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Mars Express science results and goals for the extended mission

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Abstract. Results of the *Mars Express* mission to Mars are summarized.

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1. Results

The ESA *Mars Express* mission was successfully launched on 02 June 2003 from Baikonur, Kazakhstan, onboard a Russian Soyuz rocket with a Fregat upper stage. The mission comprises an orbiter spacecraft, which has been placed in a polar martian orbit, and the small *Beagle 2* lander, due to land in Isidis Planitia but whose fate remains uncertain.

In addition to global studies of the surface, subsurface and atmosphere of Mars, with an unprecedented spatial and spectral resolution, the unifying theme of the mission is the search for water in its various states everywhere on the planet. A summary of scientific results from all experiments after more than one Martian year in orbit (687 days) is given below.

The High-Resolution Stereo colour imager (HRSC) has shown breathtaking views of the planet, pointing to very young ages for both glacial and volcanic processes, from hundreds of thousands to a few million years old, respectively.

The IR Mineralogical Mapping Spectrometer (OMEGA) has provided unprecedented maps of H_2O ice and CO_2 ice in the polar regions, and determined that the alteration products (phyllosilicates) in the early history of Mars correspond to abundant liquid water, while the post-Noachian products (sulfates) suggest a colder, drier planet with only episodic liquid water on the surface.

The Planetary Fourier Spectrometer (PFS) has confirmed the presence of methane for the first time, which would indicate current volcanic activity and/or biological processes.

The UV and IR Atmospheric Spectrometer (SPICAM) has provided the first complete vertical profile of CO_2 density and temperature, and has discovered the existence of nightglow as well as that of auroras over mid-latitude regions with paleomagnetic signatures.

The Energetic Neutral Atoms Analyser (ASPERA) has identified solar wind scavenging of the upper atmosphere down to 270 km altitude as one of the main culprits of atmospheric degassing.

The Radio Acience Experiment (MaRS) has studied the surface roughness by pointing the spacecraft high-gain antenna to the Martian surface. Also, the martian interior has been probed by studying the gravity anomalies affecting the orbit, and a transient ionospheric layer due to meteors burning in the atmosphere, identified by MaRS.

Finally, results of the subsurface sounding radar (MARSIS) following the late deployment of its antennas due to safety concerns, indicate strong echoes coming from the surface and

the subsurface allowing to identify buried craters and tectonic structures. Also, probing of the ionosphere reveals a variety of echoes originating in areas of remnant magnetism.

Mars Express is already hinting at a quantum leap in our understanding of the planet's geological evolution, to be complemented by the ground truth being provided by the American *MER* rovers. The nominal mission lifetime of one Martian year for the orbiter spacecraft has already been extended by another Martian year.

During the extended mission, priority will be given to fulfill the remaining goals of the nominal mission (e.g., gravity measurements and seasonal coverage), to catch up with delayed MARSIS measurements during the nominal mission, to complete global coverage of high-resolution imaging and spectroscopy, as well as subsurface sounding with the radar, to observe atmospheric and variable phenomena, and to revisit areas where discoveries were made.

Also, an effort to enlarge the scope of existing cooperation will be made, in particular with respect to other missions to Mars (such as *MGS, MER, MRO*) and also missions to other planets carrying the same instruments as *Mars Express* (i.e., *Venus Express*).

2. Mission details

Launch date: 2 June 2003
Arrival at Mars: 25 December 2003
Mass of payload: 116 kg
Primary science instruments:
HRSC (High-Resolution Stereo Camera): high-resolution surface imaging.
ASPERA (Energetic Neutral Atoms Analyser): how the solar wind erodes the Martian atmosphere.
PFS (Planetary Fourier Spectrometer): study of the atmospheric composition and circulation.
OMEGA (visible and infrared Mineralogical Mapping Spectrometer): determination of the surface composition and evolution processes.
MARSIS (sub-surface Sounding Radar Altimeter): search for water in the subsurface.
MaRS (Radio Science experiment): sounding of the internal structure, atmosphere and environment.
SPICAM (ultraviolet and infrared Mars Atmospheric Spectrometer): determination of the composition of the atmosphere of Mars.
Lander (*Beagle 2*): geochemistry and exobiology (lost).

3. In the literature

A detailed description of the Mars Express scientific payload has been published in book form; see Chicarro (2004).

The Mars Express mission has resulted in the publication of several hundred papers and abstracts to date, far too many to cite here. A large number of these results can be found in issues of the journals *Icarus, Journal of Geophysical Research: Planets*, and *Planetary and Space Science* for the years 2005 and 2006.

Reference

A. Chicarro (ed.) 2004, *Mars Express: the Scientific Payload*, ESA SP-1240

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