LDM (Life Detection Microscope): In situ imaging of living cells on surface of Mars

*Akihiko Yamagishi[1], Takehiko Satoh[2], Atsuo Miyakawa[1], Sasaki Satoshi[3], Yoshitaka Yoshimura[4], Eiichi Imai[5], Takeshi Naganuma[6], Kensei Kobayashi[7], Yoko Kebukawa[7], Hikaru Yabuta[8], Hajime Mita[9], Hirohide Demura[10], Sohsuke Ohno[11], Masanori Kobayashi[11], Hidehiro Hata[12]

1.Tokyo University of Pharmacy and Life Science, Department of Molecular Biology, 2.Japan Aerospace Exploration Agency, 3.Tokyo University of Technology, 4.Tamagawa University, 5.Nagaoka University of Technology, 6.Hiroshima University, 7.Yokohama National University, 8.Osaka University, 9.Fukuoka Institute of Technology, 10.Aizu Univerisy, 11.Chiba Institute of Technology, 12.Kumamoto University

Past trial of detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of GC-MS onboard the Viking mission was not very high, and was not able to detect the microbes 10**6 cells in 1 gram clay [2,3]. Here we propose Life Detection Microscope (LDM) that has much higher sensitivity than the instrument onboard Viking.
Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has reported the temporal increase of methane concentration in Martian atmosphere [4]. The presence of reduced sulfur compound such as pyrite in Martian soil was also detected by MSL [5]. Methane and reduced sulfur compound can be the energy source to support the growth of chemoautotrophic microbes [6]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [7]. The presence of organic compounds of Martian origin has been reported [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars.
Physical and chemical limits for terrestrial life have been major foci in astrobiology [9], and are summarized in ref. [6]. Combining the environmental factors, anywhere in the Martian environment where we can find the three components, water molecules, reducing compounds and oxidative compounds could be an environment where life can be sustained for long periods of time, if other factors such as temperature, pressure, UV and other radiations permit [6]. Among these factors, most of the factors including ionic radiation, can be endured by terrestrial extremophiles. Only UV can kill the most UV-resistant microbes within minutes. However, UV can be shielded by a-few-centimeter sail layer. These evaluation lead to the conclusion that the Martian soil under a few cm can be the place to support the growth of microbes, if the water activity is higher than 0.6.
We will report the current status of the development of the LDM. We propose to search for cells from a depth of about 5 - 10 cm below the surface, which is feasible with current technology. Microscopic observation has the potential to detect single cells. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane. The subsequent analysis of amino acids, in the following mission, will provide the information needed to elucidate the origin of the cell.
LDM that we propose here could detect less than 10**4 cells in 1 gram clay [6]. LDM is capable of identifying what we think to be the most fundamental features that a cell should possess to constitute life. 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 any type of 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.

References: [1] Margulis, L. et al. J. Mol. Evol. 14, 223-232 (1979). [2] Glavin, et al, Earth Planet. Scie. Lett., 185, 1-5 (2001). [3] Navarro-González, et al., Proc. Natl. Acad. Sci. USA. 103, 16089-16094 (2006). [4] Webster, C.R. et al. Science Express Dec. 16 (2014). [5] Ming, D.W. et al. Science Express Dec.19 (2013). [6] Yamagishi, A. et al. Biol. Scie. Space, 24, 67-82 (2010). [7] Ojha, L. et al. Nature Geoscie. 8, 829-832 (2015). [8] Freissient, C. et al. J. Geophys. Res. Planets (2015). [9] Marion, G.M. et al. Astrobiol. 3, 785-811 (2003).

Keywords: Mars, Fluorescence microscope, Life search

