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Water Related Environment Modelling on Mars

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During a human Mars exploration because of the lack of time astronauts need fast methods for the interpretation of unexpected observations which give them flexibility and new, important targets. With in-situ modelling it is possible to get information on various past and present processes at the same location on a far wider spectrum than would be realized even during a long mission. This work summarizes the potential technical requirements and benefits of the modelling. Based on a simple estimation with a 300 kg package, and 1-10% of the working time of 1-2 astronauts at the same location, they can get plenty of new and important information for the whole past and present Mars. With the proposed five test groups astronauts will be able to make better and newer kinds of interpretations of observations, and find better targets and methods during the same mission.

Keywords: Mars, human mission, modelling, environment reconstruction, subsurface

1. Introduction

The aim of this work is to outline a possible new method for future human Mars missions to gain more results on the evolution of Mars and above all on any sign of possible past life. Based on the problems with the interpretation of the Viking Landers' observations, the structures inside ALH 84001, the carbonate and faint young protosun paradoxes, the presence of liquid water on the surface in the past etc., it is obvious astronauts will meet with similar problems during human exploration and new analysing methods are necessary. In this article a method is suggested which helps in the realization and theoretical reconstruction of ancient processes, chemistry, later changes, consequences of weathering and the distinction between biogen and abiogen structures.

2. Process of Modelling

Because of the special Martian environment the way of interpretation of certain physical and chemical processes in the past is uncertain. The knowledge of changes that took place inside partly unexpected structures during planetary evolution discovered during exploration is essential in the reconstruction of paleoenvironments. Astronauts can not get this knowledge as a whole in the near future because:

1. They will not be able to observe various structures great enough in number to have exact and unquestionable knowledge on the formation of each one of them.
2. astronauts are not able to reach "every kind" of environment even during a long mission [1, 2].
3. astronauts cannot account for signs that disappeared during planetary evolution and weathering. The solution could be the modelling of past processes and environments on present Mars with artificial changes inside Martian samples. This process can be called "real modelling on real Mars".

All of the test experiments mentioned in this article are for a future human mission. During the modelling astronauts have to:

1. extract "original" regolith samples with as small alteration inside them as it is possible.
2. put them into isolated modelling chambers in an isolated inflatable tent laboratory [3].
3. make changes inside the "original" samples.
4. analyse the physical and chemical changes with in-situ detectors.
5. get small samples out of the "original" samples in the chambers regularly.
6. observe them with detectors are already planned be present in the mission.
7. after the end of any test the "original" samples would be taken away from any chamber, packed inside simple isolating packing matters and put to the storing part of the tent laboratory.
8. after cleaning the chamber new test can be started.

The duration of a test can be between 1-2 days and the whole length of the mission. It would be possible to repeat the tests at several times.

With the 6 proposed tests astronauts have the possibility to realize various kind of changes inside the regolith samples which help to reach the ideal result in the theoretical reconstruction of possible ancient processes. They can make the following changes:

1. change of the location of "original" samples ("original" samples can be taken to the lab during long excursions with rovers from faraway locations too).
2. change of the physical parameters/their distribution in space/time and the time length of any certain test.
3. change of the detectors/their location/detecting method (special kind of detectors could be put together during the mission from "half-ready" packages).

3. Technical Requirements

The technical requirements of the modelling are the following:

- *Inflatable tent laboratoryfor* planetary protection to avoid substantial changes of the natural Martian environment. The restrictions here are substantially lower than in the case of a habitat. They just have to avoid the diffusion of altered chemicals to the natural Martian environment.
- *Modelling chambers:* the author suggests 3-8 different modelling chambers with the following general characteristics:
  - Hard heat insulator walls around the "original" sample
  - Isolated chambers to analyze gases released during the test
  - Transparent top roof of the chambers and transparent top cover of the tent laboratory for natural solar insolation
  - Built-in detector chain inside the wall (pressure, temperature, gas composition)
  - Mobile detectors
  - Built in sampler along the edge of the chambers
  - Mobile sampler.
- *Detectors* are basically of two kinds: already finished ones and flexible versions which can be put together from basic "half-ready" components.
- The lab is divided into three parts: a small part for input of new samples, a greater part for the storing of samples after tests, and the greatest part for modelling with the chambers and analysis of small samples extracted during the tests. The latter can be transported and analysed in the "normal" lab too.
- *Completion of the lab:* the build up of simulating chambers requires only human work that takes about 3-4 days with test operation included. The whole tent laboratory can be built up during 1 day with the help of simple machines [4, 5].
- *Sample extraction* requires high mass equipments which are designed partly for other purposes like core drill, artificial outcrop making, extraction and matter transport for building the habitat. This is the most difficult part of the work, because it requires high mass machines and much energy, and all of these have to be done with less effect on the "original" samples.
- *Cooling:* some expreiments produce heat that has to be conducted away avoiding the heating of other chambers.

The generalized structure of one modelling chamber and the simulated processes on "real" Mars are visible in Fig. 1.

4. Test Types

Based on our current knowledge the following tests can give important information on past and present processes on Mars. It is not necessary and not possible that all of the tests would be realized in different chambers. Figure 2 shows the modelling tent laboratory, and the details of the proposed 6 tests are shown in Table 1. The estimated mass of the modelling chambers is 100 kg, of the equipments for analysis 50 kg (excluding analysers already present in a "normal" mission), of the equipment for sample preparation, storing and cleaning 50 kg,and of the tent laboratory 100 kg. Altogether the proposed modelling can be realized with a package with mass of 300 kg on the most simple way.

Among the proposed tests three are to model processes during global climate warming: internal induced cryosphere melting (simulating the effect of geothermal heat on cryosphere) (CM1), external induced cryosphere melting (simulating global warm period by greenhouse gas release and greater insolation by orbital element changes) (CM2), and chemical evolution in liquid water filled crater lakes and subsurface pore water (AL). These help in the analysis of volatile release, migration, refreezing, chemical and isotopical differentiation, meltwater circulation, changes of chemistry, weathering, subsurface distribution of liquid water and ice. Three tests are to analyse processes between warm periods under present-like climate: gas migration (GM), reactions with ice (RWI), and decomposition of organic material (OMD). Results can be organized into an "evolutionary trend":

1. warming (CM1 and 2).
2. processes during warm climate (AL, CM1 and 2).
3. cooling and freezing (CM1 and 2).
4. processes between warm periods (GM, RWI, OMD).

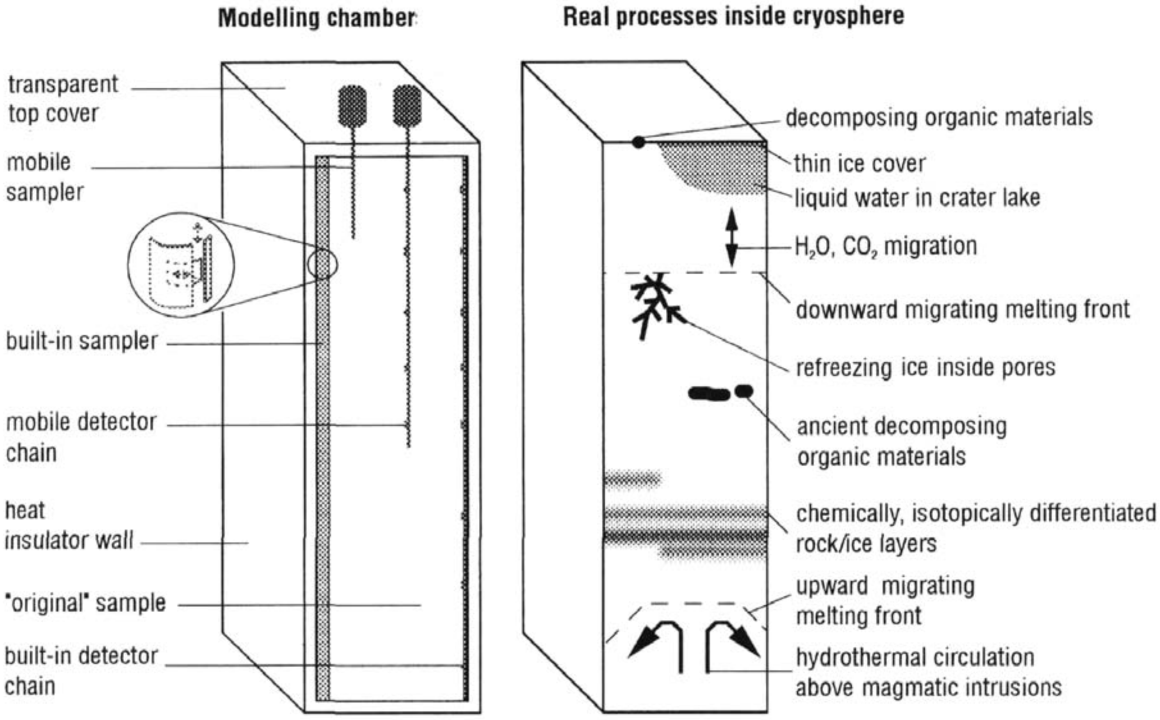

Fig. 1 Generalized structure of one chamber (left) and simulated processes in Mars (right).

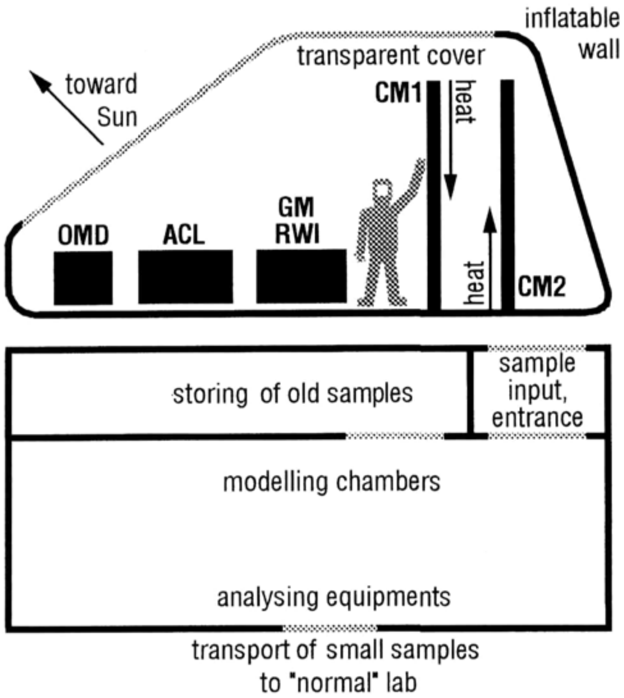

Fig. 2 Structure of the inflatable modelling tent laboratory.

With these six tests astronauts can model complex changes and behaviour of materials/environments on Mars. The results could be essential in the interpretation of new observations on various structures formed under different past environments during a human mission. Without this in-situ modelling astronauts on Mars cannot get out in realtime the most benefits of observations.

5. Working Method in the Lab

Astronauts spend 1-10% of the time in the tent lab in the case of any certain test. This 1-10% time is for preparation and extraction (1/3), analyses during tests (1/3), and cleaning the chambers after tests (1/3). Astronauts work inside the tent lab in spacesuits. The analysis of small samples can be done inside the tent lab but they can be transported to the "regular" lab too. An important part of the modelling is the refinment: based on the results they have to find out new methods in certain tests which give better results. An example for this working schema is shown in Fig. 3. During the available short time astronauts can realize only the major ways of alteration in the materials and their changes, but the whole alteration processes cannot be modelled because of lack of time. In spite of this the results are probably of high scientific value for the reconstruction of past Mars and search for signs of ancient life.

6. Conclusion

The modeling has the following advantages:

- the same test can be repeated several times.
- certain factors can be changed during the tests.
- processes and environments can be analysed on a far wider spectrum than would have been done during even a long mission.
- modelling helps in the interpretation of observations; with the knowledge of some aspects of the original processes and the later alterations it is possible to reconstruct theortically the original environments and materials, which is very important for astrobiology
- part of the team stays at the central base for a long time [6]; during this they can simulate various

TABLE 1: *Details of the Proposed Tests.*

Name of test	Method of simulation	Analyzed characteristics	Analogies on real Mars	Mass of equipment (kg)	Size (cm)	Power requirement (W)
Cryosphere melting 1 (CM 1)	heating and melting from above by artificial insolation	- subsurface volatile sinks - ice melting - volatile migration - chemical and isotopical differentiation - change of subsurface weathering - gas release - refreezing	cryosphere melting during insolation or greenhouse driven global warming	20	200x10x10	2000-4000
Cryosphere melting 2 (CM 2)	heating and melting from below by heat radiator	- subsurface volatile sinks - ice melting - volatile migration - chemical and isotopical differentiation - change of subsurface weathering - hydrothermal processes - metasomatism - gas release - refreezing	cryosphere melting above magmatic intrusions and at volcanic centers	20	200x10x10	2000-4000
Artificial crater lake (AL)	liquid water filled crater lakes heated form above or below	-chemical reactions in liquid water -lake-atmosphere communication -deposited sediments -formed minerals -infiltration -hydrothermal alteration -metasomatism	crater lakes heated by geothermal, impact or greenhouse heat	30	100x50x50	2000-4000
Gas migration (GM), Reactions with ice (RWI)	analysis without any p/T effect, sometimes with artifical markers	- gas migration - reactions with ice - chemical and isotopical differentiation - consequences of weathering	processes inside "cold" cryosphere between warm periods	15	50x20x200	0
Organic material decomposition	decomposition under present conditions	Decomposition of sediments and their weathering with different mechanical/chemical or no shielding	surface, subsurface buried organic materials ("real" chondrites, pure artificial organics)	10	20x50x20	0

environments and adapt the tests to various environemnts according to the directions of astronauts working far from the central base.

Modelling can be an important part of flexible scientific work on Mars and helps to realize any signs of past life in a new way. It is also suggested to make simple tests at analog locations [7] with currently available experiments. This can help in the better understanding of Mars, and the development of future methods and technologies together.

7. Acknowledgement

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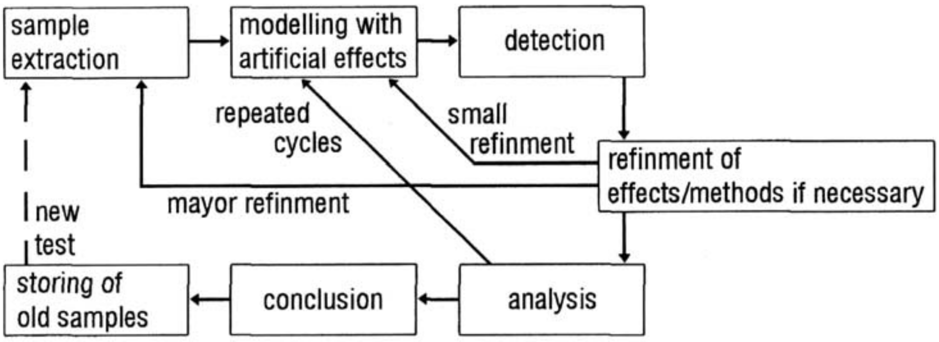

Fig. 3 Steps of the working method of modelling.

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