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Loess chromaticity as an environmental change recorder: spectrophotometric study of aeolian dust and its role in paleoclimate studies

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Colour is a fundamental morphological feature commonly documented during the description of loess layers and soils developed on loesses – both contemporary and fossil. These colours are typically identified directly in the field, matching specific hues from the Munsell Soil Colour Chart. However, this method is highly subjective, with accuracy hinging on the observer's expertise and weather conditions. Introducing digital spectrometers for colour analysis, conducted in the lab on powdered samples, enhances objectivity. This approach was applied to samples from the Middle-Upper Pleistocene loess-palaeosol sequences (L2-S1-L1-S0) in Ukraine's Dnieper basin.

The laboratory work aimed to pinpoint chromatic parameters that typify each loess layer, considering their distinct features and stratigraphic positions, as well as various soil horizons, each with unique degrees of pedogenic alteration. Key colour metrics included lightness (L*), redness (a*), yellowness (b*), chroma (c*), and the R-index. The resultant database of spectrophotometric data helps identify colour patterns characteristic of different sequence components.

Our analysis revealed considerable variation across all measured parameters, yet maintained the distinct coloration typical of loess and soils. We also created a digital colour record corresponding with the analogue Munsell scale, lending further objectivity to colour descriptions. Notably, digital colour identification often markedly differs from traditional, "analogue" methods. Applying RGB tuning, we devised models that realistically replicate colours observed in the field.

The documented chromatic parameters enable geological profile analysis in both vertical and spatial dimensions – following the Dnieper valley's sub-meridian and sub-latitudinal orientations across the river basin. These colour profiles mirror the diverse litho-, pedo-, and diagenetic processes across different genetic stages. Crucially, we identified diagnostic colour characteristics unique to primary loesses (L2 vs. L1), various soil types, their development stages (full-profile vs. reduced), and preservation forms (modern vs. ancient).

Thanks to the high resolution and sensitivity of our spectrophotometric analysis, we detected nuanced chromatic shifts, often abrupt. This revealed otherwise invisible erosional surfaces and concealed boundaries, shedding light on changes in loess lithology or the progression of

pedogenic processes. The documented colour shifts illustrate the dynamic evolution of the natural environment, from loess accumulation (cold phases) to soil formation (warm periods).

It should be noted that primary loesses of varying ages, collected from different geological sites, which are primarily described as light yellow, show significant differences in the L*, a*, b*, c* parameters in light of spectrophotometric analyses. This variability aligns well with the findings of geochemical analyses.

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