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Morphological and mineralogical forms of technogenic magnetic particles in industrial dusts

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Most of the magnetic particles occurring in urban and industrial dusts have a technogenic origin. With this term we define iron minerals that were produced in a wide variety of technological processes (metallurgy, fuel combustion, ceramics, cement production, coke production, etc.) in high temperatures and emitted into the atmosphere. They are mostly iron oxides with ferrimagnetic or antiferrimagnetic properties. This feature makes it possible to use them as tracers of industrial pollution because their presence, even in trace amounts, in dusts, soils, or sediments can be easily detected by magnetic measurements. The morphology, mineralogy, and magnetic properties of technogenic magnetic particles (TMPs) were analysed in four kinds of industrial dust produced during high temperature technological processes of different branches of industry (lignite and hard coal burning, cement production, coke production). The study was carried out by means of magnetic susceptibility measurement, energy dispersive spectroscopy (EDS), scanning electron microscope (SEM), X-ray diffraction, Mössbauer spectroscopy, and thermomagnetic analysis. To assess the total content of the magnetic fraction in bulk dust samples, mass specific magnetic susceptibility (χ) was measured using an MS2B "Bartington" sensor, and then a physical separation of magnetic particles (mostly of technogenic origin) was conducted. The dusts revealed high diversity of the χ value, which was dependent on the magnetic particles' concentration and mineralogical composition. Significant differences in the magnetic mineralogy of dusts coming from different branches of industry were observed. Particular technological processes from many branches of industry are sources of very characteristic morphological and mineralogical forms of technogenic magnetic particles. Their crystalline structure morphology and mineralogical composition determine different magnetic behaviours. These TMPs could be distinctive for pollution source identification and could serve as a tracer of dust origin and (if found in topsoil) in identification of soil pollution sources. Magnetic particles from coal burning usually occur in spherical forms of magnetite, maghaemite, or magnesioferrite with skeleton morphology. Such technogenic iron oxides create an inner part of spherules that is coated with a thin silicate or aluminosilicates layer or occur on the surface of silicates as well as amorphous silica forms. Magnetic spherules of another type are empty inside and their crust consists for the most part of a magnetite or an intermediate magnetite-maghaemite phase. In dusts and ashes after lignite burning, haematite with antiferrimagnetic properties appears in larger quantity. As a result, fly ashes and dusts after lignite burning have considerably lower values of magnetic susceptibility compared with those after hard coal burning. A variety of technogenic iron minerals in cement dust, including magnetite, maghaemite, haematite, ferrites, and goethite, which occur in different stoichiometric and morphological forms, are caused by different raw materials, fuels, and iron-bearing additives used in the cement production process. A characteristic magnetic mineral for this kind of dust is Ca-ferrite and iron oxides co-occurring with calcite, anhydrite gypsum, and bassanite. Strongly magnetic metallic iron (α Fe) and ferrimagnetic pyrrhotite are characteristic components of dust formed in the coking processes. These minerals occur as densely packed aggregates of well developed crystals or in irregular forms. Metallic nickel particles also occur rarely in this kind of dust.