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Enhanced rock weathering as a strategy to enhance and stabilize mineral associated organic matter in soil

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Effective and scalable nature-based solutions are receiving increasing focus in mitigation of climate change. Thus, enhanced rock weathering has been encouraged in agriculture given its potential co-benefits to soil and agricultural crops, in addition to the geological sequestration of carbon dioxide by mineral weathering. However, organo-mineral interactions arising from the relationship between soil organic matter and transformed or newly formed minerals from rock powders are another potential mechanism that has yet to be explored [1], highlighting the need for understanding the capacity of these materials to stabilize organic carbon (OC) in the soil, ultimately promoting OC increase. This study aimed to verify the effect of different rock powders on the stabilization of carbon in an Eutric Nitisol under tropical climate and agricultural cultivation. It included four treatments consisting of three contrasting rock powders – diabase, phonolite and granite – at a 5 Mg ha^{-1} dose + control (no rock powder), in a completely randomized design with six replications. *Urochloa brizantha* was grown in 8 kg pots in a greenhouse in Piracicaba/SP, Brazil. Rock powders were homogeneously mixed with the soil, and plants trimmed every 60 days. After 10 months of cultivation, rhizospheric soil was collected and followed by physical fractionation of the organic matter to isolate the mineral associated fraction (MAOM, <20 µm) and determine their OC content. Sequential extraction in MAOM was performed with sodium pyrophosphate (organo-mineral complexes), ammonium oxalate (short-range ordered oxides) and sodium dithionite (crystalline oxides) via elemental quantification and dissolved OC. Results were subjected to uni and multivariate analysis. The diabase conditioned soil showed the highest OC concentration in MAOM (3.59%), which differed significantly from the control (3.42%) (Fig.1). Permanova indicated a multivariate difference between treatments (p-value < 0.001), with multilevel paired comparison showing that granite and phonolite differed statistically from the control (p = 0.001 and 0.038) (Fig.2). Enhanced rock weathering in tropical agriculture increased MAOM, with diabase showing the highest OC stabilization in a loamy Nitisol, demonstrating this technique relevance to not only sandy soils, but also improving carbon dynamics to finer-textured soils.

[1] Tao & Houlton (2024), Global Change Biol 30, 17132.

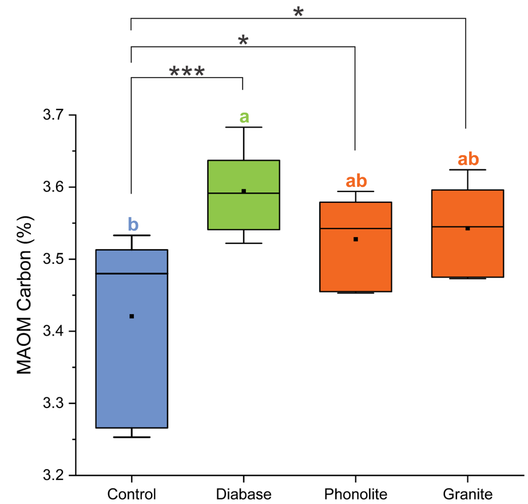

Figure 1. **Organic carbon** content of mineral associated organic matter (**MAOM**, <20 µm) in a Eutric Nitisol conditioned with **different rock powders.** Different letters indicate significant differences between treatments, determined using **Tukey's** *post hoc* test at 5% probability of error, while "*" and "***" indicate significant differences between the treatment and the control at 10% and 1% probability of error, respectively, using **Dunnett's** *post hoc* test.

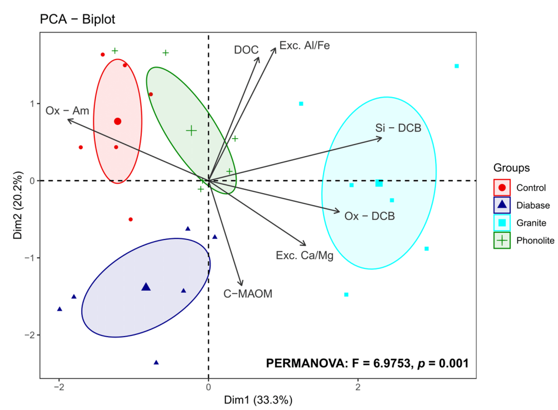

Figure 2. Principal component and Permanova analysis for a Eutric Nitisol conditioned with **different rock powders** (n = 24). **C-MAOM**: mineral associated organic matter carbon content; **DOC**, **Exc. Ca/Mg** and **Exc. Al/Fe**: dissolved organic carbon, exchangeable calcium and magnesium and exchangeable aluminum and iron (sodium pyrophosphate extract); **Ox – Am**: short-range ordered oxides (ammonium oxalate extract); **Ox – DCB** and **Si – DCB**: crystalline oxides and silicon (sodium dithionite extract).