DETAILED MAPPING AND CHRONOLOGY OF THE DAO VALLIS CANYON, MARS. J. Korteniemi and S. Kukkonen, University of Oulu (Astronomy, Department of Physics, P.O. Box 3000, FI-90014 University of Oulu, Finland, jarmo.korteniemi@oulu.fi).

Introduction: The canyon of Dao Vallis starts on the lower flanks of the volcano Hadriaca Patera as a wide and up to 3 km deep depression. It continues down the eastern rim of Hellas basin as a much narrower ~1 km deep canyon, and reaches the basin floor after a ~750 km traverse. The estimated volume of the canyon is 11027 km^3 [1], roughly 2.5 times that of the Grand Canyon (4170 km^3, [2]). Dao can be traced along the Hellas floor at least for another 500–700 km as a much shallower channel bed than the canyon part.

Previous lower resolution (~100–500 m/pixel) mapping [e.g., 3–5] has suggested that the canyon floor is entirely covered by a single, albeit very varied, sedimentary unit of Hesperian to Amazonian age.

In this study we provide age determinations from our high resolution mapping project of the Dao floor units [6,7]. We show that the canyon floor consists of several units, with distinct morphologies and ages. Our work suggests that parts of the original Dao Vallis floor may still remain observable, covered by only a thin veneer of later deposits, and that the flow units have been partly resurfaced very recently. This is part of our ongoing work to determine the small scale morphology of the eastern rim region of the Hellas basin, their relations to the surrounding terrain, and the overall geology of the region [6,7].

Data and methods: We used CTX (Context Camera; [8]) mosaics with re-centered equirectangular projection to map out the geomorphology of the canyon system at full ~5–6 m/pixel resolution. Digital terrain models (DTMs) from both CTX and HRSC (High Resolution Stereo Camera) instruments were used in conjunction with MOLA data to determine elevations.

Our study region is a 650 km stretch along Dao, starting from the head and ending just after a U-shaped turn at 39.76°S, 84.70°E. We divide the Dao Vallis canyon into four parts according to its large scale morphology: (1) *Dao head*, the wide and deep part at the start of the canyon (length ~190 km, width 20–40 km, depth 2–3 km); (2) *Upper canyon*, extending from the head to where Dao is met with Niger Vallis; (3) *Dao neck*, the section of the upped Dao immediately after the head with 500–600 m higher floor elevation (34.433°S, 92.318°E, Fig. 1); (4) *Lower canyon*, extending from the Niger confluence to the southwestern edge of our study zone (Fig. 2).

For estimating the ages of the identified units, we counted the craters seen in the CTX mosaic at full resolution. Additional HiRISE (High Resolution Imaging Science Experiment, ~0.25–0.5 m/pixel; [9]) images were used where applicable (units with red borders in Fig. 2). Crater counts and their size–frequency distribution (SFD) analysis was done using the Craterstats software [10]. The crater SFDs generally have multiple slope breaks due to partial resurfacing, erosion or deposition. The SFD requires multiple curve fits: The oldest preserved surface may be fitted directly to the large diameter craters, but the resurfaced surfaces require a correction to find the absolute model ages [10]. Additionally, the question of the usability of small craters arises. Since the small units of Dao Vallis mostly postdate the latest secondary-forming impacts, and are located in the deepest parts of the canyon, we expect that by far most of the small craters are primaries. Obvious clusters of secondary craters were also identified and excluded from the counts, and large sections showing signs of modification by nearby large impacts were avoided altogether in order to minimize the error. Our age estimates agree closely with previous ones on the units immediately surrounding Dao Vallis and on the adjacent Hadriaca Patera flanks [1,7,11].

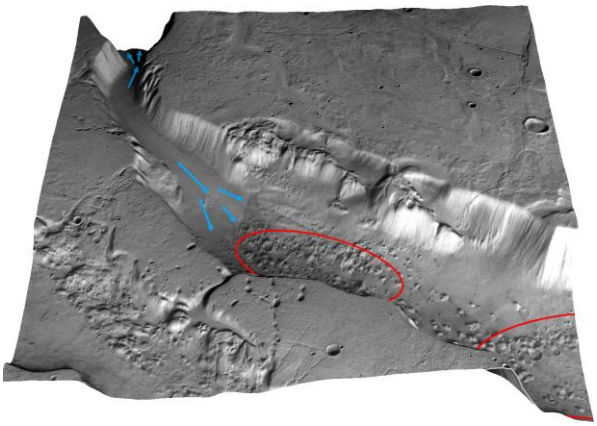

Figure 1. Oblique view of the Dao head end. Viscous flows (blue arrows) are directed to both directions from the high neck region. Red circles indicate areas where the oldest model ages on the Dao floor were measured. Note the small channels cut by Dao (right and top). Image and DTM from HRSC orbit 0550, 5x vertical exaggeration, looking west.

Results: The longitudinally central part of the Dao head harbors several different knobby and hummocky units. The knobs and mesas have steep eroded flanks and small tops, unsuitable for crater counting. The knobs are in places, but not everywhere, surrounded by much younger viscous flow units. Model ages derived

from crater counting reveal that the hummocky parts of the canyon are similar in age to the surrounding highlands, and channels cut by Dao Vallis (Fig. 2).

The flow units in the head region originate from the walls and cover much, but not the entire floor around the knobs. The flows from the south facing slope are systematically more extensive than on the north facing slope [see also 6].

Much of the upper Dao Vallis is similar in complexity to the head region, although it exhibits no knobs or mesas. Wide extensive flows originate from the walls and cover much of the floor. Longitudinal viscous flows occur around the neck area, just prior to meeting with Niger Vallis, and almost throughout the lower Dao canyon. These flows are distinctly separate, and generally not very extensive (up to ~100 km long). According to prior topography the flow has moved to both toward Hellas basin as well as toward the Dao head. The longitudinal flows reveal no distinct starting points.

Model ages for the viscous flow units indicate that they are the youngest features on the Dao Vallis floor. The oldest positively identified ages from the units are in the order of only several hundred million years. While the crater data from CTX images indicates that partial resurfacing has taken place on the flow units within the latest several tens of millions years, HiRISE data suggests that the same has continued over the latest few million years. This may be the result of a very slow but continuous process of surface modification, or, as SFDs suggest, several distinct episodes with bursts of activity.

Conclusions: We find that most of the Dao Vallis floor is covered by several separate viscous flow unit patches. The oldest recognizable surfaces of the flows have model ages well in the Amazonian. In places, especially in the central head region, and in parts above the Niger Vallis confluence, patches of units underlying the flows can be identified. These often have much older model ages, mostly concentrating around 3.5 to 3.7 billion years, similarly to the terrains surrounding Dao Vallis. This indicates that these may be sites where the original Dao Vallis floor is still observable.

The viscous flow units have the very youngest model ages, in places just under a million years but most often less than 20 million years. This suggests that most of the flow units on the channel floor have been partly resurfaced within the very recent history.

References: [1] Musiol S. et al. (2011), JGR 116, E08001. [2] National park service (2012), Park statistics, http://www.nps.gov/grca/parkmgmt/statistics.htm . [3] Price C. (1998), USGS Map I-2557. [4] Leonard G.J. & Tanaka K.L. (2001), USGS Map I-2694. [5] Bleamaster L.F. & Crown D.A. (2010), USGS Map SIM 3096. [6] Korteniemi J. et al. (2012), LPS XLIII, abstract #2034. [7] Korteniemi J. & Kukkonen S. (2013), submitted. [8] Malin M. et al. (2007), JGR 112, E05S04. [9] McEwen et al. (2007), JGR 112, E05S02. [10] Michael G.G. & Neukum G. (2010), EPSL 294, 223-229. [11] Williams D.A. et al. (2007), JGR 112, E10004.

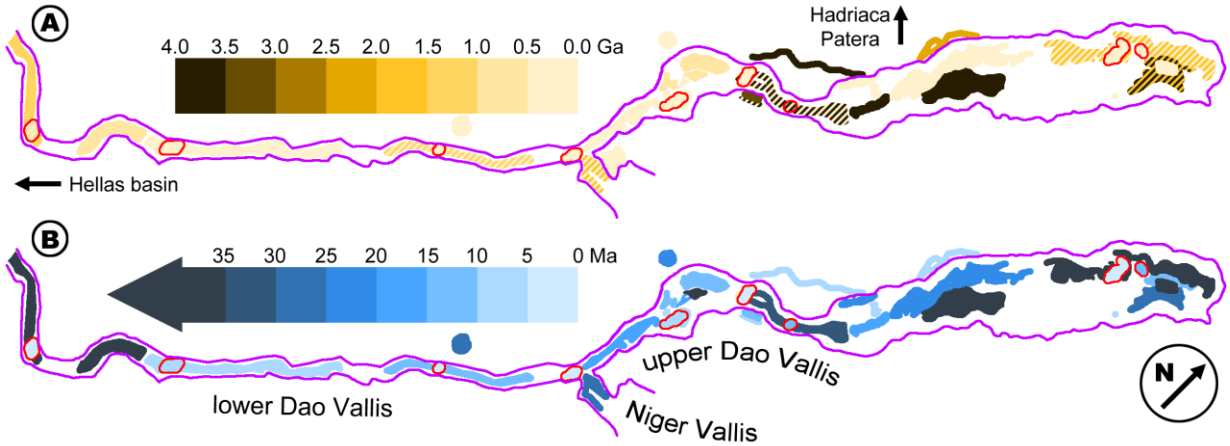

Figure 2. (A) The oldest identified model ages for key surface units in the mapped region. Dao Vallis outline is shown in purple. Note the very old age of parts of both the channel head floor region and the adjacent small side channels, as well as the very young age of the lower Dao canyon. In the dashed units, the oldest ages indicated by the crater SFD curves could only be roughly estimated. The intervening brighter color indicates the oldest but well established resurfacing age. HiRISE images are circled in red. **(B)** The youngest identified model ages for the same surface units as in fig. 2A. The darkest colors indicate ages of 100 million years at maximum. Note that all the HiRISE images (circled in red) reveal significantly younger ages than CTX images from the same and surrounding area.