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Recent and Paleofeatures in Soils of Mountainous Cryo-Steppe Landscapes, Southeastern Altai

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Surface soil profiles are generally interpreted and classified as containing features consistent with the actual environment. However, detailed hierarchical morphogenetic analysis gives us opportunity to identify paleofeatures in recent surface soils due to soil capability to record environmental conditions and pedogenic processes in stable elements of the soil body. We studied profiles of cryoxerophyte steppe soils on the Southeastern Altai based on the hierarchical morphogenetic analysis, with a special focus on soil micromorphology.

Three studied soils compose a landscape-altitudinal sequence: Skeletic Kastanozems (Cambic) under a cryoxerophyte steppe with alpine elements (2400 m), Skeletic Cambisols (Protocalcic) under a cryoxerophytic steppe (2200 m) and Skeletic Cambic Calcisols (Yermic) under a desertic cryoxerophyte steppe (1900 m). All those soils are united within a cryoaridic soil type in the Russian soil classification. They occur under extremely cold, ultra-continental aridic conditions (MAT below zero, MAP 100-200 mm, annual temperature amplitude up to 55°C). Soils are formed on skeletal sandy loams and have AK-BPL-BCAic (Ae-Bw-Bk) horizons. The upper part of the soil profile (0–40 cm) comprises two horizons: dark brown A and dull yellowish brown B. Both have granular microstructure, abound in weakly decomposed plant residues with silty-clay-organic coatings on them and on mineral grains. Dry, weakly decomposed "root felt" is accumulated in the upper Bk, the Bk horizons are very stony. Abundance of low-decomposed fine (0.1-0.5 mm) plant residues, clay-silty-sandy cappings on the upper surfaces of stones, ooidal and lens-like microstructure, postshlieren texture, frost-shattered aggregates are typical features of these soils and interpreted as recent cryogenic processes.

The most humid object has the thickest humus horizon with well-developed structure and microfeatures related to mesofauna; the most distinct and developed cryogenic ooid aggregates in B horizons. The most arid object has yermic properties: elements of desert pavement, and vesicular and fine platy crust over the humus horizon, it contains carbonates all over the profile. Impregnation of plant residues by iron compounds and carbonates are expressed here, and the lower Bk horizons has carbonate cementation. The following pedogenic processes well agree with current arid-semi-arid and ultracontinental cold conditions: 1) accumulation of specific organic matter in A horizon; 2) biogenic micro-structuring; 3) cryogenic processes: frost shattering, frost sorting, formation of silt cappings; 4) recrystallization of calcite in pendants followed by possible short-distant eluvial-illuvial redistribution of carbonates; 5) impregnation of plant residues.

Para-extreme lithological conditions (coarse fragments content is 30-80% by volume) determine localization of pedofeatures on the surface of rock fragments, so Bk horizons soils have various multi-layered calcite and humus pendants on gravels and stones. The morphology of layers in pendants made it possible to reconstruct the main evolutionary phases of cryoaridic soils. These are: 1) formation of microsparite–micritic dense silica-containing coatings due to short-term fluctuations of the shallow alkaline bicarbonate groundwater level in the semiarid–arid climate; 2) formation of sparitic dense coatings under the slow accumulation of carbonates from low-mineralized bicarbonate water in less arid conditions; 3) the eluvial-illuvial formation of micritic loose coatings under stable automorphic semiarid conditions; 4) formation of Fe-humus coatings in cool humid climate: Al-Fe-humus phase of pedogenesis; 5) the recommencement of the eluvial-illuvial formation of micritic loose coatings under aridization of the last thousand years of the Holocene.

Cryoaridic soils in Altai mountains are polygenetic. Their Bk horizons contain relic features — evidences of former carbonates (7-8 cal ky BP) and humus (3.8 cal ky BP) migration in the soil, whereas the upper horizons (Ae, Bw) have features, basically related to recent environment with cryogenic and biogenic pedogenic processes.

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Palaeopedogenesis of Red Palaeosols in Southwestern China and Their Paleoenvironmental and Landscape Evolution Implications

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Red palaeosols are widely distributed in the plateau regions of southwestern China. The palaeopedogenesis recorded in the red palaeosols greatly increase our understanding on the palaeoenvironmental changes, landscape evolution and tectonic uplift pattern in the plateau. Pedogenic features, geochemistry, mineralogy and rock magnetism of red palaeosols collected at 2200 to 2400 m elevations from the Yunnan Plateau were investigated to interpret the pedogenical weathering processes and palaeoclimatic conditions recorded in the palaeosols. Pedologically, the red palaeosols were characterized by the dark red color (a hue of 5YR or redder), strong acidity, and high free iron oxide (>50 g/kg) and clay (>50%) contents. Chemical weathering indices, such as CIA (CIA=[Al2O3/(Al2O3+CaO+Na2O+K2O)]×100), Sa (Sa=SiO2/Al2O3), Saf (Saf=SiO2/Al2O3+Fe2O3), and A-CN-K diagram (Al2O3-CaO+Na2O-K2O) revealed that the red palaeosols had experienced strong chemical weathering processes. Quartz grains of the red palaeosols were characterized by a number of deep dissolution pits and cracks on their surfaces. The clay minerals of the red palaeosols were composed of kaolinite, gibbsite, hematite, and vermiculite in the order of abundance. Pedological, geochemical and mineralogical studies indicated that the red palaeosols possess palaeopedogenic features of the laterization processes associated with the tropical and subtropical pedogenic conditions. Red palesols are characterized by highly magnetic signals and contain significant amount of fine-grained superparamagnetic (SP) grains, which is attributed to the higher concentration of pedogenic SP maghemite. Magnetic evidence suggests that the red paleosols experience a strongly pedogenic processes. Pedogenic processes result in the neoformation of hematite and maghemite, and causes a substantial increase in the magnetic susceptibility and other magnetic signals. It concluded that these highly magnetic red paleosols could not be formed under the present climate of plateau. It is deduced that the red paleosols had been uplifted by the neotectonics since its original formation. The tectonic movement of Plateau forced the soils uplifting to the plateau planation surface with an elevation of 2000–2400 m, which led to the contrast vertical distribution pattern of soils in Plateau. This explains why the highly weathered red palaeosols are widely distributed in the plateau. The presence of highly weathered soils at an altitude of 2200-2400 m indicated the influence of of tectonic uplift on the soil vertical distribution. Palaeopedogenesis of red palaeosols provides new insight into the palaeoclimatic and palaeoenvironmental reconstruct and tectonic movement of plateau. Therefore, the palaeoclimatic reconstruction based on palaeopedological analyses may be a powerful proxy for reconstructing palaeopedogenical environments in plateau. The neotectonics revealed by the red palaeosols are important not only for understanding the amplitude and the age of plateau uplift but also for reconstructing the paleoclimates.