SMALL VALLEYS NETWORKS ON MARS: THE GLACIAL MELTWATER CHANNEL NETWORKS OF DEVON ISLAND, NUNAVUT TERRITORY, ARCTIC CANADA, AS POSSIBLE ANALOGS. Pascal Lee[1] and James W. Rice, Jr. [2]. [1]NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035-1000, USA, pclee@mail.arc.nasa.gov, [2]Lunar and Planetary Laboratory, Univ. of Arizona, Tucson, AZ 85721, USA.

Introduction: Small valley networks are perhaps the clearest evidence for episodes of sustained fluid erosion by water on Mars. While small valley formation has occurred even in Amazonian times, notably on the flanks of some volcanoes, most small valley networks on Mars are associated with the heavily cratered Noachian terrains and are thought to be as old as these terrains. We discuss here the recent identification of *glacial meltwater channel networks* on Devon Island, Nunavut Territory, Arctic Canada, as possible analogs for many small valley networks seen on Mars [1]. A meltwater channel network interpretation for the martian networks may help solve critical problems plaguing more classical interpretations of their origin such as surface runoff following precipitation or groundwater release, including the need for warm climatic conditions.

Small valley networks on Mars: Two alternative modes of formation for the small valley networks on Mars are generally considered: a) the valleys resulted from surface runoff following precipitation or b) they resulted from the release of groundwater, with or without the involvement of hydrothermalism [e.g., 2]. In some instances, a case for the possible role of sapping has been made (such valleys would belong to "b"). For instance, Lee et al. [1] have reported ground-ice sapping valleys within the distinctive impact breccia formation at Haughton crater, Devon Island, Canada, that are possible analogs to martian small valleys such as Nirgal Vallis. Although many other martian small valleys do not present the morphologic traits typical of sapping, groundwater remains a commonly favored source for the water involved in small valley formation (over an atmospheric origin) because of the general absence of obvious catchment areas associated with martian small valley networks and the lack of eroded upland surface adjacent to them [e.g., 2, 3]. However, in both cases a and b a sustained flow of liquid water at the martian *surface* is invoked, a need difficult to satisfy under current martian climatic conditions. Much effort has been devoted to constructing climatic models that will warm up the martian atmosphere at the time of valley formation and to invoking processes, such as flow under the protective cover of icings, that might help support the flow of water on Mars, but these efforts have met with considerable difficulties. For instance, climate models suggest that it is extremely difficult to achieve average temperatures above freezing on Early Mars, mainly because the Early Sun was too faint. Short-timescale climatic excursions above freezing at later times (invoked to explain more recent martian networks) also appear implausible, mainly because of the low martian atmospheric pressure [e.g., 4].

Meanwhile, the morphology of many martian small valley networks has been recognized as presenting several unusual, "seemingly non-fluvial" characteristics [2]. The following combination of traits are distinctive: i) the networks are spaced apart with large undissected areas between networks, ii) the networks display open, branching patterns with large undissected areas between branches, iii) branches often have ill-defined sources but mature in width and depth over short distances relative to the size of the network, iv) branches maintain relatively constant width and depth over long distances, v) branches split and rejoin to form steep-walled islands, vi) branches have U-shaped cross-sections with steep walls and flat floors, vii) channels on valley floors are absent or poorly expressed. Their scale also varies by over an order of magnitude [Fig.1].

Fig.1. Valleys networks on Mars. Scene is 200 km wide. (Viking Orbiter mosaic).

Meltwater channel networks on Devon Island: In the course of Mars analog-motivated field investigations conducted at the Haughton impact structure site, Devon Island, Arctic Canada, networks of small valleys were identified that present all the above distinctive characteristics. The networks on

Devon, however, are smaller in scale than their potential martian counterparts by 1 to 2 orders of magnitude. The Devon networks are found ubiquitously across the island, including at Haughton crater. Their morphologies present some variation which may be due to differences in valley maturity, age, substrate erodibility, or specific formational history (e.g., subglacial vs ice-marginal formation location, glacial reoccupation).

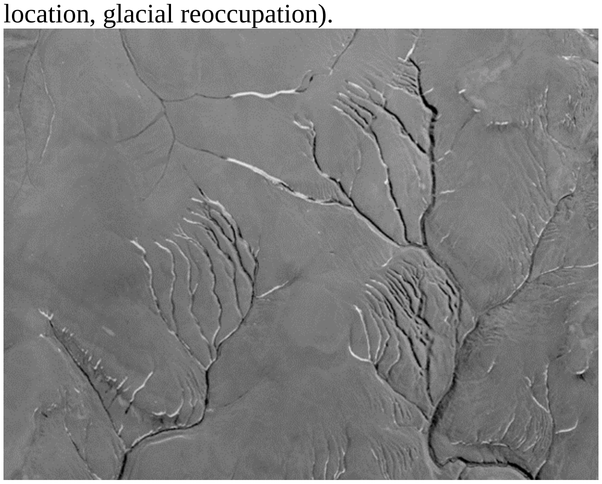

Fig.2. Glacial meltwater channel networks on Devon Island near Haughton crater. Scene is 10 km wide. (Airphoto A16752-182, Geological Survey of Canada)

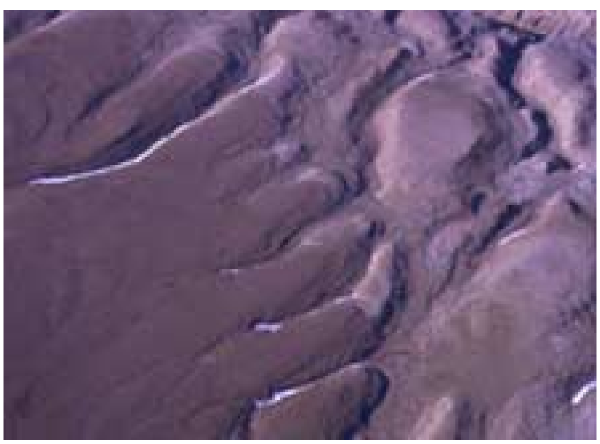

Fig.3. Aerial view of subdued forms of meltwater channel networks on Devon Island. Scene is 2 km across (Photo HM98-0718-160, P. Lee/NASA).

Some valley networks on Devon Island appear as distinct dendritic systems with well-developed branches and crisp outlines [Fig.2]. Other networks are more subdued [Fig.3] and may be described in the same terms as those used by Malin and Carr [3] for the upper reaches of Parana Vallis on Mars: the networks there consist of short, adjacent, tapered “gullies” feeding into a broad, shallow irregularly outlined trunk, the entire network exhibiting little topographic, structural, or material control. None of the above morphologic traits necessarily argues in favor of subsurface fluid sources. Our ongoing investigations on Devon Island have allowed visits to several networks of small valleys. Ground observations reveal no contribution from either sapping or hydrothermalism to their formation, although small (insignificant) trickles of active-layer meltwater drains down some valleys. Channels are absent or poorly expressed on valley floors.

We interpret the Devon valley networks to be glacial meltwater channel networks: they formed as a result of the decay and retreat of an ice cover, possibly with intervals of glacial reoccupation. The proposed mode of formation is supported by our observation that similar networks can been seen actively emerging at the margin of the ice cap in the eastern part of Devon Island. Both subglacial and ice-marginal streams, and in some instances supraglacial streams and their ice-marginal falls, were seen to present significant discharges and contribute to valley formation at several sites along the receeding edge of the cap. The interpretation of valley networks on Devon Island as meltwater channel networks is consistent with the island’s overall landscape of glacial *selective linear erosion*, which suggests extensive former glacial occupation (mostly static ice) [5].

Discussion and Conclusion: The identification of meltwater channels on Devon Island with morphologies uniquely similar to martian small valley networks with the outstanding exception of their scale may have profound implications for climatic conditions on Mars [1]. *If* many of the martian small valley networks are former meltwater channel systems possibly formed under the protective insulation of an ice or snow cover, then warm climatic conditions at the time of valley formation might not be needed. Originally hypothesized by Clow [6], the melwater channel interpretation for martian small valleys is reintroduced here with supporting evidence from terrestrial morphologic analogs. A plausible scenario would have water released into the martian atmosphere from subsurface reservoirs by impacts or volcanism, precipitating as snow on highland terrains or volcano flanks under a cold climate, accumulating into localized snow or ice caps subject to basal melting due to high but possibly localized subsurface heat fluxes, and draining to incise networks of valleys under the control and protection of the overlying ice or snow. Ice covers as water source alleviate many issues of aquifer recharging associated with groundwater interpretations. The selective linear erosion associated with mostly static ice covers could also explain the dearth of small-scale dissection or signs of glacial erosion on terrains adjacent to small valleys and their near-lack of upstream tributaries.

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