Mars Express - A dark spot on Mars - Syrtis Major

02 February 2012

Amateur astronomers who on occasion observe Mars through the eyepiece of their telescopes are quite familiar with the region of Syrtis Major; when observing conditions are good, it can be easily identified as a dark spot on Mars. This large volcanic region just north of Mars' equator covers an area of roughly 1300 by 1500 kilometres – about half the size of Europe. The High Resolution Stereo Camera (HRSC), operated by the German Aerospace Center (Deutsches Zentrum für Luft und- Raumfahrt; DLR), on board ESA's Mars Express spacecraft imaged a 90 by 180 kilometre section of Syrtis Major at a resolution of about 19 metres per pixel during orbit 9487 on 8 June 2011.

Syrtis Major was first observed in 1659 by the Dutch mathematician, physicist and astronomer Christiaan Huygens (1629-1695), who was also the first to recognise Saturn's rings. The pronounced dark colouring of the region allowed Huygens to determine Mars' rotation through the change in position of Syrtis Major in the course of his telescopic observations; he was thus able to, for the first time, estimate the length of the planet's day – and he did so relatively precisely, arriving at a value of 24.5 hours (in fact it is 24 hours and 37 minutes). The name Syrtis Major is derived from the Roman name for the Gulf of Sidra on the coast of Libya.

Earth and Mars soon in opposition

At present, Mars is once again approaching opposition to Earth; on 2 March 2012 the Sun, Earth and Mars will be in a straight line with Earth in the middle. Mars will rise in the east immediately after sunset and stand high in the southern sky at midnight. It is not, however, a very favourable opposition for astronomers because, due to its highly elliptical orbit, Mars will be at its furthest point from the Sun in March. As a result, the distance between Earth and Mars will be 100.8 million kilometres; during opposition on 28 August 2003 they were only 55.8 million kilometres apart, their closest approach for nearly 60,000 years.

The images shown here were produced by the Department of Planetary Sciences and Remote Sensing at the Institute for Geological Sciences of the Freie Universität Berlin, using HRSC image data systematically pre-processed by DLR. They show a section of Syrtis Major at 16 degrees north and 73 degrees east. Visible on the general image map are volcanic lava flows that flooded the older highland material, leaving mesas (flat-topped mountains) behind. These can be easily distinguished from their surroundings due to their lighter colouring. The flow fronts of the individual solidified lava flows resemble lobe-shaped lines with some irregularities (image box 1); in the anaglyph image they are revealed as subtle height differences.

Low-viscosity lava flooded the old Mars highlands

Some impact craters in the region were partially or completely filled with volcanic material. One large impact crater with a diameter of about 18 kilometres was filled almost to the top by low-viscosity lava; the circular outline is barely visible through the more recent lava cover (image box 2).

Finally, the landscape was shaped by the force of the wind. Here the prevalent wind direction, at least in the more recent past, from east-southeast can be derived by means of the lighter aeolian deposits to the sides of the smaller impact craters sheltered from the wind.

The largest impact crater in the area shown here (image box 3) has a diameter of about 20 kilometres with a small mountain at its centre. West of this central mountain (above it in the image) is a small, dark field of dunes. In particular, the dunes at the front here nearly mimick the 'perfect shape' of typical sickle-shaped dunes, or barchans, common in deserts on Earth.

Another noticeable feature is that the older impact craters are found in the old highlands (in the upper half of the perpendicular views). In contrast, only smaller impact craters can be found on the younger volcanic surface in the lower half of the image. Dating by means of the crater size-frequency distribution reveals that the surface is of Hesperian age: in Mars' geological history this period, characterised by widespread volcanic activity, corresponds to about 3.7 to 3 billion years ago.

Image processing and the HRSC experiment on Mars Express

The colour images were created from the nadir channel, the field of view of which is aligned perpendicular to the surface of Mars, and the colour channels; the oblique perspective views were generated from HRSC stereo channel data. The anaglyph, which creates a three-dimensional impression of the landscape when viewed with red/blue or red/green glasses, was derived from the nadir channel and one stereo channel. The black-and-white image is based on data acquired by the nadir channel, which has the highest resolution of all the channels. The colour-coded plan view is based on a digital terrain model of the region, from which the topography of the landscape can be derived.

The HRSC camera experiment on the European Space Agency's Mars Express mission is headed by Principal Investigator (PI) Professor Gerhard Neukum (Freie Universität Berlin), who was also responsible for the technical design of the camera. The science team consists of 40 co-investigators from 33 institutions in ten nations. The camera was developed at DLR under the leadership of the PI and it was built in cooperation with industrial partners EADS Astrium, LEWICKI microelectronic GmbH and Jena-Optronik GmbH. The instrument is operated by the DLR Institute of Planetary Research in Berlin-Adlershof, through ESA/ESOC. The systematic processing of the HRSC image data is carried out at DLR. The images shown here were created by PI-group at the Institute of Geological Sciences of the Freie Universität Berlin.

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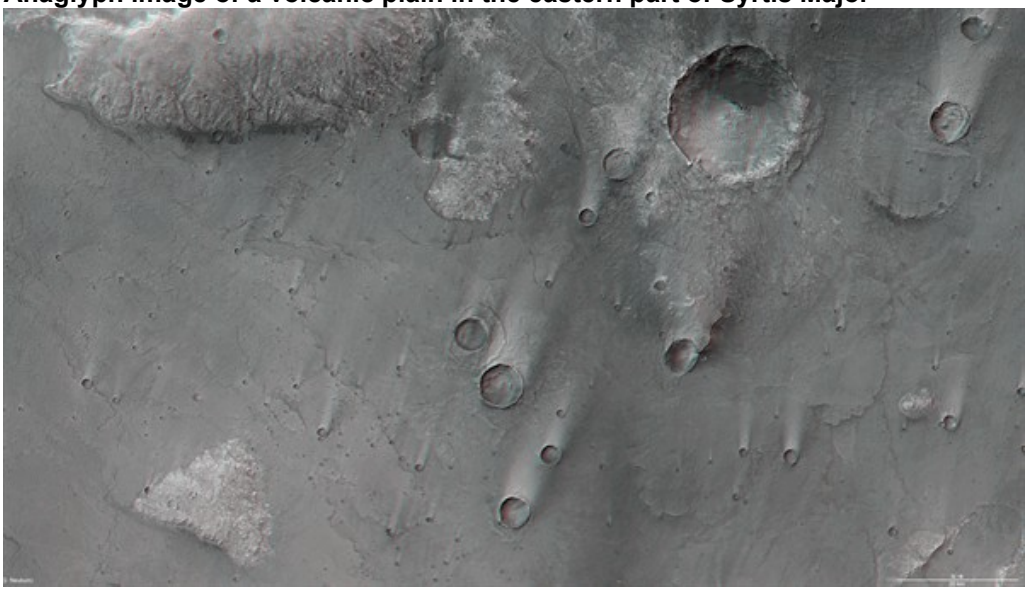
Anaglyph image of a volcanic plain in the eastern part of Syrtis Major



Anaglyph images can be created using data from the nadir channel of the High Resolution Stereo Camera (HRSC) camera system, the field of view of which is which is directed vertically down onto the Martian surface, and one of the four stereo channels, which are directed obliquely towards the surface. By using red/blue (cyan) or red/green glasses, a three-dimensional impression of the landscape can be obtained; north is to the right in the image. At first glance, the topographical differences of the volcanic plain formed from solidified lava flows are not particularly distinctive. But if one zooms in on the image and observes it at full resolution, the differences in altitude at the edges of the individual lava flow tongues (their flow fronts) can be seen. With their edges rising above the plain, the circular outlines of some large impact craters are easily recognisable. The wind has blown dust and sand on the lee side of the craters, forming drop-shaped deposits behind the edges of the craters. In the top right of the image, and in the largest crater in the region, is a central mountain formed by the Martian crust springing back as a result of an impact. 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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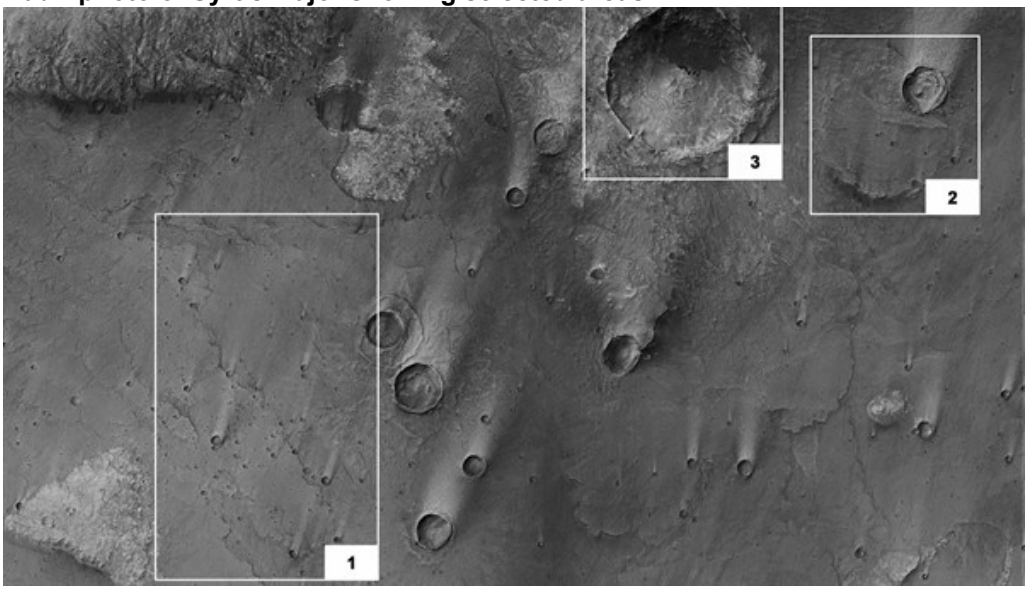
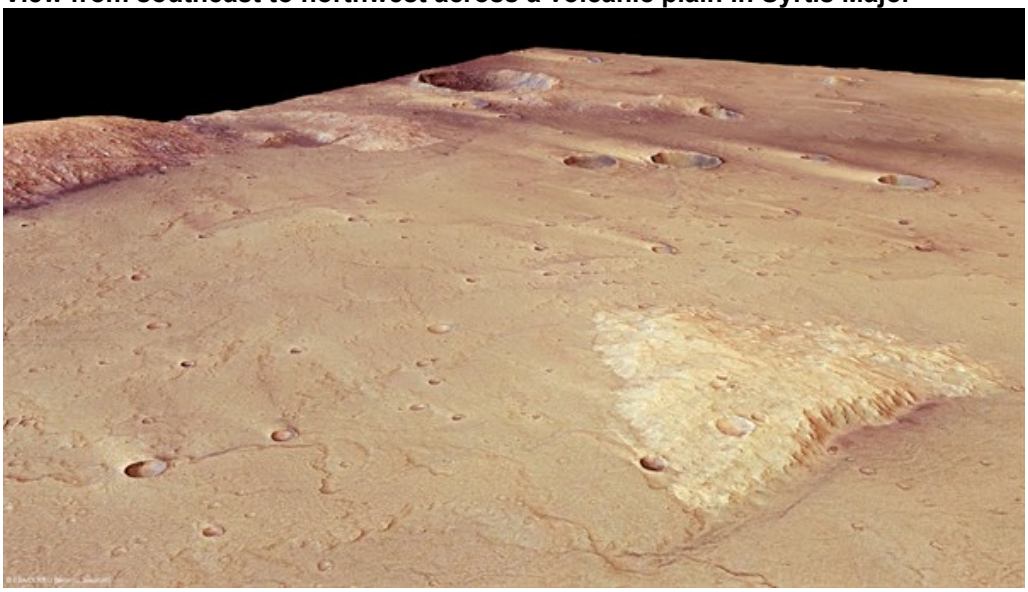
Nadir photo of Syrtis Major showing selected areas



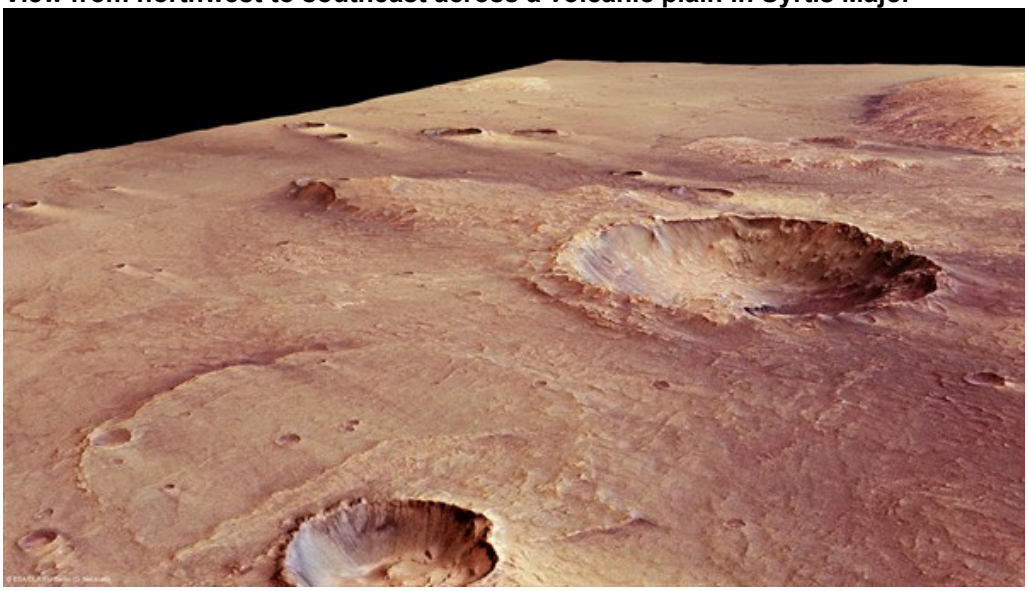
The nadir channel, pointed vertically at the surface, supplies the highest resolution data of any of the HRSC camera system channels. During orbit 9487, Mars Express was about 440 kilometres above the volcanic region of Syrtis Major, giving a resolution of 19 metres per pixel. The area shown is about 180 kilometres by 90 kilometres. Image box 1 shows how various solidified lava flows overlap and can be differentiated from one another through their flow fronts. Image box 2 shows two impact craters – the shape of the older crater is barely discernible through the low-viscosity lava cover. A little higher is an old crater about 20 kilometres in size (image box 3), which was not affected by the lava flows. In its interior lies a central mountain and an extensive field of sickle dunes whose dark colouring indicates that its composition is of volcanic nature.

View from southeast to northwest across a volcanic plain in Syrtis Major



Realistic perspective views of the Martian surface can be generated from data acquired by the stereo and colour channels of the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. The image shows a vast volcanic plain, characteristic of the Syrtis Major region. Solidified streams of low-viscosity basalt – a lava rich in iron and magnesium that occurs on Earth in what are known as 'flood basalts', or 'trap basalts', for example in the Paraná Basin in Brazil or the Columbia River basalts in the west of the United States – flowed here millions of years ago. Some of the individual streams can still be differentiated by their flow fronts. They run as sinuous lines across the image.

View from northwest to southeast across a volcanic plain in Syrtis Major



Realistic perspective views of the Martian surface can be generated from data acquired by the stereo and colour channels of the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. The circular outline of an older crater, which was almost completely filled by low-viscosity lava, can be seen between the two distinctive impact craters in the foreground and to the right of the centre 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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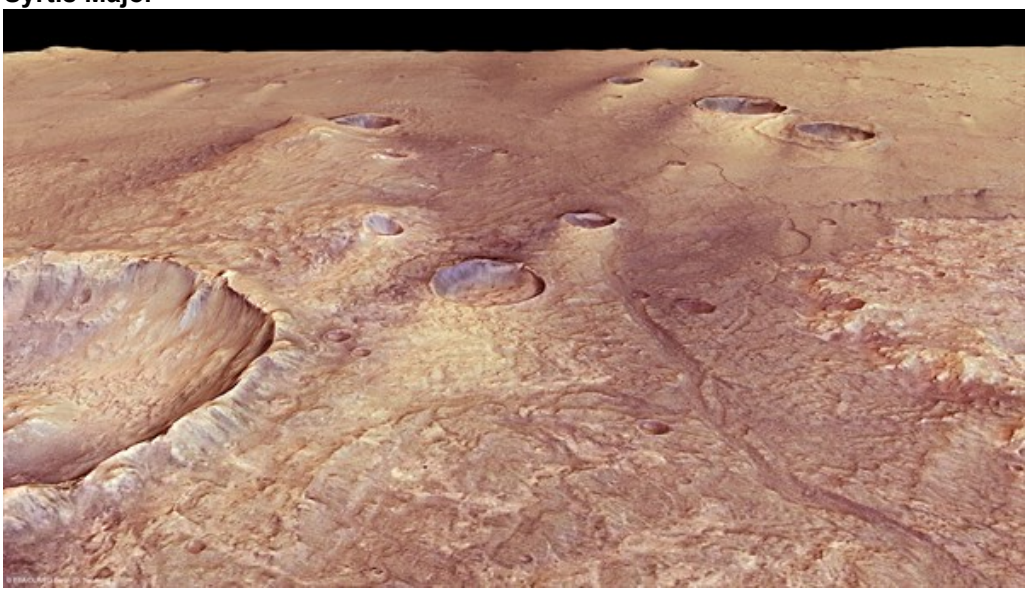
View from the Martian highlands across a volcanic plain in the eastern part of Syrtis Major



Realistic perspective views of the Martian surface can be generated from data acquired by the stereo and colour channels of the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. The foreground shows very old remains of the Martian highlands. Its surface is noticeably more textured than that of the solidified lava flows in the background of the image, which are younger. Once volcanism had ceased, asteroids left a number of kilometre-sized impact craters with their typical, raised walls. In the more recent past, long, drop-shaped deposits of sand and dust formed on the lee side of these craters. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are published under a Creative Commons licence

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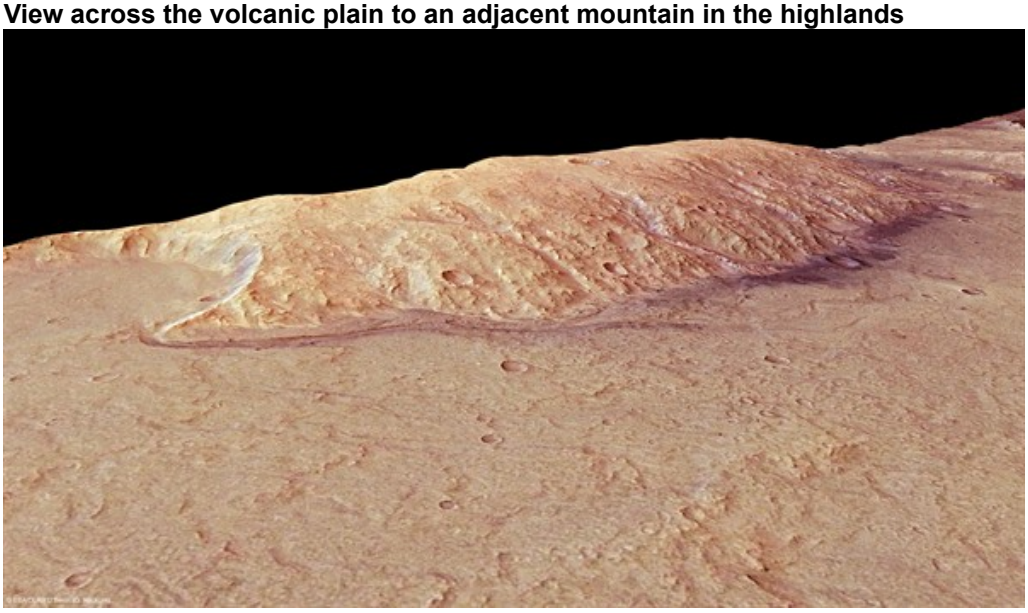
View across the volcanic plain to an adjacent mountain in the highlands



Realistic perspective views of the Martian surface can be generated from data acquired by the stereo and colour channels of the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet’s surface. Visible in this image is a vast plain in the eastern part of Syrtis Major, a large volcanic region north of the Martian equator. Low-viscosity lava flowed from here across the Martian highlands millions of years ago. In the background, an approximately 1000-metre-high mountain rises above the plain; at its base, a valley-like depression forms the border between the solidified lava flows and the mountain. This could be a former lava channel through which the low-viscosity lava, at a temperature of more than 1000 degrees Celsius, flowed away from its source. But it is also possible that flowing water eroded a valley into the solidified volcanic rock. 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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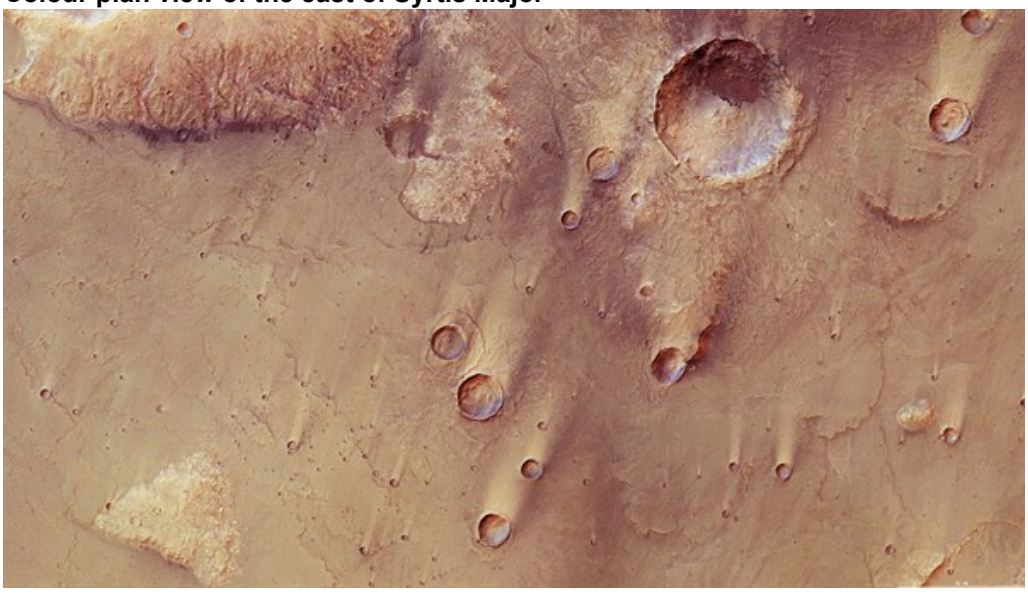
Colour plan view of the east of Syrtis Major



This colour view has been created using the nadir channel, which is directed vertically down onto the Martian surface, and the colour channels of the HRSC camera system on board ESA's Mars Express spacecraft; north is to the right in the image. The image section shown comprises an area of about 16,000 square kilometres – roughly the size of metropolitan New York. The surface of Mars, mostly tinged in earthen, orange-red tones, shows colour variations in these HRSC pictures. These could be due to the composition of the rocks and the regolith, the topmost dust and sand layer, in this region. They could also be caused by differences in the structure of the surface, its roughness, the grain size of the regolith components or its porosity.

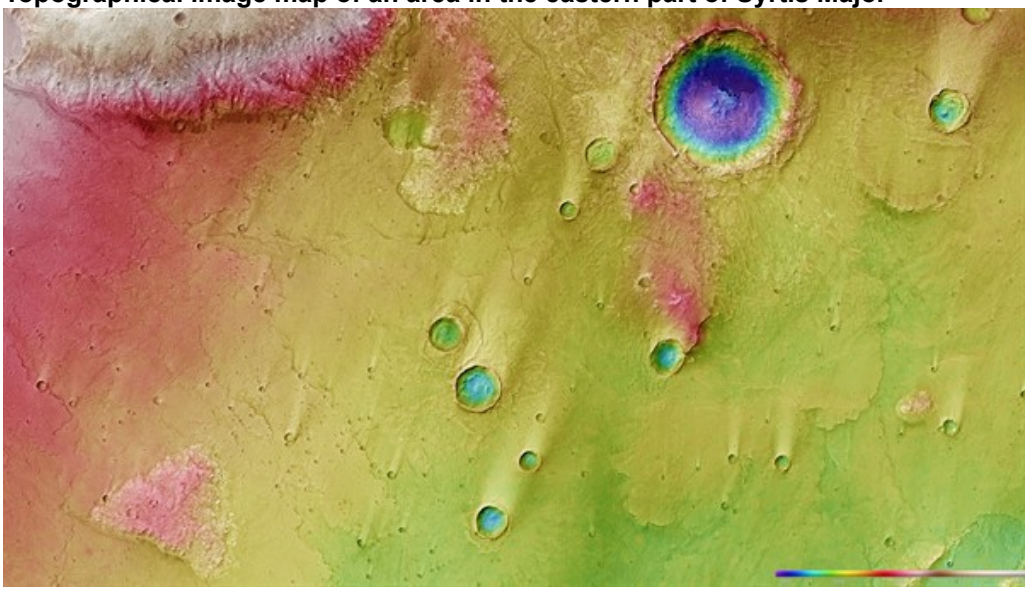
Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO.

HRSC nadir image of the east of Syrtis Major

The nadir channel, which points vertically down towards the planet's surface, enabled HRSC image data to be captured with a resolution of 19 metres per pixel as Mars Express flew over the northeast of Tempe Terra during orbit 9487. This allows small-scale geological structures to be identified; north is to the right of the image. The image detail shown covers an area of about 180 kilometres by 90 kilometres. This area is characterised by volcanic activity that took place during the early history of Mars. A large part of the image comprises a plain formed by solidified streams of low-viscosity lava. Some of the individual lava flows can be distinguished by the subtle flow fronts that twist through the image like finely-chiseled seams. The wind has deposited light dust trails in the lee of impact craters formed at a later time. The landscape to the west of the scene (top of the image) that was not covered by lava flows has a noticeably rougher texture.

Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO.

Topographical image map of an area in the eastern part of Syrtis Major



Digital terrain models can be generated using data acquired by several of the nine channels of the High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft, which image the planetary surface from different angles. The use of false colours enables the topography to be pictorially represented – the elevation scale is on the lower right; north is to the right of the image. 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 volcanic plain progressively rises more than 2000 metres in a southerly direction (left) towards the Martian highlands, forming a ramp several hundred kilometres wide. What look like turquoise green ‘bull’s eyes’ on the plain are in fact impact craters that formed after the end of the volcanism phase. Visible in the right upper quadrant is the floor of a crater about 20 kilometres in diameter; although it lies significantly lower than the volcanic plain formed by the lava flows, its high wall prevented lava from flowing inside and filling the crater. 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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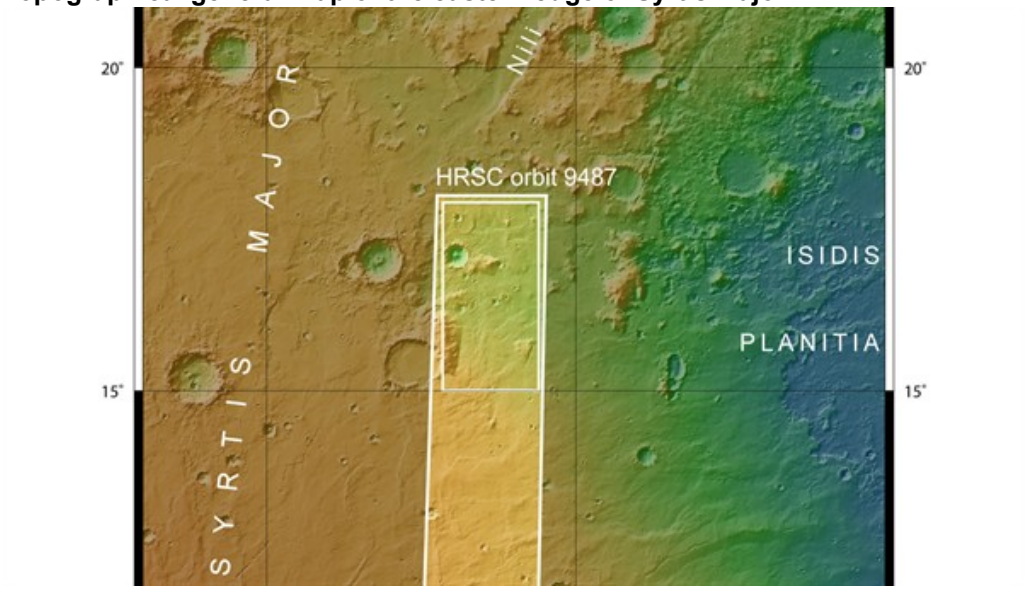
Topographical general map of the eastern edge of Syrtis Major



The volcanic region of Syrtis Major is one of the most conspicuous areas on Mars – as a large dark area half the size of Europe it is well known to amateur astronomers. ESA's Mars Express spacecraft flew over Syrtis Major on 8 June 2011 during orbit 9487 and photographed a strip

roughly 400 kilometres in length using the HRSC stereo camera. The images selected for publication here show the smaller, inner rectangle.

Credit: NASA/JPL/MGS (MOLA); FU Berlin.
