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Chronostratigraphy of soil organic matter in volcanic ash soils in Northern Ecuador as influenced by tephra deposition and bioturbation

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Volcanic ash soils (Andosols) offer great opportunities for paleoecological studies, due to their characteristic accumulation of soil organic matter (SOM), which includes paleoecological proxies such as pollen and biomarkers. However, a proper understanding of the chronostratigraphy of SOM is required to take advantage of such opportunities. Boundary conditions for the vertical distribution of SOM in Andosols are set by tephra deposition. However, its actual vertical distribution depends on subsequent pedogenetic processes, of which particularly bioturbation has a potentially destructive impact on the stratigraphic integrity. Pedogenetic processes are prominent in soils developed in distal facies with complex tephra chronology. We combined proxies traditionally used in stratigraphic research (mineral assemblages, grain size distribution, and chemical element ratios) with SOM contents and radiocarbon dating both at a high vertical spatial resolution, to unravel the tephra stratigraphy of these complex soils. To determine the influence of bioturbation we additionally performed a semi-quantitative micromorphological analysis of soil faunal pedofeatures. Our results show that soil profiles along an altitudinal transect intersecting the upper forest line in Northern Ecuador were formed in three thick and distinct tephra deposits. Although the deposits contained a similar assemblage of minerals, we were able to differentiate them because of their characteristic SOM distribution, grain size distribution and typical SrO to Na_2O, CaO and crystalline Al_2O_3 ratios. Furthermore, we demonstrated that biotur-

bation plays an important role in current pedogenesis, even resulting in overprinting of the first paleosol. Surprisingly, in spite of bioturbation, a linear age depth relationship exists, which could not be attributed to intermittent burial by tephra. Chronostratification in the presence of bioturbation is seemingly conflicting. Chronostratification was possible because mixing occurred mainly by endogeic species over short vertical distances, thus having only limited effect on radiocarbon ages. We conclude that the vertical resolution of paleoecological records contained in the studied soils is at least 5 cm ($\sim$ 400 ^{14}C year), certainly allowing for paleoecological reconstructions. A major consequence, however, is that any sample taken inevitably would produce a mixed signal.