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Atomic Force Microscopy for Soil Analysis

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Atomic Force Microscopy (AFM) is a high-resolution surface-sensitive technique, which provides 3-dimensional topographical information and material properties of both stiff and soft samples in their natural environments. Traditionally AFM has been applied to samples with low roughness: hence its use for soil analysis has been very limited so far. Here we report the optimization settings required for a standardization of high-resolution and artefact-free analysis of natural soil with AFM: soil immobilization, AFM probe selection, artefact recognition and minimization. Beyond topography, AFM can be used in a spectroscopic mode to evaluate nanomechanical properties, such as soil viscosity, stiffness, and deformation. In this regards, Bruker PeakForce-Quantitative NanoMechanical (QNM) AFM provides a fast and convenient way to extract physical properties from AFM force curves in real-time to obtain soil nanomechanical properties. Here we show for the first time the ability of AFM to describe the topography of natural soil at nanometre resolution, with observation of micro-components, such as clays, and of nano-structures, possibly of biotic origin, the visualization of which would prove difficult with other instrumentations. Finally, nanomechanical profiling has been applied to different wettability states in soil and the respective physical patterns are discussed.