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Linking solid phase molecular diversity with soil organic matter persistence

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Molecular diversity has emerged as a critical factor controlling soil organic matter (SOM) persistence. Despite extensive studies revealing the distinct molecular properties of dissolved organic matter, large remains unknown about the molecular diversity of solid phase organic matter. Here we show the diverse feature of solid phase molecules (0-10 kDa) through a direct mass spectrometric scan on surfaces of particulate and mineral associated organic matter (POM and MAOM) and determine their contribution to SOM persistence in soils with low to high SOM turnover rates, collected from long-term grassland recovery field experiments of 0, 23, and 43-y-old, respectively. We find that more complex molecular composition prevails in MAOM, which possesses a molecular richness and diversity xx and xx times higher than that of POM. Classes of trades-off lignin-protein and carbohydrate-char are identified as the dominant categories corresponding to the variation of molecular diversity in these solid-phase organic matter. Among solid phase fractions, the enriched molecular diversity of MAOM exhibits stronger correlation with the declining of SOM turnover rate than that of POM, highlighting the importance of MAOM molecular diversity in controlling overall SOM persistence. Solid phase comprises the majority of SOM and represents the largest carbon pool in mineral soils. Better understanding of the diversity pattern of solid phase molecules not only improves the prediction of SOM turnover dynamics but also advances implementation of multi-pool carbon management strategy.