HYPERCONCENTRATED FLOW DEPOSITS AND VALLEY FORMATION OF HAVEL VALLIS, XANTHE TERRA, MARS. M. Voelker[1], T. Platz[1], K.L. Tanaka[2], C. Fortezzo[2], R. Fergason[2] and T.M. Hare[2], [1]Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany, thomas.platz@fu-berlin.de [2]U.S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ, USA.

Introduction: Havel Vallis is a SW-NE trending, ~260 km long valley (Fig. 1). It is adjacent to Juventae Chasma and Baetis Chaos systems which are the source regions for Maja Valles [1] and (partially) for Havel Vallis. The elevation of Havel Vallis ranges from about 0 m in Mutch crater up to 1030 m above Martian datum in crater A. This abstract focuses on the formation of Havel Vallis and discusses two possible scenarios. In addition, potential depositional mechanisms for some related fluvial deposits are presented.

Methods: Mapping of Havel Vallis and adjacent areas is based on THEMIS IR day/night time datasets. For detailed observations in the visible spectra HRSC, CTX, and MOC data were utilised. Topographic analysis is based on a HRSC-DTM mosaic. We used ESRI's ArcGIS suite for the vector mapping, crater statistics, and raster overlays. Crater counts were performed and analysed following the procedures described in [2-5].

Topography and hyperconcentrated flow deposits: The valley system is divided into four areas: 1) crater A with its two outlets to the east and west, 2) a central valley, 3) a basin-like depression, and 4) the floor of Mutch crater. Gorges, 250-400 m of relief, separate areas 2-4 (Fig. 2). Floor deposits in areas 2-4 are interpreted as multiple, embaying fluvial deposits. We assume that these fluvial deposits represent sheet deposits partially originated from hyperconcentrated flows. Hyperconcentrated flows are gravity-driven two-phase (debris and water) flows with sediment concentrations up to 60% [6].

Hyperconcentrated flow deposits have similar characteristics to fluvial deposits with smooth upper surfaces and distinct and lobate margins. In IR night data, those surfaces appear bright potentially indicating high thermal inertia which might be caused by post-depositional consolidation (e.g., cementation or gravel lag development). Their thickness is several meters to tens of meters at maximum. In addition, valley shoulders of the two outlets as well as the exterior surface of crater A display characteristic features of an overbank facies where sediment-laden water passed valley and crater rim crests.

Preliminary crater model ages: Ten geological units were selected for crater counting on CTX imagery. Two marginal units at elevated positions within the central valley and the basin-like depression reveal model ages of approx. 2.4 Ga and 2.6 Ga, respectively. Deposits west of crater A adjacent to chaos terrains, intra-crater A filling, parts of the exterior surface of crater A, central valley and basin-like depression floors, and the northern Mutch crater interior surface yield model ages of 460 to 900 Ma. These assessments indicate that several fluvial events occurred during the Middle to Late Amazonian.

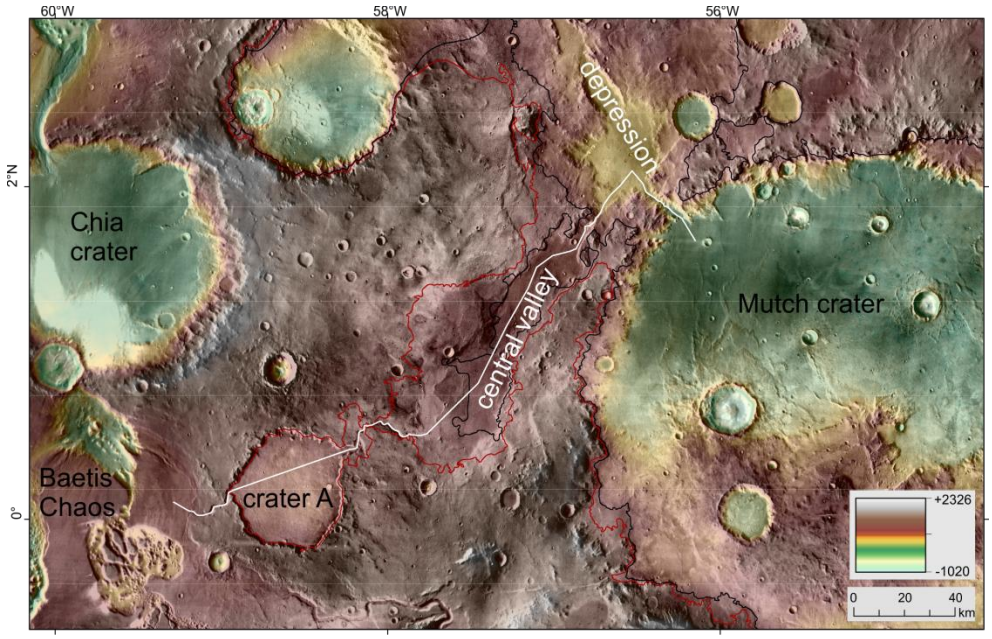

Figure 1: Havel Vallis and surrounding terrain. White line shows profile portrayed in Fig. 2. Red and black lines represent 1000 m and 900 m contour lines, respectively. Remaining contours omitted for clarity. Elevation colour-coded HRSC-DTM superimposed on THEMIS IR daytime mosaic (both 100 m/pixel).

Water source(s): Juventae Chasma and Baetis Chaos represent the source regions for Maja Valles floods which drained northward into Chryse Planitia. Portions of Baetis Chaos formed

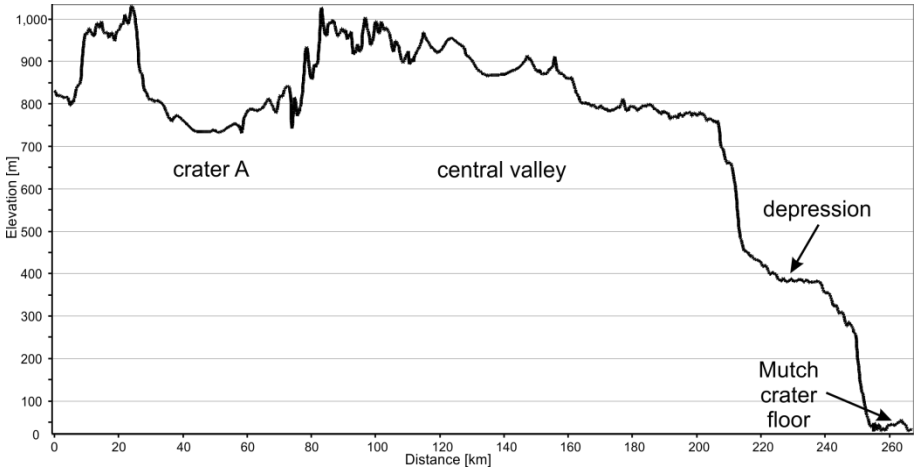

Figure 2: Profile through Havel Vallis. Profile location is shown in Fig. 1.

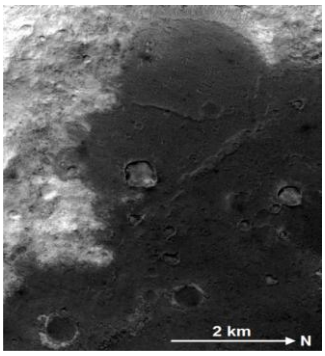

Figure 3: Sheet deposit within the basin-like depression.

less than 30 km of crater A. The lower crater rim has clearly been fluvially eroded. Therefore, waters originated at or near Baetis Chaos may have also developed Havel Vallis. Alternatively, an intra-highland (temporal?) lake may have formed east of crater A. Figure 1 highlights the 1000 m and 900 m contour lines in this area. A potential lake may have had its base level between those two elevations at the location of the central valley. Except for a few short channels surrounding the tentative lake, no major feeder river valleys are observed, though they could have been buried by later aeolian deposits. A volcanic origin for both the water source and the origin of hyperconcentrated flow deposits can be excluded. The deposits are confined in proximity to Havel Vallis. Although approx. 70 km southwest of crater A an old volcanic edifice is recognised with exposed radial flank incisions, their origin is unclear. Albeit volcanic activity at this edifice might have established a hydrothermal system, groundwater melting of a substantial subsurface ice reservoir pears unlikely, particularly during the Middle/Late Amazonian.

Reconstruction of valley formation: In the area east of Baetis Chaos we assume a maximum water level of 1,030 m where water was able to overtop the western rim of crater A. When the water breached the western crater rim fluvial erosion began to incise a valley into the rim. When crater A was filled with water and sediments a breach of the eastern rim at about 1000 m occurred. Here, the same erosional process took place as in the western channel. The first ten kilometers of the eastern channel are broad and straight. This may indicate the presence of a radial fault. Once the water level in Baetis Chaos dropped, the lake in crater A began to drain to the east and west. Trapped water inside the crater likely evaporated ing observed polygonal patterns.

Downstream of the eastern channel of crater A a broad valley drops in elevation from about 900 m to 780 m. This central valley is covered by at least two sheet deposits. The valley is parallel to a several tens-of-kilometers-long fracture zone, which probably led to a third breach through a narrow, 10-km long gorge connecting the central valley with the basin-like depression. Erosive hyperconcentrated flows likely formed this gorge with its approx. 400 m elevation drop over a short horizontal distance. These slurries accumulated in the confined basin-like depression until they breached the Mutch crater rim to the south along a pre-existing radial fault scar. Here again, erosion formed a narrow and steep gorge with a total elevation drop of about 350 m. Incoming sediment-laden floods spread onto Mutch crater floor, primarily in the northern portion.

Another possibility for the formation of Havel Vallis is the existence of temporal lake(s) in the central valley as well as the basin. This theory could explain the flooding of crater A through its eastern breach as well as the formation of the western outlet into Baetis Chaos. Contour lines are consistent with this potential lake (Fig. 1).

References: [1] Chapman M.G. (2003) *JGR*, 108, E10, 5113. [2] Kneissl, T. et al. (2011) *PSS*, 59, 1243-1254. [3] Michael, G.G. and Neukum, G. (2010) *EPSL*, 294, 223-229. [4] Hartmann, W.K. and Neukum, G. (2001) *Space Sci. Rev.*, 96, 165-194. [5] Ivanov, B.A. (2001) *Space Sci. Rev.*, 96, 87-104. [6] Vallance, J.W. (2000) in Sigurdsson, H. (ed.) Encyclopedia of Volcanoes.