ALLUVIAL FANS OF NORTHERN CHILE AS AN ANALOG TO MARS.

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Introduction: The widespread alluvial fans on Mars mostly date to the post-Noachian, a period generally considered to be dominated by a hyperarid and cold climate [1]. These fans tend to form within enclosed crater basins and are characterized by their large size, inverted distributary channels, and dominantly fine grain sizes [2, 3]. This contrasts with the small size and dominantly course grain size typical of most arid terrestrial fan systems. Fine grained fans tend to form in humid climates [4]; hence the alluvial fans in the Pampa del Tamarugal of northern Chile's Atacama Desert may comprise a unique terrestrial analog to the martian fans. Because of the potential similarities in processes forming fans in the Atacama and on Mars, lessons learned from field work at this analog site can be applied to understanding the formative conditions of the martian fans.

Methods: Study of martian fans has primarily been with CTX and HiRISE visual and MOLA topographic datasets. Our Atacama study was a combination of remote sensing and field work on a fan in the Pampa del Tamarugal centered on 21°S, 69.3°W. Mapping was done with Quickbird visual imagery and SRTM topographic data. Field work consisted of extensive surveying using a differential GPS, ground penetrating radar (GPR) tracts, and sample collection for laboratory analysis. Estimates of flow velocity were approximated using several methods: the superelevation of deposits on channel beds for channel velocity, flows climbing over blocks for overbank velocity, overbank shear calculations and bubble entrainment for viscosity.

Observations: Atacama fans of are similar spatial scale (tens of kilometers in length) and gradient (~2°) to fan systems on Mars. In addition, the hyperaridity (Atacama fans receive less than 2mm/year rainfall), results in very little vegetation. Lack of fan surface drainage indicates essentially all runoff is sourced from the upland basin area rather than falling on the Atacama fans themselves, which also appears to also be the case for the martian fans. Differential erosion of the fan surface, whereby finer grained overbank material is stripped away by the wind, has left paleochannels on inactive fan surfaces in 1-2m of inverted relief. Martian fan channels are also similarly inverted (although by up to 70m)**.** The Atacama fans feature sand to boulder bedload grain sizes with muddy overbank deposits. HiRISE images of martian fan channel deposits indicate a similar grain size distribution (layered fine grained, wind erodible overbank deposits, coarse grained channel deposits). Channel branching densities are low in both settings, and evidence for significant lateral channel migration (e.g. scroll bars) is uncommon and spatially restricted in both cases. Such surface features in the Atacama may be similar to surface morphologies in Gale Crater, which can be confirmed with future results of the MSL Curiosity rover.

Results: In the Atacama, fans formed through many hundreds of flow events, often with long intervals between. Only a small portion of a fan complex receives flow and sedimentation during any single event. Different flow events are of varying grain size composition depending on flow intensity, but the bulk of deposited sediment (and overall fan material) consists of fine-grained overbank deposits. These overbank deposits can extend long distances downslope but are restricted in their lateral extent. Avulsions are common as channels and natural levees aggrade. GPR transects show subsurface channel deposits. Individual distributary segments may be reoccupied during later flow events, resulting in a complex intertwining of channel deposits, including interaction with already inverted topography. Vertical aggradation appears to dominate overall lateral migration, but some channel segments do migrate and preserve scroll bars, especially more distally on the fan.

Conclusions: Our results indicate that we have good reason to believe that the Atacama fans formed over many seasons during infrequent episodes of increased runoff. From our analysis of multiple bedding layers and cross-cutting relationships of martian fans [6], we infer that they too formed over long periods of time from many flood and deposit events. This implies that there was a significantly long climatic period that was amicable to surficial liquid water.

References: [1] Grant, J. A. and Wilson, S. A. (2011) JGR, 38 [2] Carr, M. H. and Head, J. W. (2010) Earth and Planetary Science Letters, 294, 185-203 [3] Moore, J. M. and Howard, A. D. (2005) JGR, 110 [4] Grant, J. A. and Wilson, S. A. (2012) Planetary and Space Science, 72, 44-52 [5] Blair, T. C. and McPherson, J. G. (1994) Geomorphology of Desert Environments, 354-366 [6] Morgan, A. M., Howard, A. D., Moore, J. M., Hobley, D. E., Beyer, R. A. (2012) AGU Fall Meeting, Abstract #1830

Figure 1. Context. (top) General region. (bottom) Close up of fans on the Pampa del Tamarugal region. Images from Google Earth.

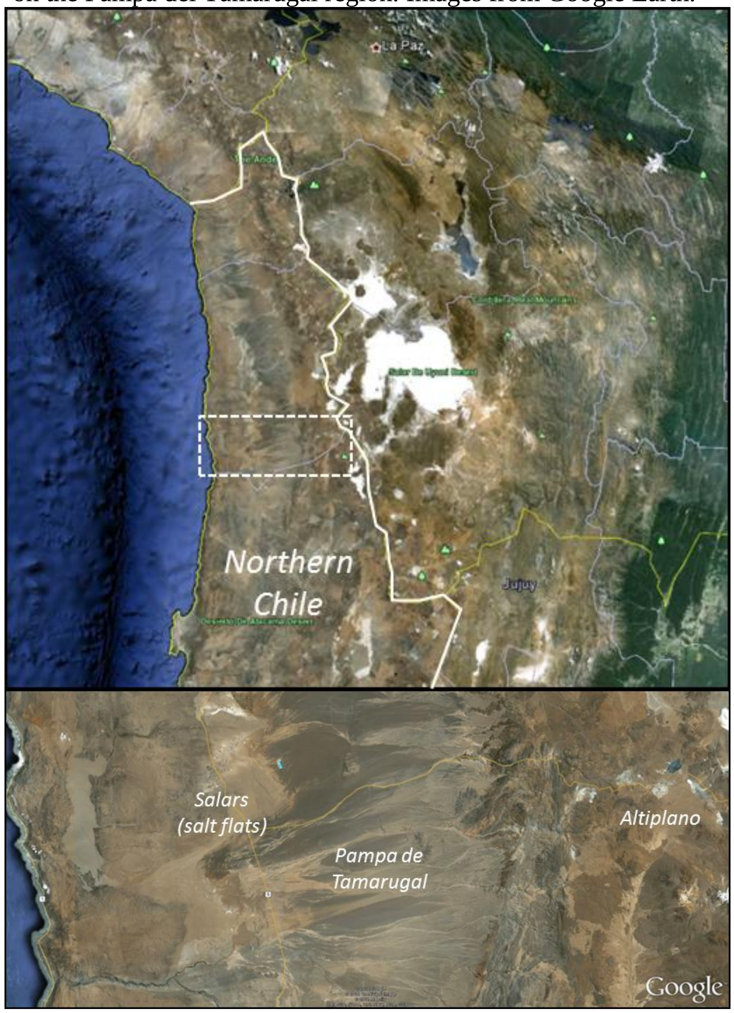

Figure 2. Wind-scoured fan surface in the Atacama Desert.