Japan Association of Mineralogical Sciences

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AQUAPLANETOLOGY—A PROJECT THAT QUESTS FOR PLANETARY HABITABILITY IN THE SOLAR SYSTEM AND BEYOND

Is there life beyond Earth? This has been a long-standing question ever since Galileo's era. Yet, many scientists have not seriously tackled this question until recently. Liquid water, organic matter, and energy are considered to be the ingredients for life; nevertheless, they were considered unlikely to coexist over geological time, besides on Earth. Our planet is the only miracle "aquaplanet" and this was the general understanding until ten years ago.

Recent advances in solar system exploration, however, have changed that understanding. Spacecraft have found the ingredients for life—liquid water, organic matter, and energy—on multiple bodies in the solar system. On Mars, for instance, NASA's *Curiosity* rover found evidence for the past presence of organic matter and of redox disequilibrium energy within ancient lake sediments at Gale Crater (e.g., Hurowitz et al. 2017). The *Cassini* spacecraft found evidence for ongoing hydrothermal activity within the organic-rich subsurface ocean of Saturn's moon Enceladus (e.g., Hsu et al. 2015). Carbonaceous-type (C-type) asteroids in the main asteroid belt are remnants of water-rich planetesimals powered by radiogenic heating in the early solar system. Turning our eyes beyond the solar system, more than 20 Earth-sized exoplanets have been found within the habitable zone around their central stars.

The discovery of life's ingredients elsewhere in our solar system has totally changed our view of life in space. But what would be the next step towards finding life? An important step would be to understand the geochemical cycles that occur on aquaplanets (Fig. 1). For example, on aquaplanets, photochemistry and subsequent hydrogen escape will irreversibly oxidize the surface, producing oxidants. On the other hand, water–rock reactions within the subsurface produce various reductants and ions to the aqueous environment (e.g., Shibuya et al. 2013). These chemical species are transported and mixed through hydrological cycles, generating redox and pH gradients near the surface (Fig. 1). Such dynamic systems on aquaplanets could provide disequilibrium energy for chemoautotrophic life to exist. But without a knowledge of the geochemical cycles on other planetary bodies, we cannot predict what biomarkers and biomass might be present.

A Japanese research project Aquaplanetology, launched in 2017, aims at comprehensively understanding the geochemical cycles on planetary bodies in research interactions among geology, geochemistry, biosphere science, astronomy, and planetary science. This project tries to achieve this goal (a) by constructing a theory of chemical reactions and hydrological cycles and (b) by collecting evidence through spacecraft observations and chemically analysing extraterrestrial samples. To this end, the project will develop new and unique experimental equipment. The new equipment will include chemical reactors that simulate high-pressure water–rock reactions in deep subsurface, reaction chambers that simulate ultraviolet light irradiation of ice materials on icy planets, and an improved beam line for scanning transmission X-ray microscopy for investigating extraterrestrial samples. The project also promotes analyses of spacecraft observations of asteroids and planets in collaboration with space missions, including JAXA's *Hayabusa2* mission to C-type asteroid Ryugu.

The expected achievements of the Aquaplanetology project include (1) an understanding of the hydrological cycles and consequent volatile fixation in planetesimals and (2) an understanding of water chemistry (e.g., redox states, salinity, and pH) and of geochemical cycles (e.g., timescale of transport) on early Mars and icy moons. The former allows us to explicitly treat the fate of water in planetary formation theory, which is necessary to predict the probability of forming Earth-like aquaplanets in our solar system and beyond (Genda 2016). The latter enables us to predict biomarkers and biomass on both early Mars and icy moons. The Aquaplanetology project is an interdisciplinary research endeavor whose quest is for the universality of planets that can support life in space.

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REFERENCES

Genda H (2016) Origin of Earth's oceans: an assessment of the total amount, history and supply of water. Geochemical Journal 50: 27-42

Hsu H-W and 14 coauthors (2015) Ongoing hydrothermal activities within Enceladus. Nature 519: 207-210

Hurowitz JA and 22 coauthors (2017) Redox stratification of an ancient lake in Gale crater, Mars. Science 356, doi: 10.1136/science.aah6849

Shibuya T and 5 coauthors (2013) Reactions between basalt and CO_2-rich seawater at 250 and 350°C, 500 bars: implications for the CO_2 sequestration into the modern oceanic crust and the composition of hydrothermal vent fluid in the CO_2-rich early ocean. Chemical Geology 359: 1-9

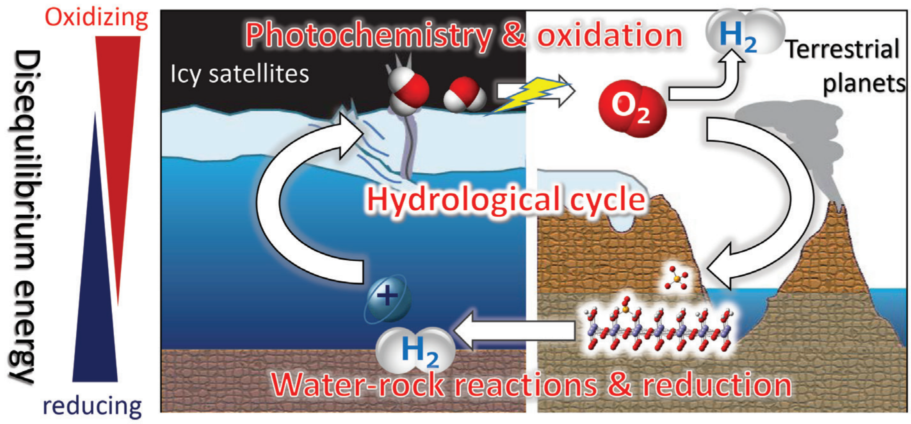

Figure 1 Schematic illustration of oxidant and reductant formation on aquaplanets. Hydrological cycles transport the chemical species, creating chemical gradients and disequilibrium energy available for chemoautotrophic life.

INTERNATIONAL SYMPOSIUM & SCHOOL ON CRYSTAL GROWTH FUNDAMENTALS MEETING REPORT

Talk by Hiroshi Ohmoto in memory of Prof. Ichiro Sunagawa

The International Symposium & School on Crystal Growth Fundamentals, which had the specific title "New Insights into Crystal Growth Fundamentals: A Tribute to Profs. Ichiro Sunagawa and Pieter Bennema", was successfully held 3–7 November 2018 in the Hotel Sakan (Sendai, Japan). The Japan Association of Mineralogical Sciences co-sponsored the symposium, and the International Joint Graduate Program on Earth and Environmental Sciences of Tohoku University provided financial support to the school part. The memorial and keynote speakers included Jim De Yoreo, Takeshi Fukuma, Juan Manuel García-Ruiz, Taketoshi Hibiya, Koichi Kakimoto, Geun Woo Lee, Chaorong Li, Qiu-Sheng Liu, Xiang-Yang Liu, Mihiko Maruyama, Teruyasu Mizoguchi, Teruki Sugiyama, An-Pan Tsai, Katsuo Tsukamoto, Elias Vlieg, and Mu Wang. For more, please see (http://www.nsc.nagoya-cu.ac.jp/~miurah/ISSCGF2018/).

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Original Articles

Three-dimensional observation of the boundary region between massive feldspar and graphic granite by X-ray computed tomography – Susumu IKEDA, Yoshito NAKASHIMA and Tsukasa NAKANO

An in situ Raman study on katoite $Ca_3Al_2(O_4H_4)_3$ at high pressure – Masato KATO and Atsushi KYONO

Retrograde pumpellyite in the Yunotani garnet blueschist of the Omi area, Japan: An update on the cooling path – Yuzuki SHINJI and Tatsuki TSUJIMORI

New data on ferri-ghoseite in Sanbagawa quartz schist from the Iimori region, Wakayama Prefecture, Japan: solid solution between magnesio-riebeckite and clino-suenoite – Yasuyuki BANNO, Koichi MOMMA, Ritsuro MIYAWAKI and Shigeo YAMADA

Letter

Viscosity of melt of soda melilite composition at high pressure – Akio SUZUKI

NATURALLY OCCURRING ASBESTOS: FROM GEOLOGICAL TO MEDICAL ASPECTS

Short Course Title: The 2nd European Mineralogical Union (EMU) School on Mineral Fibres

Location: Casale Monferrato
(Alessandria, Italy), 9–13 September 2019

Chairs: Ruggero Vigliaturo and Alessandro F. Gualtieri

Following the success of the first European Mineralogical Union (EMU) school on mineral fibres, which took place June 2017 in Modena (Italy), this second edition will be more focused on naturally occurring asbestos (NOA). Naturally occurring asbestos became a global public health issue since the publication of scientific evidence of increased risk of malignant mesothelioma in people exposed to airborne asbestos released from natural occurrences. The presence of NOA in the environment affects everyone: therefore, the human activities aimed at its modification and all engineering/geological actions in the natural environment should take it into account.

The school will be multidisciplinary and is aimed at students with a background in biology, chemistry, geology, materials science, medicine, and physics and who are keen to work in this challenging research field of environmental protection.

Each participant will receive a copy of EMU Notes Volume 18 (2017) (see https://www.minersoc.org/emu-notes-18.html), which will be used as the textbook during the school.

The following topics will be covered:

- Crystal chemistry and the occurrence of mineral fibres and naturally occurring asbestos (NOA)
- Definitions (e.g., of asbestos, fibre, NOA, NOMF, NOE)
- Identification of the occurrence, formation, and associated host rocks of the various NOA minerals
- Geological assessment and field sampling methods for NOA in rock and soil
- Experimental methods for the investigation of mineral fibres, with special attention to optical and electron microscopy
- Laboratory rock and soil testing, sample preparation, and analysis protocols
- Selected examples of NOA
- Protection of workers and the public from large and small construction projects
- Surface and biochemical properties of mineral fibres
- Asbestos-related diseases and biochemical mechanisms, inducing adverse effects in the human body
- In vitro and in vivo tests to assess cyto/genotoxicity and carcinogenicity of mineral fibres
- Epidemiological studies of asbestos-related diseases and genetic factors

During the school, there will be afternoon practical sessions to let students practice the experimental methods for studying mineral fibres, two field trips, and an educational visit. At the end of each day, there will be time for open discussion. The distinguished Italian and international lecturers will be delighted to share their own outstanding scientific and life experiences with participating students and with interested colleagues.

Registrations will open in late February 2019

Max number of attendees: 60
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