Shifflet Farm – Soil & Groundwater Results, Part II

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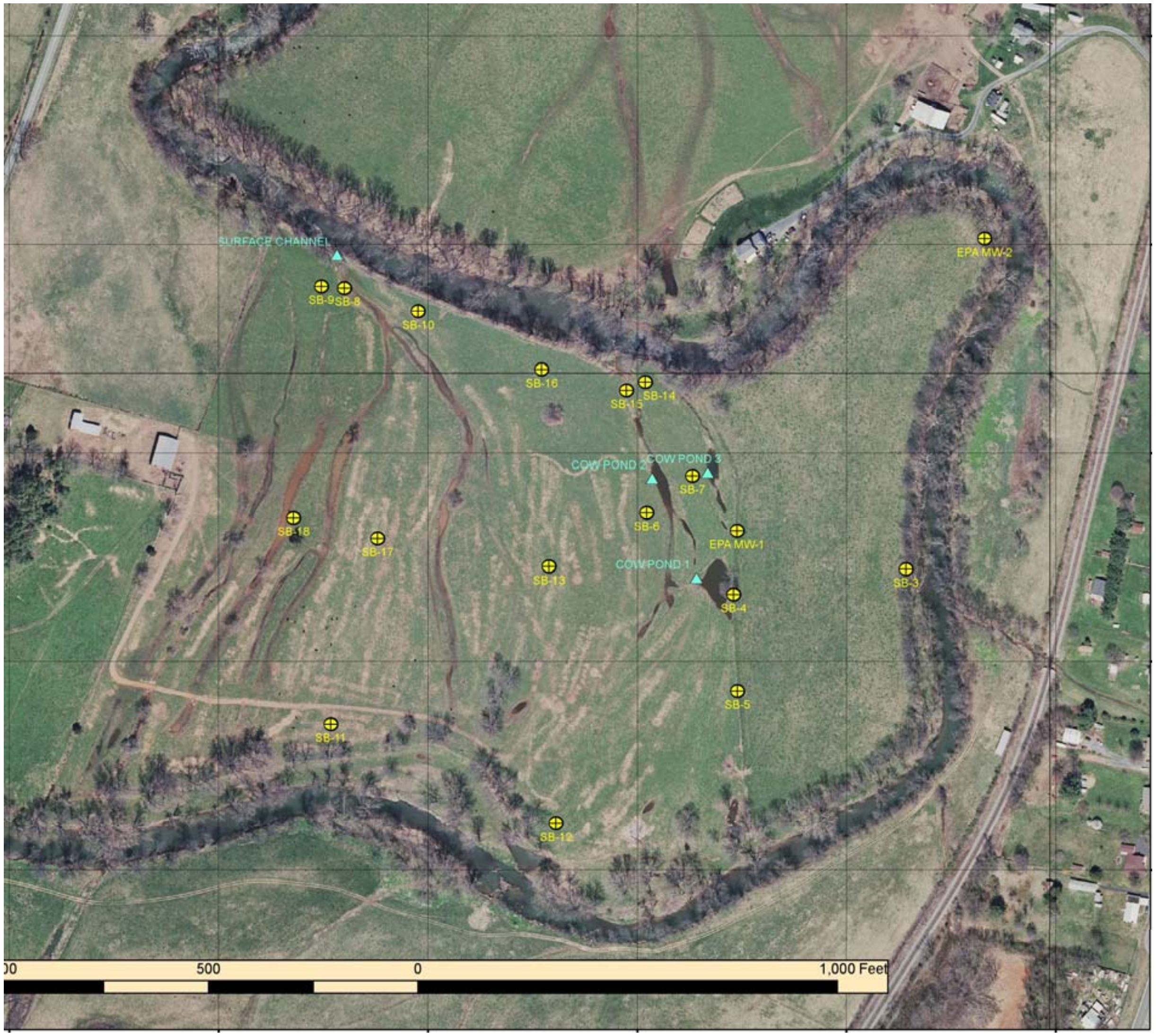
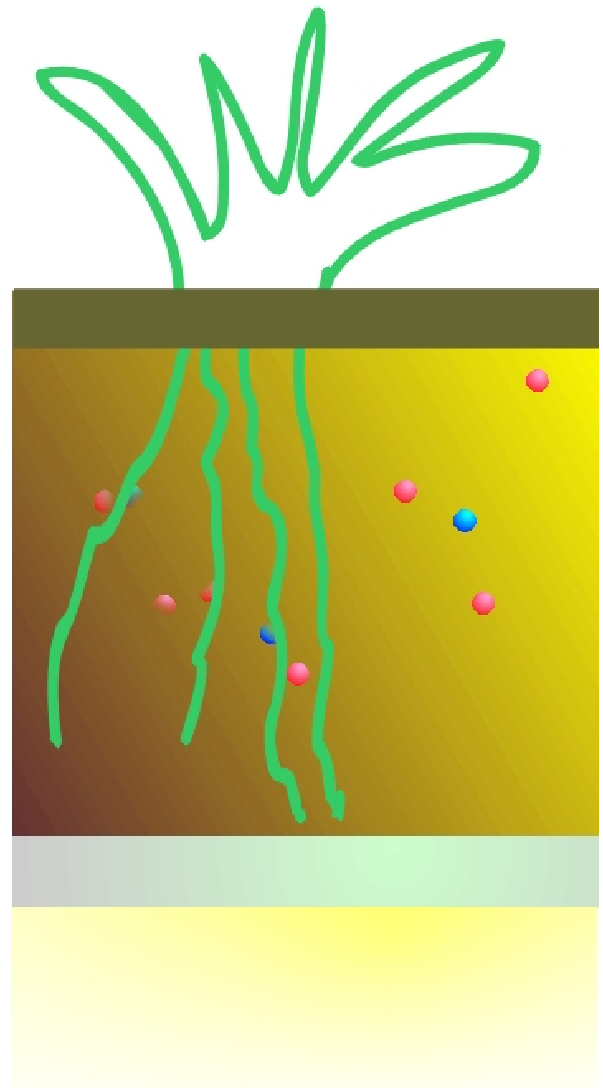
Shifflet meander



Generalized soil profile



A horizon

B_1 horizon

Vadose zone,

between 4 – 8 inch depth

E horizon

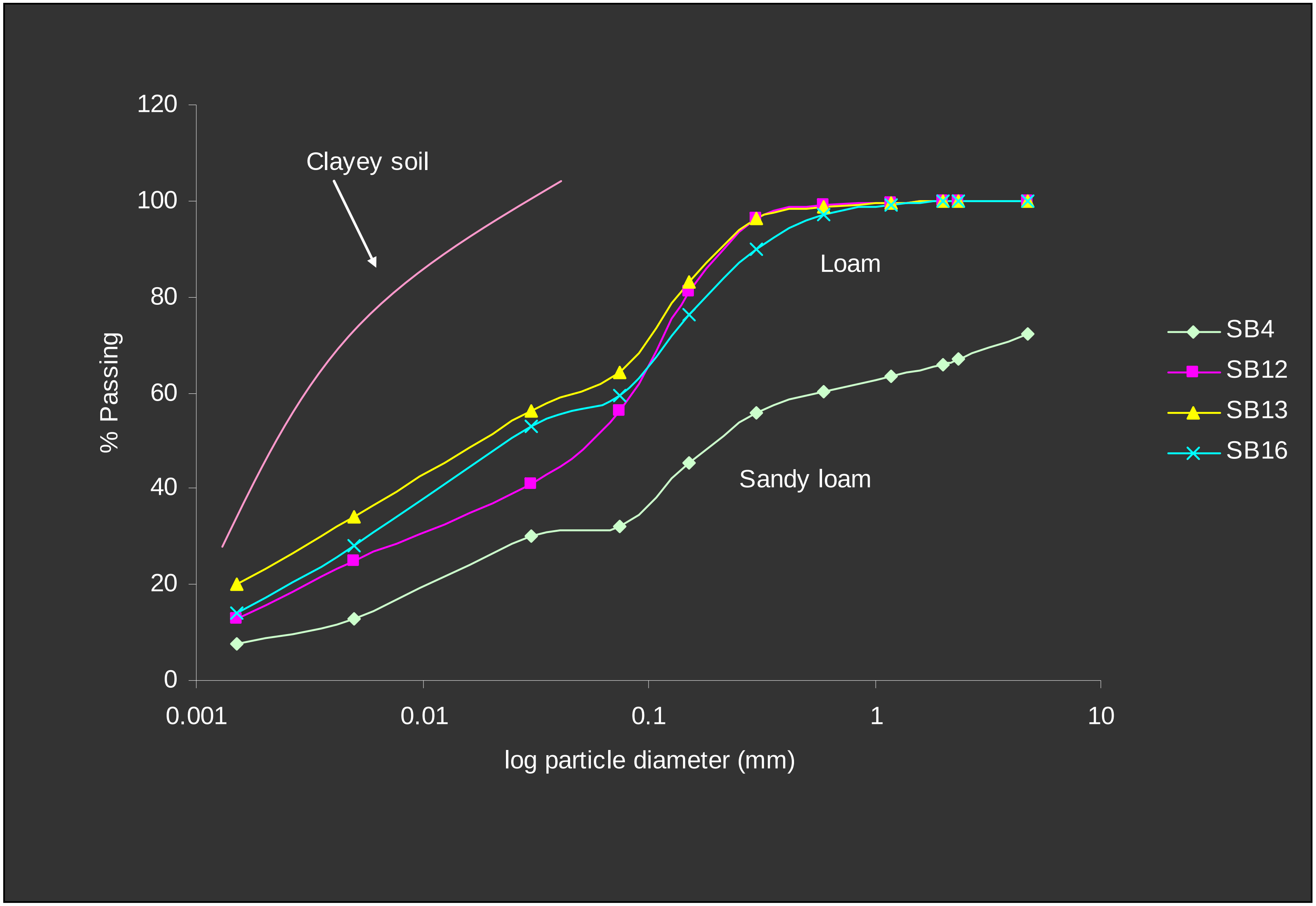
Gleyed region (~ 1 inch)

B_2 horizon

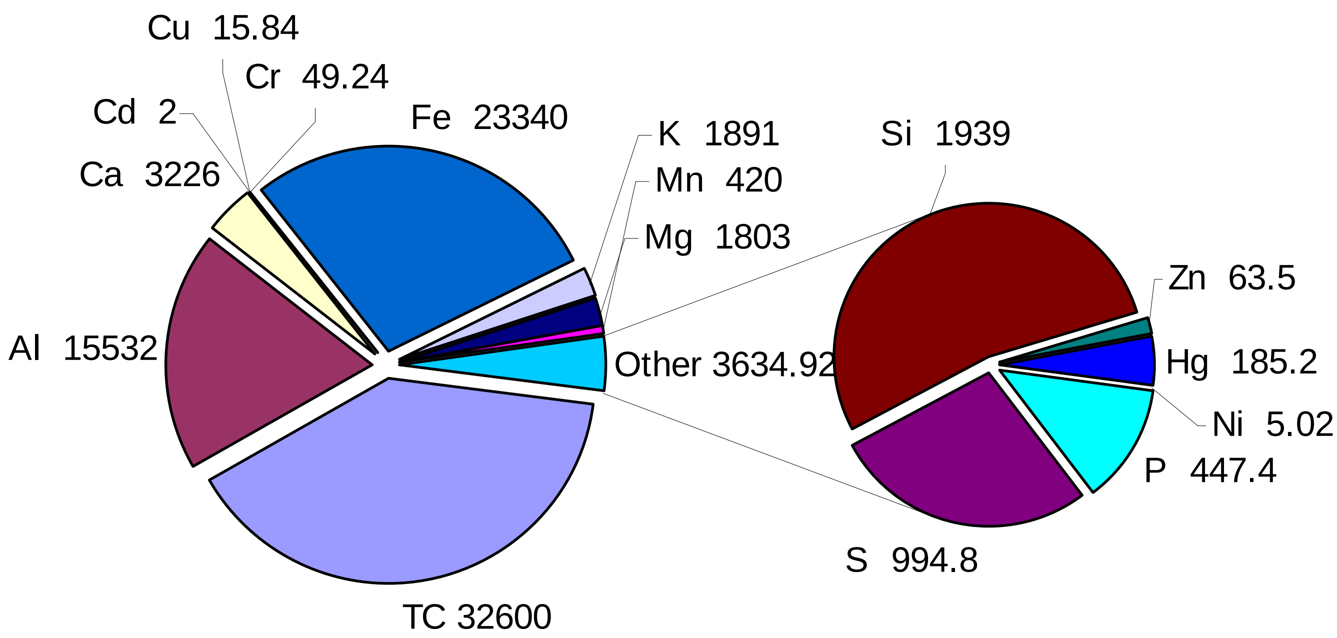
Sand & pebbles

Soils description

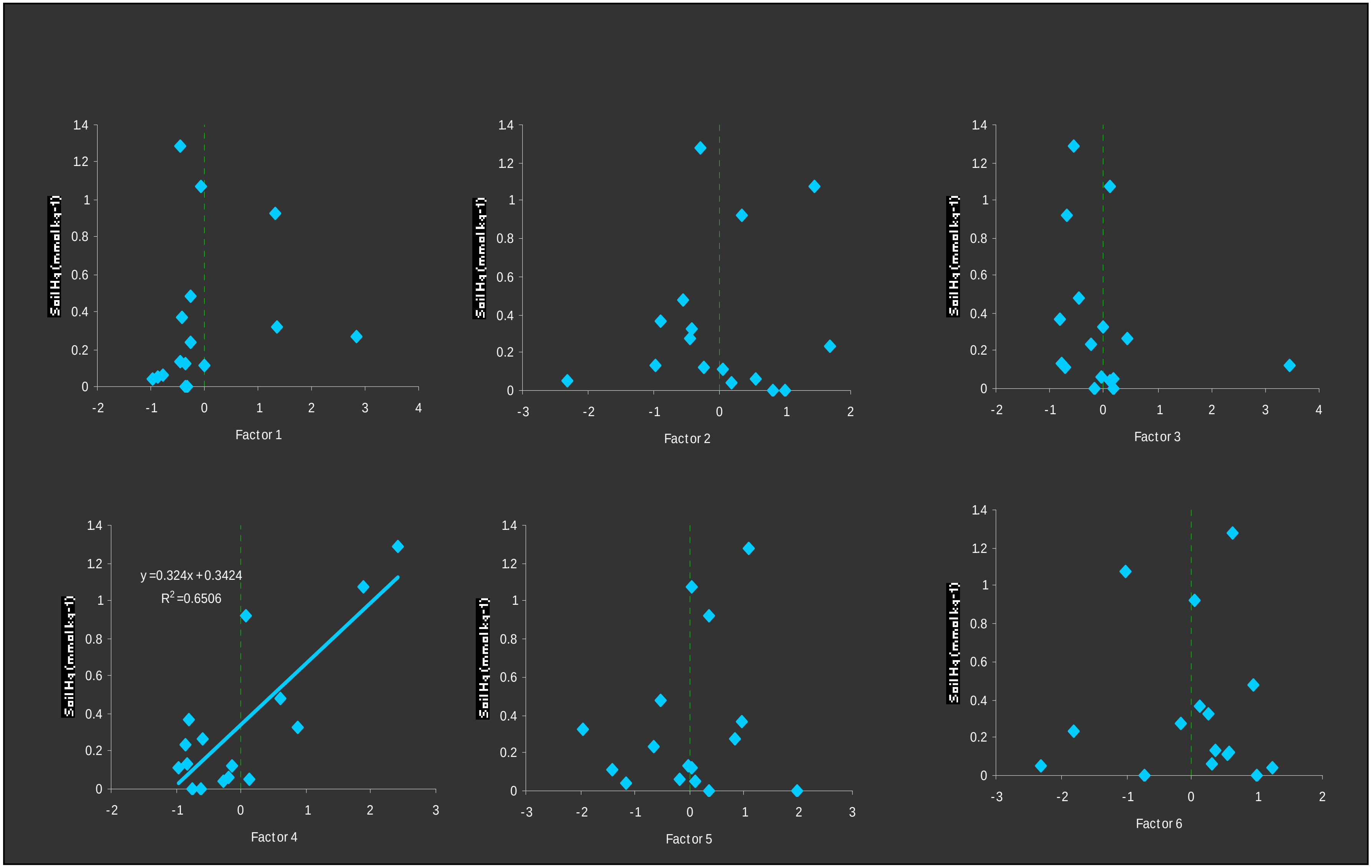
Soil texture



Chemical characterization



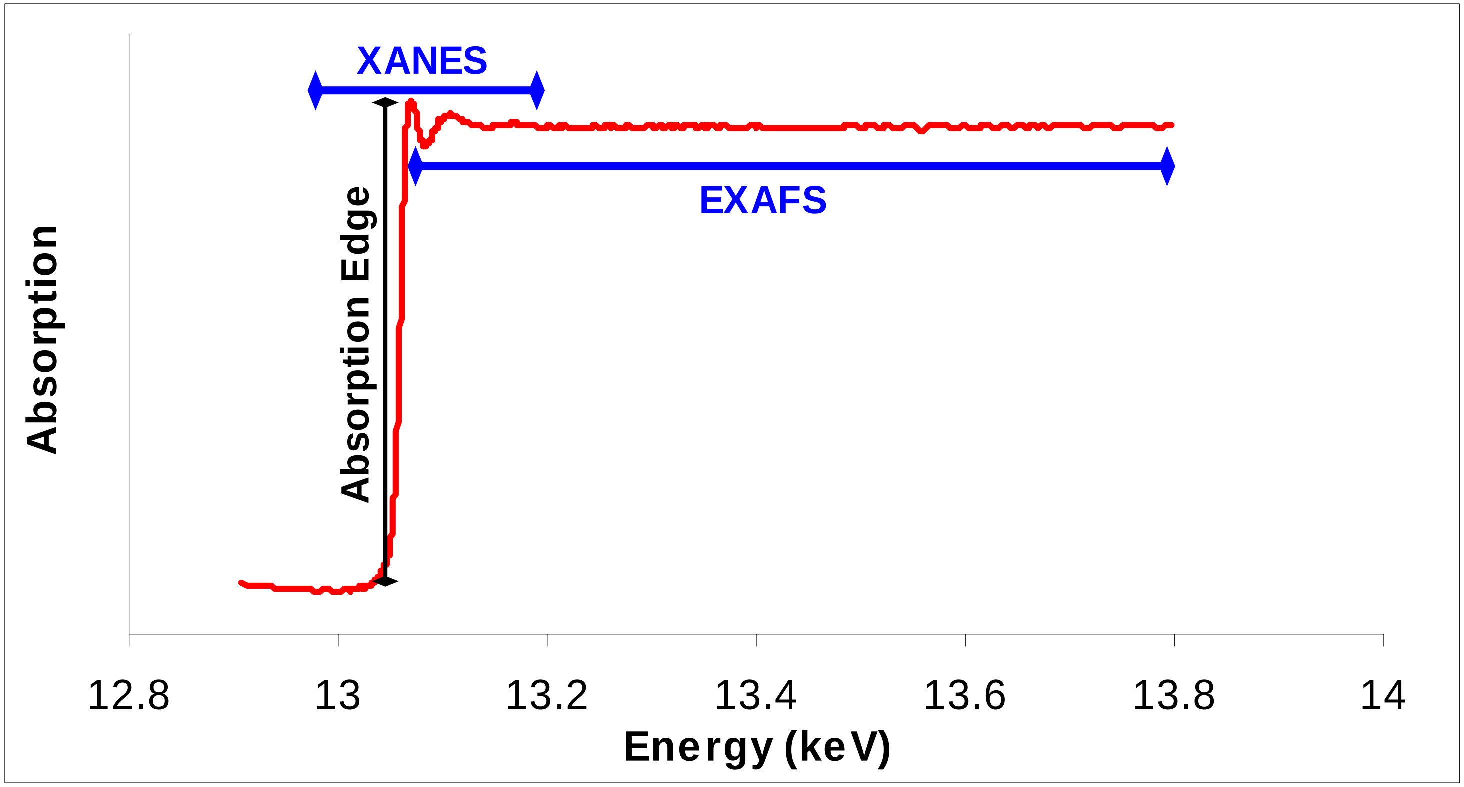
Principal factor analysis



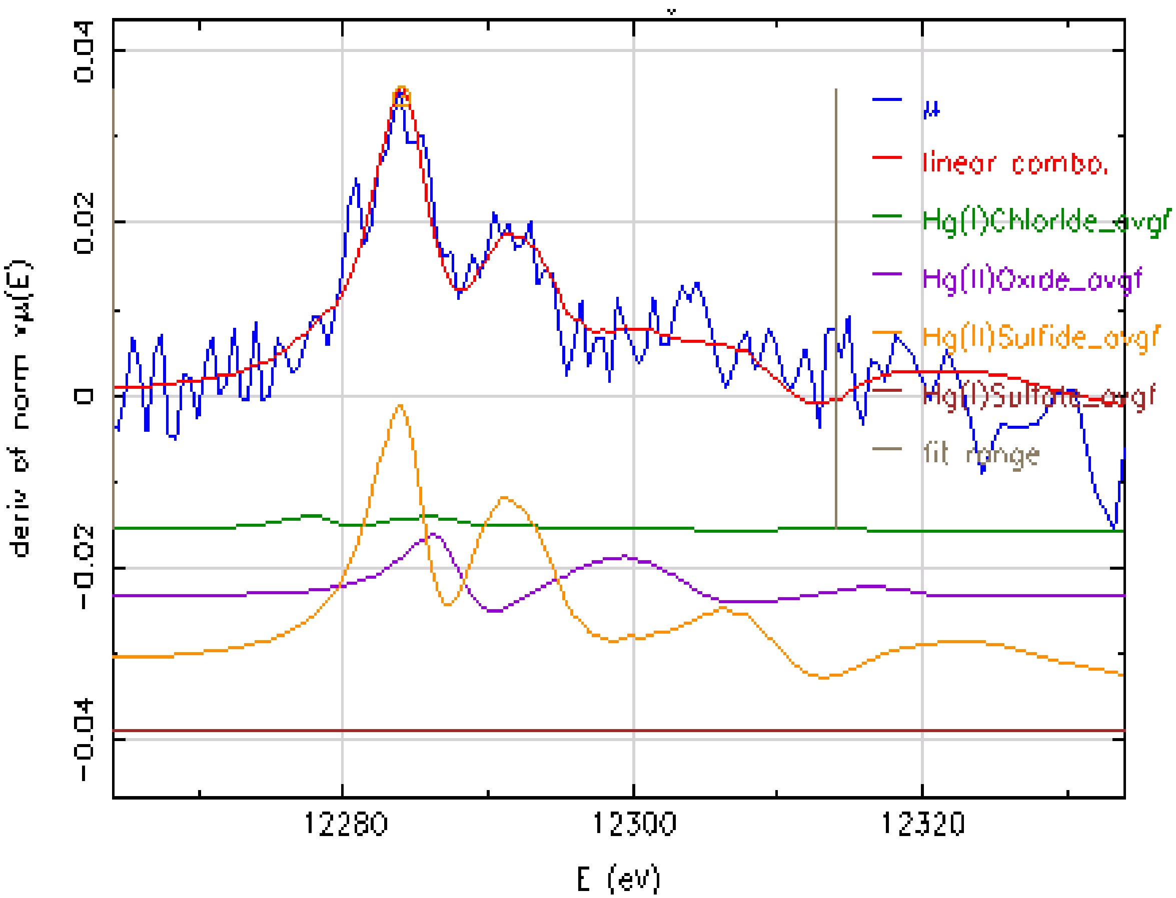
Factor breakdown

- 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)

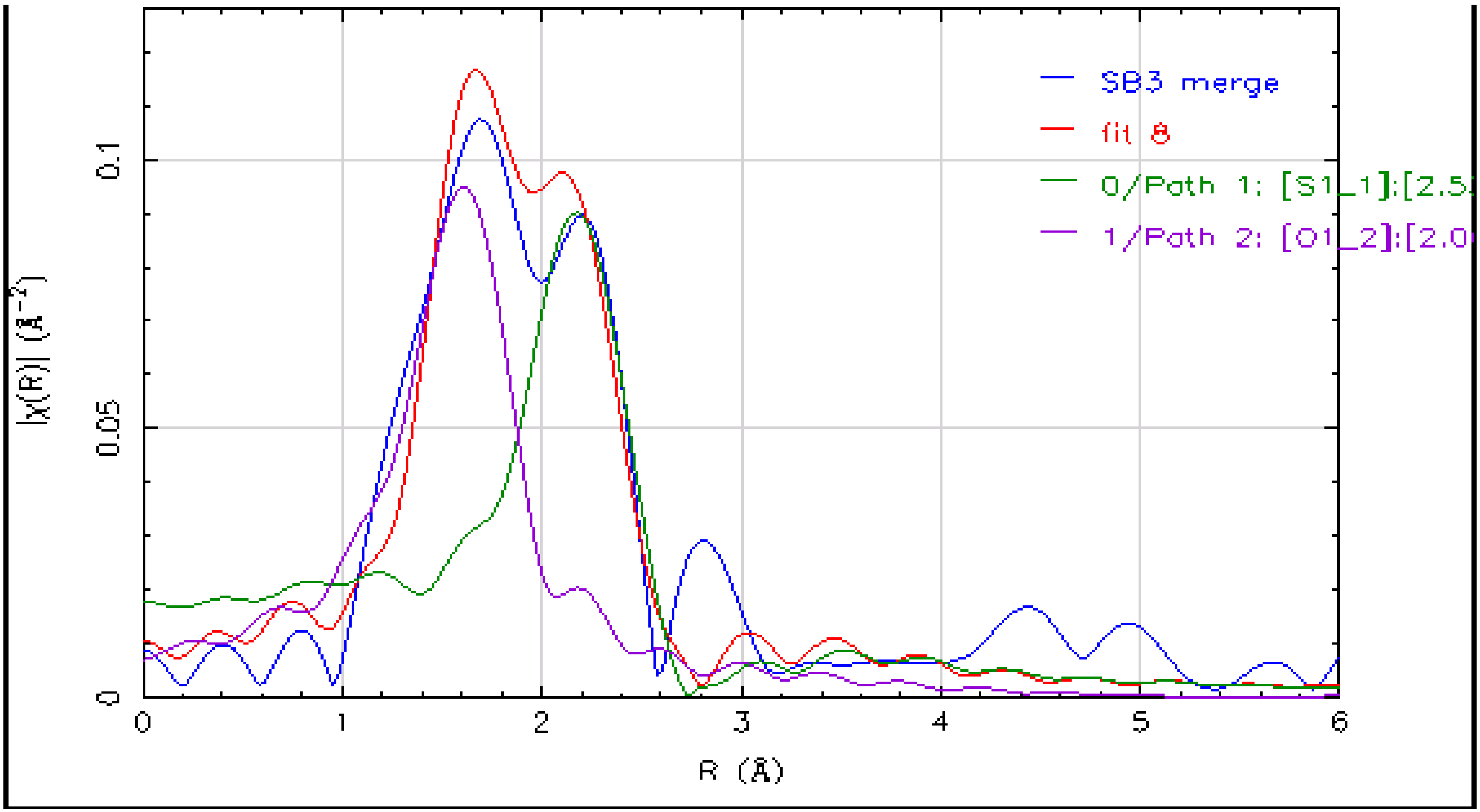


LCF Fits:

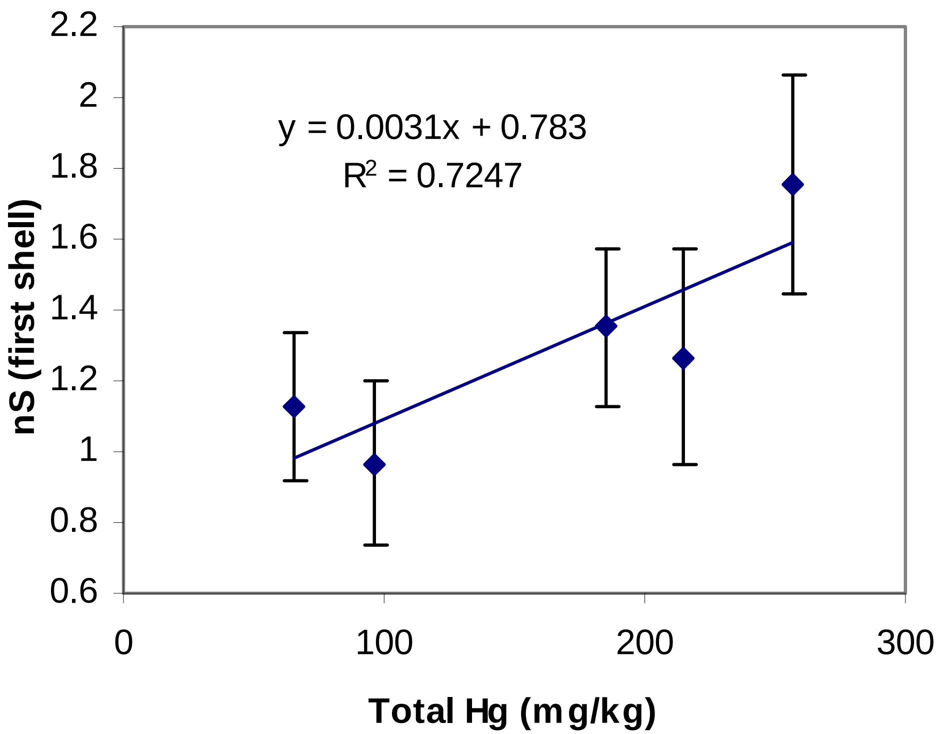
Std	fraction
Hg(I)Cl	0.051
Hg(II)O	0.170
Hg(II)S	0.802

R-factor = 0.082450

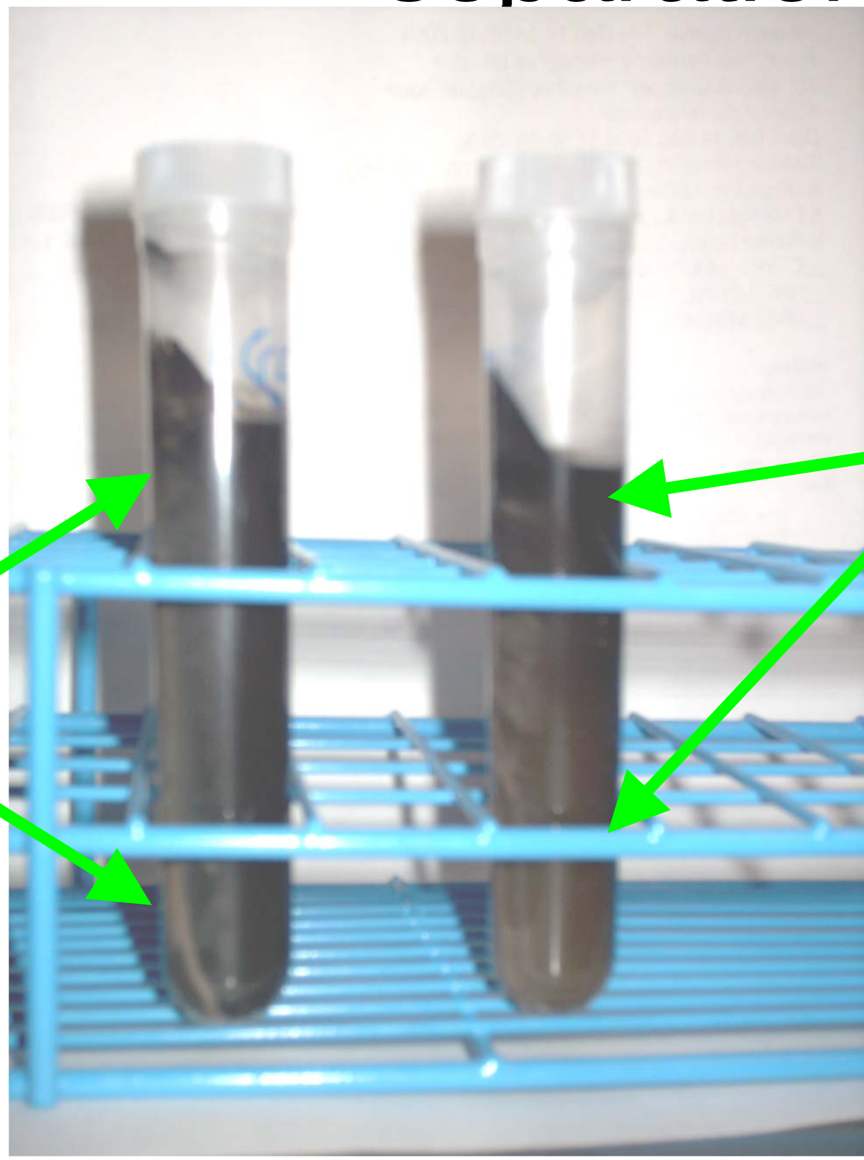
Soil Hg coordination (EXAFS)



Organic S coordination



Surface speciation: Density separation



Crystalline-black layer and streak

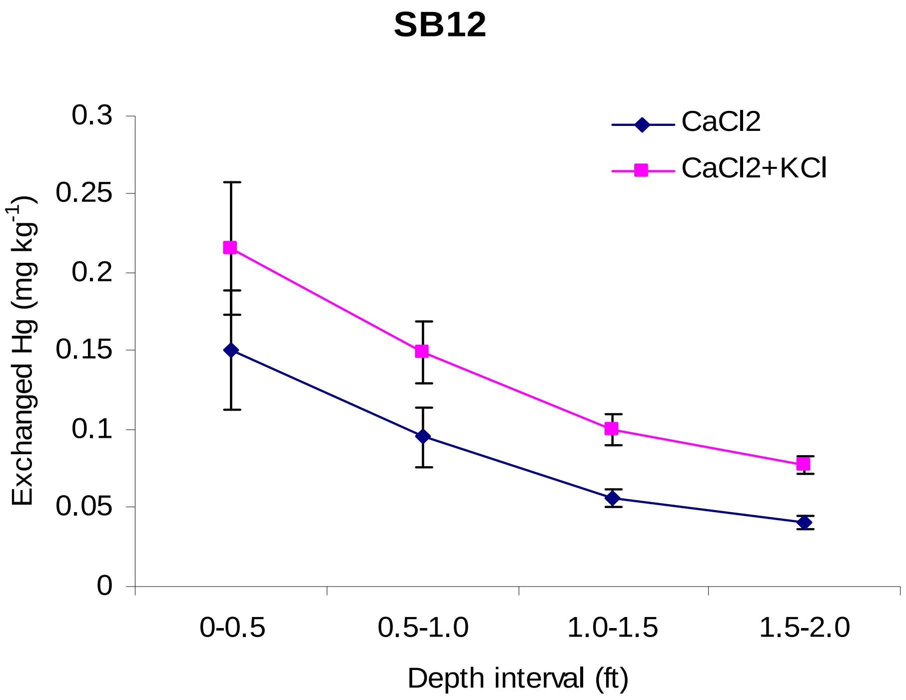
Dull-brown precipitate and streak

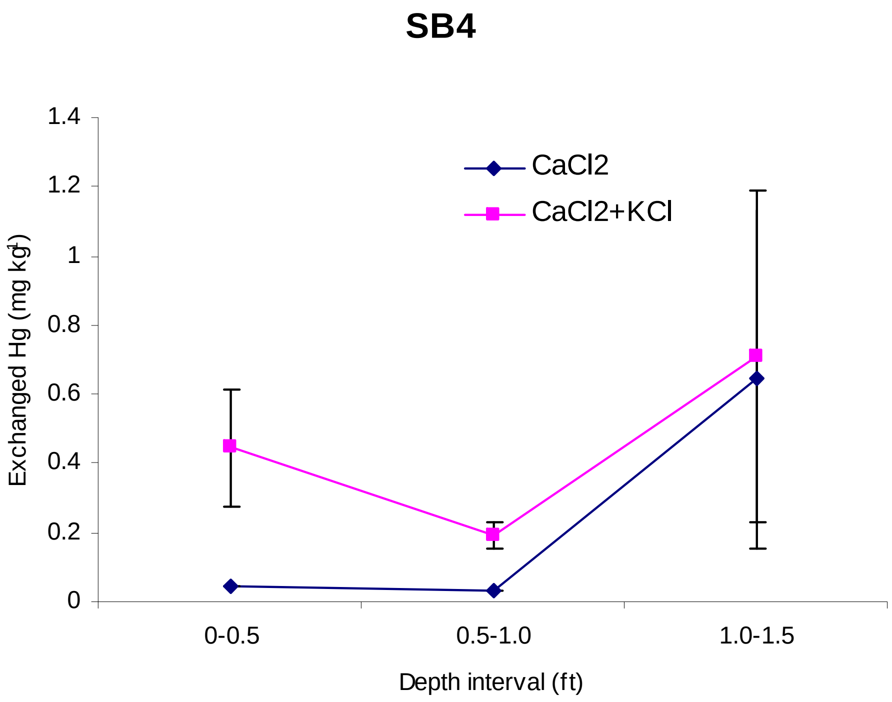
1.5 g cm^{-3} sodium polytungstate solution

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	*nd*	516
		high	1.6	2
	1.0-1.5	low	*nd*	871
		high	0.6	1

Exchange reactions





Exchange chemistry

For the exchange reaction,

$$ExCa + Hg^{2+} = ExHg + Ca^{2+}$$

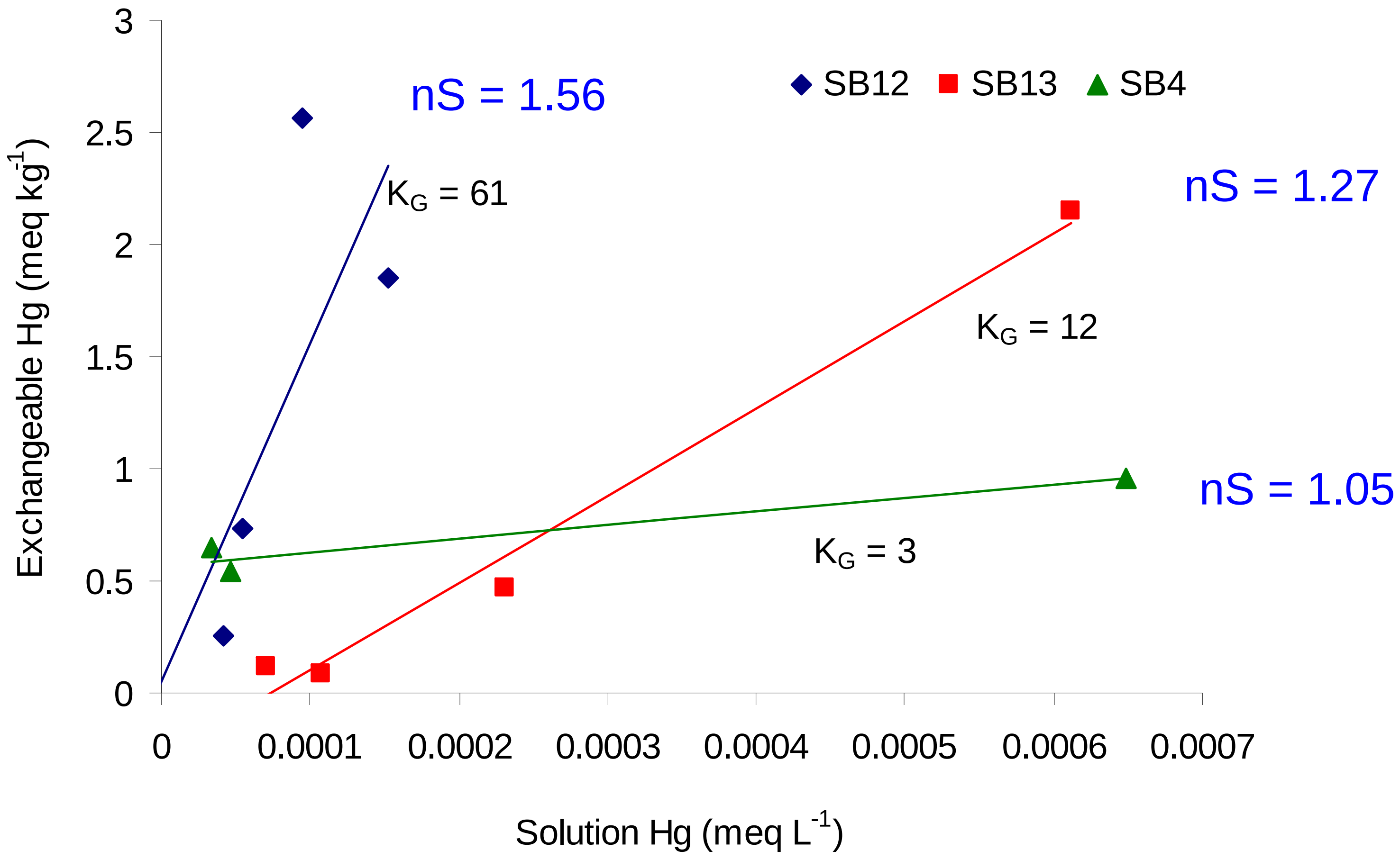
the Gapon Exchange coefficient is defined as

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

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

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

Gapon exchange constants



Conclusions

Soil Hg is:

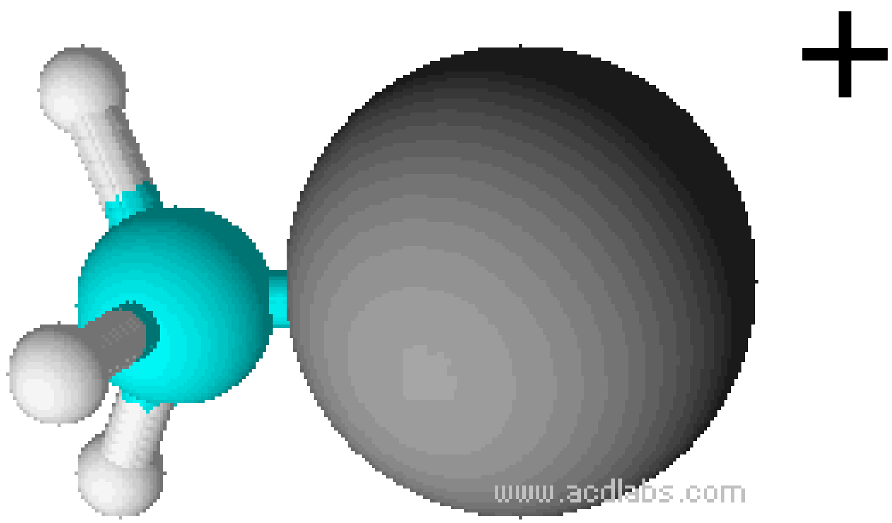
- Present as divalent cation.
  - Readily adsorbed to soil exchange phase.
- Physically associated with the organic carbon fraction.
- Poorly exchangeable due to strong complexation, particularly organic S.
  - Suggests soil Hg is stable under abiotic conditions

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