

Distribution, Speciation, and Elemental Associations of Soil Organic Carbon under Varying Landscape Topographic Positions at the Molecular Scale



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Introduction

The role of carbon (C)-mineral interactions in the long-term accumulation of soil organic matter is increasingly recognized as a key process in terrestrial C cycling.

We hypothesize that differences in mineralogy, as well as the nature of organic matter, as influenced by landscape topography, can result in different types of organic matter-mineral complexes.

In this preliminary study, we examined the structural composition of organic matter and its interaction with soil minerals along a pasture hillslope transect within the Christina River Basin Critical Zone Observatory (CRB-CZO)

Methods

Field Sampling

Soil samples were collected from a pasture hillslope transect within the CRB-CZO. The CRB-CZO is underlain by metamorphosed sedimentary bedrock and is located in the southeastern Piedmont region of Pennsylvania. Soil samples were collected from A and B horizons at the ridge and the base of the hillslope. The same plant species at each site is critical to the study because they minimize the influence of primary organic sources on the chemical variability of organic matter. The soil samples represent well and poorly drained areas.

Approach

Bulk soils were ultrasonically dispersed and the clay fractions were obtained by repeated centrifugation.

C (1s) NEXAFS spectra of the clay samples were collected using a photodiode at the SGM beamline at the Canadian Light Source (CLS) and were recorded from 280 to 310 eV. Four Spectra were averaged for each sample.

Coupled with STXM, NEXAFS images were recorded at different energies below and above the C absorption (1s) edge (284.3 eV) at SM beamline of CLS. The stack measurements for C NEXAFS were done from 280 eV to 310 eV with pixel size of 40 nm. K-edge maps of Al and Si, and L-edge maps of K, Ca, and Fe were obtained over the same areas using the same pixel size that C spectra and maps were collected.

Results: C Distribution and Associations with the Major Elements in Soil Clay Particles

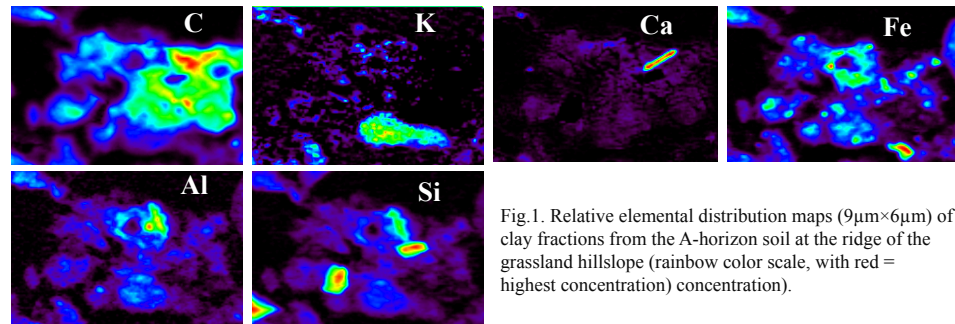


Fig.1. Relative elemental distribution maps (9µm×6µm) of clay fractions from the A-horizon soil at the ridge of the grassland hillslope (rainbow color scale, with red = highest concentration) concentration).

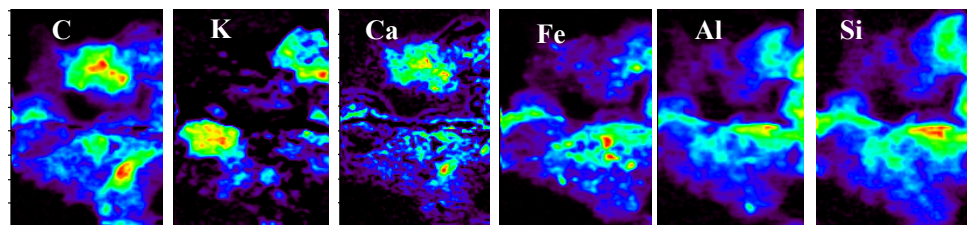


Fig.2. Relative elemental distribution maps (6µm×9µm) of clay fractions from the A-horizon soil at the base of the grassland hillslope (rainbow color scale, with red = highest concentration).

The results show that:

- (1) the elemental distributions are broadly dispersed and there is a locally concentrated distribution of C in the clay fractions.
- (2) the thickness of C coatings on the clay particles is up to 50 nm.
- (3) the regions with highest Si concentration (distinct quartz particles) (Fig. 1) seem to contain no C.
- (4) high C concentrations are located at the regions with low K concentrations but high Ca concentrations

Results: C speciation of clay particles

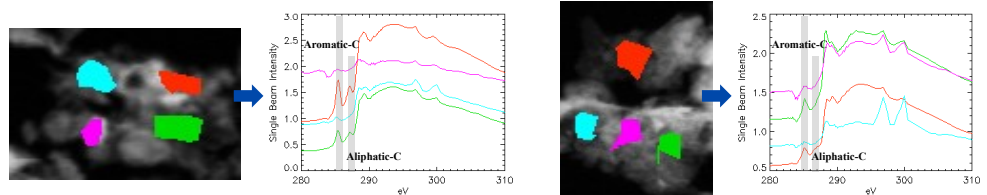


Fig.3. C functional group distribution of clay fractions from the A-horizon soil at the ridge (left) and base (right) of the grassland hillslope.

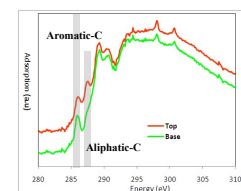


Fig.4. C NEXAFS Spectra of A-horizon clay fractions at the ridge and base of the grassland hillslope.

The results indicate that:

- (1) the more labile aliphatic-C, which was present at the ridge of the hillslope, was not found at the base of the hillslope.
- (2) the more recalcitrant aromatic C was enriched at the base of the hillslope compared to the ridge of the hillslope.
- (3) organic matter (especially aromatic-C and aliphatic-C) exhibited great variability in the clay particles.

Conclusions

Our preliminary results suggest that: (1) the C distribution in the clay particles is related to the distribution of other major elements; and (2) the stability of soil organic matter is greater at the base of the hillslope than at the ridge of the hillslope which could be ascribed to the selective preservation of recalcitrant carbon forms by the soil mineral matrix.

Acknowledgement

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