the large scale properties have been therefore well documented. However, the details of the geology of the upper Reull Vallis system (WMR), and some of the missing parts of the evolution scheme are now studied with the new, high resolution data (Figs. 2-8). The CTX-mosaic (Fig. 2) based geological mapping of the study region is presented in Figure 3. Figures 7 and 8 show some of the indications of the embayed continuation of the valley structure.

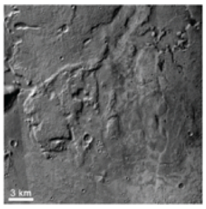


Fig. 4. CTX detail image of the early phases of the Waikato Vallis. The ejecta from the eastern impact crater embay the continuation of the valley structures. Location (7) is shown in Fig. 2.

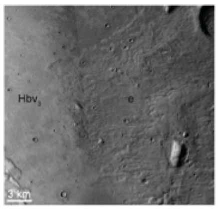


Fig. 5. Connection of the Vallis floor unit Hbv3 in the crater 1 and the ejecta blanket (e) from the crater 4 to the east of the Waikato Vallis southern parts. Location (8) is shown in Fig. 2.

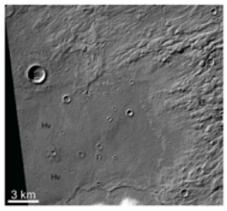


Fig. 6. Remnants of the Hv unit are observed (11) on top of the older regional valley/basin floor units. The ejecta (e) from the eastern crater 4 embay the older flow units.

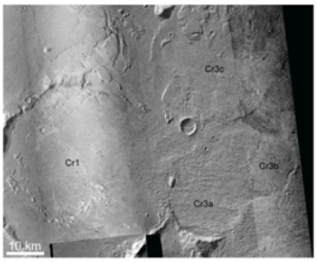
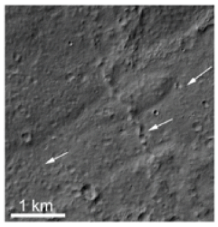


Fig. 7 (left). CTX image of the connection of the Waikato Vallis and the crater cluster to the north of Morpheos basin. Crater 1 and 3a are partly well defined whereas the crater 3b and 3c remnants are seen mostly as changes in topography. Fig. 2 location (9).

Fig. 8 (right). Detail image from the floor of Morpheos basin showing the subdued form of a tear-shaped island within a topographic channel. White arrows show the flow direction.



5. Conclusions

The analysis of the study region confirms the existence of the previously suggested on-surface reservoir of Morpheos basin between Waikato and Reull Valles. Also, the more exact size for Morpheos basin was determined. Geological mapping supported by the crater counts imply that the basin was filled up to the ~500-550 m contour line.

Necessary information for a refined evolution scheme for the WMR fluvial system was found (Fig. 10). 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 study shows that the system was formed and was subject to several pulses rather than just one phase of activity during a limited period of time between 3.52-3.67 Ga.

References

[1] Kostama, V.-P., et al. 2010, Earth and Planet. Sci. Lett., 294, doi:10.1016/j.epsl.2009.11.021, [2] Kostama, V.-P. et al. 2007, J. Geophys. Res., 112, doi:10.1029/2006JE002848, [3] Mest, S. C. and Crown, D. A., 2001, Icarus, 153, DOI: 10.1006/icar.2001.6655, [4] Ivanov, M. A., 2005, Journ. Geophys. Res., 110, Doi: 10.1029/2005JE002420, [5] Neukum, G. and Hiller, K, 1981, J. Geophys. Res. 86, 3097–3121, doi:10.1029/JB086iB04p03097, [6] Werner, S.C., 2005, PhD thesis, Freie Universität Berlin.