Black dunes on the Red Planet

15 May 2014

These images, acquired by the High Resolution Stereo Camera (HRSC), which is developed and operated by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and carried on board ESA's Mars Express spacecraft, show Rabe Crater, situated in the southern highlands of Mars. A vast field of black dunes, some towering up to 200 metres high, is located at the centre of the crater, which is about 100 kilometres across.

These dark dunes are composed of fine volcanic ash, which is also visible as a dark layer clinging to the sides of the depressions in the crater floor. The ash is carried out of this layer by the wind, accumulating elsewhere to produce impressive dune fields. Referred to as 'basalt dunes' due to their volcanic mineral composition, these formations are particularly frequent on Mars. Indeed, basalts represent the most common volcanic rock found on the Red Planet. This kind of dune is a very rare occurrence on Earth, found on Hawaii, New Zealand and Iceland, for example. They only arise where volcanic activity occurs in a dry climate.

Signs of the winds in Rabe Crater

The dunes display a variety of patterns that indicate the different prevailing wind directions. Scientists determine the wind direction that produced a dune based on the orientation of the dune ridge and the upwind side of the dune. For instance, the dunes in image 1 can be seen spreading over a cliff and down into a depression; these are referred to as 'falling dunes'. Dunes elsewhere in the field are aligned in a variety of different directions.

The dark dunes on Mars were produced in the more recent geological past, less than 100 million years ago, when the water once found on Mars had probably disappeared. This is evident from the absence of chemical weathering, that is, the oxidation of the iron-rich ash with its typical reddish discolouration – which is seen on the majority of the Martian surface.

Another unusual feature of Rabe Crater is that a large part of its floor has subsided. Of the layered sediments that once filled this crater, only a kind of table mountain remains, protruding from the floor. Its cause is yet unknown, although it may have been produced by ice that previously filled cavities beneath the crater and then melted and flowed away as water. The large, dark field of dunes formed on the plateau later on.

A smooth environment produced by 'terrain softening'

Rabe is an impact crater with a diameter of 108 kilometres. Like most craters in this region, it has a severely weathered appearance. Characteristics that define young impact craters, such as high crater walls, terraces or central mountains are no longer as pronounced or have disappeared.

Some craters in the vicinity, especially to the north of Rabe, remain visible only as outlines; the material creep occurring along slopes gradually levels the terrain. The geological process that shapes the surface in this way is referred to as 'terrain softening'. A high concentration of ice in the substrata probably assisted this process, permitting surface material to 'creep' on the slippery layers of subterranean ice, even at low slope angles. Additionally, most craters in this region possess a smooth floor, as they are filled with sediment. Only one smaller, substantially younger, impact crater at the bottom left of image 3 is an exception.

The location of Rabe Crater on Mars

Rabe Crater (named after the astronomer Wilhelm Rabe, 1893-1958, former director of the Munich University Observatory in Bogenhausen) is situated roughly 320 kilometres to the west of the gigantic impact crater Hellas Planitia. Measuring 2300 kilometres in diameter and with a depth of over seven kilometres, the Hellas Basin is among the largest impact craters in the Solar System. Rabe Crater and Hellas Planitia are both located in the southern highlands of Mars, a region far older than the northern lowlands and one that therefore possesses a large number of impact craters. This topographical dichotomy is one of the most noticeable features of our neighbouring planet.

Image processing

The images acquired by the HRSC and used to produce this image mosaic come from Mars Express orbits 12,736 and 2441. The image resolution is approximately 15 metres per pixel. They show an area located at approximately 44 degrees south and 35 degrees east. The colour plan view (image 3) was acquired using the nadir channel, which is directed vertically onto the surface of Mars, and the colour channels; the oblique perspective view (image 1) was derived from data acquired by the HRSC stereo channels. The anaglyph (image 2), which produces a three-dimensional impression of the landscape when viewed through red-blue or red-green spectacles, was derived from the nadir channel and one stereo channel. The colour coded aerial view (image 4) is based on a digital terrain model of the region from which the landscape topography can be derived.

The HRSC experiment on the Mars Express mission

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) Ralf Jaumann, consists of over 40 co-investigators from 33 institutions and 10 countries. The camera is operated by the DLR Institute of Planetary Research in Berlin-Adlershof. The images presented here were created by the Planetary Sciences Group at the Freie Universität Berlin.

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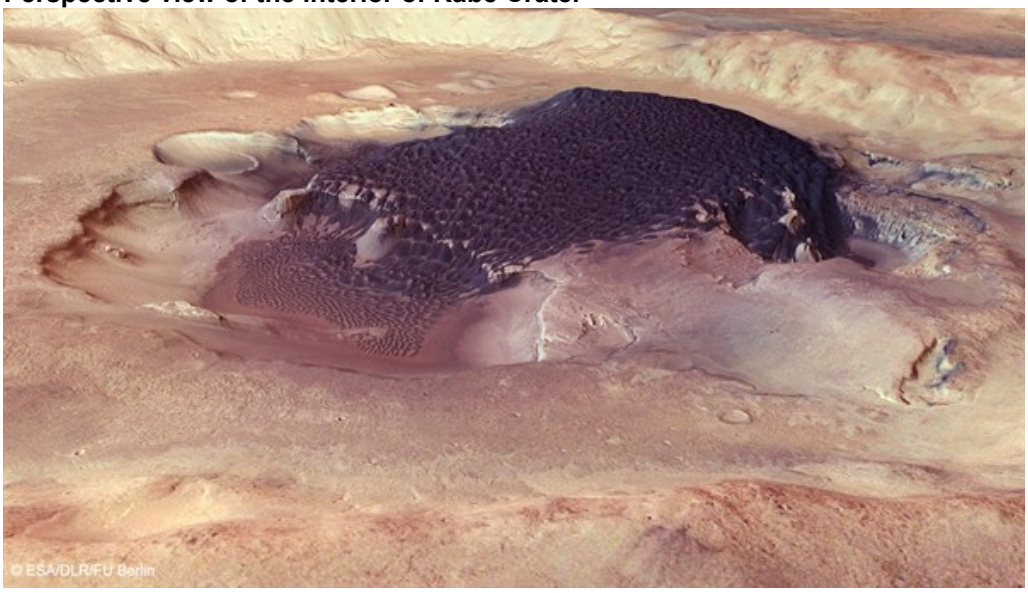
Perspective view of the interior of Rabe Crater



Stereo images from the High Resolution Stereo Camera operated by DLR on ESA's Mars Express spacecraft can be used to show the landscape from various angles. This image shows the centre of Rabe Crater, which is approximately 100 kilometres across, where a large field of black dunes is located. The dunes are up to 200 metres high. The data used to create this image was acquired by the High Resolution Stereo Camera (HRSC) during orbits 2441 and 12,736 of Mars Express. The image resolution is about 15 metres per pixel. 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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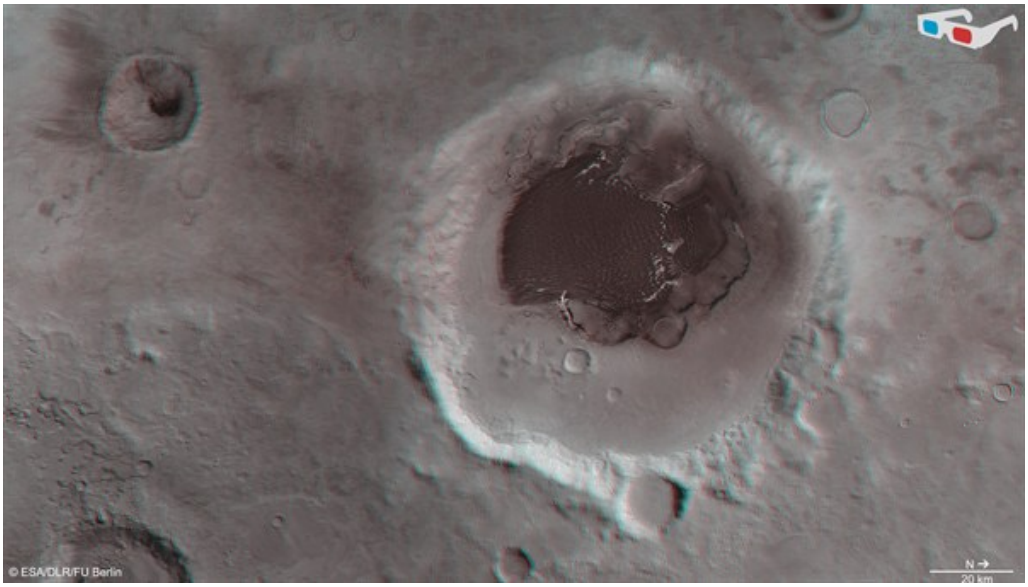
Rabe Crater in 3D



The nadir channel, which is directed vertically down onto the surface of Mars, and one of the four stereo channels in the DLR-operated HRSC camera system, can be used to create anaglyph images, which produce a realistic, three-dimensional view of the landscape when viewed with red/blue or red/green glasses. This image shows Rabe Crater, with a black dune field at its centre. The data used to create this image was acquired by the High Resolution Stereo Camera (HRSC) during orbits 2441 and 12,736 of Mars Express. The image resolution is about 15 metres per pixel. 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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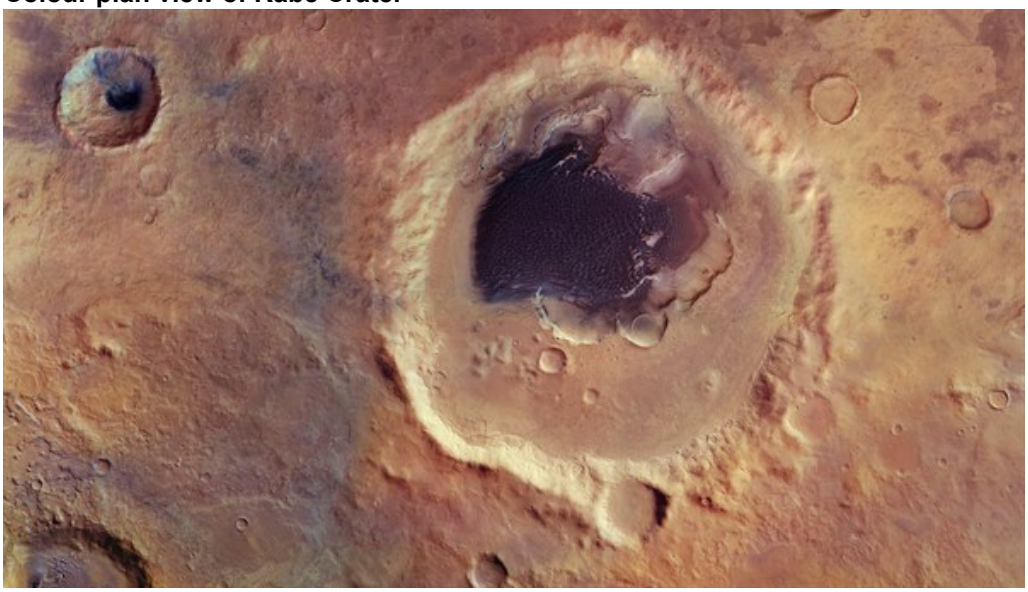
Colour plan view of Rabe Crater



In the centre of the 100-kilometre-diameter Rabe Crater is a large field of black dunes, some of which are up to 200 metres high. These dark dunes are composed of fine volcanic ash. Referred to as ‘basalt dunes’ due to their volcanic mineral composition, these formations are particularly frequent on Mars. Indeed, basalts represent the most common volcanic rock found on the Red Planet. This kind of dune is a very rare occurrence on Earth, found on Hawaii, New Zealand and Iceland, for example. They only arise where volcanic activity occurs in a dry climate. The data used to create this image was acquired by the High Resolution Stereo Camera (HRSC) during orbits 2441 and 12,736 of Mars Express. The image resolution is about 15 metres per pixel. 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

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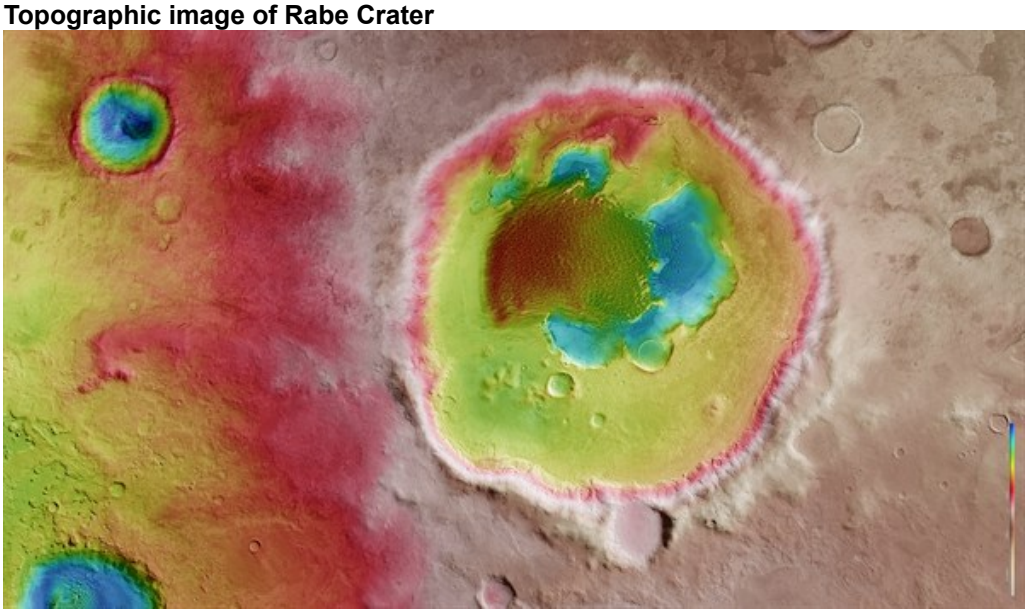
Topographic image of Rabe Crater



Topographical terrain models can be computed using stereo image data from the HSRC camera system, which is operated by DLR. In the absence of 'sea level', the elevation data is referenced to an areoid – a modelled equipotential surface on which everything experiences the same gravitational attraction towards the centre of the planet. The grey and red areas are highest, the dark blue and purple coloured areas are the lowest. The data used to create this image was acquired by the High Resolution Stereo Camera (HRSC) during orbits 2441 and 12,736 of Mars Express. The image resolution is about 15 metres per pixel. 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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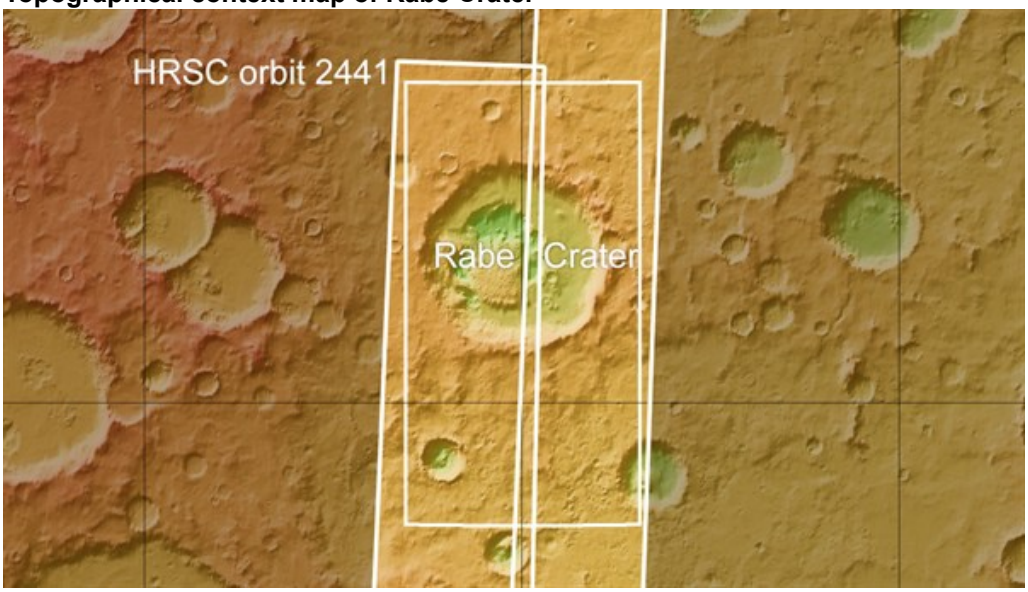
Topographical context map of Rabe Crater



This topographic map shows the location of Rabe Crater on Mars. The crater is named after the astronomer Wilhelm Rabe (1893-1958), a former director of the Munich University Observatory in Bogenhausen; it is situated roughly 320 kilometres to the west of the gigantic impact crater Hellas Planitia. The data used to create this image was acquired by the High Resolution Stereo Camera (HRSC) during orbits 2441 and 12,736 of Mars Express. The geological features shown

in the images presented in this article are located in the innermost rectangle. The outer rectangles show the swathes imaged by HRSC during the two orbits.

Credit: NASA/JPL/MOLA; FU Berlin.

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