



The interdependent relationship between C dynamics and soil-forming processes in a podzolic chronosequence under a temperate rainforest

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Amorphous and poorly-crystalline pedogenic minerals are highly reactive soil constituents (in terms of dissolution/precipitation and sorption ability), including to act in the long-term stabilization (100 to >1000 years) of soil organic carbon (SOC). Despite the crucial environmental and socioeconomic importance of SOC, the evolution of soil-forming processes involved in protecting SOC against mineralization is still unclear. The process of podzolization reflected in a soil chronosequence, characterized by mobilization, transport and precipitation of carbon, metals and silicon, provides an opportunity to serve as a basis for a better understanding of pedogenic origin and evolution of organo-mineral associations.

In this study, we investigated the interdependent relationship between formation/transformation of reactive pedogenic minerals and SOC stabilization over time. A podzolic chronosequence, developed under similar bio/geoclimatic conditions, was sampled in a temperate rainforest in the Cox Bay of West coast of Vancouver Island (British Columbia). Soils in the sequence developed on sandy beach deposits, which are advancing towards the ocean at a rate of 0.26 m per year. We carried out soil physico-chemical characterization (pH, mineralogy, C pools, soil size fractions) of six sites aged from 120 to 530 years and we also characterized the reactive pedogenic phases by analyzing Si, Fe and Al contents in selective extractants (Na-pyrophosphate, NH₄-oxalate and dithionite-citrate-bicarbonate). Here we show that the neoformation of pedogenic minerals was very slow at the beginning of soil formation (0-120 yrs: 0.2 T clay/ha.yr) and strongly increased when podzolization occurred (269-330 yrs: 10.7 T clay/ha.yr). Besides the humification process in the topsoil, the C dynamics in these soils are largely governed by the chelation of Al and Fe by organic ligands and the sorption of OC on Fe oxy-hydroxides in the first illuvial Bh and Bhs horizons. Furthermore, the evolution of amorphous and poorly-crystalline minerals in the chronosequence highlights the key role of organo-metallic accumulation/flocculation on the formation over time of short-range ordered aluminosilicates (imogolite type materials; $Al_o-Al_p/Si_o \sim 2$) in the underlying Bs horizon, which can also partly control the C dynamics through the formation of organo-mineral associations. We provide evidence that mineral phases, such as poorly crystalline Fe oxyhydroxides and aluminosilicates, can be reactive as organic phases in a similar short timescale.

To better assess the co-evolution of the formation of organic and mineral phases during pedogenesis and the protective mechanisms involved in the organo-mineral associations, geochemical tracers, C pools fractionation and surface analyses are needed.