

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

*吉村 義隆¹、山岸 明彦²、佐藤 毅彦³、宮川 厚夫²、今井 栄一⁴、佐々木 聡⁵、小林 憲正⁶、癸生川 陽子⁶、藪田 ひかる⁷、長沼 毅⁸、三田 肇⁹、藤田 和央³、臼井 寛裕¹⁰

*Yoshitaka Yoshimura¹, Akihiko Yamagishi², Takehiko Satoh³, Atsuo Miyakawa², Eiichi Imai⁴, Satoshi Sasaki⁵, Kensei Kobayashi⁶, Yoko Kebukawa⁶, Hikaru Yabuta⁷, Takeshi Naganuma⁸, Hajime Mita⁹, Kazuhisa Fujita³, Tomohiro Usui¹⁰

1. 玉川大学農学部、2. 東京薬科大学生命科学部、3. 宇宙航空研究開発機構宇宙科学研究所、4. 長岡技術科学大学生物機能工学専攻、5. 東京工科大学医療保健学部、6. 横浜国立大学大学院工学研究院、7. 広島大学大学院理学研究科地球惑星システム学専攻、8. 広島大学大学院生物圏科学研究科、9. 福岡工業大学工学部、10. 東京工業大学地球生命研究所

1. College of Agriculture, Tamagawa University, 2. Department of Molecular Biology, Tokyo University of Pharmacy and Life Science, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4. Department of Bioengineering, Nagaoka University of Technology, 5. School of Health Sciences, Tokyo University of Technology, 6. Faculty of Engineering, Yokohama National University, 7. Department of Earth and Planetary Systems Science, Hiroshima University, 8. Graduate School of Biosphere Science, Hiroshima University, 9. Faculty of Engineering, Fukuoka Institute of Technology, 10. Earth-Life Science Institute, Tokyo 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]. Here we propose Life Detection Microscope (LDM) that has much higher sensitivity than the instrument onboard Viking. LDM will achieve high sensitivity of microbial cells by observing sufficient volume of soil sample on Mars. It is also important to have the resolution 1 micrometer to detect microbial cells.

Recent 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-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]. Our life-detecting instrument has the sensitivity that is two orders of magnitude higher than the one onboard Viking. 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. 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. 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 Geoscience. 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)