# Scenes from the 'Middle Ages' on Mars – Tagus Valles deposits in Hesperia Planum

01 August 2013

These images, which were acquired using 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, show a section of the northern part of Hesperia Planum. The region is littered with numerous craters of every size, almost all of which have been heavily eroded over time. This leads to the conclusion that this highland region largely consists of one of the oldest geological formations on the planet.

Hesperia Planum is an extensive highland region near the equator on Mars, with a diameter of more than 1500 kilometres. The name Hesperia originates from the term for Occident in antiquity. Because the numerous processes that have occurred in this region and have changed the landscape are typical of the Martian 'Middle Ages', this period has been called the Hesperian Epoch, after Hesperia Planum. The Hesperian Epoch, which extends from 3.7 to 3.4 billion years ago, permanently changed the whole of Mars. These geological changes are represented to some extent in the images shown here.

To the south of the section of Hesperia Planum shown here, a small dendritic system of valleys called the Tagus Valles reaches its end (see topographic context map, image 5). The (lower) course of the valleys is not that easy to see in the images, as various geological processes have changed the surface and the course of the valleys. In places, meandering valleys can still be recognised in the distinctive, furrowed interior at the bottom (east) and right (north) of the colour-coded topographical map (image 6). The Tagus Valles are named after the longest river in the Iberian Peninsula – the Tajo, as it is known in Spain, or the Tejo in Portugal.

**Crater depressions levelled out by river sediments**

Many craters with a very smooth surface are visible in the central and lower part of images 1, 4 and 6, – to the north and northeast of Tagus Valles. It is possible that these craters were filled with sediments transported and deposited there by water that once flowed through these valleys.

In the lower right quarter of images 1, 4 and 6, a group of craters can be seen that are all connected with one another and have also been filled. At the centre of these three overlapping craters, a smaller crater is visible, with a diameter of around 6.5 kilometres and a very much more sharply defined rim. This was formed later than the flatter craters and the sediments deposited in them. The crater is surrounded by a prominent ejecta blanket, which is elevated above the plain with a distinctive, rampart-like edge. The shape of the ejecta blanket suggests that, at the time the crater was formed by the impact of a small asteroid, there were wet sediments in the target area.

**Numerous traces of erosion**

Further proof of the intermittent presence of water is provided by the dark-coloured crater to the south (upper left section of images 1, 4 and 6). The crater is around 34 kilometres in diameter. Numerous large mesas and yardangs (wind alleys) are evident in the interior of the crater; these formed when the crater was previously partially filled with sediment.

There are many indications that the crater was inundated several times at different periods in its history. Sediments were deposited in the crater during such events. In order for the unusually chaotic looking landscape in the interior of the crater that we see in the images today to have arisen, some of this sediment must have been eroded away again. One possible explanation for how the sediments inside the crater could have been removed is release processes occurring beneath the surface, which led to the formation of cavities where material collapsed. In the upper right corner of the crater floor, the remains of a narrow valley that once existed there can be seen.

Another interesting feature is the dark-coloured deposits covering part of both the interior and exterior of the crater. The deposits might have been formed from fine volcanic ash deposited over a wide area. Such ash deposits may potentially have originated from the Elysium volcanic province, located to the northeast of the region shown here, or from the adjacent, somewhat smaller volcano Tyrrhena Patera to the southeast.

**Image processing and the HRSC experiment on the Mars Express mission**

The images were acquired by the High Resolution Stereo Camera (HRSC) on 15 January 2013, during Mars Express orbit 11504. The image resolution is about 22 metres per pixel. The images show a section at 4 degrees south and 114 degrees east.

The colour plan view (image 1) was acquired using the nadir channel, which is directed vertically down onto the surface of Mars, and the colour channels of the HRSC; the oblique perspective views (images 2 and 3) were computed from data acquired by the HRSC stereo channels. The anaglyph image (image 4), 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 colour-coded elevation map (image 6) 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 (ESA's) Mars Express mission is headed by principal investigator (PI) Professor Gerhard Neukum (Freie Universität Berlin), who also came up with the technical concepts for the high resolution stereo camera. The science team consists of 40 co-investigators from 33 institutions and ten countries. The 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). It is operated by the DLR Institute of Planetary Research in Berlin-Adlershof. Systematic data processing is carried out at the DLR. The images were generated by the Institute of Geological Sciences at the FU Berlin in conjunction with the DLR Institute of Planetary Research in Berlin.

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### Colour plan view of the northern lower course of the valleys of Tagus Valles


Tagus Valles, a small, dendritic valley system in the Martian highland, originates south of the landscape shown here. The lower course of the valleys can still be seen in the image to the right (north) and bottom (east) of the striking crater in the upper left corner of the image. The heavily eroded rims of the large impact craters in particular indicate that this is a very old Martian landscape that has been changed by the deposition of sediments and by subsequent erosion processes. 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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### Landslides in an ancient impact crater


On the steep slopes inside this roughly 1500-metre-deep and 17-kilometre-wide crater, numerous landslides have occurred that have aggregated in places on the crater floor. The morphology of this crater with its striking rim stands in stark contrast to the already heavily eroded rim of the somewhat larger crater in the background. The interior of that crater has been covered by a flat layer of sediments, which were presumably deposited by the lower course of the valleys from Tagus Valles. 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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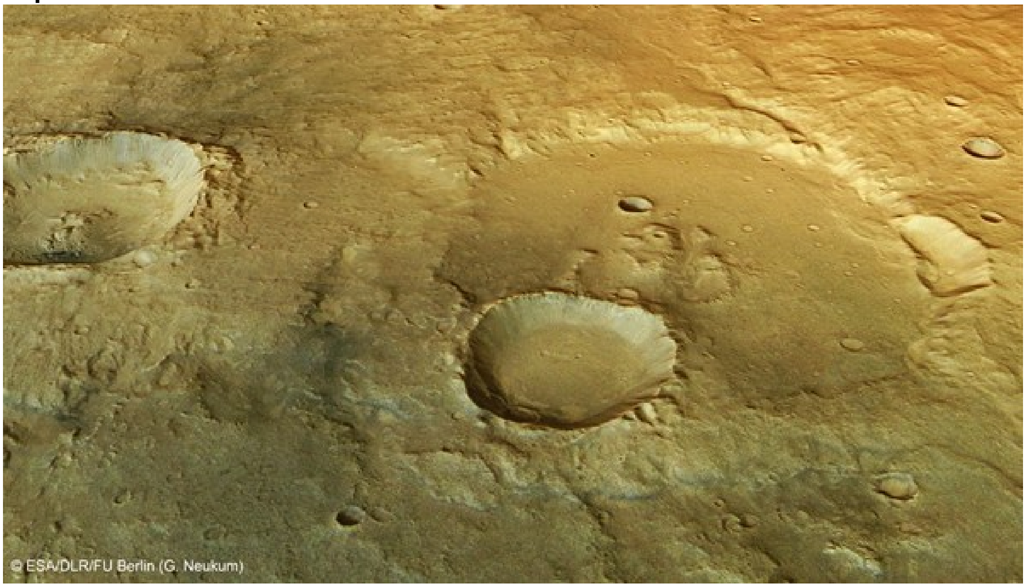
**Impact crater filled with sediment**




The contours of this 30-kilometre-wide crater in the right half of the image can barely be made out. Over billions of years, erosion has stripped away most of the rim, which was once several thousand metres high. The interior of the crater has been filled with a flat layer of sediment, which was presumably – at least in part – transported and deposited in the interior of the crater by a river. The entry point of the river valley can still be seen to the upper right in the background of the image. The smaller crater in the centre of the image is substantially younger, as it cuts into the rim of the larger crater and still has considerably more sharply defined contours. 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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**3D view of the north of Hesperia Planum**

Anaglyph images can be created using data from the nadir channel in the HRSC camera system, which looks vertically down at Mars, and one of the four stereo channels, which are aligned obliquely with respect to 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. The high resolution of 22 metres per pixel enables even small differences in altitude to be seen, for example the (lower) course of the valleys of Tagus Valles to the right of the striking crater in the upper left corner of the image, which originate to the south (left) of the landscape shown here. 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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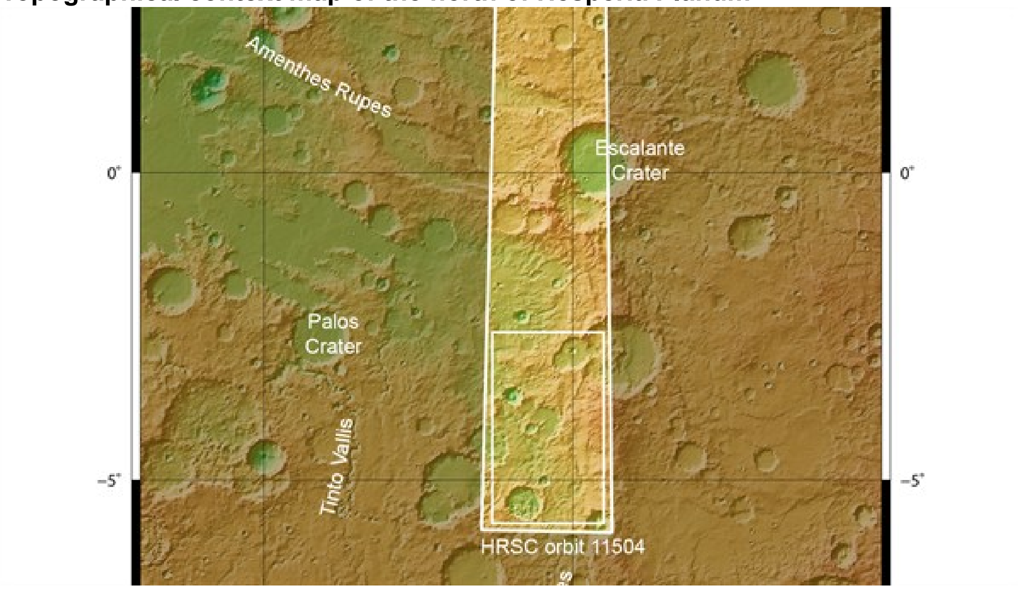
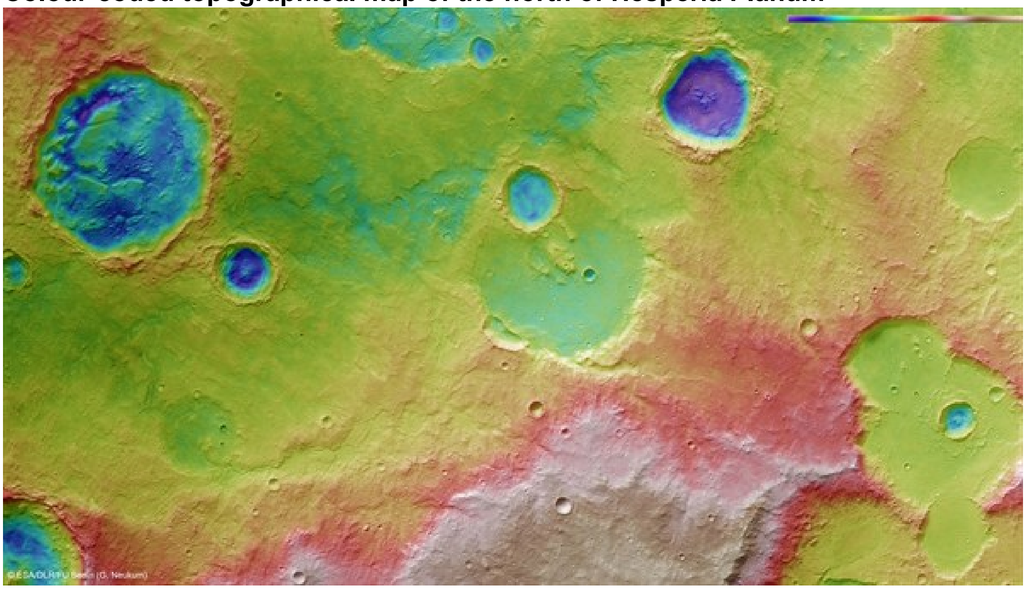
**Topographical context map of the north of Hesperia Planum**




Tagus Valles originates in the north of the Hesperia plain in the Martian highlands. The lower course of the small valleys extends to a very old region heavily marked by eroded craters. This was imaged by the HRSC camera system on the ESA Mars Express spacecraft on 15 January 2013 during orbit 11504. The scenes shown here are located in the rectangular section in the lower third of the HRSC image strip.

Credit: NASA/JPL/MOLA Science Team; FUB.

**Colour-coded topographical map of the north of Hesperia Planum**



Using the image data from the stereo channels in the HRSC camera system, digital terrain models of the Martian surface can be derived in which the topography can be seen using false colours. The altitude allocation can be read from a colour scale at upper right. 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. North is to the right in the image. In this picture, the former course of Tagus Valles can just be seen, rising to the south of the region shown here (outside the image border), and passing above the centre of the image as a meandering valley a few hundred metres deep. The effects of erosion processes on the landscape can easily be seen in the interior of a 34-kilometre-wide crater (upper left in the image). Copyright note: As a joint undertaking by DLR, ESA and FU

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