Clay mineralogy controls SOM formation efficiency via discriminative protection

Bin Zhang[1], kai liu[2], Yuzhi Xu[3], Shuihong Yao[4], Yueling Zhang[5], Xudong Zhang[6], Hongbo He[6], Wenting Feng[5], Georges ndzana[1], Clair Chenu[7], Dan Olk[8], and Jingdong Mao[9]

[1]Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences
[2]Northeast Institute of Geography and Agroecology Chinese Academy of Sciences
[3]Institute of Geography and Agroecology, Chinese Academy of Sciences
[4]Affiliation not available
[5]Chinese Academy of Agricultural Sciences
[6]Institute of Applied Ecology
[7]Directeur de Recherche INRA Professeur de Science du Sol AgroParisTech
[8]USDA-ARS National Laboratory for Agriculture and the Environment
[9]Old Dominion University

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Abstract

Soil organic matter (SOM) is formed through partial decomposition and transformation of plant litter inputs. Thus, litter chemistry is generally regarded as the primary control over the formation efficiency of litter-derived SOM through selective preservation of recalcitrant litter fractions. Here we used model soils and showed that the SOM formation efficiency was, instead, controlled by discriminative protection of litter- and microbially-derived residues by different clay minerals. The SOM formation efficiency was higher for vermiculite than for kaolinite and illite because vermiculite protected more labile litter- and fungal residues through surface adsorption than did kaolinite or illite through pore entrapment. We developed a novel model to quantify mineral-protection strength following litter decomposition, and demonstrated that the mineral-protection strength explained well the variation in the SOM formation efficiency among the model soils, and could be predicted for a natural soil material from those of its compositional clay mineral types and their relative abundances in the soil. Our results provide solid evidence that soil clay mineralogy plays a critical role in SOM formation as known in long-term SOM stabilization, with important implications for model improvement to predict SOM dynamics for different soil types.

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