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Introduction: The Mars Origins Mission [1] is a proposed mission submitted to the European Space Agency's Cosmic Vision AO (2007) that consists of an *in situ* investigation of the Noachian terrains of Mars. The scientific objectives are:
1. To characterise the very early geological evolution of Mars and the context in which life potentially arose;
2. To search for traces of the transition from a prebiotic world to life;
3. To trace the early evolution of life and its fate as conditions on Mars changed.

This mission will provide information on the first billion years of inner planet evolution and the appearance of life, *i.e.* critical information that is lacking on Earth.

Early Mars and early Earth: Similarities in the mode of formation of the terrestrial planets, Earth, Mars and Venus, and in their sizes and orbital positions suggest similar environmental conditions on these planets early in their histories [2-4]. All three planets had a CO_2 rich atmosphere sufficiently dense to support the presence of liquid water on their surfaces, as well as an abundance of prebiotic organic molecules. With the addition of other ingredients essential for life (H, O, N, P, and S) and a variety of energy sources (geothermal, geochemical or solar), life could have appeared independently on Earth, Mars or Venus.

Environmental conditions on all three planets have changed throughout geological time. The Earth developed plate tectonic processes and maintained its atmosphere, which was entirely altered by the products of abundant life (i.e. oxygen). Mars lost its magnetic dynamo, lost a large part of its atmosphere, and became a dry and frozen planet, while Venus suffered a "runaway greenhouse". On Earth, vigorous plate tectonic activity has largely erased the first billion years of geological and palaeontological history. Although rocks as old as ~4 billion years exist, they are so heavily altered and deformed that it is difficult to obtain information about the early environmental conditions [5]. By 3.5 Ga, the time that oldest well-preserved terrestrial rocks formed, the geological, environmental and palaeontological records that they contain pertain to a relatively geologically evolved planet inhabited by relatively evolved life forms [5].

Mars, the smallest of the three planets cooled more quickly and froze tectonically, probably between 4.2-3.8 Ga. This is of fundamental importance to our science objectives because, in its early Noachian terrains, Mars still retains the record of the first billion years of evolution of the terrestrial planets that has been erased on Earth. The geological context of early Mars therefore forms the backdrop for investigating the "missing link", the early geological evolution of the terrestrial planets and the origin of life on Earth (and elsewhere?).

Moreover, irrespective of whether life appeared on Mars the planet remains a calibrationary dipstick in terms of testing null hypotheses related to traces of life. Lacking vigorous tectonic recycling over the last >3.5 Ga, crust dating back to the time of the differentiation of the planet still exists at the surface, or close to the surface. This crust will contain traces of the endogenous and exogenous prebiotic molecules that eventually developed into the first cellular life.

Mission architecture: The scientific objectives will be addressed by a ~40 kg payload of rover-based instrumentation inherited partly from already existing (but improved) technology of Beagle 2, ExoMars, and MER, and partly on completely new instrumentation. A specific goal will be rock dating by rock/mineral isotopic analysis (with an accuracy of 100-400 My). Dating is fundamental to the objectives (e.g. dating the cessation of the martian dynamo and being able to select and cache of the most relevant Noachian-aged samples in preparation for a Mars Sample Return mission). Two complementary techniques are proposed: K-Ar and Ar-Ar. Other new instruments essential for the objectives include a fixed and "flying" magnetometer (Marsfly) for information on the early crustal history. The proposed instrument suite provides information on the context geology and geophysics as well as more detailed information on the organic and inorganic geochemistry of the rocks. It includes a panoramic camera; Marsfly (flying geologist); a close-up imager/microscope; a magnetometer; Raman LIBS; K-Ar and 40Ar-39Ar dating instrumentation; a multispectral microscope; cathodoluminescence; GC-MS; Mössbauer/XRF; and XRD/XRF. Sample acquisition will use a 60 cm drill.

Mars Sample Return: Among the highest priorities for Mars Sample Return are materials containing evidence related to traces of life. Thus, in view of preparations for a future Mars Sample Return mission (2020), our Mars Origins Mission will be extremely timely for testing systems that will be necessary for such a mission, such as a caching system for samples of

[5.] R. Arvidson, B. Hofmann, A. Coradin, J.-L. Josset, A. Griffiths, R. Jaumann, I. Wright, F. Rull, E. Jessberger, D. Tallboys, L. Marinageli, M. Trieloff, P. Ehrenfreunde, L. Becker, F. Gössmann, C. Ramboz, C. Briois, C. D'Uston, B. Weiss, C. Schröder, N. Arndt, M. Grässlin, R. Laufer,H.-P. Röser, O. Zeile, S. Gorevan, J. Bada, M. Madsen, F. Raulin, A. Brack, J.-P. Bibring, M. Sims, R. Morris, A. Hofmann, C. Cockell, D. Breuer, H. Edwards, J. Parnell, C. Sotin, F. Costard, N. Mangold, M. Toplis, D. Lentink, C. Passchier.

the highest scientific interest (origins), a communications orbiter; lander insertion from orbit; soft landing; precision landing (10 km ellipse); rover (rough terrain capabilities); alternative energy sources (RTGs for longevity, night operations); direct command of the rover with provision of communications from orbit; and data retrieval from orbit. The spacecraft can be launched using a Fregat B launcher from Baikonur in a direct hyperbolic transfer to Mars.

Further mission adaptations: The mission that we have proposed is an ideal mission to the Noachian Terrains. Various elements of this mission can be adapted to other MSR precursor missions. Within the framework of Mars missions up to MSR, it is essential that precursor missions provide as much context information as possible to understand the history of Mars and to enable the best choice of rocks to be returned. Engineering constraints may restrict the range of localities from which rocks may be returned, at least by the first MSR mission; indeed, many of the Noachian terrains are, from this point of view, out of bounds. Those terrains that are accessible may not necessarily provide the necessary information on past (present?) life but suitable samples from any locality can provide very important information about the preservation of organic molecules and potential biosignatures. It is therefore clear that the exploration of Mars necessitates both sample return and complementary *in situ* investigation.

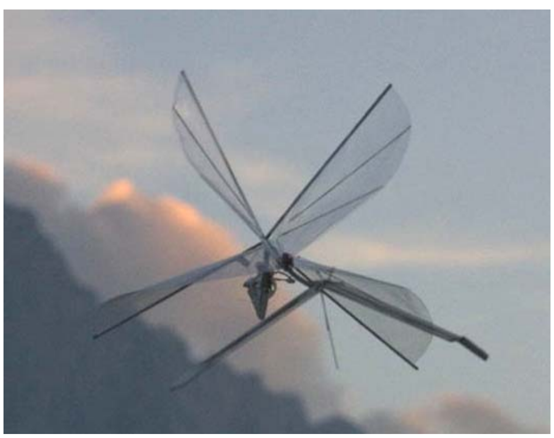

Figure 1. The Marsfly, 20 cm long, weighing < 20 g, can carry a lith payload e.g. magnetometer, in its head as well as a camera. Autonomous flight for 1-10 km.

Figure 2. The caching system (Honeybee Electronics).

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