Detecting potential bio-signatures for Enceladus

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Summary:
This project will investigate the feasibility of detecting organic biosignatures in the plumes of Enceladus using laboratory simulation experiments, including in the presence and absence of microorganisms.

Project Highlights:

- Microbial growth experiments using state-of-the-art simulation facilities.
- Pioneering hypervelocity dust experiments that can be applied to understanding data returned from the Cassini mission.
- Training in interdisciplinary techniques including microbiology, geochemistry and organic geochemistry.

Overview:

The plumes emitted from the south polar region of Enceladus have been investigated extensively by the Cassini mission. Returned data implies they are fed by a global ocean situated below an ice shell atop a silicate interior.

Further information regarding the sub-surface ocean has been obtained from the Ion and Neutral Mass Spectrometer instrument, which detected water, ammonia, molecular hydrogen, simple organic compounds, and possibly sulfur; whilst higher molecular weight organic molecules, salts, biologically available nitrogen, and nanosilica particles have been detected in plume ice grains by the Cosmic Dust Analyzer. Based on these observations, it is predicted that all of the key elements required for life, e.g., C, N, O, P and S are expected to be present in the sub-surface ocean since they have either been detected in the plumes or are expected to be present due to water-rock interaction at the ocean floor. Hence, Enceladus is of interest from an astrobiology perspective.

Although the sub-surface ocean may be deemed habitable, finding evidence of life is dependent on detecting the bio-signatures that are uniquely produced by microbial life. The aim of this studentship is to therefore determine the feasibility of detecting these unique bio-signatures being detected in the plume. This will involve using a combination of simulation facilities at the Open University, Freie University Berlin and the University of Stuttgart to: 1) identify bio-signatures that would uniquely be produced by life in the oceans and 2) investigate the appearance and modification of molecular bio-signatures

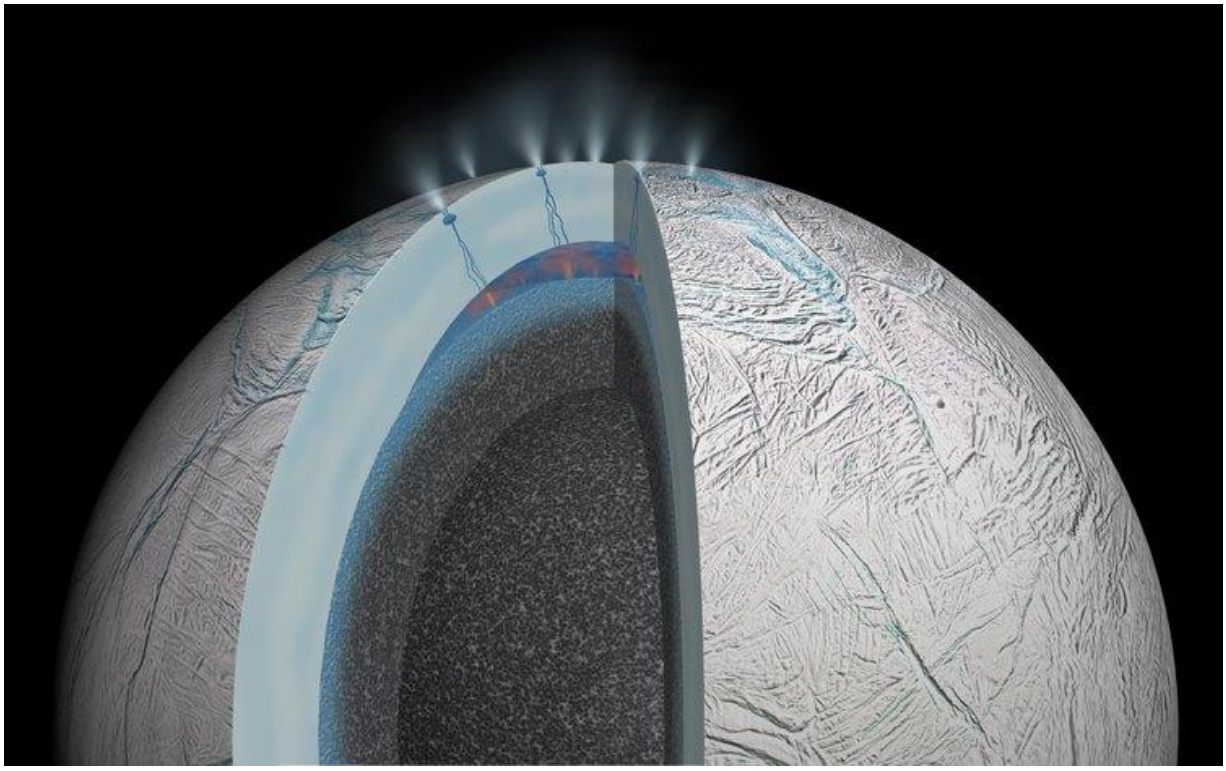

Figure 1: *Illustration of the interior of Enceladus showing the global ocean**.** Credit NASA/JPL-Caltech.*

during plume emission and mass spectrometric analysis from a space craft.

Methodology:

To investigate the feasibility of detecting bio-signatures from Enceladus the following experiments will be conducted in conjunction with the use of Cassini data:

1) simulate the abiotic processes occurring within the sub-surface oceans using dedicated simulation chambers;
2) understand how these processes are influenced by microorganisms, by introducing microorganisms into simulated environments and conducting growth experiments;
3) determine the plausible biosignatures that may be generated by microorganisms in these environments by applying analytical techniques;
4) investigate the effects of the hypervelocity environment that such biosignatures might experience as they are ejected within plumes, using dedicated plume simulation facilities.

Training and skills:

The student will gain training in specific techniques in organic geochemistry and microbiology. The student will carry out an extensive review of possible conditions at Enceladus' hydrothermal sites and the ocean. The Open University has comprehensive laboratory facilities for all required analyses.

The groups at Freie University Berlin and the University of Stuttgart are world-leading in the simulation and analysis of impact ionisation mass spectra, with strong links to not only the Cassini Cosmic Dust Analyzer, but also future missions to e.g. Europa. The student will receive training and experience in the analysis of time of flight mass spectra, as well as in the laboratory simulation of hypervelocity impacts both at Freie University Berlin and the University of Stuttgart in Germany.

The student will benefit from a diverse training programme, ranging from skills that support their PhD studies, e.g., writing skills, time management, presentation skills, research skills and thesis writing, and skills that prepare them for the future after graduation, e.g., CV writing, and networking, including making

active contact with to industry and academic partners.

Possible timeline:

Year 1: Perform a literature review and set up laboratory-based sub-surface ocean simulation experiments with/without an analogue microbial community. Infer suitable samples for the hypervelocity experiments.

Year 2: Submit manuscript regarding feasibility of life in the sub-surface ocean of Enceladus. Present results at a national conference. Prepare samples for simulated plume hypervelocity sampling experiments and help executing these experiments during extensive visits in Berlin and Stuttgart, respectively.

Year 3: Submit manuscript regarding survival of bio-signatures in simulated plume experiment. Write and submit thesis. Present data at an international conference

Further reading:

Spencer & Nimmo (2013). Enceladus: An active ice world in the Saturn System. Ann. Rev. Earth Plant. Sci. 41, 693.

Postberg et al. (2018). Plume and surface composition of Enceladus. In Enceladus and the icy moons of Saturn (P.M. Schenk et., eds.), pp. 129. Univ. of Arizona, Tucson.

Taubner et al. (2018). Biological methane production under putative Enceladus-like conditions. Nature Communications 9, 748.

Further details:

Students should have a strong background in geochemistry/organic geochemistry, or a laboratory-based discipline. The student will join a research team that has extensive experience in running laboratory simulation experiments at the Open University, as well as visit and collaborate with the group at Freie University Berlin, in simulating and analysing hypervelocity impact ionisation mass spectra.
Please contact Karen Olsson-Francis (karen.olsson-francis@open.ac.uk) for further information.

Applications must include:

- a cover letter outlining why the project is of interest and how your skills are well suited to the project
- an academic CV
- an application form and an Open University application form, downloadable http://www.open.ac.uk/students/research/system/files/documents/Application%20form%20-%20uk-eu_0.docx
- contact details of three academic references

Applications should be sent to STEM-EEES-PhD@open.ac.uk by 5pm on 30th September 2019.

About us:

AstrobiologyOU has recently been awarded a £6.7m 'Expanding Excellence in England' award by Research England to grow capacity and capabilities. This will allow us to expand and bring together expertise in technology, international development and governance to address the scientific and governance challenges associated with the advancement of astrobiology and related space exploration missions. As part of this expansion we will be recruiting new PhD students who will span these discipline areas. Each studentship will play an important role in the growth of AstrobiologyOU.

The PhD candidate joining us for this project will be working in a vibrant interdisciplinary environment, alongside PhD students from STEM, Law and Governance, and Social Sciences. They will also be part of the wider OU student community, which is a friendly and supportive cohort, with regular social events organised through groups such as RocSoc, HookeSoc and the OU Club.