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# Vertical $\delta^{13}$C and $\delta^{15}$N changes during pedogenesis

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The natural abundance of soil organic matter (SOM) stable C and N isotope ratios are subjected to vertical changes throughout the soil profile. This vertical distribution is a widely reported phenomenon across varieties of ecosystems and constitutes important insights of soil carbon cycling. In most ecosystems, SOM becomes enriched in heavy isotopes by several per mill in the first few centimeters of the topsoil. The enrichment of $^{13}$C in SOM with soil depth is attributed to biological and physical-chemical processes in soil e.g., plant physiological impacts, microbial decomposition, sorption and transport processes. Such vertical trends in $^{13}$C and $^{15}$N abundance have rarely been related to SOM composition during pedogenesis. The aims of our study were to investigate short and long-term $\delta^{13}$C and $\delta^{15}$N depth changes and their interrelations under progressing pedogenesis and ecosystem development.

We sampled soils across the well studied fordune progradation Haast-chronosequence, a dune ridge system under super-humid climate at the West Coast of New Zealand's South Island (43° 53' S, 169° 3' E). Soils from 11 sites with five replicates each covered a time span of around 2870 yr of soil development (from Arenosol to Podzol). Vertical changes of $\delta^{13}$C and $\delta^{15}$N values of SOM were investigated in the organic layers and in 1-cm depth intervals of the upper 10 cm of the mineral soil.

With increasing soil depth SOM became enriched in $\delta^{13}$C by 1.9 $\pm$ SE 0.1 ‰ and in $\delta^{15}$N by 6.0 $\pm$ 0.4 ‰. Litter $\delta^{13}$C values slightly decreased with increasing soil age (r = -0.61; p = 0.00) likely due to less efficient assimilation linked to nutrient limitations. Fractionation processes during mycorrhizal transfer appeared to affect $\delta^{15}$N values in the litter. We found a strong decrease of $\delta^{15}$N in the early succession stages $\leq$ 300 yr B.P. (r = -0.95; p = 0.00). Positive relations of vertical $^{13}$C and $^{15}$N enrichment with soil age might be related to decomposition and appeared to be affected by a change of hydrology, nutrient limitations, secondary minerals and root impacts.

The investigation of vertical changes of soil organic matter (SOM) stable isotope ratios provides the opportunity to detect combined processes that enhance our understanding of terrestrial ecosystem functioning and pedogenetic processes leading to stabilization/destabilization in soil and therefore addressing the soil's sink/source function.