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Microbiological contamination assessment from drilling activities – recognition and design of prevention strategy

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Abstract

The search for traces of extinct and extant life combined with sub-surface sampling on Mars will be investigated for the first time in ExoMars Exploration Mission. Sub-surface sampling will be addressed using a robotic drill that will minimize the risk of forward contamination. Hence the risks associated with drill contamination must be addressed. This paper describes contamination assessment related to dry drilling activities in Terrestrial Martian analogues.

1. Introduction

Current Martian surface conditions are unfavorable to most known organisms, due to UV radiation, oxidizing agents. Thus the search for evidence of life will focus beneath Martian surface (underground, permafrost, or within surface rocks). The planetary protection policy of the Committee on Space Research (COSPAR) established Planetary Protection Category III for the Orbiter Module, Category IVa for the Entry, Descent and Landing Demonstrator (2016) and Category IVb for Rover Module (2018).

The selection of drilling technique is very important. Dissemination of non-indigenous microorganism through the drilling fluids from the exterior to the interior of the core and inappropriate handling of the samples constitute the main sources of microbial contamination. This is a critical aspect in extreme environments, where it is expected to find very low quantity of microorganisms. The use of drilling equipment that requires no drilling fluids or uses filtered compressed air decreases the probability of contamination but does not eliminate it [1].

Drilling on Earth analog environments can provide important information for testing aseptic drilling methods for a Mars drilling mission. This paper presents the lessons learned during drilling activity performed by Crew 104, between April-May 2011, at MDRS (Utah Desert, USA). The drilling used the MARTE drill, a robotic coring drill system developed to search for subsurface life on Mars [2]. Cleaning and contamination protocols [3] were used.

2. Preventing and assessing contamination

Contamination assessment is a crucial issue for geomicrobiological research on Mars as uncontaminated samples are mandatory. This process can be addressed within similar studies on Earth analogues.

It is mandatory to perform validation studies with the aim of quantifying all sources of contamination associated with each step of the drilling and post drilling processing (Figure 1): (i) establishment of type and location of sources of contamination and the nature from potential contaminant types, (ii) definition of the sampling design strategy, and (iii) a detailed site investigation.

2.1 Sources of contamination

The most likely sources of contamination using MARTE are the drilling/coring equipment and drilling environment, including the compressed air used for flushing the cuttings away from the drill bit [2]. In terrestrial Mars analog experiments airborne dust is regarded as primary vector of microbiological environmental contamination. However in a Mars mission this type of contamination is not relevant due to the sterile conditions expected at Mars atmosphere. Other relevant sources of contamination at a drilling site are human associated microorganisms, sample handling and containers. Retrieval and reintroduction of the core barrel is a crucial step in the process.

2.2 Minimizing contamination

In order to minimize contamination, strict cleaning procedures should be implemented before and during drilling (Figure 1). Appropriate sample collection methods and cleaning equipment protocols should be followed. Cross-contamination between samples can be avoided when appropriate decontamination procedures are followed between different cores. Background sampling to determine the level of contamination in the adjacent areas unaffected by potential contaminant sources at drill site is also essential. The use of field blanks allows measurement of the input from contaminated dust or air into the sample. After the core retrieval, sample collection is the next most important step in terms of contamination. Qualified and experienced field staff (drilling and sampling) are required. Samples must be processed and analyzed as soon as possible to avoid contamination. Sampling has to be conducted in an anaerobic glove box if anaerobic conditions are required [5] (cultivation of anaerobes, analysis of redox-sensitive organisms). In order to minimize potential microbiological contamination previous drilling missions used a dust containment and vacuum device [3].

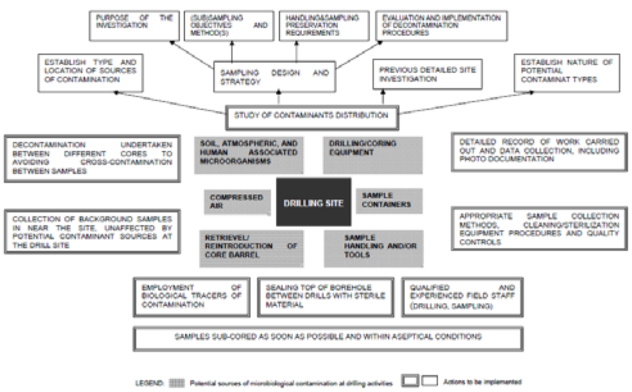

Figure 1: Microbiological contamination assessment.

2.3 Contamination tracers

Contamination from the drilling process can be determined using tracers. The employment of biological (*Serratia marcescens*, *Bacillus globiggii*, *Saccharomyces cerevisiae*, *Chromobacterium violacem*, *Escherichia coli*), naturally occurring and non-biological tracers (dyes, chemical substances, ionic tracers, fluorescent microspheres) have been reported [5]. Fluorescent microspheres and dyes are most used for contamination assessment [4][5]. Biological tracers will not be permitted on Mars.

3. Summary and Conclusions

Search for life in the subsurface of Mars presents a lot of challenges concerning the assessment of microbiological contamination. This paper outlines some issue when using a robotic system operated by humans remotely, supported by human sample handing. Sample handling and containment were identified as determining factors in the field drilling process, because of the environmental contamination. In future contamination assessment it is essential to keep detailed records, including careful monitoring of blanks at each stage of the drilling process.

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References

[1] Juck, D. F., Whissell, G., Steven, B., Pollard, W., McKay, C. P., Greer, C. W.: Utilization of Fluorescent Microspheres and a Green Fluorescent Protein-Marked Strain for Assessment of Microbiological Contamination of Permafrost and Ground Ice Core Samples from the Canadian High Artic, App. Environ. Microbiol., 71(2), pp. 1035-1041, 2005.

[2] Stoker, C.R., et al.: The 2005 MARTE robotic drilling experiment in Rio Tinto, Spain: objectives, approach and results of a simulated mission to search for life in the Martian subsurface, Astrobiology, 8(5), DOI 10.1089/ast.2007.0217.

[3] Miller, D. P., Bonaccorsi, R., Davis, K.: Design and practices for use of automated drilling and sample handling in MARTE while minimizing terrestrial and cross contamination, Astrobiology, 8(5), pp. 947-965, 2008.

[4] Mangelsdorf, H. and Kallmeyer, J.: Integration of Deeo Biosphere Research into the International Continental Scientific Drilling Program, Scientific Drilling, 10, pp. 46-55, 2010.

[5] Smith, H. D. and Mckay, C. P.: Drilling in ancient permafrost on Mars for evidence of a second genesis of life, Planet. Space Science, 53, pp. 1302-1308, 2005.