Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3]

1. College of Agriculture, Tamagawa University, 2. Tokyo University of Pharmacy and Life Science, 3. Japan Aerospace Exploration Agency, 4. Nagaoka University of Technology, 5. Tokyo University of Technology, 6. Yokohama National University, 7. Hiroshima University, 8. Fukuoka Institute of Technology

Past trial of direct 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 the gas chromatograph mass spectrometer 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]. Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has found 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 centimeters soil layer. These evaluations 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.

For exploring extant life on Mars, we have proposed to search cells from a depth of about 5 - 10 cm below the surface by the Life Detection Microscope (LDM) [6, 10]. LDM has the potential to detect single cells in the resolution of 1 micrometer and could detect less than 10^4 cells in 1 gram clay, which is much higher sensitivity than the instrument onboard Viking. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane, which 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. The current status of development of LDM will be presented.

References

[1] Margulis, L. et al. *J. Mol. Evol.* 14, 223-232 (1979)

[2] Glavin, et al, *Earth Planet. Sci. Let.*, 185, 1-5 (2001)

[3] Navarro-González, et al., *Proc. Natl. Acad. Sci. USA*. 103 (2006)

[4] Webster, C. R., et al., *Science*, 360 (2018).

[5] Ming, D., et al., *Science*, 343 (2014)

[6] Yamagishi, A. et al. *Biol. Sci. Space*, 24 (2010)

[7] Ojha, L. et al. *Nature Geosci.*, 8 (2015)

[8] Freissient, C. et al. *J. Geophys. Res. Planets* (2015)

[9] Marion, G.M. et al. *Astrobiol*. 3 (2003)

[10] Yamagishi, A., et al., *Trans. JSASS, Aerospace Tech. Japan*, 16 (2018)

Keywords: fluorescent microscope, extraterrestrial life

