AN ALTERNATIVE VIEW OF MARTIAN CHAOTIC TERRAIN FORMATION. K. P. Harrison, Dept. of Space Studies, Southwest Research Institute, 1050 Walnut St, Ste 300, Boulder, CO 80302, harrison@boulder.swri.edu.

Introduction: Martian chaotic terrains (CTs) are assemblages of mesas and knobs most widely recognized for their putative role in the formation of huge flooding channels bordering Chryse Planitia, a large topographic basin east of the Tharsis volcanic province. They are traditionally thought to have resulted from disruption and collapse of an icy permafrost layer (cryosphere) initiated by pressurized groundwater beneath [1]. Groundwater reached the surface through the CTs, whence it produced catastrophic flooding and channel erosion. This flow sequence arises from the observation that outflow channels spring full born from the borders of CTs. However, on closer inspection, a water source can be observed upstream of almost every CT in the circum-Chryse (CC) region (Fig.s 1, 2, and 3) and in other outflow channel contexts (Fig. 3). In most cases the water source is a surface channel, but it may be a subsurface conduit (inferred from surface collapse features) or another CT. The overall pattern that emerges is one of CT formation at some point along the length of the water course, rather than at its head. Consequently, groundwater discharge might not have been important in CT formation.

Any challenge to the widely accepted model of CTs as groundwater sources must either refute evidence of groundwater discharge or show it to be, at best, ambiguous. Furthermore, a convincing alternative mechanism for CT formation must be given and amply supported. These goals can best be reached by an exhaustive analysis of all Martian CTs because the characteristics of those CTs associated with non-CC outflow channels, or with no outflow channels at all, are likely to provide valuable insight. As preface to a detailed study of this kind we present here preliminary arguments against the traditional groundwater discharge interpretation of CT formation.

Inlets: As shown in Fig.s 1 and 2, circum-Chryse CTs have inlets that can be traced either to the Valles Marineris (VM) or the Argyre surface waterway. The only two terrains without obvious inlets (Juventae and Ganges) lie along a major fault system that may have provided water (see below). CT inlets are also ubiquitous along smaller outflow channels in the CC area and elsewhere on Mars (Fig. 3). Formation of some CTs along Ravi Vallis may actually have been triggered by channel incision [2]. CTs in the group of eastern Hellas channels (Dao, Niger, Harmakhis, and Reull Valles) are largely restricted to Dao Vallis, which has upstream collapse features suggesting an inlet structure [3]. Likewise, CTs do not appear at the head of Mangala Valles west of Tharsis, but along its length only (Fig. 3). In some cases, CTs appear at the dissection of multiple close-lying channels (Fig.s 3b and 3f).

Ponding: CTs are found preferentially in topographic depressions, suggesting substantial collapse

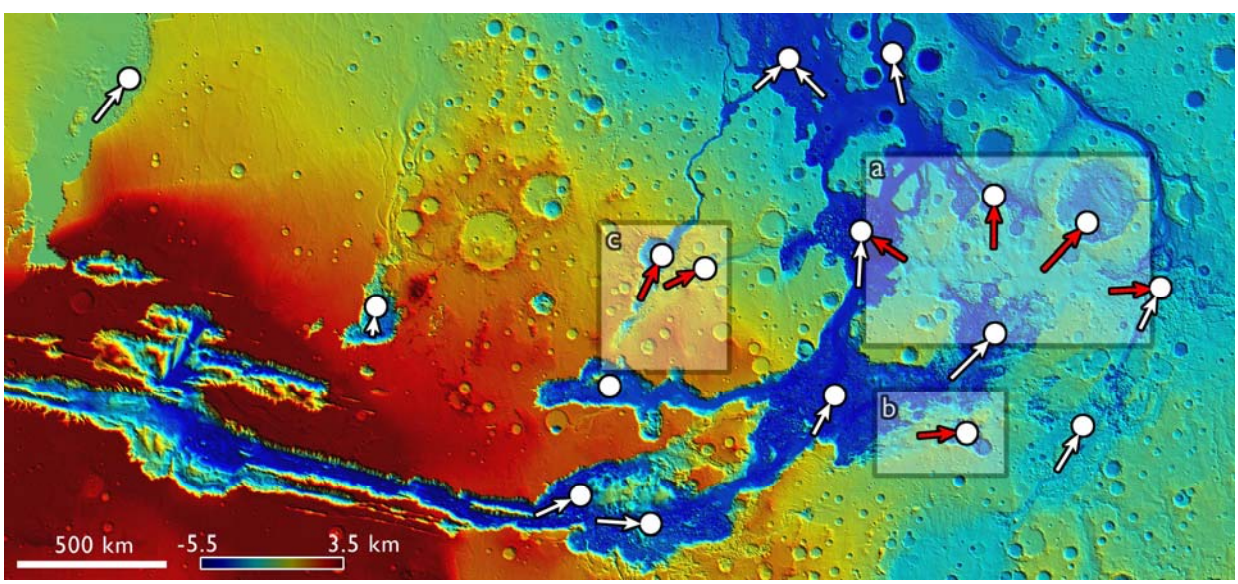

Figure 1. Circum-Chryse chaotic terrains (white dots) have fluvial inlets and outlets. The location and flow direction of each inlet is indicated by an arrow(s) at each dot. White and red arrows indicate surface and subsurface inlets, respectively. Semitransparent labeled boxes indicate the regions depicted in Fig. 2.

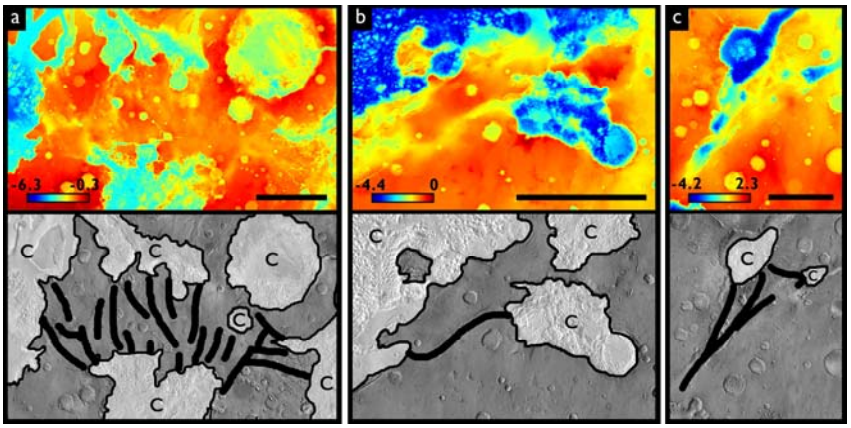

Figure 2. Chaotic terrains with subsurface conduit inlets. MOLA topography (top) reveals associated curvilinear collapse features. These are delineated with thick black lines in sketch maps (bottom). "C" = chaotic terrain. Context is given in Fig. 1. Black scale bars represent 200 km. Color scale labels indicate elevation in km.

during formation. However, in many cases depressions appear to have existed prior to formation (e.g., Shalbatana and Aram Chaos). An important consequence is that groundwater discharge likely ponded before incising channels [4,5,6,7,8], a process supported by possible shoreline features [9,10]. Additionally, hematite and sulfate signatures in interior layered deposits may be the products of aqueous alteration in a lacustrine environment [11,12,13]. Ponding may have allowed catastrophic channel flooding to occur through the rapid release of water from lakes instead of aquifers which generally resist high flow rates [14]. Ponding also implies that energetic surface flows would not be expected within the CTs, leading to the paucity of observed fluvial erosion features on mesa surfaces. Alternatively, CTs formed after the development of channels. In either case it seems that an upstream source of surface water was likely.

Fractures: The arrangement of CC channels and CTs suggests that their source of water may be large fault systems associated with the VM [3]. Fractures permit significant water fluxes, although these might be limited by the supply from canonical aquifer sources. It is generally undisputed that certain outflow channels elsewhere on Mars, such as Athabasca Valles, have fracture system source regions [15]. Mangala Vallis, with its fracture source and midstream CTs [16], may be a suitable analog for the much larger VM fracture system and associated CC channels and CTs. Further study of the latter features will constrain the role of groundwater flow and other processes in CT formation.

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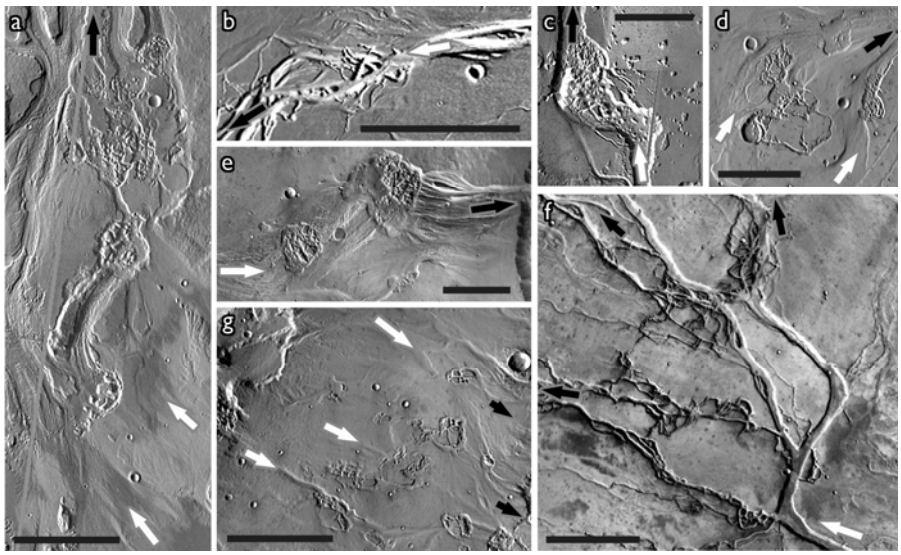

Figure 3. Small chaotic terrains have obvious inlets (white arrows) and outlets (black arrows). Examples include terrains at (a) Mangala Vallis, (b) Olympica Fossae, (c) Shalbatana Vallis, (d) Ganges Chasma, (e) Ravi Vallis, (f) Granicus Valles, and (g) Aurorae Chaos. Black scale bars represent 30 km.