ORGANIC AND INORGANIC GEOCHEMISTRY OF SAMPLES RETURNED FROM MARS

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BACKGROUND

Viking 1 and Viking 2 performed three biology experiments and one organic molecular analysis experiment at only two sites on Mars. Interpretation of the results from these experiments and simulations in laboratories on the earth have not satisfactorily answered questions regarding past or extant biological processes. In fact, arguments may be constructed that lead to opposite conclusions concerning present day biology based on the results of the Labelled Release and organic molecular analysis experiments. With respect to the detection of signatures of ancient Martian biological processes, the landing sites and the type of experiment may not have been the most suitable ones. The inorganic chemical cómposition of Martian materials was also determined using x-ray fluorescence spectrometry by the two landers. Samples that were analyzed by the landers were essentially near-surface samples, at most from about 10-20 cm below the surface. Without a knowledge of the mineralogy and a better understanding of the effects of Martian weathering it is difficult to convincingly explain the biology, organic and inorganic chemical data without resorting to speculation. Fortunately, future missions to Mars can benefit from a decade of data analysis and the development of new models for the evolution of the Martian atmosphere, climate and crust.

SAMPLING

Although a tremendous amount of knowledge can be obtained by in-situ experiments on Mars, greater benefits will be realized with sample return missions from the perspective of exobiology. Ideally, an astronaut-driven rover or an intelligent rover would contain a complex of instruments capable of performing in-situ experiments that can serve several scientific disciplines and would have the capability of collecting surface and 1-2 meter core samples. Since the question of extant biology is yet to be totally resolved, an improved life detection experiment package is an essential part of the first missions. This is important whether the focus of such missions is to be the search for present day Martian life or not as positive findings would have a major impact on quarantine issues.

Organic geochemistry has evolved to a mature state in the last few decades with the development of techniques that can detect ppb and sub-ppb levels of individual organic compounds. Models of the fate of the bulk of biological organic matter in the recent sedimentary environment and interpretations of the record of the earth's earliest biosphere have been developed to a sophisticated level. This knowledge can be applied to understand the chemistry of any carbon compounds present in samples from Mars. We propose an analytical scheme similar to those utilized for the analyses of lunar samples and carbonaceous chondrites. Total carbon and total organic carbon analyses and pyrolysis are rapid means to determine whether further studies are warranted. An automated elemental analyzer on a roving vehicle would facilitate organic geochemical sample selection and would also be able to detect carbonates. Aqueous and organic solvent extracts can be screened for amino acids, hydrocarbons and other soluble molecules by a variety of techniques. Insoluble organic matter can be characterized to complement the information obtained from the soluble phases. If the chemistry of Martian materials is indeed exotic, analytical schemes will have to be altered suitably.

In the post-Viking era with Mars appearing to be a planet which possibly had an abundance of liquid water on the surface, places such as the Valles Marineris layered deposits may be ideal locations for organic geochemical sampling. These Martian 'sediments' may contain remnants of any past biological material. If the deposits are analogous to earth lake deposits, they may contain layers rich in organic matter assuming that the same modes of deposition and preservation of organic matter apply. Spectral imaging capability on a rover would enhance the chances of selecting appropriate samples for geochemical studies. The low abundance of liquid water currently on Mars limits the type of localities to sample for evidence of present biology to those such as in the polar regions. One possibility is to search within Martian rocks. An analog on the earth may be the endolithic organisms reported from desert environments. Such organisms may also leave distinctive weathering patterns on the surfaces of rocks.

The Viking biology experiments showed that the surface material on Mars can respond in a manner that mimics biological processes. Earth-based simulations showed that a number of inorganic materials could have been responsible indicating a complicated surface inorganic geochemistry. To support the organic analyses and interpretation, basic inorganic geochemical and mineralogical data will be required. In addition, Martian diagenetic processes have to be understood in the context of both the organic and inorganic components. Toward these goals we propose to characterize Martian samples using a variety of x-ray, microbeam, activation and spectroscopic techniques. The chemistry and mineralogy of clays and hydrous phases in particular is of interest as they may reveal the nature of the paleoclimate of Mars. The nature of carbonates and sulfates is also of interest as they might contain clues regarding volatile evolution.

SCIENTIFIC QUESTIONS TO BE ANSWERED BY SAMPLE RETURN

The combined results of in-situ experiments and investigations with returned Martian material should be able to answer the questions regarding present or past biology and organic chemical processes. If Mars and the earth accreted with nearly equal complements of volatiles and early tectonic and atmospheric processes were similar, it is reasonable to predict that organic chemical evolution led to the emergeance of life. If ultimately, it is discovered that Mars does not and never did possess a biosphere, it would be crucial to understand why this is so. Such an understanding will have a profound impact not only on theories of the origin and evolution of life but also on theories of planetary evolution.