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Effect of climate on carbon storage, humus fractions, allophanes, imogolite and poorly crystalline and crystalline oxy-hydroxides in volcanic soils of Etna (Sicily)

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Climate is of growing interest with respect to landscape and consequently soil evolution. This interest is bound to worldwide climate changes. Due to anthropogenic emissions of greenhouse gases, the earth's average surface temperature is predicted to increase during the next 50 – 100 years. Landscape may respond very noticeably and differentially to climate change as it integrates all ecological and historical factors. 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. Soil sequences may give insight into the influence of a soil forming factor such as climate on the weathering rates and processes. Precipitation and temperature particularly influence soil properties by affecting type and rates of chemical, biological, and physical processes. Earlier studies documented the effect of differences in climate on plant communities and soil types along an altitude gradient that is characterized by decreasing temperature and increasing precipitation. Common trends reported in these studies included changes in soil types, soil organic matter, clay content, soil acidity, and exchangeable ions. We investigated Mediterranean soils ranging from subtropical to subalpine climate zones. The sites can be found on one single lava flow. Age (15000 years) as well as chemical and mineralogical composition of the parent material were, therefore, identical. The chosen soils are assumed to be representative of the altitude zones.

Taking advantage of the excavated profile pits, undisturbed soil samples were taken down to the C horizon. The soils were analyzed for several physical (bulk density, particle size distribution) and chemical properties. The dithionite-, pyrophosphate- and oxalate-extractable fractions were measured for the elements Fe, Al and Si. Additionally pH, org. C and C/N ratios have been determined. Fulvic and humic acids have been extracted from the soil organic matter. The chemical characterization of their compounds and functional groups has been performed with FT-IR. The stocks of organic matter, humic acids, ITM (imogolite type material), organically-bound Al and Fe phases, and weakly or poorly crystalline Al phases distinctly decreased with altitude. In contrast to this, poorly crystalline Fe-phases (ferrihydrite) increased and the stocks of fulvic acids did not show any changes. Regarding altitude, the chemical composition of the humic acids remained more or less unchanged while fulvic acids showed some distinct trends that were correlated with the vegetation type. The accumulation of organic C in the soil and the amount of humic acids was most probably dependent on the type and amount of vegetation litter. Also, fire activity most probably influenced many processes in the investigated soils. Fire activity was much higher at low altitudes. Precipitation occurred at higher altitudes also in summer and the vegetation and soils were consequently less dry. Furthermore, the impact of burning on soil mineralogy may have the potential to cause mineral transformations with moderate and severe fires. Fire activity has most probably influenced the chemistry of Fe and the crystallinity of oxy-hydroxydes. A higher amount of secondary crystalline Fe-phases was measured at lower altitudes. The increased accumulation and stabilization of SOM at lower altitudes is hypothesized to be due the specific climatic conditions with periods of humidity changing with periods of droughts, the amount and type of litter, the organo-metallic complexes that hinder biodegradation and fire activity. A change in annual temperatures, and thus climate, should theoretically lead to a slow shift (several hundreds of years) of C accumulation and stabilization with altitude.