An eight-thousand metre mountain with sulphate layers in Hebes Chasma

10 October 2013

If an astronaut were to stand in the Hebes Chasma basin, the view would be extraordinary. Precipitous walls rise almost 8000 metres into the skies, and a massif similar in size to Mount Everest lies at the centre. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) High Resolution Stereo Camera (HRSC), on board ESA's Mars Express spacecraft, imaged Hebes Chasma during several overflights. The vast extent of this impressive landscape formation is revealed by a mosaic created using eight of the acquired images.

Hebes Chasma is an endorheic (enclosed) basin stretching 315 kilometres in an east-west direction and 125 kilometres from north to south. The mesa, or flat-topped mountain, rising from the centre is over 100 kilometres long and between 10 and 20 kilometres wide. The summit of this elevation towers approximately 8000 metres above the lowest points of Hebes Chasma. A multitude of gullies are etched into the basin's precipitous cliffs. Landslide deposits, possibly the remains of formations dislodged from the flanks, are scattered at the foot of the rock walls. These landslide deposits, which have been eroded, form a one to two thousand metre 'mountain range' in the basin.

Aqueous minerals formed after the crust ruptured

Hebes Chasma is located north of the vast Valles Marineris canyon. Like Valles Marineris, scientists suspect the origins of Hebes Chasma lie in the emergence of the Tharsis volcanic region, during which the surrounding crust bulged to a height of around four kilometres. As the bulge was swelled by the underlying magma, the crust fractured, creating deep scars in the high plains.

The 8000-metre flat-topped mountain at the centre of Hebes Chasma is made up of numerous strata of different rocks, as can be seen clearly in the banded and layered flanks. These are sediment layers, most likely deposited by flowing or standing water. In some places, they consist of minerals with water molecules embedded in their crystalline structure, for instance calcium sulphate (gypsum) or magnesium sulphate (kieserite). These minerals – salts of sulphuric acid – also form in aqueous environments on Earth. OMEGA, the spectrometer on board Mars Express, and the CRISM experiment on the NASA Mars Reconnaissance Orbiter, identified gypsum and kieserite here and in morphologically similar areas.

These sediment strata are referred to as 'interior layered deposits'. It is not clear how the huge mountain in Hebes Chasma formed, whether it is the remains of an older plateau, sediment that formed when a lake or inland sea existed in the enclosed basin, or whether it may indeed be an accumulation of deposits blown in by the wind. What is clear is that there must have been water in a liquid state for at least part of its history. With time, the rock layers were exposed by erosion, which now permits their analysis using the experiments on board the Mars orbiters, and which provide important information on the geological development and climate in Mars' early history.

Image processing and the HRSC experiment in the Mars Express mission

The images used here were acquired by HRSC during the overflights on orbits 7237, 2149, 5178, 5160, 5142, 6241, 3217 and 0360. The nadir channel, which is directed vertically down onto the surface of Mars, and the HRSC colour channels were used to produce the colour aerial view (image 2). The HRSC stereo channels formed the basis for generating the oblique-angle perspectives (images 1 and 3). The anaglyph (image 4), which when viewed through red-blue or red-green-blue spectacles conveys a three-dimensional impression of the landscape, was

derived from the nadir channel and one stereo channel. The colour-coded vertical plan view (image 5) is based on a digital elevation model of the region's terrain, used to derive the landscape topography. The centre of the image is situated at one degree south and 284 degrees east.

The High Resolution Stereo Camera was developed at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and built in collaboration with partners in industry (EADS Astrium, Lewicki Microelectronic GmbH and Jena-Optronik GmbH). The science team, which is headed by principal investigator (PI) Prof. Ralf Jaumann, consists of over 40 co-investigators from 33 institutions and ten countries. The camera is operated by the DLR Institute of Planetary Research in Berlin-Adlershof. The images shown here were generated by the Institute of Geological Sciences at FU Berlin in conjunction with the DLR Institute of Planetary Research in Berlin.

Contacts

Elke Heinemann
German Aerospace Center (DLR)
Corporate Communications
Tel.: +49 2203 601-2867
Fax: +49 2203 601-3249
elke.heinemann@dlr.de

Ulrich Köhler
Deutsches Zentrum für Luft- und Raumfahrt (DLR) - German Aerospace Center
Tel.: +49 30 67055-215
Fax: +49 30 67055-402
ulrich.koehler@dlr.de

Dr Daniela Tirsch
German Aerospace Center (DLR)
DLR Institute of Planetary Research
Tel.: +49 30 67055-488
Fax: +49 30 67055-402
daniela.tirsch@dlr.de

Oblique perspective of the layered sediment mountain

This roughly 8000-metre-high flat-topped mountain in Hebes Chasma is made up of mineral deposits stacked in almost horizontal layers. Scientists continue to analyse whether these deposits would suggest a lacustrine origin or whether they were transported to their current location by the wind. The darker areas visible in the image consist of volcanic sand, which is found in various places at the bottom of the basin and also incorporated in the sediment mountain itself. This appears indicative of relatively recent sediment and ash deposits.

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Aerial view of Hebes Chasma

The Hebes Chasma basin north of the Valles Marineris canyon system is 315 kilometres long and 125 wide. It was created during the formation of the volcanic Tharsis region, during which the crust was stretched and fractured. The surrounding upland plains belong to the Tharsis volcanic plateau. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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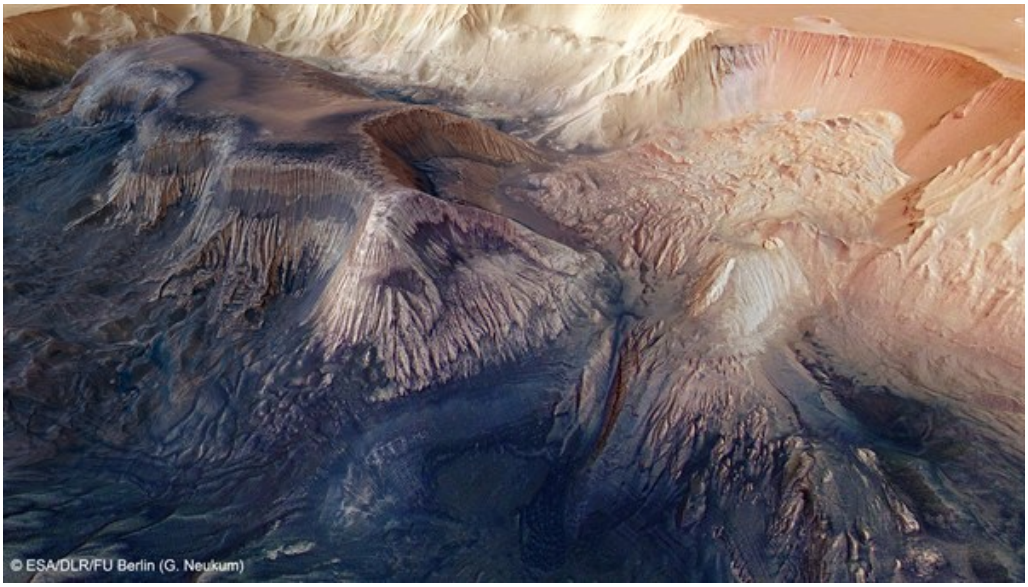
A view into the Hebes Chasma basin from the northwest



The coloured strata in the sediment mountain indicate the presence of different materials, alternations of various sulphurous minerals with aqueous content such as gypsum and kieserite (light layers) and minerals of volcanic origin such as olivine and pyroxene (bluish layers). Debris from a rockslide dislodged from the northern cliffs of the basin can be seen on the right side of the image. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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Anaglyph image of Hebes Chasma

Anaglyph images of the surface of Mars are produced using the nadir channel in the HRSC camera system, which is directed vertically down towards the planet surface, and one of the stereo channels aligned at an oblique angle. Red-blue (cyan) or red-green-blue spectacles create a three-dimensional impression of the landscape. The Hebes Chasma basin, almost eight kilometres deep, stretches 315 kilometres along a west-east direction and 125 kilometres from north to south. At its centre, the flat-topped mountain is around 100 kilometres long, some 8000 metres high, and varies in width between 10 and 20 kilometres. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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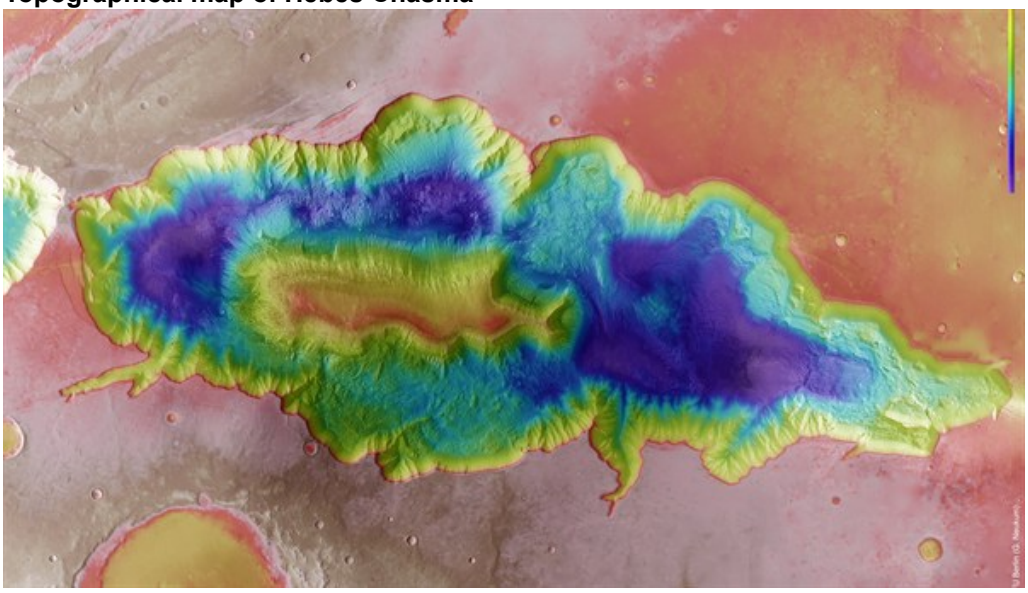
Topographical map of Hebes Chasma



This colour-coded elevation model of Hebes Chasma emphasises just how deep the depression is at roughly eight kilometres. The lowest points of the basin are over 4000 metres below zero elevation on Mars. Rising approximately 4000 metres above zero elevation, the loftiest points in the image belong to the high plains of the Tharsis Plateau. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence since December 2014: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO. This licence will also apply to all HRSC images released to date.

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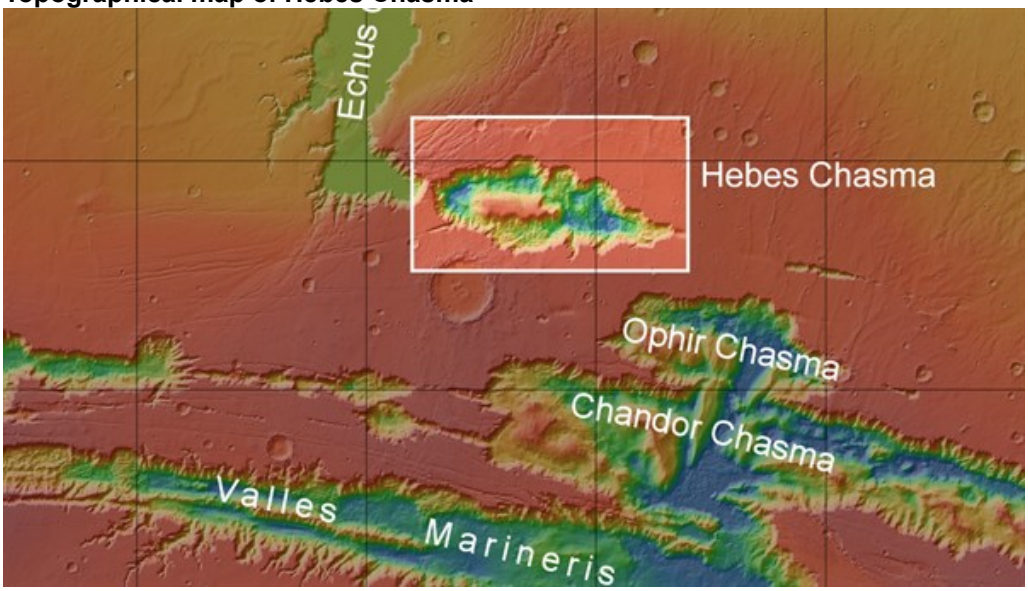
Topographical map of Hebes Chasma



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Credit: NASA/JPL/MOLA; FU Berlin.

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