Using VisNIR spectroscopy to estimate soil organic carbon

David J. Brown

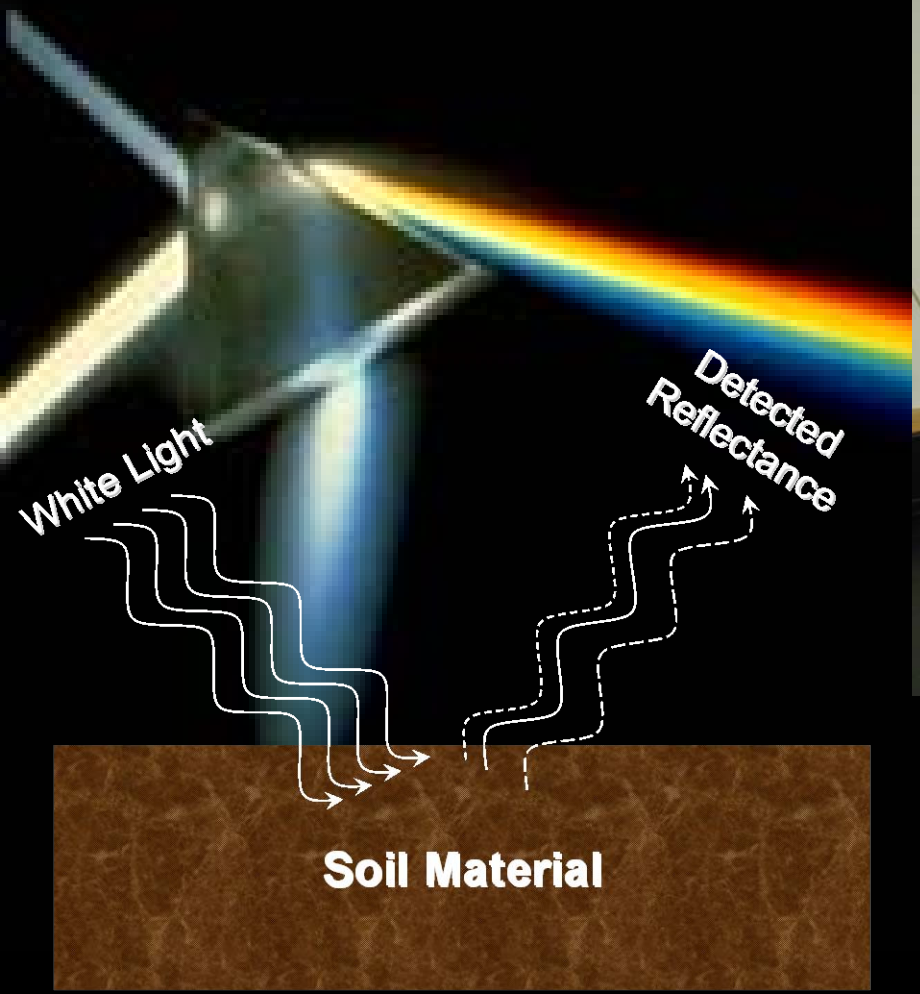
Western Regional Cooperative Soil Survey Conference

June 22, 2010, Las Vegas, NV

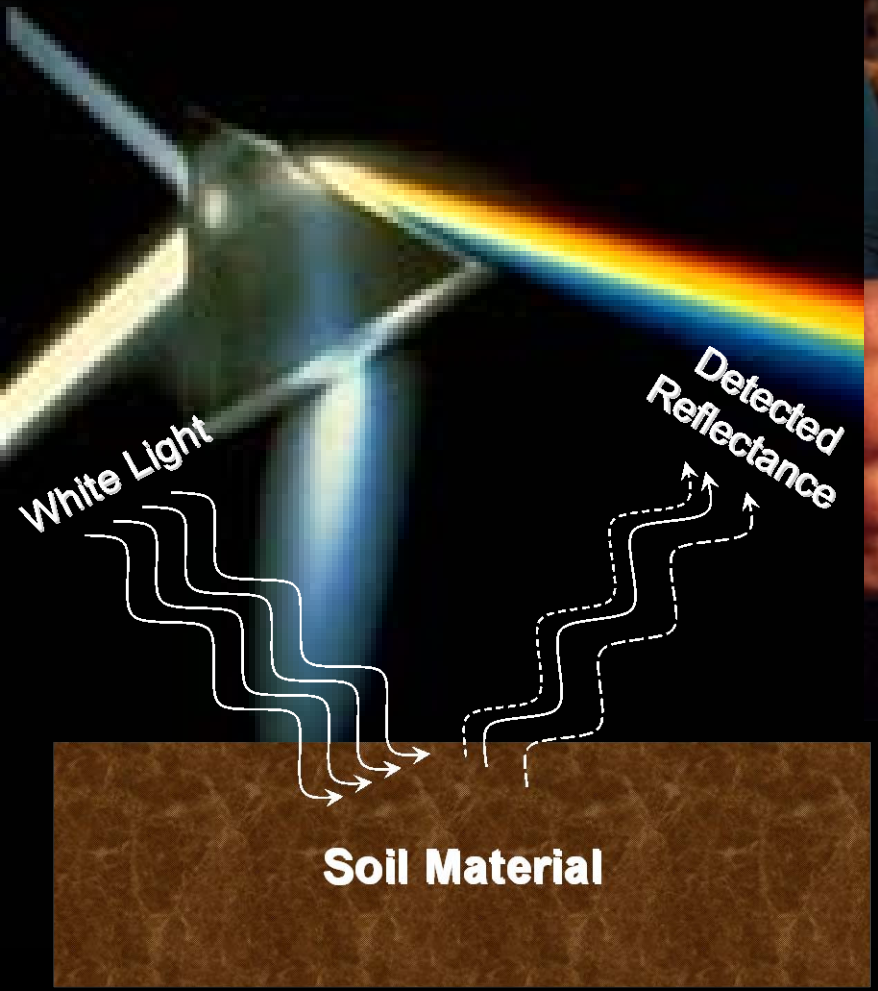
Washington State University

Big Sky Carbon Sequestration Partnership

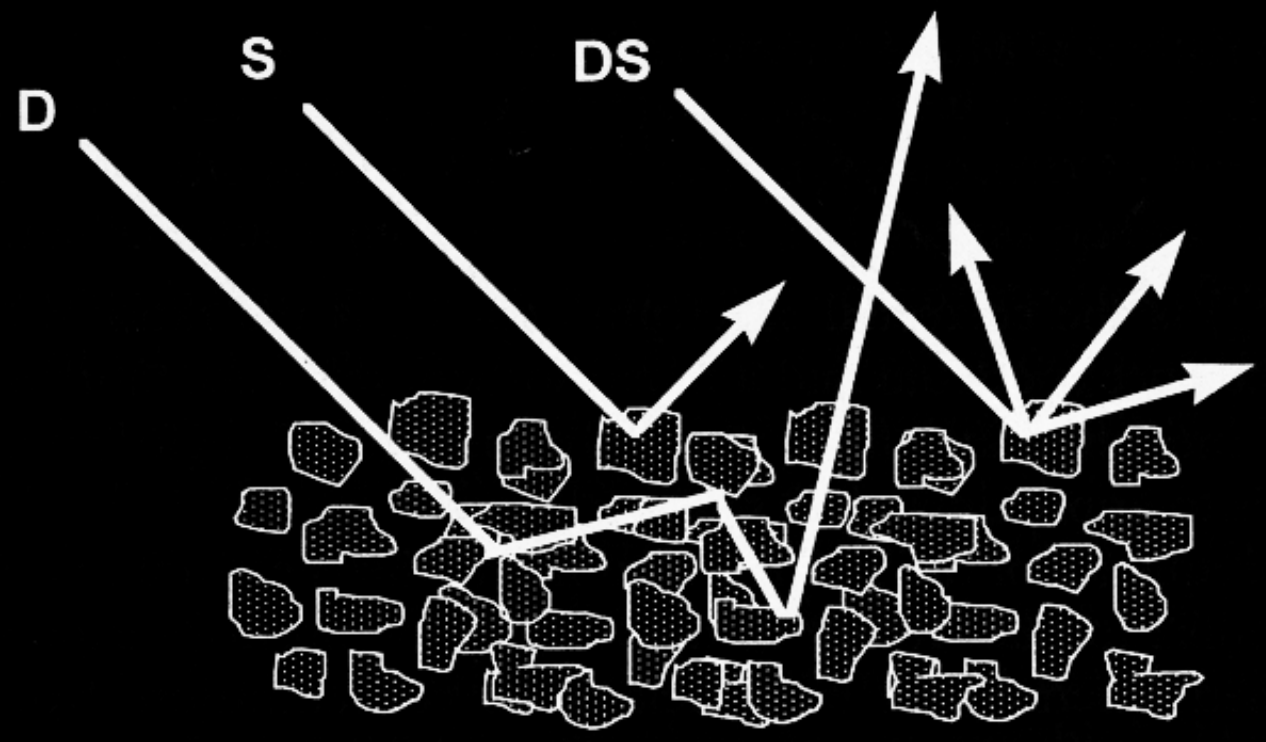
Proximal Visible and Near-Infrared (VisNIR) Diffuse Reflectance Spectroscopy (DRS)



Proximal Visible and Near-Infrared (VisNIR) Diffuse Reflectance Spectroscopy (DRS)



Reflectance Spectroscopy



D = diffuse reflectance
S = specular reflectance
DS = diffuse specular

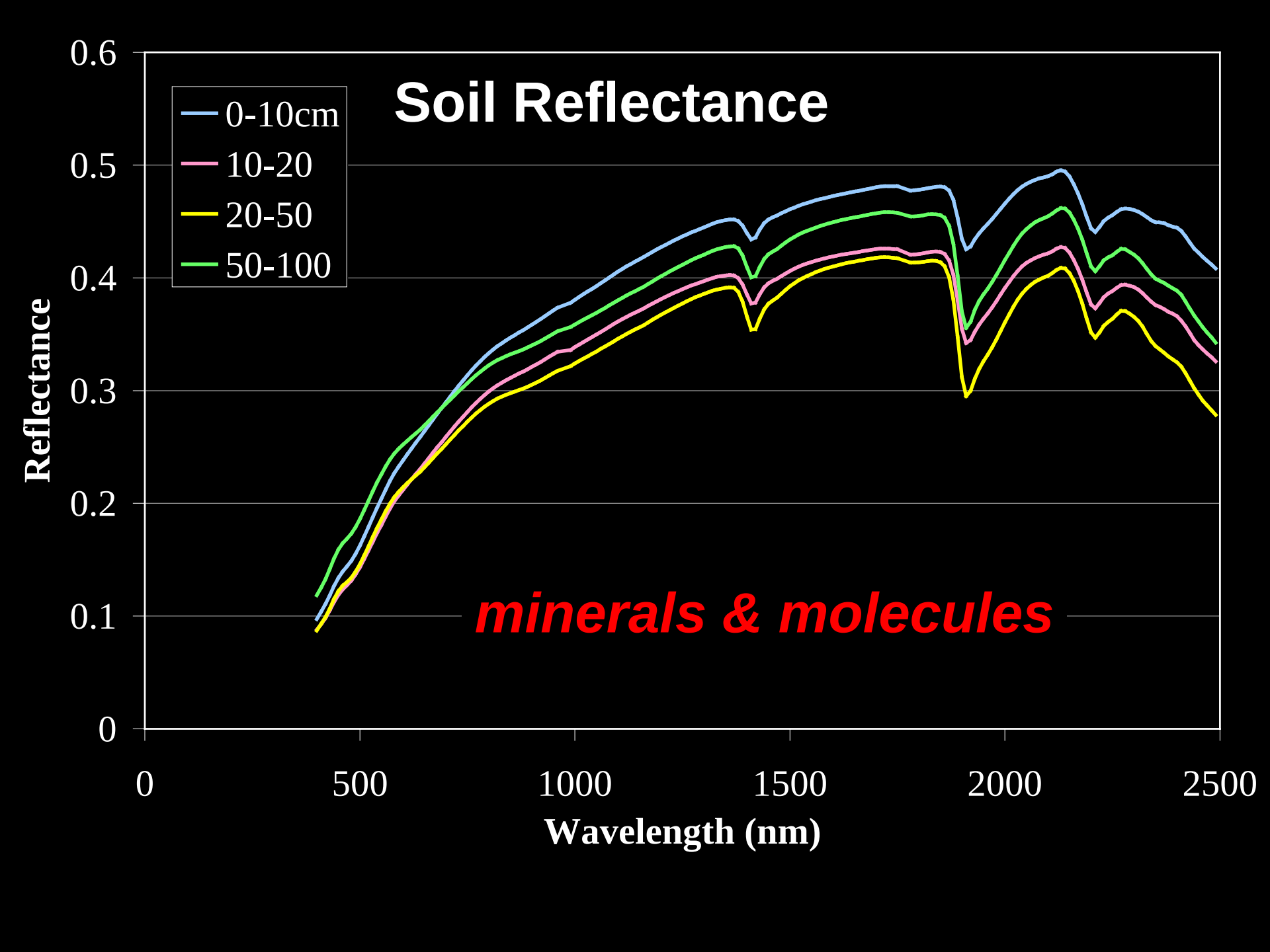
(Coates 1998, p. 73)

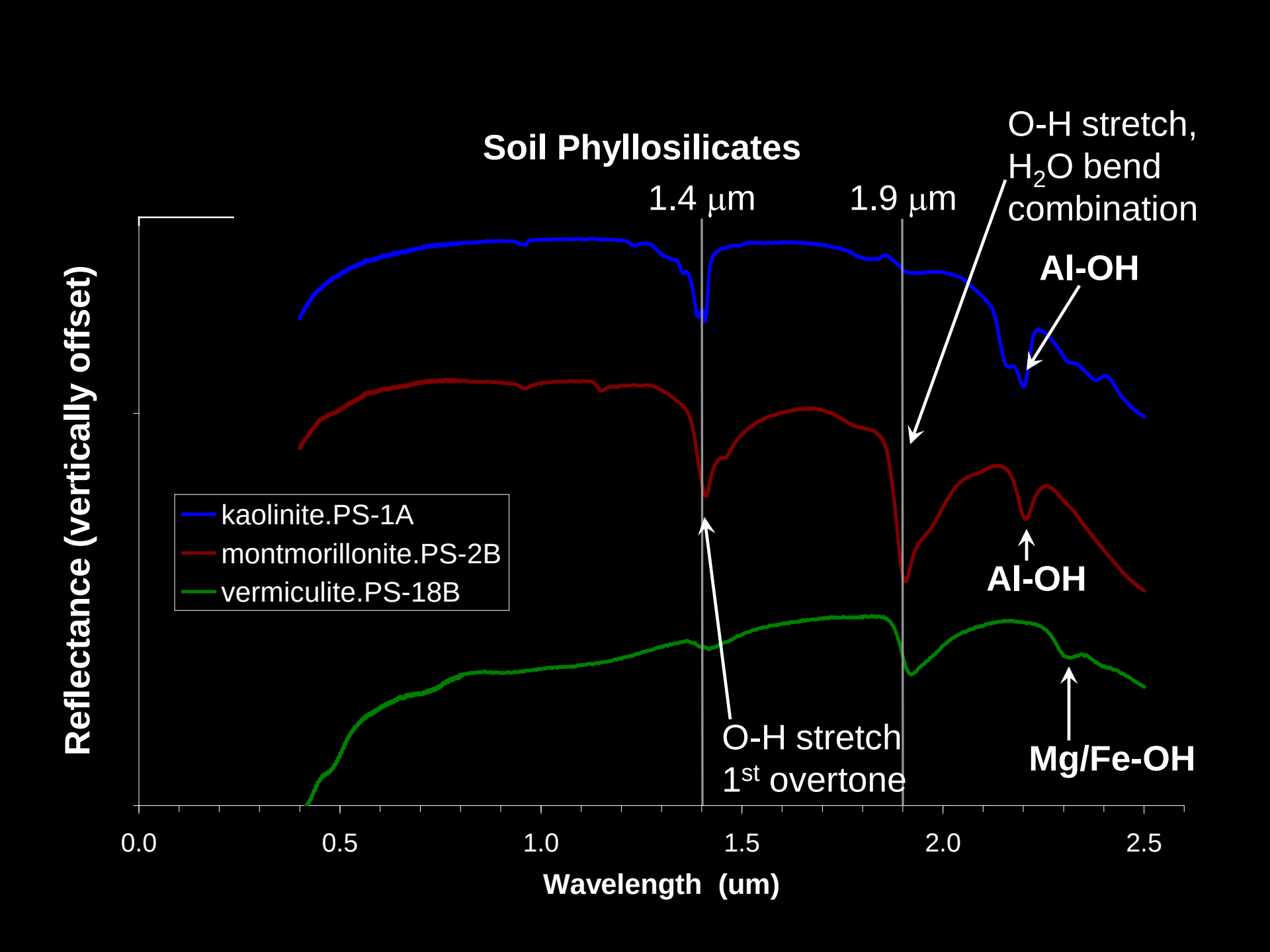
Liquid H_2O

	Frequency	& Wavelength
Fundamental	ν	λ
1st overtone	2ν	$\frac{1}{2}\lambda$
2nd overtone	3ν	$\frac{1}{3}\lambda$

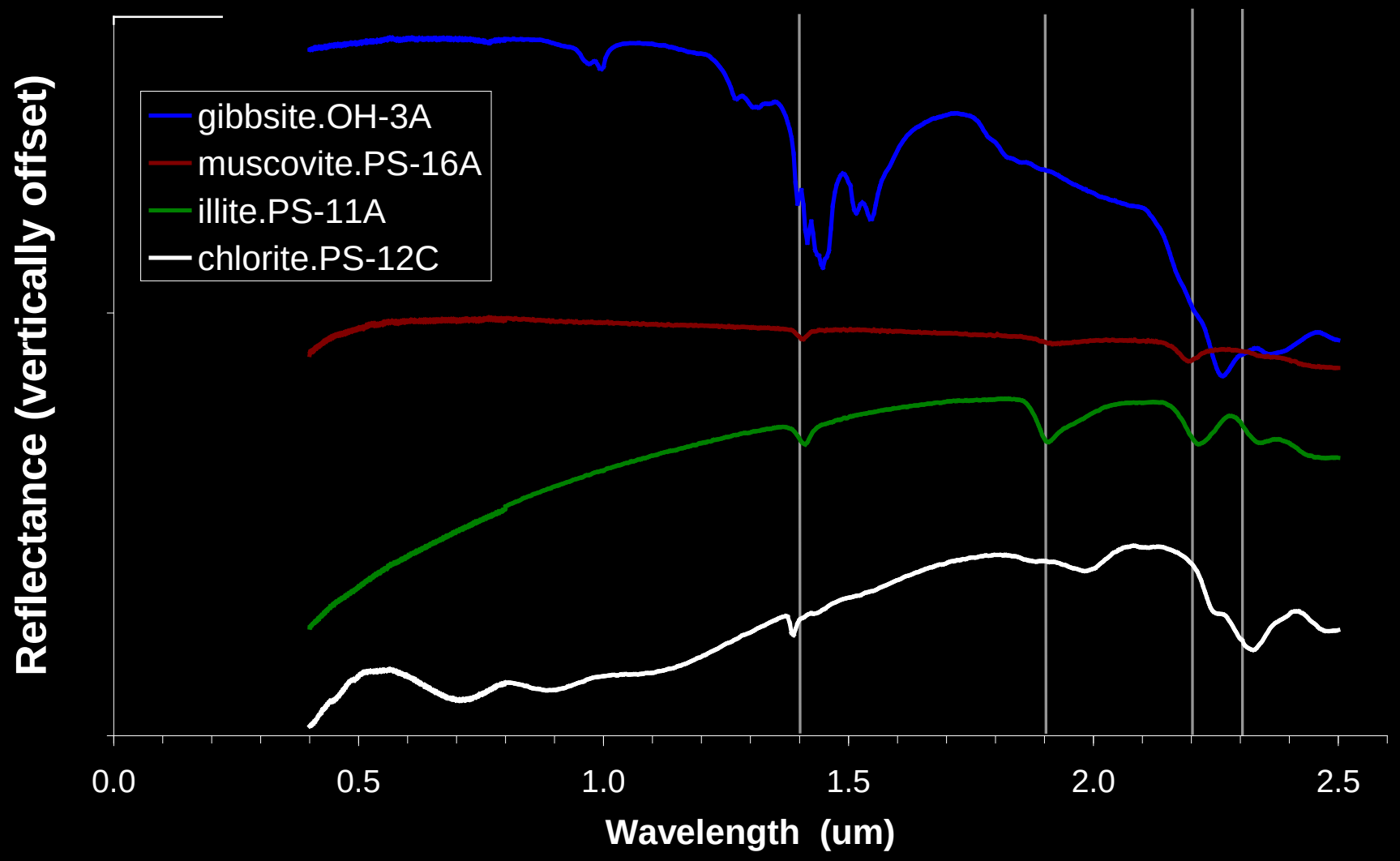
Magnitude decreases by 30-100 × for each

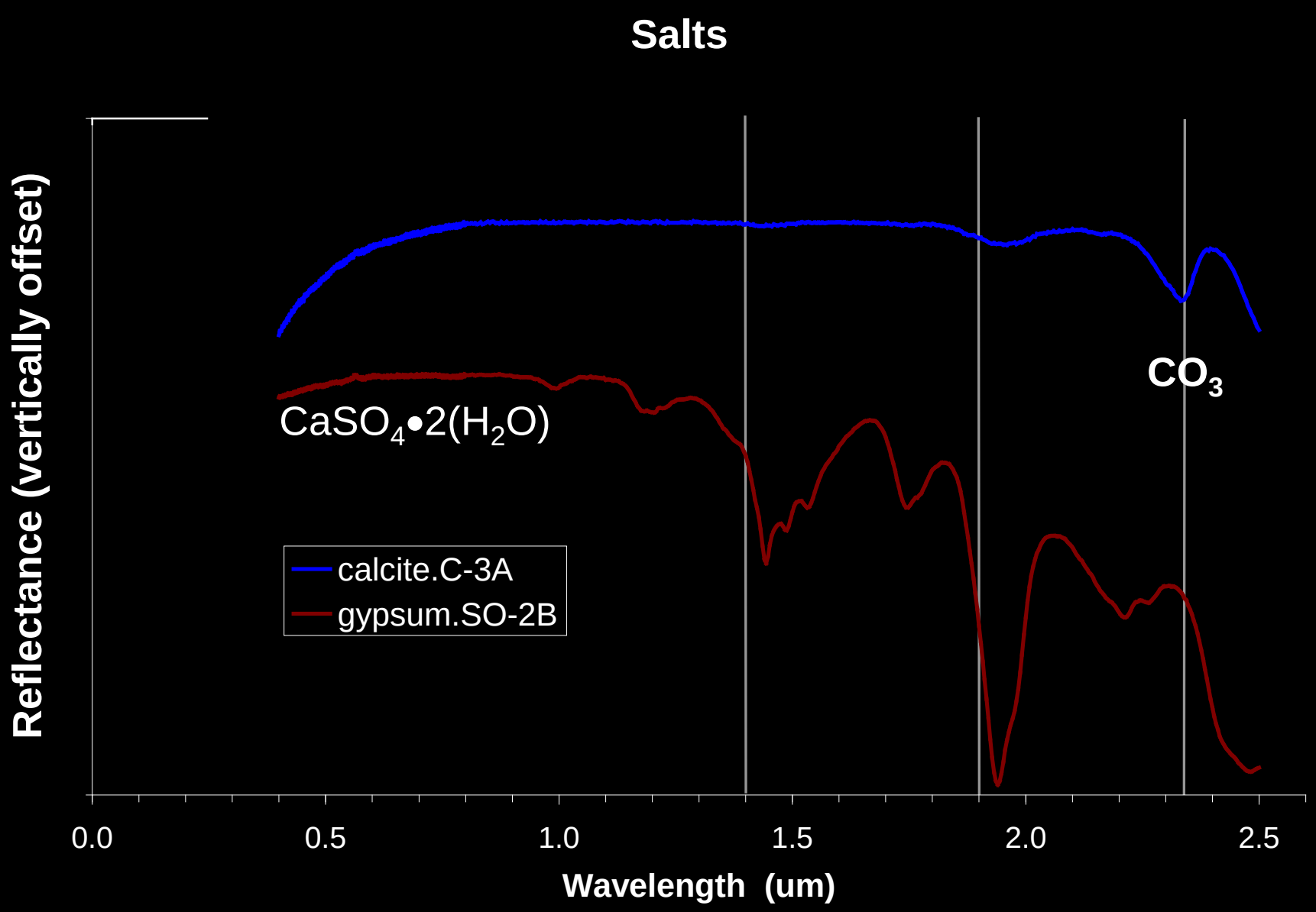
http://www.lsbu.ac.uk/water/vibrat.html

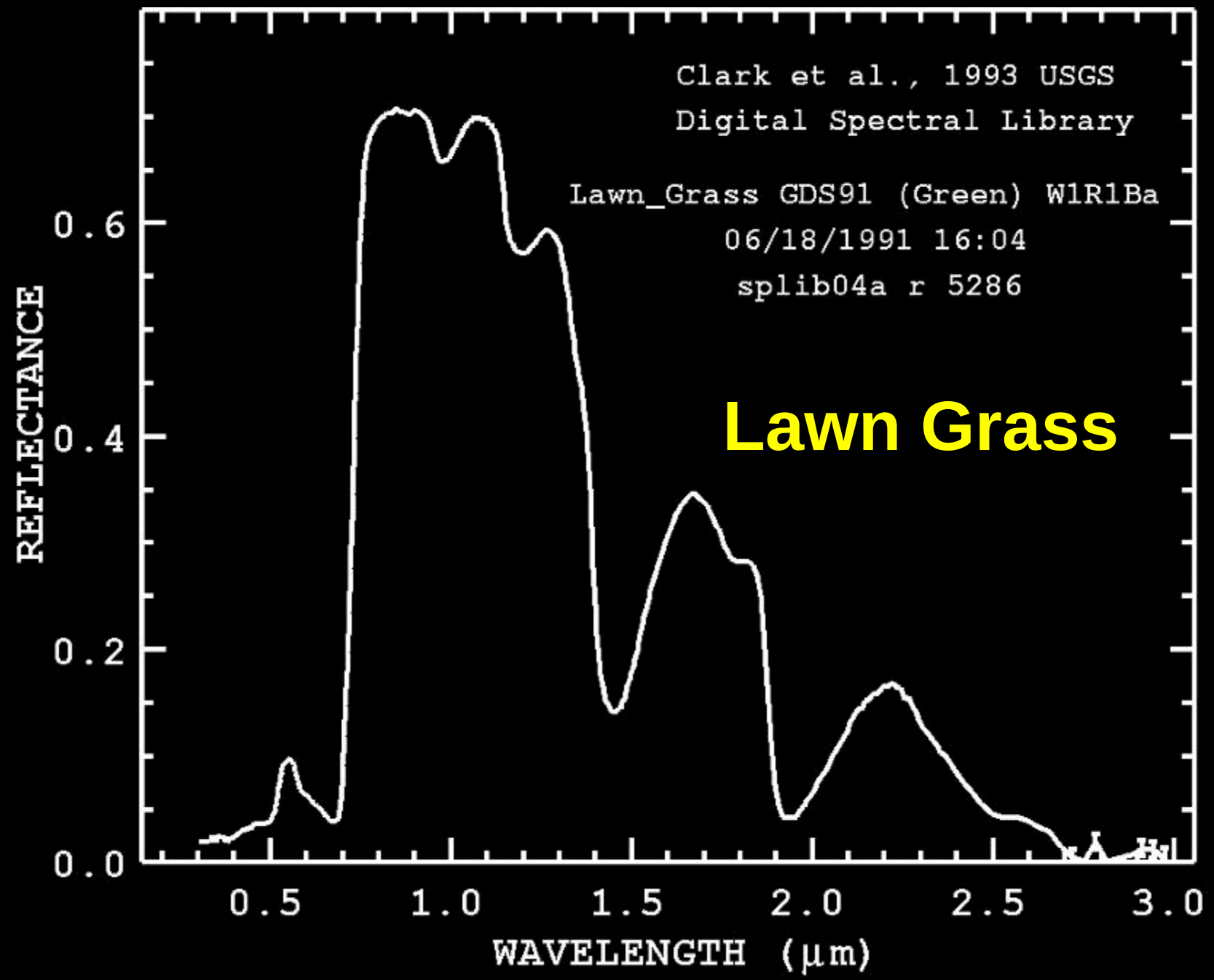

Soil Reflectance
0-10cm
10-20
20-50
50-100
minerals & molecules
Reflectance
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
Wavelength (nm)


Soil Phyllosilicates
1.4 μm
1.9 μm
O-H stretch,
H2O bend
combination
Al-OH
Al-OH
Mg/Fe-OH
O-H stretch
1st overtone
kaolinite.PS-1A
montmorillonite.PS-2B
vermiculite.PS-18B
Reflectance (vertically offset)
0.0
0.5
1.0
1.5
2.0
2.5
Wavelength (um)

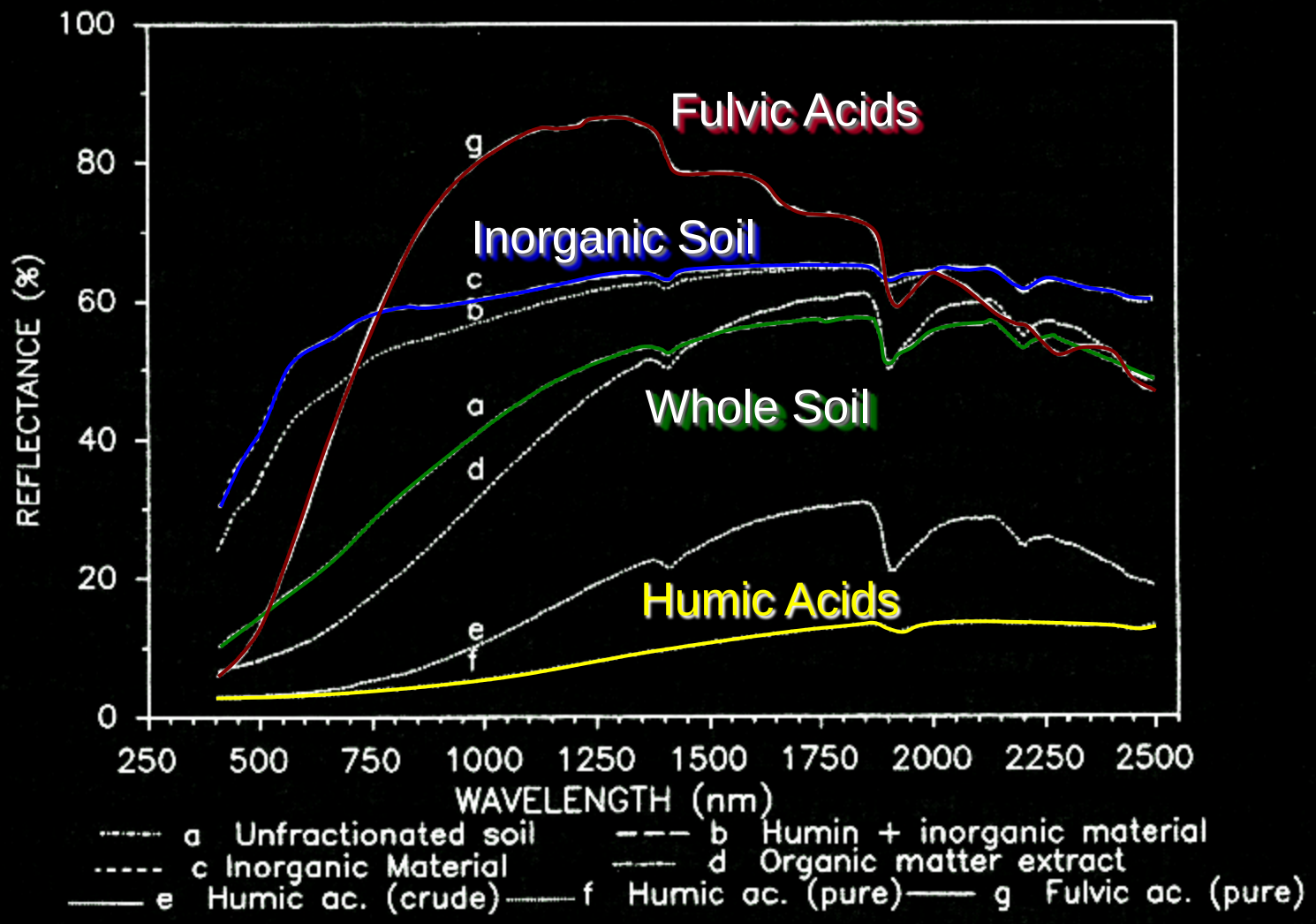
Other clay minerals



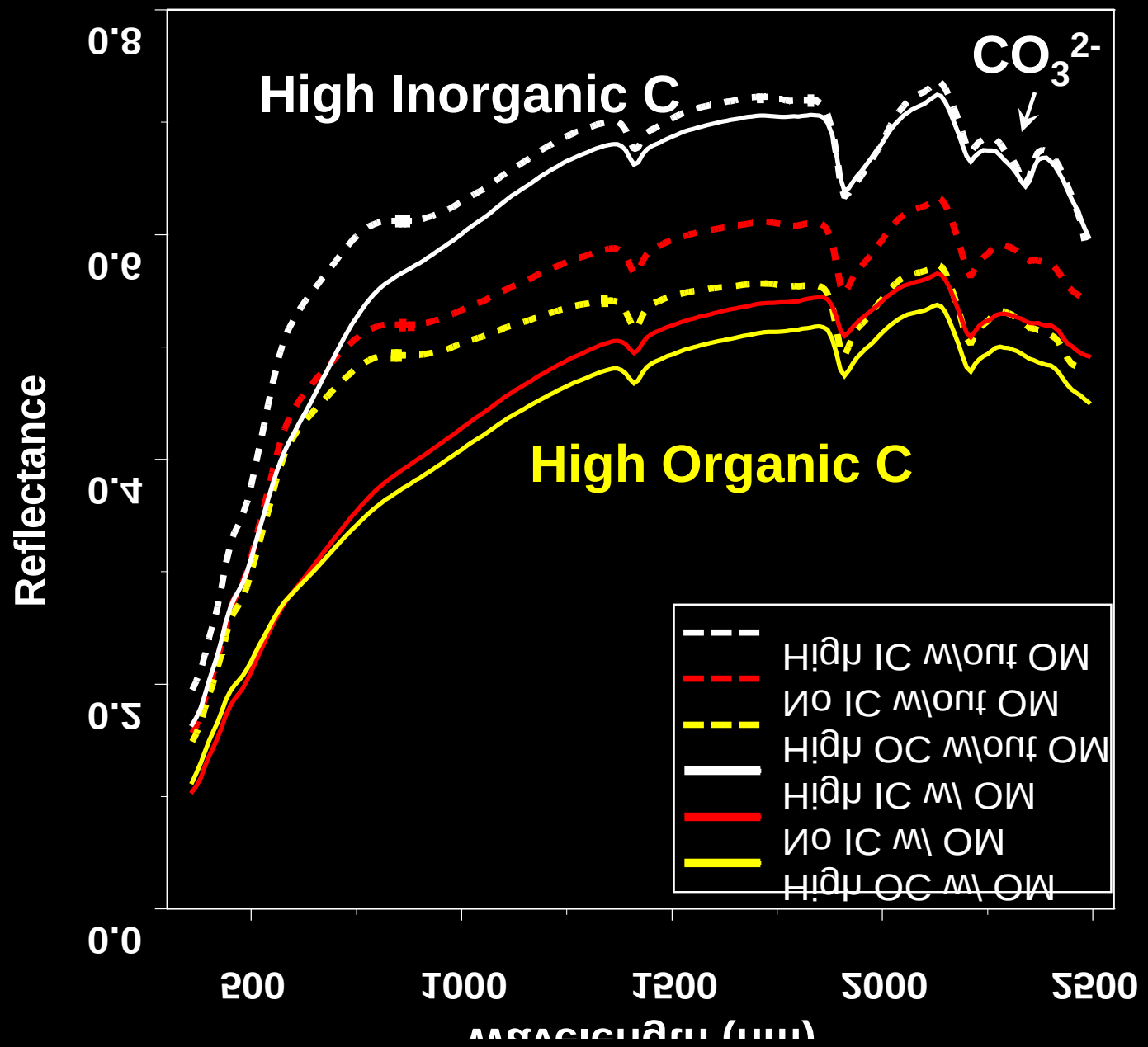

Salts
Reflectance (vertically offset)
CO3
CaSO4•2(H2O)
calcite.C-3A
gypsum.SO-2B
0.0
0.5
1.0
1.5
2.0
2.5
Wavelength (um)


Clark et al., 1993 USGS
Digital Spectral Library
Lawn_Grass GDS91 (Green) W1R1Ba
06/18/1991 16:04
splib04a r 5286
Lawn Grass
REFLECTANCE
0.0
0.2
0.4
0.6
0.5
1.0
1.5
2.0
2.5
3.0
WAVELENGTH (μm)

Soil Organic Matter



(Henderson et al., 1992)



VisNIR

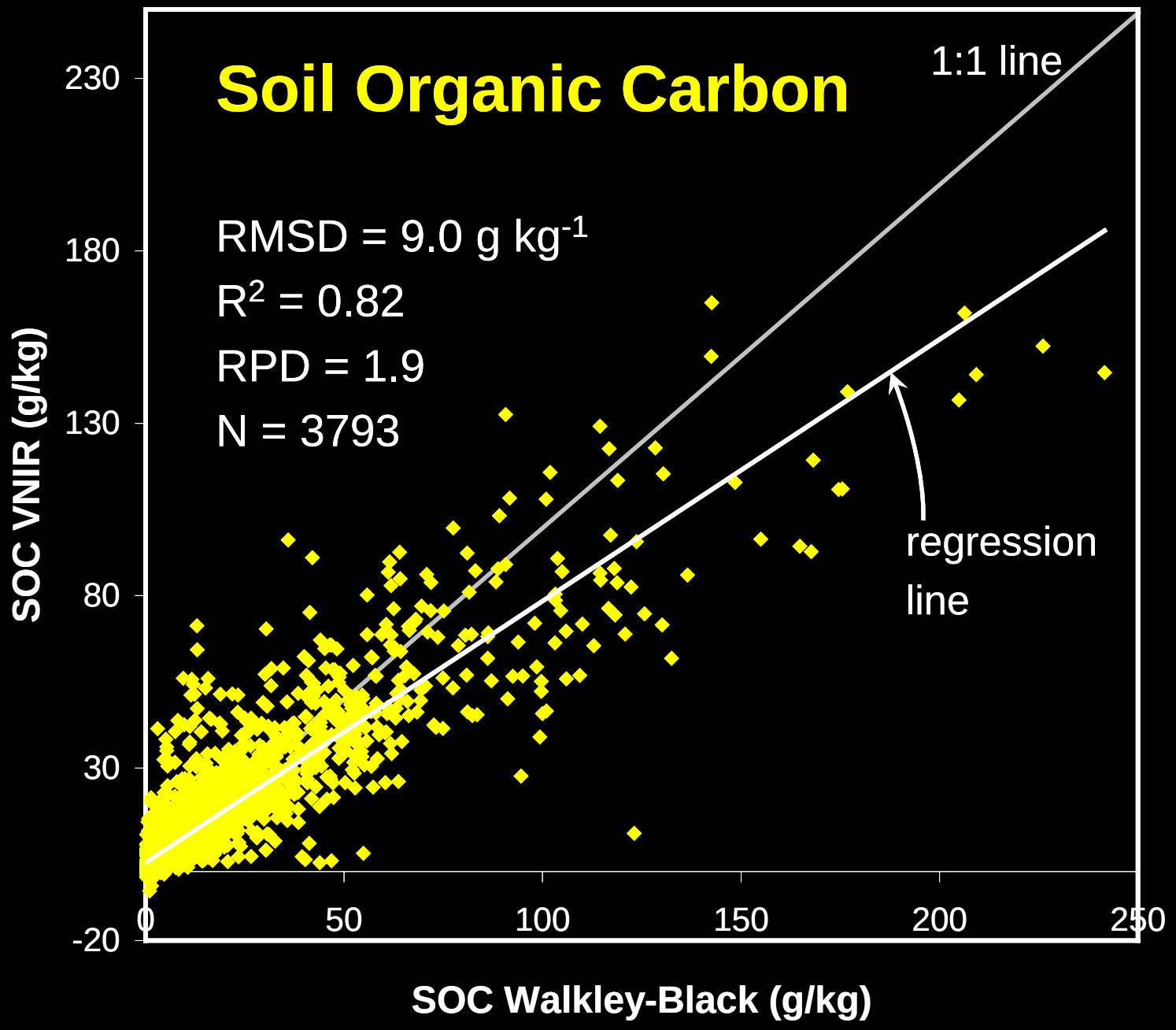
3 Samples With and Without Organic Matter

Statistical modeling (chemometrics)

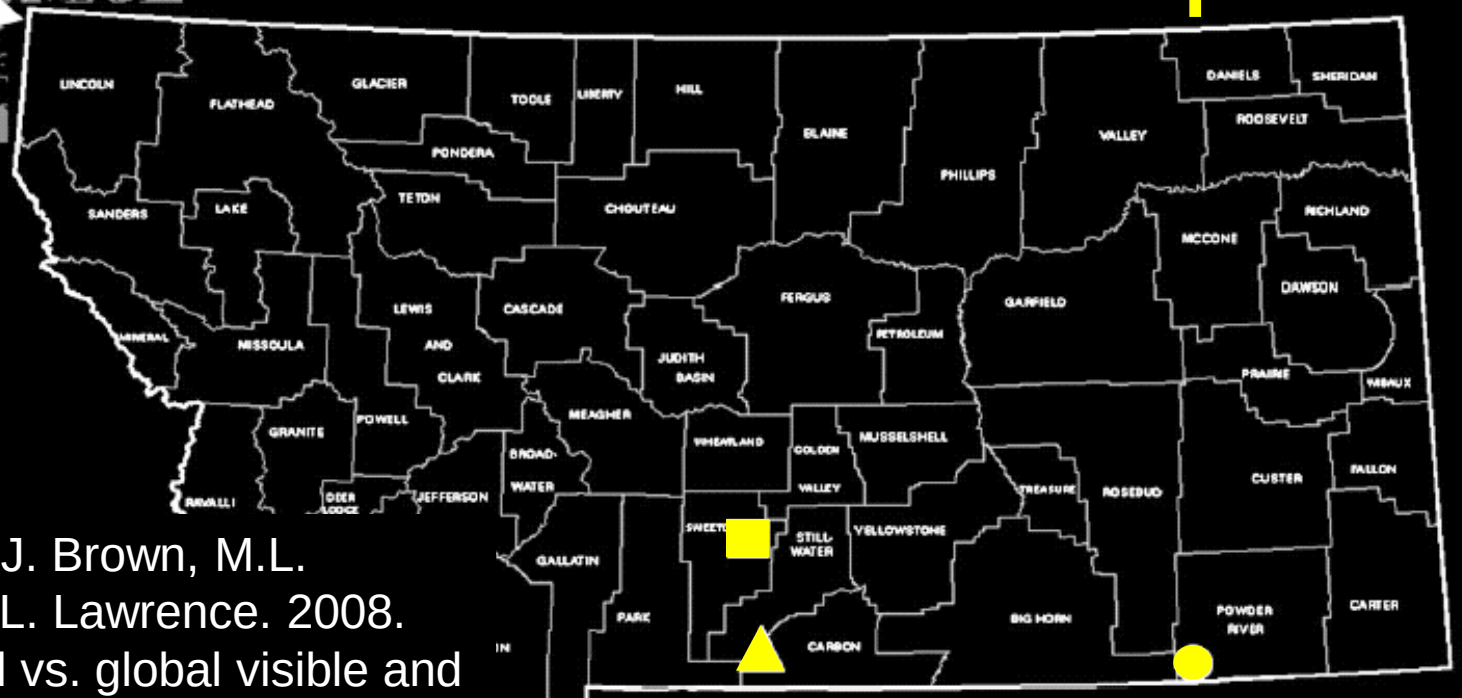
National Soil Survey Center Archives

- 4184 samples from 4184 pedons
  - Diverse, independent, global sampling
  - Air-dried, crushed & sieved
  - Mineralogy, CEC, SOC, $CaCO_3$, pH, texture,…
  - Boosted Regression Trees (Treenet®)
  - 6-fold cross-validation

Brown, D.J., K.D. Shepherd, M.G. Walsh, M.D. Mays, and T.G. Reinsch. 2006. Global soil characterization with VNIR diffuse reflectance spectroscopy. Geoderma 132:273-290.


Soil Organic Carbon
1:1 line
RMSD = 9.0 g kg-1
R2 = 0.82
RPD = 1.9
N = 3793
regression line
SOC VNIR (g/kg)
SOC Walkley-Black (g/kg)
230
180
130
80
30
-20
0
50
100
150
200
250

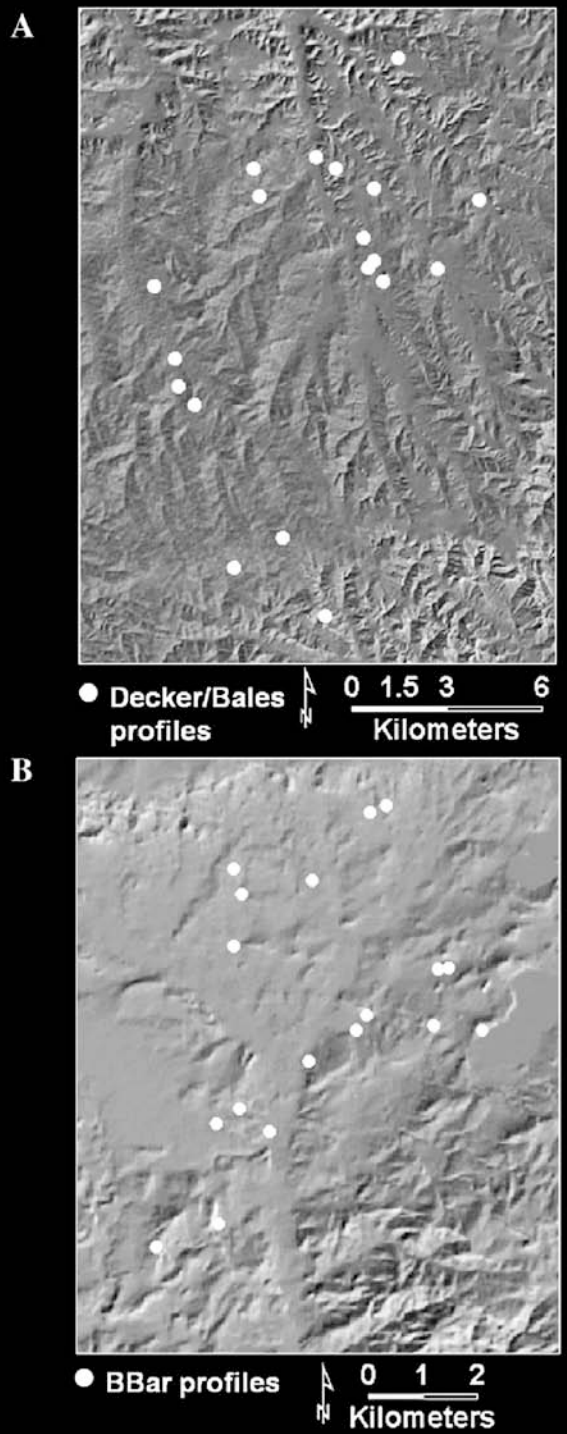
global soil-spectral library
+
local calibration samples

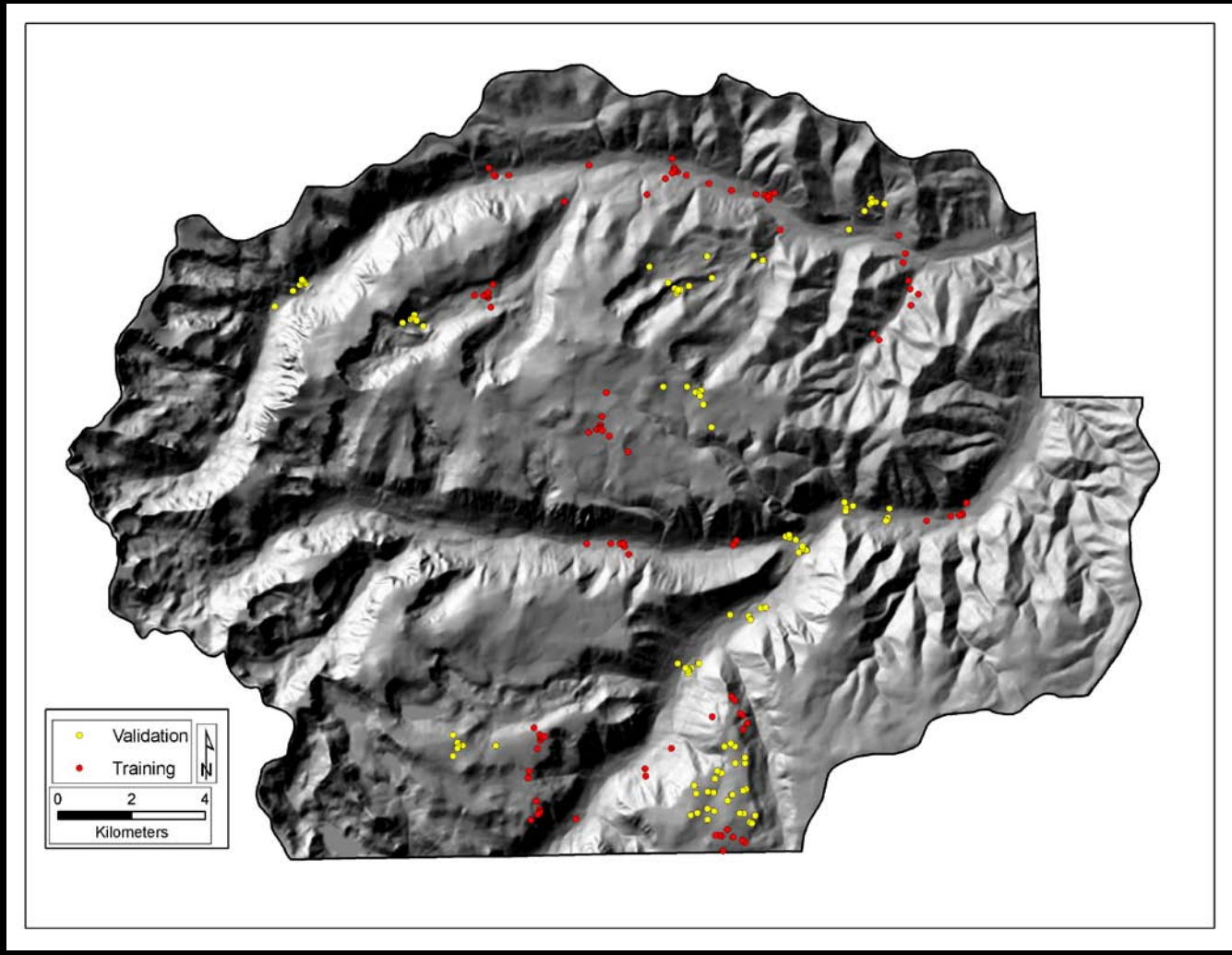


Montana Counties
BBar semiarid grassland
Decker/Bales semiarid grassland
Rock Creek subalpine forest

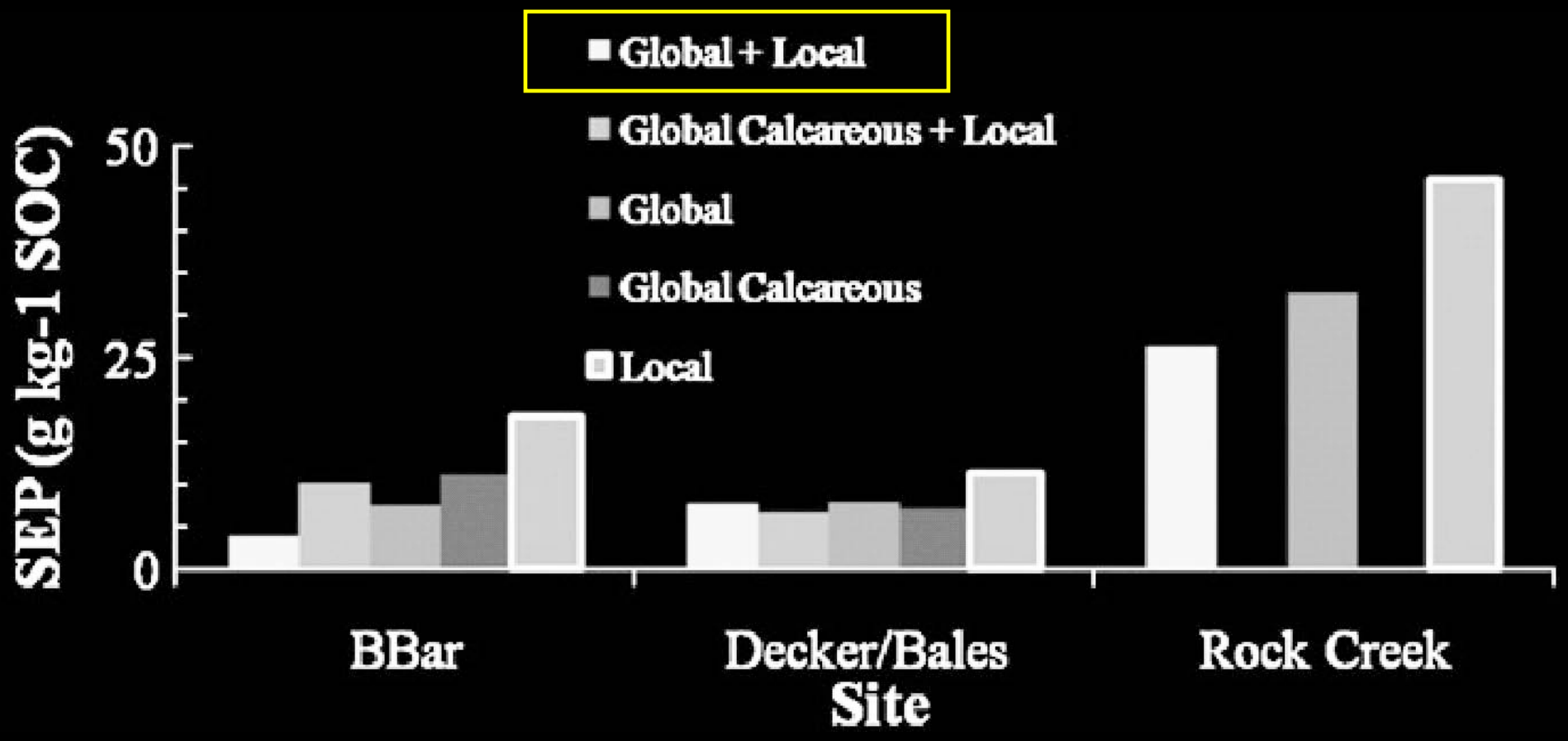
Sankey, J.B., D.J. Brown, M.L. Bernard, and R.L. Lawrence. 2008. Comparing local vs. global visible and near-infrared (VisNIR) diffuse reflectance spectroscopy (DRS) calibrations for the prediction of soil clay, organic C and inorganic C. Geoderma 148:149-158.

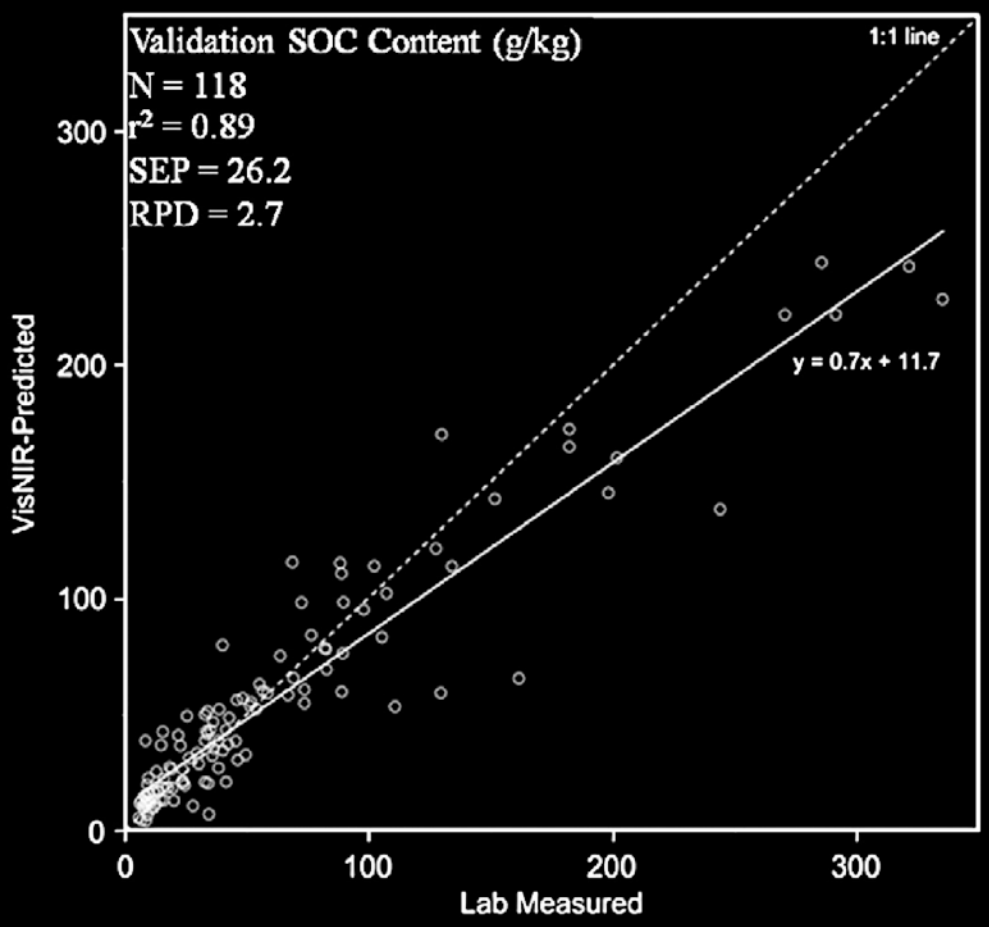
Site-level sampling





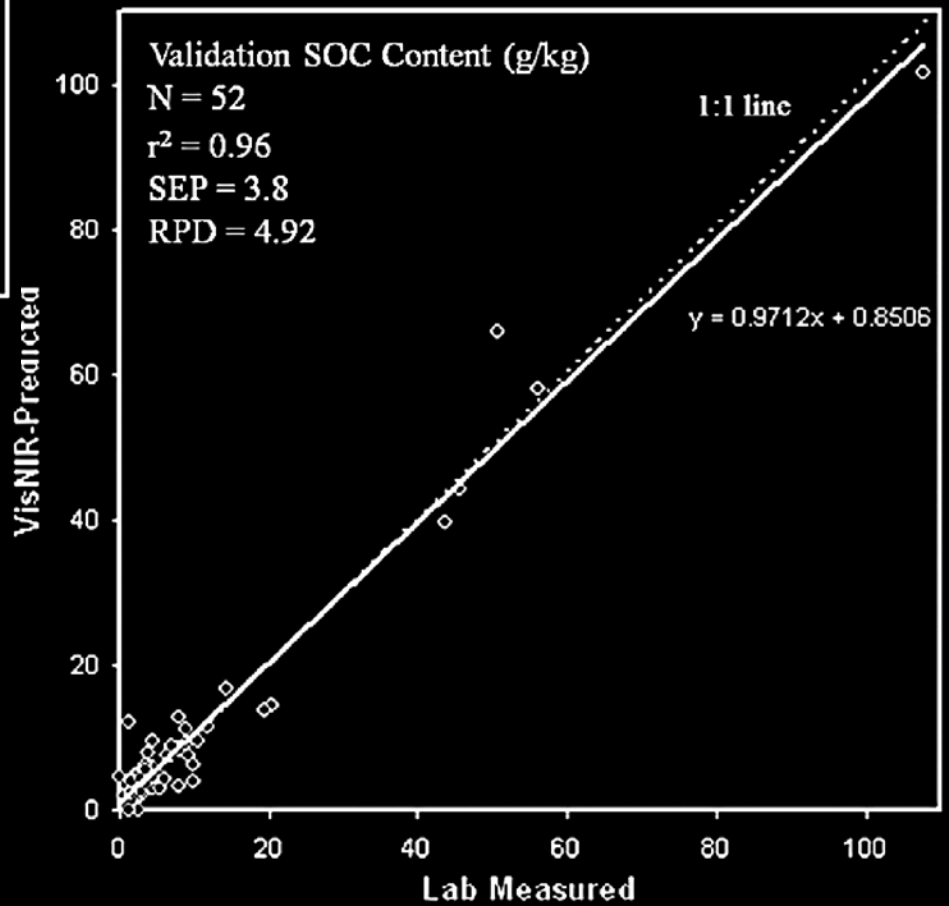
Best results: combine local calibration samples with “global” library

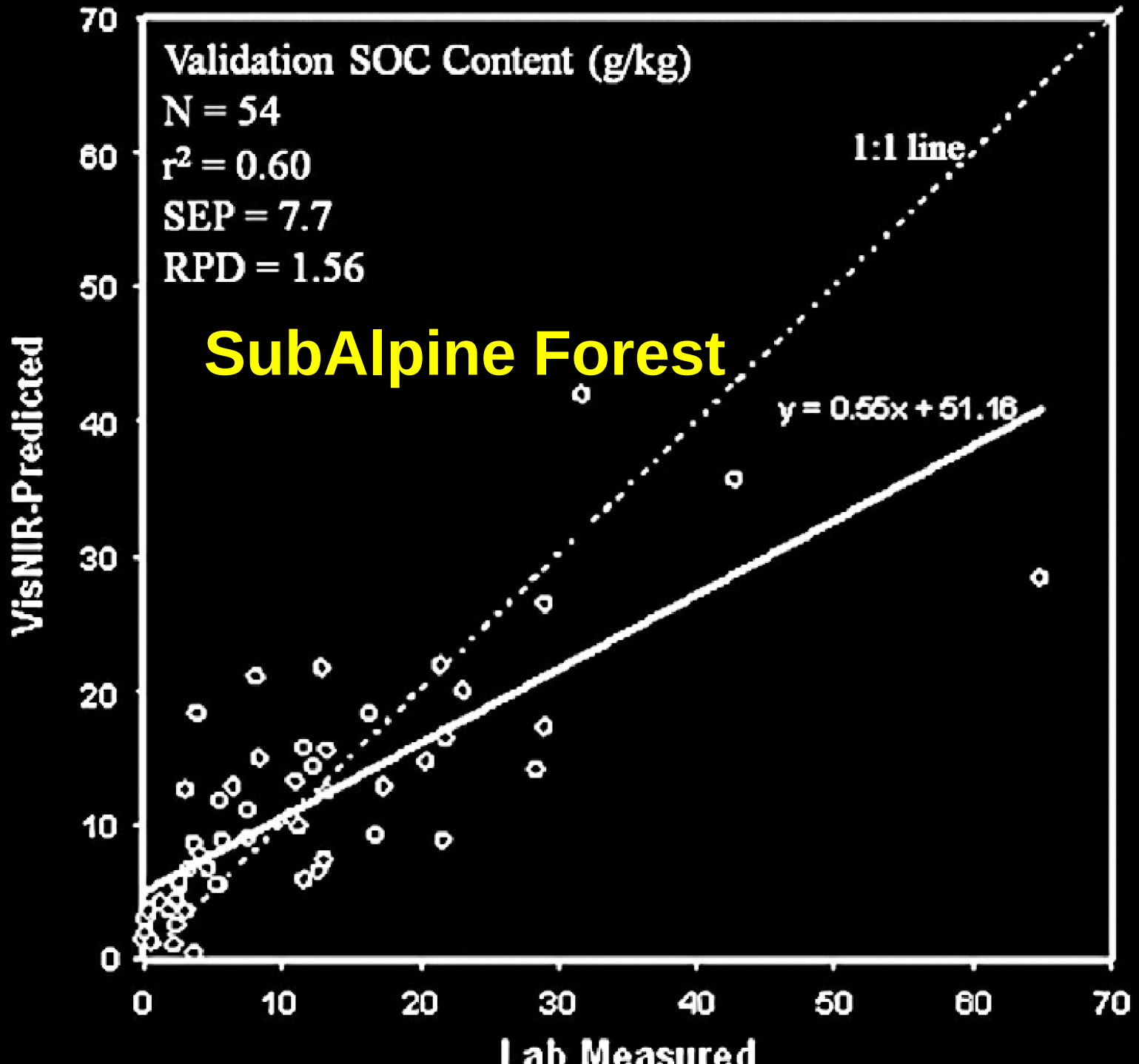




Decker/Bales Ranch

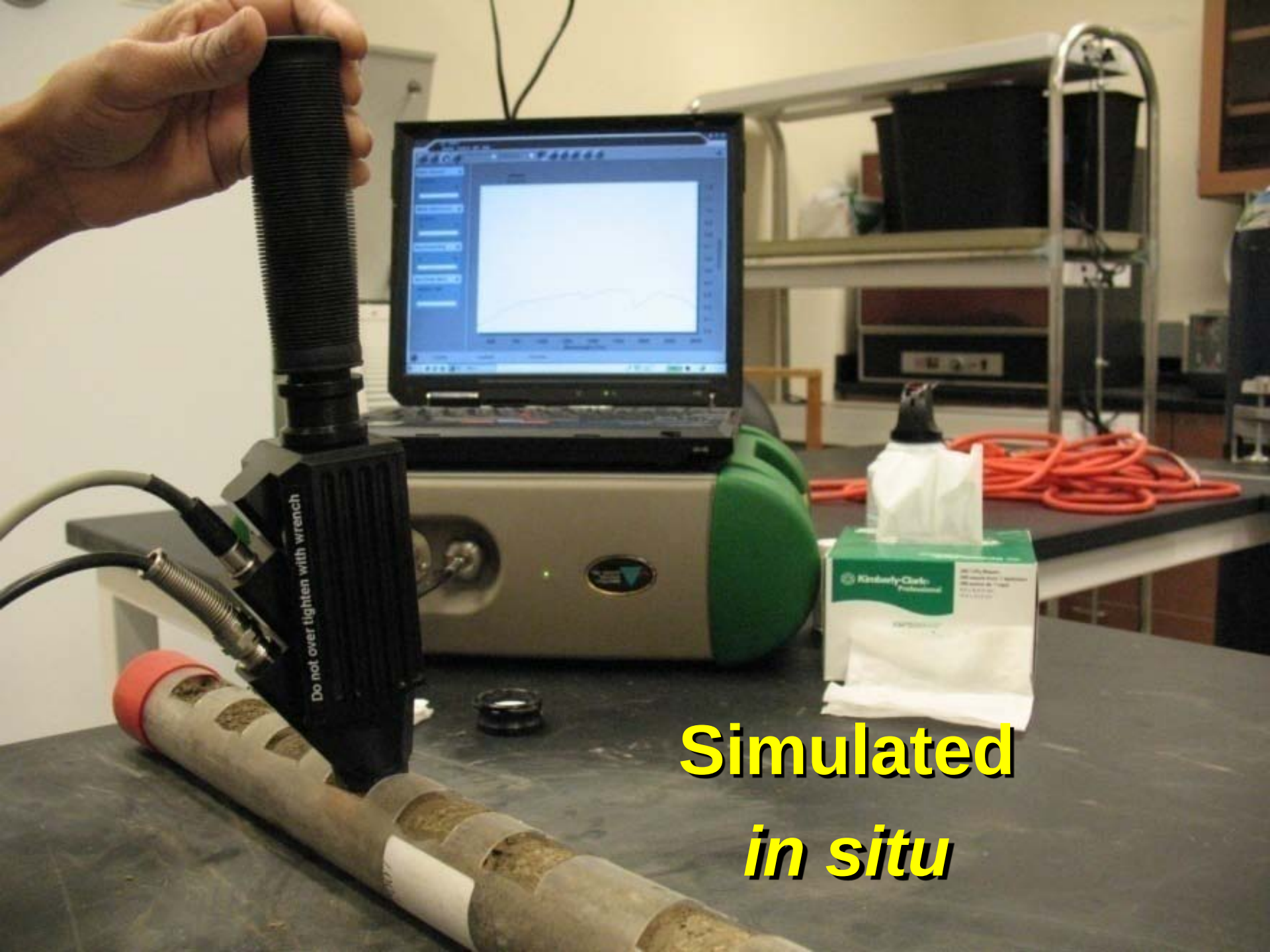
BBar Ranch



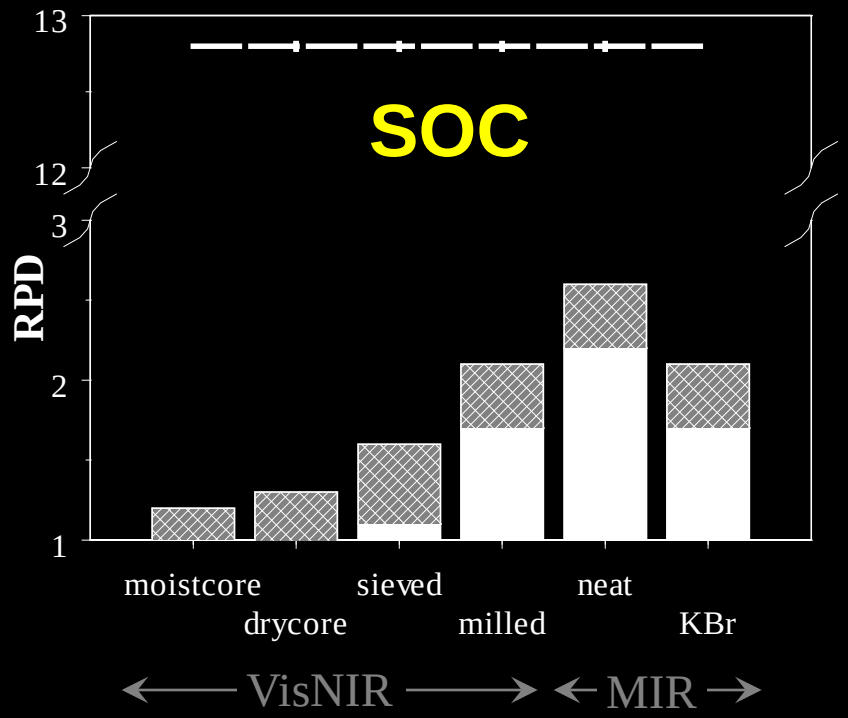


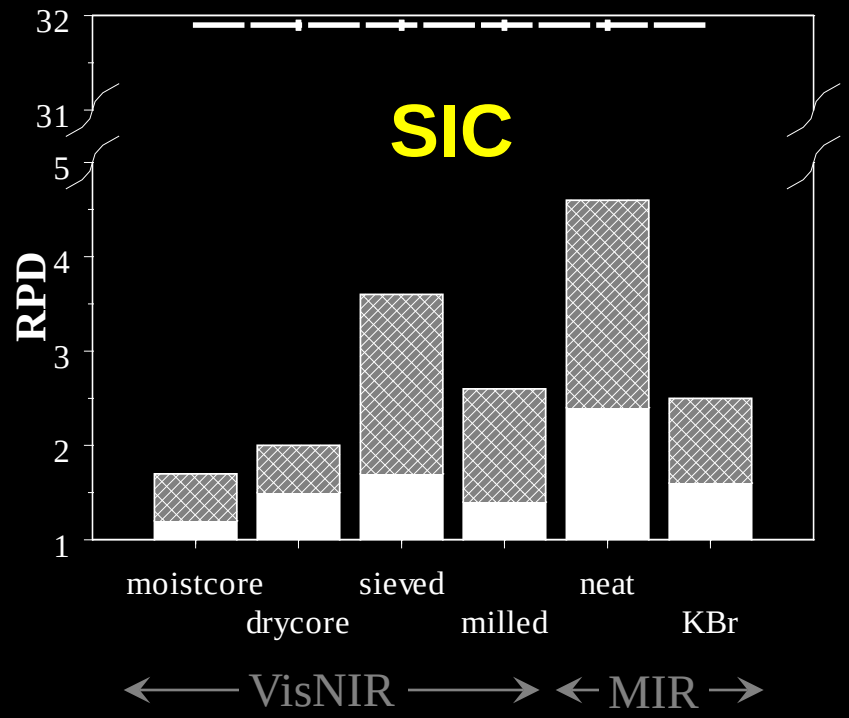
SubAlpine Forest

VisNIR Penetrometer


Do not over tighten with wrench
Kimberly-Clark
Simulated
in situ

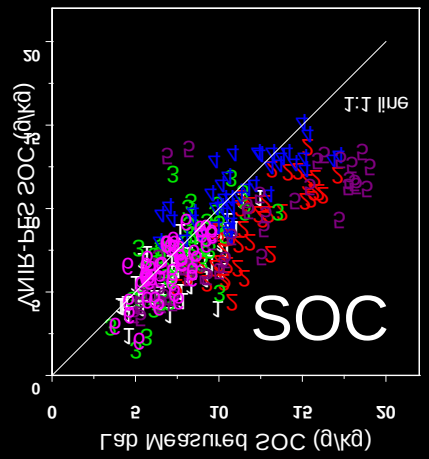
VisNIR – 6 fields in Montana

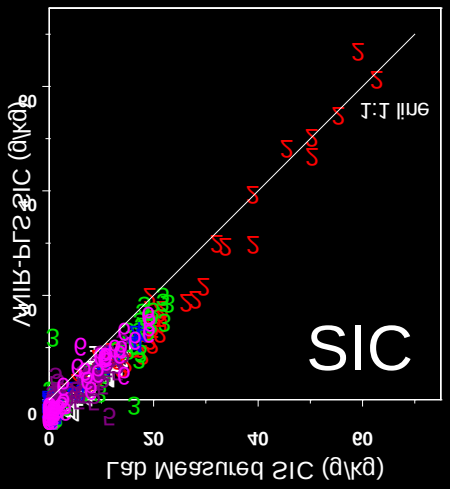




Regional Calibration
+ 2 local cores
Lab Reference

$$RPD = \frac{SD_y}{SEP_y}$$





QUESTIONS?