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Mineralogical controls on organic N, accumulation, transformation, and bioavailability along a 120,000-year soil chronosequence

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Nitrogen mineralized from soil organic matter (OM) is a major driver in ecosystem productivity and sustainability. Despite this, the role of mineral-organic associations in nitrogen cycling is poorly understood. Here, we study the time-dependent accumulation and transformation of organic nitrogen (ON) in mineral-bound OM as a function of soil mineralogy along the temperate 120,000-year-old Franz Josef chronosequence (New Zealand). Seven sites along the chronosequence were examined for organic carbon (OC) and ON contents, with mineral-bound OC and ON being quantified by density fractionation using sodium polytungstate (ρ = 1.6 g cm^{-3}). Heavy soil fractions were characterized by powder X-ray diffraction for assessment of the mineralogical composition as well as by X-ray photoelectron spectroscopy and hydrolyzable amino acids to account for mineral-induced shifts in the chemical composition of mineral-bound OM. The apparent ^{14}C age of mineral-associated OM was revealed by accelerator mass spectrometry. The bioavailability of mineral-bound OC and ON was tested in 90-day incubations under aerobic and anaerobic conditions, and was related to soil mineralogy and enzymatic activities (protease, urease, aminopeptidase). Initial results show that the mineral-associated OM in the A horizons was young (Δ^{14}C values: 57 to 75 ‰, while more negative Δ^{14}C values (7 to -889 ‰ in deeper E, B, and C horizons point to a large fraction of stabilized OM. The ON in mineral-organic associations accounted for the majority of total N (94 $\pm$ 6%; n = 32), corresponding to ON stocks ranging between 0.3 and 1.0 kg m^{-2} (1 m depth). Enzyme activities strongly decreased with soil depth, while cell-normalized activities were higher in subsoil, likely reflecting a higher efficiency of subsoil microbial communities in accessing mineral-bound ON. The incubation results in relation to soil mineralogy and ON composition, thus, allow elucidating the controlling parameters on the acquisition of mineral-bound ON in soils representing various development stages.