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Carbon release from tropical forest soils informed by soil chemistry, fertility, and carbon quality derived from geochemistry of the parent material

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Tropical forest soils are a vital component of the global carbon (C) cycle and their response to environmental change will determine future atmospheric carbon dioxides (CO₂). For example, increasing biomass productivity in tropical forests suggests a potential sink for C. However, its storage and stability are driven by factors acting from small to large scale. For tropical Africa, these factors are not well known and documented. Predicting tropical soil C dynamics ultimately depends on our understanding and the ability to determine the primary environmental controls on soil organic carbon content and respiration.

Here, using samples collected along strong geochemical gradients in the East African Rift Valley, we demonstrate how soil chemistry and soil fertility, derived from the geochemical composition of soil parent material, can drive soil respiration even in deeply weathered soils.

To address the drivers of soil respiration, we incubated soils from three regions with contrasting geochemistry (mafic, felsic, and mixed sedimentary). For three soil depths, we measured the potential maximum heterotrophic respiration as well as the radiocarbon isotopic signature ($\Delta^{14}\text{C}$) of the bulk soil and respired CO₂ under stable environmental conditions.

We found that soil microbial communities were able to mineralize C from fossil as well as other poor quality C sources under laboratory conditions representative of tropical topsoils. Despite similarities in terms of climate, vegetation, and the size of soil C stocks, soil respiration showed distinct patterns with soil depth and parent material geochemistry. Our study shows that soil fertility conditions are the main determinant of C stability in tropical forest soils. Further, in the presence of organic carbon sources of poor quality or the presence of strong mineral-related C stabilization, microorganisms tend to discriminate against these sources in favor of more accessible forms of soil organic matter as energy sources, resulting in a slower rate of C cycling.

Our results demonstrate that even in deeply weathered tropical soils, parent material has a long-lasting effect on soil chemistry that can influence and control microbial activity, the size of subsoil C stocks, and the turnover of C in soil. Soil parent material and its lasting control on soil chemistry

need to be taken into account to understand and predict C stabilization and rates of C cycling in tropical forest soils.