The Influence of Soil Organic Matter Stabilization Mechanisms on Carbon Mean Residence Time Within Various Ecosystems in the United States

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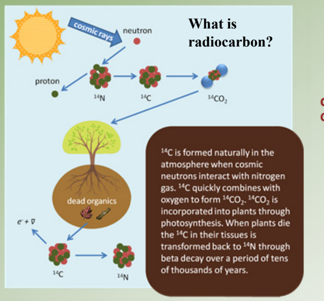
Abstract

Some terrestrial ecosystems and soils serve as carbon sinks, partially offsetting rising atmospheric CO_2 levels. Physiochemical mechanisms of soil organic matter (SOM) stabilization affect how carbon stocks respond to global warming. In order to clarify the variance in SOM stabilization mechanisms across different soil types, SOM abundance, distribution and mean residence time (MRT) were compared for thirty-two soil samples from six ecosystems across the United States. Soils were previously described, collected and archived by the United States Geological Survey. Samples were processed by LLNL at the Center for Accelerator Mass Spectrometry (CAMS) using density fractionation to separate particulate organics from mineral components. SOM abundance and distribution were compared among sites. Graphitization and radiocarbon analysis conducted at CAMS determined $^{14}C/^{13}C$ ratios which were used to evaluate differences in SOM MRT across the various ecosystems. Results confirmed SOM turnover varied among sites; therefore the response of SOM to global warming may vary among soils. Data from this investigation will be used in quantitative ranking of soil stabilization mechanisms and management of this important carbon sink. Initial investigation will allow for quantitative ranking of soil stabilization mechanisms and management of this important carbon sink. Further work will explore how variance in SOM MRT is related to particular soil physiochemical properties such as mineral assemblage.



Soil sampling ecosystem locations: Arizona, California, Hawaii, Iowa, Michigan and Mississippi.

Objectives

•**Context**: The global pool of soil organic carbon is large and therefore changes in its flux rate can have a significant impact on atmospheric CO_2 values. However, the mechanisms regulating the stabilization of soil organic carbon are not well understood.

•Objective 1: Examine different soil types and soil organic matter stabilization mechanisms and observe how they vary among ecosystems.

•Objective 2: Observe the variance in distribution and mean residence time of carbon in six different soils types and ecosystems.

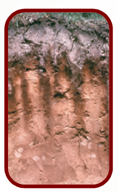
ARIZONA

CALIFORNIA

HAWAII

IOWA

MICHIGAN



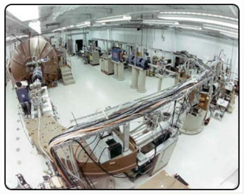
MISSISSIPPI

Soil types and locations: Arizona-Mollisol, California-Alfisol, Hawaii- Andisol, Iowa- Mollisol, Michigan-Spodosol, and Mississippi-Ultisol

Methods

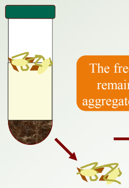
•Soils are density separated using a Na polytungstate solution.
• Free-light, occluded and high-density soil fractions samples are converted from organic carbon to carbon dioxide then to graphite.
•The graphite is sent through the accelerator mass spectrometer to calculate the $^{14}C/^{13}C$ isotopic ratios.
•Radiocarbon values are used to model the mean residence time of C in each fraction.

Graphite reduction line



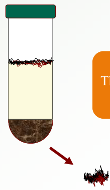
Accelerator Mass Spectrometer at CAMS-LLNL.

Bulk soil is mixed with Na polytungstate, with a density of 1.65 g cm^{3}



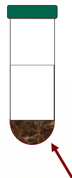
The free/light fraction is floated off, the remaining soil is sonicated to disrupt aggregates and liberate occluded organics.

Free/Light fraction is composed of particulate organics at different stages of decomposition.



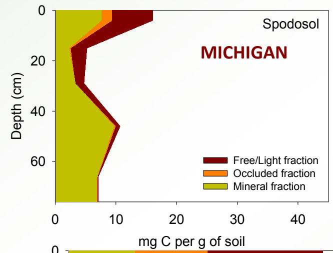
The occluded fraction is floated off and rinsed.

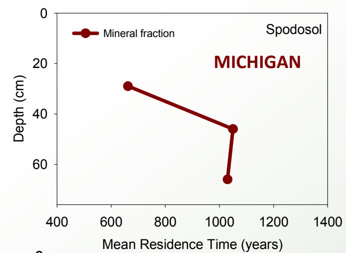
Occluded fraction is composed of particulate organics which have been preserved through occlusion within aggregates.

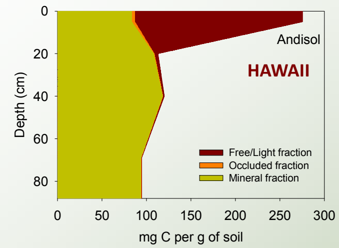


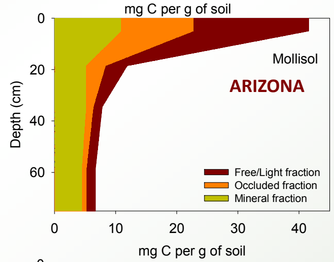
The remaining material is rinsed and dried.

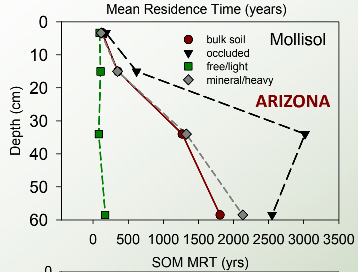
The remaining soil is composed of minerals and organics bound to mineral surfaces through a variety of mechanisms.

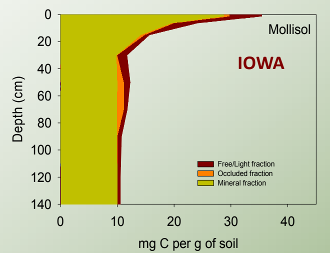


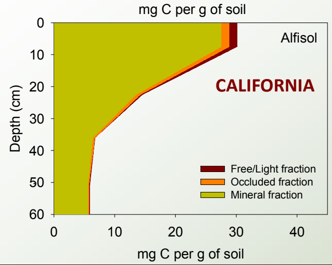


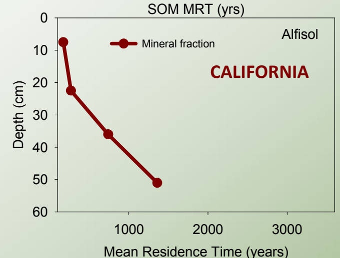


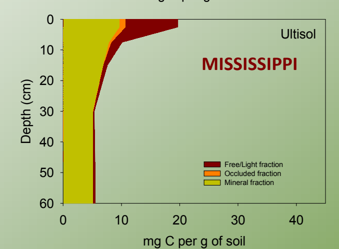












Results

•Soil organic matter abundance and distribution among density/aggregate fractions varied significantly according to soil/ecosystem type.

•Soil organic matter mean residence time varied among soil/ecosystem.

•Soil organic matter mean residence time also varied among soil density/aggregate fractions for soils examined.

•Differences in soil organic matter abundance and mean residence time are likely linked to differences in climate and also specific mineral assemblages of the soils examined.

Discussion

•Previous research indicated that soil organic C varies in abundance and mean residence time across ecosystem type, and these variances are the product of environmental and edaphic properties (Jenny, 1941). Quantifying the relative influence of climatic and edaphic properties on soil organic matter stability is crucial to predicting the response of soil C stocks to changing climatic conditions (Lal et al., 1997).

•The current work involves preliminary characterization of soil organic C cycling in a variety of ecosystems and is the first step in a broader effort to quantify the influence of the mineral matrix on the stabilization of organic C. The results illustrate a broad variance of soil C abundance and mean residence time in these ecosystems.

•Patterns of soil C distribution and stability are a reflection of the differences in the vegetation, climate, and soil mineral assemblage at each site.

•Future work will characterize the unique mineral assemblage at each location. Following characterization of the mineral component, statistical analysis will be used to identify key stabilization mechanisms in each soil type. Results will be used to model the response of soil organic C stocks to changes in climate.

References

Jenny H, 1941. Factors of Soil Formation: A System of Quantitative Pedology. Dover Publications Inc., New York, NY.

Lal R, J M Kimble, R F Follett and B A Stewart (eds), 1997. Soil Processes and the Carbon Cycle. CRC Press, Inc, Boca Raton, FL.

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