Variations of Organic Matter Composition with Climate, Soil Age, and Depth

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Undertanding the controls on soil organic matter storage and stability is paramount to predictions of global carbon cycling. Recently, scientific attention has focused toward improving our understanding of the mechanisms leading to organic matter protection - particularly how those mechanisms vary with soil depth, degree of soil development, and climate.

To assess the relative importance of these factors, we have conducted a detailed, long-term, study of two soil chronosequences in California, USA. The Santa Cruz and Mattole River Chonosequences each represent at least 225 ka of soil development on paleo marine terraces, currently occupied by coastal prairie plant communties. Precipitation inputs differ significantly between the two sites, with the more northern Mattole soils receiving nearly twice as much rainfall (~1000 mm/yr) as the Santa Cruz soils (~500 mm/yr). We have previously described differences in mineralogy, surface area, carbon and nitrogen content, and carbon isotopic composition within and between the soils of these chronosequences.

Here, we relate those findings to high-resolution characterization of organic matter composition from pore waters and bulk soil water extractions. This work supports previous evidence that downward transport of organic matter is limited in the drier Santa Cruz soils, resulting in greater recycling and longer bulk residence time of carbon compared with wetter Mattole soils. Measurements of soil organic matter compositon by Fouier Transform – Ion Cyclotron Resonance – Mass spectrometry (FT-ICR-MS) show large differences between the sites, which we interpret as indicative of fundamentally different carbon regimes.

Preliminary analysis of FT-ICR-MS data indicates an accumulation of compounds with a strong microbial signature (i.e., greater recycling) in the deep Santa Cruz soils compared with Mattole. In contrast, the Mattole soils accumlated significantly more plant-derived compounds, particularly those that are considered less favorable for decomposition. We futher compare these data in the context of mineralogical gradients and discuss the utility of such information for a new generation of reactive transport based soil carbon models.