Soil Organic Matter Characterization in Bolivia and Ecuador

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Introduction

- Conservation agriculture (CA)
  - 13 countries, 5 yrs
- Short-term indicators of soil fertility needed
- Carbon = common indicator
- Fractionation of labile vs. recalcitrant C
- C sequestration: Is all carbon the same?
- Chemical & physical protection

Does fractionation result in chemically different C pools?

- Fractionation methods
  - Density
  - Size-based
  - Empirical models
- Assumed C stability:
  - Phenols ≥ aromatics > aliphatic > carbonyl > O-alkyl

Objective

- To characterize and quantify SOM from Bolivia and Ecuador sites before (and after) CA implementation.

Hypothesis

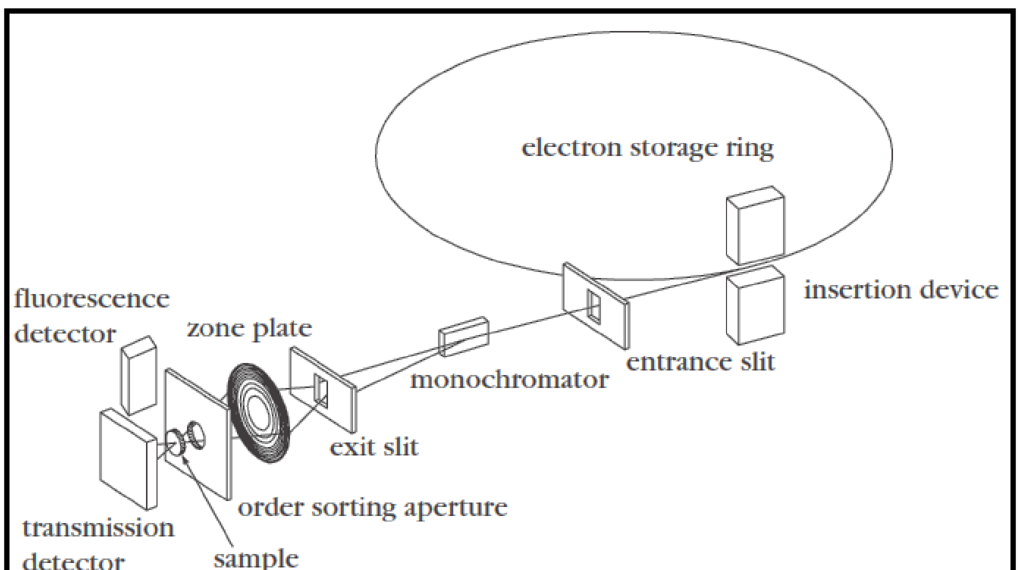
- Denser fractions have more recalcitrant C.

Methods

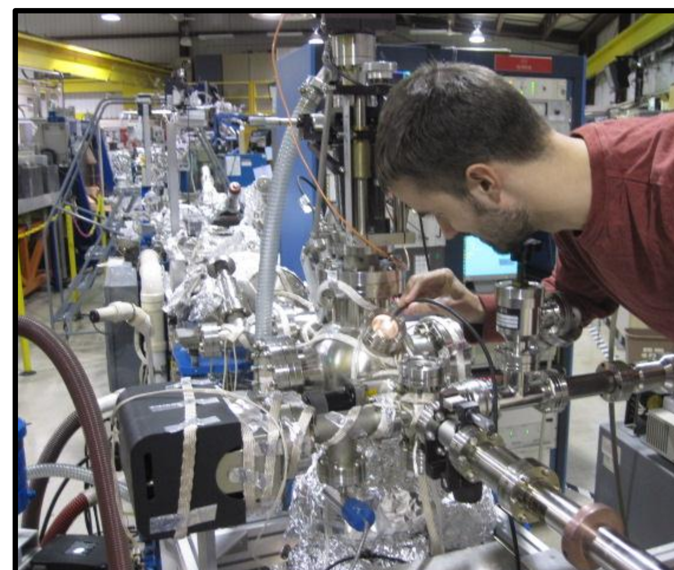
- 4 sites in 2 countries
- RCB with 3 reps at each site
- Time 0 = 2010
- 0-5, 5-10 cm depths
- SAS Proc GLIMMIX
- 90% confidence level for treatments comparisons

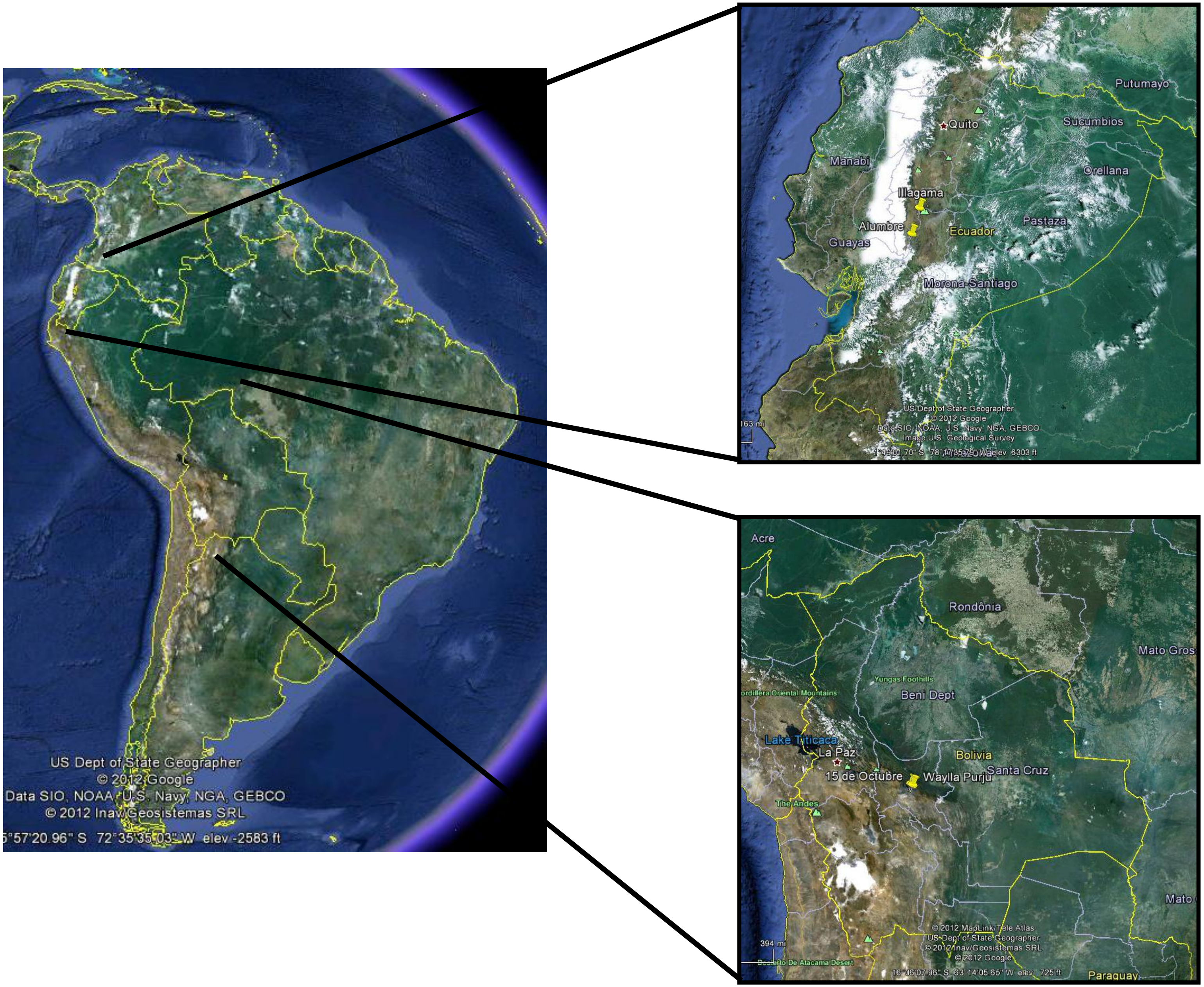
Methods

- Density fractionation
  - SPT, <1.8, 1.8-2.0, >2.0 g cm^{-3}
- C speciation
  - C near-edge X-ray absorption fine structure spectroscopy (NEXAFS)



Lehmann *et al*. 2009.





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5°57'20.96" S 72°35'35.03" W elev -2583 ft
Putumayo
Quito
Sucumbios
Manabi
Orellana
Illagama
Alumbre
Ecuador
Pastaza
Guayas
Morona-Santiago
US Dept of State Geographer
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Acre
Rondônia
Mato Gros
Yungas Foothills
Beni Dept
Cordillera Oriental Mountains
Lake Titicaca
La Paz
Bolivia
Santa Cruz
15 de Octubre
Waylla Purju
The Andes
Mato
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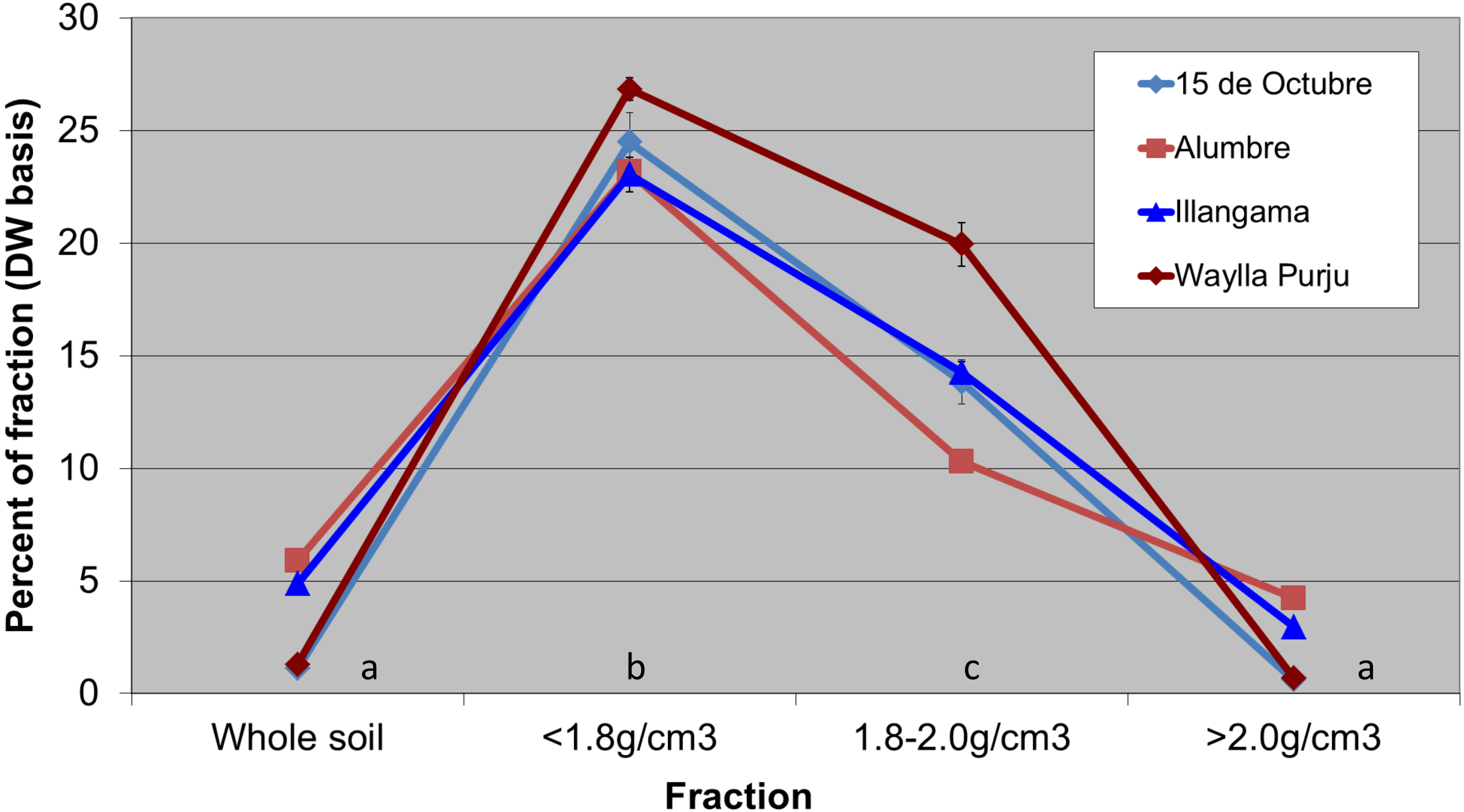
Desierto De Atacama Desert
Paraguay

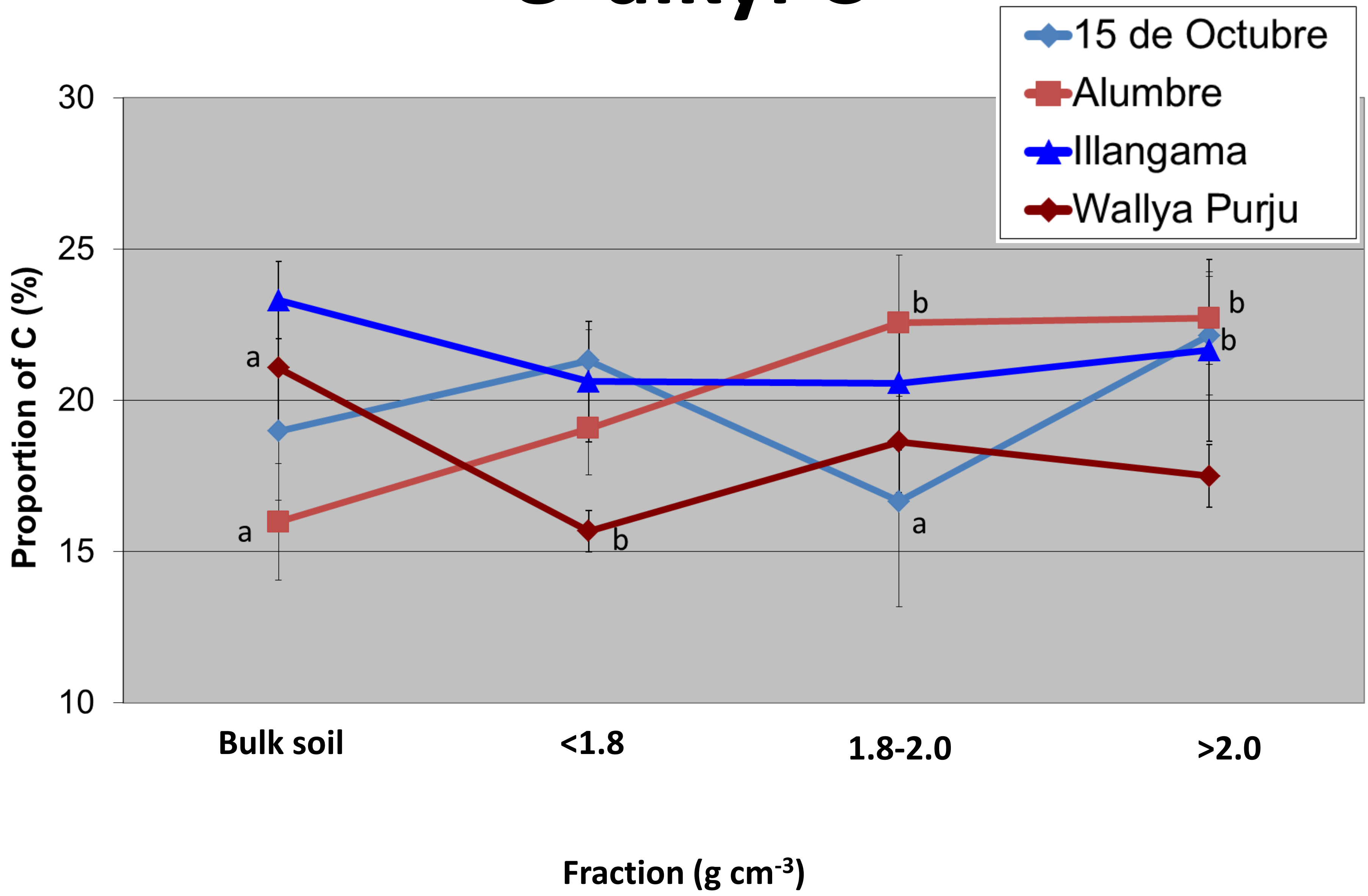
Select site characteristics

Country	Ecuador	Ecuador	Bolivia	Bolivia
Site	**Alumbre**	**Illangama**	**15 de Octubre**	**Waylla Purju**
Annual ppn (mm)	570	690	510	510
Mean annual temp (°C)	11.2-22.2	8.1-20.0	10.7	9.9
Elev.(m)	2600	3371-3665	3276	3648
Dom. soil type(s)	Andic Haplustolls & Entic Dystrandepts	Troporthents, Cryandepts & Dystrandepts	Typic Ustropepts	Udic Ustochrepts
Soil texture	Loam	Loam	Loam to clay loam	Loam
pH (1:1)	5.86 (0.06)	6.64 (0.29)	5.85 (0.16)	5.63 (0.31)
P (ppm, mean (SD))	2.15 (0.64)	3.24 (1.20)	44.6 (23.8)	17.29 (2.91)
CEC (meg/100g)	13.7 (1.1)	13.7(0.9)	6.2 (1.4)	4.4 (0.3)
Cropping history	Maize-bean, full tillage	Potato-pasture, full tillage	Potato-bean-cereal-fallow, full tillage	Potato-bean-cereal-fallow, full tillage

Total Organic Carbon

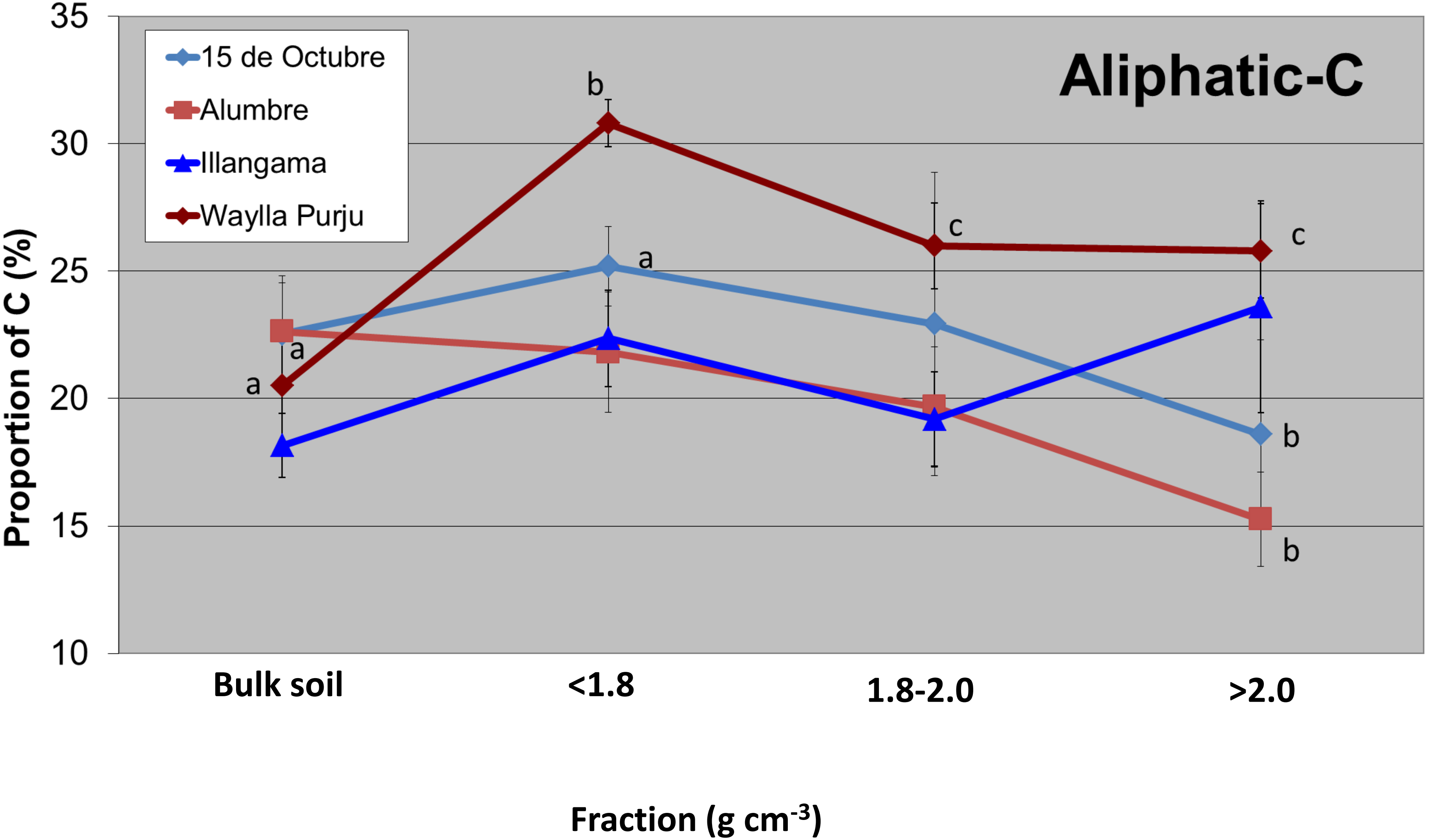


O-alkyl C



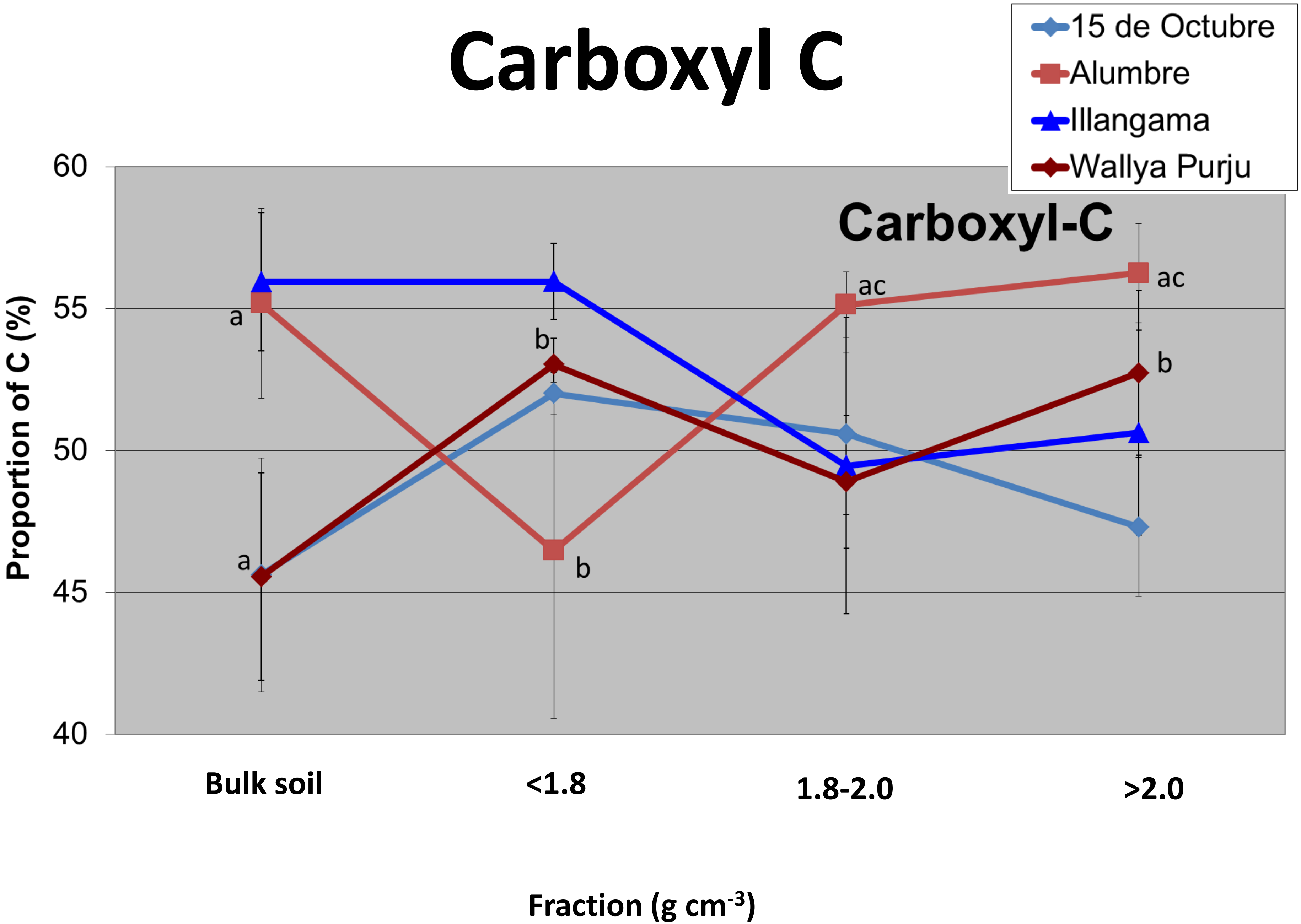
15 de Octubre
Alumbre
Illangama
Wallya Purju
30
25
20
15
10
Proportion of C (%)
a
a
b
b
a
b
b
Bulk soil
<1.8
1.8-2.0
>2.0
Fraction (g cm-3)

Aliphatic C



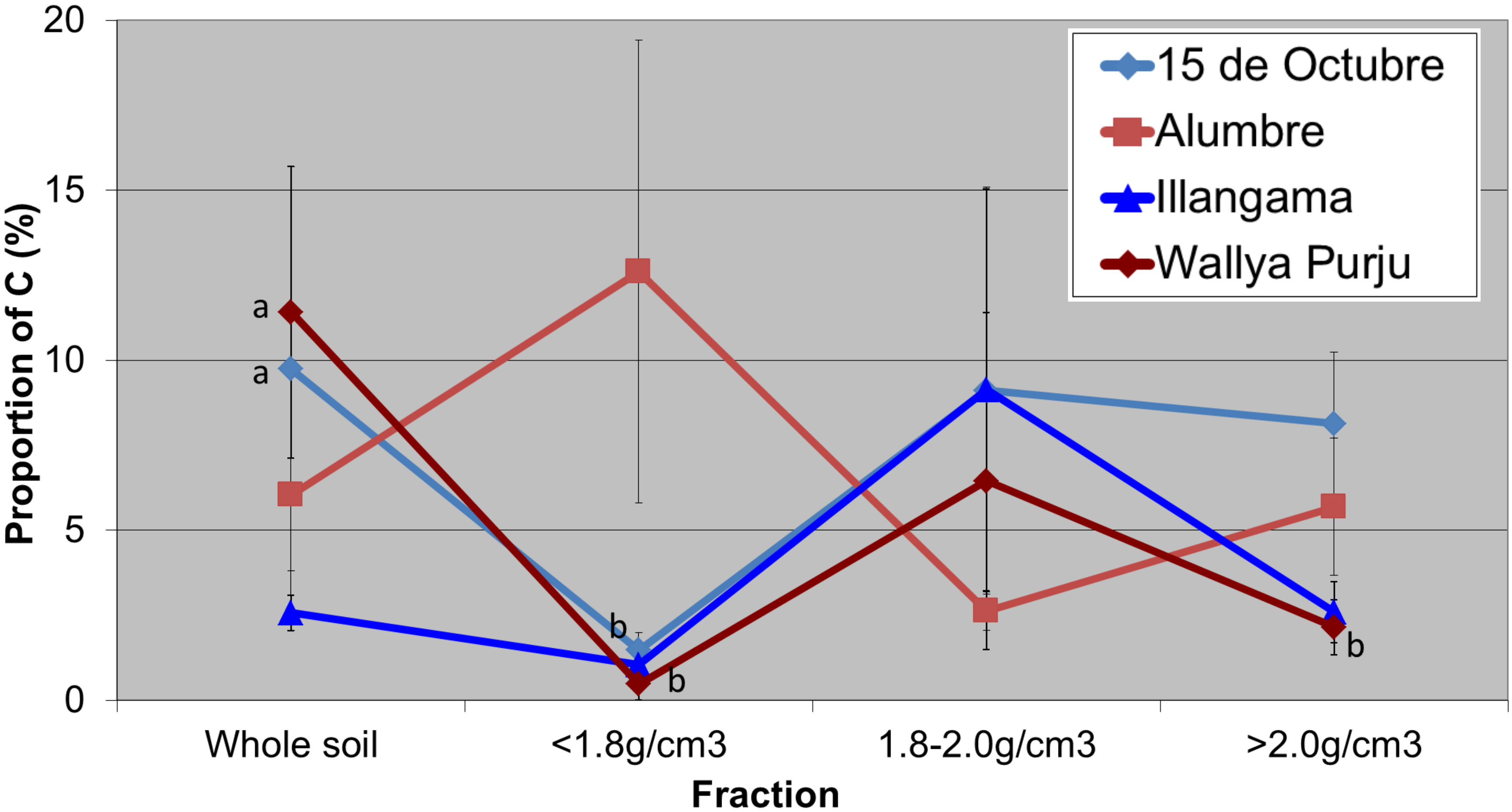
Aliphatic-C
15 de Octubre
Alumbre
Illangama
Waylla Purju
Proportion of C (%)
35
30
25
20
15
10
Bulk soil
<1.8
1.8-2.0
>2.0
Fraction (g cm-3)
a
a
b
a
c
c
b
b

Carboxyl C



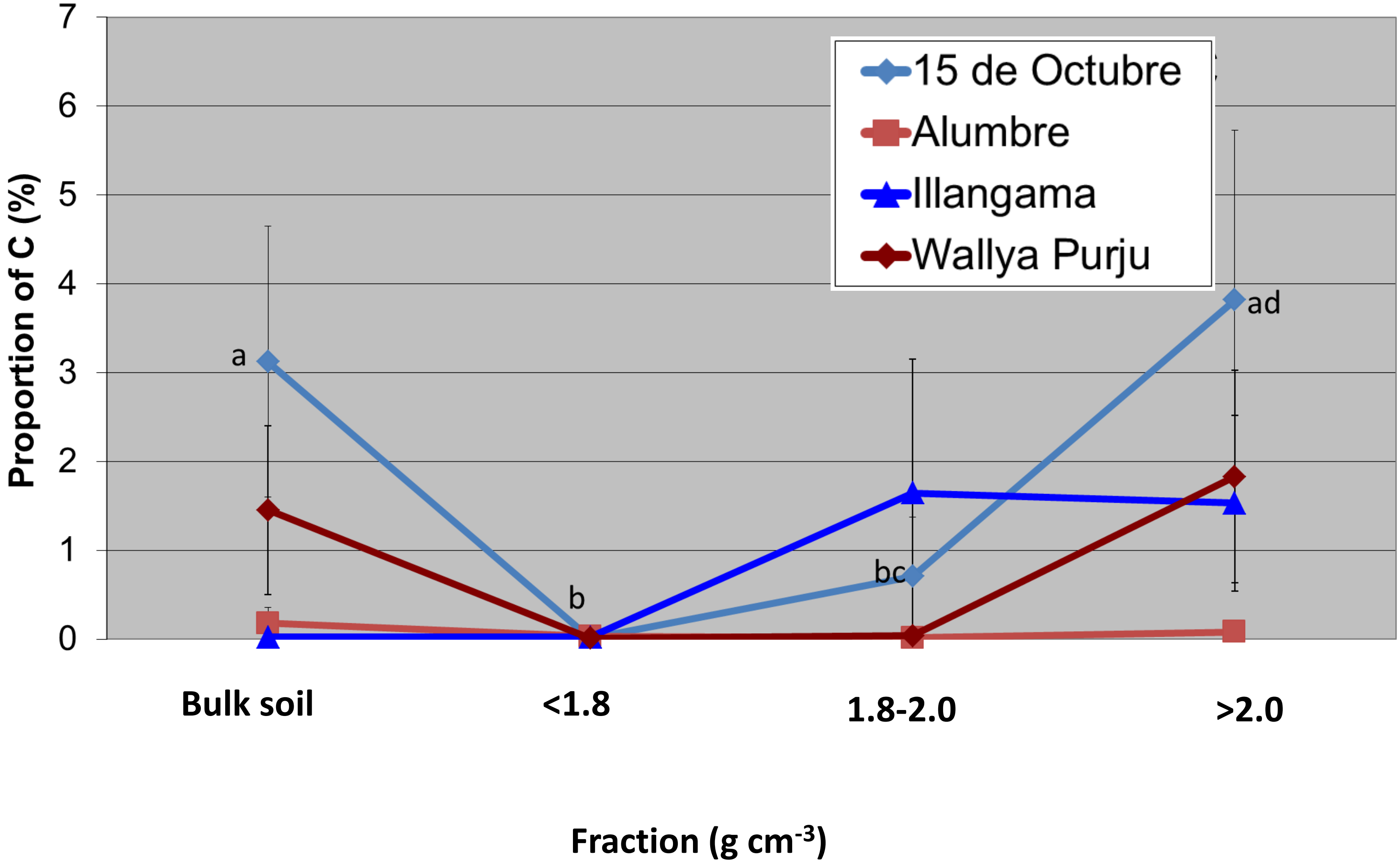
15 de Octubre
Alumbre
Illangama
Wallya Purju
Carboxyl-C
60
55
50
45
40
Proportion of C (%)
a
a
b
b
ac
ac
b
Bulk soil
<1.8
1.8-2.0
>2.0
Fraction (g cm-3)

Aromatic C



20
15
10
5
0
Proportion of C (%)
15 de Octubre
Alumbre
Illangama
Wallya Purju
a
a
b
b
b
Whole soil
<1.8g/cm3
1.8-2.0g/cm3
>2.0g/cm3
Fraction

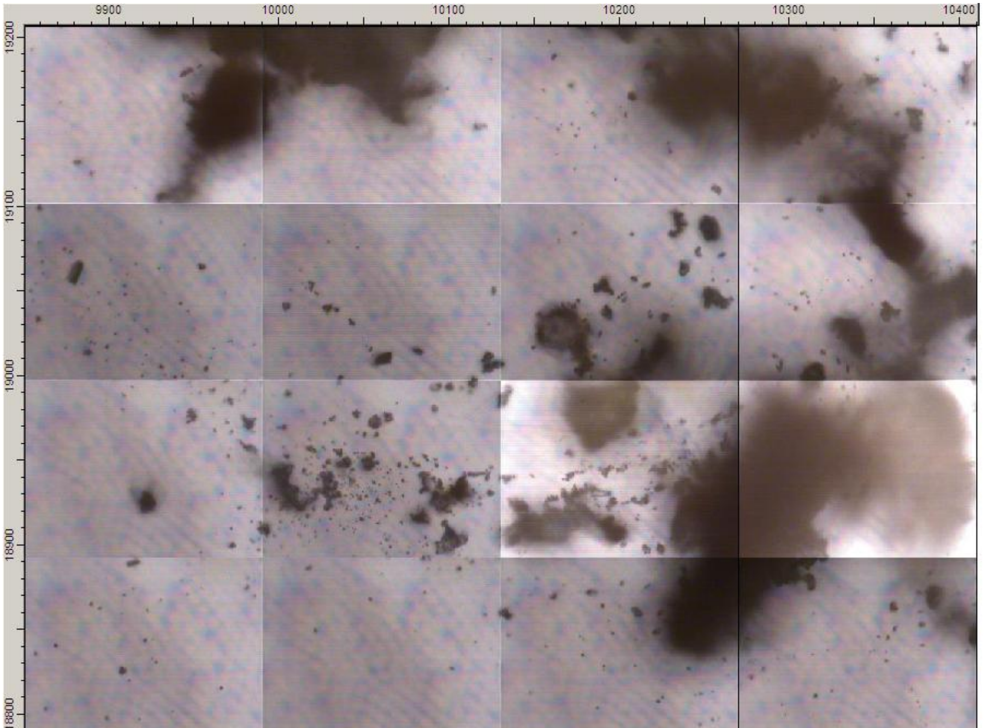
Phenolic C

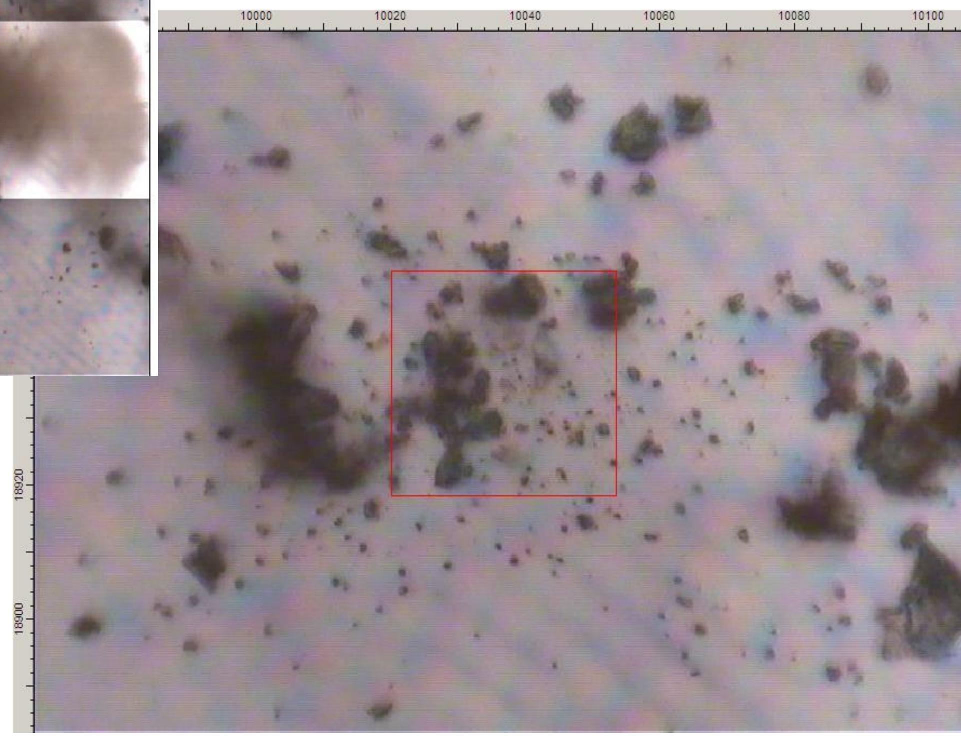


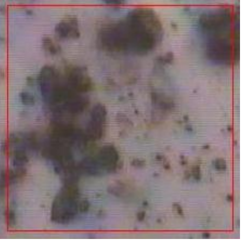
7
6
5
4
3
2
1
0
Proportion of C (%)
15 de Octubre
Alumbre
Illangama
Wallya Purju
a
b
bc
ad
Bulk soil
<1.8
1.8-2.0
>2.0
Fraction (g cm-3)

Infrared Environmental Imaging (IRENI)

- Carol Hirschmugl, SRC
- Scan 30x30 µm area
- 1 µm^2 IR spectra

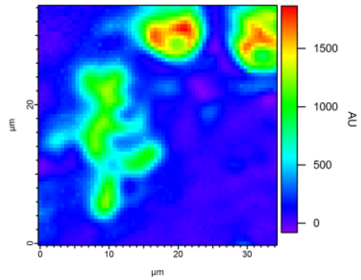




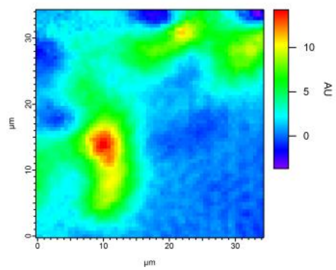


Bolivia, 0-5 cm, >2.0 g cm^{-3}

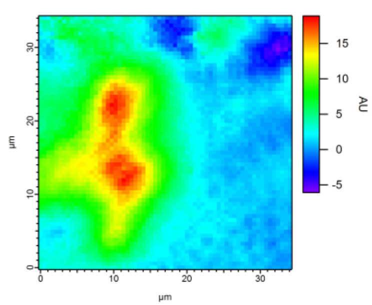
chemigram



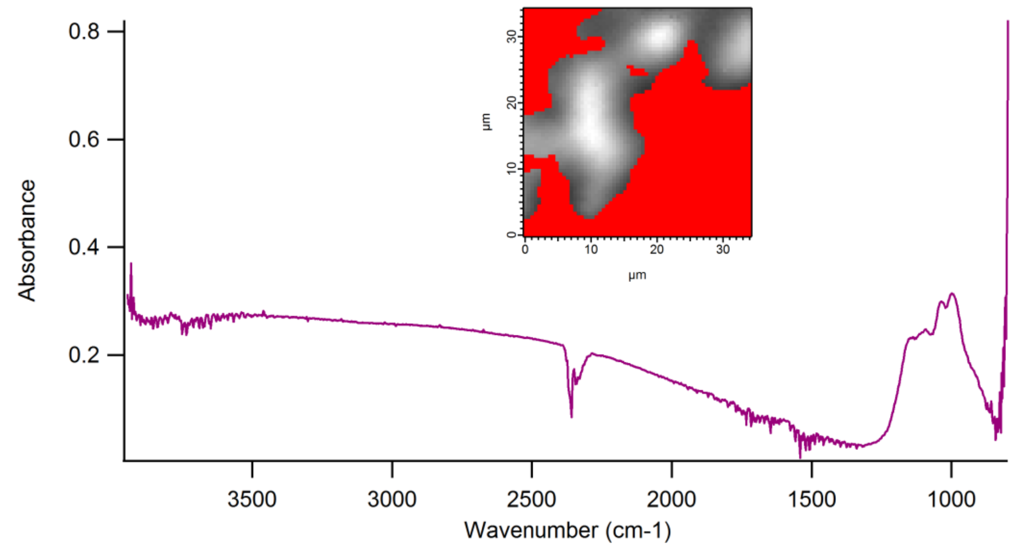
Integration over 1086-1223cm-1

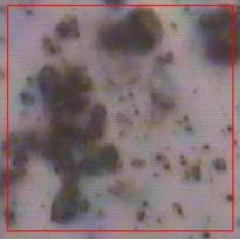


Integration over 943-1086cm-1



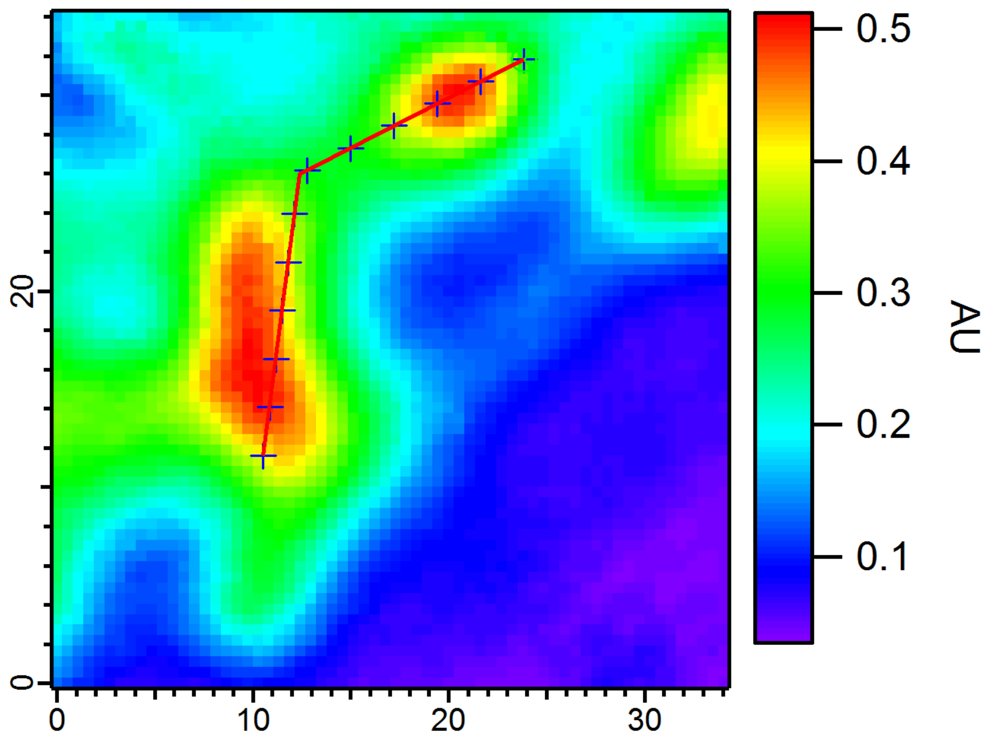
Avg spectrum with mask

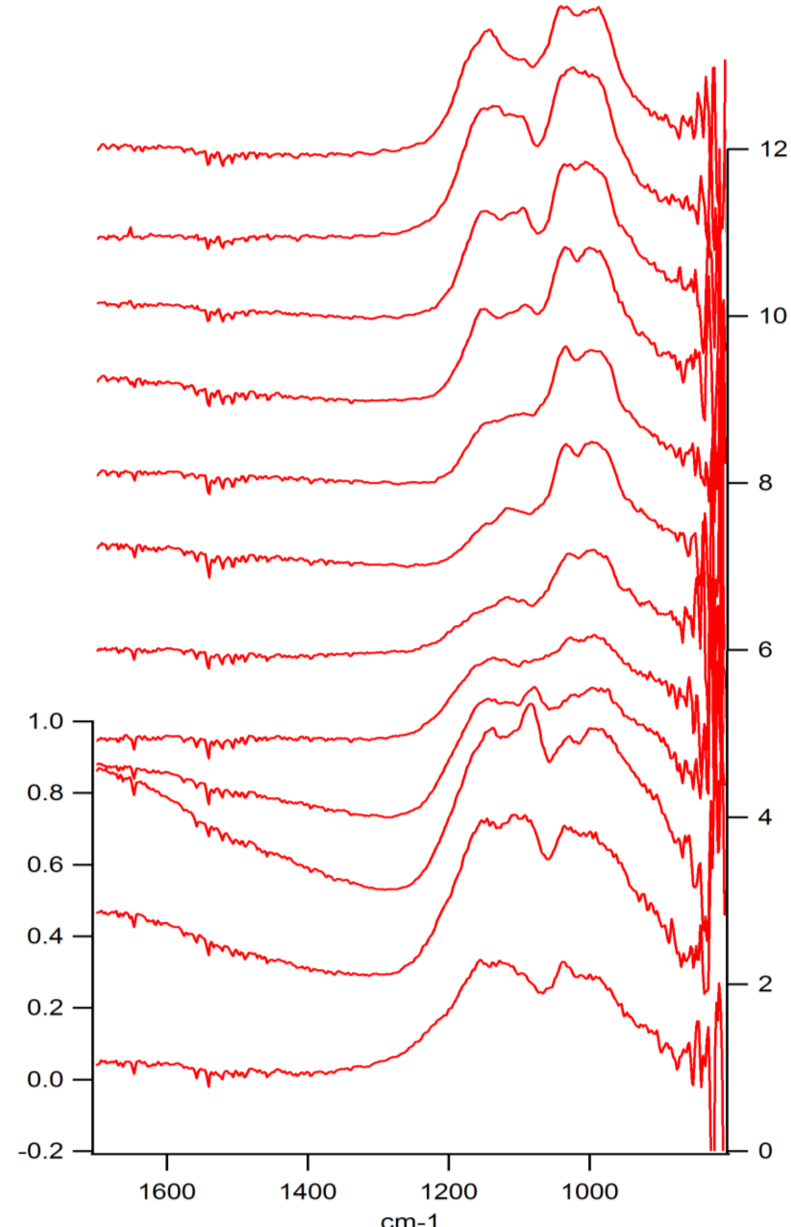




Bolivia, 0-5 cm, >2.0 g cm^{-3}

Section @ 1027cm-1 with line





Conclusions

- The SOM at these sites is structural SOM
  - High SOC recovery in fractions = low DOM
- Does density fractionation represent chemically different carbon pools?
  - Sometimes, but not often
- Majority of C is carboxyl
  - Relatively chemically reactive sites

Conclusions

- Structural, stable OM may not be chemically recalcitrant
- If so, then:

1. Density fractionation may not be a good indicator of chemical recalcitrance.
2. Chemical recalcitrance may not be as important as physical protection.

Future work

- MRTs of fractions
- Compare how CA affects the chemical nature of SOM
- Determination of microbial- or plant-derived OM?
- Where does chemically stable C reside in size-based fractions?

Thank you.