Differences between deltas on Earth and Mars

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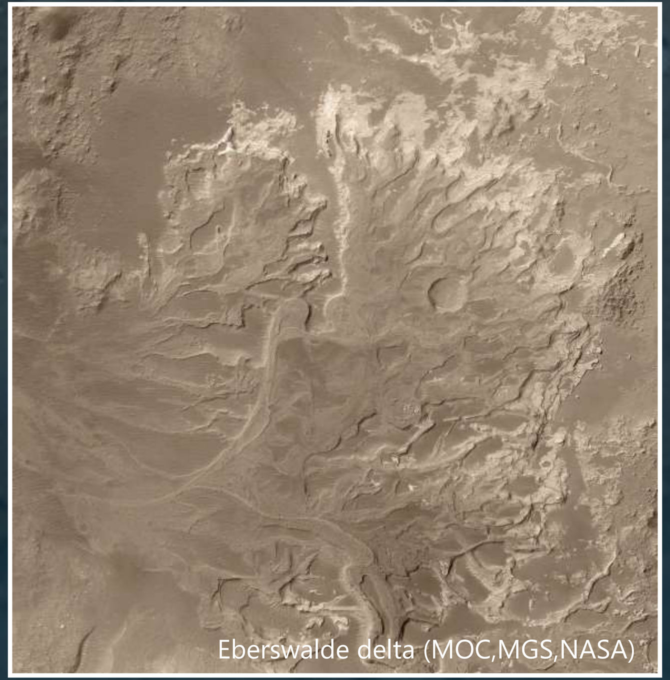
Objective

River deltas are important landforms on Mars because they indicate past fluvial activity, contain a sedimentary record amenable to study, and have the potential to store signs of past life. The sedimentary records that are visible today on satellite and rover images are used to deduce the hydrological and climate history of Mars. To achieve this, we apply our knowledge of terrestrial deltas and Earth analogues. Therefore, any interpretations require understanding of **differences in delta morphodynamics and stratigraphy between Earth and Mars**.

Even though the processes on Mars are similar to those on Earth, the sediment flux differs significantly due to gravity, sediment density, presence of ice, and lack of ecology. Differences in transport can lead to differences in morphology and stratigraphy, which should be considered when making interpretations of past conditions based on orbital imagery. In this research, we isolate and examine **the effect of gravity on sediment transport** and discuss **implications for delta morphology and stratigraphy**.

Jezero data (HRSC, MarsExpress, ESA)



Eberswalde delta (MOC,MGS,NASA)

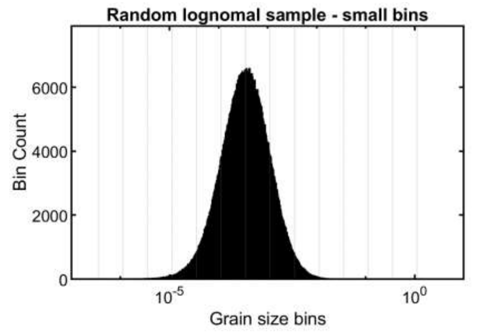
Method

We use terrestrial hydrodynamics, bedload and suspended transport equations to calculate fluvial sediment transport. We run two models with Earth and Mars gravity, with fixed discharges, densities, channel morphologies, and lognormal sediment distributions.

Additionally, we developed a 2D depth-averaged delta model in Delft3D. This model uses similar input conditions as the 1D model equations. The 2D model results on this poster are preliminary.

Input parameters and values

Gravity	$g = 3.71 - 9.81\ m/s^2$
Discharge	$Q = 2000\ m^3/s$
Channel width	$W = 200$ m
Slope	$S = 0.001$ m/m
Water density	$\rho = 1000\ kg/m^3$
Sediment density	$\rho_s = 2800\ kg/m^3$
Sediment size	D = lognormal weight distribution (D50 = 355 µm, D90 = 1.5mm)



Sediment transport equations

$$w_s = \frac{RgD^2}{12\nu + \sqrt{0.75RgD^3}} = Ferguson\ and\ Church\ 2004$$

$$\theta = \frac{\tau}{(\rho_s - \rho)gD}$$

$$\theta_{cr} = Zanke\ 2003$$

$$Q_b = 2.97(\theta - \theta_{cr})^{1.5} = Einstein\ 1950$$

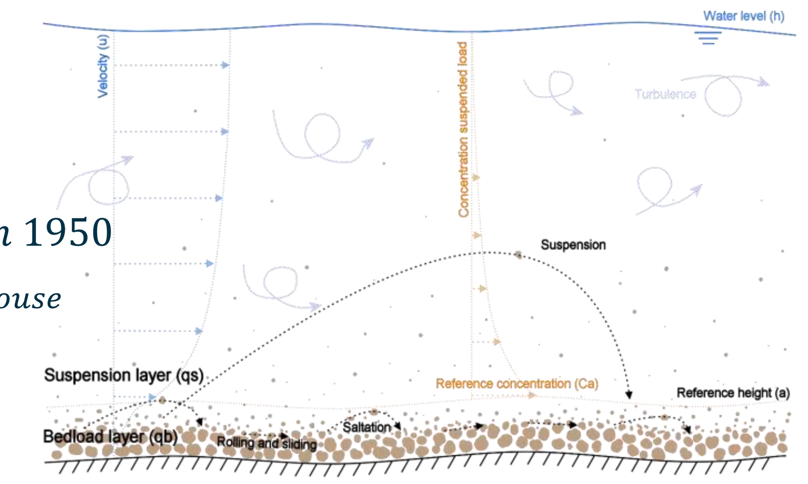
$$q_b = Q_b\sqrt{gRD^3}$$

$$Rouse = \frac{w_s}{Ku_*}$$

$$C_a = \frac{\left(\frac{1}{32.2}\right)Q_b}{\sqrt{\theta}} = Einstein\ 1950$$

$$q_s = \int_a^h C_a\left(\frac{h-z}{z}\frac{a}{h-a}\right)^{Rouse}$$

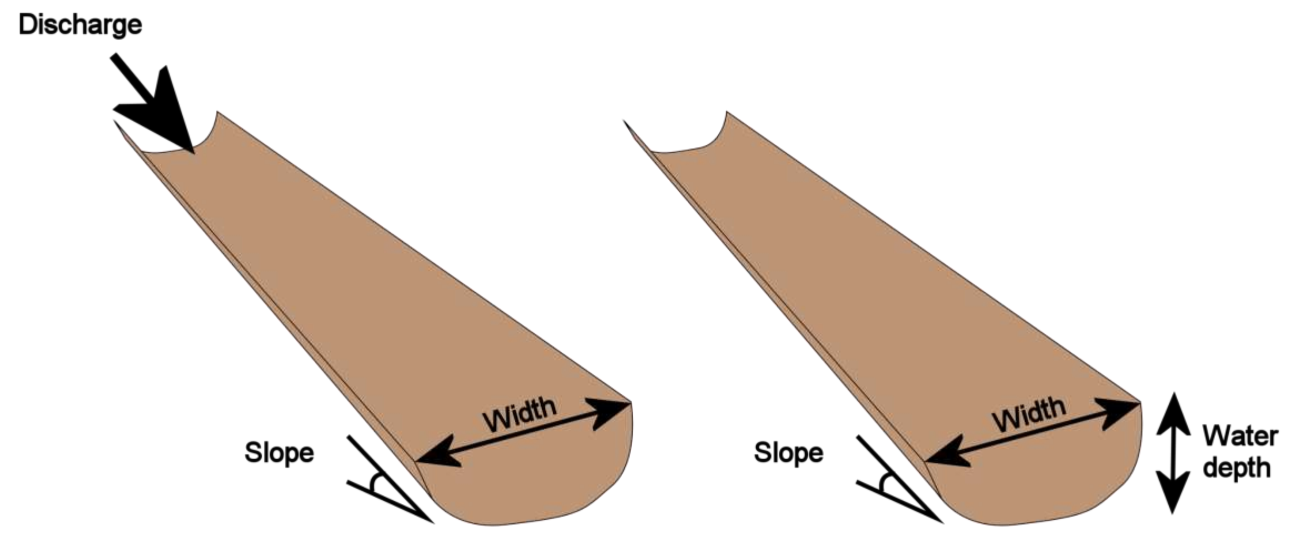
$$q = q_b + q_s$$



Note: Our research covers 21 bedload, 11 suspended load and 1 total load transport equations, but for the purposes of this poster, we use the equations of Einstein (1950).

Importance of defining input

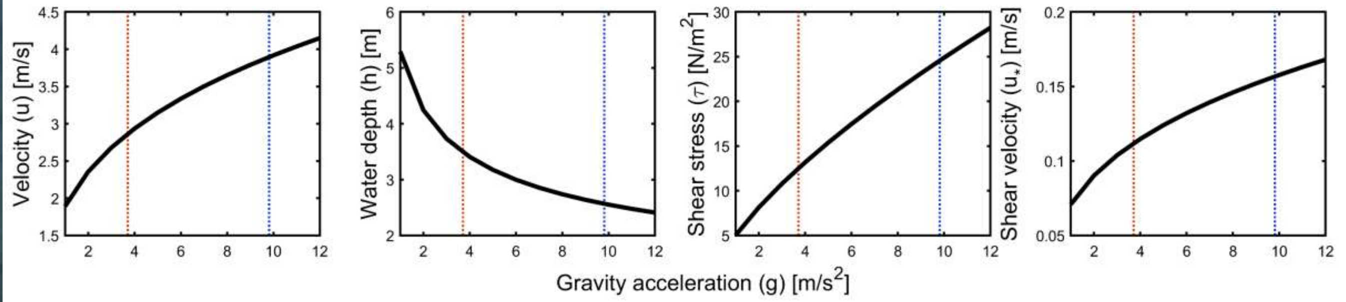
When comparing results of Earth and Mars, it is important to realise that for different independent variables (eg. water depth instead of discharge), the relation between sediment flux and gravity changes.



Results

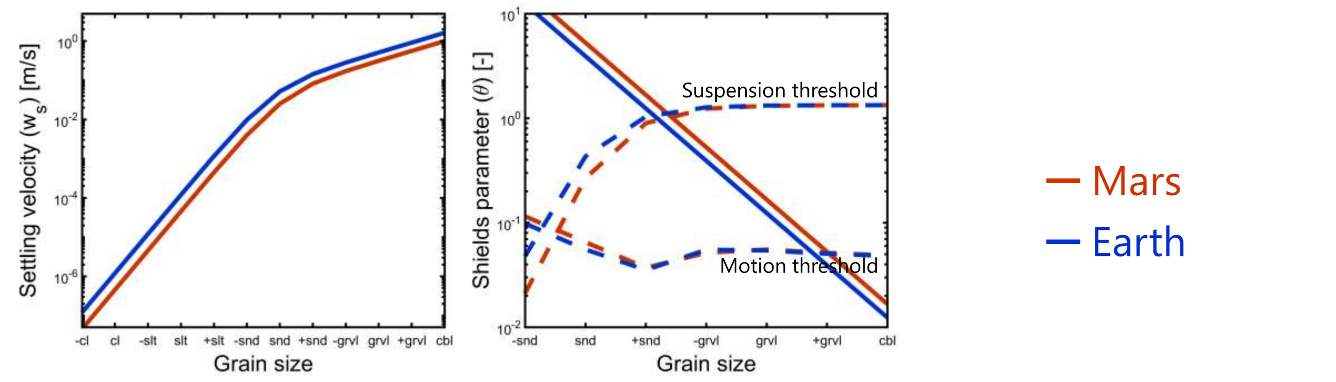
Hydrodynamics

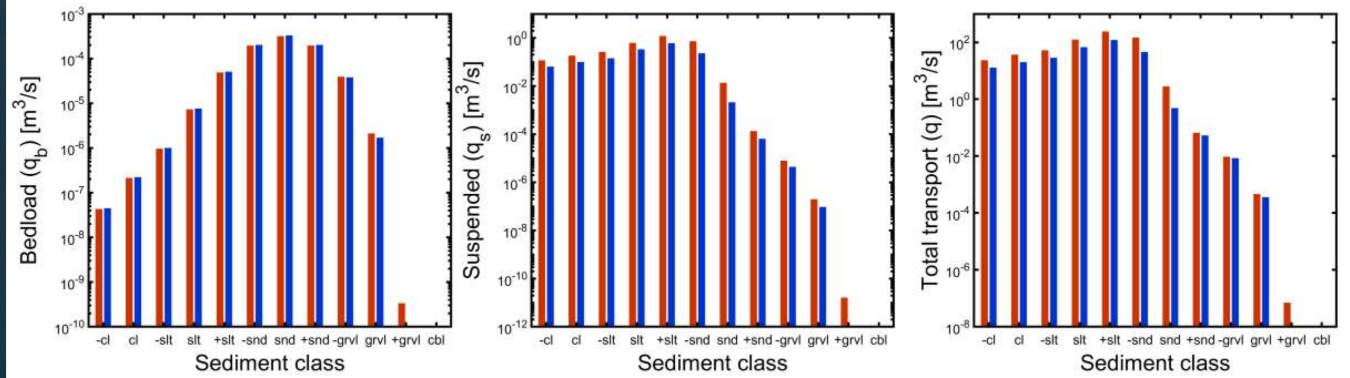
For the same discharge, velocity is lower on Mars and water depth is higher. The resulting shear stress and shear velocity are also lower.



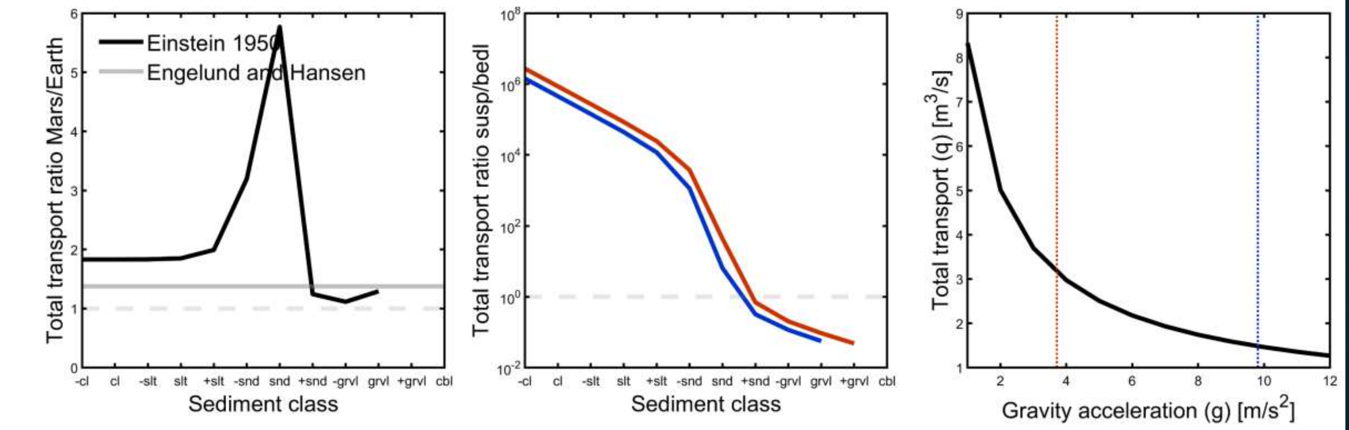
Sediment transport

- Settling velocity is lower on Mars
- Mobility is higher on Mars: larger grains are brought into motion and larger grains are transported in suspension





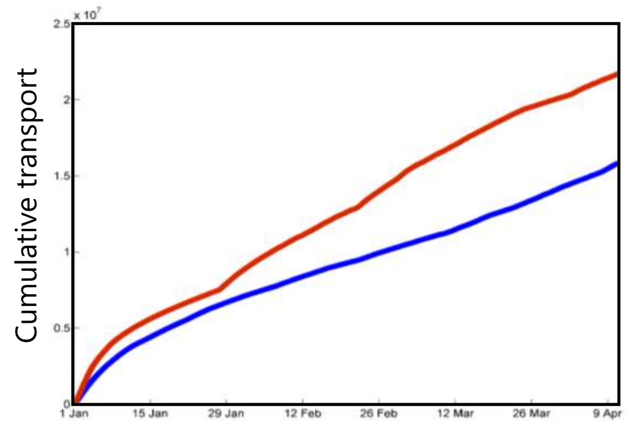
- The effect of gravity on bedload transport is minimal
- Suspended transport is higher on Mars *(Note logarithmic scale!)*
- Total transport is twice as high on Mars compared to on Earth

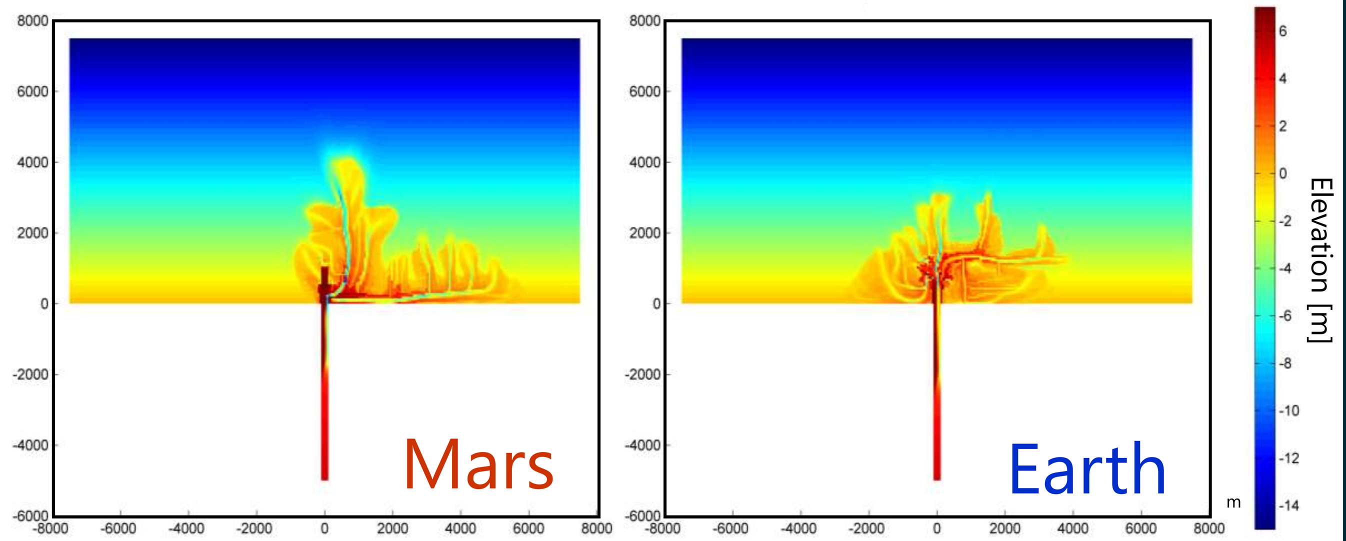


The sand grain size classes (snd) experience the largest impact of gravity. This is the effect of more **and** coarser suspended transport on Mars with respect to Earth. On Mars, the initiation of motion and suspension threshold are reached at larger grain sizes.

2D model results

- Preliminary study
- 3 grain size fractions





Discussion

Implications for Martian geomorphology

- Fluvial landforms can develop in less time for the same discharge
- Larger landforms can develop in the same time span
- We expect an effect of gravity on sediment sorting, as sediment classes are effected differently by gravity
- Therefore, total load equations should not be used
- Higher chances on hyper-concentrated and density-driven flows

Influence of gravity on Martian deltas

- Bigger deltas → faster formation times
- Wider channels
- Sedimentation farther away from channel → less steep foresets
- Coarser fraction expected in delta

Take home messages

The effect of gravity on sediment transport is not straightforward.

The effect is scenario-dependent, because the results are dependent on the choice of independent variables and grain size distribution.

For equal discharge, sediment transport is twice as efficient on Mars.

The biggest effect of gravity occurs on grain size classes around the suspension threshold.

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