**Doctoral position at CEREGE, Aix-en Provence, France**

**Mechanisms controlling the soil carbon pool: dynamics of organomineral interactions during forest / crop transition**

Social context, scientific context

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 main part of the PhD work will be aimed understanding the fate of organomineral interactions during transition from forest to crop soil. The objective is to quantify the C pool enclosed in nCOMx and determine its dynamics during forest/crop transition. This issue is addressed together with a study of the impact of three factors expected to control nCOMx formation and destabilization, i.e. soil mineralogy, climate and land-use. Additionally, we will explore the genericity of our results by proposing nCOMx quantification as an index of the stabilised-C pool in soils.

The experimental work will be devided in two tasks:

##### Task 1: Combined forest/crop soil site survey

The first task is dedicated to a 2-steps soils selection procedure:

***- Step 1.*** Explorative survey to select soils based on the following criteria: (*i*) three contrasted climates representative of climatic conditions of France (semi-oceanic, mediterranean and tropical climates); (*ii*) three contrasted mineralogies (soils developed on plutonic rock (granite), volcanic rock (andesite) and sedimentary rock (calcareous clay sediments)); and (*iii*) sites that presented a combination of two modalities (forest and cultivation).

***- Step 2.*** Extensive investigation on five selected combined profiles. The aim is to explore, in topsoils (0-30 cm auger sampling), the expected contrast in organic C content between forest and crop soil. The combined soils will be selected if the forest soil concentration is around 2-fold higher than the crop soil concentration.

We expect to obtain a selection of five combinations of forest/crop sites with contrasted organic C contents in the 0-30 cm horizon. Moreover, this selection will represent a broad range of soil mineralogies and climates. This selection represents five combined soils, *i.e.* 10 soil profiles.

##### Task 2: organomineral inteactions in soil profiles

The second task is divided in three steps :

***- Step 1.*** For the 10 profiles selected in task1, soil pits will be opened down to 1 m if possible, described for soil-type identification and sampled. Samples will be analyzed for conventional soil analysis (TOC, TN, pH, CEC), mineralogy (by XRD) and major elements (by ICP-AES).

***- Step 2.*** In each profile, two samples will be selected above and below the ploughpan (around 15 cm and 50 cm deep). For each sample, nCOMx will be extracted with a method of tangential flow filtration (TFF) to collect soil particles down to few tens of nanometers. For each fraction, organic matter will be characterized: TOC, major elements and NMR (or FTIR if NMR is not accurate due to the Fe content) will be performed. The C dynamics of the fractions will be assessed through 14C measurements with up to date MICADAS spectrometers. The nano-sized nCOMx fractions will be further characterized for the atomic structure of the mineral phases. The ANR project partners (including a post-doctoral fellow) will perform this characterization using the nanoscale approaches developed in a joint work package of the ANR nanoSoilC project (WP1).

***- Step 3.*** Finally, the PhD student will attempt to propose a simple index of the presence of nCOMx in soils as a pool of stable C. Quantification of nCOMx in soils through chemical extractions will be tested and compare to the TFF results. If both approaches show convergent results, this experiment will validate the use of chemical extraction to quantify nCOMx on a broad range of soil types, soil mineralogies, and land-uses. We will then propose to merge a correlation of nCOMx quantification with C stocks at two selected sites (four profiles). Based on this correlation, which is expected to be positive, we will review the literature to compile a large database focused on the correlation between chemical extraction quantification and C stocks in soils. nCOMx quantification may then represent a promising index of stabilized OM in soils.

In the first step, we expect to determine the C stock trends throughout the soil profiles. We will be able to determine the net loss of C through land-use transition. These comparisons will be performed in the light of the mineralogy and climate parameters. In the second step, we will determine the C pools and their dynamics within the extracted fractions. We expect to observe marked variations in C-nCOMx pools before and after cultivation. An explanation linked to nCOMx destabilization is expected. Effects of climate and mineralogy will also be considered. Finally, in the third step, we will show if a correlation between nCOMx quantity and C stocks or mean residence time exists in soils. This step will allow us to generalize our results at a larger scale.

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

The PhD 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 is organized in five Work Packages. nCOMx formation is addressed by experimental laboratory approaches (WP1) and field experiments (WP4). nCOMx destabilization is addressed by both laboratory (WP1) and field experiments (WP3), but also by an innovative modelling approach (WP2). The thesis integrates into the WP3.

The consortium brings together four partners (CEREGE, ECOSYS, BEF and Recyclage et Risque) representing 5 French institutes (CNRS, Aix-Marseille Université, Collège de France, INRA 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.

I. Basile-Doelsch, coordinator of nanoSoilC project, will supervise the PhD work. Together with the PhD student, they will conduct the soil site survey in metropolitan France. The PhD student will implement the survey for metropolitan soils (fieldwork, sampling and soil analyses). T. Woignier will perform the survey and sampling at Martinique (tropical climate) where he is posted. For all the field works, the PhD student will be assisted by A. Duvivier (technical staff) and other participants of nanoSoilC if necesssary. TFF fractionation will be performed with A. Duvivier and S. Legros. C. Hatté, E. Bard, T. Tuna and Y. Fagault will contribute to the 14C measurements. Spectroscopic analyzes at nano-scales will be supervised by C. Levard.

Conditions and location

The monthly net income is € 1,515. It includes retirement pension and partial health coverage (for total health coverage, the estimated cost is around € 40 for a student, depending on the insurance company chosen). Professional costs will be covered by the programm.

The work will be carried out mainly at CEREGE (Aix-en-Provence, France) with regular and frequent missions in France to carry out the sampling and analyses. CEREGE is a research laboratory in the field of environmental sciences. It brings together scientists from various research institutes (CNRS, INRA AMU, IRD, Collège de France). It is located in the Provence Alpes Cote d'Azur region, 15 km from Aix en Provence, in a technological park dedicated to the environment. Access by bus from Aix-en-Provence and Marseille.

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 / mass spectrometry / physical or chemical fractionation of soils / 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 and application

I. Basile-Doelsch (basile@cerege.fr)

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 2017.