mars express

→ A DECADE OF OBSERVING THE RED PLANET

European Space Agency

THE FIRST EUROPEAN MISSION

FROM EUROPE TO MARS

Mars Express is the first European mission to another planet. It was launched on 2 June 2003 for a nominal mission lifetime of 687 days (one martian year). Ten years later, it is still operating, and it will continue to return scientific data at least until the end of 2014.

The spacecraft has been monitoring all aspects of the martian environment, from the subsurface to the upper atmosphere and beyond to the two tiny moons, providing an in-depth analysis of the history of the planet and taking stunning 3D pictures.

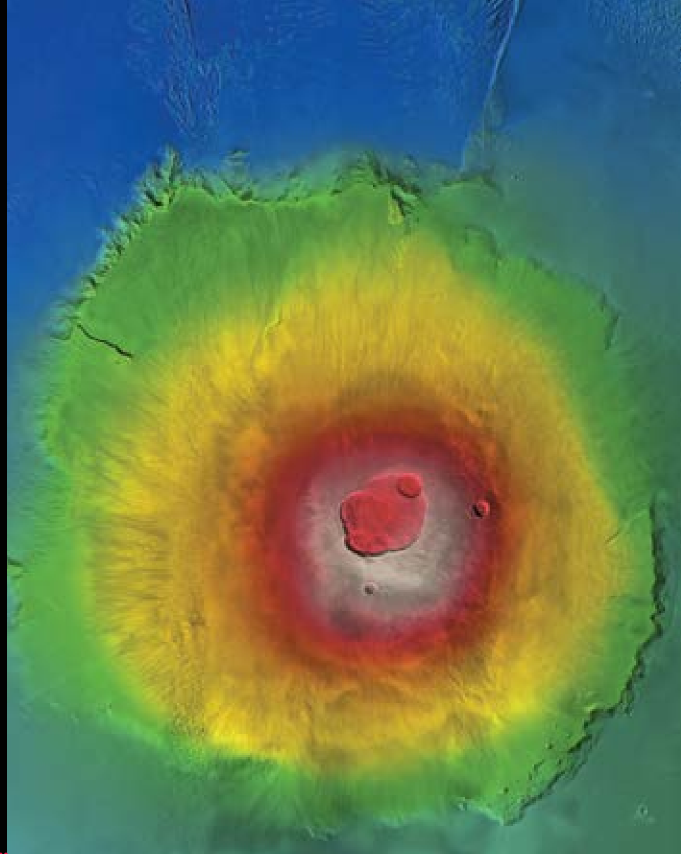
Mars Express has also supported NASA Mars missions. Regular contact events have taken place with the Spirit and Opportunity rovers, and it monitored the entry, descent and landing phases for both the Phoenix lander in 2008 and the Curiosity rover in 2012. Mars Express information was key in selecting the landing site for Curiosity, and the spacecraft has since relayed scientific data from the rover back to Earth.

Tharsis Tholis rises 8 km above the surrounding terrain, with a base that stretches 155 x 125 km and a central caldera measuring 32 x 34 km. (ESA/DLR/FU Berlin–G. Neukum)

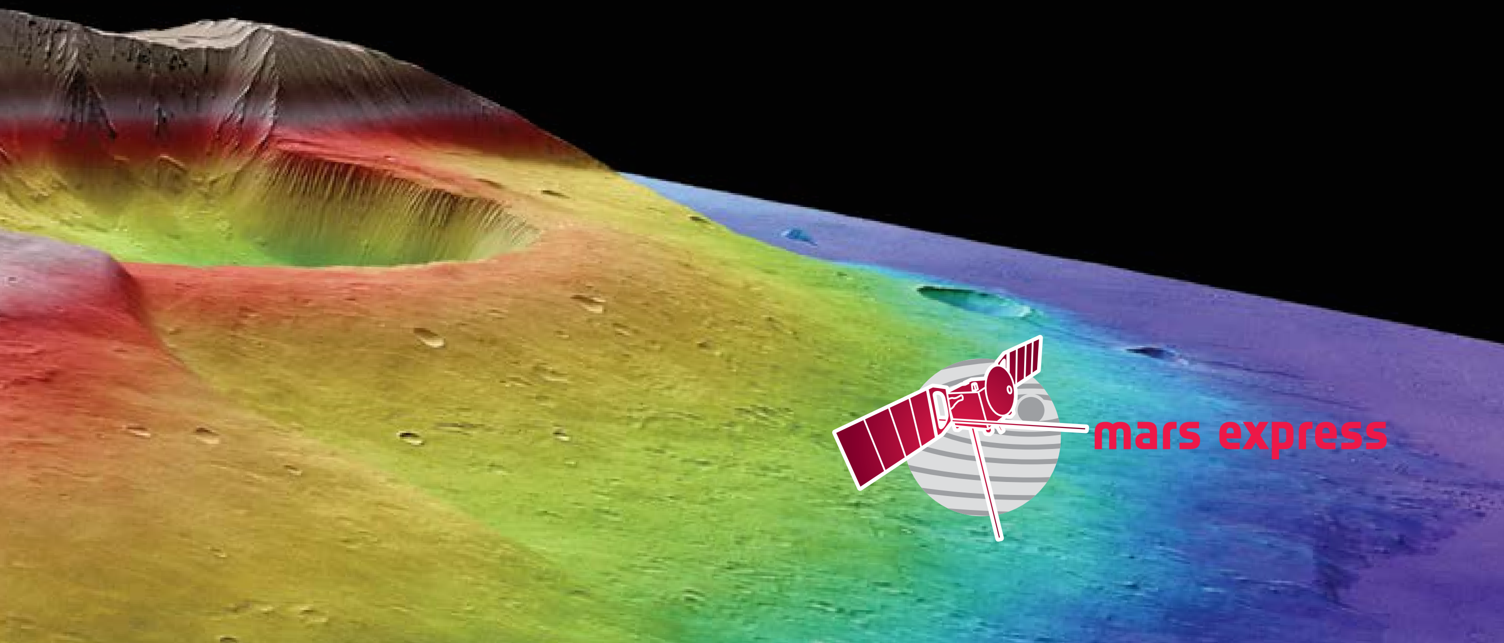
TO ANOTHER PLANET

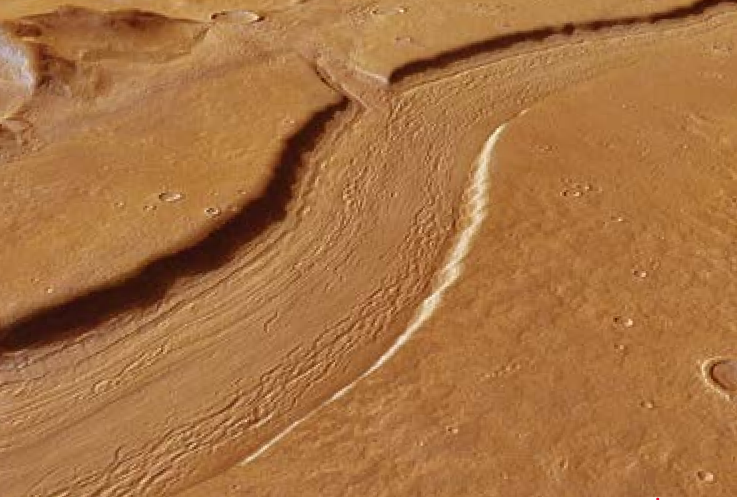
ACTIVE VOLCANOES?

Mars boasts the largest volcano in the Solar System, Olympus Mons – evidence of an active volcanic past. Analysis of High Resolution Stereo Camera (HRSC) images reveals that the largest volcanoes on Mars were active during the last quarter of its 4.5 billion year history, with phases of activity as recently as a few million years ago. Some small volcanoes might even still be active today.

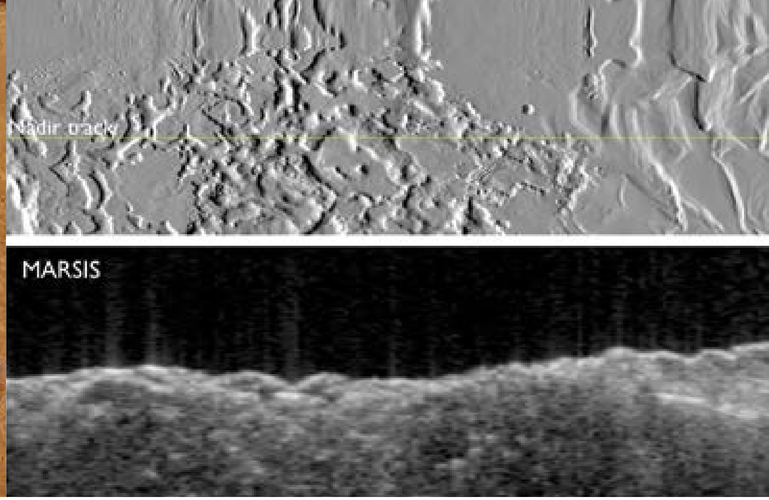


Colour-coded topography map of Olympus Mons, the largest volcano in the Solar System, which towers 26 km above the surrounding plains. (ESA/DLR/FU Berlin–G. Neukum)





Reull Vallis, formed by flowing water and icy debris. (ESA/DLR/FU Berlin–G. Neukum)



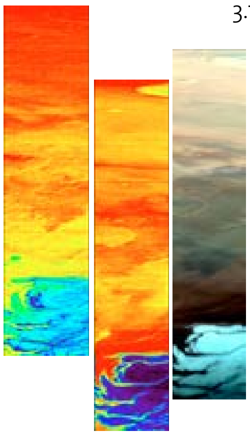
ON THE WATER TRAIL

Mars Express has rewritten the story of water on Mars. OMEGA, the visible and infrared mineralogical mapping spectrometer, has detected a family of minerals that form only in the presence of water: phyllosilicates. Found in the oldest terrains, they record an ancient era during which the Red Planet may have harboured conditions suitable for life.

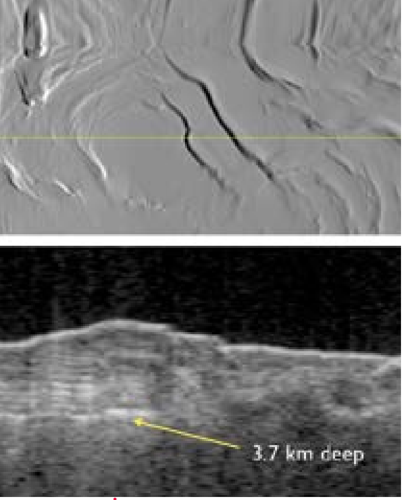
In younger terrains, OMEGA has detected sulphates, which are formed in more acidic conditions. Meanwhile, certain iron-based minerals that form in dry conditions (and which are responsible for Mars being red) were identified in even younger areas. Together, these results indicate that liquid water played a major role very early in the planet's history, but that the planet has remained dry and cold for the last 3.5 billion years.

A SLICE OF MARS

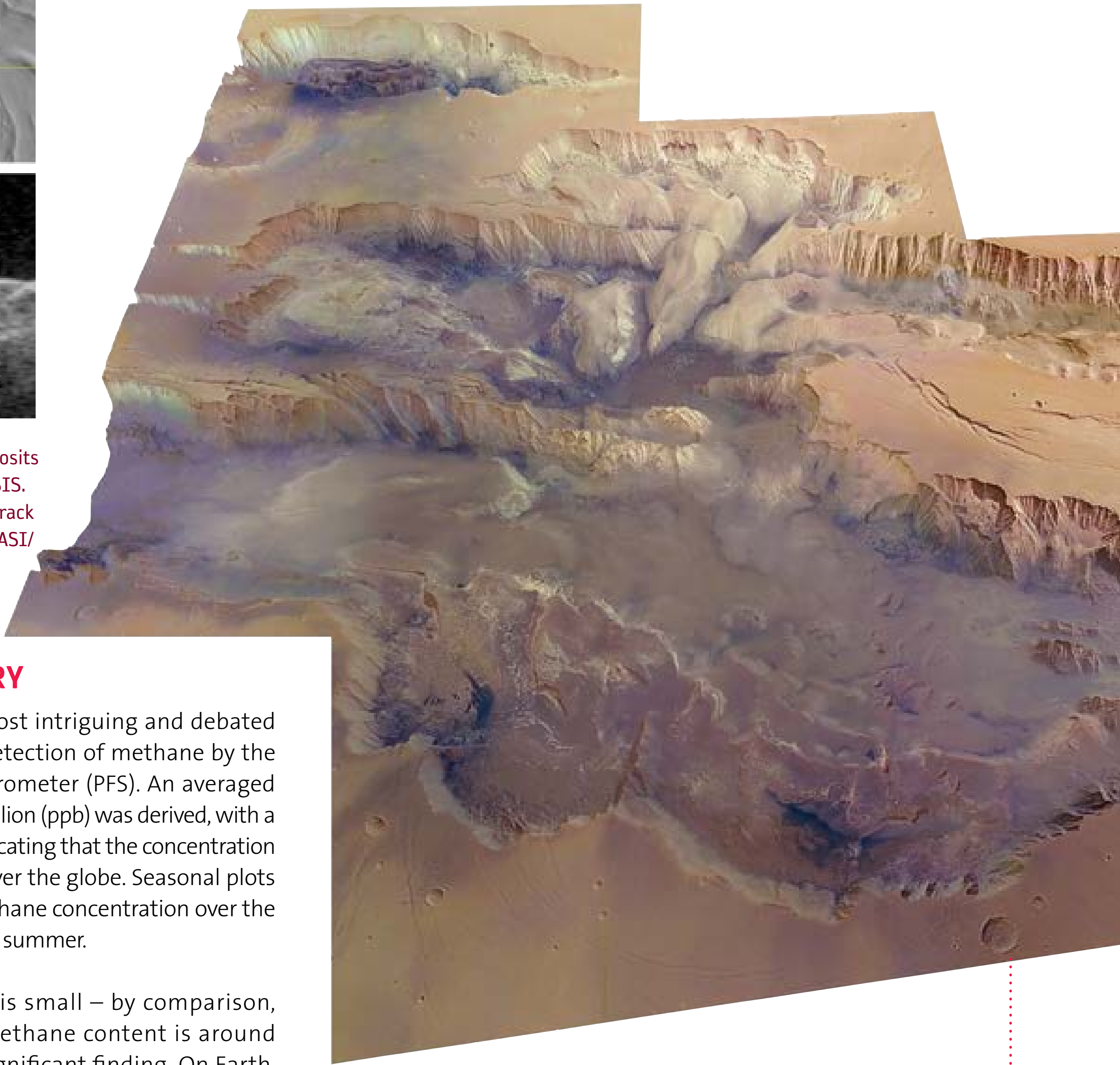
OMEGA has observed the north and south polar ice caps of Mars in great detail, determining their composition to be mostly water ice, and monitoring their seasonal carbon-dioxide- and water-frost coverage over several martian years. MARSIS, a ground-penetrating radar, has added the third dimension to this view, by seeing through the icy layers to determine their vertical extent: down to 3.7 km at the south pole, and 2 km at the north pole. These measurements also allow estimation of the quantity of water locked up in the ice: at the south pole there is enough ice to cover the entire planet with a layer of water 11 m deep.



OMEGA observed the southern polar cap of Mars after orbit insertion in January 2004, in all three bands, representing: (left) frozen water; (centre) carbon dioxide ice; (right) visible appearance. (ESA/CNES/CNRS/IAS/Université Paris 11 Orsay)



Looking through the ice deposits at the south pole with MARSIS. The corresponding ground track is shown above. (ESA/NASA/ASI/JPL Caltech/Univ. Rome)

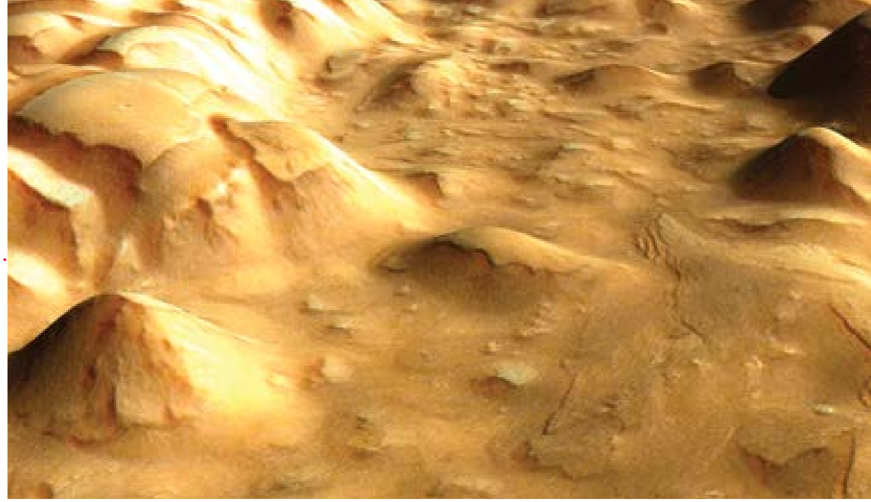


Valles Marineris, the largest canyon in the Solar System. (ESA/DLR/FU Berlin–G. Neukum)

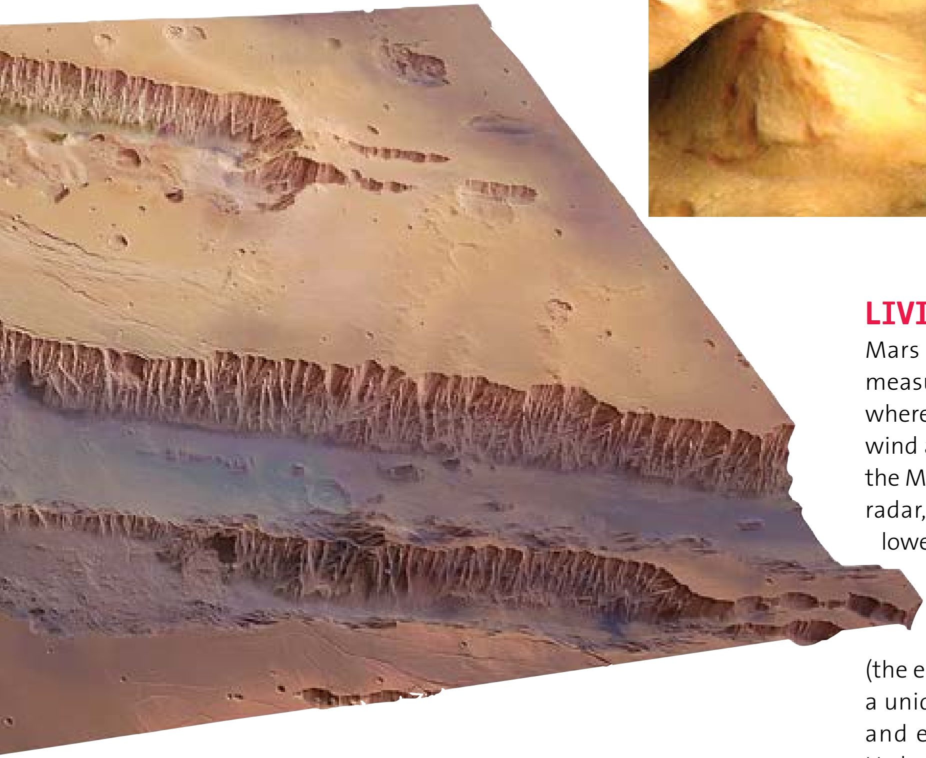
METHANE MYSTERY

One of the mission's most intriguing and debated results was the 2004 detection of methane by the Planetary Fourier Spectrometer (PFS). An averaged quantity of 10 parts per billion (ppb) was derived, with a maximum of 30 ppb, indicating that the concentration of the molecule varies over the globe. Seasonal plots show an increase of methane concentration over the northern polar cap during summer.

Although the amount is small – by comparison, Earth's atmospheric methane content is around 1750 ppb – it is still a significant finding. On Earth, methane is produced almost exclusively by biology, with a small fraction from volcanic activity. The detection on Mars has therefore led to an intense debate in the scientific community concerning the potential source of the methane: could it be from active biological or geological processes?



The Aureum Chaos region, located in the eastern part of Valles Marineris, is characterised by randomly oriented, eroded blocks. (ESA/DLR/FU Berlin–G. Neukem)

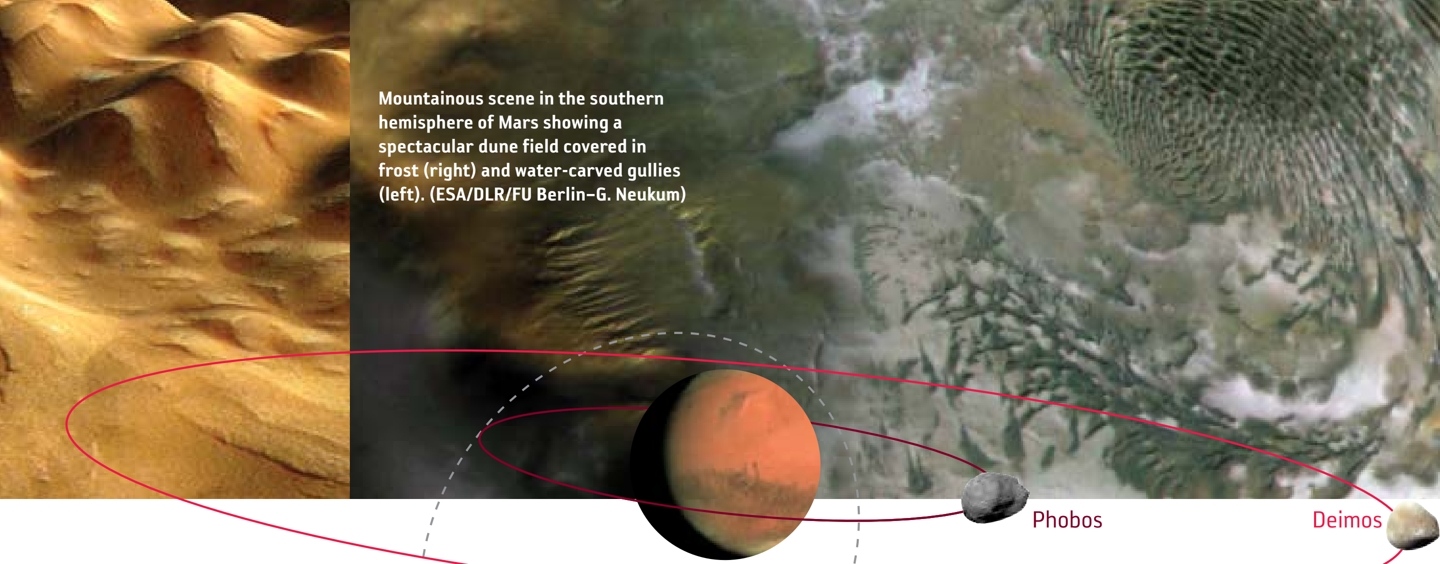


LIVING ON THE EDGE

Mars Express is currently the only orbiter making measurements in the upper martian atmosphere, where the thin air interacts strongly with the solar wind and the highly energetic solar flux. Thanks to the MaRS radio-science experiment and the MARSIS radar, Mars Express has identified the upper and lower boundaries of the ionosphere, known as the ionopause and the meteoritic layer.

Meanwhile, the ion instrument on ASPERA (the energetic neutral atoms analyser) has enabled a unique global analysis of the mass composition and escape rates of planetary ions into space. Hydrogen and oxygen ions (most likely from water) dominate the escape from Mars. Conversely, the escape of carbon dioxide is minute. The ion escape rate is highly variable, depending strongly on the solar wind and ultraviolet fluxes. ASPERA also measures energetic electrons, channelled by the crustal magnetic field anomalies, which produce the auroras detected by SPICAM.

How an aurora might look to an observer orbiting on the night side of Mars. (M. Holmström, IRF)



Mountainous scene in the southern hemisphere of Mars showing a spectacular dune field covered in frost (right) and water-carved gullies (left). (ESA/DLR/FU Berlin–G. Neukum)

CLOUDY ATMOSPHERE

Mars Express was the first mission to detect high-altitude carbon dioxide ice clouds in the martian atmosphere. Hints of their presence were first given by PFS and SPICAM (the ultraviolet and infrared atmospheric spectrometer) in 2006, with an unambiguous characterisation made a year later by OMEGA, complemented by HRSC visual observations.

Then, in 2011, SPICAM revealed for the first time that the martian atmosphere is supersaturated with water vapour. Supersaturation occurs when water in the atmosphere remains as vapour, instead of condensing or freezing. Although the atmosphere of Mars holds 10 000 times less water vapour than that of Earth, high levels of supersaturation were detected on Mars, up to 10 times greater than those found on Earth. This discovery has major implications for understanding the martian water cycle and the historical evolution of the atmosphere.

MOONS UP CLOSE

Mars Express has provided new views of the two martian moons, in particular of the innermost, Phobos. Forty-six flybys between 2004 and 2012 have brought the spacecraft to well within 1000 km of the tiny moon, which has an average radius of 11 km, the closest pass to date being at 77 km from the centre of the moon. In December 2013 an even closer pass of just 58 km is planned.

Mars Express has acquired the sharpest ever images of Phobos, and improved the knowledge of the positions of both Phobos and Deimos along their orbits. The mission has also provided the most precise values on Phobos' shape, dimensions, gravity field and density.

Phobos.
(ESA/DLR/FU Berlin–G. Neukum)

FACTS AND FIGURES

Spacecraft size	1.5 x 1.8 x 1.4 m
Launch vehicle	Soyuz/Fregat from Baikonur, Kazakhstan
Launch mass	1120 kg (including 113 kg orbiter payload and 60 kg Beagle 2)
Orbit	Elliptical (330 x 10 530 km) around Mars, 86.9° quasi-polar inclination, 7 h period
Nominal lifetime	1 martian year
Payload	ASPERA (energetic neutral atoms analyser) HRSC (High Resolution Stereo Camera) MaRS (Mars Radio Science experiment) MARSIS (subsurface sounding radar altimeter) OMEGA (visible and infrared mineralogical mapping spectrometer) PFS (Planetary Fourier Spectrometer) SPICAM (ultraviolet and infrared atmospheric spectrometer)
Beagle 2	Surface lander with analytical payload (failed during landing)
Satellite control centre	ESOC, Darmstadt, Germany
Science operations centre	ESAC, Villanueva de la Cañada, Madrid, Spain; Rutherford Appleton Laboratory, Harwell, UK (up to 2009)
Ground station	ESA tracking station network, NASA's Deep Space Network

www.esa.int/marsexpress

THE OUTLOOK FOR MARS EXPRESS

A further mission extension for 2015–16 is being considered. This would enable atmospheric data to be collected for the remainder of a full solar cycle (11 years), while also increasing the global coverage of high-resolution image mapping.

Mars Express has already paved the way for the next generation of European-led Mars exploration missions. It has helped to characterise the landing site for ESA's ExoMars Entry, Descent and Landing Demonstrator Module, and will most likely be monitoring the mission's arrival at the Red Planet in October 2016. Mars Express data are also supporting the selection of potential landing sites for NASA's Insight mission, due to land in 2016.

Cover image: Water ice in a 35 km-wide crater in the Vastitas Borealis region near the martian north pole (ESA/DLR/FU Berlin–G. Neukum)

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