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Production of Superparamagnetic Magnetite During Thermal Demagnetization of Chinese Loess/Paleosol

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We have measured bulk susceptibility (MS) at room temperature (MS_{293K}) and liquid Nitrogen temperature (MS_{77K}) after each demagnetization step on loess/paleosols (L1/S1) samples from the southeastern margin of the Chinese Loess plateau. The ratio R_{MS} = MS_{77K}/MS_{293K} was found to be less than 1.0 for paleosol and slightly weathered loess samples, while pure loess has R_{MS} >1.0.

The ratio R_{MS} has a theoretical maximum of 3.83 for an assemblage of only paramagnetic minerals decreasing with increasing concentrations of magnetite. Values of R_{MS} <1.0 may either indicate a transition of magnetic grains (magnetite or maghemite) from a superparamagnetic (SP at 293K) to single domain (SD) state at 77K, or indicate the presence of magnetite passing through the Verwey transition above 77K. The linear relationship between frequency dependent susceptibility (K_{fd}) and R_{MS} supports the SP-SD interpretation, apparently ruling out a significant contributions from Verwey-transition magnetite.

R_{MS} of paleosol samples decreases dramatically with heating above 200˚C, and we suggest that this reflects thermally induced production of SP-magnetite, a finding that is at variance with other reports. We propose that the ratio R_{MS} can be used as a rapid and non-destructive parameter to assess the presence of SP-grains and that it may add to the protocol of paleoenvironmental proxies.

Zero field warming (ZFW) curves of isothermal remanent magnetization (IRM) imposed at 77K indicate continuous blocking/unblocking of SP particles reflecting a wide grain size distribution. However, ZFW-curves of both heated (600˚C) and pristine paleosol samples do not show significant differences in inferred SP-magnetite un-blocking temperature spectra; a finding that remain to be further assessed.