Delta deposits in the Jezero paleo-lake on Mars: a study by hydro-morphodynamic modelling

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Objective

We **aim to determine the hydrological active period of the Jezero crater** by reconstructing the delta by morphological numerical modelling. This will subsequently provide information about paleo-environments and conditions.

Our second goal is to indicate likely locations where clays deposited, as clays have a high chance of preserving exobiological signatures. Since this research is still ongoing, we do not have many results yet about this part of the research.

Method

In this study we apply terrestrial numerical modelling software to the surface of Mars. We use the software Delft3D Flexible Mesh in depth averaged mode with an unstructured grid. This software is state-of-the-art, open source, well tested and used for many river and coastal applications on Earth.

The grid is more refined in the channels and in the delta area. For the other parts of the crater a coarser grid is used. The bathymetry is based on HRSC and CTX stereo images, from which we removed the delta and recent imact craters. The boundaries are water level boundaries that are based on the lowest river terraces observed. However, because these estimations are quite uncertain, we tested a range of relastic boundary conditions to also study their sensitivity. Such a sensitivity analyses was also conducted for grain size.

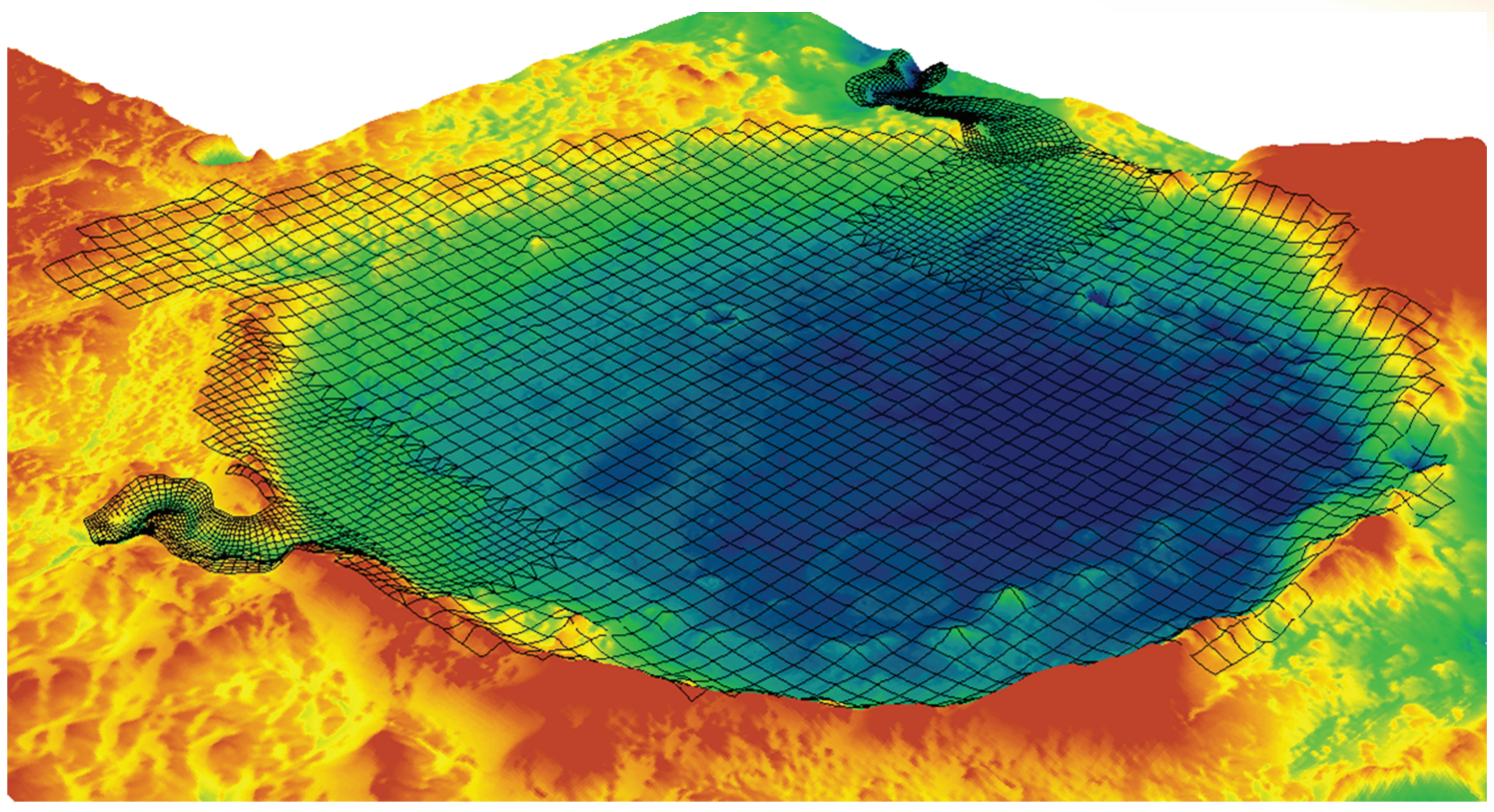

Figure 2: Unstructured model grid of the Jezero crater numerical model. The grid is more refined in channels and at the delta.

Background Jezero

The Jezero crater on Mars is the landing site of the next NASA rover mission. The number one goal of this exploration missions, is to determine whether life ever existed on Mars. The rover will seek preserved biosignatures by taking rock samples. The presented numerical modelling study will be able to help by selecting suitable sample locations.

Jezero is a Martian paleo-crater-lake. Many signs indicate that the crater experienced a period of fluvial activity, including a well-preserved delta. However, the druration of this hydrological period is still unclear, and how long did it take to develop the delta? The diameter of the crater is 45 km and has 2inflow channels and one outflow channel. The western inflow channels is significantly bigger and is the focus of the research, since this channel created the delta.

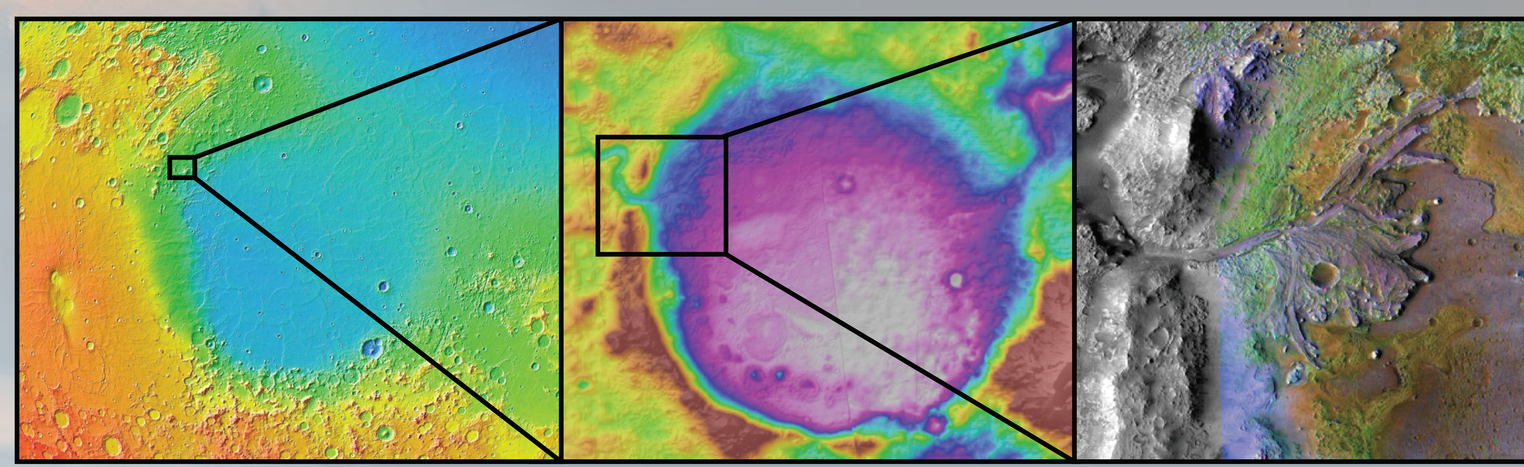

Figure 1: a) Jezero on the border of Isidis basin. MOLA elevation data. b) The Jezero crater. HRSC+CTX data. c) Close-up of the delta in Jezero. NASA/JPL/JHUAPL/MSSS/Brown University.

Hydrodynamic results

The crater fills with water in about 2.4 years by a discharge of 3200 m^3/s.
(For the most realistic boundary condition: 6 m water depth in inflow channel)

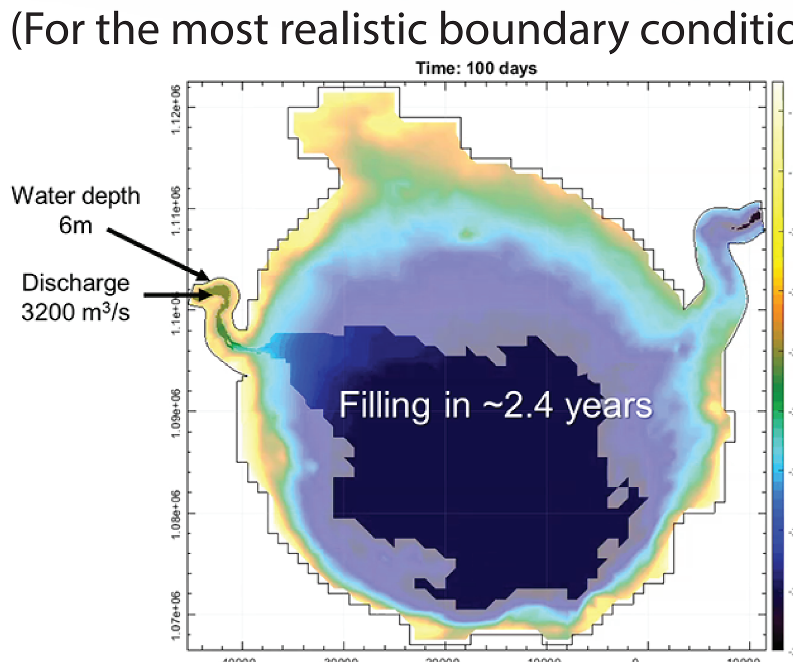

Figure 3: Still image from animation about filling of the crater and the development of the delta. Soft colours are the crater elevation and strong colours indicate the extend of the water.

Morphologic results

A delta of similar size can form in the order of 5 years.
(Under unlimited sediment supply and 6 m water depth inflow channel.)

The growth speed of the delta is sensitive to changes in boundary conditions, but the time to create the delta remains the same order of magnitude.

The delvelpment of the delta is slower when there is water in the crater before the inflow channel becomes active.

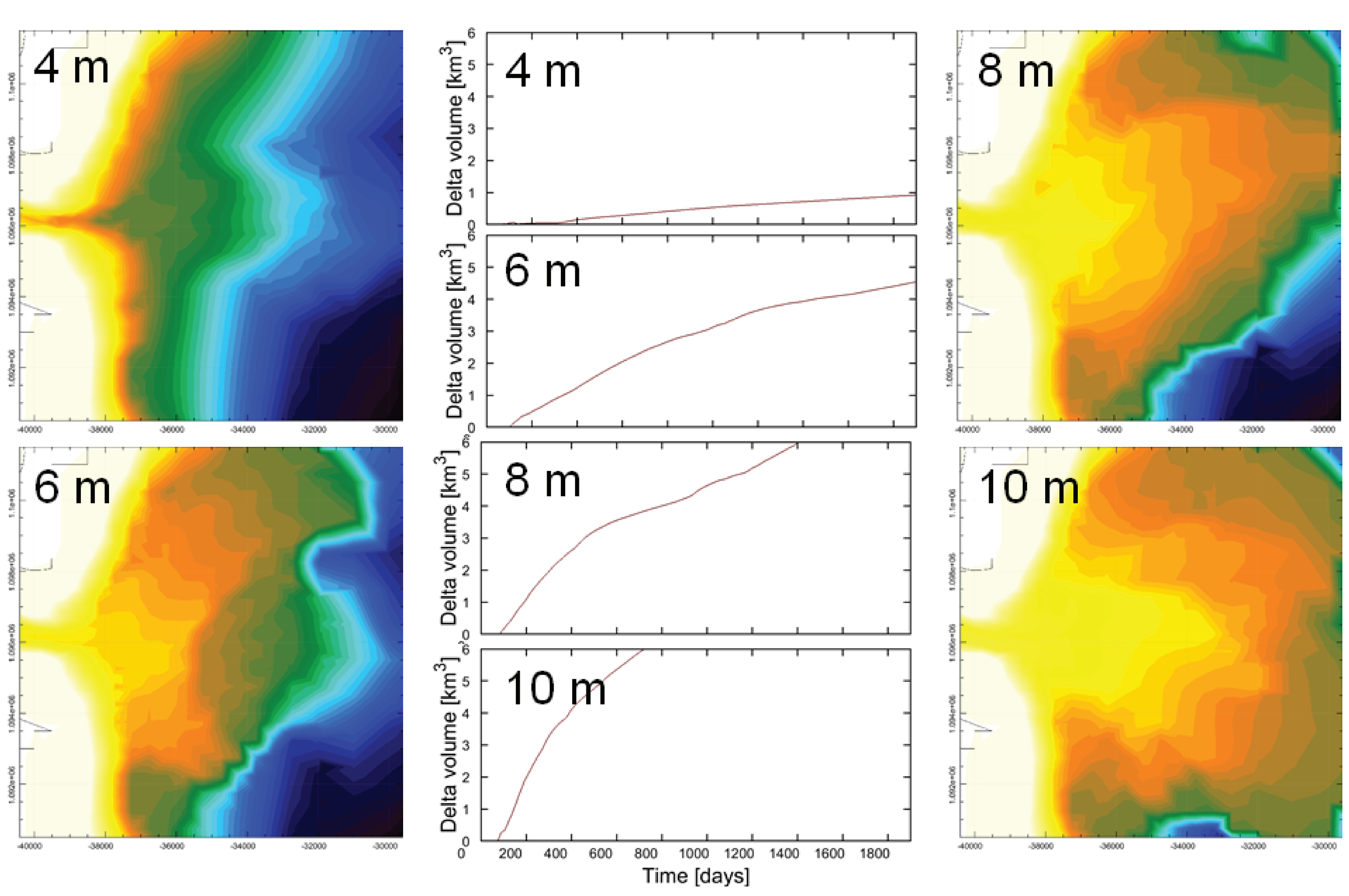

Figure 4: Sensitivity of the delta development to 4, 6, 8 and 10 m water depth at the inflow boundary after the same amount of time. Although the variation is large, the time in which it takes to develop the delta is in the order of years or a few decades.

Mars compared to Earth

Due to lower gravity on Mars, discharges on Mars are smaller than on Earth, because the water is not pulled as hard down slope. On the other hand, sediment mobility is higher under lower gravity and therefore easier brought into motion. Our results show that the combined effects show a faster development of deltas under Martian conditions, despite the smaller discharge.

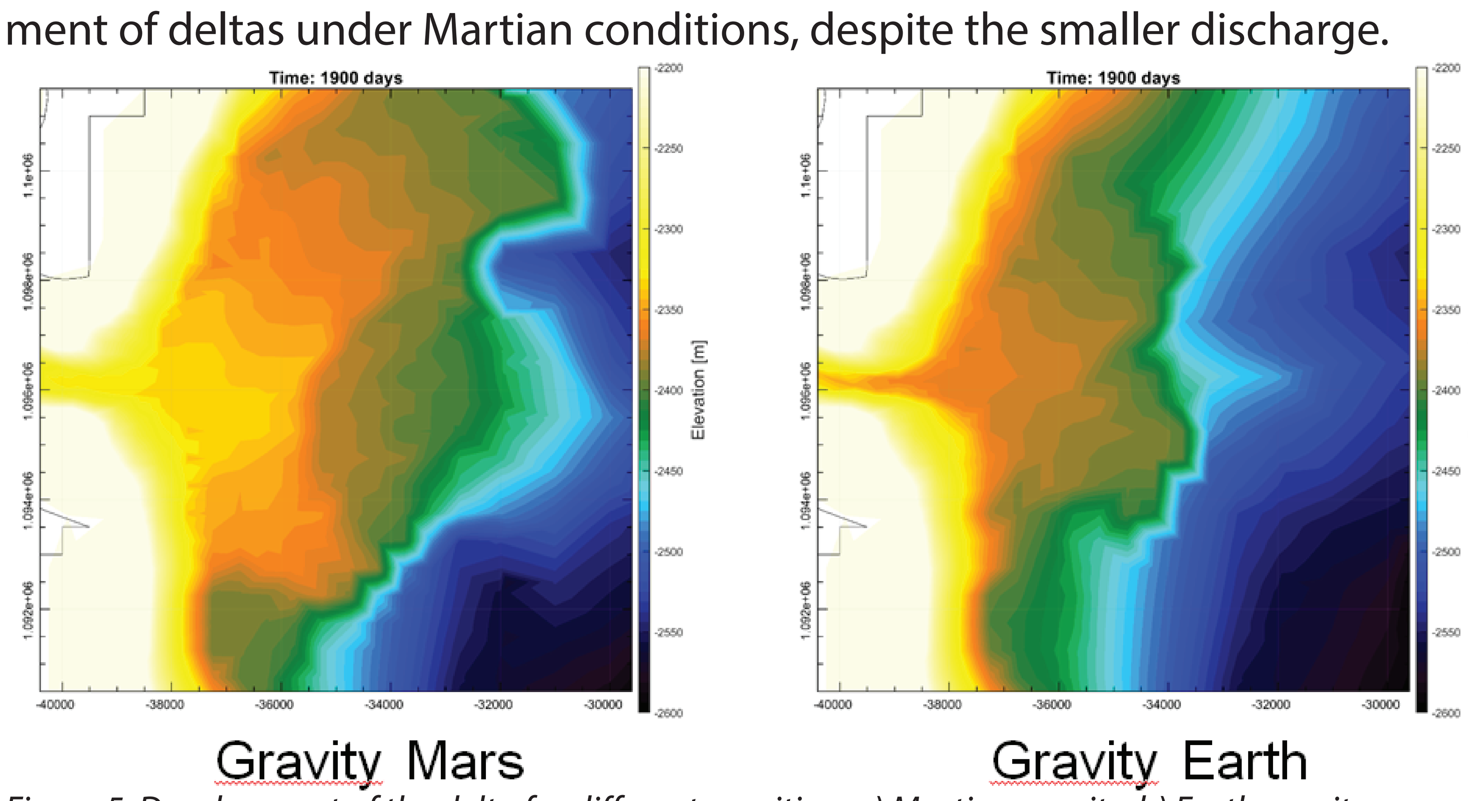

Figure 5: Development of the delta for different gravities. a) Martian gravity, b) Earth gravity.

Discussion

Based on the scenarios tested so far (grain size sensitivity not shown), we estimate that the **delta was formed in the order of a few decades to a century**. So far this is assuming unlimited sediment supply. This research can not establish if the delta has formed in several shorter events or one continuous event. It should also be noted that water could have occured in the crater for a much longer time than the period of activity of the channels and delta. However, these modelling results show a **novel approach** and contradics several ideas of prolonged hydrodynamic activity in Jezero.

In the future we will test more scenarios and also study the deposition and preservation of clays.