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Identification of Metallic Iron in an Urban Dust Using Magnetometry, Microscopic Observations and Mössbauer Spectroscopy

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Abstract

Thermomagnetic experiments for indoor dust, outdoor dust, street dust and dust from cabin air filters from cars were conducted for identification of magnetic mineralogy. Firstly, the temperature changes of magnetic susceptibility κ(T) in the range of 30–700°C were determined. Secondly, the induced magnetization M(T) in the wider temperature range of 30–800 °C was obtained with applied magnetic field of 500 mT.

Both κ(T) and M(T) thermomagnetic curves revealed the Curie temperature (T_c) of ~585°C which confirms the presence of magnetite as the primary magnetic phase. The "tail" on the heating curves visible as substantial decreasing of κ between 600°C and 700°C was the attribute of the second magnetic phase. The curves of M(T) for samples heated up to 800°C revealed the second magnetic transition at 760°C characteristic for metallic iron and/or iron-based alloys.

The microscopic observation coupled with energy-dispersive X-ray spectroscopy and Mössbauer spectra confirmed the presence of metallic iron fraction in non-heated samples. The magnetic extract of dust from different environments contained the elongated shaving-like particles comprised of metallic iron.

The "tail" appearing on the heating curve of κ(T) between 600°C and 700°C is often interpreted as the effect of presence of hematite. Probably in other studies that phase is not recognized as iron due to 700°C limit of heating. Our study shows that heating samples up to 800°C and measuring magnetic properties is the effective method to distinguish between hematite and metallic iron in dust.

The study was also concerned on the process of oxidation of metallic iron to magnetite by measuring the hysteresis parameters during heating-cooling treatment and after step-wise

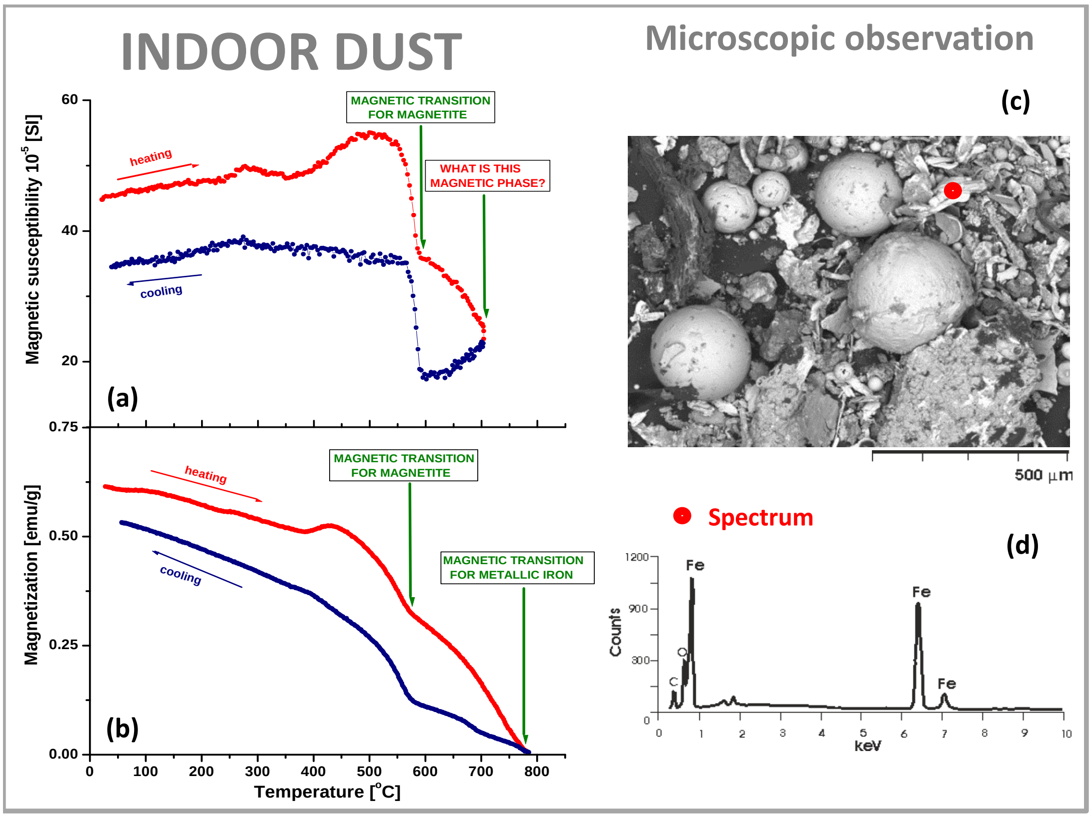

Fig. 1. Temperature changes of magnetic susceptibility κ(T) in the temperature range of 30–700°C (a), changes of induced magnetization M(T) in the temperature range of 30–800°C (b), electron scanning microscopy observation (c), energy-dispersive X-ray spectra (d).

annealing. It was found that the process of oxidation of metallic Fe is responsible for the changes of hysteresis parameters of samples after heating-cooling cycle and relocation of hysteresis parameters ratios on the Day-Dunlop diagram. This is due to the fact that both hysteresis parameter ratios M_{rs}/M_s and H_{cr}/H_c do not depend on the concentration of magnetic particles but only on the magnetic mineralogy and domain state.

Airborne particle matter may have adverse health effects because with breath millions of solid particle including metallic iron can enter our respiratory system. Iron plays substantial role in many cellular functions, in particular in electron and oxygen transport, nitrogen fixation and deoxynucleotide synthesis. It can be also toxic to cells by acting as a catalyst for the production of free radicals that are reason of damage of lipid membranes and other cellular constituents.

Keywords: magnetic methods, thermomagnetic curves, magnetite, metallic iron.

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