DELTAS ON MARS. G. G. Ori[1,2], G. Di Achille[3] and M. Pondrelli[1], [1]IRSPS, Università d'Annunzio, viale Pindaro 42, 65127 Pescara, Italy. [2]Ibn Battuta Centre, Universite' Cady Ayyad, Marrakesh, Morocco, ggori@irsps.unich.it, [3]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA.

Introduction: Deltaic depositional systems are an important component in the geological history of Mars. Deltaic deposits provide evidence of a complex and vast hydrological system and are the most prominent features suggesting the existence of long-lasting standing bodies of water. Since the first detailed observation in the late '90s [1, 2, 3] it was clear that the deltaic deposits display a remarkable variety of facies and depositional settings, mimicking the Terrestrial variability. Due to the their genetic link to the presence of bodies of water they are of paramount importance for the reconstruction of the paleohydrological cycle and paleoclimates.

Depositional systems: The Martian deltaic systems are similar to the terrestrial fan-deltas. Regardless their depositional models, the feeding river systems directly upstream the deltas are contained in valleys and no alluvial plains are present. On Earth, these systems are called fan deltas [4, 5] in analogy with the alluvial fans that debouch directly from the erosional reaches of the streams. For this reason, fan deltas may show similarities with the alluvial fans, but, of course, they bear substantial differences and peculiar characteristics. In a few Martian instances the valleys near the mouth may be filled by alluvial deposits forming a plain. However, this plain is still contained within the valley walls and its formation is controlled by the vertical accretion of the deltaic system in a transgressive architecture. In this abstract we will use also the term delta as a contraction of fan delta.

Broadly speaking and in the shake of simplifying a complex matter, two type fan deltas are observed: (i) deltas with a simple and flat plain with little and faint channels and a simple front simple made up of a steep step [3, 6, 7] (Figure 1), (ii) deltas with complex plain and non-uniform delta front [8, 9, 10] (Figure 2 and 3). The first type as been referred as Gilbert-type delta (see discussion in [3]), whereas the second type is referred as large-scale fan-deltas or simply as fan-delta [4, 5].

Figure 1. HRSC color view of a Gilbert-type delta in Shalbatana Vallis.

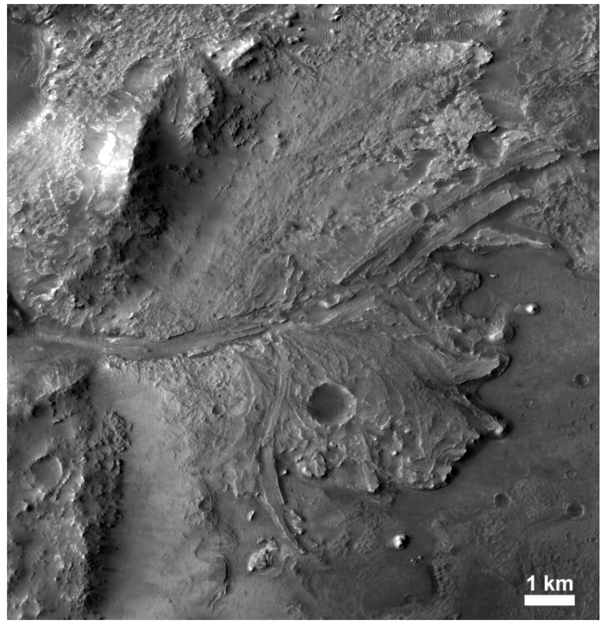

Figure 2. CTX image of the main delta in the Jezero paleo-lake.

HIRISE data show, as far as the present coverage is concerned, that the delta are coarse-grained. Clastic lithologies ranging from pebble to small boulders are clearly observable in many high-resolution images from the delta depositional systems [11].

The Gilbert-type deltas are small (a few of kilometers wide) bodies made up of a flat deltaic plain bounded externally by a sharp step (Figure 1). The step forms the delta front that links the upper deltaic plain with the basin floor. The deltaic plains show a few shallow and poorly defined channels. In some cases the crater density obscure the morphologies of the channels. However, where observable they display a braided pattern made up of shallow channels and poorly defined longitudinal bars. The delta fronts display pervasive chute channels. The channels of the delta plain suggest that the activity was basically dominated by highdischarge events forming flows unchannelled or partially contained in poor-defined braided streams.

Unlike the Gilbert-type deltas, the plain of the large-scale fan-deltas show well-defined and, at places, complex systems of distributary channels. These channels ranges from low-sinuosity (e.g. the Jezero delta, Figure 2) to high-sinuosity (e.g. the Eberswalde delta) and form distinct features in the deltaic plain. Lateral accretion is the main process filling the channels, forming side (lateral) bars in the more straight channels and point bars in the meandering ones. The latter case is well developed in the Eberswalde delta where exhumed coarse-grained to gravel point bars deposits indicate that they where cut into fine-grained cohesive deposits (probably clay) that has been subsequently removed by wind blown action. Meander cut-offs, cravasse splays, and other fluvial system features are present in the deltaic plain. Mouth bars can be observed at places in the delta front and stratifications clearly display foresets (Figure 3).

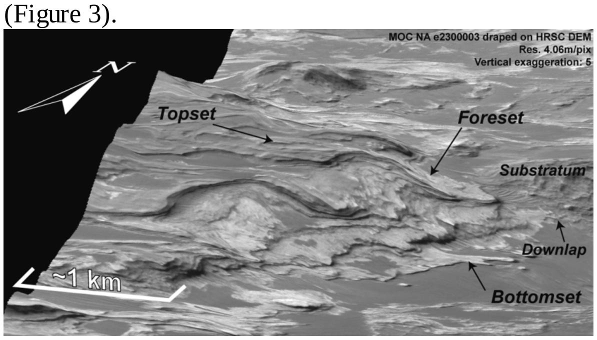

Figure 3. Progradation of a mouth bar in the Eberswalde fan delta developed during an highstand.

Wave action and reworking: On Earth fan deltas are fluvial-dominated because the energy of the fluvial processes is higher than the competing processes. Nevertheless, they keep the fan shape and do not resemble the bird-foot plan view of the fluvial-dominated deltas. This is basically true also for the Martian fan deltas. However, in the case of a distributary channel of the Jezero Fan delta it seems that it protrude into the basin surrounded by levee deposits (Figure 2). However, to account for the formation of prominent levees we have to imply overbanking and the deposition of large amount of fine-grained suspensed-load sediments.

Even if the deltaic sedimentation on Mars is fluvial-dominated there are possible hints of wave action. Wave action has been suggested for the formation of terraces in some crater-lakes [3, 12] and, in some instances, terraces are seen associated to the delta bodies. In these cases, terraces are at the same elevation of the delta plain suggesting a strong genetic link. The few cases observed are related to Gilbert-type deltas. In the large-scale fan-deltas some curved ridges perpendicular to the distributary channels can be interpreted as beach spits (e.g. [11]).

Deltaic evolution: The two types of deltas show two distinct evolution patterns. The Gilbert-type deltas are simple in stratigraphic terms. Some of them consist of a single body deposited in a single high-stand system tract. In a few cases moderate low-stand events produce a downward shifting of the delta front break with the consequent entrenchment of the feeding channel(s) and/or the formation of a wave-cut terrace. Transgressions in the Gilbert-type delta usually produce the formation of stacked deltaic bodies due to the superimposition of consecutive deltas.

The large-scale fan-deltas are internally more complex. They display several stages in the basin development that in plan view correspond to several lobes marked by different distributary channel systems. The internal geometry of the delta deposits, as observed in outcrops, match this more complex evolutionary pattern by showing prograding high-stand system tracts, transgressive system tracts marked by the vertical accretion of horizontal strata, and trasgressive surfaces marking the abandonment of sectors of the delta.

Conclusions: The presence of fan-delta systems on Mars suggests a lively and extensive hydrological cycle. Gilbert-type delta probably formed relatively fast being deposited in one or few high-stand events. The fluvial processes were probably similar to flash floods even if their actual characteristics (velocity, discharge, power) cannot be quantitatively assessed. Large-scale fan-delta, instead, show a complex evolution that suggest a longer life of the delta system, probably formed into a standing body of water that underwent a history of alternating water-level rises and falls. The sedimentary facies and environments of the delta plain clearly indicate well-developed fluvial processes due to perennial and stable rivers.

References: [1] De Hon (1992), *Earth, Moon and Planets*, *56*; [2] Cabrol and Grinn. (1999), *Icarus*., *125(2)*; [3] Ori et al. (2000), *J. Geophys. Res*., *105*; [4] Colella and Prior (1990), *Spec. Publ. int. Ass. Sediment*. 10, 357 pp.; [5] Ricci Lucchi et al. (1981), *IAS Guidebook 2nd Regional Meeting,79 -162*. [6] Irwin et al. (2005), *J. Geophys. Res*., *110*; [7] Di Achille et al., (2007), *J. Geophys. Res*., *112* ; [8] Malin and Edgett (2003), *Science*, *302*; [9] Fasset and Head (2005), *Geophys. Res*., *32* ; [10] Pondrelli et al., (2005), *J. Geophys. Res*., *110*; [11] Pondrelli et al., (2008), *Icarus*, *197*; [12] Di Achille et al., (2006), *J. Geophys. Res*., *111*.