**Doctoral position (3 years)**

**at INRA Grand Est-Nancy, France**

**Impact of amorphous minerals on C sequestration in forest soils**

Social and scientific contexts

Land uses disrupt the natural functioning of soils, leading to degradation of soil resources. At the same time, forecasts estimate that agricultural production has to be increased by 1.85-fold to meet the food demand of 9 billion people by 2050. Agroecological practices thus have to fulfil two main objectives simultaneously—minimize soil degradation while improving ecosystem services. Agroecological strategies for restoring soil functioning mainly strive to enhance the soil organic matter pool. This would represent a win-win strategy since long-term C storage in soils is also an issue in terms of climate change. This has been highlighted recently by the French Minister of Agriculture when proclaiming the launch of the "4 per 1000" project at COP 21.

A better understanding of the mechanisms that control organic matter stabilisation in soils is therefore needed. Mineral surfaces are suspected to play a major role in C storage in soils. The new French ANR “nanoSoilC” project, launched in January 2017, focuses specifically on the study of OM stabilization by organomineral interactions. The overall objective of the project is to explain the process of soil organic matter stabilization and destabilization by describing the mechanisms that control the organomineral interactions at the nanoscale. Organomineral complexes, considered at nanoscale, are called nCOMx.

The doctoral scientific project

 The PhD project addresses C storage in forest soils. The objectives are: (1) to investigate the processes of stabilisation and destabilisation of soil organic C, with a specific focus on the mechanisms that control the interactions between amorphous minerals and organic matter, (2) to identify pedoclimatic conditions, which favor the formation of amorphous minerals, considering the soil profile down to one meter depth and (3) to propose proxies of the silvicultural and pedoclimatic contexts favorable to C storage.

The work will be devided in two main tasks:

##### Task 1: Experimental investigations of the conditions of destabilization of MO-amorphous associations (nCOMx) and quantification of the degradation rates of OM stabilized within nCOMx.

Incubations will be performed to test the impact of various factors on nCOMx stability, on the weathering of the minerals involved in the nCOMx and on the degradation of organic matter involved in nCOMx. The factors tested will be the type of interaction (adsorption and co-precipitation), the nature of the initial mineral, the weathering degree of the mineral surface, the physicochemical conditions as well as the spatial accessibility to micro-organisms.

These experimental approaches will first be conducted first in the laboratory, using simplified systems in columns (Calvaruso et al., 2006), and then in situ. Changes in the structure and chemistry of nCOMx will be studied, ions and organic compounds released from destabilised nCOMx will be monitored over time.

***Task 2: Explorative survey of the functional database of the Biogeochemistry of Forest Ecosystems (BEF) Research Unit to identify pedogenetic factors ruling C storage over the soil profile.***

The BEF research Unit has developed one unique expertise in setting up and running observational sites and in highly instrumented experimentations in temperate and tropical forest ecosystems. These sites are very well characterised for their pedoclimatic properties and have been monitored over the long term (up to 40 years monitoring) by measuring stocks and fluxes of water, nutrients, carbon…

The exploration of this functional database on forest soils profiles of the BEF unit will be carried out in order to determine whether the conditions of pedogenesis inducing the formation of amorphous minerals is a strong driver of carbon stocks. The PhD student will also determine whether the organic matter associated with amorphous minerals is young or old by acquiring additional data such as the amount of C as coarse plant debris indicative of the young C, or radiocarbon data (14C) indicative of the age of the C (Moni et al., 2012; Mathieu et al., 2015). These additional data will only be acquired for a limited number of soil profiles, selected on the basis of large stocks of C and amorphous and soil typologies.

The PhD student will continue the analysis of the database by examining other potential determinants of the C stock over the soil profile in forest ecosystems. He/she will attempt to express a function indicative of the stock and age of C as a function of the typology of the soils (for example, based on the stock of amorphous minerals, on the distribution of the root profile, on vertical transfers, etc.) and forest management.

***Cognitive and technical skills acquired by the PhD student***

Through this research project, the PhD student will acquire skills in biogeochemistry, soil sciences, data processing. He/she will gain a know-how on advanced analytical techniques.

He/she will develop a fine-scale knowledge of the functioning of organo-mineral associations, but also on the drivers of C storage at the ecosystem scale. He/she will have to interact with many people, due to the integration of his thesis project with an ANR project. All these aspects will be an asset for his/her integration into the professional life, as an acadamic fellow but also possibly as stakeholder.

The NanoSoilC ANR project and the contribution of nanoSoilC scientists to the PhD work

The PhD project is a part of an ANR project: nanoSoilC 2017-2021. This project focuses on mechanisms of nCOMx formation (during phases of soil formation and steady-state), and on mechanisms of nCOMx destabilization (loss of soil OM during the transition from forest to cultivated soil). These different mechanisms are addressed by complementary approaches. The project includes experimental laboratory and field experiments, but also by an innovative modelling approach.

The consortium brings together four partners (BEF, CEREGE, ECOSYS and Recyclage et Risque) representing 5 French institutes (INRA, CNRS, Aix-Marseille Université, Collège de France and CIRAD). The panel of scientists provides expertise in various disciplines. It aims to bring together the science of nanoparticles (and their characterization tools) with soil science.

D. Derrien and M.-P. Turpault will jointly advice the PhD work. M.-P. Turpault will supervise the experimental work related with mineral weathering, while D. Derrien will supervise the work dealing with organic matter characterisation and degradation. Isolation and characterization of nCOMx will be performed in close collaboration with the scientists from the CEREGE group (I. Basile - coordinator of nanoSoilC project, C. Levard, S. Legros. J. Balesdent). The PhD student will also interact with some scientists from the BEF research group and from the French Office for Forestry.

Conditions

The monthly net income is ca. 1400€. Salary will be covered by funds from the ANR and by the EFPA division of the INRA.

The work will be carried out mainly at the INRA Grand-Est Nancy (at Champenoux, near Nancy in France – access for free with local bus) with regular missions in France to carry out analyses.

Required profile

The candidate must have a Master 2 in one of the following fields: soil sciences and / or earth sciences and / or environmental sciences and / or life sciences. Specializations in methods of organic matter characterization / mineralogy / field pedology could be additional assets.

In order to satisfy the requirements for documenting and publishing scientific results, the candidate is expected to be proficient in English. The applicant must be able to work independently, be service minded and have a flexible attitude towards internal and external project partners. Emphasis will also be given to the applicants’ teamwork skills and personal suitability.

Short-listed applicants will be invited for interviews.

Contacts

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Submit your application with a detailed CV, cover letter and copies of degrees and grade reports issued by univeristies attended after secondary school as well as names of scientists who could be contacted by the selection board.

Students from both European and non-European countries are welcome to apply.

The selection process will start on March 1St 2017 and will continue until the position is filled. Expected beginning of the PhD: September or October 2017.

Cited references

Basile-Doelsch, I., Derrien, D., Amundson, R., Balesdent, J., Borschneck, D., Doelsch, E. and Levard, C. (2015) Dynamics of organic compounds associated with non-cristalline minerals in andosols: a key for understanding long term SOM stabilization in any soils?, Soil Organic Matter 2015, Structure Origine Mechanisms, Göttingen, Germany.

Calvaruso, C., Turpault, M. P., & Frey-Klett, P. (2006). Root-associated bacteria contribute to mineral weathering and to mineral nutrition in trees: a budgeting analysis. Applied and Environmental Microbiology, 72(2), 1258-1266.

Kleber, M., Eusterhues, K., Keiluweit, M., Mikutta, C., Mikutta, R. and Nico, P.S. (2015) Chapter One - Mineral–Organic Associations: Formation, Properties, and Relevance in Soil Environments, in: Donald, L.S. (Ed.), Advances in Agronomy. Academic Press, pp. 1-140.

Kögel-Knabner, I., Guggenberger, G., Kleber, M., Kandeler, E., Kalbitz, K., Scheu, S., Eusterhues, K. and Leinweber, P. (2008) Organo-mineral associations in temperate soils: Integrating biology, mineralogy, and organic matter chemistry. Journal of Plant Nutrition and Soil Science 171, 61-82.

Moni, C., Derrien, D., Hatton, P.J., Zeller, B. and Kleber, M., 2012. Density Fractions versus Size Separates: Does Physical Fractionation Isolate Functional Soil Compartments? Biogeosciences 9, 5181-5197.

Mathieu, J. A., Hatté, C., Balesdent, J., & Parent, É. (2015). Deep soil carbon dynamics are driven more by soil type than by climate: a worldwide meta-analysis of radiocarbon profiles. Global change biology, 21, 4278-4292.