

National CZO
Program

Christina River Basin Critical Zone Observatory

CZO National Meeting, Arizona, May 2011

Distribution and Speciation of Soil Organic Carbon along Hillslope Transects: Importance of Fe-Redox Cycling

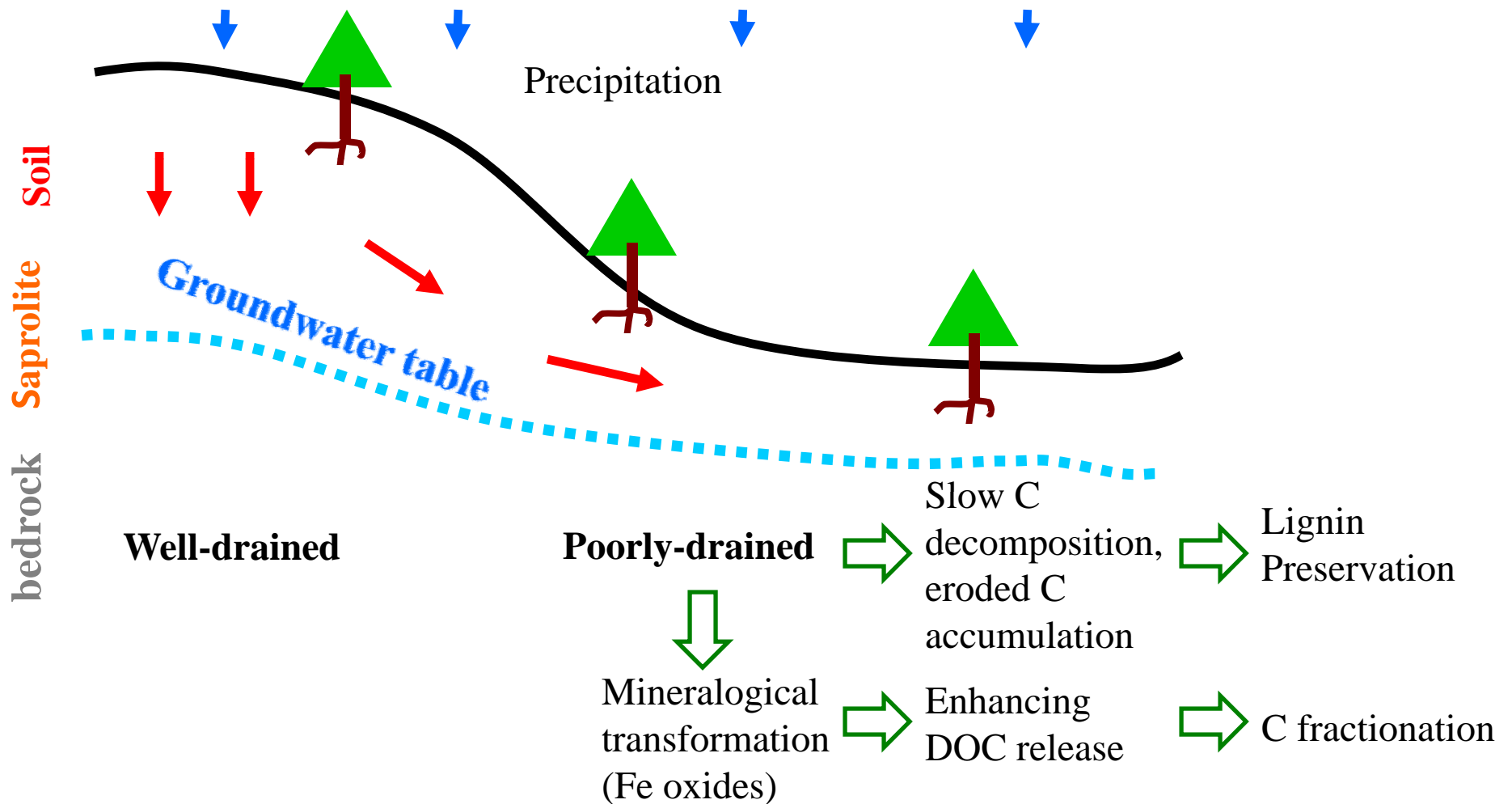
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Anthony K. Aufdenkampe, Donald L. Sparks



Introduction

Organic matter-mineral interaction:

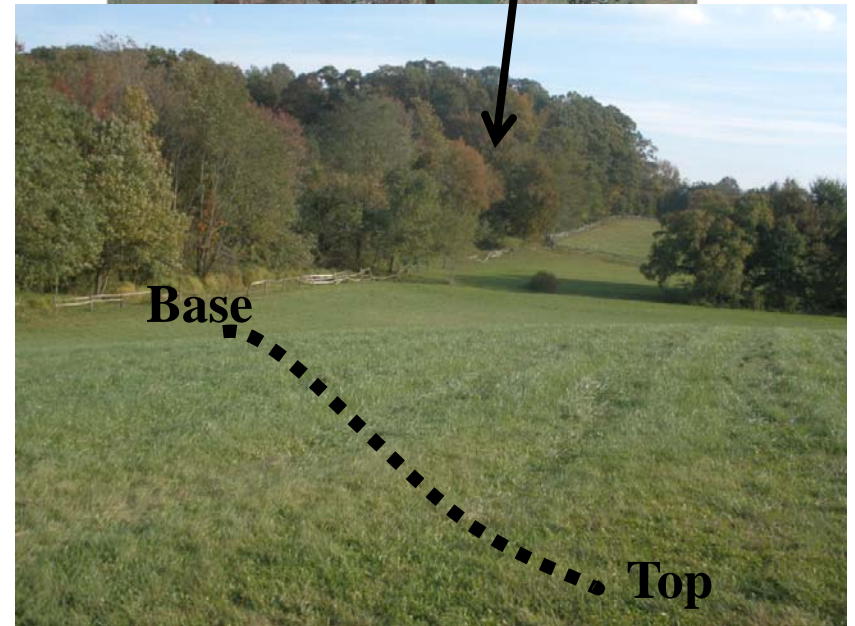
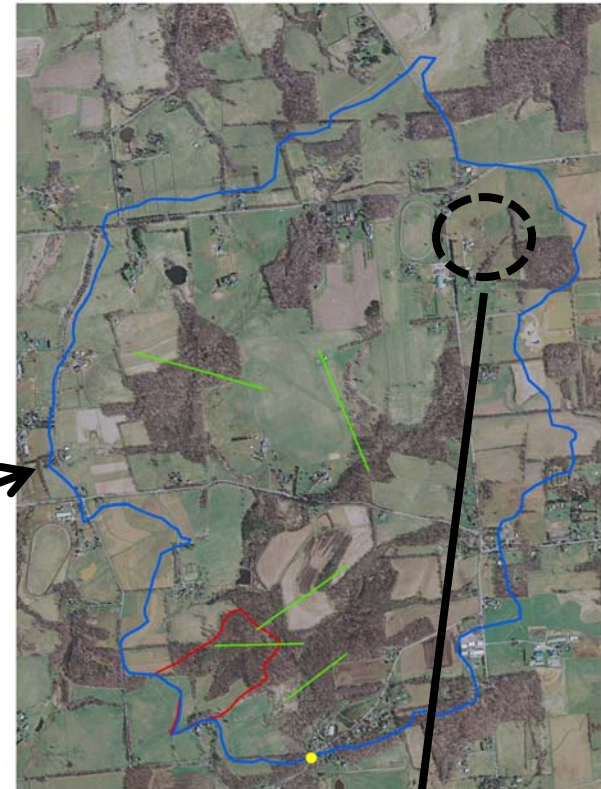
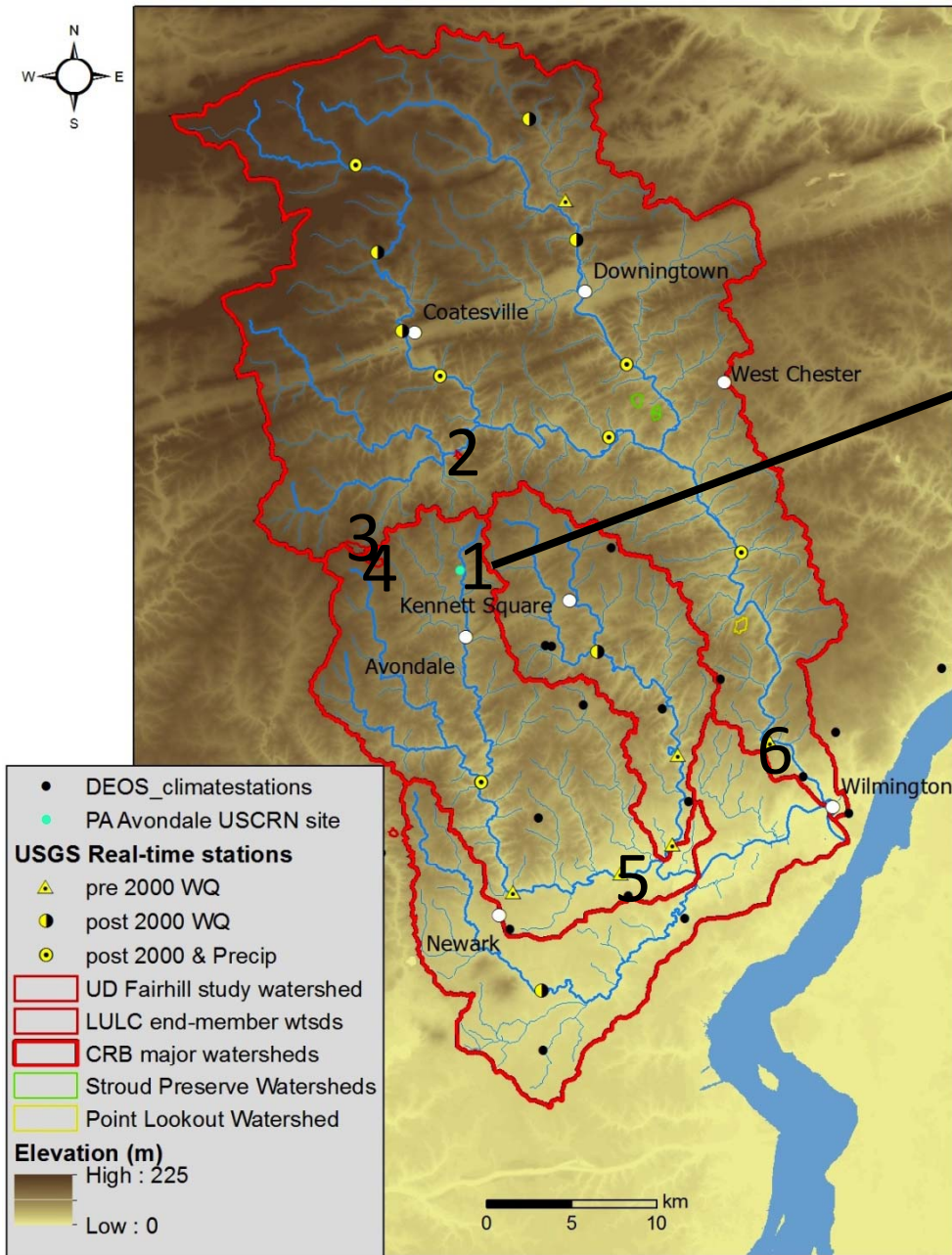
- One of major mechanisms for C stabilization
- Impacted by coupled geomorphological, hydrological & microbial processes



Objectives

- **Investigate soil organic matter molecular composition at varying landscape topographic positions**
- **Assess interactions of C with specific soil minerals at the molecular scale**
- **Determine Fe speciation of soils along redox gradients**

Field Site

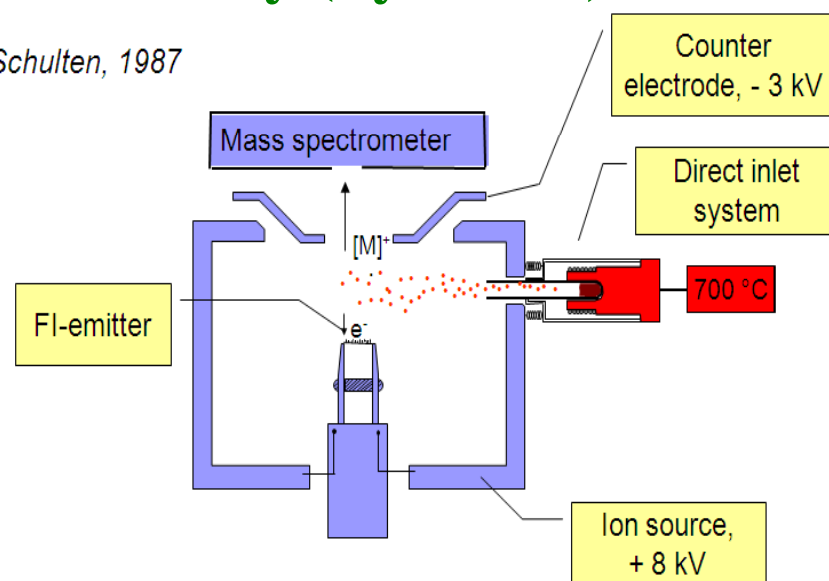


Advanced Characterization

Pyrolysis-Field Ionization Mass Spectrometry (Py-FIMS)

- Soft ionization enables detection of non-fragmented molecules which can be assigned to compound classes and reflect composition of original sample.
- Temperature-resolved pyrolysis indicates thermal stability of compounds, reflects biological stability.

H.-R. Schulten, 1987



Near-edge X-ray Absorption Fine Structure (NEXAFS)

- Characterize C functional groups of soil organic matter without any pretreatment.

Scanning Transmission X-ray Microscopy (STXM) -NEXAFS

- Map distribution of C and C forms and the major elements (K, Ca, Fe, Al, Si) in soils at nanometer scale.
- Assess the interactive mechanisms of C with specific soil minerals.

Soil Properties

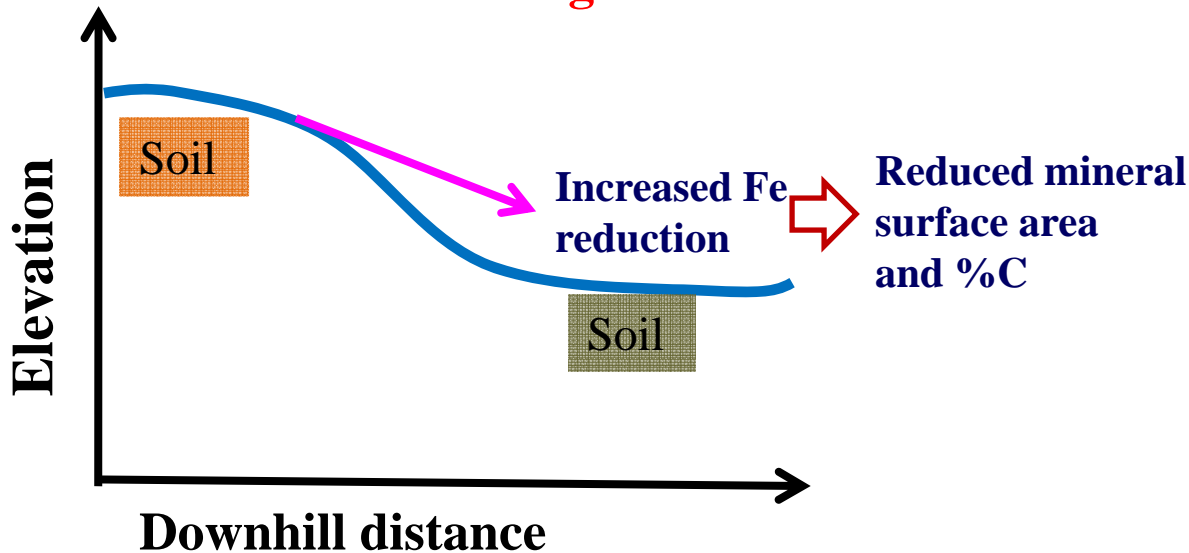
Depth (cm)	Amorphous Fe oxides (g kg ⁻¹)		Crystalline Fe oxides (g kg ⁻¹)		Clay content (%)	
	Top	Base	Top	Base	Top	Base
0-15	3.91	3.00	5.47	3.84	16%	22%
15-25	4.14	3.92	7.20	3.43	22%	25%

Reduction of Fe oxides occurred at the base of the hillslope.

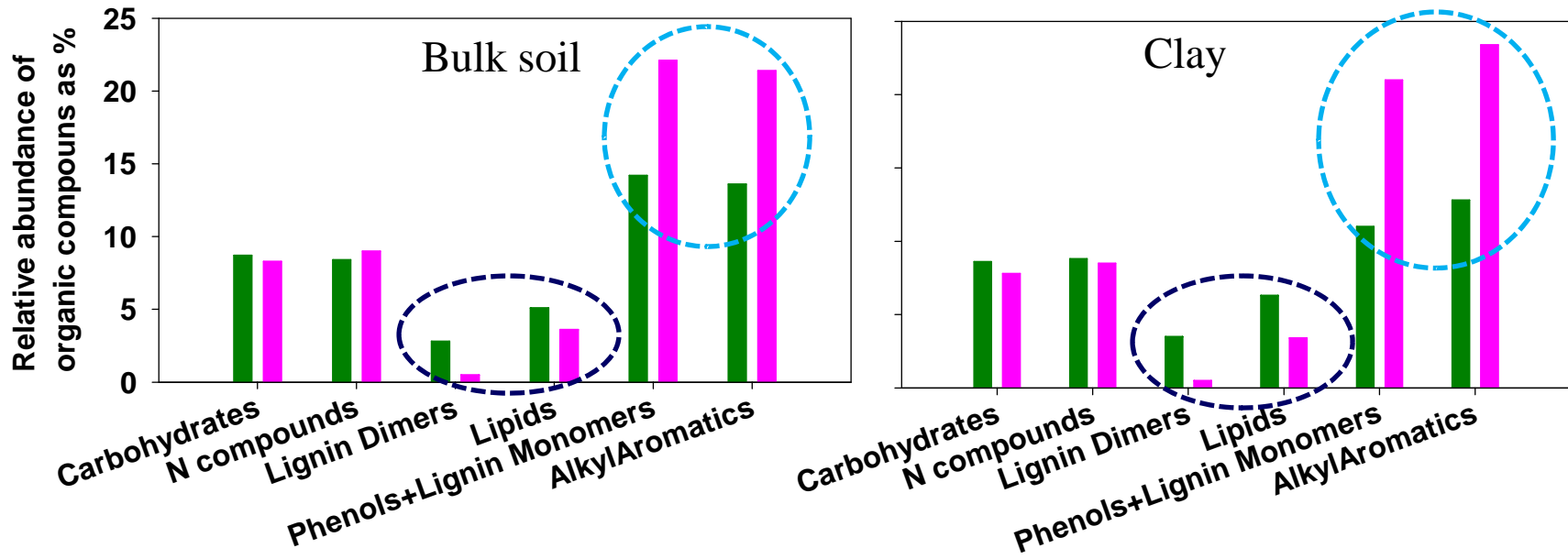
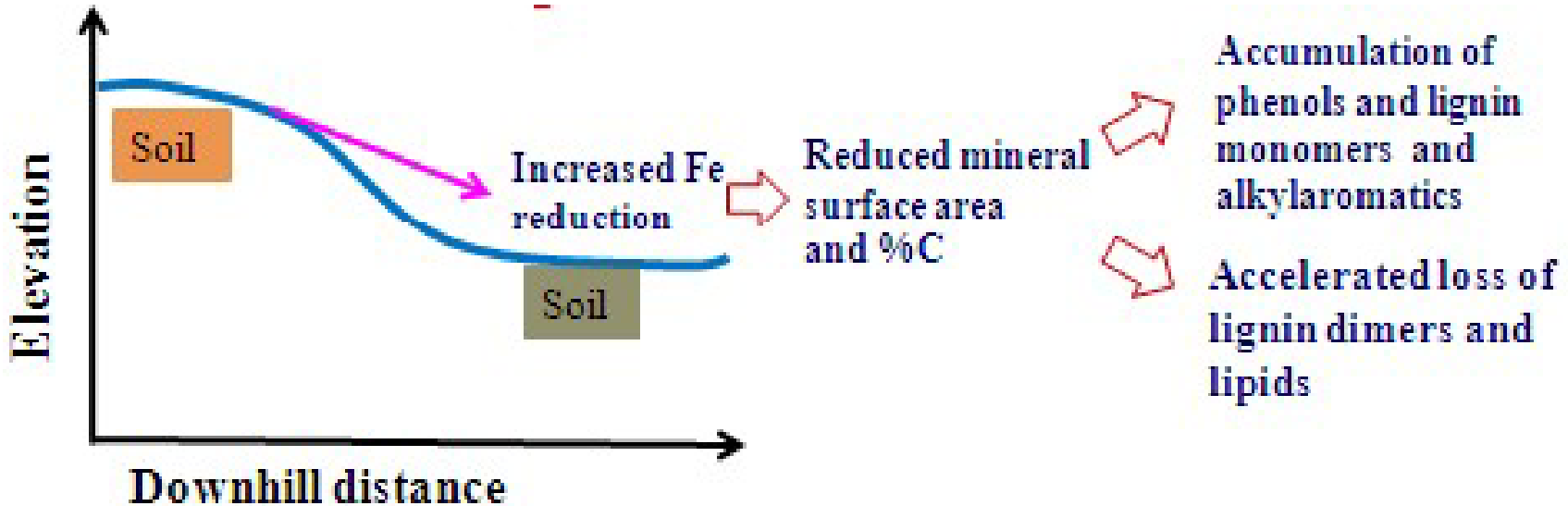
Carbon and Soil Mineral Surface Area

Depth (cm)	Fraction	% C		Mineral surface area (m ² g ⁻¹)		C loading (C/mineral surface area) (mg m ⁻²)	
		Top	Base	Top	Base	Top	Base
0-15cm	Bulk soil	3.06	2.76	14.52	11.52	2.11	2.46
	clay	7.26	6.87	70.79	53.22	1.02	1.29
15-25 cm	Bulk soil	1.75	0.52	19.41	10.44	0.90	0.50
	clay	4.91	1.33	72.23	50.40	0.68	0.26

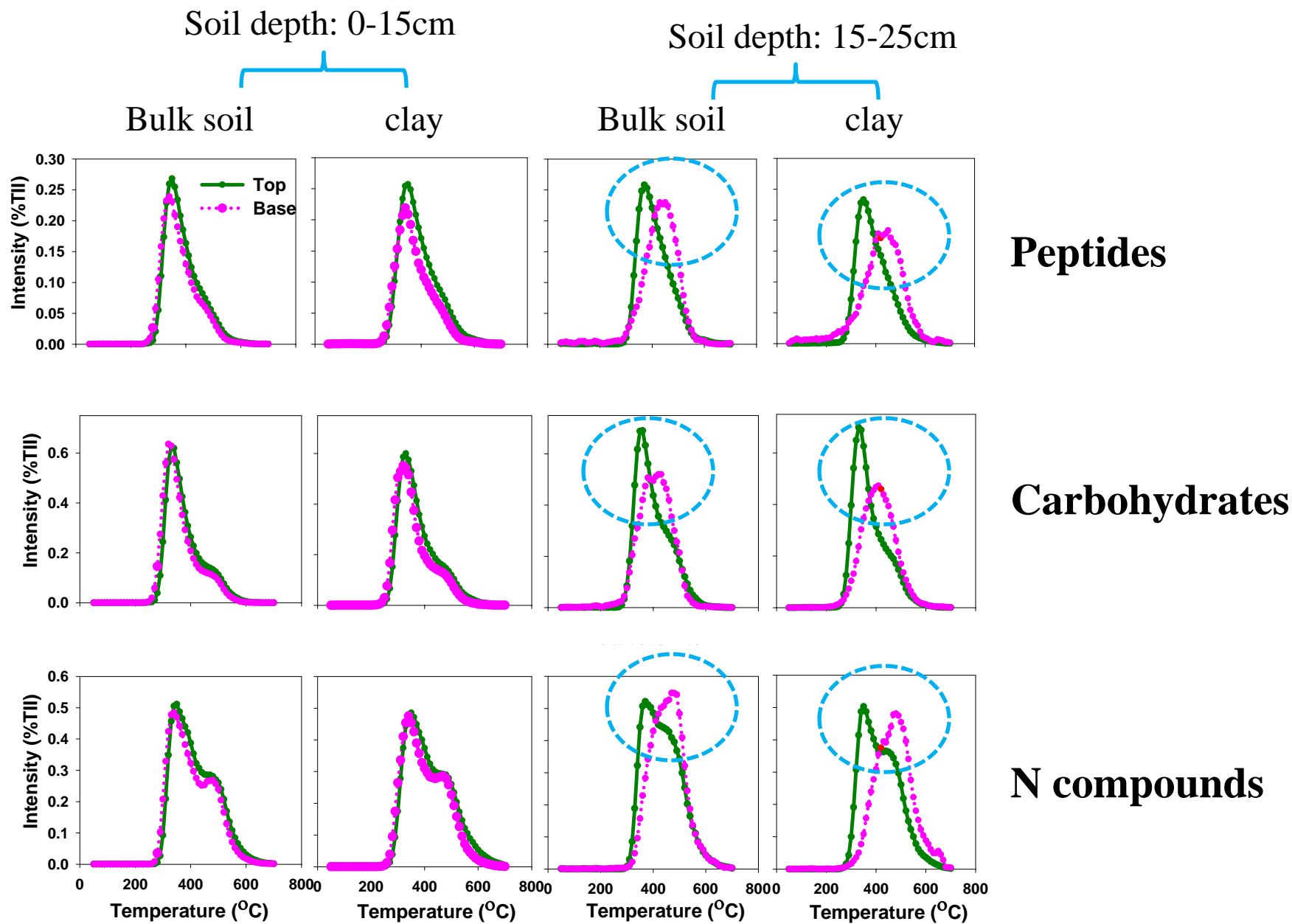
Lower C concentration at the base of the hillslope is likely due to enhanced DOC leaching as a result of reduction of Fe oxides.



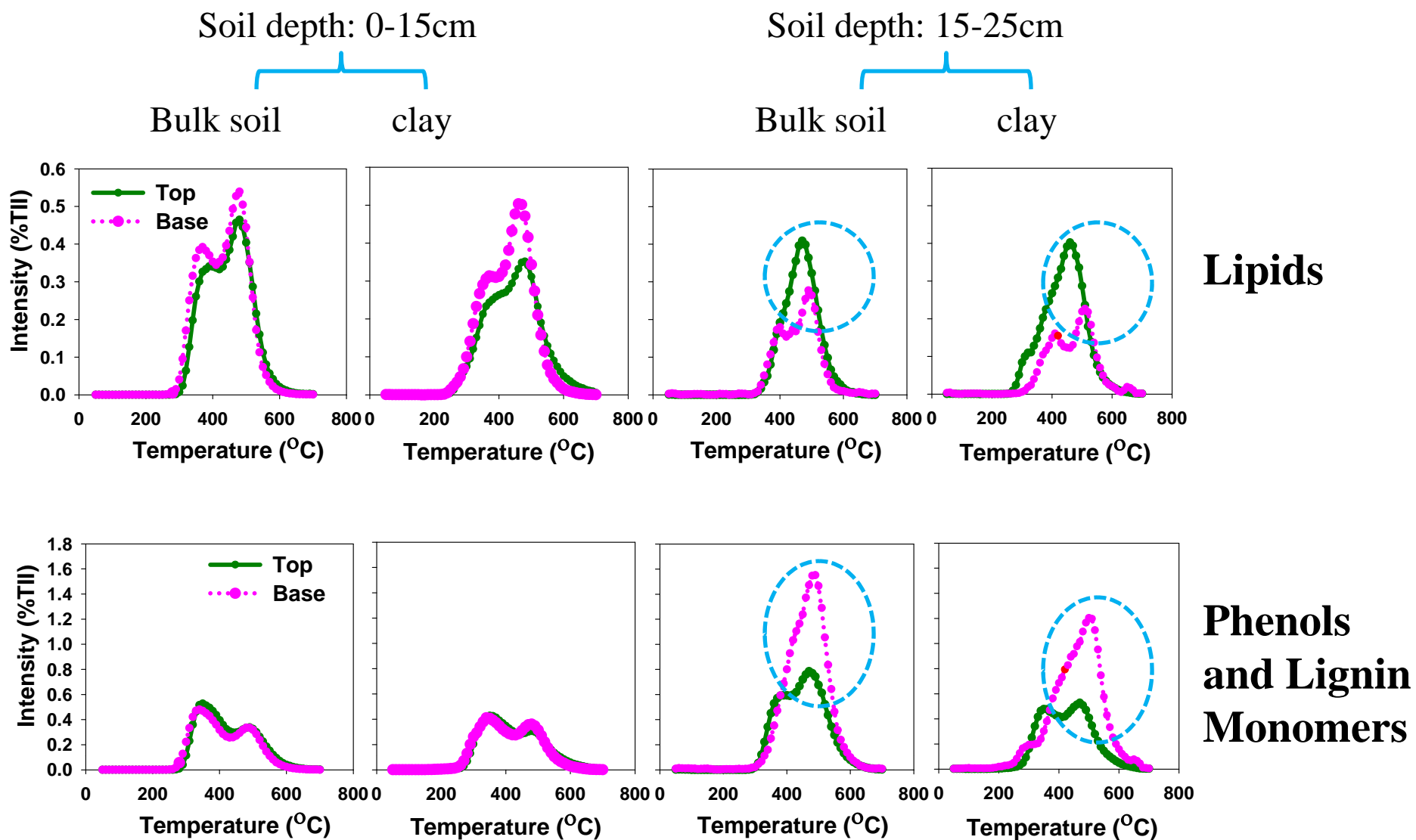
OM compound classes from Py-FIMS



Volatilization Temperatures by Py-FIMS

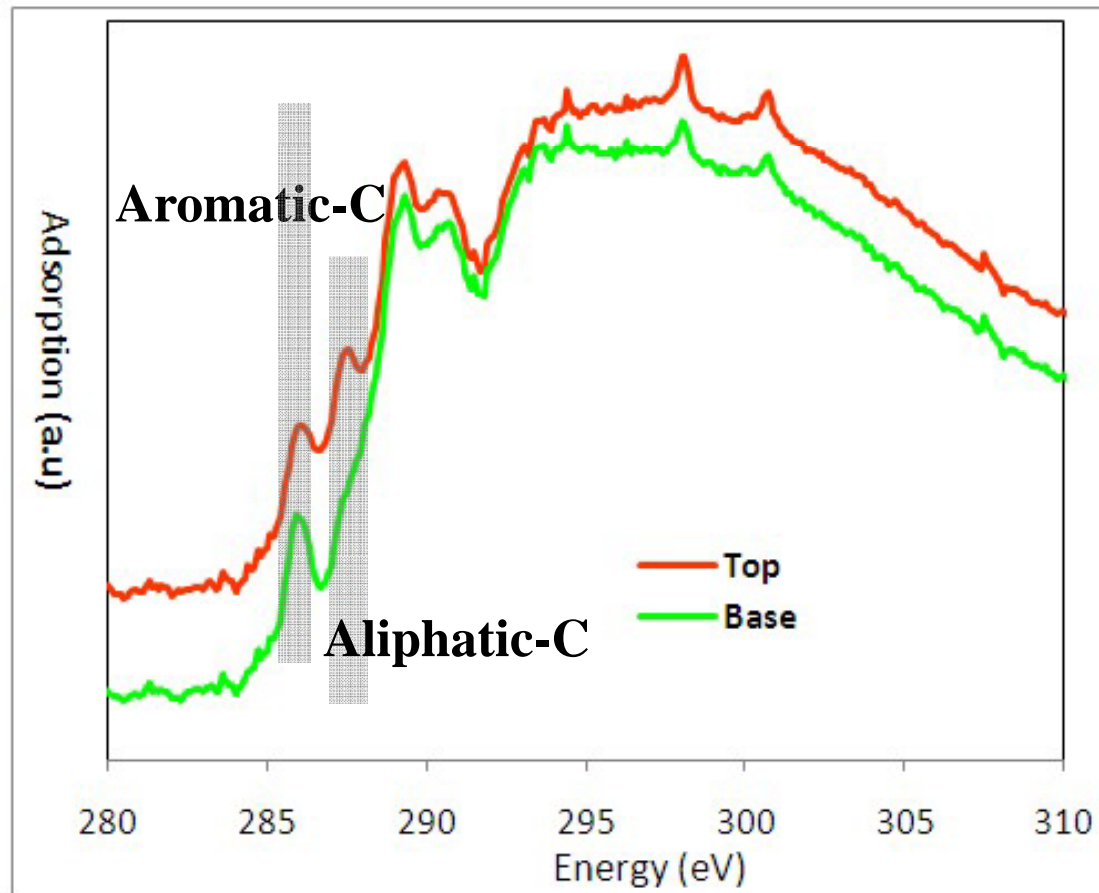


Volatilization Temperatures by Py-FIMS



C NEXAFS spectra of clay fractions

Soil depth: 0-15 cm



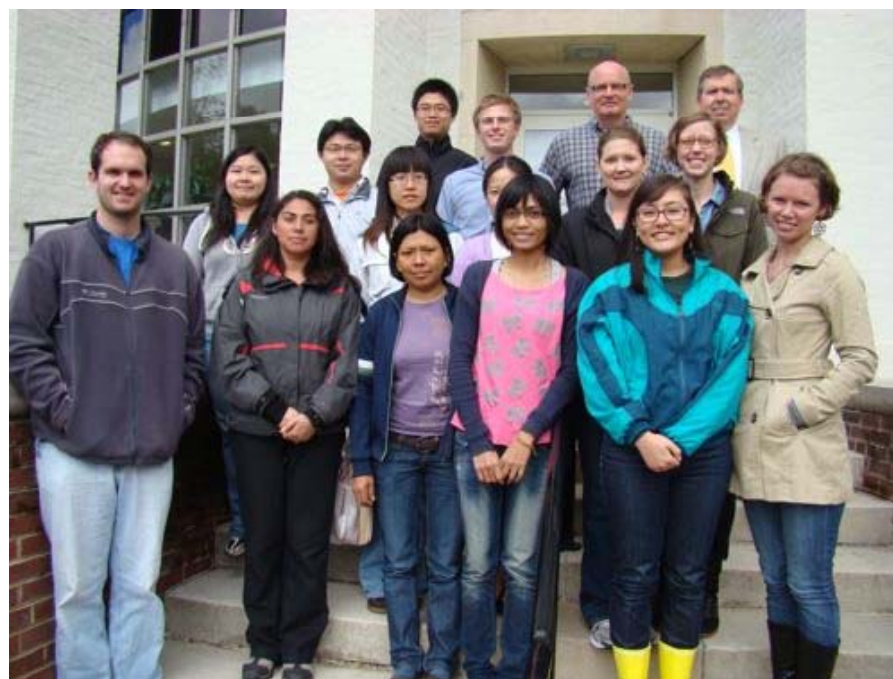
Hill base soil: enriched in aromatic C
depleted in aliphatic C

Conclusions

- C concentration and speciation along the pasture hillslope transect are linked to redox cycling of Fe oxides.
- The stability of soil organic carbon is related to carbon content and/or the normalized carbon content by mineral surface area.

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National Science Foundation
WHERE DISCOVERIES BEGIN