Radiation exposure of microorganisms living in mineral radioactive sources

Laboratory : Laboratoire de Physique de Clermont (LPC), Université Clermont Auvergne & CNRS/IN2P3

Research team: Environnement

Supervisor : Vincent Breton (vincent.breton@clermont.in2p3.fr)

Introduction

Mineral sources are unique ecosystems where physico-chemical and radiological parameters are significantly different from their surroundings and extremely stable over very long periods of time. They offer therefore an exceptional window on the history of life on earth : the earliest signs of life on land have been discovered in hot spring deposits as old as 3.5 billion years [1].

Due to their peculiar properties, the living organisms colonizing the sources are exposed to specific selection pressures over hundreds or even thousands of years. Of particular interest to LPC is the impact of their natural radioactivity. In general, the role of radioactivity on the emergence and evolution of life on earth is today completely unknown [2]. While radiation-induced mutations could significantly contribute to evolution, ionizing radiations are also serious candidate for providing the energy needed for prebiotic chemistry resulting in life

appearance [3]. Radioactive mineral sources are among the most radioactive natural ecosystems on earth: several are known and registered in Auvergne. The microorganisms living in their environment can experience radiobiological damages up to 1000 times more than in normal surface waters. Recent observations of diatom communities in “La Montagne” source (Chateldon, Puy-de-Dôme), one of the most radioactive in France, reveal anomalous shapes that can be interpreted as a response to stress.

Within the context of Zone-Atelier Territoires Uranifères dans l’Arc Hercynien (http://zatu.in2p3.fr), a collaboration of biologists, ecologists, physicists and radiochemists has undertaken to characterize mineral radioactive sources in Auvergne in order to understand the impact of radionuclides on living systems. Of particular importance to the interpretation of the observations is the correct assessment of the radiation dose received by the organisms living in the sources. This dose depends on the radiological parameters but also significantly on the chemical properties of the source water and the behavior of the organisms, whether they hang on rocks or walls or they stay in water.

Goals

The Master 2 training period will focus on evaluating the radiation dose received by organisms living in radioactive mineral sources. LPC Clermont has a 15-years long experience in running Monte-Carlo simulation codes to evaluate impact of ionizing radiation on living systems.
The successful student will use the GATE Monte-Carlo toolkit (http://www.opengatecollaboration.org/) to simulate the source environment and to evaluate the contributions to radiation exposure coming from dissolved radon, radium and other radioelements present in the water and on the source walls.

Application

The successful applicant will learn how to use the GATE Monte-Carlo simulation platform. He/she will implement a model of the source “La Montagne” in Chateldon. The model will be used to evaluate the dose received by different microorganisms living in the water or on the walls and the rocks inside the source. In a second step, the model will be extended to other sources of biological interests in the Auvergne region.
The student will also participate to field trips locally to collect water sample for activity measurement on LPC germanium spectrometer.

Students interested to apply are invited to send to the supervisor a short CV and a letter of motivation. They are expected to have interest and skills for programming as well as curiosity for biological and environmental issues.

References

[1] Djokic T, Van Kranendonk MJ, Campell KA, Walter MR, Ward CR, 2017. Earliest signs of life on land preserved in ca. 3.5 Ga hot spring deposits. ***Nature Communications*** 8 : 15263.
[2] Nathanael Lampe, Vincent Breton, David Sarramia, Télesphore Sime−Ngando, David G. Biron. Understanding low radiation background biology through controlled evolution experiments. Evolutionary Applications, Blackwell, 2017, 10 (7), pp.658 − 666.
[3] Westall, F, Hickman-Lewis, K, Hinman, N *et al*. (10 more authors), 2017. A hydrothermal-sedimentary context for the origin of life. ***Astrobiology.*** ISSN 1531-1074