THE AUSTRALIAN PALEOFLOOD MODEL FOR UNCONFINED FLUVIAL DEPOSITION ON MARS.

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Introduction: Central Australian river systems are analogous to unconfined reaches of Martian channels [1,2]. The Australian model compliments existing Earth analogs [3-7] that focus on confined channel reaches and provides an additional range of fluvial features that are primarily located in unconfined reaches.

We suggest that unconfined reaches are more valuable for interpreting fluvial processes from remotely sensed data. In these locations the channel can laterally migrate, switch, avulse, expand and contract with changing flow. In addition, there is a higher probability of preservation of evidence of these activities in the resultant 'horizontal' stratigraphies. In confined reaches this channel history is also preserved but is buried in vertical sequences that are not easily identified in high-altitude imaging. A study of the paleoflood forms of unconfined channel reaches in central Australia have shown that information on the type of flow (braided, avulsive), relative magnitudes (inferred from sediment transport distances), and relative timing (confluence dynamics) can be obtained from satellite images [8]. Here we apply the Australian paleoflood model to Mars Orbiter Camera (MOC) images.

The Australian Analog: The low latitude, low relief continent of Australia is the second driest on Earth with signs of aridity in the early Cenozoic time [9]. Australia's arid features reflect prolonged periods of tectonic stability and weathering over a range of timescales and many landforms are relict features formed under the more humid Tertiary times [10]. Dryland features such as extensive duricrust plains, a continental-scale whorl of longitudinal dunes, drainage-aligned systems of playas and clay pans, and a network of disorganized internal drainage patterns occupy almost three quarters of the continent [10].

A series of large-scale catchments debouch from the semi-arid MacDonnell Ranges onto low gradient, unconfined piedmont fans and alluvial plains, terminating in floodouts within the longitudinal dunes of the Simpson Desert [8]. Unconfined channels are located downstream from areas of confined flow such as rock gorges and incised channels (Fig. 1) [2,8,11]. Flood sediment is preserved in areas along the channel bed and in marginal backwater areas, varying from coarse gravel to mud with decreasing sediment size downstream [2]. Bedforms include large-scale (gravel and sand) longitudinal and expansion bar complexes and transverse bar fields [2]. Suspended load deposits are emplaced in marginal areas where ponding occurred, preserved as clay pans in dune swales (Fig. 3) and slackwater deposits in tributary mouths [2].

The Search for Unconfined Fluvial Deposits on Mars: We have undertaken a preliminary search of the MOC images released thus far. Even this early pass through the available MOC data reveal fluvial features similar in scale, type, pattern and location to those predicted in the Australian paleoflood model (Fig. 2 and 4). The deposit locations and general morphology in Figure 2 are precisely what would be predicted for a sediment-charged fluid leaving a confined channel reach. The low relief of the deposits in Australia encouraged us to concentrate on images with shallow illumination angles, to enhance subtle features, and fortunately the MGS orbit does provide opportunities for these kinds of images (the incidence angle in Figs. 2 and 4 is 47°).

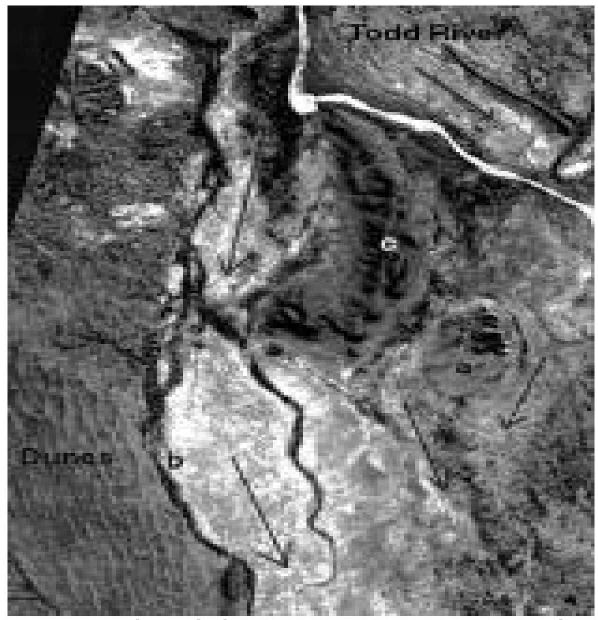

Figure 1. Enhanced Thematic Mapper image (30 m/pixel) of unconfined paleoflood channels in the Todd River catchment, central Australia. Arrows indicate multiple flood channels. Feature labels: a - lee-side aeolian remnant; b - marginal channel; c - bedrock ridge.

Channel and floodplain features: Figure 2 contains several features that suggest a fluvial origin. A channel runs across the image from bottom right. The average width of 70 m is a similar scale to the active ephemeral channels in central Australia. On Earth, variable width is a signature of many ephemeral systems, with high sediment load, erodable banks and variable discharge. The channel expansions in Figure 2 have a 'notched' planform. These notches may indicate the deflection of channel flow against the bank typically found in braided and meandering patterns. Of note, on the Martian example, is that the preserved inner channel pattern is a low sinuosity levee channel and is different from the hypothesised meander or braid pattern. This difference may indicate a change in the flow conditions. It may reflect diminishing flow energy typical of the recessional limb of a large flood or it may represent a more gradual change over longer time periods. These notches may also be influenced by the location of degraded impact craters. The floodplains adjacent to the levee channel is relatively flat (d) at this resolution and there are indications of avulsion/splay development (between b and c).

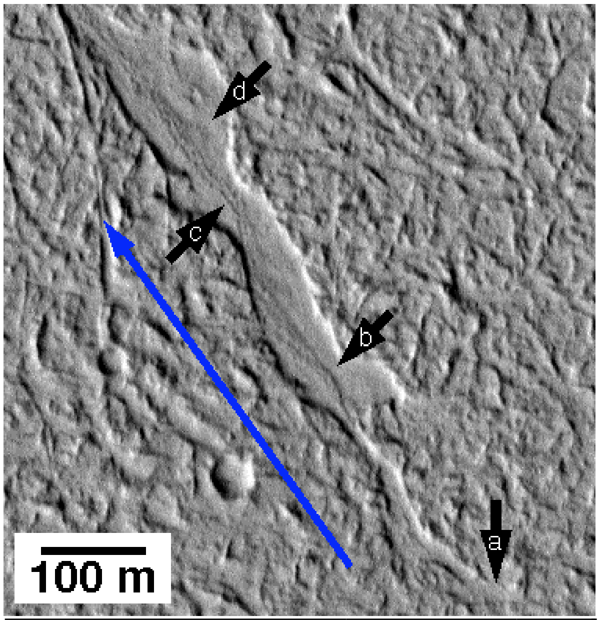

Figure 2. Possible fluvial features on Mars. Portion of MOC frame M04-04068, near 20.1°N, 157.1°W, north to top. A well-defined channel starts within the irregular knobs typical of the area (a). Where channel expands sediment is clearly deposited along the flow path (b). Portions of the deposit may have a central levee section (c), but distal margins show no clear morphology even at MOC resolution (d). Direction of flow is indicated by blue arrow.

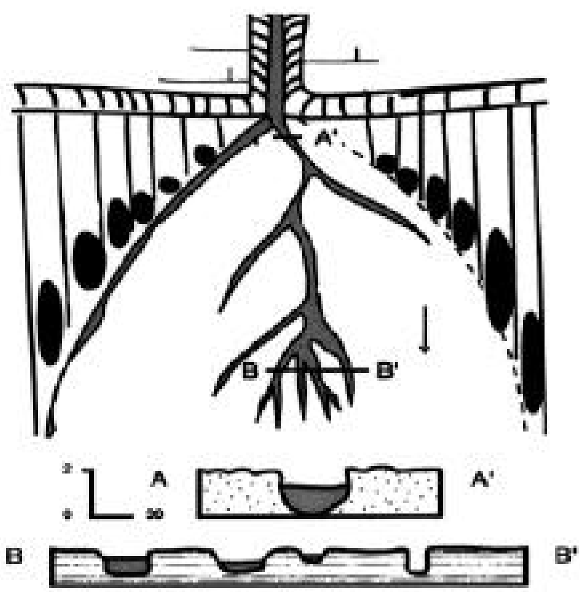

Figure 3. Schematic diagram of a distributary channel in central Australia (after 11). Typical components include a marginal channel that branches and dissipates from the main channel shortly after expansion. Marginal clay pans occur at the mouth of truncated longitudinal dunes (black). Flow is from top of figure. A - A' represents a single channel at the expansion point. B - B' shows multiple channel distributary network with reduced channel capacity. Compare this with a distributary channel network on Mars (Fig. 4).

Floodouts: Many unconfined channels in central Australia terminate in floodouts. These alluvial features are sedimentary basins formed at the end point of a primary or distributary fluvial system, where channeled flow ceases and floodwaters spill across adjacent alluvial surfaces [12]. In Figure 4, a distributary avulses away from the channel, possibly triggered by flow deflection at a resistant ridge in the channel. This channel bifurcates, channel number increase and channel dimensions decrease rapidly, eventually disappearing and forming a floodout (see Fig. 3). On Earth this is attributed to a downstream reduction of discharge [12] caused by increased evaporation and transmission losses. If these features are floodouts on Mars they indicate a permeable surface or evaporation of fluid.

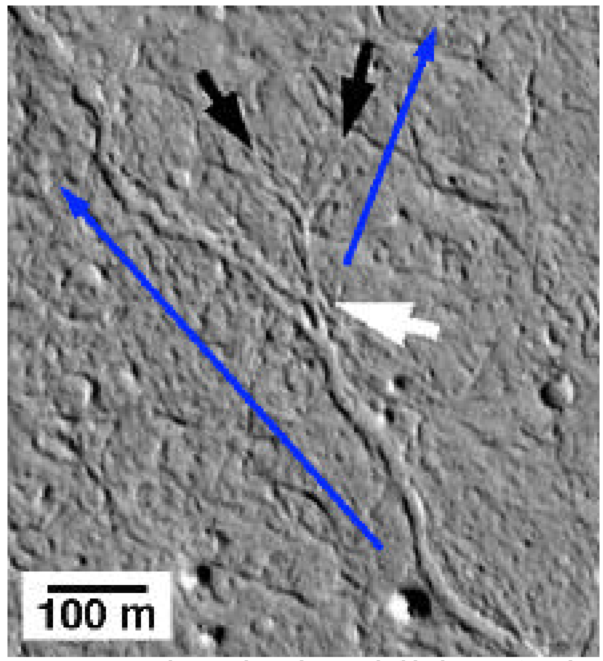

Figure 4. Distributary channel network (black arrows) avulses from main channel on Mars (white arrow). Portion of MOC frame M04-04068, near 20.1°N, 157.1°W, north to top. Direction of flow is indicated by blue arrows.

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References:

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