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 have 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 four soils span a wide range of climate conditions, soil morphology and mineral assemblage
- This variety in soil type was used to determine whether there is a trend 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)

Results

- All soils were dominated by <2.6 g cm⁻³ minerals, following with >3.0 g cm⁻³ with the exception of Permafrost and Highly Weathered soils.
- In general, <2.6 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-DH stretches and O-Si-O stretching
- Both soils at all densities tested had a peak at 1600 cm⁻³

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 g cm⁻³ and 3.0 g cm⁻³.

3. Graphitisation and radiocarbon measurement
- Samples were combusted at 900 °C for 4 hours
- CO₂ was purified and reduced to graphite using the following reaction:
  \[ CO_2 + H_2O \rightarrow CO + H_2 + O_2 \]
- 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 cm⁻¹ to 4000 cm⁻¹, 128 scans were taken at a resolution of 4 cm⁻¹

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 cm⁻¹, possible sign of residual SPT in soils.
- Basalt Pine Forest have very similar minerals with density >3.0 g cm⁻³ despite different depths
- Basalt Pine Forest minerals with density 2.6-3.0 g cm⁻³ show IR absorbances associated with aliphatic CH₂ and CH₃ 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.

References:


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