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Deciphering magnetoclimatological patterns of early-to-mid Pleistocene loess in the western Chinese Loess Plateau

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A detail environmental magnetic investigation in conjunction with geochemical, grain size and redness analyses of the early-to-mid Pleistocene loess–paleosol sequences at the Jiuzhoutai and Caotan loess sections has been carried out, aimed to explore reliable paleoclimatic proxies in the western Chinese Loess Plateau (CLP). The results show that magnetic enhancement of loess–paleosol sequences in the western CLP is not only solely due to the neoformation of ultrafine magnetic particles through pedogenesis, but at some depth intervals is more attributed to significant input of coarse-grained magnetic minerals associated with advance of desert and/or significant input of local sources. Since magnetoclimatological patterns studied here are obviously controlled both by pedogenesis and wind vigor, magnetic susceptibility (X) and saturation isothermal remanent magnetization (SIRM), both of which are responsive to both the ultrafine pedogenic magnetic particles and the eolian coarse-grained pseudo-single domain/multi-domain magnetic particles, could not provide unambiguous interpretation of the magnetic response to the East Asian summer monsoon intensity. By contrast, anhysteric remanent magnetization (ARM) and frequency-dependent magnetic susceptibility (Xfd%), which are notably responsive to ultrafine magnetic particles, can aptly trace changes in the concentration of pedogenic magnetic particles and therefore can be used as reliable proxies of pedogenic intensity. The magnetic grain-size dependent proxies, e.g., ARM/X and ARM/Ms (Ms, saturation magnetization), geochemical indices (e.g., chemical index of alteration, Zr/Rb and Al/Si ratios), and grain size records exhibit concordant variations and appear to be more straightforward proxies for addressing the East Asian monsoon variability. Therefore the combination of multi-parameter mineral magnetic, geochemical and grain-size analyses is enormously helpful to distinguish, delimit and correlate the units, and further to accurately decode paleoclimatic signals embedded in the weakly weathered loess. As the classic precipitation-driven pedogenic model is not entirely applicable to the loess developed in the semi-arid western CLP, considerable caution should also be warranted in quantitative reconstruction of paleoprecipitation using magnetic susceptibility-based data.