Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04578, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04578
EGU General Assembly 2008

Mars origins Mission

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The Mars Origins Mission (MOM [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. It is complementary to, and prepares for, a future international Mars Sample Return Mission. MOM has the following scientific objectives :

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.

Given the similarities in the modes of formation of the terrestrial planets and the strong probability that life could have arisen on Mars and Venus, as well as the Earth, 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 because of plate tectonic recycling of the crust. However, environmental conditions on all three planets have changed throughout geological time. Earth developed and O_2-containing atmosphere and retained its surface volatiles, Mars lost a large part of its atmosphere, and became dry and frozen planet, while Venus suffered from a "runaway greenhouse" effect and has been completely resurfaced by volcanic activity. On the other hand,

because Mars froze tectonically between 4.2-3.8 Ga, it still retains the record of the first billion years of evolution of the terrestrial planets in its early Noachian terrains. The geological context of early Mars therefore forms the backdrop for investigating the “missing link”, i.e. the early geological evolution of and the origin of life on the terrestrial planets.

The scientific objectives will be addressed by a $\sim$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.

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 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.

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.

References:[1] Westall, F and Klingelhöfer, G., 2007. Mars Origins Mission. ESA.Cosmic Vision proposal. [2] Westall, F., 2005. Early Life on Earth and Analogies to Mars,in T. Tokano (Ed.) Water on Mars and Life, pp. 45–64

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