



Surface alteration of soil bedrocks in the vadose zone

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The development of the aggregate system in soils may be strongly dependent on the type of bedrock and the initial spatial structure of its void system. We study the alteration processes of the fractured and weathered rim of lithified bedrocks in transition to soil at different scales. Alternating drying and flushing by meteoric waters in the vadose zone provides alternating (hydro)geochemical conditions for fluid-rock interactions (e.g. Eh, pH, solubility etc.) and provokes the dissolution, displacement and placement plus authigenic formation of minerals as well as the release or adsorption of colloids. Additionally, biogeochemical processes support the alteration of fluid-solid interfaces in the bedrock. The accessibility of pristine rock surfaces to weathering is favored by fractures and voids. We aim to elucidate the differences and similarities of bedrock and surface alteration processes in dependence on mineral and water composition, seepage vs. saturation and the fracture network during weathering. To do so, we explore the spatial sequence starting from the unweathered bedrock to regolith and subsoil of different bedrock types including sedimentary, magmatic and metamorphic rocks. Methods employed cover stereo and polarization microscopy (millimeter to micrometer scale), scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX, mikrometer to nanometer scale), FTIR-spectroscopy as well as inductively coupled plasma mass spectrometry (ICP) in order to gain information about textural, petrological, mineralogical and chemical properties.

Typical alteration characteristics are dissolution features of rather unstable minerals vs. precipitation of clay minerals. In limestones for example (Muschelkalk, Thuringia), edge pits at fresher surfaces of the bedrock point to initial carbonate dissolution. In contrast, strongly weathered surfaces (bedrock clasts in the covering soil and fractures and voids in the bedrock) exhibit advanced carbonate dissolution and the formation of clay mineral coatings instead, whereas iron oxide formation is rare. Dissolution of unstable minerals is also observable in siliciclastic rocks (Bundsandstein, Thuringia, Hesse). In part, dissolution of the entire carbonate or anhydrite as binding agent caused complete decementation of the sandstones. Clay mineral formation during recent weathering in the bedrock seems rare, but the weathering favors the development of existing clay minerals having expanding lattices. Iron oxide minerals may exhibit leaching or dissolution and in parts mobilization and local reprecipitation. The decementation by dissolution and the alteration of clay minerals supports the breakup and disintegration of the sandstone particles. Stable minerals such as the quartz grains are incorporated in the covering soil forming the skeleton of the soil aggregate system. In sheltered areas the quartz grains may be coated with relicts and aggregates of small clay minerals.

Generally, initial dissolution features (edge pits, solution pores and vugs) enlarge the surface roughness and the reactive surface area in the unstable minerals promoting further mineral solution, while clay mineral coatings may inhibit further dissolution of unstable minerals, but provide large surfaces with large roughness for the adsorption of colloids, organics and aggregate precipitation.