



# Assessing the influence of mineral surface chemistry on soil organic matter stability in the US in response to climate change



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## Background

- Soil carbon (C) represents a significant pool of carbon storage and sequestration
- Previous works has suggested that some mineral assemblages may be more effective in preserving soil organic matter (SOM) from microbial degradation
- Due to climate change, it is important to quantify differences in SOM stability among soil types and mineral assemblage
- This study focused on
  - examining the distribution of soil mass and C among different mineral density classes
  - estimating differences in C stability by measuring radiocarbon abundance
- The fours soils span a wide range of climate conditions, soil morphology and mineral assemblage
- This variety in soil type was used to examine whether there were trends in the SOM structure or average age of the density fractions across soil types

The four soils were used from different parts of the US at various depths

- Andisols: Volcanic fir forest (Oregon)
- Ultisols: Highly weathered oak forest (Mississippi)
- Gelisols: Permafrost spruce forest (Alaska)
- Mollisols: Basalt pine forest (Arizona)

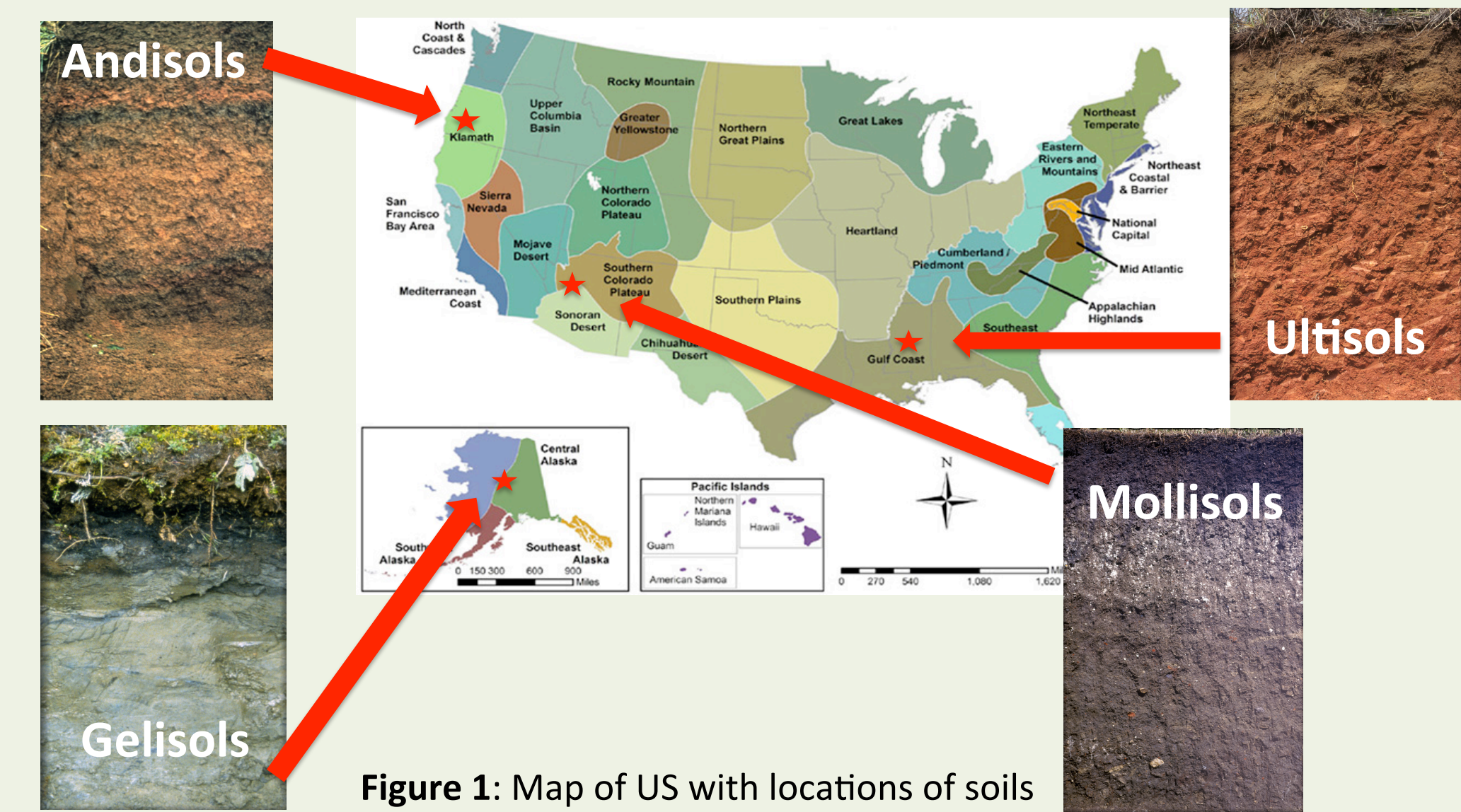


Figure 1: Map of US with locations of soils

## Results

- All soils were dominated by  $<2.6 \text{ g cm}^{-3}$  minerals, following with  $>3.0 \text{ g cm}^{-3}$  with the exception of Permafrost and Highly Weathered soils
- In general,  $<2.6 \text{ g cm}^{-3}$  fraction contained the most C than the densest fraction but the absolute %C varied with depth
- Average age of C increased for all soil types, but differences in avg. age among density fractions did not show a consistent pattern among soils
- Both Volcanic and Basalt soils have Metal-OH stretches and O-Si-O stretching
- Both soils at all densities tested had a peak at  $1600 \text{ cm}^{-1}$

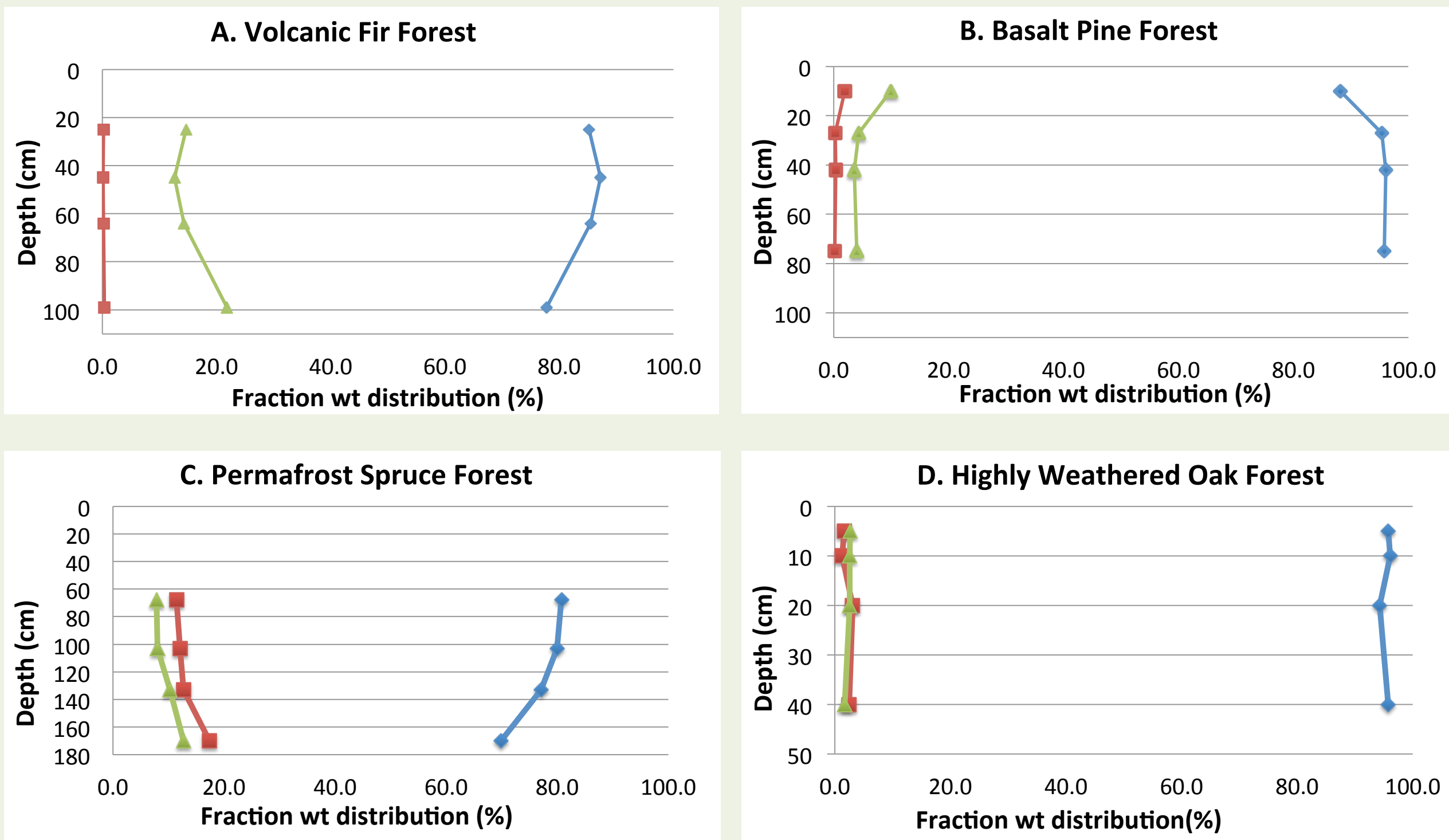


Figure 3: Depth plots for the soil types. Blue line is the minerals with densities  $<2.6 \text{ g cm}^{-3}$ . Red line is the minerals with densities  $2.6\text{-}3.0 \text{ g cm}^{-3}$ . Green line is the minerals with densities  $>3.0 \text{ g cm}^{-3}$ .

### References:

Heckman, Katherine, et al. "Changes in water extractable organic matter during incubation of forest floor material in the presence of quartz, goethite and gibbsite surfaces." *Geochimica et Cosmochimica Acta* 75.15 (2011): 4295-4309.

Nguyen, T. T., Leslie J. Janik, and M. Raupach. "Diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy in soil studies." *Soil Research* 29.1 (1991): 49-67.

### Acknowledgment:

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## Methods

### 1. Soil Sampling

- Samples from four soil profiles were taken from archives collected by the USGS, EPA and University of Arizona.

### 2. Sequential density separations

- Minerals were separated by density into 3 categories: light, intermediate, and heavy mineral fractions
- Separations were carried out using solutions of sodium polytungstate (SPT) at densities  $2.6 \text{ g cm}^{-3}$  and  $3.0 \text{ g cm}^{-3}$

### 3. Graphitization and radiocarbon measurement

- Samples were combusted at  $900^\circ\text{C}$  for 4 hours
- $\text{CO}_2$  was purified and reduced to graphite using the following reaction:  
$$\text{CO}_{2(g)} + \text{H}_{2(g)} \xrightarrow[\text{Fe}^{2+}]{\Delta} \text{C}_{(\text{graphite})} + \text{H}_2\text{O}_{(l)}$$
- Radiocarbon abundances for the fractions were measured on the Accelerator Mass Spectrometer (AMS) at CAMS

### 4. Fourier Transform Infrared-Attenuated Total Reflection (FTIR-ATR)

- Samples were measure from  $650 \text{ cm}^{-1}$  to  $4000 \text{ cm}^{-1}$ , 128 scans were taken at a resolution of  $4 \text{ cm}^{-1}$

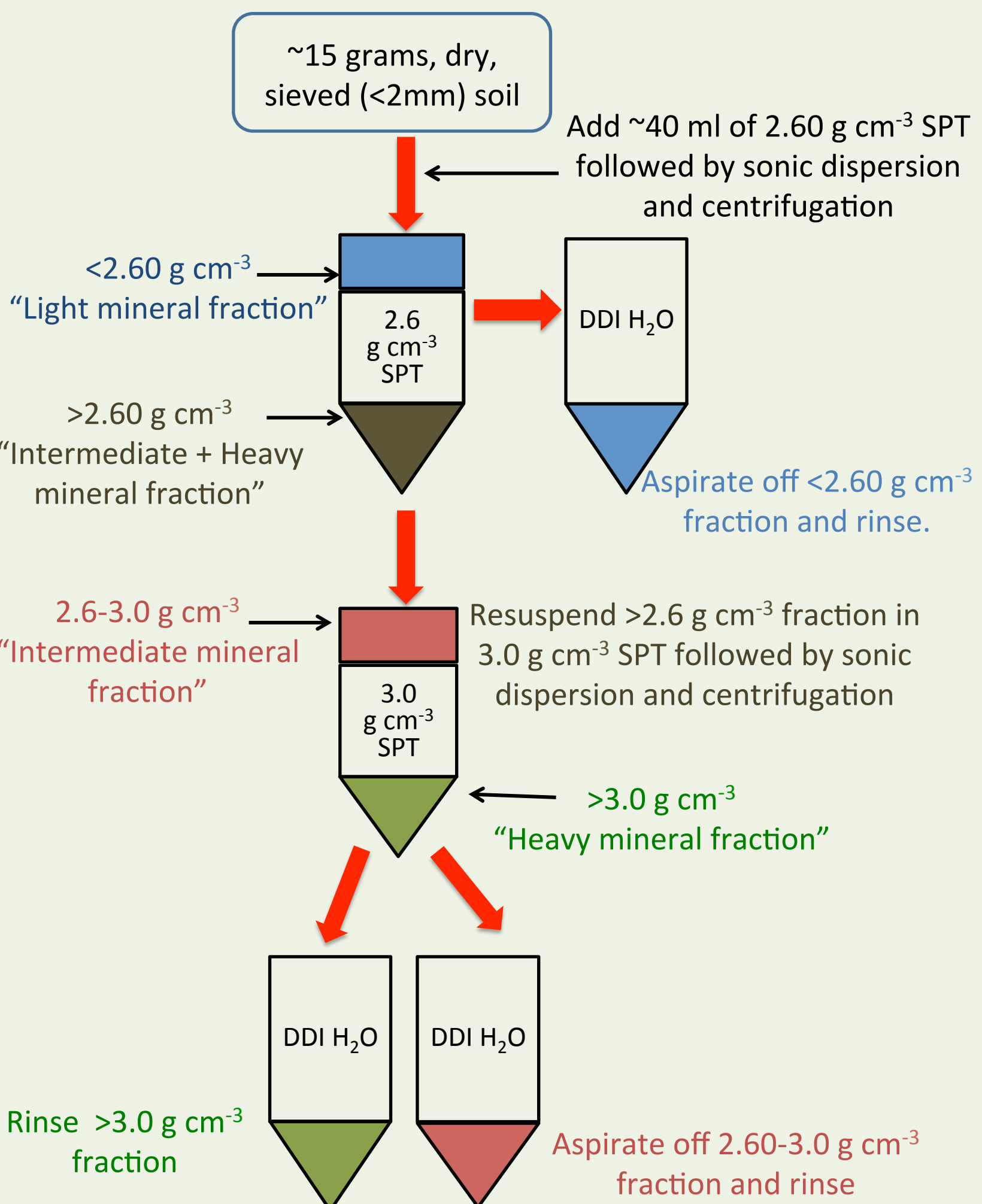


Figure 2: Sequential density separations schematic

Wavenumber (cm <sup>-1</sup> )	Assignment
3600-3575	Hydroxyl + Al-OH deformation vibrations
3460	Metal-OH stretch
3300	-OH stretch
2900-2800	CH <sub>2</sub> and CH <sub>3</sub> stretching
1600	SPT + C=O stretch (amides) + asymmetric COO <sup>-</sup> stretch
1450	CH <sub>2</sub> scissoring
1400	Symmetric COO <sup>-</sup> stretch
1200	-CO (polysaccharides) + -OH deformation of COOH
980	-CO stretch (polysaccharides) + minerals
950	-CO stretch (polysaccharides)
~915-800	O-Si-O stretching + Al-OH deformation vibrations
~780-675	O-Si-O stretching

Table 2: Wavenumbers (cm<sup>-1</sup>) and their corresponding peak assignments for the FTIR-ATR graphs for Volcanic Fir Forest (Figure 4.A) and Basalt Pine Forest (Figure 5.B)

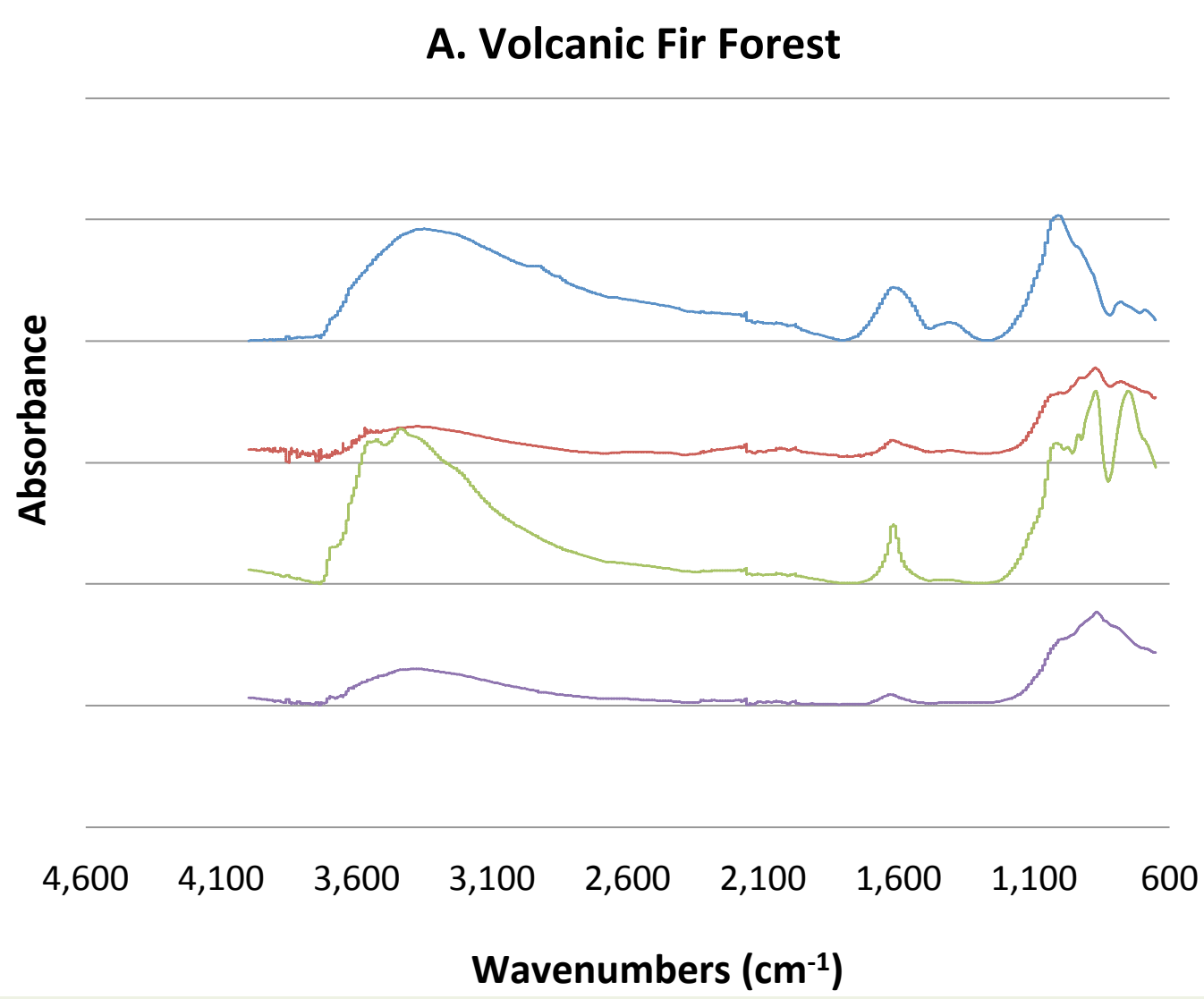


Figure 4: FTIR-ATR data for Volcanic Fir Forest. Blue line is soil sample 45 cm deep with density  $<2.6 \text{ g cm}^{-3}$ . Red line is soil sample at same depth density  $>3.0 \text{ g cm}^{-3}$ . Green line is soil sample 99 cm deep with density  $<2.6 \text{ g cm}^{-3}$ . Purple line is soil sample at same depth with density  $>3.0 \text{ g cm}^{-3}$ . Automatic baseline correction as well as ATR correction was applied to the data.

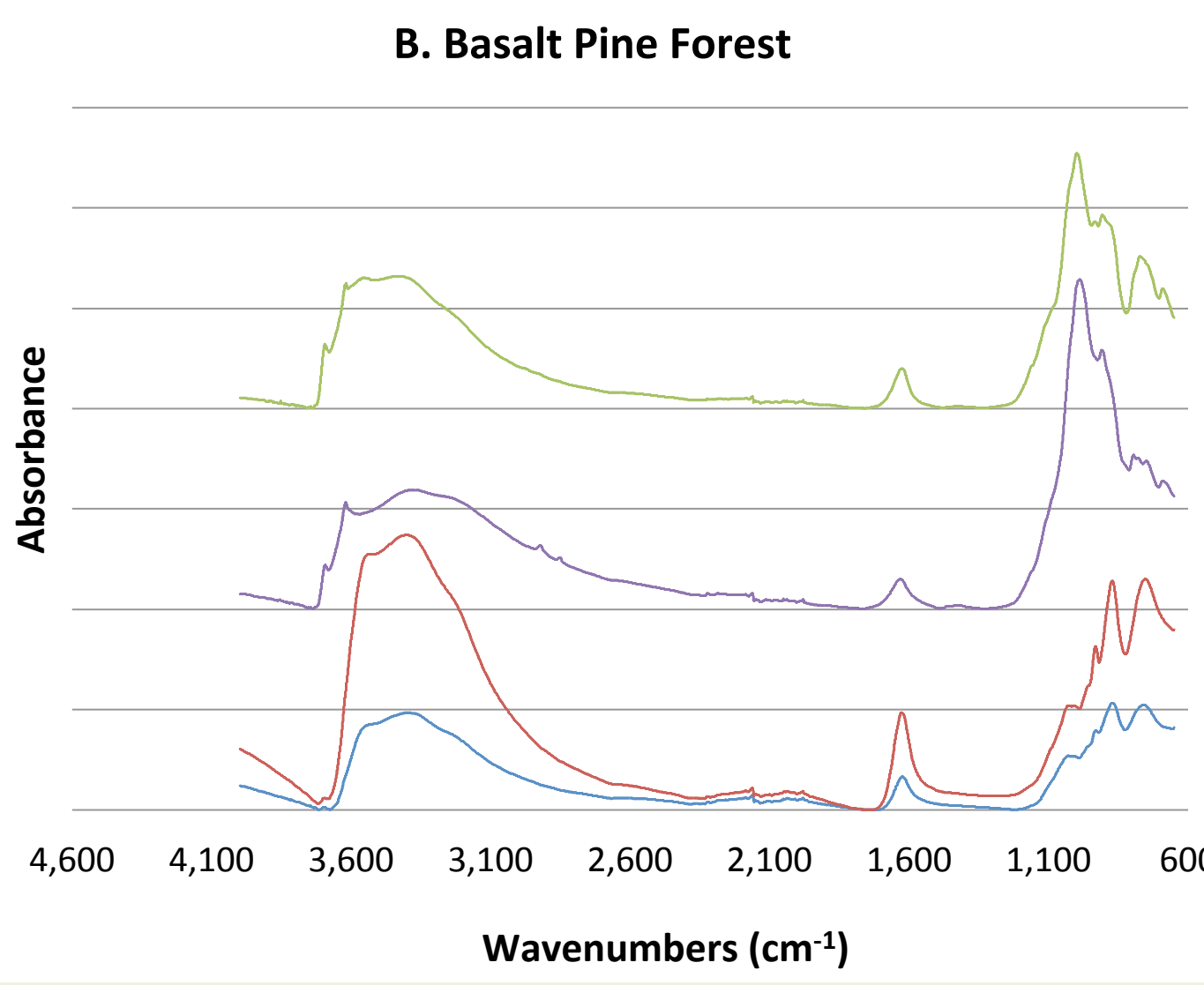


Figure 5: FTIR-ATR data for Basalt Pine Forest. Green line is soil sample 27 cm deep with density  $<2.6 \text{ g cm}^{-3}$ . Purple line is sample at same depth density  $2.6\text{-}3.0 \text{ g cm}^{-3}$ . Red line is soil sample 75 cm deep with density  $>3.0 \text{ g cm}^{-3}$ . Blue line is soil sample 27 cm deep with density  $>3.0 \text{ g cm}^{-3}$ . Automatic baseline correction as well as ATR correction was applied to the data.

## Conclusion

- FTIR-ATR data implied variation in mineral assemblage and C structure among the density fractions
- Both Volcanic and Basalt soils have peaks at  $1600 \text{ cm}^{-1}$ , possible sign of residual SPT in soils
- Basalt Pine Forest have very similar minerals with density  $>3.0 \text{ g cm}^{-3}$  despite different depths
- Basalt Pine Forest minerals with density  $2.6\text{-}3.0 \text{ g cm}^{-3}$  show IR absorbances associated with aliphatic  $\text{CH}_2$  and  $\text{CH}_3$  stretching, suggesting there minerals may be absorbing fatty acids
- Differences in SOM abundance among the fractions and average age of C likely linked to differences in climate

## Future Work

- Rinse samples with DI water to remove SPT from samples to recollect FTIR-ATR and radiocarbon measurements
- More sequential density separations on different soil types in different locations
- X-Ray Diffraction on the samples to confirm differences in mineral composition
- Results will be used to model the response of soil organic C stocks to changes in climate



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