Mars Express: Current flows and 'islands' in Ares Vallis

07 October 2011

The Ares Vallis outflow channel meanders for more than 1700 kilometres across the southern highlands of Mars and ends in a 100-kilometre-wide delta-like region in the lowlands of Chryse Planitia. On 11 May 2011, parts of the Ares Vallis channel were photographed 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 during orbit 9393. The images show a large, partially eroded crater, streamlined 'islands' and terrace-like 'river banks' on the valley walls; all signs of erosion by the water that, in the period of Mars' early formation, would have flowed through Ares Vallis.

The photographs, acquired from an altitude of 300 kilometres, show a section of the Ares Vallis channel located at 16 degrees north and 327 degrees east. The image resolution is about 15 metres per pixel. The valley was named after Ares, the Greek god of war, whose counterpart among the Roman deities was Mars.

The Ares Vallis outflow channel was discovered in 1976 in images acquired by the US Viking spacecraft. In 1997, the small Mars Pathfinder rover landed in the Ares Vallis channel to investigate the signs of water flow. The most distinctive landscape characteristic is the large impact crater Oraibi, about 32 kilometres across. The crater lies just 100 kilometres south of where Pathfinder landed (see context map) on 4 July 1997; it explored the area for 12 weeks.

Crater flooded by large quantities of water

The signs of erosion are easily spotted on the Oraibi crater. The landscape formation shows that the crater was heavily engulfed; the force of the water was so strong that the southern rim of the crater was breached and the interior of the crater flooded and filled with sediment (frame 1 in the overview picture; north is towards the right). It seems that water would have once flowed through the valley with considerable force and managed to erode large quantities of material. As a result, the 'river banks' have a stepped, terrace-like morphology (frame 2 in the overview picture). Parallel ridges and troughs running in the direction of flow also suggest powerful erosion. Other patterns of erosion on the valley floor can be identified by means of the streamlined islands (frame 3 in the overview); these indicate the former direction of flow.

Just as revealing are the 'ghost craters' – the outlines of which can just be made out. They are found both in the valley itself and on the plateau (left half of the overview image). This suggests that some areas of the plateau, which rises to about 1000 metres above Ares Vallis, were also at least partially flooded. On the plateau, many isolated buttes, or monadnocks, are visible (frame 4 in the overview). They appear to be remnants of an earlier continuous coverage that has mostly been eroded. On the left edge of the image, part of an ejecta blanket from a large impact can also be seen on the plateau.

A landslide and dense clusters of impact craters

On the top left edge of the image (frame 5 in the overview image) we see an interesting detail – a landslide. It is about four kilometres wide and could have resulted from the impact of the asteroid whose crater ejecta blanket is shown in frame 4. Some of the individual rays of these ejecta can be followed to the landslide.

Also characteristic of this region are the unusually dense clusters of impact craters (frame 3 in the overview image) that are either arranged in clusters or in a directed pattern. Two processes can be responsible for forming crater groups like this. Some crater groups develop when an asteroid penetrates the atmosphere and breaks into numerous small pieces of debris, which

then individually impact the surface. Other crater groups are characteristic of secondary craters; that is, many pieces of rock are thrown up by the impact of an asteroid – these then fall back to the surface over a distance of several kilometres and form smaller craters.

The colour image was generated from data acquired by the HRSC nadir channel and colour channels; the oblique perspective images were generated from HRSC stereo channel data. The anaglyph image, which conveys a 3D impression of the landscape when seen through red/blue or red/green glasses, was derived from data acquired with the nadir channel and one of the stereo channels. The black-and-white detail image was acquired using the nadir channel, which captures image data at the highest resolution of all the channels.

The High-Resolution Stereo Camera, HRSC, 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 of 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 on Mars Express 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 Geosciences of the Freie Universität Berlin.

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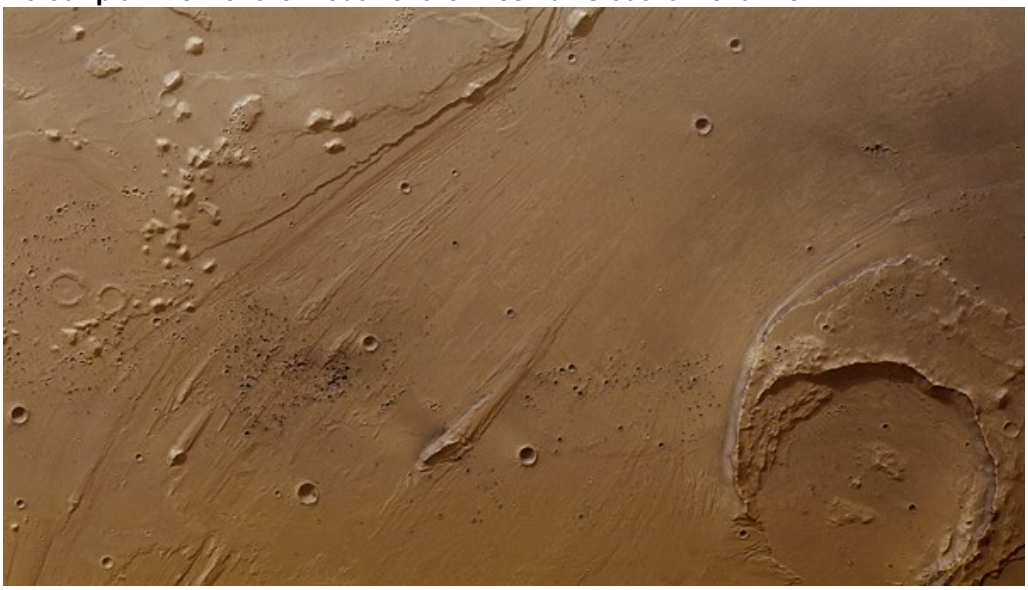
Colour plan view of the mouth of the Ares Vallis outflow channel



This image, looking vertically down at the Ares Vallis outflow channel, was created from data acquired by the nadir and colour channels of the High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft. The imaged region has an area of about 220 × 70 kilometres; north is to the right. Although the image is dominated by the typical Martian soil colour, variations in both colour and texture are visible. Slightly to the left of the centre is an 'island' that has resisted erosion by flowing water. Darker areas suggest the transport of material, possibly by the wind. 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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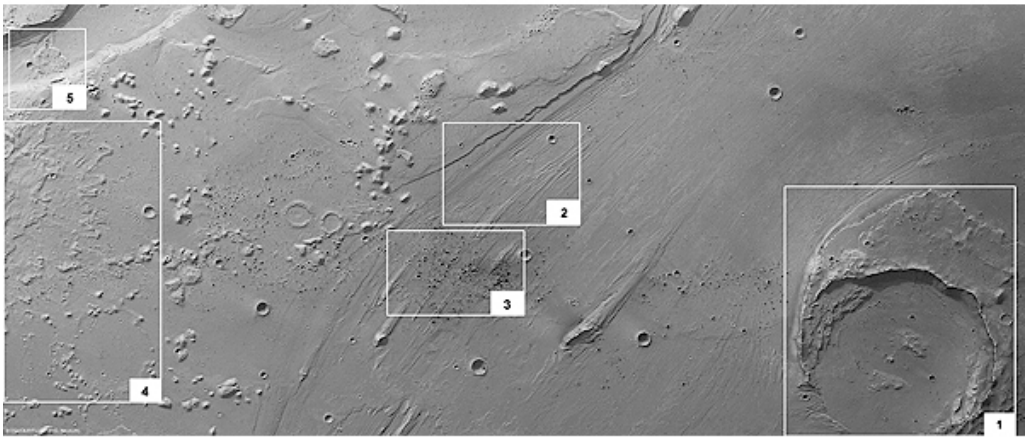
Overview of the mouth of the Ares Vallis outflow channel showing key features



During the period of Mars' early formation, large quantities of water flowed through the Ares Vallis outflow channel, leaving signs of erosion. The High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft acquired images of these erosion marks on 11 May 2011 during orbit 9393. The resolution is about 15 metres per pixel; north is to the right. The large impact crater Oraibi (frame 1) was inundated by water, which broke through its southern rim. On the sides of the valley are terraced 'river banks' resulting from the water flow (frame 2). The streamlined 'islands' on the valley floor (frame 3) reveal the former direction of flow. On the high plateau, many isolated buttes, or monadnocks, are visible (frame 4); they appear to be remnants of an earlier continuous coverage that has been largely eroded. An approximately four-kilometre-wide landslide can be seen in the upper-left corner (frame 5); it may have been triggered by the impact of the asteroid whose crater ejecta are visible in frame 4. 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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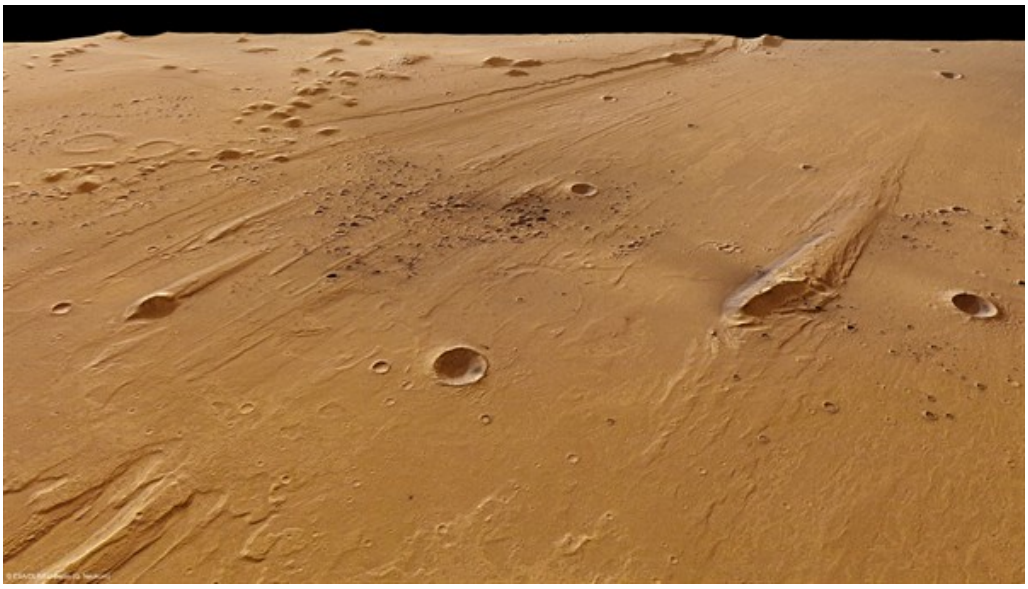
Oblique perspective view from east to west across the Ares Vallis outflow channel



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 ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. This image shows an oblique perspective view from east to west across the Ares Vallis outflow channel. Water once flowed with considerable force through Ares Vallis towards the lowlands of Chryse Planitia. The patterns on the valley floor provide evidence of the flow. A particularly striking feature in the centre of the image is a field of small craters in an unusual grouping. This cluster of craters could be the result of the impact of the debris resulting from an asteroid as it broke up in the atmosphere. An alternative explanation is that they are secondary craters, formed when pieces of rock ejected by an asteroid impact fell back to the surface. 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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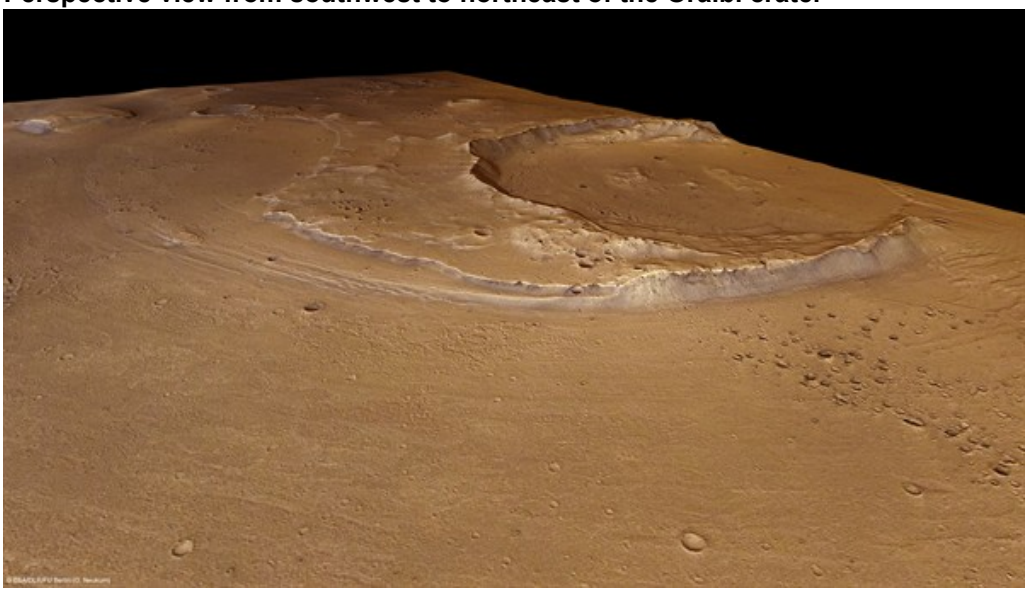
Perspective view from southwest to northeast of the Oraibi crater



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 ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. This image shows an oblique perspective view from southwest to northeast of the 32-kilometre crater Oraibi in the mouth of the Ares Vallis outflow channel. Water that once flowed through this valley has eroded a portion of the crater rim. The striking, terrace-like formations on the western slope were 'milled' from the layers of the raised land area by water flowing with considerable force. On the right of the image, a cluster of many small craters can be seen, which could be the result of the impact of the debris resulting from an asteroid as it broke up in the atmosphere. An alternative explanation is that they are secondary craters, formed when pieces of rock ejected by an asteroid impact fell back to the surface. 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 from the northwest of a 'river island' in Ares Vallis

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 ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. This image shows an oblique perspective view from northwest to southeast of an 'island' in the mouth of Ares Vallis, a large outflow channel that ends near the equator, on the lowlands of Chryse Planitia. The water that once flowed through Ares Vallis did not erode all the obstacles in its path; isolated 'islands' were left behind. The terrace-like levels at varying elevations are indicative of erosion in a watercourse. 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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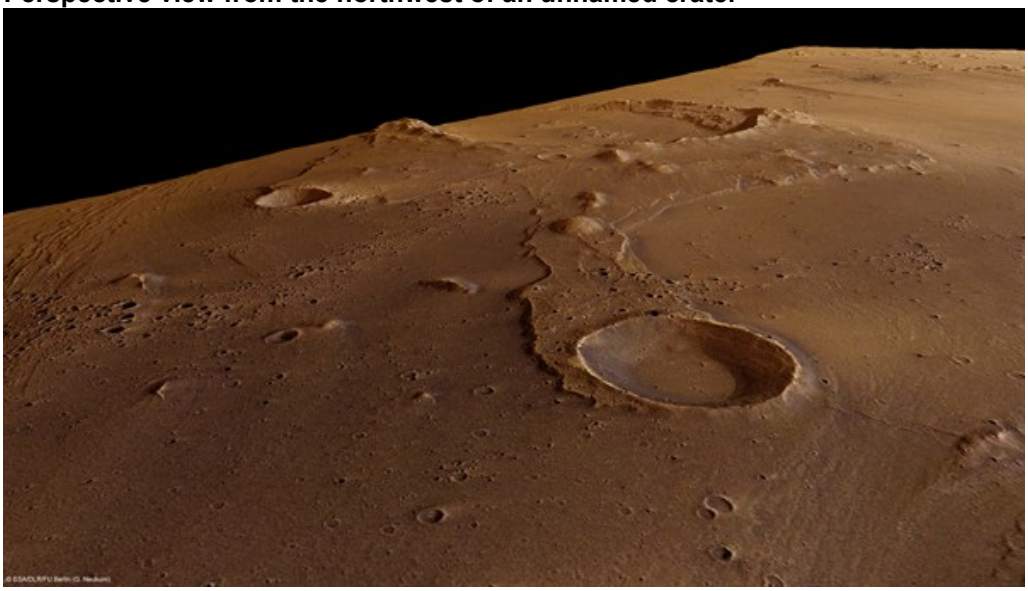
Perspective view from the northwest of an unnamed crater



Realistic perspective views of the Martian surface can be generated from data acquired by stereo and colour channels of the High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft, which are oriented at an angle with respect to the planet's surface. This image shows an oblique perspective view from the northwest of an unnamed, 10-kilometre crater on the high plateau north of Ares Vallis, a large outflow channel in the Martian highlands. The 32-kilometre Oraibi crater is visible in the background; its southwestern rim has been eroded by the large quantities of water that once flowed through Ares Vallis. Terraced levels are visible in the centre of the image; these were 'milled' by the erosive power of water flowing from the highlands. 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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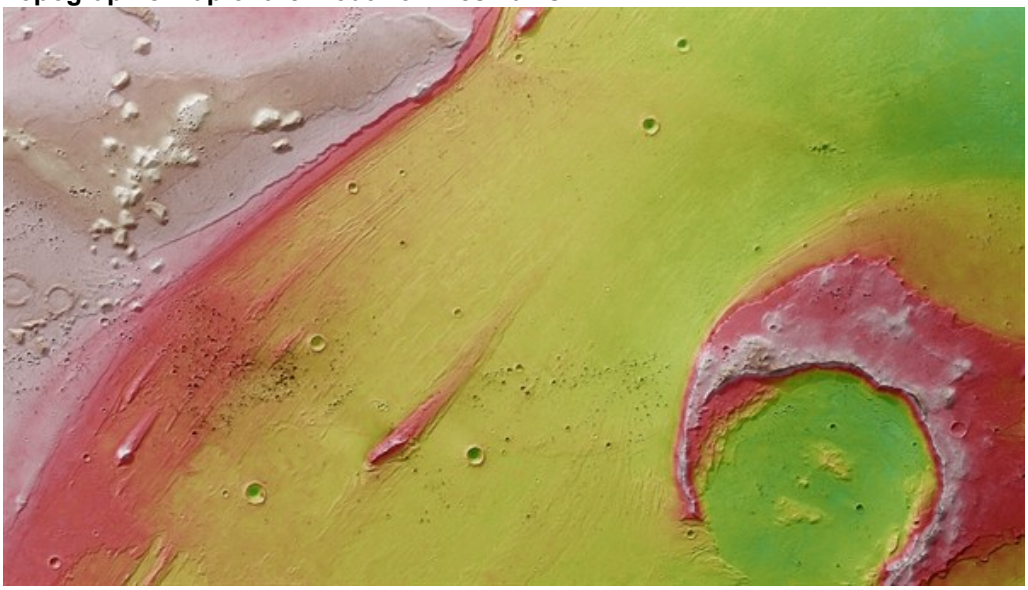
Topographic map of the mouth of Ares Vallis



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 top right of 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. The water that once flowed through Ares Vallis produced a valley about 1000 metres deep and 50 kilometres wide at the mouth of the outflow channel. The erosion of the rim of the Oraibi crater is clearly visible. The prominent 'islands' in the watercourse were able to resist the erosive power of the flow. 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 the mouth of Ares Vallis

Anaglyph images can be generated using data acquired by the nadir channel in combination with data from one of the four stereo channels of the High Resolution Stereo Camera (HRSC) on ESA’s Mars Express spacecraft that are directed obliquely towards the planet’s surface. When viewed through red-blue or red-cyan glasses, these provide a three-dimensional impression of the landscape. In this image, north is to the right. The 3D view clearly shows the water level of the river that once flowed through Ares Vallis, which has eroded the surrounding elevated areas at different heights. It is also clear that islands existed as obstacles in the flow channel and they were ‘streamlined’ by the water flowing around them. The plateau-like elevated land on both sides of Ares Vallis is about 1000 metres above the valley floor. The largest crater in the picture bears the name Oraibi and has a diameter of 32 kilometres. Its southeastern rim was eroded by the floodwaters; they flowed into the crater interior and deposited sediments. 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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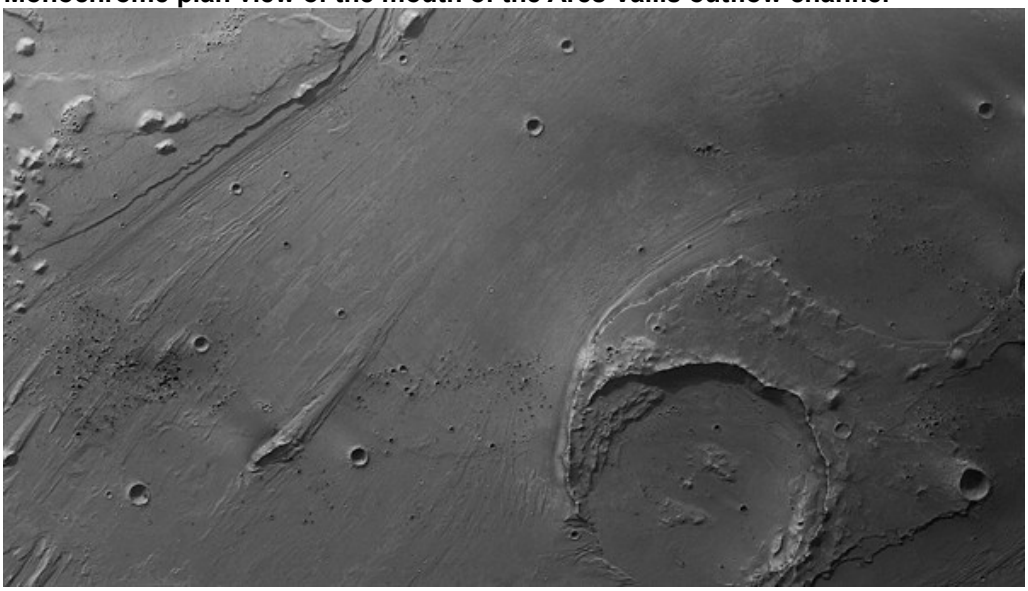
Monochrome plan view of the mouth of the Ares Vallis outflow channel



The nadir channel of the High Resolution Stereo Camera (HRSC) on ESA's Mars Express spacecraft acquired this image looking vertically down at the Ares Vallis outflow channel. The nadir channel provides the highest image resolution. The spacecraft passed over the mouth of Ares Vallis on 11 May 2011 at an altitude of about 300 kilometres, giving an image resolution of 15 metres per pixel. Ares Vallis meanders for over 1700 kilometres across the southern highlands of Mars and ends in an over 100-kilometre-wide delta-like region in the lowlands of Chryse Planitia. During the period of Mars' early formation, large quantities of water flowed through the valley and eroded the rim of the 32-kilometre crater, Oraibi (right of centre). Streamlined 'islands' and terrace-like 'river banks' on the valley walls are also signs of erosion left on the landscape by the water that once flowed 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 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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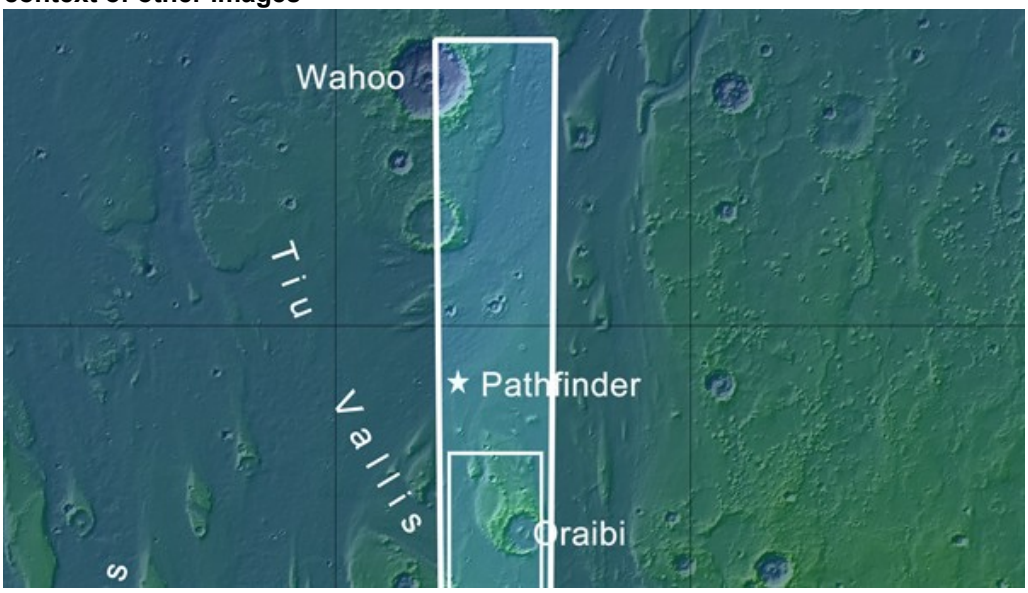
Topographic map of the mouth of the Ares Vallis outflow channel showing context of other images



This map shows the area surrounding the mouth of Ares Vallis, a large outflow channel with its origin in the southern highlands of Mars and, at about 15 degrees north, flows out into the lowlands of Chryse Planitia. The larger framed area shows the location of the entire image strip that was acquired by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express orbiter on 11 May 2011 during orbit 9393. The smaller framed area shows the location of the images described in this article. The asterisk marks the site where NASA's Pathfinder

mission landed on 4 July 1997. A small rover, Sojourner, spent 12 weeks exploring the area around the landing site.

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