中国レスにおける二次生成磁性ナノ粒子の探査

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Investigation of pedogenic nanoparticles causing magnetic enhancement in Chinese loess sediments

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Paleoclimatic signals have been recorded in various ways in Chinese loess sediments. Enhanced magnetic susceptibility (MS) of paleosol, about ten times higher than loess at most, is reflected by pedogenesis, the degree of which depends on intensity of summer monsoon. MS of loess-paleosol sediments is used even as a tool to estimate summer monsoon intensity, especially paleo-precipitation. However, these interpretations and application of magnetic enhancement are theoretically vulnerable because the pedogenic magnetic particles causing magnetic enhancement have never been detected.

In this study, we search for a detritus grain size band that is concentrated with pedogenic magnetic particles, using loess-paleosol sediment samples from a sequence from loess L8 to paleosol S8 in Lingtai, central Chinese Loess Plateau. MS ranges from 31~123 E-8m^3/kg for sequence L8-S8. We selected 2 specimens showing lowest (L8: 29 E-8m^3/kg) and highest (S8: 113 E-8m^3/kg) MS, which reflect extremely low and high degree of pedogenesis in each sequence respectively. The following experiments were conducted. First, we divided bulk samples into 3 subsamples with different grain size bands (D1: over 10 micrometers, D2: 10~1 micrometers, D3: below 1 micrometer). Trial and error was repeated to find a method of separation with small sample loss (below 1 % in sample mass). Second, we estimated their magnetic contribution to bulk magnetism by measuring MS. Third, we conducted IRM component analysis, magnetic hysteresis and thermomagnetic measurements to obtain more information for each subsample.

Assuming that the effect of pedogenesis is negligible for loess sample with the minimum MS (29 E-8m^3/kg), namely original MS of aeolian detritus is kept, the paleosol sample with the maximum MS (113 E-8m^3/kg) would have been subjected to an intensive magnetic enhancement by a 290 % increase in MS. Contributions to the enhancement differ with grain size bands; 8 % for D1, 45 % for D2, and 32 % for D3. Frequency dependence (FD) of MS that reflects the amount of super-paramagnetic (SP) particles for bulk samples is 5.2 for loess and 19.0 for paleosol, showing a large increase by 265 % due to pedogenesis. The pedogenic increase in FD of MS was calculated for each grain size band as 5 % for D1, 70 % for D2, and 30 % for D3. Thus, it is clear that pedogenically neoformed magnetic grains are concentrated in D2 and D3 bands, significantly contributed by SP particles. However, we note that the absolute values of MS in unit of E-8m^3/kg are 49.4 for D2 and 28.6 for D3, and FD in unit of E-8m^3/kg are 10.8 for D2 and 4.4 for D3. These results of MS measurements suggest the pedogenic magnetic particles are mainly concentrated in D2. In addition, the results of magnetic experiments mentioned above suggest that the pedogenic magnetic particles are ferrimagnetic particles with low coercivity such as magnetite or maghemite. Considering grain size of SP magnetite/maghemite particles being less than approximately 50 nanometers, the pedogenic SP particles must exist in detrital silicate minerals as inclusions. Results of other loess-paleosol sequences and TEM observations will also be shown in the presentation.