Life search on Mars by Life Detection Microscope (LDM)

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Recent findings on Mars tend to support the possible presence of living microbes near the surface of Mars. MSL Curiosity has found organic compounds [1], the temporal increase of methane concentration in Martian atmosphere [2] and reduced sulfur compounds such as pyrite in Martian soil [3]. Methane and reduced sulfur compounds can be energy sources to support the growth of chemoautotrophic microbes [4]. The detection of hydrated salts suggested the possible presence of liquid water at Recurring Slope Lineae [5]. Although present Martian environments are hostile to life, terrestrial microorganisms inhabit a wide range of environmental conditions, suggesting some microorganisms may survive near the surface [4]. Though UV radiation is harmful, it would be shielded by thin layers (less than a millimeter) of dust or regolith [6]. A depth of several centimeters from the surface, therefore, could provide sufficient covering for microorganisms to survive.

The Viking mission in 1970’ s did not find evidence for life [7], however, the sensitivity of the GC-MS (mass spectrometer) onboard the Viking mission was found not to be very high, and it was not able to detect 10^6 microbial cells in 1 gram soil [8, 9], indicating that another life detection program is necessary.

The Life Detection Microscope (LDM) that we have proposed [6, 10] has the potential sensitivity much higher than the Viking instrument. Microscopes directly image life forms and identify their shapes, sizes, and other morphological structures and have the potential to detect a single cell in field of view. Therefore, the sensitivity can be as high as desired just by increasing the volume of sample to be scanned in a reasonable duration of experiment. LDM scans about 1 mm^3 and detects less than 10^4 cells in 1 gram soil at a spatial resolution of 1 μm [10]. LDM differentiates among organic compounds surrounded by membranes or with enzyme activity by staining the samples with fluorescent pigments. This technique is especially useful for the detection of living microorganisms.

Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The search for living microorganisms is important not only for scientific interest but for planetary protection. Before future human missions begin, surveys investigating the presence of living microorganisms should be conducted to mitigate the risk of human contact with Martian microorganisms, which may be harmful to human health. The LDM would be also an effective tool for this purpose.

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