The response of *Bacillus subtilis* to simulated Martian conditions and to the space environment

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The early histories of Mars and Earth show similarities during the period when life emerged on Earth. Thus a comparable early biological evolution might have taken place also on Mars. Several ongoing international space missions are especially designed to search for past or present life on Mars. In order to develop adequate instruments and methods for *in situ* life detection analysis and to avoid the contamination of Mars by terrestrial life forms introduced to it's surface unintentionally, it is necessary to understand the potential and limits of life on Earth. The determination of the survival of microorganisms under the physical and chemical 'extremes' of Mars will provide detailed insights into the potential for contamination that will allow the development and improvement of planetary protection measures. Our knowledge about the occurrence of life, especially microbial life, on Earth has increased enormously in the last decades. Archaea, bacteria, and protista have been found living in many newly discovered extremely hostile habitats, which were regarded up to now as too harsh to harbor life. Whereas many newly discovered extremophile species are specialized to cope with one extreme environmental parameter like high or low temperature, high or low pH, high salt concentration, desiccation, high flux of ionizing or non-ionizing radiation, there are also long-known dormant stages of certain bacteria such as the *Bacillus* endospores, that are capable to withstand most of the environmental parameters on the surface of Mars like low average temperature, desiccation, CO_2 dominated atmosphere, low pressure, high ionizing and UV radiation.

For the study of the responses of organisms to space environment and for the future exploration of Mars the survivability of *Bacillus subtilis* spores exposed to different subsets of the extreme environmental parameters in space and on Mars (vacuum, simulated Martian UV climate, shielding by different Martian soil analogue materials) was investigated in the laboratory as well as in the ESA facility BIOPAN onboard of the Russian Earth-orbiting Foton M-2 satellite from Mai 31 to June 16, 2005. The basic questions adressed in the experiment MARSTOX on FOTON M-2 are (i) To which extent are different martian soil analogues able to protect bacterial spores against the effects of UV radiation in vacuum? (ii) What are the effects of different mineralogical characteristics (grain size, dust vs. compact material) on the efficiency of protection by martian soil analogues? (iii) Are there (photo-)toxic effects of different martian soil analogues in intimate contact with bacterial spores during UV exposure? After exposure in space the survival as well as the mutation induction was analyzed in the laboratory together with parallel samples from the corresponding ground control experiment performed in the space simulation facilities of DLR.

The results of this experiment provide new insights into the adaptation to environmental extremes on Earth or other planets which define the principal limits of life and at the same time bear the potential for the evolution and distribution of life.