



Rate of clay mineral, poorly crystalline and crystalline oxy-hydroxide formation and humus development in volcanic soils of Etna (Sicily)

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Soil sequences may give an insight into the influence of a factor on the weathering rates. The currently occurring worldwide climate changes are fuelling a growing interest in the effect that the factors of climate and time are having on the landscape and consequently soil evolution. Soils play a major role in the biogeochemical cycle including storage of nutrients and carbon. Carbon dioxide is converted to bicarbonate and nutrients are released during carbonic acid weathering of silicate minerals, thus contributing to both carbon and nutrient cycling. Climate change can have significant impacts on the global biogeochemical cycle by altering the type and rate of soil processes and the resulting soil properties. The rate of reactions is of fundamental interest in the understanding of the soil system and its interaction with the surrounding environmental conditions. The aim of our research was to determine soil changes in the Mediterranean volcanic area of the Etna region in order to derive time-trends that elucidate the rate of element leaching, mineral formation or transformation and humus development and stabilization.

The age of the investigated soils ranged from 100 to 115000 years. Element pools in the soil (Ca, Mg, K, Na, Fe, Al, Mn, Si, and Ti) as well as selective extractable Fe, Al, Si (dithionite-, oxalate- and pyrophosphate-extracts) were determined. Clay minerals were characterized by XRD and FT-IR. Additionally, pH, org. C and C/N ratios were determined and organic matter was analyzed more in detail by extracting fulvic

and humic acids. The chemical characterization of these acids was carried out with FT-IR. Although soils develop on volcanic parent material, they could be classified as (Vitric) Cambisols and not as Andosols. In regard to the leaching of elements from the soil column, weathering seemed to progress rather slowly when compared to other known chronosequences. Weathering consisted predominantly in a breakdown of the volcanic glass and the formation of ITM (imogolite type materials). At the start of soil formation some kaolinite-like minerals (kaolinite, halloysite) were present. Initial stages of glass alteration by aqueous solutions were accompanied by a selective loss of alkalis. In the surface horizons some 2:1 clay minerals could be found, that were probably liberated from the inner part of volcanic glass debris. The accumulation with time of poorly and weakly crystalline Al- and Fe-phases in the soils was remarkable. Within short periods of time (< 3000 years) a substantial accumulation of these oxy-hydroxides occurred. These chronofunctions could be fitted to data using nonlinear regression procedures or an exponential model. Regarding the production of Fe- and Al-oxy-hydroxydes, the measured values after 115000 years were still not close to an asymptotic value. The rate of changes (accumulation rate) was especially pronounced at the beginning of soil formation (< 10000 years). Organic matter, however, accumulated to a maximum after about 20000 years and then decreased significantly (c. -40%). This trend was similar to the organically bound Al and Fe. The increasing transformation of iron oxides into crystalline phases and Al into imogolite-type material with time might be a determining factor in humus destabilization after several decades of millennia years. Total extractable C as well as humic acids showed a similar behavior of accumulation with soil evolution. A very sharp increase in the fulvic acid stocks during the first thousands of years was observable and soon reached an asymptotic value, although the concentrations in the topsoil remained more or less unchanged. Main chemical and mineralogical reactions during the observable 115000 years were the formation and transformation of oxy-hydroxides, allophanes or imogolite. The content of 2:1 clay minerals was surprisingly low and of minor importance.