Well-preserved Amazonian-aged Fluvial System in the Terra Cimmeria Region, Mars. S. Adeli[1], E. Hauber[1], M. Kleinhans[2], L. Le Deit[3],T. Platz[4], P. Fawdon[5] and R. Jaumann[1,6], [1] Institute fuer Planetenforschung, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Rutherfordstr. 2, 12489 Berlin, Germany (Solmaz.Adeli@dlr.de)., [2] Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany. [3] Laboratoire de Planétologie et Géodynamique, LPG Nantes, CNRS UMR 6112, Université de Nantes, Nantes, France. [4] Max Planck Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany. [5] Department of Physical Sciences, The Open University, Milton Keynes MK7 6AA, UK. [6] Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany.

Introduction:

A wide range of evidences shows that Mars has undergone extensive ice accumulation in non-polar areas, during Amazonian [e.g. 1]. Landforms of recent glacial origin have been observed in both mid-latitude regions of Mars. These features, such as rock glaciers, ground ice, and latitude dependent mantle, formed during earlier epochs of the late Amazonian, tens to hundreds of millions of years ago [2]. They strongly suggest that the climate in the geological recent past have favored the accumulation of snow and ice. Global circulation models suggest that oscillations of the obliquity of the planet caused the transportation of ice from polar regions and its re-deposition at lower latitudes [3, 4]. Over the past 10 Myr, Mars' obliquity has ranged from 14° to 48°. These variations caused significant changes in the seasonal cycles. Orbital variations from before 20 Myr are not very well known [5] but there are several evidence of fluvial-related features during the earlier time, in Amazonian [6]. These observations and evidences show a major change in the Amazonian climate, under which the water ice was stable on the Martian surface in a very large scale.

In this study we report the presence of well-preserved fluvial features (Fig. 1) and glacial-like deposits in the Terra Cimmeria region, which had not been previously reported in the literature. We believe these observations represent evidence of multiple episodes of snow and ice accumulation and melt, which hold a crucial record of the recent Amazonian climate, and possible evidence of recent or past habitable conditions on Mars.

Geomorphological observation:

The fluvial system in Terra Cimmeria has a length of ~340 km (Fig. 1). The first observable traces of this fluvial activity appear on the rim of an impact crater, which has sharp rims with no traces of fluvial activities on its inner rim. Fig. 1-b shows a deposit that is ~5 km wide and being preserved in the shadow of the high crater wall (~2000 m height). Next to this deposit is a narrow channel that is most likely derived from the deposit. This channel is linked to a wider channel traceable to the visible beginnings of the fluvial system. The link between deposit, narrow channel, and wider channel may suggest the deposit to be a preserved ice-rich residue, which had, in the past, partly melted and formed the narrow channel, and consequently fed the main stream. Along the main stream path, smaller channels that flow from higher elevations join the main trench. At the head of most of these smaller channels, several depressions are observable, which could have been the source of water release. They may have hosted ice/snow deposit that have melted and incised these smaller channels.

The floor of the channel is partly incised by scour marks, and deep grooves. Well preserved streamlined islands are observable. On the channel bed, there are several fan-shaped deposits, whose morphology points toward fan delta formation because of their flat surface with a sharp frontal scarp, in comparaison with alluvial fans, which are commonly characterized by conical or concave geometry, and a distal margin that grades smoothly into the adjacent plain [7]. These fan deltas are mostly deposited on the floor of what seems to be a flood plain. One fan delta has also been observed on a crater floor, which has an outlet channel as well, suggesting the presence of a temporer standing body of water (a crater lake).

The downstream part of this fluvial system is composed of a ~60 km long outflow channel, named Kārūn Valles, located on the rim of the Ariadnes Colles (Fig. 1). The Kārūn Valles extends through the ejecta blanket of an impact crater and has partly eroded the ejected material and deposited them in a wide alluvial fan, which spreads out over an area of $\sim 14*10^3$ km^2 (Fig. 1-c). The deposit contains several bars of various sizes, which are all elongated in flow direction. The main flow was birfucated by these bars and was divided into noumerous smaller channels. On Earth, the mechanism of birfucation in a depositional environment rather than erosional, where the sediments are deposited in an alluvial fan and being shaped by the flow into the several bars, is known as braiding. Kārūn Valles features a braided alluvial fan, which is to our knowledge a unique feature on Mars.

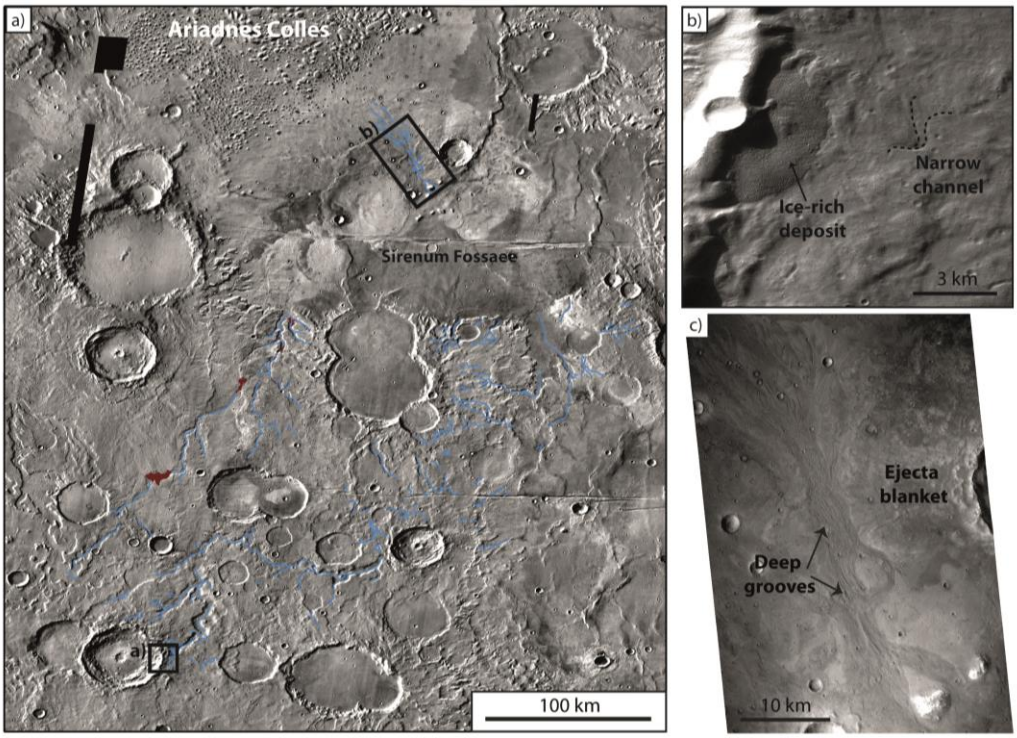

Figure 1: a) THEMIS daytime data showing the fluvial system in Terra Cimmeria. North is toward the top. The locations of Ariadnes Colles and Sirenum Fossae are indicated.b) A well-preserved ice-rich deposit and a narrow channel, which may be the result of past melt event(s). c) Kārūn Valles, located on the rim of the Ariadnes Colles basin, incised into the ejecta blanket of an impact crater, and features a wide alluvial fan at its terminus.

Age determination:

In order to estimate the age of this fluvial activity in Terra Cimmeria, we performed the crater size–frequency distribution (CSFD) analysis on CTX images. The model absolute age of the surface, where the fluvial system was incised yields an early Amazonian age (Martian epoch bounderies from [8]) of ~1.8 (±0.2) Ga. The result from the Kārūn Valles alluvial fan surface shows a middle Amazonian age of about 510 (+0.3/-0.7) Ma, which likely refers to the latest stage of the fan formation since previous floods would have erased either by erosional or depositional mechanisms.

Discussion and conclusion:

The paleo-catchment of the fluvial system is composed of narrow channels joining the main stream. These channels start either at remnants of ice-rich deposits (Fig. 1-a) or at small depressions, which may have had hosted snow or ice that melted and fed the fluvial activity. Therefore, we suggest that surface water of ice and/or snow melt was the most likely source of water, in this area, and the observation of groove markes and streamlined-islands argues for high energetic fluvial event(s).

The Kārūn Valles alluvial fan composed of elongated bars and multiple channels, which divided and rejoined around the bars. Its morphology implies that it is a fan-shaped feature built up from a braided system. Such braiding on Mars has been rarely observed.

The fluvial system was formed between ~1.8 (±0.2) Ga to 510 (+0.3/-0.7) Ma, which corresponds to early and middle Amazonian, respectively. Clearly the climate, at the time of this complex fluvial system formation was different than the current conditions. Therefore one or more catastrophic climate change(s) may have taken place in the past Amazonian Mars. Our observantions and results suggest that fluvial activity was episodic and widely distributed from Noachian to middle Amazonian.

References:

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