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Metals in the 0.25-0.05 mm sand fraction of forest soils in central European Russia

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This study was undertaken to examine the vertical and lateral geochemical differentiation of 0.25-0.05 mm sand fraction partitioned from uncontaminated forest soils on the central part of the Russian Plain. The vertical distribution of Fe, Ti, Mn, Zr, Zn, Cu, Cr, Ni, Pb and Co was examined in 5 soil profiles: two podzoluvisols developing on sheet loam on interfluvial summits, two poorly differentiated soddy and soddy gleyic soils occupying slope and footslope positions, and one floodplain soil. The spatial variations of 0.25-0.05 mm fraction geochemistry were characterized using elemental data from the humus horizons of two soil catenas and the topsoil of an erosional landform (a gully system), typical for the study area.
Analyses show the following median concentrations in the sand fraction: Fe – 3,2%, Ti – 3000 ppm, Mn – 500 ppm, Zr – 640 ppm, Zn, Cu, Cr – 50 ppm, and Ni, Pb and Co – 23, 18 and 8 ppm, respectively. Variation coefficients diminish in magnitude: Mn, Cu (70-80%) > Co, Zn, Ni, Fe (60-65%) >Zr, Ti (45%) > Cr, Pb (35%).
The sand fraction content in the soils varied widely, from 0.4 to 56% depending on the lithological features of parent material and underlying strata. No even distribution of the fraction across soil profiles was registered. In soils on loamy deposits sand enrichment was observed in the upper horizons, in contrast to the lower horizons for soils underlain by sandy glacio-fluvial deposits. The higher contents of metals in the sand fraction in all soil profiles were found in the topsoil, characterized by more active humus accumulation, biogeochemical processes and sand grain weathering. However, Ti and Zr were distributed more evenly, implying their presence in a form of stable primary minerals.
The spatial distribution of the metals in 0.25-0.05 mm particles revealed important soil-geochemical convergence processes in lateral direction along catenas. Fraction samples partitioned from soils in the lowermost positions on the two catenas show very little differences in metal concentrations, while soils in the summit positions show significant differences in abundances of Fe, Cu, Co, Ni, Zn and Mn (2 - 3 times).
The metal distribution across topsoils of various geomorphic units of the gully system displays that in the sand fraction the highest element concentrations, except for Zn, occur in catchment soils developing on sheet loam, while topsoil of the slope units is significantly depleted in metals, due to the incision of the landform into glacio-fluvial strata and the different genesis of soil particles. Observations show that the concentrations of the majority of the elements are 1.5 to 2 times higher in the gully bottom unit compared to the slope units. A monotonous decrease of Fe as well as Mn, Co, Ni and Zr in the longitudinal profile of the gully highlights the influence of transport processes.
Results imply that variations in metal concentrations in the 0.25-0.05 mm sand fraction can be derived not only from the genesis of soil particles, but also from transformations taking place during soil-forming processes and physical migration of soil material.