OUT-OF-PHASE SUSCEPTIBILITY AND VISCOUS MAGNETIZATION: ALTERNATIVE TOOLS FOR MAGNETIC GRANULOMETRY OF SEDIMENTS AND SOILS

Martin Chadima[1, 2*]

[1] AGICO, Inc., Brno, Czech Republic.
[2] Institute of Geology AV CR, v.v.i., Prague, Czech Republic.
[*]e-mail: chadima@agico.cz

ABSTRACT

Out-of-phase susceptibility and viscous magnetization are suggested as alternative methods in magnetic granulometry of weakly magnetic loess/paleosol sections. The relative amount of the ultra-fine grains assessed by both out-of-phase susceptibility and viscous magnetization decay methods correlates very well with the frequency-dependent susceptibility measurements.

Keywords: Out-of-phase susceptibility, Viscous magnetization

RESUMEN

La susceptibilidad fuera de fase y la magnetización viscosa se sugieren como métodos alternativos para las secciones granulométricas de paleosuelos/loess con señales magnéticas débiles. La cantidad relativa de granos ultrafinos determinada por ambos métodos de susceptibilidad fuera de fase y decaimiento de la magnetización viscosa, correlacionan muy bien con las mediciones de susceptibilidad dependiente de la frecuencia.

Keywords: Susceptibilidad fuera de fase, Magnetización viscosa

Problem

In some geological and environmental processes, such as diagenesis, very low-grade metamorphism, pedogenesis, origination of anthropogenic pollutants, new ultra-fine magnetic minerals can be formed. The variation in content of these minerals has been routinely investigated by frequency-dependent magnetic susceptibility. Although this technique is well-established, the calculation of the frequency-dependent coefficients requires repeated measurements at least in two different operating frequencies which significantly prolongs measurement time and may be prone to operator mistakes and specimen mishandlings. Moreover, the frequency-dependent susceptibility reaches its limits when applied to very weakly magnetic (i.e. low-susceptibility) materials.

Proposal

To overcome these drawbacks, a refined technique is proposed which utilizes the phase angle between in-phase and out-of-phase susceptibilities. The phase angle is directly related to the frequency-dependent susceptibility via the $\pi/2$ law assuming that the out-of-phase susceptibility is solely due to the viscous phenomena and not due to electrical eddy currents or weak field hysteresis. Using MFK1 or KLY5 models of Kappabridges (both manufactured by AGICO, Inc.), phase angle is directly measured, although very rarely considered and processed, together with the routine in-phase susceptibility measurements.
Alternatively, especially in case of low-susceptibility materials, the relative content of ultra-fine particles can

be assessed by quantification of time-decay of viscous remanent magnetization. Using artificially-imparted magnetization, much stronger signal is usually obtained compared to that of magnetic susceptibility. For that purpose we employed a LDA5/PAM1 Pulse Magnetizer coupled with a JR6 Spinner Magnetometer (AGICO, Inc.). Both instruments are simultaneously controlled thus they work in the same time frame. Magnetic remanence is measured repeatedly as a function of time and exponential decay curves are fitted on the acquired data and the relative ratio of viscous and non-viscous particles is estimated.

Application

Our approach is demonstrated on a collection of loess/paleosol specimens from various locations in the European loess belt. The relative amount of the ultra-fine grains assessed by both out-of-phase susceptibility and viscous magnetization decay methods correlates very well with the frequency-dependent susceptibility measurements.