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# A comparative survey of some aspects of fluvial landforms on Mars and Titan

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## Abstract

Although similar fluvial erosive and depositional processes occur on Mars and Titan as occur on Earth, the climatic forcing, geologic context, and mechanisms for coarse fluvial sediment generation differ for these processes on each of these bodies.

## 1. Introduction

As on Earth, the surfaces of Mars and Titan are marked by landforms generated by volatile cycling with surface liquid flow. A comparative examination of these landforms points to similarities and differences in the surficial processes of each body.

## 2. Drainage networks

On Mars, a past climate supportive of surface liquid flow is evidenced in the degraded craters and valley networks located primarily on the southern highlands [1,2] and dated to the end of the Noachian period (~3.7 Ga; [3]). The limited number of valley networks outside of the southern highlands with post-Noachian ages are attributed to local conditions involving snow deposition and/or ground ice [3,4,5].

On Titan, the most integrated drainage networks appear clustered at the north pole, although poorly integrated drainages are globally distributed [6,7,8,9]. Ongoing or recent activity is indicated by, e.g., the radar-brightness of some fluvial features [10], the near-angle-of-repose river valley walls in Descent Imager/Spectral Radiometer (DISR) data [11], and the inferred global stratigraphy of landforms [12,13]. Most drainages are rectangular [14], indicative of control by tectonic structures or their associated topographic landforms. A survey of rectangular networks on Earth suggests control by extensional structures [14], consistent with the interpretation based on other data for rectangular networks on southwestern Xanadu [15].

## 3. Sediment deposits

The sediments transported through these drainage networks form a variety of deposits. On Mars, some deposits within ancient impact craters are interpreted as deltas based on their layered and fan-shaped appearance, sinuous (meandering) channels, and topographic slope (e.g., [16,17]. In Hesperian-age impact craters, large semi-conical deposits are interpreted as alluvial fans formed of fluvial (instead of debris-flow) deposits [18, 19, 20]. Other fluvial sediments form channel fills and lateral accretion deposits (e.g., scroll bars, cut-off meanders), which are often preserved in positive-relief [e.g., 21].

On Titan, channel fill is evident as radar-dark deposits, likely fine-grained drapes of organic-rich aeolian sands [7,9]. Coarse-grained, icy, fluvial sediments have been suggested on the basis of SAR data of radar-bright fluvial features, and correspond in inferred grain size with the icy cobbles measured on in situ images from the Huygens landing site [10]. These radar-bright sediments are interpreted as coarse-grained channel fill within some river valleys in mountainous highlands [6,15] and as braided river systems that traverse dark or mottled plains [7,9,10,13]. Radar-bright deposits also form fan-shaped features [9], although comparison with terrestrial alluvial fans shows some inconsistencies.

## 4. Coarse sediment generation

Drainage networks and coarse-grained liquid-lain deposits indicate incision of bedrock by bedload impact during fluvial transport. On a lower-gravity body like Mars, bedload impact (and thus fluvial incision) would be less than on Earth. Titan has both lower gravity and different materials, so the comparison to terrestrial processes is more complex. Abrasion-saltation modeling using experimentally derived values of cryogenic ice tensile strength indicates that, with the lower gravity and greater buoyancy of Titan sediment, Titan's rivers would incise less efficiently than do rivers with equivalent geometry on Earth [22 and refs therein]. Landscape modeling of drainage morphologies likewise suggests that incision on Titan may be inefficient compared to incision on Earth [23]. Thus, generation of fluvial sediments in mountainous terrain on Titan may be less efficient than on Earth, and other sediment sources, e.g., fractured impact ejecta, may be more significant. That the two largest deposits of icy cobbles observed to date are both adjacent to impact craters may indicate the importance of pre-fracturing by impact in the generation of coarse-grained sediments on Titan.

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