COMPLEX INTERMONTAINE GLACIAL SYSTEMS IN ARABIA TERRA, MARS: EVIDENCE FOR AN AMAZONIAN PROGLACIAL LAKE WITH ASSOCIATED GLACILACUTRINE DEPOSITS. G. Di Achille[1] and G. G. Ori[1,2], [1]International Research School of Planetary Sciences, Università "G. D'Annunzio", Pescara, Italy; [2]Ibn Battuta Centre, Universite Cady Ayyad, Marrakech, Morocco.

Introduction: Compelling evidence for the presence of an extensive system of former valley glaciations and bebris-covered glaciers have been recently documented in the Arabia region of Mars [1, 2, 3]. An overall Amazonian age has been inferred for this glacial activity and it has been suggested, in combination with predictions of climate models, that at this time the obliquity of Mars could have exceeded a mean of 45° for a sustained period [1, 3].

In this study we focus on an undescribed proglacial lake formed within an impact crater traversed by one of the interconnecting glacial branches forming the above mentioned intermontaine glacial system (Fig. 1). Based on geomorphology, sedimentology, and terrestrial analogs, we reconstructed the hydrological evolution of the system [4]. In the same time, we also recognized the possibility that fan deltas could have formed on Mars as proglacial deposits during the Amazonian epoch.

Study area: The studied crater is approximately centered at 34°N and 17°E (Fig. 1). It has a diameter of about 60 km and is breached in its northern and southern parts by a few kilometer-wide linear glacial troughs. The latter show lineated valley fill [1, 3] on their floor that wane at the southern entrance of the crater and re-appear at its northern outlet. The main crater appears rather eroded and modified and is characterized by the presence of a deeper portion on its floor. This starts almost in the crater center and terminates just below a topographic threshold connecting to the northern trough (Fig. 1). Four small (a few tens of kilometer-long) valleys are found along the crater rim, arranged in a centripetal pattern. The valleys emanate from theater-shaped alcoves and have a floor also characterized by lineated valley fill (Fig. 2a). Finally, three of them show fan-shaped deposits when they open into the crater floor (**a**, **c**, **d** in Fig. 1), whereas an additional lobate feature is found at the terminus of the valley trough breaching the crater to the South (**b** in Fig. 1).

Paraglacial sedimentary associations: On Earth deltas can be produced in glacierized basins and form in association with glaciers in two main settings [5]: (i) as *glacier-fed* deltas, which do not differ much from regular deltas, apart from the fact that they receive sediment from glacial meltwater streams after transportation across an intervening land surface; and (ii) as *ice-contact* deltas (also referred to as kame deltas), which are built out directly from glacier

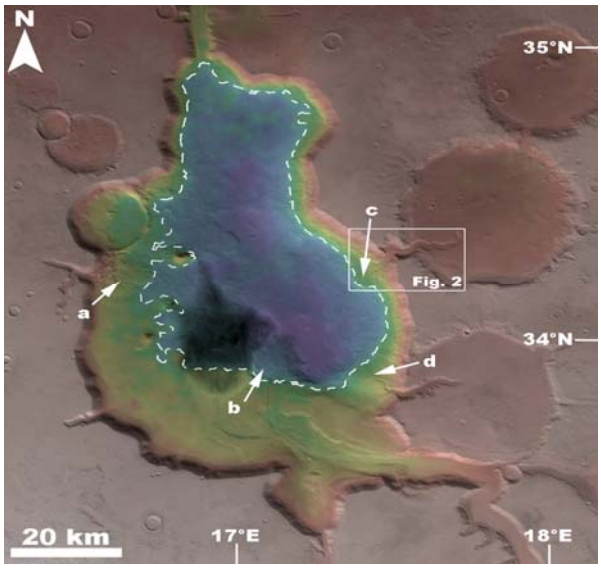

Figure 1. HRSC nadir image draped on HRSC topography of the studied proglacial lake. **a**, **b**, **c**, and **d** indicate fan-shaped features found at glacier margins. The dashed white line encompasses the surface of the putative proglacial lake.

margins. Among glacilacustrine depositional environments, grounding-line fans (also referred to as subaqueous fans) and Gilbert-type deltas are the most common sedimentary associations.

Grounding-line fans form where water from subglacial meltwater channels open directly into deep water and sediment load is deposited rapidly as a result of the sudden drop in stream velocity. Moreover, if sediment supplies are high and glacier margins remain stationary for enough time to let them to aggrade, grounding line fans can build up to the water surface to form deltas [6]. In particular, normal Gilbert-type deltas can form at relatively stable glacier termini due to a low ice-retreat to sedimentation ratio [6].

Above mentioned processes could have occurred also on Mars at glacier margins opening into standing bodies of water, moreover, previous studies suggested, on a theoretical base, that flows of water under an ice cover and ice-covered lakes could have occurred under subzero conditions and survived long enough to sustain significant hydrological activity [7, 8, 9].

Interpretation: We interpret the four small valleys (Fig. 2) to be sites of former small valley glaciers or debris-covered glaciers [e.g. 3]. Deposits found at their mouth were formed as proglacial features at glacier margins. In particular, deposits **a**

and **d** are interpreted to be remnants of former piedmont glaciers or outlet glaciers formed in subaerial conditions. Whereas, deposits **b** and **c** were likely formed as glacilacustrine ice-contact deltas, after evolving from subaqueous grounding-line fans. In particular, deposit **c** shows typical morphology of Gilbert-deltas (Fig. 2) and was likely formed due to a favorable ice-retreat to sedimentation ratio.

On this base, we suggest that the deepest part of the crater was occupied by a proglacial lake possibly covered by ice. Under these conditions, in fact, ice-retreat to sedimentation ratio would have been low and strongly supportive of delta formation. Moreover, the interruption of the lineated valley fill within the main intermontaine glacial valleys traversing the crater, could fit with the presence of the lake, especially if this would have been covered by ice. This for two main reasons: (ii) the presence of standing water/ice could have determined an energy drop of the glacial streams, (ii) the subsequent disappearance of the lake could have broken the continuity of these features. Finally, a detailed, HRSC based, morphometric analysis of the basin is consistent with this hypothesis (see dashed line in Fig. 1).

Summary and conclusions: We have investigated an area located in the Arabia region of Mars, which has been interpreted to be the site of former activity of a large intermontaine glacial system [1, 2, 3]. Here we have found evidence for the presence of a relatively recent 50-km-diameter proglacial lake [4]. In fact, several deposits were identified in association with glacier margins. In particular two of them have been interpreted to be formed as ice-contact deltas within a glacilacustrine environment. The lake was likely covered by ice, which would have prevented its disappearance also under subzero conditions [8, 9]. Sediment supplies could have been provided by subglacial meltwater channels and built up at the opening of the glaciers into the lake. The system shows well-preserved glacial morphologies suggesting its relatively recent formation. This is also confirmed by previous works, which suggested an overall Amazonian age for the local glacial activity [1]. Finally, our results suggest that fan deltas could have formed on Mars as proglacial deposits during the Amazonian epoch.

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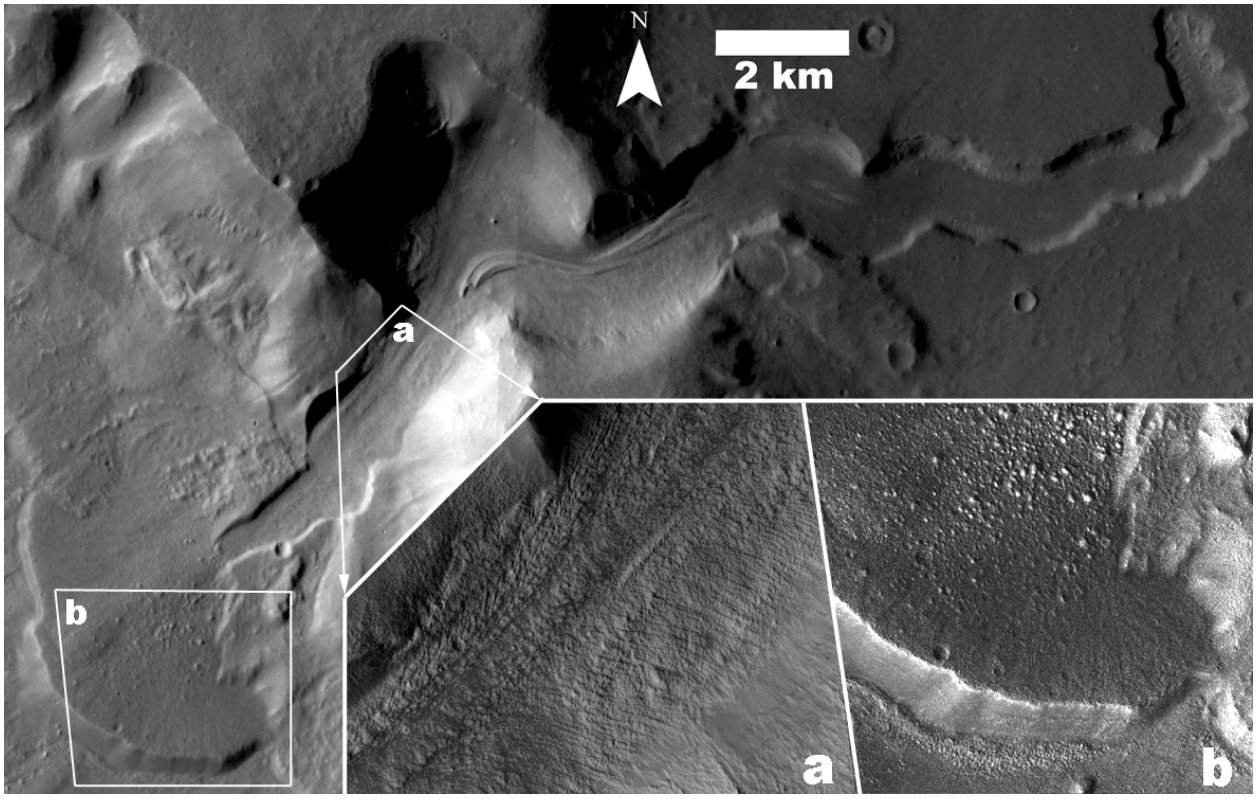

Figure 2. Gilbert-type deposit found at a glacier margin. (a) MOC close up of the lineated valley floor; (b) MOC view of the delta surface showing large boulders abandoned over the proximal portion of the deposit.