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AFM – nanothermal analysis to distinguish material types in soil samples on the micrometer and upper nanometer sca

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Atomic force microscopy (AFM) can provide information on topography, the localized distribution of surface chemistry and other surface properties like stiffness or stickiness. Numerous constituents of soil have, however, similar chemical composition and cannot clearly be distinguished solely by these methods. Probing additional material characteristics like phase transition temperatures, will help to achieve clearer distinguishment between materials. In this study, we tested the applicability of AFM coupled with nanothermal analysis (nTA) to characterize localized material characteristics in selected microregions of using the example of soil samples from a chronosequence from the Damma Glacier forefield, Switzerland. Adhesion force spectra of the soils exhibited different groups with respect to the peak adhesion force. Thermograms of all investigated soil samples could be subdivided into three types of nanothermograms exhibiting different expansion-compression characteristics with specific phase transition temperatures. The combination of these characteristics showed that regions revealing similar adhesion forces belong to different materials with respect to thermal characteristics. Vice versa, not all regions exhibiting the same thermogram type, revealed the same adhesion force. Thus, neither adhesion force spectroscopy nor Nanothermal analysis alone help to clearly identify individual materials. Combination AFM with nanothermal analysis, however, allows probing additional material-specific characteristics, which can be helpful information for clearer distinguishment of material characteristics and identification of material types. If sufficient reference materials are available, AFM-nTA has the potential to identify certain materials in complex soil samples with higher certainty than AFM alone. Thus, AFM-nTA allows performing one step forward towards the aim to identify individual materials and their localized distribution within microregions of soil grains.