Stage niveau Master 2 2017: 5 - 6 mois

Soil organic matter stabilization by organomineral interactions at the nanoscale

Societal issues

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 by increasing organic matter input fluxes. We argue that future agroecological techniques should also be geared towards increasing the residence time of organic matter in soil. 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 future launch of the "4 per 1000" project at COP 21.

Context and framework

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 and the newly funded ANR "nanoSoilC" project (2017-2012) focuses specifically on the study of OM (organic matter) stabilization by organomineral interactions. We propose a conceptual breakthrough of organomineral interactions: our model no longer consider mineral surfaces as stable, but instead, subject to weathering. Weathering generates nanometric amorphous Al Si and Fe polymers with large specific surface areas and high reactivity towards organic compounds that they may stabilize on long-term timescales (Basile-Doelsch et al. 2015). 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 nanoSoilC project will focus 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).

Training objectives and experimental approaches

The M2 study will deal with nCOMx formation in controlled laboratory experiments (included in the Work Package 1 of nanoSoilC). We will seek to synthesize nCOMx that cover a wide range of realistic environmental scenarios. The batch syntheses have the advantage of being quite fast to implement while enabling scanning of many conditions representative of natural systems. 3 minerals and 1 rock will be targeted (labradorite, biotite, vermiculite and basalt). Mineral weathering will be mimicked by a first powdered mineral dissolution step in acidic solution. A second step will consist of precipitating nCOMx from previous leachate solutions by slowly increasing the pH in presence of OM. 2 types of organic compounds will be used (a small molecule with functional groups that are reactive at different pH and representative of natural organic matter and a large biomolecule representative of a type of natural organic matter that is known to efficiently complex metals). nCOMx will then be characterized by complementary approaches : TEM-EDX (observation of nanoparticles of nCOMx and analyses of their chemical composition), IRMS (C content of the nCOMx), an Rock Eval 6 (thermal analysis to evaluate the stability of OM in nCOMx). This sample collection will then represent the references for the analysis of the natural samples of nanoSoilC project.

Expected skills: It is expected that the student has skills in chemistry and / or geology / mineralogy and / or soil science.

PhD opportunities: This Master2 training may be followed by PhD opportunities in the framework of the ANR project nanoSoilC.

Training allowances will correspond to the legal amount.

Location of the training : CEREGE, Aix-en-Provence with a few days at CINAM (Marseille) and a few days at ENS (Paris).

Supervisors: Isabelle Basile-Doelsch, Jérome Rose, Clement Levard (CEREGE). The M2 student will interact with other scientists namely: P. Chaurrand and E. Doelsch for batch synthesis (CEREGE), B. Angeletti for leachate solution analyses (CEREGE), W. Achouak and C. Santaella for collection of microbial exopolysaccharide (LBVME, Cadarache), O. Grauby for TEM-EDX analyses (CINAM, Marseille), L. Cécillon and Pierre Barré for thermal analyses (ENS-Paris).

Contact: Isabelle Basile-Doelsch, basile@cerege.fr. Include a detailed CV to apply.