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Changes in soil organic matter stability with depth in two alpine ecosystems on the Tibetan Plateau

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Soil organic carbon (SOC) decomposition can potentially feedback to climate change. However, the biotic and abiotic factors controlling the stability of soil carbon, and changes in these factors with soil depth, remain poorly understood. In this study, we combined a number of methods to quantify the biological, thermal, chemical, molecular and isotopic indexes of soil organic matter (SOM) stability along the soil profile (0-70 cm) in two contrasting alpine ecosystems on the Tibetan Plateau. The two ecosystems include a Kobresia humilis meadow and a Potentilla fruticosa shrubland in Haibei station, Northeast of Tibetan Plateau. We sampled five soil layers (0-10, 10-20, 20-30, 30-50 and 50-70 cm) along the soil profile in August 2016.

Firstly, we conducted an aerobic lab-incubation experiment on root-free, sieved soils (180 days, 25oC and 60% field capacity). Soil respiration rate per gram soil declined with depth, but soil respiration rate per gram SOC increased with depth. The number of days to respire 5% of initial SOC, which was used as a biological index of SOM stability, decreased with soil depth. Moreover, thermal analysis showed that deeper soils tended to lose mass at increasingly higher temperatures. The temperature at which half of the mass loss (TG-T50) increased with depth, which was used a thermal index of SOM stability, increased with soil depth. Additionally, hot-water extractable organic carbon (HWEOC) per gram soil declined greatly with depth, but HWEOC per gram SOC, often used as a chemical index of SOM stability, showed weak (meadow) and little (shrub) declining trend with depth. Further, we used Fourier-transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR) spectroscopy to characterize the molecular composition of SOM. The index of recalcitrance (rA1630/rA2930 ratio of FTIR spectra) increased with depth, and the combined index of aliphaticity and aromaticity of NMR spectra also increased with depth. These results suggest that the molecular composition of SOM tended to be more complex with increasing depth. Finally, we are measuring the isotopic values of soil organic matter (13C, 15N, and 14C), which should provide another index of SOM stability and turnover rate.

Overall, our results suggest that the thermal, chemical and molecular indexes of SOM stability all showed increasing trend with increasing soil depth in the two alpine ecosystems, although the biological index (as measured by aerobic incubation of root-free sieved soils) provided the opposite results. Further studies should consider using a few complementary methods to quantify SOM stability, and interpret the lab incubation results with caution because altered soil structure, different environmental conditions, and lack of rhizosphere may confound the turnover rate or stability of SOM, particularly in subsurface soils.