FAN-SHAPED DEPOSITS ON EARTH, MARS, AND IN THE LABORATORY.

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Background: Fan-shaped sedimentary deposits, such as alluvial fans and deltas, are formed by surface-water flow, with different degrees of fluvial or debris flow components. On Earth, different sedimentary deposits have been identified and classified based on various different factors such as upstream (e.g. discharge, sediment type, feeder structure) and downstream (e.g. basin architecture) characteristics [1]. Martian fan-shaped deposits vary greatly in terms of size, shape and morphology, but these deposits exhibit architectural elements similar to those of terrestrial analogues, e.g. lobes, terraces, and incised delta fronts. The presence of these elements aid in the understanding of the processes present during formation of the deposit. Many of these elements are visible in the high-resolution images taken by the High Resolution Stereo Camera (HRSC) onboard the Mars Express, as well as in other satellite imagery.

On Mars: Both alluvial fans and deltas have been studied in detail with the use of HRSC topography, and we have re-classified Martian fan-shaped deposits (see earlier work by [2]) into three classes based on morphology, size, and fan gradient (of which two classes contain two sub-types each). We define both alluvial fans and deltas as fan-shaped deposits, with the main difference being the ponding water in the receiving basin in the case of the delta. Alluvial fans (formed into dry basins) are a class on their own, and deltaic deposits (formed into ponding water), comprise the other two classes. Included in the range of deltaic deposits are various subtypes, discussed in more details below.

On Earth: Good terrestrial examples for arid alluvial fans are found in Svalbard, Northern Chile, and other hyper-arid regions. Good terrestrial analogues for deltas are harder to find due to the large amounts of vegetation that occurs on the delta floodplain, however, some analogues do exist, for example the Pleistocene Emme delta in Germany [3] (example of a stepped delta in a lacustrine environment) and the modern day Okavango river delta in Botswana [4] (example of a branched delta in a lacustrine environment).

In the laboratory: We have formed morphological analogues under controlled conditions for all the different types of Martian deltaic deposits in the Eurotank facility in Utrecht, The Netherlands (see [5]). We investigate the similarities and differences in deltaic deposits on Mars and on Earth, and compare that to the different deposits that were formed in the laboratory. The study of both terrestrial deposits as well as deposits formed in the laboratory is an important way to connect aerial satellite views of Martian deposits with ground-based analysis in order to understand the formation processes.

Classes of Fan-shaped Deposits and Examples:

Class 1: Classic, cone-shaped alluvial fan deposits with high gradients of roughly 3 degrees and lengths of 10-30 kilometers. Martian examples include those in Ostrov crater in the southern highlands. Terrestrial examples include fans in Svalbard and Northern Chile. The relatively high gradients of the Martian alluvial fans could indicate debris-flow dominated processes (as evident from terrestrial analogues).

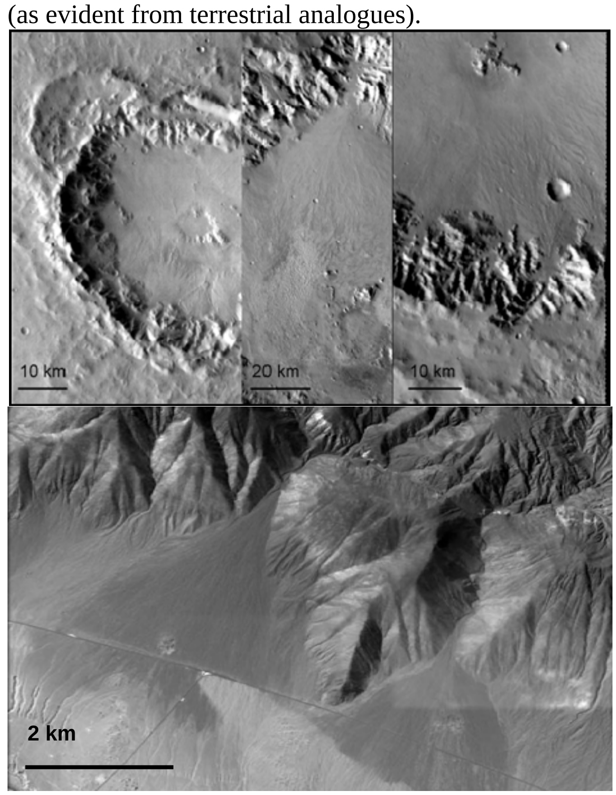

Figure 1: Alluvial fans on Mars (top) and on Earth (bottom; Atacama Desert, Northern Chile).

Class 2: Typical, flat-topped, semi-circular delta-like deposits with clear fronts (also including some deposits with large branching networks as a second sub-type in this category). The average gradient is about 1 degree and lengths are approximately 5-10 kilometers. Typical Martian examples of this type include the Aeolis Mensae deltas and the Nanedi Val-lis and Nili Fossae deposits. Terrestrial examples in-clude the typical Gilbert-type lacustrine deltaic depos-its as well as the Okavango lacustrine deltaic deposit. We have formed analogues of these deposits under a controlled environment in the laboratory. The low gradients on the sub-aerial slopes of these deposits indicate the dominance of sheet-flow processes.

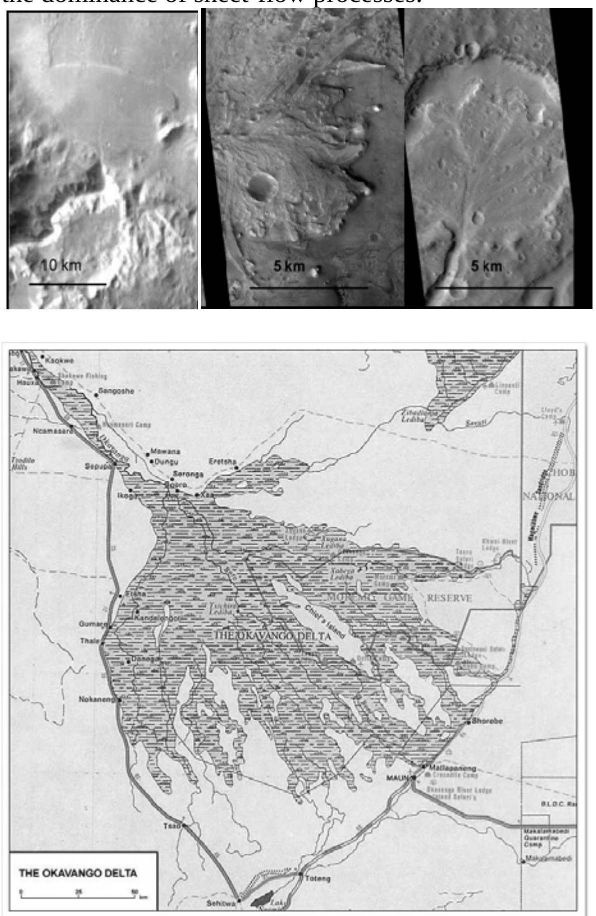

Figure 2: Typical flat-topped, scarp-fronted delta deposits on Mars (top) and an example of a lacustrine fan-delta deposit on Earth (bottom; Okavango Delta)

Class 3: Typical back-stepped or terraced fan deposits with clear fronts (also including some deposits with smoother "steps" as a second sub-type in this category). The gradients range from as high as 10 degrees to as low as 2 degrees. A well-known Martian example of this type is the Coprates Catena terraced deposit. Terrestrial examples include the Pleistocene Emme delta. Kraal et al. [7] were first to create analogues of back-stepping deposits in the laboratory, and we have continued to successfully create these analogue deposits in our own lab set-up (see also [5]).

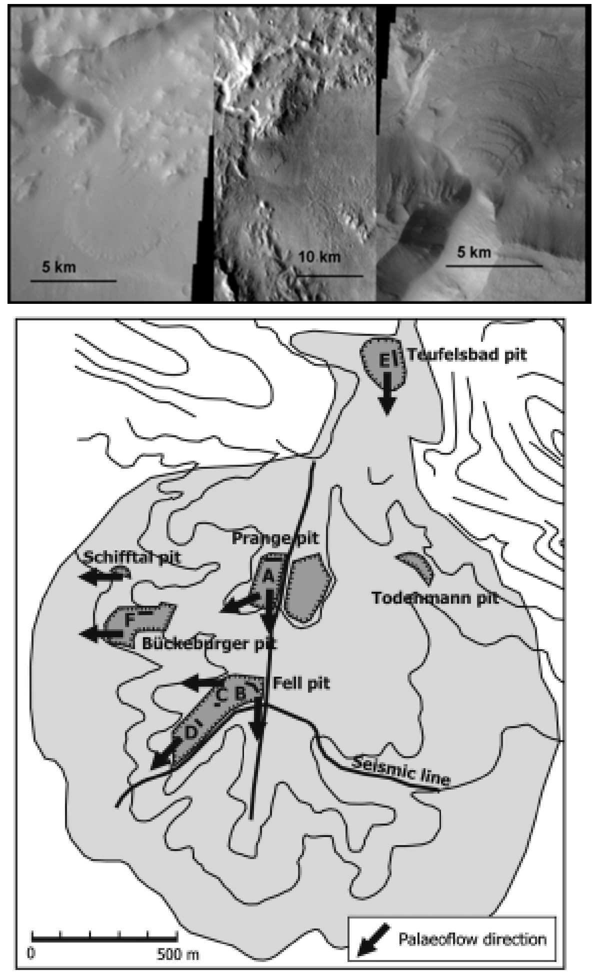

Figure 3: Typical back-stepping, terraced delta deposits on Mars (top) and an example of a back-stepping fan-delta deposit on Earth (bottom; Emme Delta)

Summary: We show similarities and differences between fan-shaped deposits on Earth and Mars and we compare these deposits to analogue deposits that have been formed in the laboratory.

References: [1] Postma (1990) *Spec. Publs. Int. Ass. Sediment. 10*, 13-17. [2] De Villiers et al. (2009) *LPSC* abstract # 1901 [3] Winsemann et al. (2010) *Basin Research*, doi 10.1111/j.1365-2117.2010.00465.x [4] Stanistreet and McCarthy (1993) *Sedimentary Geology 85*, 115-133. [5] De Villiers et al. (2011) *LPSC* abstract submitted [6] Kraal E. R. et. al. (2008) *Nature 451*, 973-977.

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