THE ORIGIN AND EVOLUTION OF DAO VALLIS: FORMATION AND MODIFICATION OF MARTIAN CHANNELS BY STRUCTURAL COLLAPSE AND GLACIATION. J. D. Arfstrom, University of Colorado, Department of Geological Sciences, Boulder 80309. (John.Arfstrom@colorado.edu).

Introduction: The formation of large depressions on Mars with kilometer-scale relief has been attributed to ground collapse caused by removal of subsurface ice. One suggested terrestrial analog is a type of thermokarst feature know as alases, which are circular-to-irregular, flat-floored, steep-sided, shallow depressions [1], but relief of alases is on the order of meters or tens of meters. Ground collapse on the order of kilometers implies a volume of *supersaturating* ground ice (ice in addition to ice filling pore spaces) approaching the volume of the void space of the depression produced by the collapse [2], thus requiring a very high fraction of ice at depths unheard of on Earth.

The formation of large Martian channels has been attributed to a combination of ground collapse and erosion caused by the emergence of enormous quantities of groundwater, derived from melting subsurface ice or confined aquifers, producing catastrophic floods one or two orders of magnitude greater than *any* type of known terrestrial flood [3,4]. The largest known terrestrial floods occurred when large bodies of surface water gained sudden access to areas of lower elevation by the removal of a glacial or earthen dam [3]. Although minor flooding has occurred on Earth when groundwater has been forced to the surface by ground shift associated with earthquakes, "groundwater floods" of the magnitude thought to have eroded the Martian channels do not have terrestrial analogs.

Channel-like troughs formed by tensional forces, through structural collapse and modification by mass movement [5], are common on Mars (Figure 1). Glaciers may have eroded channels on Mars [6], and may have produced features seen within some channels [7] that have been attributed to floods [8]. Glaciers naturally exploit tension cracks and could occupy and modify preexisting or developing structural troughs. I suggest that the very common processes associated with tensional forces and glaciation, acting separately or together, can explain the origin, evolution, and morphology of a variety of Martian channels.

Dao Vallis: Harmakhis, Niger, and Dao Vallis are km-scale relief channels that trend radially from the Hellas basin (Figure 2a), possibly reflecting structurally weak zones created by the basin forming impact [2,9].

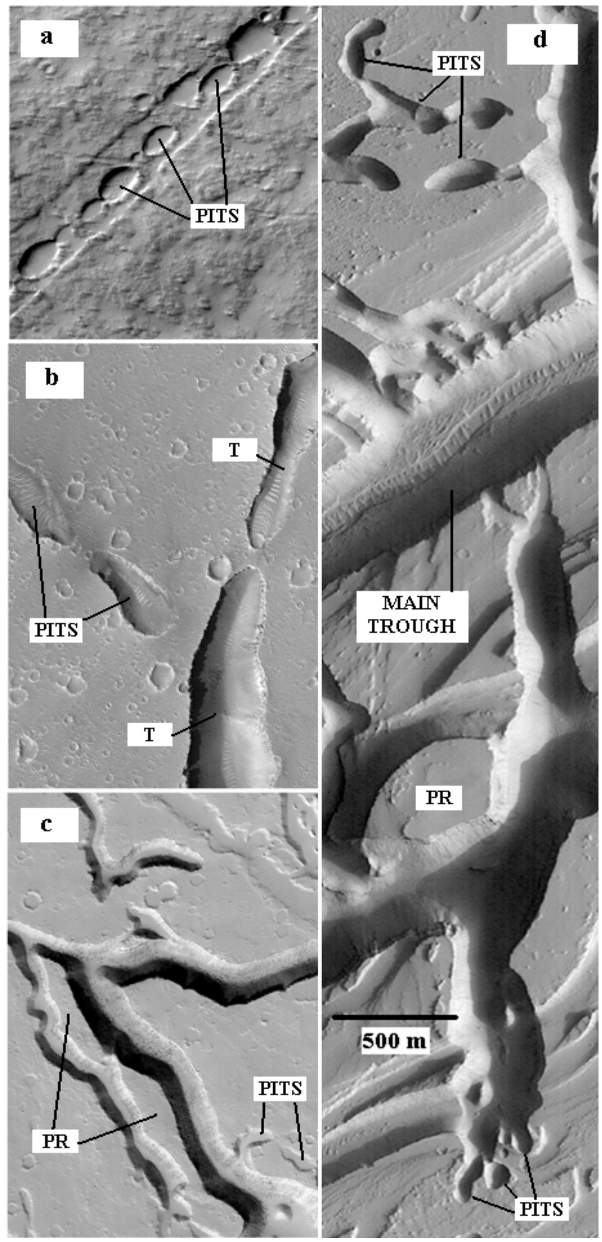

Figure 1: Trough evolution: **(a)** pits developing between a pair of fault scarps bounding a graben; **(b)** pits joining to form short troughs; **(c)** parallel troughs merging, creating plateau remnants (PR); **(d)** multiple troughs merging into a single large trough system similar to Niger Vallis in (2b). Tension can also form simple fluvial-like troughs [5]. Same scale for (a-d). Captioned release MOC images from MSSS.com.

Geothermal heating associated with Hadriaca Patera, an extinct volcano to the north (Figure 2a), may have sped erosion of Dao Vallis by increasing glacier temperature profiles and, therefore, flow rates [10].

Upper Dao Vallis and the Middle Dao Vallis basin (Figure 2b,c) are anomalously wide and deep, causing changes of slope direction along the length of Dao Vallis. This condition could not have existed when Dao Vallis first formed, assuming it was originally eroded by flow in one direction only (toward Hellas). If so, Upper Dao Vallis and the Middle Dao Vallis basin must have collapsed and widened after Dao Vallis initially formed, probably by local structural collapse and mass movement, in which case both areas are graben.

The floor of Upper Dao Vallis (Figure 2c) shows no regional slope along its length and is characterized by numerous rounded hills that are partially inundated by material with viscous-flow patterns [11]. The rounded hills are consistent with eroded down-dropped plateau remnants and mass movement deposits associated with graben development. Also, the morphology of the material between the rounded hills and the lack of a regional slope is consistent with partial infilling by ice-rich material that was leveled by deformation.

The morphology of the viscous materials in the narrow segment or "neck" of Middle Dao Vallis (Figure 2b) is consistent with terrestrial tributary and main-valley glacier systems [10,12]. The greater width of Upper Dao Vallis and the Middle Dao Vallis basin may preclude the formation of main-valley flows. However, sheet-like viscous flows extend several kilometers onto the floors, but only from the pole-facing walls [11], suggesting the flow material is ice-rich (Figure 2 b,c).

Conclusion: Dao Vallis was probably first formed by glacial erosion, acting along structurally weak zones that may have included developing structural troughs, as a slightly curvilinear channel of near-constant width and slope. This was followed by the evolution of Upper Dao Vallis and the Middle Dao Vallis basin, which, if graben, are mostly the products of tensional forces, with some modification by glaciation

References: [1] Theilig E. and Greeley R. (1979) *JGR,* 84, 7994-8010. [2] Squyres S. W. et al. (1987) Icarus, 70, 385-408. [3] Baker V. R. (1974) *Icarus,* 23, 27-41. [4] Carr M. H. (1979) *JGR,* 84, 2995–3007. [5] Schumm S. A. (1974) *Icarus,* 22, 371-384. [6] Lucchitta B. K. (1984) *JGR*, 89, B409-418. [7] Lucchitta B. K. (2001) *GRL*, 28, 3, 403-406. [8] Baker V. R. and Kochel R. C. (1979) *JGR*, 84, B14, 7961-7983. [9] Crown D. A. et al. (1992) *Icarus*, 100, 1-25. [10] Arfstrom J. D. (in prep.). [11] Arfstrom J. D. (2003) LPS XXXIV, Abstract #1208. [12] Arfstrom J.D. (2002) LPS XXXIII, Abstract #1092.

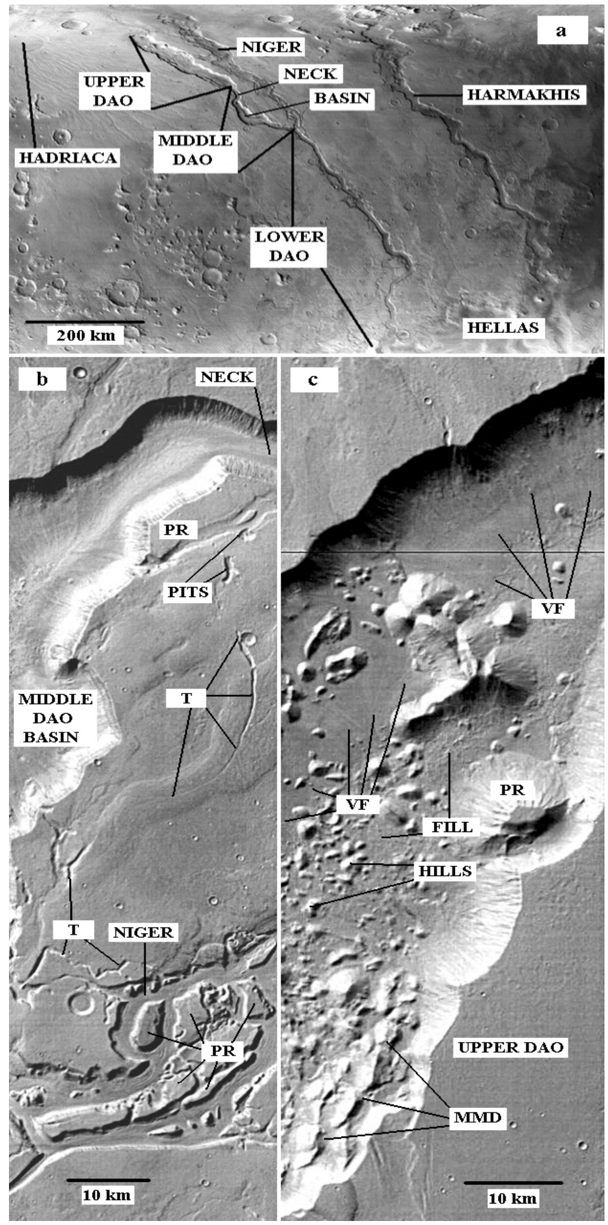

Figure 2: (a) Context image of NE Hellas. MGS image. **(b)** Area between basin and troughs (T) is depressed by collapse. Niger, with many plateau remnants (PR) is not as developed as Dao. Themis. I01121002 **(c)** Plateau remnant, mass movement deposit (MMD), viscous flows (VF), and viscous fill. Themis I02132002.