Mars Express: Tharsis Tholus, a collapsed 8000-metre peak

04 November 2011

The volcanoes on Mars are true giants. As well as being home to the largest volcano in our Solar System, the 24-kilometre-high Olympus Mons, and its three neighbouring shield volcanoes Arsia, Pavonis and Ascraeus, there are a number of less-frequently observed volcano complexes on the Tharsis bulge near the Martian equator that also reach impressive heights. With a base measuring 155 by 125 kilometres, the 8000-metre Tharsis Tholus may only be a 'mid-range' volcano, but when measured against terrestrial standards, this volcano is truly gigantic. 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 acquired images of Tharsis Tholus over the course of several orbits, which have been combined to form a mosaic image with a resolution of 14 metres per pixel. The images show an area located at 13 degrees north and 268 degrees east.

Just as on Earth, volcanoes on Mars played an important role in both its climatic history and the thermal evolution of its interior. Volcanic eruptions fed 'fresh' gases into the atmosphere, thereby affecting the density and composition of this gaseous envelope. Whether a water cycle existed on Mars or whether it once rained are some of the most exciting questions addressed by Mars exploration. Closely related to this is the question of whether conditions were ever favourable for the development of life on the now dry planet.

A caldera two and a half kilometres deep and the size of Berlin

Tharsis Tholus differs from many of the other volcanoes on Mars in that its edifice has undergone extensive modification. The complex has not developed in the usual way, for example as a cone or a shield surrounding the volcanic centre; instead, it shows signs of substantial deformation. At least two major collapses on the western and eastern flanks have taken place in the course of its four billion year history. Evidence of these events is still visible, taking the form of the steep flanks some several kilometres in height, as well as concentric and ring faults.

The main feature of Tharsis Tholus is, however, the size of its central caldera. This slightly elongated collapse crater at the summit of the volcano, measuring roughly 32 by 34 kilometres, extends over an area almost as large as Berlin and the base is as much as 2.7 kilometres below the rim. The caldera may have formed when a shallow magma chamber under the volcano emptied, primarily through volcanic eruptions – during which the magma emerged at the surface in the form of lava. This emptying process caused a large cavity to form inside the volcano. As lava accumulated over this cavity, there came a point when it could no longer support the additional weight and it collapsed, forming a depression known as a 'collapse caldera'.

But the true size of Tharsis Tholus is concealed. As the nadir image shows, the volcano is surrounded by numerous solidified lava flows, hiding the original base of the volcano. Taking into account the number and massive extent of these lava flows, it is possible that Tharsis Tholus is 'submerged' in lava to a depth of several kilometres.

The image data used to create the images shown here were acquired using the HRSC between 28 October and 13 November 2004 during orbits 0997, 1019, 1041 and 1052. The images were produced by the Department of Planetary Sciences and Remote Sensing in the Institute for Geological Sciences of the Freie Universität Berlin. The perspective views were computed from the HRSC stereo channels. The anaglyph was derived from one stereo channel and the nadir channel, which captures image data at the highest resolution of all the channels. The black-and-

white detail image was acquired with the nadir channel. The false-colour images are based on digital terrain models of the region, from which the topography of the landscape can be derived.

November 2011 – Mars in the spotlight

Mars continues to be one of the most important targets for planetary research. On 25 November, NASA's Mars Science Laboratory, a lander carrying a rover named Curiosity, will be launched on its journey to the Red Planet. Curiosity is five times heavier than the two 'veteran' rovers, Spirit and Opportunity, which have been exploring the Martian surface since 2004. Equipped with the most comprehensive and sophisticated suite of experiments, Curiosity will continue the quest to find evidence for the existence, past or present, of organic molecules on Mars.

Even the Russian space programme will again contribute to the exploration of Mars; on 5 8 November 2011 at 22:16 CET, the Phobos Grunt spacecraft will embark on its journey to Phobos, the larger of Mars' two moons. Once it lands in 2013, the small lander will collect samples for roughly a year. The loaded return vehicle will then blast off from Phobos and arrive back at Earth in 2014. DLR is participating in this mission by developing digital terrain models derived from HRSC image data, to support the Russians in the selection of the landing sites. Though manned missions to Mars are in the distant future, the Mars500 long-term experiment will help with preparations. In this experiment, the subjects embarked on a 520-day virtual flight to Mars inside a simulated spaceship. This journey will come to an end on 4 November, when they will 'return to Earth'.

The High Resolution Stereo Camera (HRSC) experiment on the European Space Agency's Mars Express mission is led by the Principal Investigator (PI) Prof. Dr Gerhard Neukum, who was also responsible for the technical design of the camera. The science team for the experiment consists of 40 co-investigators from 33 institutions and 10 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, through ESA/ESOC. The systematic processing of the HRSC image data is carried out at DLR. The scenes shown here were processed by the PI-group at the Institute for Geological Sciences of the Freie Universität Berlin.

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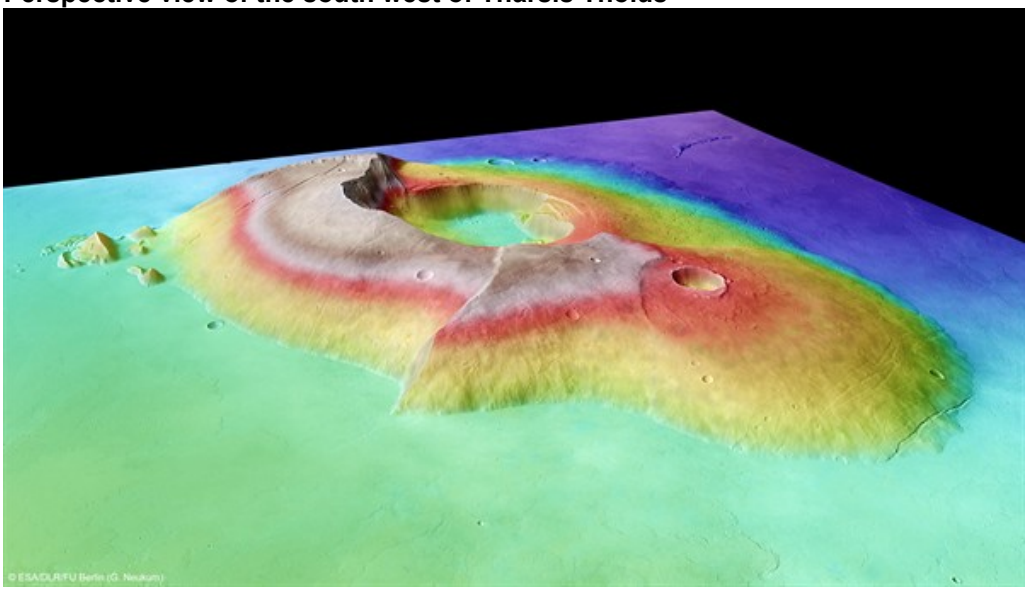
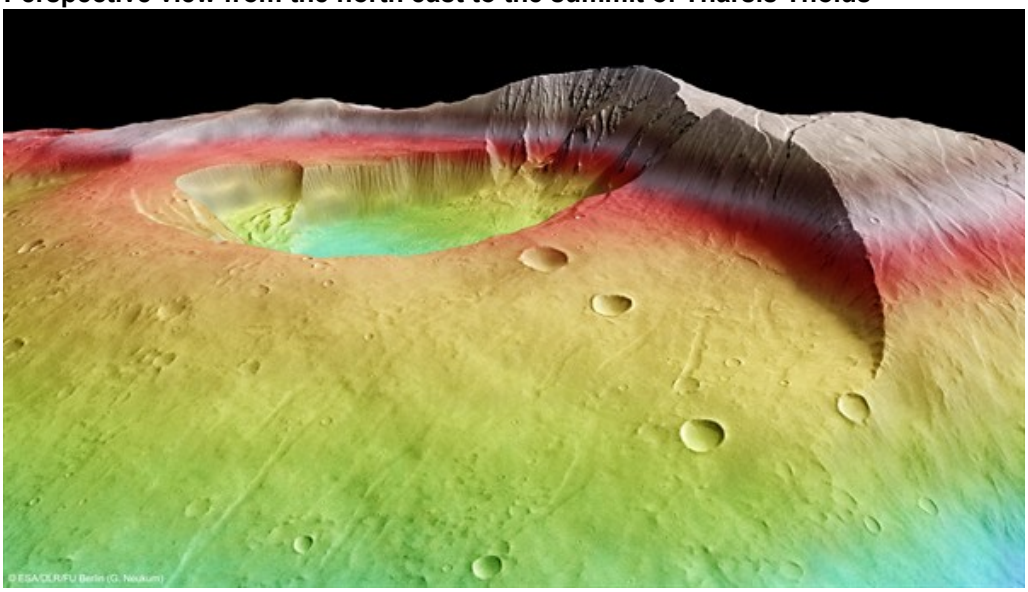
Perspective view of the south west of Tharsis Tholus



Between 28 October and 13 November 2004, the High Resolution Stereo Camera (HRSC) on board Mars Express acquired a series of images during orbits 0997, 1019, 1041 and 1052, which have been combined to form this mosaic image showing the Martian volcano Tharsis Tholus. With a base measuring 155 by 125 kilometres, the 8000-metre Tharsis Tholus may only be a 'mid-range' volcano, but when measured against terrestrial standards, it is truly gigantic. The false-colour image is based on digital terrain models of the region, from which the topography of the landscape can be derived. The illustration shows the caldera at its centre, which has a depth of more than 2500 metres. 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.

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

Perspective view from the north east to the summit of Tharsis Tholus



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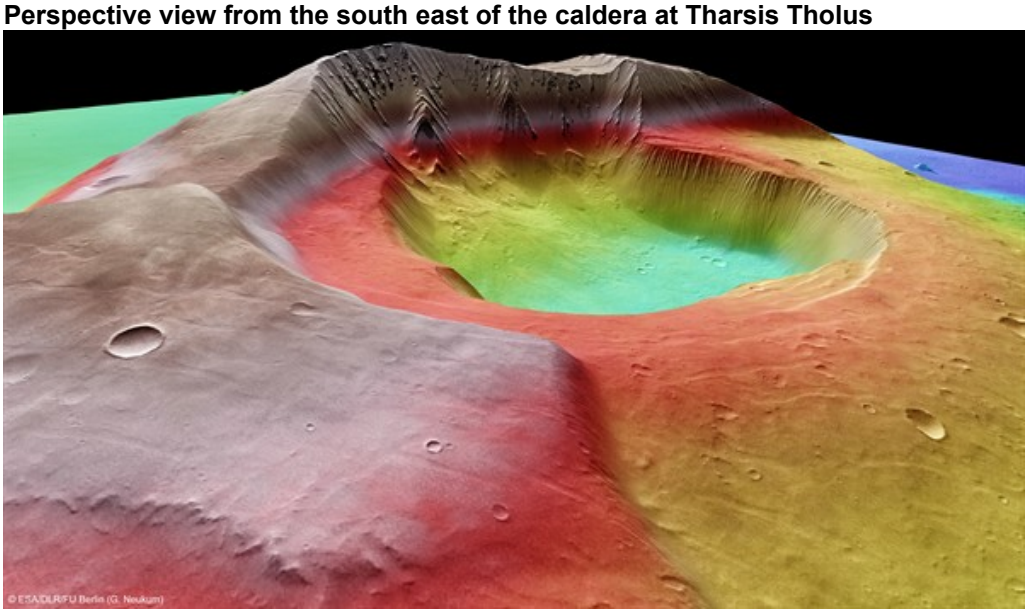
Perspective view from the south east of the caldera at Tharsis Tholus



The main feature of Tharsis Tholus is the size of its central caldera. This slightly elongated collapse crater at the summit of the volcano, measuring roughly 32 by 34 kilometres, extends over an area almost as large as Berlin and the base is as much as 2.7 kilometres below the red-coloured rim. Between 28 October and 13 November 2004, the High Resolution Stereo Camera (HRSC) on board Mars Express acquired a series of images during orbits 0997, 1019, 1041 and 1052, which have been combined to form this mosaic 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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Perspective view into the caldera at Tharsis Tholus

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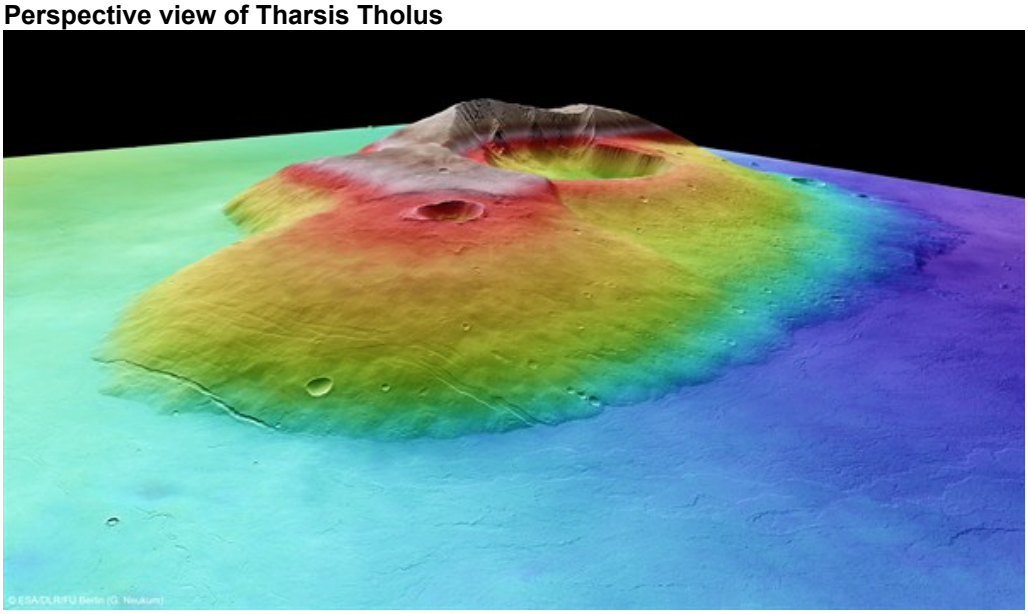
Perspective view of Tharsis Tholus



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Black and white top view of Tharsis Tholus

The impressive size of Tharsis Tholus is easily visible in this top view. The base of Tharsis Tholus measures 155 by 125 kilometres. As the nadir image shows, the volcano is surrounded by numerous solidified lava flows, hiding the original base of the volcano. Taking into account the number and massive extent of these lava flows, it is possible that Tharsis Tholus is ‘submerged’ in lava to a depth of several kilometres. The High Resolution Stereo Camera (HRSC) acquired images of Tharsis Tholus over the course of several orbits, which have been combined to form a mosaic image with a resolution of 14 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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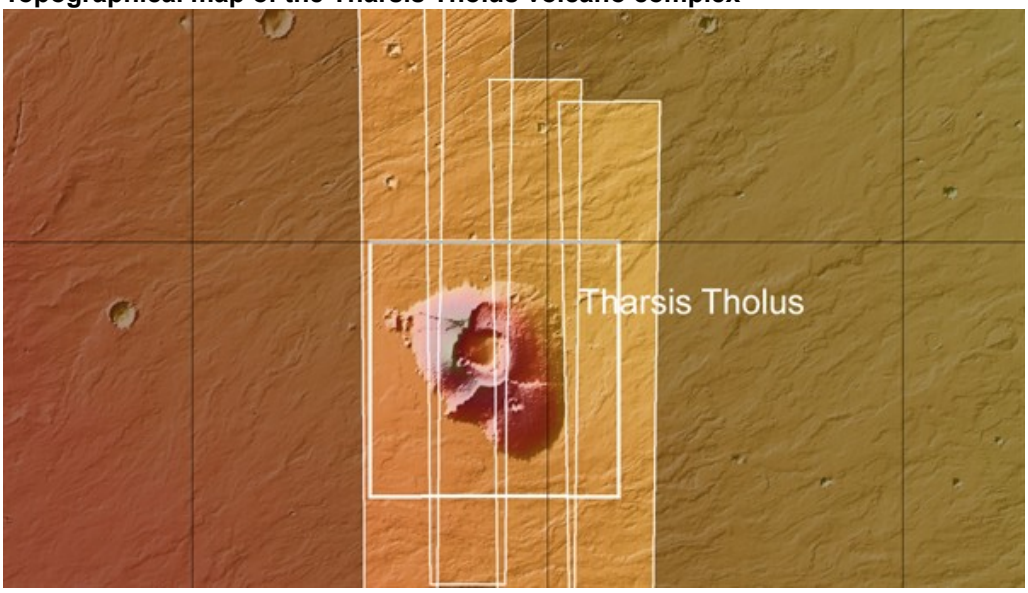
Topographical map of the Tharsis Tholus volcano complex



This map shows the location of the Tharsis Tholus volcano to the northeast of the Tharsis volcanic region on Mars. The image mosaic was generated using a single image strip. The High Resolution Stereo Camera (HRSC) obtained these images between 28 October and 13 November 2004 from an altitude of nearly 300 kilometres above the Martian surface.

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

Anaglyph image of the Tharsis Tholus volcanic complex

This anaglyph image of Tharsis Tholus was acquired using the nadir channel and one of the four stereo channels of the High Resolution Stereo Camera on board Mars Express, which are directed obliquely towards the planet's surface. When viewed using red-cyan glasses, the landscape can be seen in 3-D. The distinctive two and a half kilometre deep caldera and the partially collapsed flanks of the volcano are visible in this 3-D view. The image also shows the numerous lava flows on the Red Planet. Taking into account the number and massive extent of these lava flows, it is possible that Tharsis Tholus is 'submerged' in lava to a depth of several 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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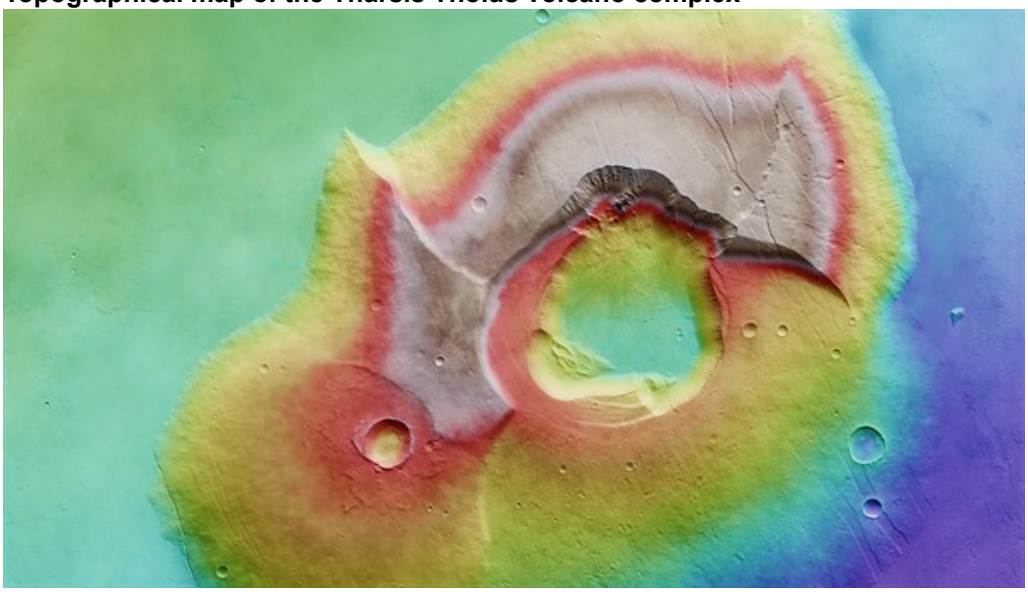
Topographical map of the Tharsis Tholus volcano complex



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. These allow the landscape profile to be represented pictorially and can be used to create topographic maps. North is to the right in this image. In the absence of 'sea level', the height information (see key at the top of the full-size image) is referenced to what is known as an areoid, a modelled equipotential surface on which everything experiences the same gravitational attraction towards the centre of the planet. Copyright note: As a joint undertaking by DLR, ESA and FU Berlin, the Mars Express HRSC images are

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