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Mars Express – Scientific discoveries of the extended mission

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The ESA Mars Express mission, launched on 02 June 2003 from Baikonur, Kazakhstan, onboard a Russian Soyuz rocket, includes an orbiter spacecraft which was placed in a polar martian orbit. 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 by all instruments using different techniques. A summary of scientific results from all experiments after more than three terrestrial years in orbit is given below.

The High-Resolution Stereo Colour Imager (HRSC) has shown breathtaking views of the planet from both hemispheres, 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 and iron oxides) suggest a colder, drier planet with only episodic 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 and very high-altitude CO_2clouds. 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 and determine the current rate of atmospheric escape. The Radio Science 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, was 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 impact craters and tectonic structures, as well as the very fine structure of the polar caps. The Northern crust appears thus just as old as the Southern one, owing to the large number of impact basins being recognized. 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 (687 days). During the extended mission, priority is being 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 is being made, in particular with respect to other missions at Mars (such as MER, Mars Odyssey and MRO) and also missions to other planets carrying the same instruments as Mars Express (i.e. Venus Express). Finally, Mars Express is providing valuable data for the preparation of ESA's Aurora Exploration Programme first mission to Mars (called ExoMars and including a capable rover to perform astrobiological, geophysical and climatological investigations), in terms of helping identifying potential landing sites on Mars, establishing a useful surface/subsurface geological database, as well as refining the existing atmospheric one, in order to assess potential risks for the exploration of Mars. For further details on the Mars Express mission and its science results: **http://sci.esa.int/marsexpress**