THE EUROPEAN ROBOTIC EXPLORATION OF THE PLANET MARS

A.F. Chicarro, European Space Agency, Solar System Missions Division, ESTEC/Code SRE-SM, Postbus 299, 2200 AG Noordwijk, The Netherlands (agustin.chicarro@esa.int).

The ESA Mars Express mission was launched in June 2003 and has been orbiting Mars for over seven years providing data with an unprecedented spatial and spectral resolution on the surface, subsurface, atmosphere and ionosphere of the red planet. The main 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 is given hereafter. 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 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 (also seen in ground-based observations), 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 night-glow, as well as that of auroras over mid-latitude regions with paleomagnetic signatures and very high-altitude CO_2 clouds. 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 ionospheric and subsurface sounding radar (MARSIS) indicate strong echoes coming from the surface and the subsurface allowing to identify buried tectonic structures, as well as layers of water-ice and the very fine structure of the polar caps. Also, probing of the ionosphere reveals a variety of echoes originating in areas of crustal remnant magnetism. Mars Express is flying at the closest distance ever of Phobos (less than 100 km), allowing to determine the mass of Phobos with great accuracy, to sound its interior with a radar for the first time, to obtain the sharpest images ever, to observe the satellite in the visible, UV and IR, and to monitor the solar wind interaction with its surface.

Mars Express will be followed by the new joint ESA-NASA Mars Exploration Programme, starting in 2016 with the Trace Gases Orbiter (TGO) focusing on atmospheric trace gases and in particular methane. The ESA ExoMars rover will follow in 2018 together with NASA's MAX-C rover to perform geochemical and exobiological measurements on the surface and the subsurface. Then in 2020 or soon after, a Network of 3-6 surface stations would be launched, in order to investigate the interior of the planet, the rotational dynamics, the atmospheric dynamics and the geology of each landing site. Such network-orbiter combination represents a unique tool to perform new investigations of Mars, which could not be addressed by other means. In particular, i) the internal geophysical aspects concern the structure and dynamics of the interior of Mars including the state of the core and composition of the mantle; the fine structure of the crust including its paleomagnetic anomalies; the rotational parameters (axis tilt, precession, nutation, etc) that define both the state of the interior and the climate evolution; ii) the atmospheric physics aspects concern the general circulation and its forcing factors; the time variability cycles of the transport of volatiles, water and dust; surface-atmosphere interactions and overall meteorology and climate; iii) the geology of each landing site concerns the full characterization of the surrounding area including petrological rock types, chemical and mineralogical sample analysis, erosion, oxidation and weathering processes to infer the geological history of the region, as well as the astrobiological potential of each site. To complement the science gained from the Martian surface, investigations need to be carried out from orbit in a coordinated manner, such as i) global atmospheric mapping to study weather patterns, opacity and chemical composition; ii) a detailed map of the crustal magnetic anomalies from lower orbit (150 km); iii) study of these magnetic anomalies need to be studied in light of the magnetic field induced by the solar wind interaction with the upper atmosphere of the planet. The Network Mission concept is based on the fact that some important science goals on any given terrestrial planet can only be achieved with simultaneous measurements from a number of landers located on the surface of the planet (primarily internal geophysics, geodesy and meteorology) coupled to an orbiter.

The long-term goal of Mars robotic exploration in Europe remains the return of rock and soil samples from the Martian surface before Humans go to Mars. For further details on Mars Express science results: **http://sci.esa.int/marsexpress/**