Chemical complexity matters: differential mobilization of mineral-associated organic matter driven by functionally distinct rhizodeposits

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Protective mineral-organic associations are the quantitatively most important soil carbon storage mechanism, but their vulnerability to environmental change is largely uncertain. While it is well established that root growth can promote (or “prime”) the microbial decomposition of organic matter (OM), our mechanistic knowledge of the ability of roots to destabilize OM protected within mineral-organic associations remains limited. Here we examined how the composition of root-derived compounds (rhizodeposits) affects the stability of mineral-organic associations.

In model systems, we first tested the ability of functionally distinct low-molecular weight compounds (ligands, reductants, simple sugars) commonly observed in the rhizosphere to cause the mobilization and mineralization of isotopically labeled OM from different mineral types (Fe and Al hydroxides). Our results showed that all compounds stimulated mobilization and mineralization of previously mineral-associated OM. However, OM bound to Al hydroxide was less susceptible to mobilization than OM bound to Fe hydroxide. Further, sugars and reductants revealed a greater mobilization potential than ligands for both mineral types, suggesting that OM mobilization in soils may be microbiobly mediated, rather than driven by direct mineral dissolution. In complementary pot experiments, we investigated the effect of rhizodeposition on the mobilization of mineral-associated OM. We grew Avena sativa in soils amended with isotopically-labeled mineral-organic associations and followed mobilization dynamics over four weeks. First results indicated that rhizodeposition dynamics dictate the mobilization and mineralization of mineral-associated OM. Together, our results suggest a strong mechanistic linkage between the composition and functionality of rhizodeposits and their ability to destabilize mineral-associated OM.