Title of PhD project : Study of extreme solar events, solar activity and the geomagnetic field during the last deglaciation using beryllium-10 and chlorine-36 measured in the Talos Dome ice core (Antarctica).

Laboratory : CEREGE (Centre de Recherche et d'Enseignement des Géosciences de l'Environnement, https://www.cerege.fr/fr/) , Aix-en-Provence, France.

Project description :

The study of cosmogenic nuclides, beryllium 10 (^{10}Be) and chlorine 36 (^{36}Cl) in polar ice and carbon 14 (14C) in tree rings, allow to reconstruct variations of their production rate in the atmosphere. They are constantly produced by the interaction of galactic cosmic rays on target atoms in the Earth's atmosphere. Their production rate depends on the intensity of the magnetic fields of the Sun and the Earth, which modulate the flux of charged particles to Earth. By measuring cosmonuclides in different archives, it becomes possible to reconstruct variations of solar activity or those of the geomagnetic field on long timescales during which direct indicators were not yet available.

Cosmonuclides can also be used to detect unusual solar events linked to extreme particle events generated by the Sun. These extreme events lead to an overproduction of cosmonuclides, which can be found, more widely, in geological records. The discovery of these peaks in the cosmonuclides production calls into question our knowledge of solar storms, which is based on instrumental observations over the last century, during which solar flares were much weaker than those detected with cosmonuclides. As a result, it is necessary to determine the upper limit of the energy emitted during these events in order to prepare our societies for the risks they run, such as severe blackouts or breakdowns of electricity and telecommunications systems. The frequency of these extreme solar events is low, but the conditions under which they occur remain to be determined. We therefore need to improve our knowledge in order to try to predict them.

An extreme solar event has been detected in the Δ^{14}C tree-ring data at 14,300-14,299 years B.P. (Before Present, before 1950), followed by a minimum of solar activity between 14,000 and 13,900 years B.P. (Bard et al., 2023 ; https://doi.org/10.1098/rsta.2022.0206). This new ^{14}C information needs to be confirmed by independent data. To date, there are no ^{10}Be and ^{36}Cl data from ice cores with sufficient resolution to discuss these two periods with precision. In addition, the determination of the energy spectrum of a solar event is based on the ^{36}Cl/^{10}Be isotopic ratio. It is therefore essential to acquire new ^{10}Be and ^{36}Cl data. Another solar event that took place at the beginning of the Holocene, at 9,124 years B.P., will also be studied (Paleari et al., 2022 ; https://doi.org/10.1038/s41467-021-27891-4).

The PhD project will include measurements of beryllium-10 (^{10}Be) and chlorine-36 (^{36}Cl) concentrations from the ice core from the Talos Dome site in Antarctica (https://www.taldice.org/). This study will be dedicated to the last deglaciation and the beginning of the Holocene, between 18,000 and 9,000 years B.P., with a focus on 14,000 and 9,000 years B.P. In parallel with the changes in solar activity, slow variations in the geomagnetic field will also have to be taken into account. In addition, the last deglaciation is a complex period because the carbon cycle was modified, influencing the values of atmospheric ^{14}C without any link to its production rate by cosmic rays. The comparison of ^{14}C data with records of ^{10}Be and ^{36}Cl fluxes will have to take account of these complications, a task that could be complemented with numerical models.

The samples will be prepared in CEREGE's polar ice chemistry unit (Laboratoire de Géochimie Organique, Inorganique et Isotopique – LGO2i) and measured on the Accelerator Mass Spectrometer, ASTER, a national facility, installed at CEREGE.

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The candidate will be a new member of the CEREGE's Climate team and will interact closely with the team at the Laboratoire National des Nucléides Cosmogéniques (LN2C).

Skills :
A sound knowledge of analytical chemistry, chemistry and skills for experimentation are required. The candidate should have a good knowledge of Earth sciences and climatology/paleoclimatology. Modelling skills would be highly appreciated.

PhD supervisors :

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Deadline for applications (Curriculum Vitae and application letter) : 27th, June 2024

Beginning of the PhD contract : 1st, October 2024