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Changing the paradigm of Mars history and evolution

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Abstract

Mars Express has triggered major discoveries, forcing an in-depth revisiting of critical paradigms of Mars history, with key outcomes for solar system evolution. Focused on findings from the OMEGA investigation, the discussion will outline key steps of Mars evolution, from geological and climatic to seasonal and diurnal timescale, with a special emphasis on the potential "habitability" of Mars in its ancient times.

Discussion

The ESA Mars Express "F-mission", although conceived as a small, fast and flexible one, has offered unprecedented results reappraising Mars formation and evolution processes. More specifically, OMEGA, the pioneer VIS/NIR hyperspectral imager, through the identification of the major surface and atmospheric constituents, put in their proper geomorphological and environmental context, has enabled a thorough deciphering of the major steps which paved Mars History.

On long timescales, distinct era were identified, primarily through the characterization of the changing environment responsible for specific alteration of the rock forming minerals. In particular, Mars seems to have hosted conditions favoring liquid water to be stable, in its ancient times, at a planetary scale. Specific phyllosilicates are the prime witnesses of this early aqueous alteration.

Mars then suffered a global climatic change, during which most gases, including the greenhouse species, escaped. Episodes of further aqueous events took place, responsible for an increased diversity of the alteration products; in a few places, they can be identified within a preserved stratigraphy, recording the time evolution of the relevant environment, thus characterized.

In happens that Mars, uniquely in the entire solar system, has preserved sites still witnessing these very early times, along its first billion years: they are of critical interest, since Mars might have then harbored a biochemical evolution. As a consequence, they constitute favor sites of astrobiological relevance, for the upcoming Mars *in situ* exploration (Mars 2020, ExoMars, HX-1).

Then started the long term era, lasting up to now, during which Mars became the arid planet we observe, with only its very shallow surface oxidized through atmospheric alteration, in ferric oxides. Transient processes, triggered by volcanic activity, impacts and obliquity changes, span over these 3.5 past billion years, with more local effects.

It is exemplary that Mars Express instruments addressed and are still addressing questions not even raised at the time they were conceived, selected and developed: their outcomes are profoundly modifying our vision of Mars history. As such, they have constituted and still constitute key drivers of the follow-on Mars exploration mission.

At a larger scale, Mars Express contributes to the true revolution of our present understanding of the processes responsible for the totally unexpected diversity of evolutionary pathways of planets within the solar system, and of stellar systems within the galaxy. The relative role of contingency, to genericity, in these processes, through the immense diversity of the specific form they can take, is key. Being able to comparing Mars to Earth, at all historical ages, is thus of utmost fruitfulness. Amongst the paradigms violently shaken, that Mars, as pioneering pointed by Mars Express, has the unique potential to renew: at what time and space scale is the Earth unique, and the life it harbors.