Does density fractionation of SOC represent chemically different carbon pools?

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Abstract

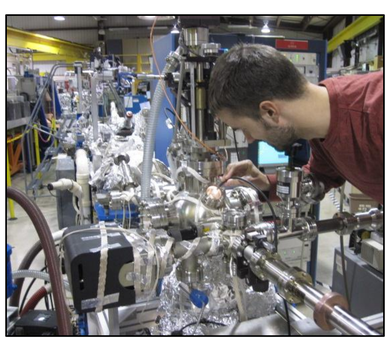
Sometimes, but not often.

Introduction

Many labs employ density fractionation as a proxy for determination of carbon (C) recalcitrance and lability. However, it is unknown if the resulting fractions correspond to chemically stable, and hence recalcitrant, C. It is generally assumed that phenolic compounds are more recalcitrant than *O*-alkyl-C and carboxyl-C moieties (Kleber *et al*., 2011). The objective was to determine if density-based fractionation of SOM represents chemically different C species.

Methods

- Soil samples were taken at 0-5 and 5-10 cm from two sites in Bolivia and two sites in Ecuador (Table 1) in 2010 before implementation of conservation agriculture (CA) treatments.
- The experiments were RCB designs with three replications at each site.
- After sequential density fractionation at <1.8, 1.8-2.0, and >2.0 g cm^{-3}, samples were analyzed for total C&N (dry combustion).
- C k-edge near-edge X-ray absorption fine structure spectroscopy (NEXAFS, Fig. 2) was used to determine the relative proportions of organic functional groups.
- SAS Proc GLIMMIX was used to determine differences among fixed effects at the 95% confidence level unless otherwise stated.



Hermon 33 beamline at the SRC

NEXAFS sample preparation

Table 1. Select characteristics from Bolivia & Ecuador sites

Country	Site	Coordinates	Mean annual ppn (mm)	Mean annual temp (°C)	Elev.(m)	Dom. soil type(s)	Soil texture	Cropping history
Ecuador	Alumbre	S01°55'19.4" W79°01'16.4"	570	11.2-22.2	2600	Andic Haplustolls & Entic Dystrandepts	Loam	Maize-bean, full tillage
Ecuador	Illangama	S01°61' W78°98'	690	8.1-20.0	3371-3665	Troporthents, Cryandepts & Dystrandepts	Loam	Potato-pasture, full tillage
Bolivia	15 de Octubre	S17°26'01.9" W65°43'22.9"	510	10.7	3276	Typic Ustropepts	Loam to clay loam	Potato-bean-cereal-fallow, full tillage
Bolivia	Waylla Purju	S17°27'36.1" W65°39'57.1"	510	9.9	3648	Udic Ustochrepts	Loam	Potato-bean-cereal-fallow, full tillage

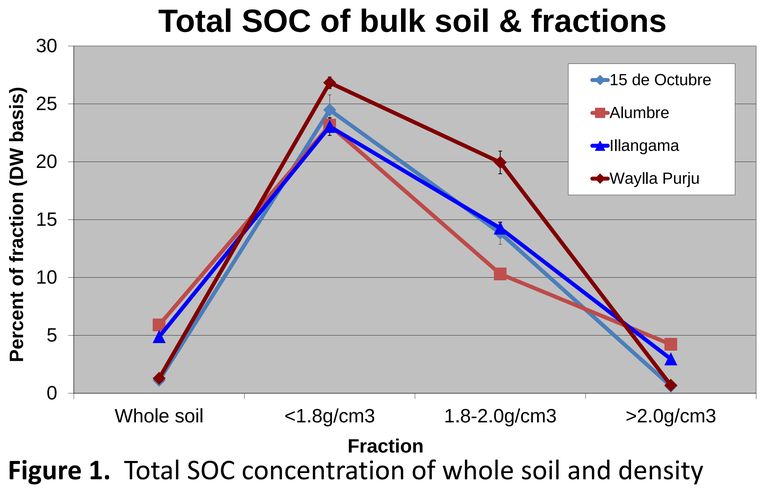


Figure 1. Total SOC concentration of whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means.

Results & Discussion

More than 90% of Bolivian whole soil mass was partitioned into the heavy fraction; in Ecuador, the figure was ≥60%. As particle density increased, C concentration decreased (Fig. 1), a result corroborated elsewhere (Sollins *et al*., 2009). Generally, SOC species did not differ by depth, nor was a depth x fraction interaction significant. Only in Alumbre was there a significant difference by depth for carboxylic-C and aromatic-C. At all sites, total C&N were significantly different by fraction, as were C:N ratios.

More often than not, fractions did not represent different proportions of C species (Fig. 3).

The data are preliminary evidence that density fractionation sometimes, but not often, represents chemically different SOC species. If density fractionation is a measure of C recalcitrance, this may imply that chemical recalcitrance is less important for C sequestration than physical protection. Future work should include determination of C mean residence times and microbial or plant derivation.

References

Kleber *et al*. 2011. Old and stable soil organic matter is not necessarily chemically recalcitrant: implications for modeling concepts and temperature sensitivity. Global Change Biology 17:1097-1107.

Lehmann *et al*. 2009. Biophysico-Chemical Processes Involving Natural Nonliving Organic Matter in Environmental Systems, John Wiley & Sons, Inc. p. 729-781.

Sollins *et al*. 2009. Sequential density fractionation across soils of contrasting mineralogy: evidence for both microbial- and mineral-controlled soil organic matter stabilization. Biogeochemistry 96:209-231.

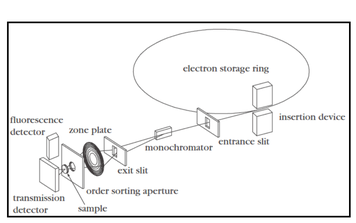


Figure 2. Schematic of NEXAFS beamline. (Adapted from Lehmann *et al*., 2009.)

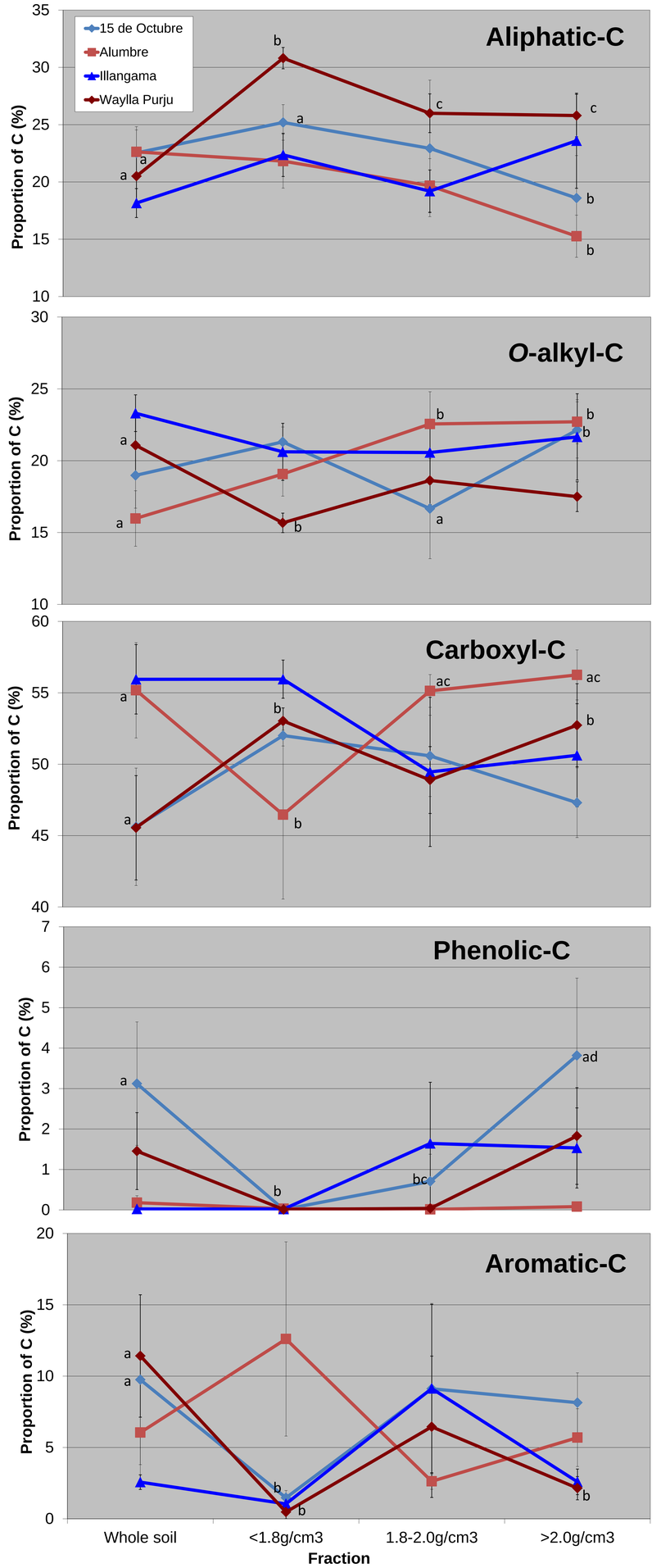


Figure 3. Proportions of C species present in whole soil and density fractions in Bolivia and Ecuador soils. Error bars represent standard errors of the means. Within a site, different letters signify significantly different fractions at $p<0.10$. All other fraction comparisons within a site are not different.