Palaeoflow and sediment delivery reconstructions from Martian delta morphology by combined physics-based numerical modelling and HRSC DTM analysis

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1. Objective
Our aim is to determine the formation time of Martian deltas, to unravel how these deposits record past hydrological conditions.

2. Modelling delta formation in a lake
* physics-based model for fan and sediment flux
* geometrical model for fan/delta growth: “cone on top of a cone”

Water and sediment input:
* water flux Q from upstream channel slope, width, depth (and g)
* sediment flux Qs from upstream flow conditions and sediment calibre

Initial conditions in lake:
* depth d from diameter D
* crater wall shape from D
* flat floor at prefill depth p

Imposed fan/delta parameters:
* measured subaerial fan slope α
* subaqueous delta slope β (angle of repose)
* max shoreline height from (breached) crater overflow height o

Model output:
* water level per time step
* delta profile per time step from "cone on top of cone" piled on top of previous step
* match modelled and observed profile?
* formative time scale

3. Data and case studies
Data:
* HRSC DTM images
* MOLA (for one case)

Derivatives:
* delta volume and channel volume
* delta gradients and channel gradient
* channel width and depth

Cases:

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<thead>
<tr>
<th>Case</th>
<th>Type</th>
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<tbody>
<tr>
<td>a</td>
<td>Sabrina fan</td>
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<tr>
<td>b</td>
<td>Nanedi delta</td>
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<td>c</td>
<td>Nepenthes delta</td>
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<td>d</td>
<td>Stair-stepped delta, Xanthe Terra</td>
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<td>f</td>
<td>Stair-stepped delta, Terra Sirenum</td>
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4. Model results
Alluvial fan
unconstrained by water level

Stepped deltas: lake level rose
steps caused by channel wall collapse

Gilbert deltas: lake spills over
progrades over a drowning stepped delta

5. Conclusions
* Deltas formed fast in single-event dilute flow within years
* Stepped fan deltas formed much faster than Gilbert-type deltas;
stepped delta feeder channels were steeper and provided more sediment and less water
* Geometrical deposition model and physics-based flow and sediment transport model predict morphology as observed with HRSC well
* New problem: why so short, while mega-outflow channels required more water? What were timing and triggers of fluid water episodes?

6. References: