Progressive and regressive soil evolution phases in the Anthropocene

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Abstract

Soils have a substantial role in the environment as they give back several ecosystem services as food supply and carbon storage. But agricultural practices can modify soil properties and soil evolution processes, threatening these services. These modifications are poorly studied and resilience/adaptation times of soils to disruptions are unknown. Here we propose to study the evolution of pedogenetic processes and soil evolution phases (progressive or regressive) in response to human-induced erosion from a 4000 years lake sediment sequence (Lake La Thuile, French Alps). Erosion in this little lake catchment in the montane area is quantified from the terrigenous sediments trapped in the lake and compared to soil formation rate. To access this quantification, soil processes evolution are deciphered from soil and sediment geochemistry comparison. Over the last 4000 years, first impacts on soils are recorded at approximately 1600 yr cal. BP with erosion of surface horizons beyond 10 t.km-^{2}.yr-1. With erosion accentuation between 1400 and 850 yr cal. BP, up to 1000 t.km-^{2}.yr-1, horizons increasingly deep are eroded during the Middle-Age, leading to remobilization of carbonated and poorly weathered material which rejuvenates soil development. Erosion overpassed soil formation rate and constitute a regression in the development of soils. Tolerable erosion limit is thus defined for erosion ranging from 25 and 30 t.km-^{2}.yr-1. Beyond this limit, the sustainability of the agroecosystem is limited and ecosystem services decreased. Since then, pedogenesis goes again from progressive (700-300 yr cal. BP) to regressive (300 yr

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cal. BP-today) phases. Erosion is less important during the last 700 years than during the Middle-age but with the same weathering stages which indicates that soils were deeply affected during the Middle-age and had not time to be recovered. The overall result highlights the importance of the human factor in the pedogenesis over last millenniums and its impact on the stratigraphy of the lake that moves this agro-ecosystem in the Anthropocene since 1400 years.