German Aerospace Center

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Rain on Mars? Four billion years ago, lake deposits formed inside impact craters

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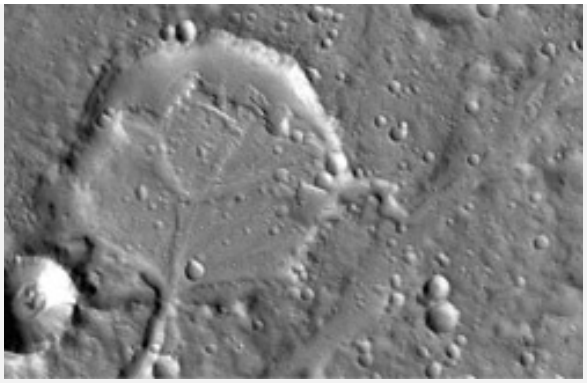


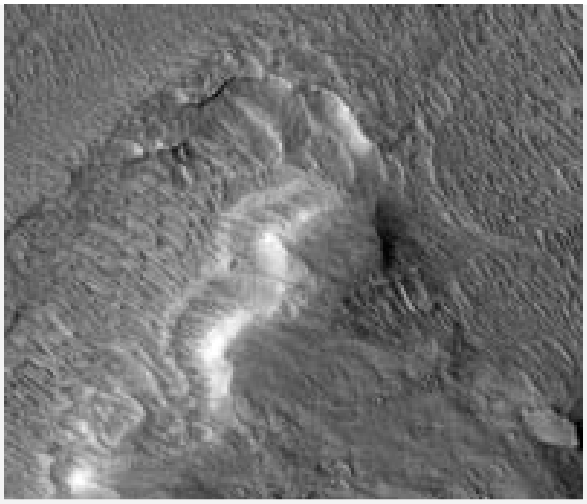
Mars, Xanthe highlands: sediment deposits in the Nanedi delta

About four billion years ago, there were lakes on Mars which may have been fed by short-lived rivers that were, in turn, fed by precipitation. These lakes filled craters that were formed by the impact of meteorites. Water accumulated in places where rivers broke through the crater rims. Deltas were formed at the mouths of the rivers, similar to how they are formed where rivers flow into lakes or seas on Earth. These are the findings of an international team of researchers led by Ernst Hauber of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), who analysed the latest image data of the Martian surface. They discovered delta deposits in these images, relatively unaffected by erosion, inside the craters.

DLR's Ernst Hauber

The scientists explored the Xanthe Terra area located near the equator in the Martian highlands. "For years scientists have been suspecting that the current appearance of the landscape has, in part, been shaped by rivers that cut into the surface," explains Mr Hauber. The geologist of the DLR Institute of Planetary Research (DLR-Institut für Planetenforschung) in Berlin-Adlershof led the research efforts and their results will be published in the scientific journal Planetary and Space Science. “We can see layered sediments where these valleys open into impact craters. The shape of certain sediments is typical for deltas formed in standing water."

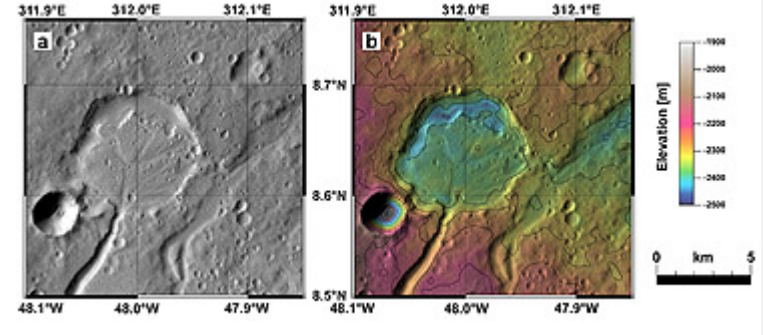
The researchers analysed images from three Mars spacecrafts. These images were taken by the German High-Resolution Stereo Camera (HRSC) on board the European Mars Express mission, by the Mars Orbiter Camera (MOC) on board NASA's Mars Global Surveyor Mission and by the HiRISE and CTX camera experiments on board NASA's Mars Reconnaissance Orbiter (MRO) mission. The HRSC, which is operated by DLR, enables the high-resolution and "3-D" representation of large contiguous areas. So-called digital terrain models can be derived from these representations and the topography of the Martian landscape can be calculated. The data recorded by the HiRISE camera on board MRO make it possible to explore small, specifically selected areas in images which show details on Mars that are not much more than a metre in size.



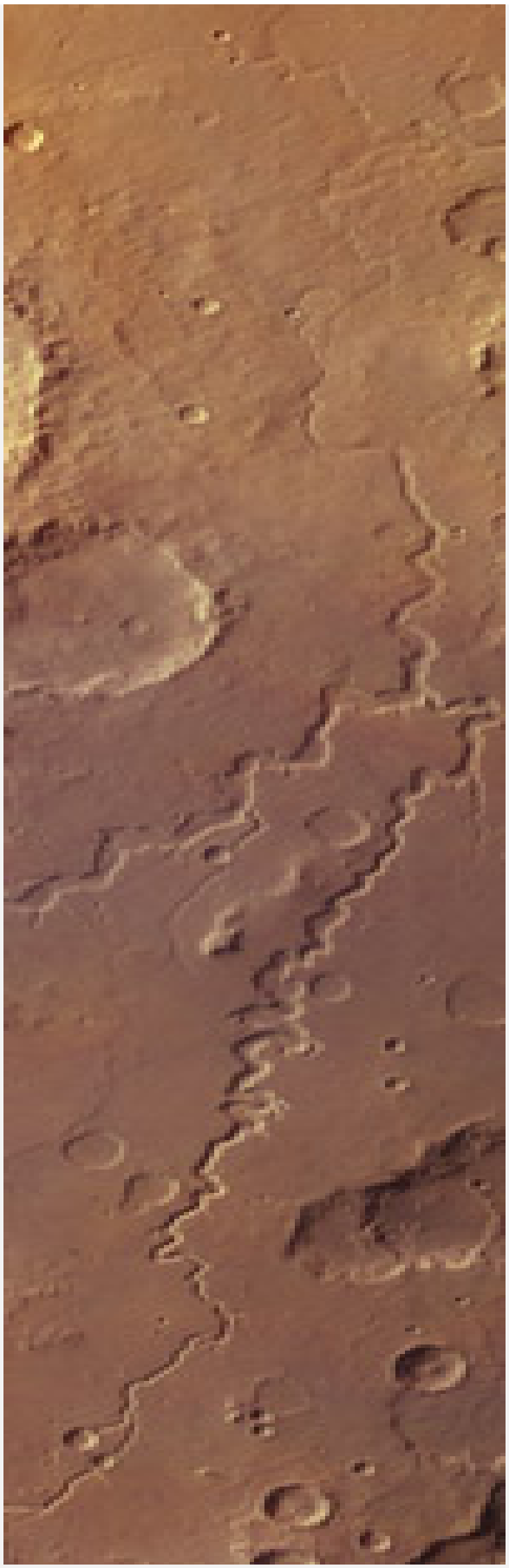
Layered deposits in the Nanedi river delta

Rivers carry eroded material downstream. When the flow rate drops, there is not enough energy left to transport this sediment load and it will be deposited. Because this typically happens in places where a river flows into a larger basin, and where the flow rate nearly completely drops to zero, sedimentary deposits form in such locations. The type of deposit then depends on the nature of the basin. If the basin is filled with water - a lake or a sea - deltas are formed. If on the other hand the basin is dry, for instance in the desert, the river slows down and gradually seeps away, in some cases forming so-called playas in the process. Deposits in such dry areas are called alluvial fans. Analysis of sedimentary bodies can therefore show if there were lakes on Mars.

The Xanthe Terra highlands in the equatorial region of Mars are traversed by deeply incised valleys. Scientists have suspected for a long time that these were formed by water erosion (see also related article "Nanedi Valles valley system on Mars"). A particularly beautiful delta can be found here in a small crater with a diameter of only five kilometres. The Nanedi river opens into the crater from the south (in the lower part of the image), where the sedimentary material is distributed over a fan-shaped area. The crater is almost completely filled with sediments. Topographic data derived from the stereo images recorded by the HRSC camera show that the layer of material is at least 50 metres thick and the deposits cover an area of about 23 square kilometres.



Topographic image map of the mouth of the Nanedi valley in the Xanthe highlands



Junction of the Nanedi valleys in the Xanthe highlands on Mars

Very thin layers can be seen along the edge of the deposits. Such thin layers are also typical for deltas on Earth. A particularly interesting discovery is the small valley which leaves the crater towards the east (towards the right in the images). This provides evidence that water must have indeed been "standing" in the crater. "If the water flowed into the crater and back out again, it must have filled it up as well", says Mr Hauber. He points out that it is quite rare to see something like this on Mars: "In this and in a few other cases, we are fairly certain that there were lakes on Mars."

The researchers can also narrow down the period when the craters were filled with lakes. In order to do so, they analyse the statistical distribution of impact craters of different sizes. These give an indication of the age of a planetary surface. The more craters are counted on a surface, the older the area is. The crater counts revealed that water was flowing through the valleys between about 3.8 and 4 billion years ago. The valleys themselves could have formed relatively fast. Maarten Kleinhans of the University of Utrecht in the Netherlands, who also participated in the research study, calculated that depending on the water volume, the deposits could have formed over a period ranging from decades to millennia. According to Mr Kleinhans, even if the water flow was very low, it would not have taken more than a few hundred thousand years for the deltas to reach their current dimensions. Compared to other geological timescales, especially in planetary geology, this is a very short period of time.

Thus, there must have been precipitation on early Mars. This precipitation then flowed over the surface - this is also one of the findings of the joint research effort. "This is actually not at all self-evident: for a long time, scientists have been trying to figure out whether the valleys on Mars were formed by groundwater seepage and headward erosion, or by surface runoff caused by rainfall or snowmelt", says Mr Hauber. In recent discussions, the role played by surface runoff has been emphasised again. "Our findings also point in this direction and we are convinced that both processes have played an important role in Xanthe Terra".

However, this situation did not last very long. Between 3.5 and 3.8 billion years ago, the precipitation became less intense and the valleys dried up. Erosion on Mars has been minimal ever since, which has contributed to the fact that deposits can still be observed although they should in fact be very susceptible to erosion. Today, Mars is a dry desert planet and water is no longer flowing through its valleys.

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