Subject offered for a contract starting October 2018

SUBJECT TITTLE: Tracing the "bio" of the biogeochemical cycles shaping the Critical Zone with boron isotopes.

Advisor: **Gaillardet Jérôme, Professeur.**
Second Advisor/ Supervisor:
Louvat Pascale
Host lab/ Team: *please fill in and leave out meaningless information*
G2E team, IPGP.

Financing: Doctoral contract with or without teaching assignment

For more information go to http://ed560.ipgp.fr, section: Offres de these (PhD offer), You must apply on the Doctoral School website

Presentation of the subject: (1 or 2 pages)

The Earth surface is a thin, dynamic pellicle of our planet that is "fueled" by the sun energy. This energy is captured by photosynthetic organisms, that store it into "free" energy within synthetized chemical molecules, that will enter a chain of reactions forming the terrestrial biogeochemical cycles.
Boron (B) is a micronutrient, *i.e.* an element necessary to life processes, but not entering into the stoichiometry of living organic matter. It is thus a perfect element to trace the fate of organic matter in soils, rivers, and more across the Earth surface. Boron is in particular responsible for wood hardness and has a role in the replication of DNA. Preliminary studies conducted in our group have revealed the following features of the boron biogeochemical cycle:

- Experiments show that boron has a great affinity for organic matter. When boron is complexed to organic molecules, the two isotopes of boron, ^{10}B (the light) and ^{11}B (the heavy) are discriminated, with organic matter preferentially taking up light boron. The so-called associated isotope fractionation is important and can be as high as 40‰ (the analytical precision being (on boron isotope ratio measurements) is in the order of 0.2‰).
- In natural environments, at the catchment scale, the major fluxes of boron are associated to recycling of boron by vegetation. Boron is leached out from the canopy, reaches the ground and is then re-adsorbed by roots, forming a recycling loop. However, only a very small fraction of boron leaves the ecosystem and is transported by the fluvial system. This "leaking" boron is strongly isotopically enriched in the heavy isotope compared to bedrock (consistently with the experimental data).
- These two lines of evidence indicate that boron isotopes are an excellent tracer of ecosystem functioning and in particular of biological recycling, the isotopic contrast between living tissues and rocks being very important.

Nevertheless, the fractionation of boron isotopes during plant uptake and translocation within the plants is still unconstrained. In order to improve our knowledge on the boron cycling in ecosystems and to incorporate boron isotopes in reactive transport models, we clearly need to improve our knowledge on boron behavior especially during plants assimilation. This is the aim of the present thesis.

This PhD project will have several dimensions: an experimental and field approaches, and modeling.

1. The experimental part of the project will consist of growing plants in solutions doped in boron of known and distinguishable isotopic composition. Experiments will be conducted in controlled conditions, possibly using the mesocosm national infrastructures.
2. The field-work part of the project will use the critical zone observatories of the OZCAR national infrastructure. In particular, we will make use of a gradient of sites more of less influenced by biological recycling. Biological tissues will be analyzed. Interpretation of data will use the experimental results obtained during phase 1.
3. Finally, all information will be synthesized and incorporated into simple models of reactive transport at the catchment scale. Different models will be used in connection with ongoing projects from members of the G2E team.

The expected results from this work will be to enable the use boron as a tracer of biological recycling and to explain the control of boron isotopes dissolved in rivers. If, as we expect, the boron isotope signature of large rivers is mainly controlled by biological processes, then we will be able to refine the current models of secular evolution of the boron isotopic composition of the ocean, and to interpret this evolution in terms of shifts in terrestrial ecosystem functioning through geological times.

The applicant would likely have a general background in Earth Sciences and (Bio)Geochemistry, as well as a strong interest for isotope geochemistry within the Critical Zone (rivers, soils, vegetation, weathering and transport processes).
The skills required to conduct this project are:

- Ability to conduct experimental work in a clean lab and using a MC-ICP mass spectrometer.
- Ability to interact with colleagues in biology and / or ecology. A minimum background in biology is required.
- Ability to incorporate experimental and observational data into process-based models.