

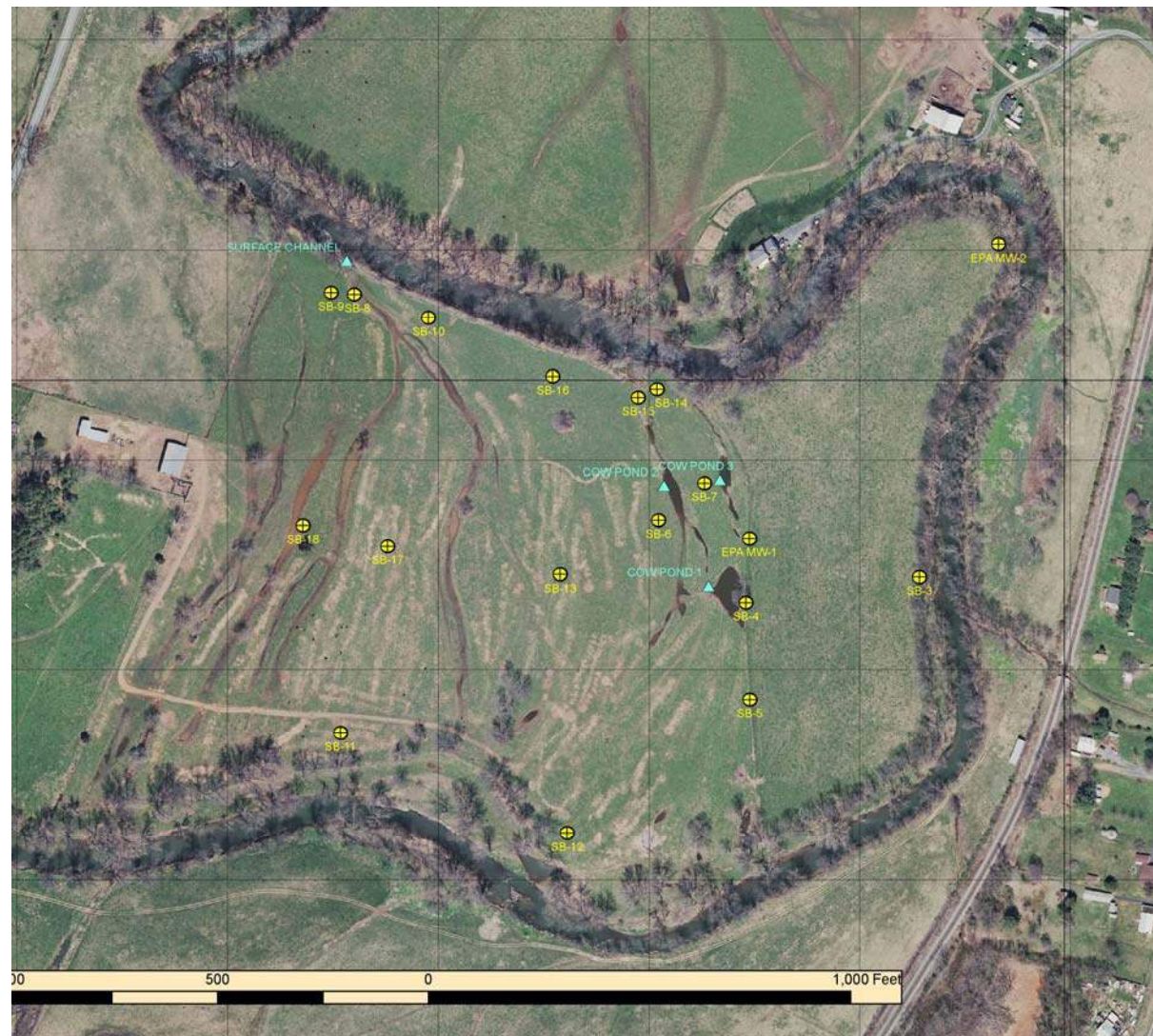
Shifflet Farm – Soil & Groundwater Results, Part II

Mark Chappell, US Army Corps of Engineers, Vicksburg, MS

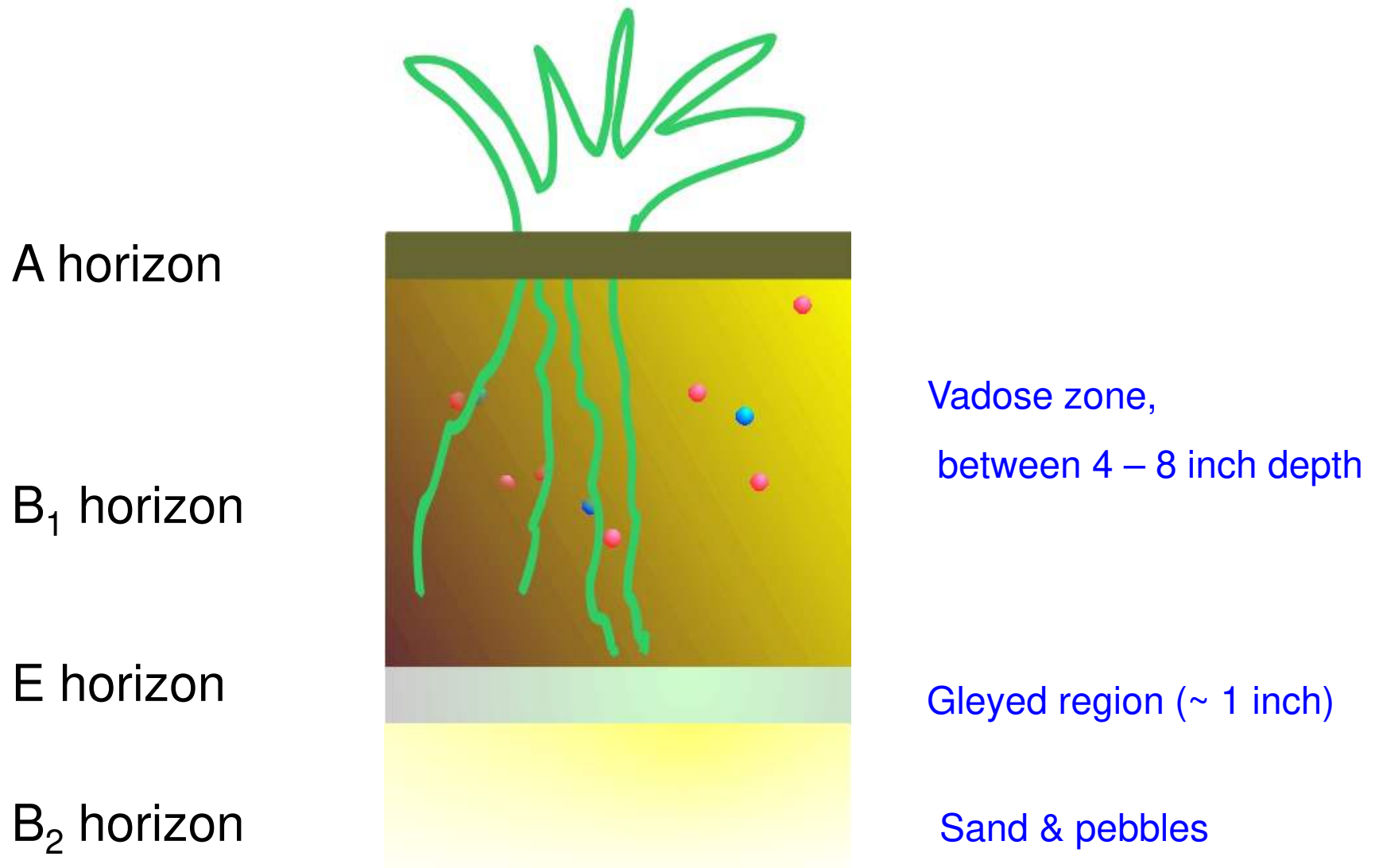
Joel Hennessy, US Environmental Protection Agency, Philadelphia, PA



Shifflet meander



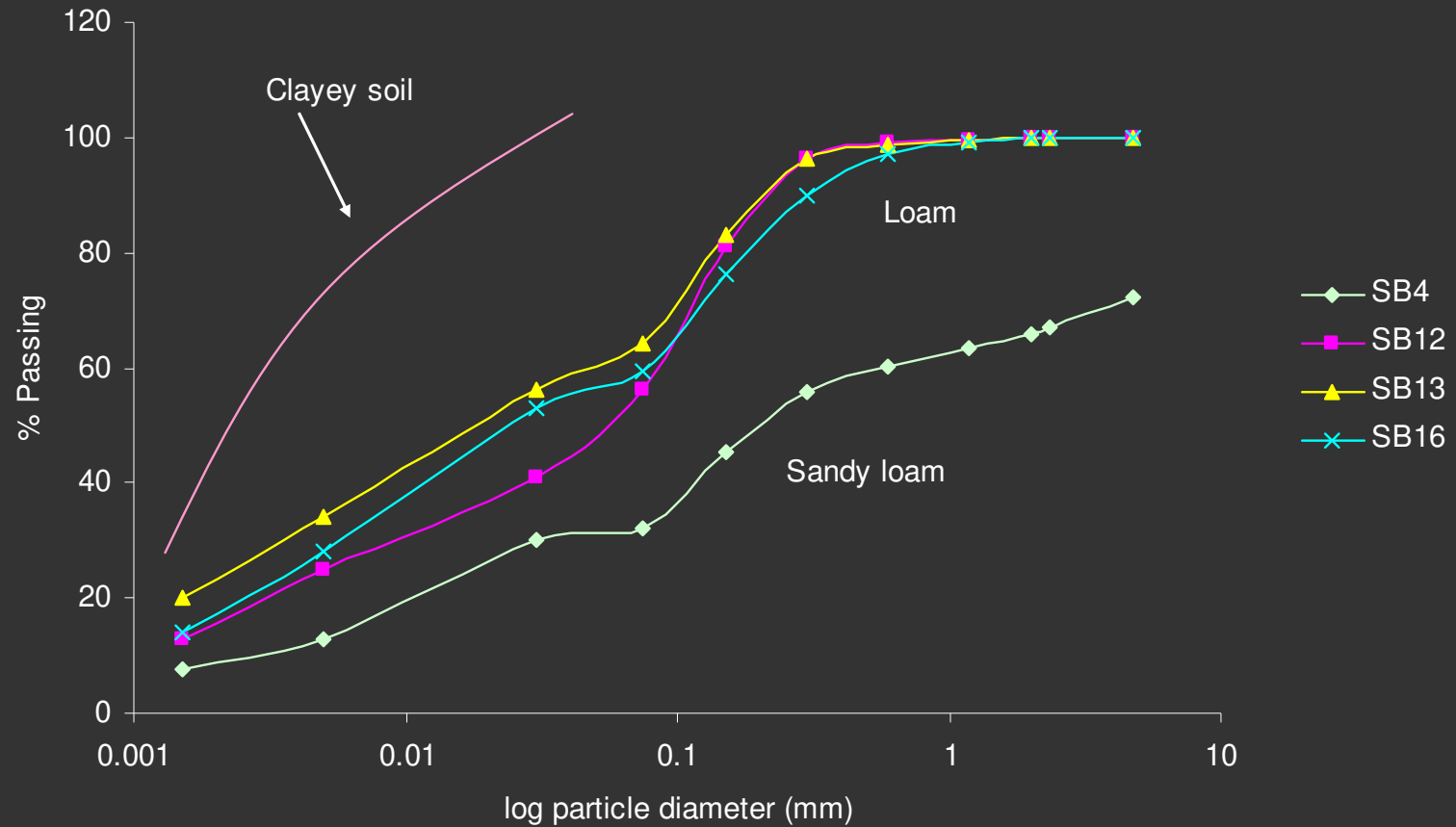
Generalized soil profile



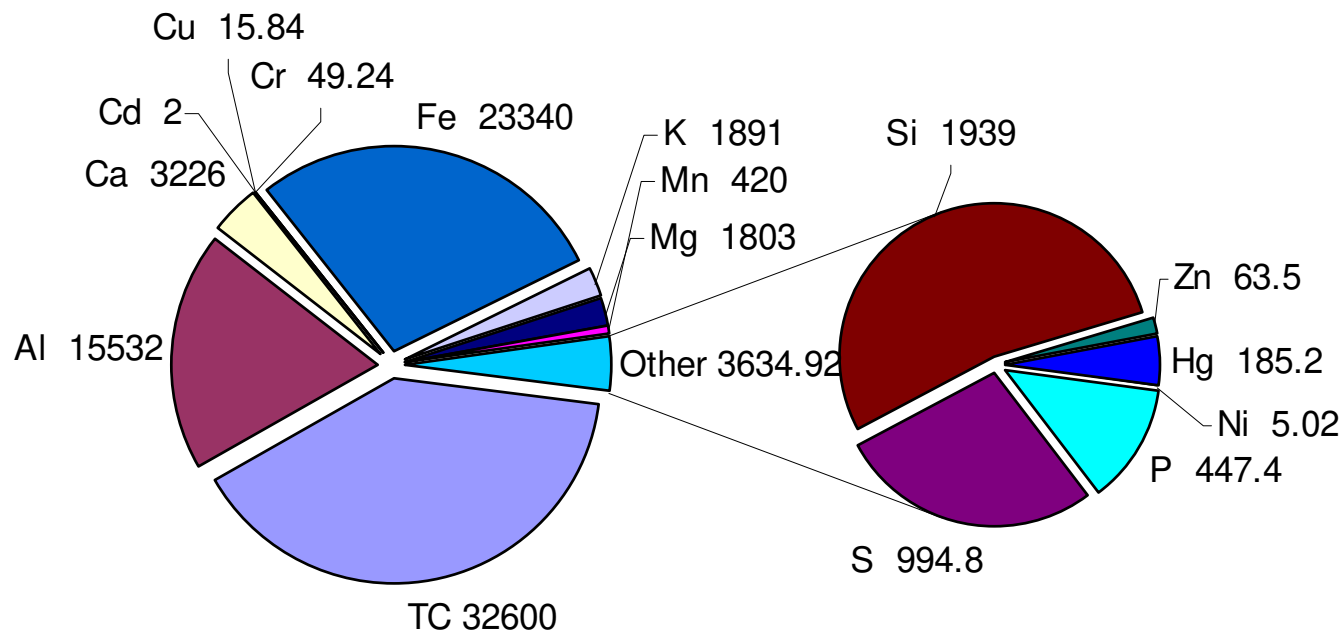
Soils description



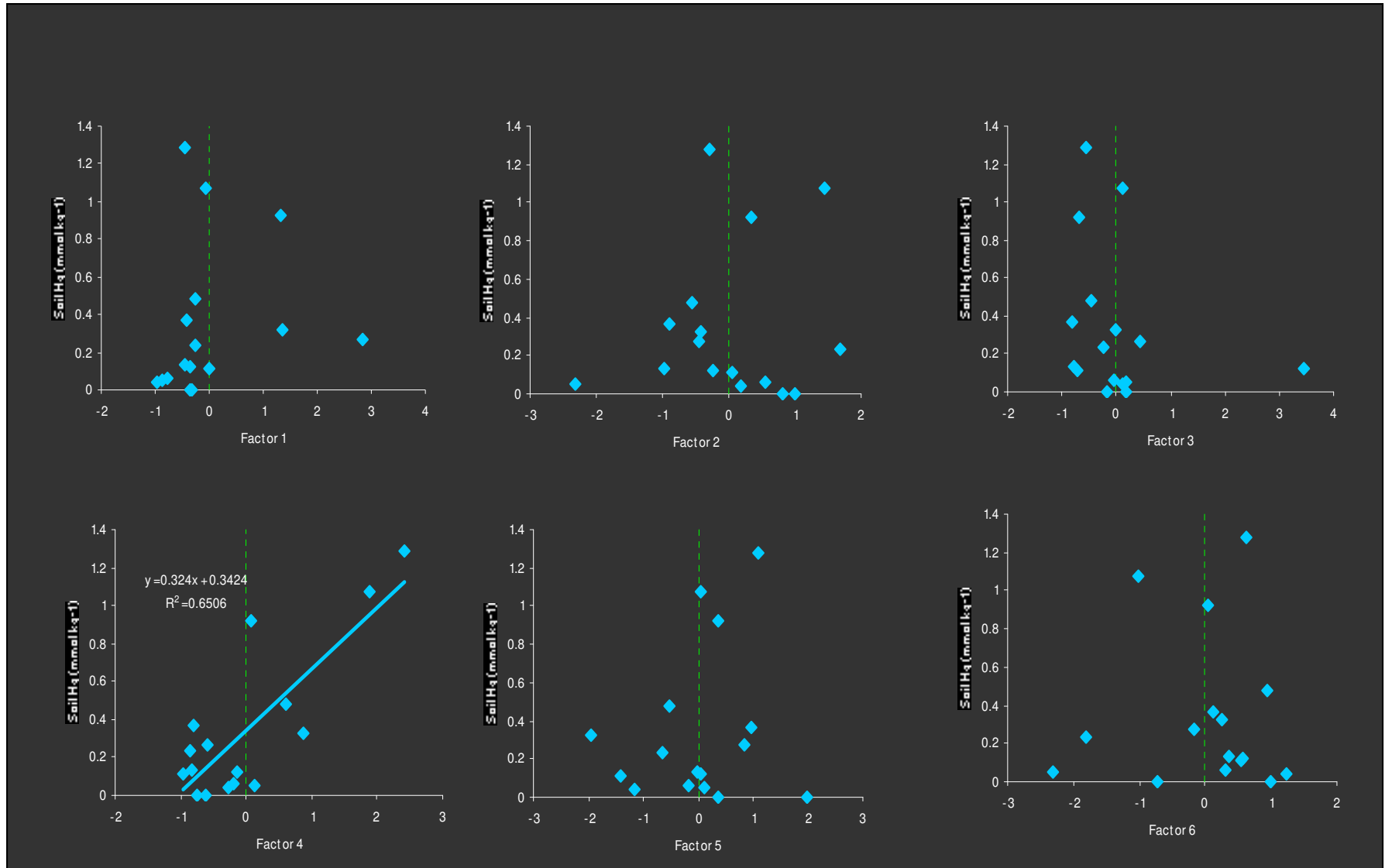
Soil texture



Chemical characterization



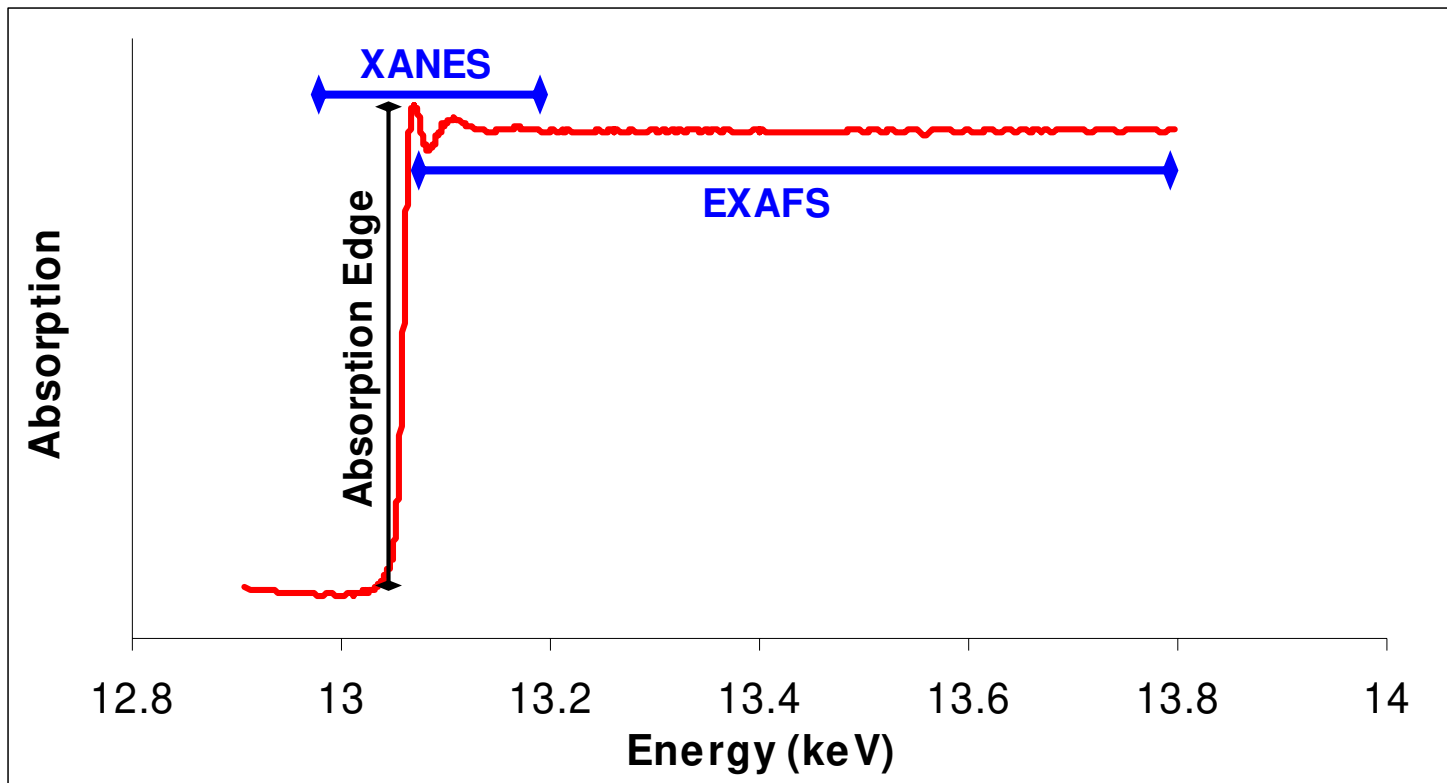
Principal factor analysis



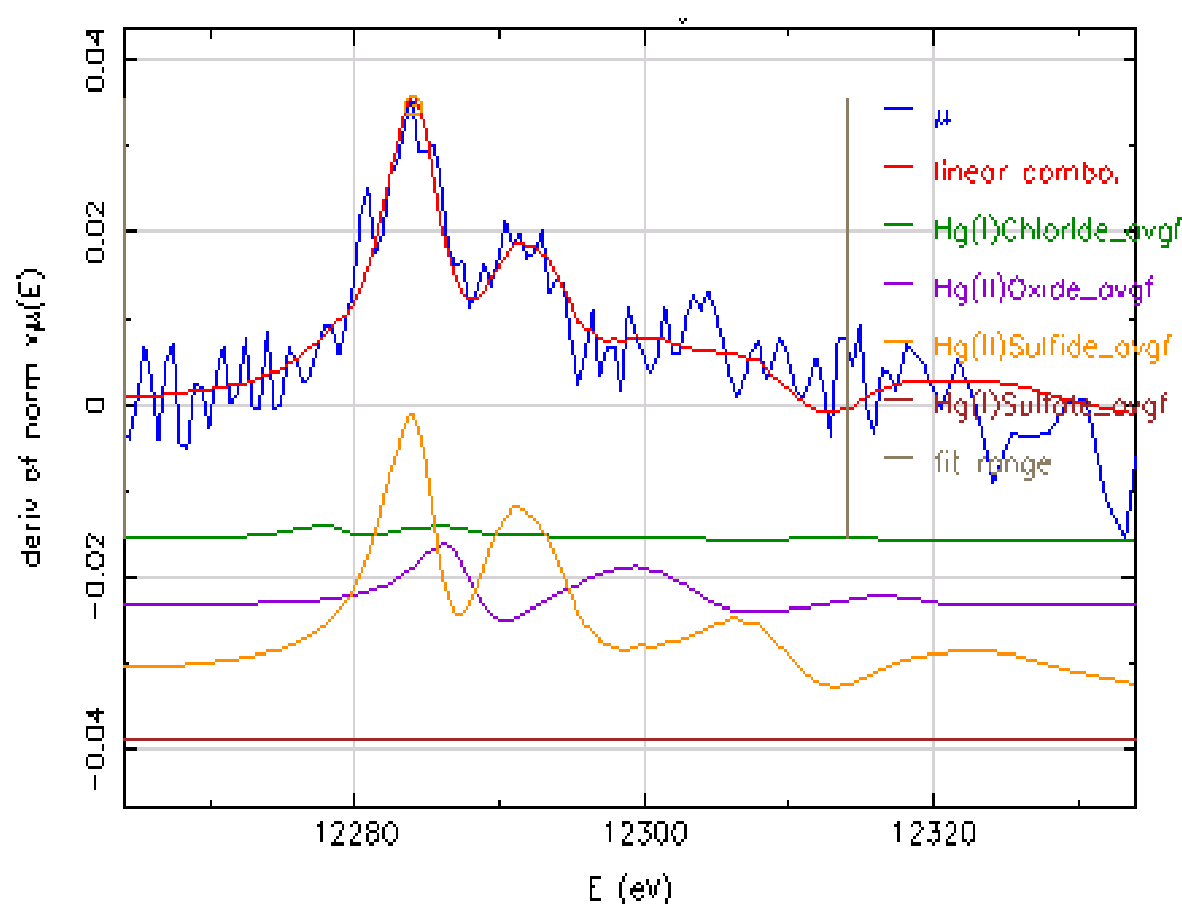
Factor breakdown

- Factor 1 (41.4%): Carbon, Ca (CEC), P, S, and other heavy metals
- Factor 2 (24.7 %): Al, K
- Factor 3 (7.4 %): Ni
- Factor 4 (6.9%): Cr, Cu, Zn
- Factor 5 (6.5%): Si
- Factor 6 (4.9%): Cd, Zn
- Factor 7 (3.2%): Mg
- Factor 8 (2.9%): S

X-ray absorption spectroscopy



Soil Hg speciation (XANES)

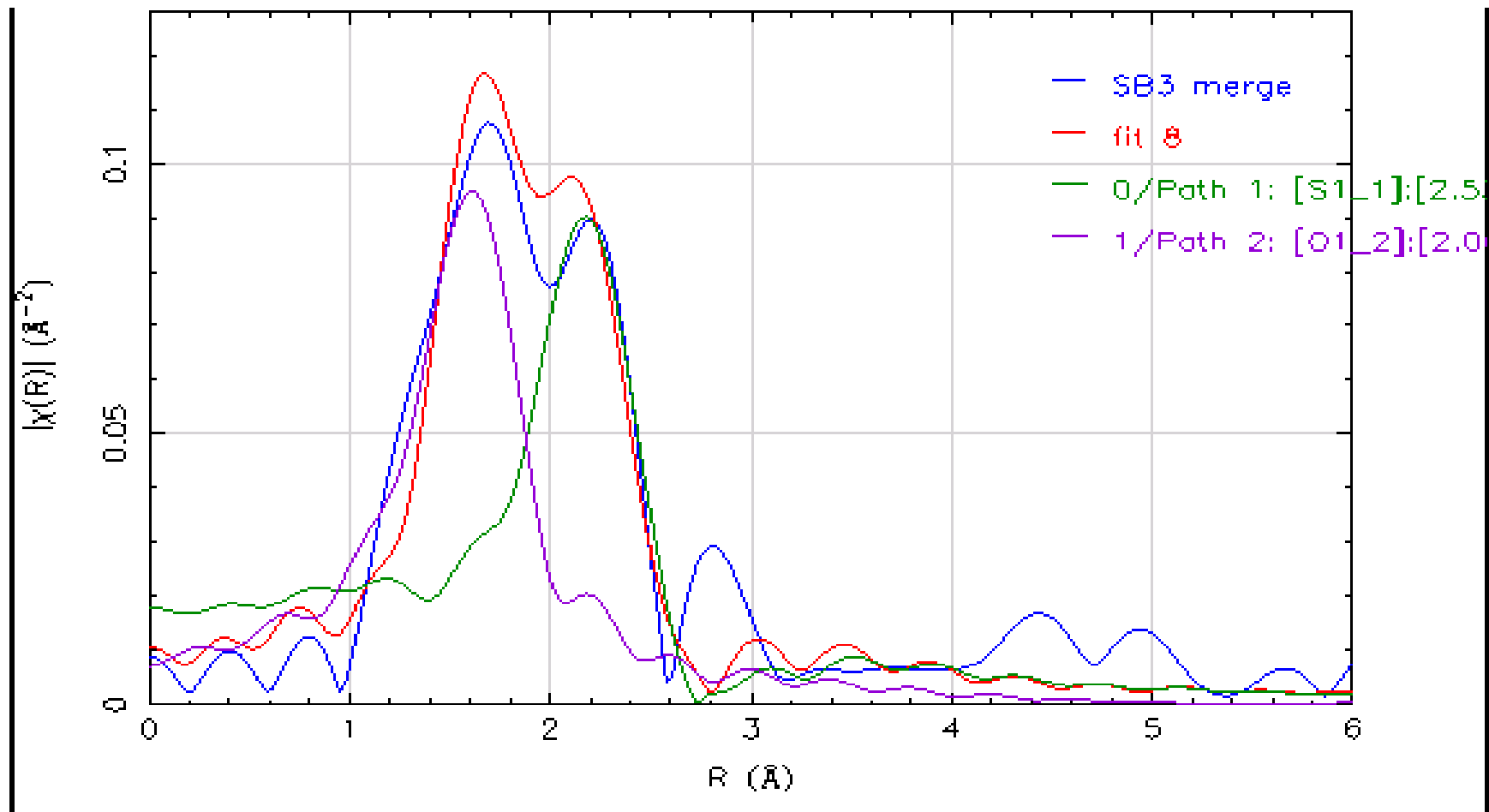


LCF Fits:

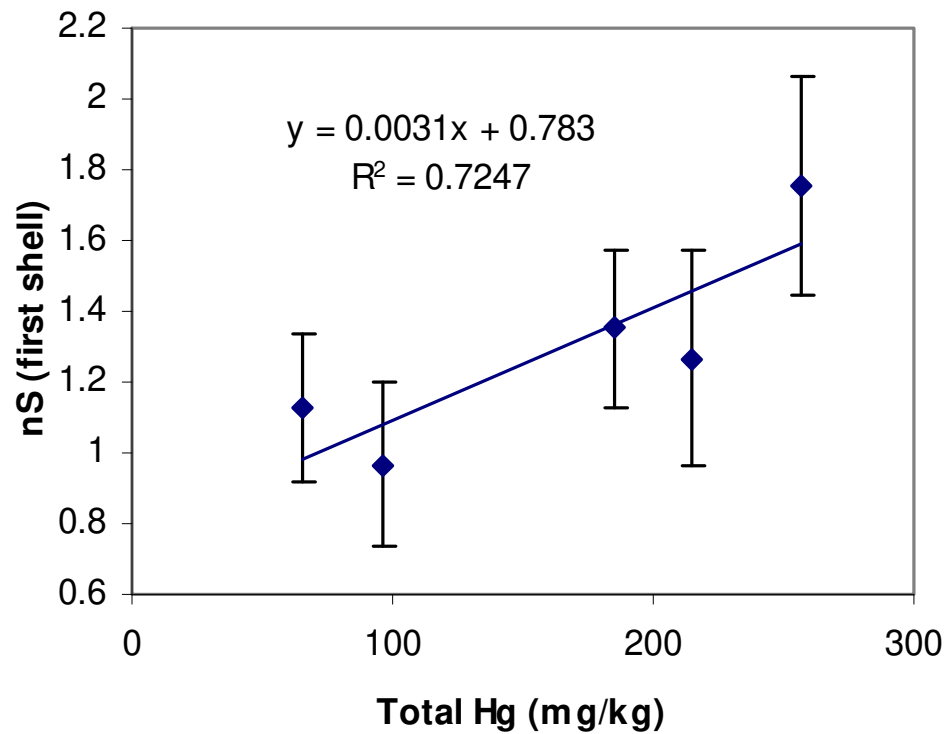
<u>Std</u>	<u>fraction</u>
Hg(I)Cl	0.051
Hg(II)O	0.170
Hg(II)S	0.802

R-factor = 0.082450

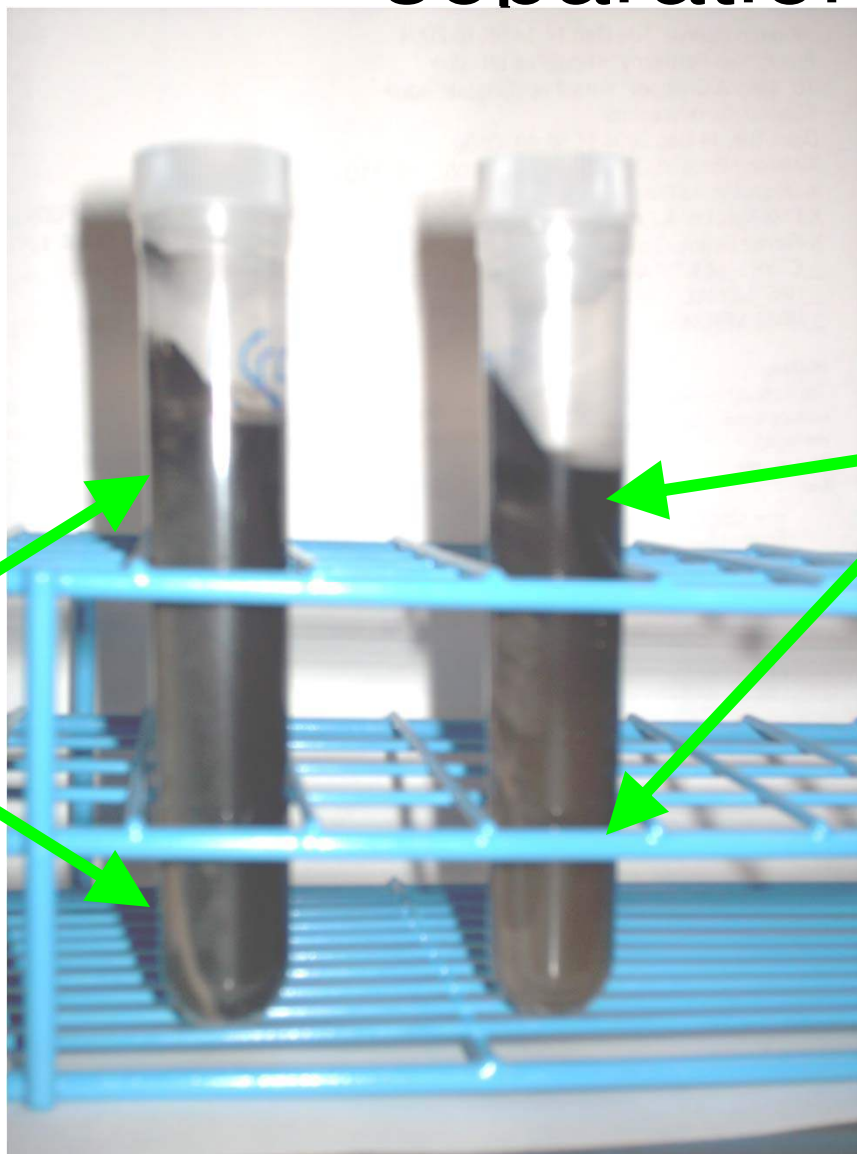
Soil Hg coordination (EXAFS)



Organic S coordination



Surface speciation: Density separation



Dull-brown
precipitate
and streak

Crystalline-black
layer and streak

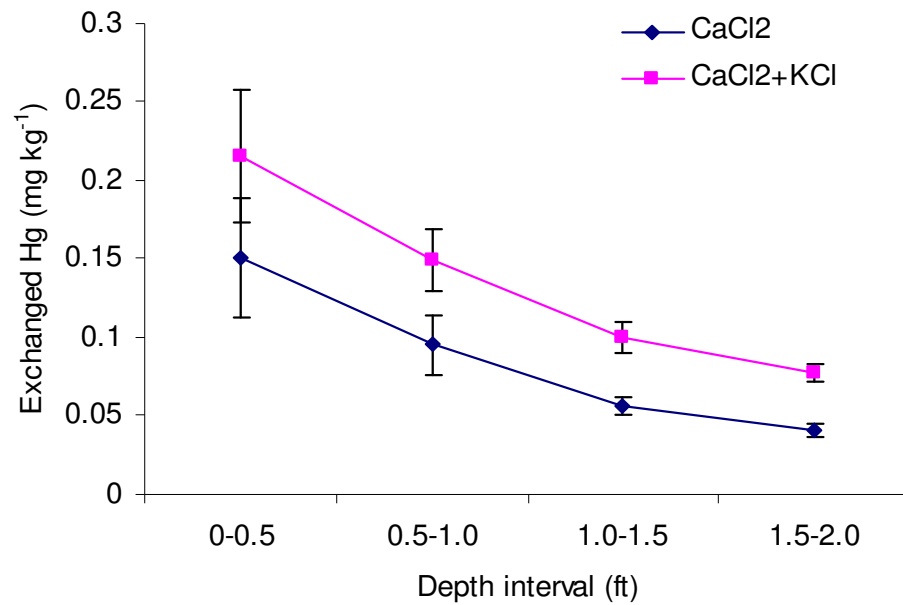
1.5 g cm^{-3}
sodium
polytungstate
solution

Surface speciation: Density separations (1.5 g cm^{-3})

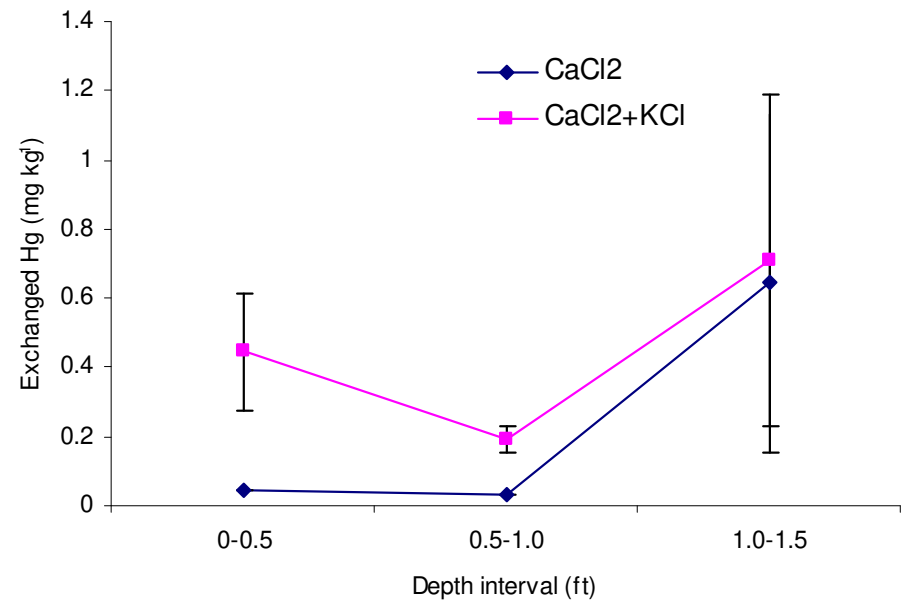
Sample	Depth	Density Fraction	TC	Hg conc.
	Ft	1.5 g cm^{-3}	%	mg kg^{-1}
SB4	0 – 0.5	low	20.6	533
		high	1.3	110
	0.5-1.0	low	<i>nd</i>	516
		high	1.6	2
	1.0-1.5	low	<i>nd</i>	871
		high	0.6	1

Exchange reactions

SB12



SB4



Exchange chemistry

For the exchange reaction,



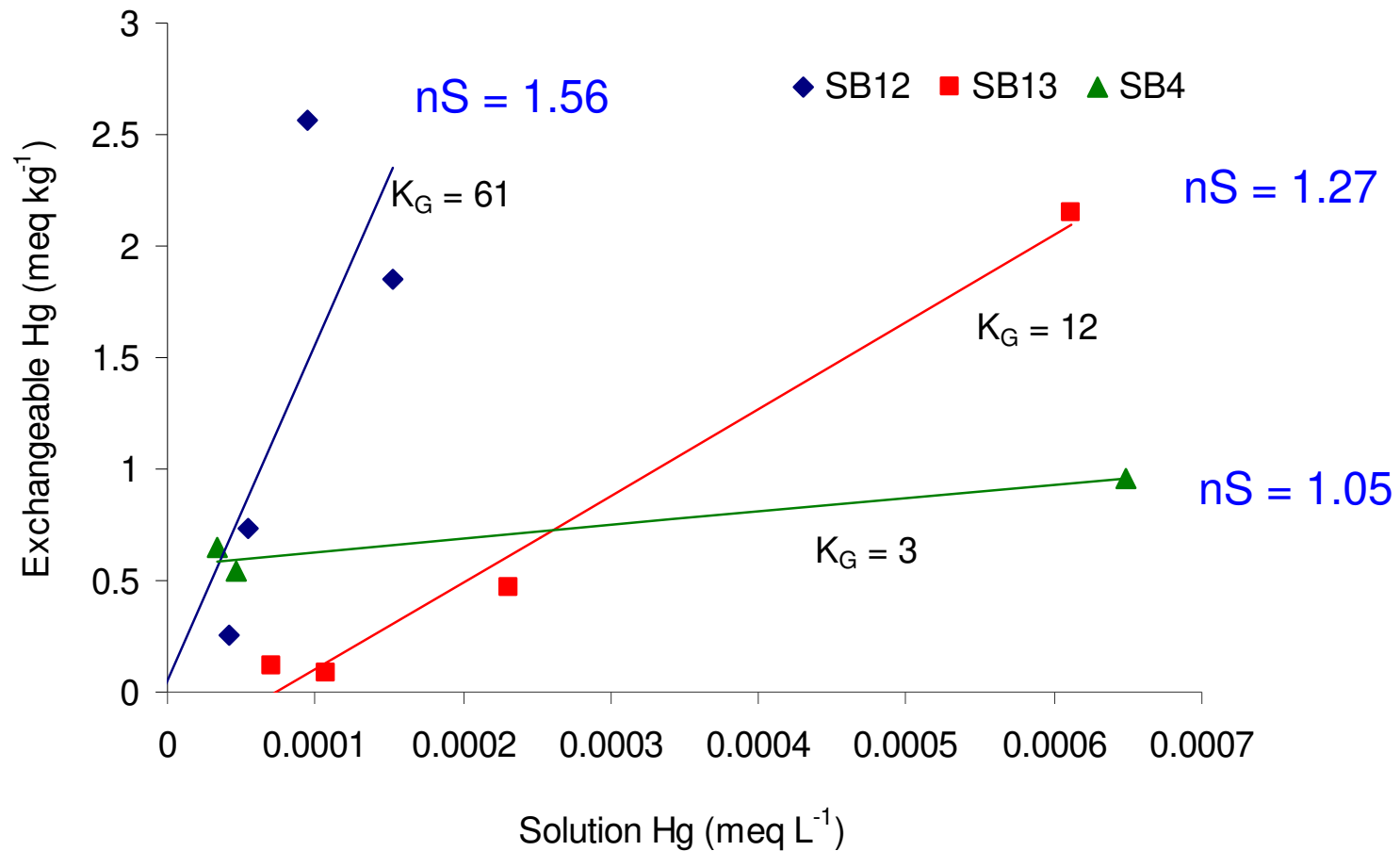
the Gapon Exchange coefficient is defined as

$$K_G = (\text{ExCa}/\text{ExHg}) (\text{Ca}^{2+} / \text{Hg}^{2+})$$

Through some simple assumptions,
exchangeable Hg can be expressed as,

$$\text{ExHg} = K_G \text{CEC} (\text{Hg}^{2+})$$

Gapon exchange constants



Conclusions

Soil Hg is:

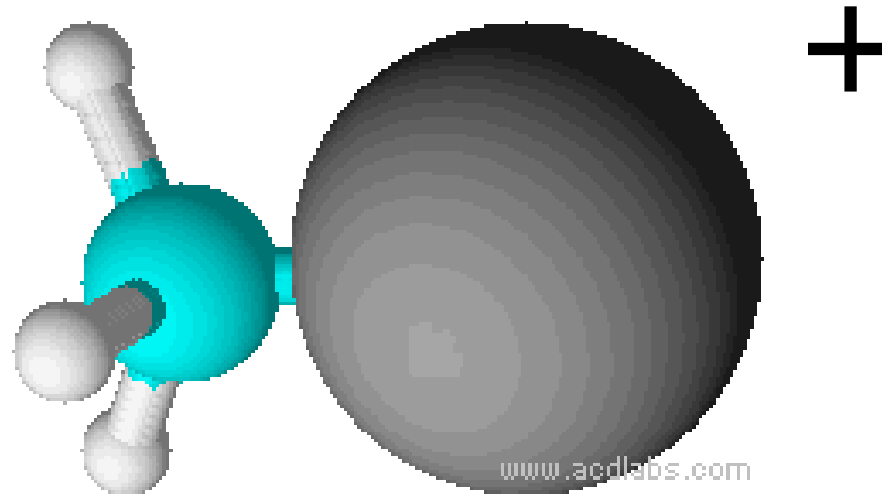
- Present as divalent cation.
 - Readily adsorbed to soil exchange phase.
- Physically associated with the organic carbon fraction.
- Poorly exchangeable due to strong complexation, particularly organic S.
 - Suggests soil Hg is stable under abiotic conditions

Conclusions

- Low release of Hg during flooding, mostly in the form of tightly adsorbed Hg on dispersed particulates at soil surface.
- Biotic activity spikes with enhanced adsorbed nutrient availability – incidental Hg methylation while C consumed.
- Results suggest soils contain very long-term supply of Hg for methylation for many years to come.

Questions

- If Hg methylation occurs in soil, what is the fate of MeHg?



Hydrophobic – adsorb to hydrophobic domains

Cationic – adsorb to exchange phase

FY08 goals

- Investigate in-situ immobilization in soil
 - High affinity for Hg limits bioavailability
 - Non-toxic yet stable
 - Inexpensive & easy to apply