MORPHOLOGY AND AGES OF UNITS ON THE FLOOR OF DAO VALLIS HEAD, MARS: PRELIMINARY RESULTS. J. Korteniemi, S. Kukkonen, V.-P. Kostama. Astronomy, Department of Physics, P.O. Box 3000, FI-90014 University of Oulu, Finland (jarmo.korteniemi@oulu.fi).

Introduction: Dao Vallis is one of the large canyons in the eastern Hellas rim region [1–3]. It is located within a large smooth-surfaced depression (Hesperia–Hellas trough, HHT, [4,5]; SW trough in [6]) extending from Hesperia Planum to Hellas basin. The difference between HHT and the Noachian cratered terrains indicates that the trough was initially deeper and has been filled by a variety of materials [4]. The region is covered by a suite of sedimentary, volcanic and mixed materials, all deposited during a time spanning from Late Noachian into Early Amazonian [7–9].

The Dao Vallis canyon cuts the sedimentary and volcanic deposit suites mostly postdating their emplacement [1,7,8]. Dao begins as a full size structure in a broad, flat-floored and closed depression and follows the regional slope toward Hellas. The general morphology and volume of the head depression (11.4×10^3 km^3 [9]) suggest that the canyon formed due to a release of a large mass of water. The current surface of the canyon floor has been modified by later processes.

We map and date the Dao Vallis head features in detail. Our aim is to identify how the units relate to each other and the canyon formation. The work is part of an ongoing project looking into the eastern Hellas fluvial systems, where the goal is to form a detailed picture of the drainage system evolution and to relate them to changes in the Martian climate.

Data sets: Mapping is done at ConTeXt camera (CTX) 6 m/pixel resolution, available throughout the entire length of Dao. Unit relations and details are determined using 0.25 m/pixel High Resolution Imaging Science Experiment (HiRISE) images. Model ages are calculated from crater size-frequency distribution (SFD) plots from both datasets. Topography is obtained from Mars Orbiter Laser Altimeter (MOLA) tracks and gridded data, and High Resolution Stereo Camera (HRSC) level 4 DTMs.

Geologic mapping: Several previously unmapped units were found to cover the Dao floor (Fig. 1) in comparison to the previous studies [cf. e.g. 3,7,11].

The upper canyon wall *Uw* is an exposure of cross-cut surrounding terrain with horizontally layered deposits and associated mass-wasting deposits, as indicated by previous mapping [e.g. 4]. The south-facing wall height is 1925 ± 175 m, and has a slope of 15.5–18.2°; values for the north-facing wall are 2525 ± 225 m and 14.4–16.5°, respectively.

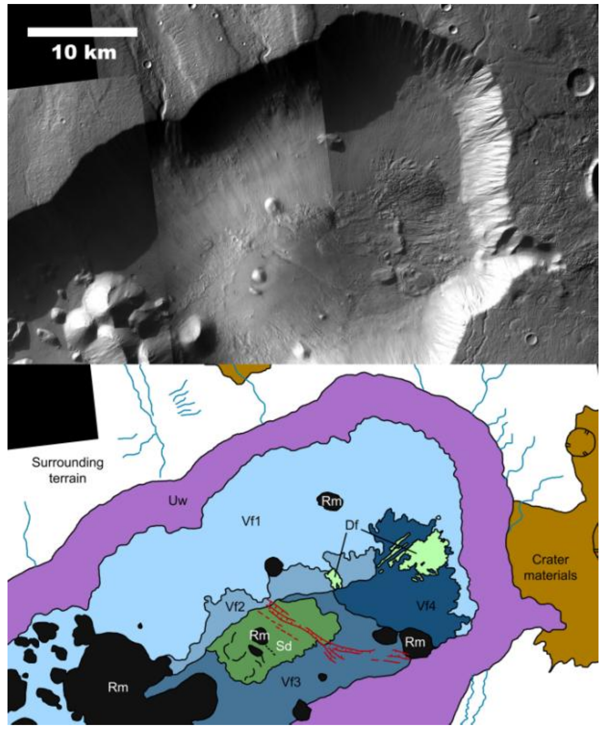

Figure 1. The head area of the main Dao Vallis (top; location 32.95°S, 92.95°E) and a morphological sketch map of its units (bottom; see text). The floor trough discussed in the text is shown in red; small fluvial channels in blue.

The lower canyon wall is covered by four distinct viscous flow units of varying ages. *Vf1* occurs on the south-to-east facing slope throughout the wall length. It consists of a 6–12 km wide, continuous lineated flow and curves around topographic obstacles such as remnant massifs (*Rm*). The flow steepness varies from 5–15° high up to 1.2–1.8° close to the valley floor. Model ages show that the flow modification has been a slow, continuous process: it has continued at least the last 60–140 Ma, ceasing 3.0–3.4 Ma ago (Fig. 2).

Vf1 is underlain by unit *Vf2*, which has a shallower slope (0.5–1.0°), slightly rougher texture and a prominent, continuous lower margin. The SFD plot for *Vf2* has a variable gradient which (poorly) fits several model ages between 7 and 3000 Ma. The north-to-west facing lower slope and many flanks of the remnant massifs (*Rm*) are covered by the *Vf3* unit. It spans several km horizontally from the *Uw* contact, and has a very shallow slope of 0.6–0.8°. It is superposed by *Vf2* and resembles it in morphology but has an even rougher texture. SFD plots fit an uncertain model age of 1000–2000 Ma (and poorly several younger ages).

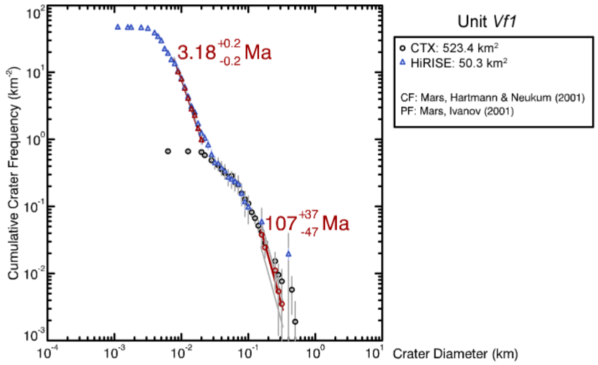

Figure 2. SFD plot for the *Vf1* flow unit; an example of model ages obtained in this study (produced with Craterstats).

The unit *Vf4* covers the northeastern corner of Dao. Its morphology is much more rugged and hummocky than that of the other flows, which all superpose it. *Vf4* exhibits broad lineations and has high terminal moraine -type hills at its lower margin. It has several prominent ~100 m wide downslope oriented ridges with narrow ~10–20 m wide cracks at their crests. Other prominent cracks are also observed, e.g. around the two massifs on the southern side of the unit. A dune field (*Df*) overlies the flow units.

The central valley unit *Sd* has a smooth appearance with minor small scale texture. It is superposed by *Vf2*, but its relation with *Vf3* is not evident. *Sd* model age is 230–390 Ma. The unit is cut by a northwest-to-southeast oriented terraced trough (depth 30–100 m, length >9 km, width 300–1500 m; Fig. 1), extending also under units *Vf3* and *Vf2*. Similarly to the *Sd* unit, the trough is in places filled and smoothened.

Interpretation: The flow units (*Vf1–Vf4*) probably consist of degrading upper wall material, mass wasting deposits, volatile-rich materials deposited onto the walls, or a mixture of the above. While *Vf1* is evidently the youngest unit (formed within the last few hundred Ma), *Vf2* and *Vf3* are significantly older: they have undergone a very slow deformation lasting through most of the Amazonian. With a lower age boundary of >20 Ma the *Vf3* unit deformation appears to have ceased before the opposing slope flows. The cracks in *Vf4* ridges indicate a decrease in material volume. Along with the bulky appearance of the unit, this suggests that *Vf4* had a significantly higher volatile content than the other units to begin with, resulting in a faster more vigorous flow, or that the original volatiles have been more thoroughly sublimated away. It is also plausible that the diverse *Vf4* unit in fact consists of several, mixed origin units in need of further scrutiny.

Flows *Vf2* and *Vf3* superpose and embay the floor trough, whereas their model ages are mostly older than that of *Sd* harboring most of the trough. The age discrepancy can be explained by an eolian deposition episode smoothening and covering the original surface. *Sd* may only be a thin veneer of deposits on top of the original Vallis floor or some flow units (e.g. *Vf3*).

For the floor trough formation we see eight scenarios. It is either (1) a meltwater channel originating from the *Vf4* unit (2) or from the *Vf2* unit; (3) a continuation of the small fluvial channels entering Dao Vallis from the surrounding plains; (4) the remains of a channel excavated at the last phases of the Vallis-forming event; (5) a graben facilitated by upwelling of the Dao head; (6) a graben caused by the Hadriaca Patera volcano and/or associated dikes; (7) a regional concentric graben due to stresses surrounding Hellas; (8) or some combination of the above.

Both fluvial and tectonic origins have pros and cons. The southern end of the trough bends towards possible fluvial sources, whereas a graben hypotheses may favour a straighter trough. Meltwater scenarios are supported by the deepening of the trough close to the viscous flow units, possibly caused by meltwater release. Terraces may indicate multiple phases of channel excavation or jökulhaups, as well as an extensive graben system. Having the trough oriented 40–90° off the Vallis floor thalweg casts doubt on the fluvial origins in general, and instead favors the graben idea. The trough orientation differs from dike pattens found around Hadriaca [5], and no obvious lineated structures on the surrounding plains follow the same orientation. Even though the trough is roughly Hellas-concentric, it seems unlikely that a long-lived rift surrounding a 2000-km basin would be manifested only through a single, few-km long graben at the floor of a deep canyon. Our working hypothesis is that the trough is a graben caused by local extension post-dating the formation of the Vallis. The most likely cause is bulging of the Vallis head floor, possibly as a rebound effect, or resulting from an intrusion.

Conclusions: The Dao Vallis head region, with its numerous flow units which differ in morphology and ages, appears much more complex than previously thought. Further mapping is being conducted.

References: [1] Greeley & Guest (1987) *USGS Map* I-1802-B. [2] Carr (1996) Water on Mars. *Oxford Univ. Press*. 229. [3] Leonard & Tanaka (2001) *USGS Map* I-2694. [4] Kostama et al. (2010) *EPSL* 294, 321–331. [5] Korteniemi et al. (2010) *EPSL* 294, 466–478. [6] Ivanov et al. (2005) *JGR*, E110, E12S21. [7] Price (1998) *USGS Map* I-2557. [8] Crown & Greeley (2007). *USGS Map* I-2936. [9] Williams et al. (2007) *JGR*. 112, E10004. [10] Musiol et al. (2008) EPSC 2008, EPSC2008-A-00438. [11] Bleamaster & Crown (2010) *USGS Map* 3096.