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Thermal stability of soils and detectability of intrinsic soil features

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Soils are products of long term pedogenesis in ecosystems. They are characterized by a complex network of interactions between organic and inorganic constituents, which influence soil properties and functions. However, the interrelations cannot easily be determined.

Our search for unifying principles of soil formation focuses on water binding. This approach was derived from water-dependent soil formation. It considers the importance of water binding in theories about the origin of genes, in the structural arrangement and functionality of proteins, and in the co-evolution of organism species and the biosphere during the history of earth.

We used thermogravimetry as a primary experimental technique. It allows a simple determi-nation of bound water together with organic and inorganic components in whole soil samples without a special preparation. The primary goal was to search for fingerprinting patterns using dynamics of thermal mass losses (TML) caused by water vaporization from natural soils, as a reference base for soil changes under land use.

301 soil samples were collected in biosphere reserves, national parks and other areas as-sumingly untouched by human activity in Siberia, North and South America, Antarctica, and in several long term agricultural experiments. The results did not support the traditional data evaluation procedures used in classical differ-ential thermogravimetry. For example, peak positions and amplitudes did not provide useful information. In contrast, using thermal mass losses (TML) in prefixed smaller, e.g. 10 °C temperature intervals allowed the determination of the content of carbon, clay, nitrogen and carbonates with high accuracy. However, this approach was applicable for soils and neither for soil-like carbon containing mineral substrates without pedogenetic origin, nor for plant residues or soils containing ashes, cinder, or charcoal. Therefore, intrinsic soil regulation processes are discussed as a possible factor causing applicability of thermogravimetry for soil property determination.

Despite of the extreme diversity of individual substances in soils, the thermal decay can be predicted with simple mathematical models. For example, the sum of mass losses in the large temperature interval from 100 °C to 550 °C (known from organic matter determination by ignition mass loss in past) can be predicted using TML in two small temperature intervals: 130 - 140 °C and 320 - 330 °C. In this case, the coefficient of determination between measured and calculated results reached an R2 above 0.97.

Further, we found close autocorrelations between thermal mass losses in different temperature intervals. They refer to interrelations between evaporation of bound water and thermal decay of organo-mineral complexes in soils less affected by human influence. In contrast, deviations from such interrelations were found under extreme environmental conditions and in soils under human use. Those results confirm current knowledge about influence of clay on both water binding and organic matter accumulation during natural soil formation. Therefore, these interrelations between soil components are discussed as intrinsic features of soils which open the opportunity for experimental distinction of natural soils from organic and inorganic materials which do not have pedogenetic origin.