NEW EVIDENCE FOR THE SHALBATANA VALLIS PALEOLAKE, MARS, FROM THE HIGH RESOLUTION IMAGING SCIENCE EXPERIMENT (HiRISE). G. Di Achille[1], B. M. Hynek[1,2], and M. L. Searls, [1]Laboratory for Atmospheric and Space Physics, University of Colorado, 392 UCB, Boulder, CO 80309, United States, [2]Department of Geological Sciences, University of Colorado, 392 UCB, CO 80309, United States.

Introduction: A recent study has identified six possible fan-delta deposits, including a main Gilbert-type delta, at the mouths of the rare contributing channels of Shalbatana Vallis, Mars, and has suggested that a former intravalley lake could have been present within one of the topographic depressions along the main valley (Fig. 1) [1]. The lake would have formed in the Hesperian (about 3.4 Ga) during the terminal hydrological activity of the valley and stabilized its main standing level at 2800 m below the Martian datum [1] (**S1** in Fig. 1). However, no shorelines were identified on the deltas with the previous datasets, making the lacustrine interpretation questionable. Here, by using the analysis of a stereo pair of HiRISE images [2] coupled with morphometric observations from the Mars Orbiter Laser Altimeter (MOLA) topographic dataset [3], we report the discovery of lake strandlines along the main Gilbert-type delta whithin Shalbatana Vallis (Fig. 2).

Sub-meter scale observation of the Shalbatana Gilbert-type delta. The PSP_009683_1830 and PSP_010316_1830 HiRISE images [2] observed the central portion of Shalbatana Vallis at a resolution of about 64 and 67 cm/pixel, respectively. HiRISE images reveal a 200-m-wide band of closely spaced (few tens of meters) and sub-parallel sinuous lineations traversing the deposit for more than 5.5 km approximately at the same elevation of the putative shoreline (**S** in Fig. 2). Although the features are eroded and not all of them continuous, a well-preserved series of alternating ridges and troughs is visible in the central part of the delta (Fig. 3a-b). We interpret these features as relict beach ridges formed at the shoreline zone during the hypothesized prominent lake stands. The most pristine feeder channel of the delta is visible for about 5 km, entrenching the deposit from its apex up to the strandlines' zone (**D** in Fig. 2). Here, a sharp terminus, lack of further incision, and expanding blankets of bright materials characterize the downslope extension of the channel (Fig. 3a-b). These observations suggest its abrupt loss of energy related to the opening into a standing body of water and resulting sediment deposition. Additionally, the strandlines mark a morphometric (slope break) and textural dichotomy across the sedimentary feature. Albedo and roughness contrasts are visible between the eastern (subaerial) and western (subaqueous) portions of the delta with respect to the strandlines' location (Fig. 3a-b). Such a sharp variation

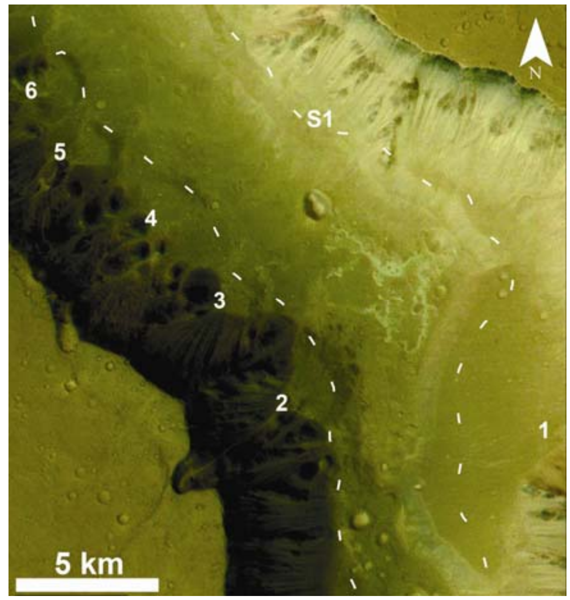

Figure 1. HRSC color combination of the sedimentary deposits (numbered from 1 to 6) along Shalbatana Vallis.

of surface properties within a few hundreds of meters is interpreted to be the results of different degrees of surficial alteration and sediment reworking between two regions affected by selective subaerial and subaqueous processes. Relatively fresh and well-preserved chutes extending downslope from the margins of the delta to the basin floor are also shown by HiRISE images (**C** in Fig. 2). Chutes represent the seaward extensions of distributary channels over the top of the submerged portions of deltas. They are distinctive submarine features of terrestrial deltas [4], originating in arcuate re-entrants on the steepest part of the deltas during rapid progradation phases when the sediment transportation from the upper slopes into deep water parts of deltas causes oversteepening of their margins, producing delta-front instability and submarine mass movements [4]. The central southern part of the Gilbert-delta front is affected by rotational sliding and mass movements with resultant lobate deposits on the basin floor (Fig. 3c). This indicates that the latest progradational activity of the fan-delta was concentrated in the central southern part of the deposit as a result of an overall southward avulsion of the feeder channel.

Discussion. At the time of the most recent hydrological configuration, as recorded by the former shore-

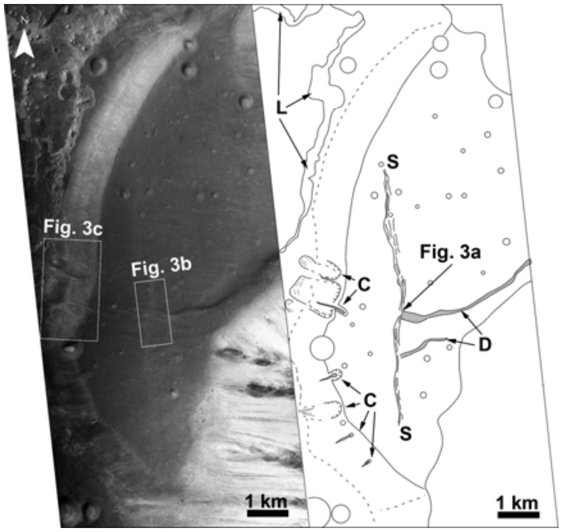

Figure 2. HiRISE image of the main sedimentary deposit and interpretative map. **S** indicate the strandlines; **D** the distributary channels; **C** the chutes; **L** the internal structure of the deposit. The white boxes show the locations of Fig. 3b and Fig. 3c.

lines, the lake water table covered an area of ~195 km^2 filling a total volume of ~29 km^3. Average discharges during the formation of the feeder channel on the delta plain can be estimated using the morphometric characteristics of the distributary channel as determined from imagery and topographic data (90 m for the width, 5 m for the depth, and 0.04 m/m for the slope) along with the Darcy-Weisbach formulas [5, 6]. Discharge values determined using both the D_{50} and D_{84} percentiles for the frictional factors range from 1.66x10^3 to 4.67 x10^3 m^{3}s^{-1} and are comparable to average-sized rivers on Earth. Assuming these inputs are continuous during the hydrological activity of the lake, the latter would have reached the inferred level after 0.19 or 0.55 yr. These values provide a minimum formation time for the lake and associated deltas since they assume uninterrupted discharge. Nevertheless, these calculations are broadly in agreement with minimum formation times obtained from sediment transport computations for Martian deltas with similar volume (e.g. Sabrina delta: 9.4 km^3; 0.54 yr in [6]). Finally, the ephemeral nature of the ponding is also consistent with the lack of major fluctuations of the Shalbatana lake, as inferred from the limited oscillation of the strandlines' level. In fact, the average slope of the delta plain (~3º) and the width of the strandlines' zone (200 m) indicate a maximum water level excursion of only about 10 m.

Conclusions. HiRISE images provide the first direct evidence of unambiguous strandlines and confirm the occurrence, although possibly short-lived, of the Shalbatana lake and fan-delta deposits during the Hesperian. These findings suggest that, at least regionally, clement conditions on Mars extended beyond the generally-accepted Noachian limit. Previously described older candidate deltas are highly eroded by aeolian deflation, which almost completely removed their fine and loose sedimentary fractions [7]. In contrast, the Shalbatana fluvio-lacustrine deposits preserve some of the youngest and unambiguous indicators of a past standing body of water and potentially any signatures from putative biological activity, making them a high priority for a future landed mission to Mars.

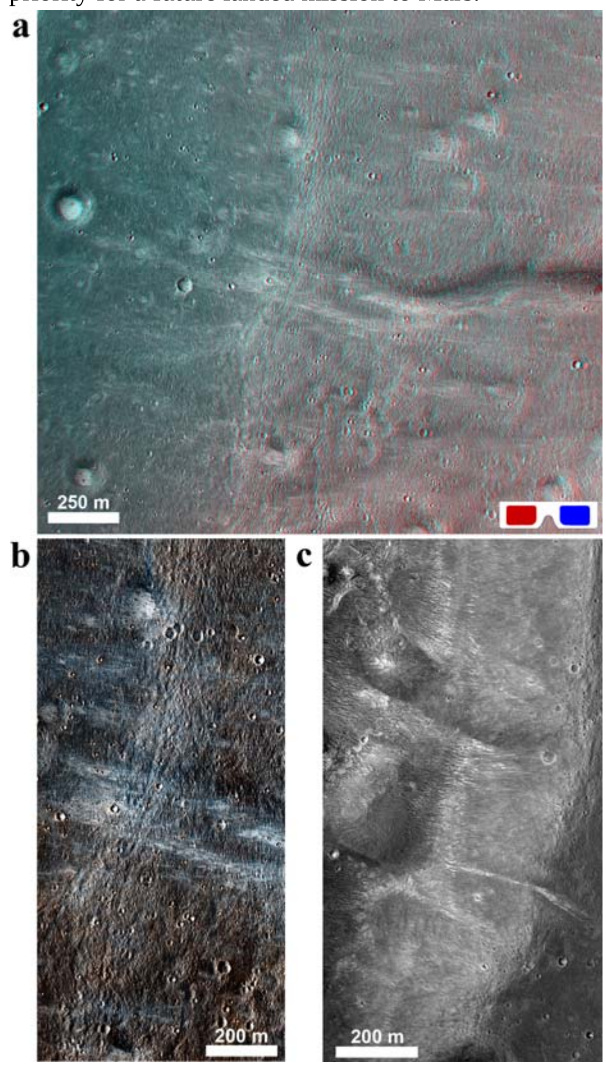

Figure 3. **a)** HiRISE stereo view of the strandlines and distributary channel terminus; **b)** HiRISE color combination showing the channel terminus and the strandlines; **c)** Close-up of the best-preserved chutes along the central southern portion of the Gilbert-type delta.

References: [1] Di Achille et al. (2007) *JGR,* 112. [2] McEwen et al. (2007) *JGR,* 112. [3] Smith et al. (1999), *Science*, 284. [4] Pior et al. (1981) *Nature* 290. [5] Wilson et al. (2004) *JGR, 109* [6] Kleinhans (2005) *JGR,* 110. [7] Malin and Edgett (2003), *Science* 302.