MAGNETOCLIMATOLOGICAL ARCHIVE IN SIBERIAN LOESS/PALEOSOL SEQUENCES

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Now it is proved that loess deposition in Siberia has gone on throughout at least one million year and has the climate-caused character. In some places the blanket of alternating loess and paleosols exeeds 100 meters in thickness. A distinct differentiation of magnetic properties in Siberian loess and paleosols and their correlation with the marine oxygen isotope records suggest that variations of magnetic parameters in Siberian loess/paleosol sequence are climatically controlled.
Changes of concentration-dependent characteristics (k, SIRM, Js) in Siberian loess/paleosol sequences fit “alaskan” or “wind-vigor” model. Values and behaviour of FD-factor correspond to those in Chinese loess/paleosol series within the limits of “pedogenic” model. Enhanced values of ARM in developed paleosols of Siberia also follow ARM behaviour in Chinese paleosols. Both of FD and ARM indicate the intensive pedogenesis in several regions of Siberia with the production of a new ultrafine (SD, SPM) magnetic minerals *in situ*. Thus, magnetism of the Siberian loess/paleosol sequences stores paleoclimatic signal in more complex way than magnetic record of “chinese” or “alaskan” models. Superposition of the two models in Siberian magnetic proxy of past global changes gives a new advantage: the concentration-dependent magnetic parameters allows to study climatic fluctuations during cold, arid glacial periods while the variations of the FD-factor and ARM allows to reconstruct the oscillations of interglacial conditions with increased precipitation and warmer temperatures.
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MAGNETIC PROPERTIES OF MODERN SOILS FROM ALTAI REGION (SOUTH SIBERIA) WITH DIFFERENT CLIMATIC CONDITIONS

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Magnetic properties of modern soils were studied in four locations of Altai region - 2 in Mountain Altai and 2 in Steppe Altai. There is no industrial activity over the investigated territory that excludes an anthropogenous pollution of soils. All areas are located within one climatic zone (continental climate), however, but the degree of continentality is various: from mid-continental up to sharp continental. Mid-annual precipitation varies from 100 up to 600 mm, average temperature of January changes from -31.7°C to -15.2°C, average temperature of July - from 13.8°C to 20.2°C. Chestnut steppe, mountain-steppe soils, soils of dry steppes and semideserts, chernozems, marsh and meadow soils are present in investigated sites. Non-oriented samples were taken from fresh cleaned surfaces both from land surface and along a soil profile into standard 8 cm^3 plastic boxes. We measured the following magnetic parameters: volume magnetic susceptibility (k), measured on two frequencies (0.47kHz, 4.7 kHz), ARM, SIRM and the FD-factor (%) was calculated. The first three parameters vary through 2 orders (for example, k changes 5 to $520*10^{-5}$ SI). The FD-factor fixes the presence of superparamagnetic grains and, at first approximation, a degree of pedogenic intensity, it varies from 0 up to 6%. All types of soils are characterized by the certain ranges of magnetic parameters, partially overlapped.

Magnetic properties of Altai automorphic soils depend on a climate. The chernozems of Steppe Altai (midcontinental climate) are most magnetically enhanced (k=150-$520*10^{-5}$SI). The chestnut steppe and mountain-steppe soils (very continental climate) are slightly less magnetic (k=50-$170*10^{-5}$SI). The soils of dry steppes and semideserts (sharp continental climate) are weakly magnetic (k=20-$80*10^{-5}$SI). The meadow chernozems (k=50-$100*10^{-5}$SI) are intermediate in magnetic parameters between the soils of mountain-steppe and dry steppe. The hydromorphic marsh and meadow soils are the least magnetic (k=5-$50*10^{-5}$SI). The FD-factor and intensity of pedogenisis with neoformation of magnetic minerals reduces in the similar way.

The scatter of magnetic characteristics within the individual site is caused by relief, thickness of humus horizon, magnetic properties of underlying deposits, grain sizes of sediments and by the distance from the magnetic source.

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MAGNETIC PROPERTIES OF PROFILES OF SOILS FROM THE SLOVAK REPUBLIC

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This report presents the study of magnetic characteristics of two soils depth profiles from the Slovak Republic. Depth variations of magnetic properties; mass specific magnetic susceptibility (χ), anhysteretic remanent magnetization (χ_{ARM}) and hysteresis parameters: saturation isothermal remanence (SIRM), saturation magnetization (Ms), coercivity (Hc) and coercivity of remanence (Hcr) were compared with pedogenic horizons.

The first profile taken from the area Rusovce (R1) represents Eutic Combisol, the second profile VOD from the area Voderady is characteristic for Calcaro-Hapic Charnozem soil type. The magnetic susceptibility in A horizon of the profile R1 is almost constant, increasing along B horizon and subsequently decreasing with depth down to reach parent rock (horizon C). The distribution of different magnetic parameters along the profiles indicates that zone of B horizon enriched with pedogenic magnetic minerals (iron-oxides and iron – oxyhydroxides) is begins at depth of 25 cm. The B horizon contains single domain grains of low coercive magnetite/maghemite that are typical of pedogenic process. The multidomain grains of high coercivity hematite are present in parent rock.

For the VOD profile pedogenic process occurs in A horizon up to depth 60cm. The A horizon contains constant concentration of magnetic particles with low coercivity. The curves of Ms and SIRM versus depth and χ_{ARM} versus χ show that parent rock occurs below 120 cm. These results correspond to pedogenic soil profile from Voderady area.

Magnetic parameters are well determined for A, B and C horizons but differences in magnetic parameters are characterized for zones situated between A and B horizons and B and C horizons. Knowledge of magnetic parameters along the profiles characteristic for particular pedogenic horizon allowed to identify vertical pedogenic structure of soils.

MAGNETIC TRANSFORMATIONS IN WATERLOGGED HOLOCENE SOILS (WEST SIBERIA)

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The waterlogging effect was studied in the ancient men settlement where the automorphic soils were waterlogged due to human activity. Three sections: 1) unaltered automophyc soil profile and underlying loess, 2) secondary waterlogged soil profile and underlying loess, 3) hydromorphic soil profile and underlying loess were studied magnetically.

Magnetic properties of hydromorphic soil are quite different from those of automorphic soils. There is no difference in magnetic properties along the soil profile. Day plot indicates nearly constant magnetic grain size which is different from automorphic soils. Coercivity of hydromorphic soil is rather high, Hcr=80-90 mT.

Unaltered soil profile shows the distinct difference in magnetic properties between soil and loess (magnetic enhancement of soil) and increase of effective magnetic grain size from soil to loess.

Secondary waterlogging of automorphic soil results in equalization of magnetic properties between soil and underlying loess which is caused by dissolution (leaching) of primarily small magnetic grains of SP and SD size. This is testified by decreasing of FD and ARM and increasing of coercivity in waterlogged soil in respect to unaltered soil (from Hcr=40 mT to Hcr=60 mT). Day plot also shows the absence of SD and reduce of PSD grains in waterlogged soil. However, size-dependent magnetic parameters (χ/ARM, χ/SIRM and SIRM/ARM) show that changes in effective magnetic grain size along the soil profiles remain even in waterlogged soil and genetic horizons can be distinguished in altered soil profile despite to constant values of χ.

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FREQENCY DEPENDENCY AND ABSOLUTE MAGNETIC SUSCEPTIBILITY OF TROPICAL SOILS AS FUNCTION OF PARENT MATERIAL AND SOIL DEVELOPMENT- INFLUENCE ON LANDMINE DETECTION WITH METAL DETECTORS

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Magnetic properties of tropical soils are a common cause of problems during demining campaigns with metal detectors. Therefore demining organisations are interested in guidelines assisting them in assessing magnetic soil properties of a region in advance of a demining campaign.
We used a comprehensive set of tropical soil samples collected from world wide locations and analysed them with regard to their magnetic susceptibility at two frequencies (465 and 4650 Hz). The results of these measurements - namely the susceptibility at the lower frequency and the difference between the susceptibility at both frequencies (frequency dependency) – were tested for dependencies on parent material and degree of weathering. For each sample the parent material and a complete chemical analysis is documented. The degree of weathering was estimated using the ratio $SiO_2/Fe2O_3+Al2O_3$ which is based on the chemical analysis of each sample. It gives a measure for the extent of desilification which is a quite common process during soil development in the tropics.
All samples show a clear increase of magnetic susceptibility with increasing degree of weathering. Possible explanations are the neoformation of magnetic minerals or the residual enrichment of existing magnetic minerals which are relatively resistant during the weathering process. With regard to the frequency dependency the correlation with degree of weathering is limited to sedimentary parent material. It is known that the frequency dependency of susceptibility is caused by superparamagnetic minerals with a size of less than 100 nm. Especially in parent materials with a sedimentary origin, primary minerals in this size fraction are scarce. This leaves the neoformation of magnetic minerals during weathering as the likely cause for the positive correlation between weathering and frequency dependency in soils with sedimentary parent material.
Based on the above observations we developed a classification scheme that may be used to predict susceptibility as well as its frequency dependency in advance of a demining campaign to give advice for the choice of proper detection technique.

MAGNETIC PROPERTIES OF THE CARPATHIAN OCHRE DEPOSIT IN THE REGION OF HERMANOWA VILLAGE NEAR RZESZÓW

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This work was concentrated on the use of magnetic susceptibility in localization of ochre soil. The deposit of Carpathian ochre is located in the region of Hermanowa village to the south of Rzeszów (southern Poland). Researches of magnetic susceptibility of ochre were carried out using the MS2 system (Bartington, UK). The measurements of the total magnetic field of the Earth (T) were performed in the place of ochre occurrence and to the south of the deposit, using the ENVI MAG proton magnetometer system (SCINTREX, Canada).
Laboratory studies of magnetic susceptibility were executed on the samples of soil. Frequency dependence of magnetic susceptibility was calculated. Ochre soils show quite stronger magnetic properties than nearby lying soil. Magnetic properties of the brown ochre are similar to properties of acid crystalline rocks. It can be connected with processes occurring in deposit or strong magnetic properties of bed rock. The large diversification of magnetic properties of ochre can be connected with minerals present in ochre and processes (e.g. claying) occurred in the deposit. The deposit of ochre causes the small disturbances of the magnetic field with the exception of anomaly (150 nT) situated in the northern part of the deposit. The enhancement of susceptibility of ochre is also observed there. Investigations of magnetic susceptibility can be successfully applied in reconnaissance investigations of ochre deposits.

MAGNETIC STUDY OF FOREST SOILS IN KRUSNE HORY REGION

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The aim of this study is to demonstrate the application of soil magnetometry in regional scale in Krusne hory Mountains. Immission level in this area is strongly affected by considerable concentration of big sources of pollution (power plants, metallurgical and chemical industry), and large urban agglomerations at the foothills. The average annual deposition of PM10 in the eastern part of Krušné hory Mts (35-46 μg/m3) is among the highest in the Czech Republic. With respect to complex geology in Krušné hory, we started with investigations of depth profiles. Especially in such cases detailed laboratory investigations are necessary in order to determine the actual ratio of anthropogenic and natural (lithogenic) ferrimagnets in top soil layers. The net of 22 permanent soil pits maintained by University of Life Sciences in Prague, is regularly used for monitoring chemical changes and profile development in forest soils. Depth of individual pits varies from 40 to 60 cm and in most cases included layer of basement rock, or soil dominated by the basement rock (C horizon). Our investigations were aimed at magnetic classification of individual soil (sub)horizons and at elucidating the problem of magnetic discrimination of the contaminated surface layer or, eventually, to resolve the depth distribution of anthropogenic and/or lithogenic magnetic particles). In most localities, increased values of magnetic susceptibility (25 – 200 x 10^{-5} SI) were clearly identified in the top-soil layers. Magnetic enhancement is limited to depths of 4-7 cm below the soil surface, usually in F, H or top of Ah soil horizons. On the other hand, deeper soil horizons are characterized by much lower values of susceptibility (5 – 30 x 10^{-5} SI).
In most localities, increased values of magnetic susceptibility (25 – 160 x 10-5 SI) were clearly identified in the top-soil layers. Magnetic enhancement is limited to depths of 4-7 cm below the soil surface, usually in F, H or top of Ah soil horizons. Magnetite–like phase (soft) was found to be responsible for the enhancement of magnetic susceptibility of the top soil. Subsoil layers show more complex behaviour in heating curves (new magnetic phases around 300^{o}C and 450-530^{o}C). A strong lithogenic effect on soil magnetic susceptibility was observed in 4 localities. Magnetic susceptibility increases with depth and reaches the highest values in bottom soil (B/C or Cn) layers. In that case separation of anthropo- and lithogenic contribution in topsoil layers is difficult.
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SOIL MAGNETIC ANOMALIES ON THE MAP OF POLAND

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The five areas of geochemical and magnetic anomalies observed on the "Geochemical Map of Poland" and on the "Map of Magnetic Susceptibility of Soils in Poland" with unclear origin were chosen for the study. These areas were located in different regions of Poland: Kolneńska Plateau, Hrubieszów area, Western Bieszczady Mts., Cieszyn – Skoczów – Jastrzębie area, Kępno area. The investigations were carried out using *in situ* soil magnetometry techniques and classical chemical analysis. The aim of this study was to explain the origin of observed anomalies and in case of their anthropogenic origin to evaluate potential ecological hazard. The clear anthropogenic origin connected with industrial and urban dust deposition, including technogenic iron oxides that were used as a tracer for heavy metal contamination was confirmed only in the case of Cieszyn – Skoczów – Jastrzebie area. These anomalies were a result of industrial and urban dust deposition containing ferromagnetic iron oxides of technogenic origin, which are sources of heavy metals. The main source of pollution in this area was metallurgical plant in Trinec (Czech Rep.) and local power plants. In some soil profiles from this anomaly, especially in those located on areas of surface subsidence connected with underground coal exploitation magnetic enhancement was connected with gleic horizons occurrence with presence of iron sulphides in superparamagnetic fraction. Other studied anomalies have natural (geogenic or pedogenic) origin. Kolneńska Plateau anomaly was a result of occurrence of Quaternary glacial tills in geological background. Soil complex of Hrubieszów area was connected with special magnetic properties of chernozem soil complex developed on less deposits, whereas Kępno anomaly was a result of local bog iron ores giving high magnetic susceptibility values and high Fe, Mn, Cr, As and B concentrations. The spatial range of the last anomaly is very local (only ca. 1 km) that is a much smaller area than observed on the "Map of Magnetic Susceptibility of Soils in Poland". Detailed field investigation in the area of anomaly observed on the "Map of Magnetic Susceptibility of Soils in Poland" in Western Bieszczady Mts did not confirm their existence. Only small local magnetic anomaly with susceptibility values up to 40 $\times 10^{-5}$ SI units was detected in area of former village Wola Michowa, which was quite a big town some centuries ago. Since Second World War this area has almost been uninhabited. However extensive areas of geochemical anomalies in Beskidy and Bieszczady Mts are connected with increased values of some elements in rocks of Carpathian Flish.

FORMATION OF TECHNOGENIC MAGNETIC ANOMALIES IN THE FOREST SOIL DEPENDING ON AMOUNT OF INDUSTRIAL DUST DEPOSITION AND THE TIME FACTOR

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The investigations were carried out on the area of about 5000 ha in 61 points (included one profile of fossil soil). Sampling points were located in reclaimed excavation of Sand Mine "Szczakowa" and surrounding areas covered with 40-100 years old forest. The aim of this study was to explain increase in magnetic susceptibility during about 100 years in dependence on dust and iron fall as well as some heavy metal fall.

The magnetic susceptibility of forest soils was measured directly in the field using a "Bartington" MS2D sensor according procedure describing by Schibler *et al*. (2002). For determining heavy metals, the samples were dissolved in 2 M nitric acid (HNO_3) and the atomic absorption spectrometry method was used (Desaules *et al*. 2001). The dust fall for the period from 1976 to 2004 ranged from 28.5 to 229.6 $g \cdot m^{-2} rok^{-1}$ and the iron fall – from 0.8 to 11.1 $g \cdot m^{-2} rok^{-1}$ (data was obtained from the Regional Sanitary Station in Katowice).

Table. Magnetic susceptibility (κ) and heavy metal content depending on the age of study points (surfaces).

age (year):	**0**	**1 - 20**	**21 - 59**	**60 - 80**	**81 - 120**
κ ($\times 10^{-5}$)	0 - 5.3	5.4 - 30	6.2 - 65	33 - 127	14 - 40
Fe (%)	0.24 - 0.58	0.88 - 4.36	0.56 - 6.1	0.32 - 7.75	0.56 - 2.38
Zn ($mgkg^{-1}$)	2.8 - 7.6	19 - 997	234 - 697	110 - 550	90 - 704
Pb ($mgkg^{-1}$)	1.2 - 7.4	4.6 - 150	8.6 - 224	19.5 - 1970	14 - 304

Magnetic susceptibility rises along with the age of study points (surfaces), while the accumulation coefficient for iron varies between 2 do 15, and for other metals it is much higher. Magnetic susceptibility of the old humic horizon of the fossil soil is 5.3×10^{-5}, but in organic horizon formed during last 120 years – 176×10^{-5}, whereas iron content increases almost 4 times (from 0.044 do 0.172 %), zinc content ranges from 2.2 to 546 $mg \cdot kg^{-1}$, and content of lead from 64 to 194 $mg \cdot kg^{-1}$.

On the assumption that in the whole study area the dust fall is at the similar level, formation of magnetic anomalies as a result of increasing period of dust deposition should be expected. Value 30×10^{-5} is often assumed as the beginning of anomaly formation, so it could be concluded that it starts after 15-20 years of dust deposition. It is mostly accompanied by geochemical anomaly, which is determined by the contents of zinc, lead and cadmium exceeding limit values (adequately: 150, 50 and 0.8 $mg \cdot kg^{-1}$) (Strzyszcz *et al*. 2006).

MAGNETIC PROPERTIES OF SOILS FROM SUDBURY, CANADA

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The mining process produces huge amounts of waste that contain heavy metals including iron, and a range of these toxic heavy metals are released to the air by smelting. Nickel-copper deposits were discovered at Sudbury, Ontario, in the late 1800's, and the area is still remains one of the world's foremost nickel and copper mining areas. As the long history of mining in Sudbury continued, it has caused significant environmental damage. The main purpose of this study is to determine the mineral magnetic properties of top soil samples collected from urban and rural areas. For this aim, the area has been divided into 10x10 km grids and in situ magnetic susceptibility measurements were made and soil cores were collected from 30 sites. The mineral magnetic measurements include magnetic susceptibility (κ), frequency dependence of susceptibility (χ_{FD}), partial anhysteretic (pARM) and isothermal remanent magnetization (IRM) and hysteresis properties. Mass magnetic susceptibility values (χ) ranges from 4 to 150 x 10^{-8} m^3kg^{-1} within the ca. 4000 km^2 area. High χ values are mainly observed around the stacks and in the dominant wind direction to southeast of the city. The laboratory measurements showed that low coercivity magnetic minerals are dominant in most of the top soil samples (S-ratio ranges from 0.8 to 1.0). The pARM measurements indicated that the grain sizes were mostly in the range of 2-5 μm and the hysteresis parameters plotted on a Day plot showed that the most of the samples were in the pseudosingle domain (PSD) state. Anthropogenic spherules (0.5 to 40 μm) are observed in SEM images, and according to EDS measurements the abundance of iron is ~50% per sphreule. SEM also gave useful information about the surface morphologies of the spherules. Our results show that the top soils in Sudbury area contain an abundance of anthropogenic spherules which can threaten human health. Continued sampling at a smaller scale in the near future is aimed at tracking the magnetic minerals and investigating their magnetic properties.

MAGNETIC INVESTIGATION OF HEAVY METALS CONTAMINATION IN URBAN TOPSOILS AROUND THE EAST LAKE, WUHAN, CHINA

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Urban soils were collected from four areas with different environmental settings around the East Lake in Wuhan, China: a heavy industrial area well known for thermal power generation and steel works; villages located in the downwind area of the industrial area; a main road with heavy traffic and roads around the lake. Magnetic measurements and heavy metal analyses show that concentrations of magnetic particle and heavy metals in urban topsoils are significantly elevated due to the input of coarser-grained magnetite from industrial (e.g., power generation and steel work) and other anthropogenic activities (e.g., vehicle emissions). Strong correlations are found between concentration-related magnetic parameters, e.g., magnetic susceptibility (χ), saturation isothermal remanent magnetization (SIRM) and anhysteretic remanent magnetization (ARM) and the concentration of heavy metals, for example, the Pearson's correlation coefficients are 0.736 for χ-Cu, 0.675 for χ-Pb, 0.678 for χ-Zn and 0.631 for χ- Tomlinson PLI, respectively. Moreover, in terms of grain sizes, the magnetic particles of different origins can be efficiently discriminated at the studied region. Therefore, magnetic measurements provide a basis for discrimination and identification of different soil-contamination sources, and can be used as an economic alternative to chemical analysis when mapping heavy metal contamination in urban soil around the East Lake region, Wuhan, China.

CHARACTERISATION OF SOIL MAGNETIC PROPERTIES ON FORMER MINEFIELDS IN SOUTHERN MOZAMBIQUE

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Mozambique suffers from a long lasting civil war which began with its independence from Portugal in 1974 and ended in 1992. It is estimated that 0.5--2 million landmines remained as a legacy of that conflict and clearing operations began in the 1990s. The metal detector based on electromagnetic induction (EMI) is the most widely used instrument for landmine clearance. The performance strongly depends on soil magnetic properties. A metal detectors ability to find land mines may be impaired to an extent that false alarms are generated and minimum metal mines remain undetected. The main soil factor that impairs metal detectors is their magnetic susceptibility. It is mainly caused by the presence of ferrimagnetic iron oxides. The most important minerals are magnetite, titanomagnetite and maghemite.

In addition to absolute soil magnetic susceptibility and its frequency dependence it is also well known that the spatial variation of magnetic susceptibility can deteriorate the performance of metal detectors seriously. Spatial variability affects In particular the ground compensation of many instruments.

With this background in mind a field investigation on former minefields in Mozambique was carried out on three different sites where metal detector performance was impaired during clearance operations. The sites of investigation are located in southern Mozambique: Two sites in Moamba in the flat coastal hinterland where soil parent rock consists of mesozoic basalts and sediments and one site in Namaacha in the Lebombo mountain range where rhyolitic rocks are prevalent.

At first a geological and pedological survey was done for a general geoscientific characterisation. The magnetic susceptibility was measured on a 10 by 10 m grid with a measuring distance of 10 cm to determine small scale spatial variability. The variogram analyses of the results show that the correlation length of the values is in the range of < 2 m which implies a notable effect on the soil compensation capabilities of most metal detectors.

In laboratory measurements the magnetic features of soil samples of the entire soil profiles were investigated as follows: Temperature variation of magnetic susceptibility (kappa (T)) was measured using a AGICO-MFK1 kappa bridge with CS-3 furnace and +CS-L low temperature cryostat apparatus at temperatures ranging from liquid nitrogen temperature up to 700 degrees centigrade. These measurements help to identify the carrier of magnetisation also in weakly magnetic specimen by determination of Curie-temperatures, Verwey- or Morin-transitions.

The results show gradients of the magnetic mineral compounds in soil profiles and give specific hints on the neoformation of magnetic minerals in the topsoil. In summary these are the main results: (i) Topsoils show similar magnetic mineral composition even though the parent rocks are different. This is an indication for the neoformation of magnetic minerals (ii) The frequency dependence of susceptibility is higher for topsoil than for parent material. This is an indication on neoformation of superparamagnetic minerals (iii) The interpretation of magnetic susceptibility vs temperature is a difficult matter due to high organic content in soils and mineral conversion during heating.

TOWARDS STANDARIZING APPLICATION OF MAGNETIC PROXY METHODS FOR POLLUTION ASSESSMENT OF THE UPPERMOST SURFACE LAYER

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Soil and sediments play an important role within environmental systems and both can act as water filters but also as sinks, storage and source media of pollutants endangering ecosystems and soil & water quality. This situation is extreme in developing and transition countries around the globe, where operational long-term environmental monitoring systems with high enough net density are practically lacking, records of human impacts on certain sites are hardly available, larger areas are affected by point source and diffuse pollutions, and limited budgets do not allow the excessive use of standard chemical sampling and testing methods in a desirable amount. Furthermore, the forthcoming European Soil Directive and national soil protection programs demand reliable methods for efficient site assessment and monitoring. We suggest a stepwise screening scheme combining fast and cost-effective proxy methods for large-scale 2D/3D overview and temporal monitoring, in combination and in suitable sequence with on-site sensors (e.g., portable XRF) and precise chemical laboratory analyses based on optimum targeted sampling. This will lead to a wider information basis, faster identification of pressures and potentially contaminated areas, and a more efficient use of traditional, precise, site investigation methods. Magnetic susceptibility (MS) processing and analysis provides new opportunities towards fast and cost-efficient discrimination and semi-quantification of anthropogenic heavy metal (HM) loads. Rapid MS measurements on vertical ultra-shallow (~0.5 m) sections generate a solid data base for optimized magnetic site characterization, allowing for reduction of HM analyses to a minimum of two analyses per site. A sufficiently large number of vertical MS curves can provide a statistically meaningful master curve. Processing of the curves allows the determination of a *boundary depth*, indicating the transition from the “polluted” upper soil layers to the “unpolluted” lower zone i.e., separating the vertical profile into two distinct layers which is crucial for standardizing of a site-independent MS processing. Introduction of a *block master curve* simplifies the complex variations of individual MS curves, representing mean values for the “polluted” and “unpolluted” soil zones. MS data of a selected individual soil core are transformed into a *block individual curve* and linked to the *block master curve* by a calibration factor. HM contents have to be only determined for two sub-samples from a selected individual soil core which is closest to the master curve, one from the “polluted” and one from the “unpolluted” part. Determination of the anthropogenic HM content which is representative for the site is performed using the calibration factor obtained from *block curve* processing. With this integrated MS and HM data processing scheme conventional time-intensive steps are performed cost and time-efficiently using magnetic methods and data processing, while HM analyses are reduced to a minimum. This provides an applicable standard tool for semi-quantification of anthropogenic HM loads in soil.

GEOSTATISTICAL EVALUATION OF MAGNETIC PARAMETERS AS AN INDICATOR OF HEAVY METAL CONTAMINATION IN FOREST TOPSOIL

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The goal of the study was the geostatistical evaluation of quantitative magnetic measures, which can be used for effective delineation of the extent of the area polluted with heavy metals. Several parameters of magnetic susceptibility, measured in the soil profile, were proposed as magnetic indicators of soil pollution and analyzed in detail. The following parameters were calculated: maximum magnetic susceptibility, magnetic susceptibility at the depth of 3 cm and 5 cm, and the area under the curve of magnetic susceptibility. Measurements were performed at forested study areas, located in Upper Silesian Industrial Area (Poland). Analyses were performed using geostatistical methods, and the results were verified using dense chemical measurements.

The results show that vertical measurements of magnetic susceptibility can be effectively used to assess the potential soil contamination with heavy metals. In particular, it is possible to use them for quantitative estimation of soil contamination level. Such method may be a useful alternative to more common surface measurements of magnetic susceptibility, often performed with MS2D Bartington sensor. Surface measurements are both fast and convenient, but sometimes they are rather difficult to interpret. In comparison with the surface measurements, the vertical ones are more informative and more resistant to possible measurement errors e.g. caused by thick forest litter. Moreover, the area under curve of magnetic susceptibility can be calculated even directly in the field, after simple SM400 software upgrade. Alternatively, the magnetic measurements of soil cores with a simultaneous integration of magnetic susceptibility signal can be performed in a laboratory using MS2C Bartington sensor. In some situations soil magnetic susceptibility at specified depth, such as κ3cm and κ5cm, can be quite an effective measure of assessing the potential soil contamination with heavy metals. The analysis of spatial distributions showed that the best threshold value of A κ equaled 75 mm × 10^{-3} SI. For this value, it was possible to assess the entire extent of polluted area, and only 28.2% of study area was incorrectly assumed to be contaminated while being clean. For A κ equal 80 mm × 10^{-3} SI this value decreased to 16.4%, but the 0.8% of polluted area was not detected. In case of κ3cm and κ5cm, the best results were obtained for threshold values equal 70 × 10^{-3} SI and 95 × 10^{-3} SI, respectively. The clean area incorrectly assumed to be a contaminated one equaled about 48% and 38% of study area, respectively. In case of κmax the modeled extent of the potentially polluted area was highly overestimated, reaching about 75% of the study area. Above results show also that the use of geostatistical methods allows for better processing of magnetometric data as well as for combining them with usually sparsely sampled chemical measurements.

COERCIVITY SPECTRUM ANALYSIS TO ASSESS THE SIZE DISTRIBUTION OF MAGNETIC PARTICLES

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Individual data points of, for example, the acquisition of an isothermal remanent magnetization (IRM) as function of applied field (at room temperature) represent the contribution of more than one mineral in cases of mixed magnetic mineralogy, the rule in natural samples. Therefore, interpretation in terms of grain size required for paleomagnetic and environmental analysis is less straightforward. Coercivity spectrum fitting enables such analysis in detail, it relies on an appropriate base function that describes the behaviour of indvidual coercivity components. In the absence of significant magnetic interaction a cumulative log-Gaussian (CLG) function is reasonable (Robertson and France, 1994, Phys. Earth Planet. Inter., 82, 223-234). Individual components making up a measured IRM acquisition curve add linearly (e.g. Carter-Stiglitz et al., 2001, J. Geophys. Res., 106, 26397-26411). A more generalized base function is the Skewed Generalized Gaussian SGG base function proposed by Egli (2003, J. Geophys. Res., 108, Art. No. 2081). In CLG fitting a particle assemblage from a single coercivity component (magnetic mineral) is characterised by three free parameters: (1) the saturation IRM (SIRM), (2) the field at which half of the SIRM is reached: $B_{1/2}$ (or $B_{cr'}$) and (3) the width of the distribution: the dispersion parameter DP, given by one standard deviation of the logarithmic distribution. Processing IRM acquisition curves by fitting log-normal components is straightforward (Kruiver et al., 2001, Earth Planet. Sci. Lett., 189, 269-276; Heslop et al., 2002, Geophys. J. Int., 148, 58-64) but limited by the symmetry dictated by the distribution. Skewed distributions must be fitted mathematically by two components while the physical meaning of the skewness is magnetic interaction and/or thermal activation (Heslop et al., 2004, Geophys. J. Int., 157, 55-63; Egli, 2004a, Phys. Chem. Earth, 29, 851-867). The physical interpretation of the parameters in SGG fitting or its simpler CLG version is still being refined. Also typical ranges for DP and skewness are being explored (kurtosis appears to be irrelevant). The current understanding of the physical meaning of the fitted parameters is as follows.

(S)IRM: The concentration parameter, the abundance of the given coercivity component.
$B_{1/2}$: The median acquisition field. The midpoint of the coercivity component.
DP: the width of a component, the distribution of microcoercivities. Ideal crystals with a minimal amount of lattice defects have a narrow microcoercivity distribution. Very wide components are physically less realistic. In IRM acquisition curves, biogenic magnetite has DP values of ~0.15 (log field units) (Kruiver and Passier, 2001, Geochem. Geophys. Geosyst, 2, Art 2001GC000181; Egli, 2004b, Studia Geophys. Geod., 48, 391-446), detrital material a DP range of 0.25-0.35, and oxidized magnetite a DP range of 0.4-0.5. High-coercivity components (hematite or goethite) seem to have slightly higher DP values than magnetite.
Skewness: skewed-to-the-left: thermal activation and/or magnetic interaction. Skewness-to-the-right may be due to a second coercivity fraction that is convolved in the fit.

MAGNETIC RESPONSE TO HYDROCARBON POLLUTION IN SOILS AND SEDIMENTS

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Contamination of soils and sediments by organic compounds is a global environmental threat. Our present research focuses on the study of magnetic properties of hydrocarbon contaminated soils and sediments using magnetic methods both on field sites as well as in laboratory batch experiments. The main objectives are (1) to assess a possible application of magnetic proxies for the delineation of organic contamination in soils and sediments and (2) to examine the role of bacteria in changing soil magnetic properties after hydrocarbon (HC) contamination. A former oil field in northern Germany (Haenigsen) and a former Soviet military airbase in Czech Republic (Hradcany) were studied, which are heavily contaminated with HC from long-term natural oil spills to the surface and leakage of aviation fuel into the ground, respectively. Additionally, three different types of natural clean soils were investigated in laboratory experiments by simulating hydrocarbon contamination in sterile and microbial active batch setups. Magnetic properties, soil properties, iron bioavailability, iron redox state and HC content of samples were measured. Additionally, magnetic susceptibility (MS) was monitored weekly in laboratory batch set-ups during several months. Results from the field sites showed that there is an increase of MS and a good correlation between MS and HC content. Weekly monitored MS results from the laboratory studies clearly indicate ~10% change (increase as well as decrease) of initial MS of respective soils in microbial active set-ups with saturation after a few weeks, whereas sterile samples did not show a change. Obviously the change of MS is caused by microbial iron mineral transformation in presence of HC contamination in soils. At Hradcany vertical sections covering unconsolidated sands of several metres were recovered by drilling. The vertical sections penetrate through the topmost saturated zone which is presently still contaminated by LNAPLs. Above the permanently saturated zone there is a transition zone of groundwater fluctuation due to natural annual variation and effects from pumping during remediation. MS values in the aquifer are generally low, probably due to magnetite dissolution. The transition zone shows a remarkable increase of MS from the lower to the upper part indicating that the temporarily upward migrating water table, containing HC compounds, lead to magnetite formation. In a core with less contaminated groundwater this effect is strongly reduced. The results suggest that the groundwater fluctuation zone is a region with enhanced bacterial activity especially at parts which are infiltrated by water only for short time.

POSSIBILITIES AND ECOLOGICAL CONSEQUENCES OF THE FERRIMAGNETIC MINERALS FORMATION IN THE PROCESS OF CEMENT PRODUCTION

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For the last two centuries the province of Opole was highly influenced by cement emissions as a consequence of strongly developed cement industry in this region of Poland. There are big deposits of marls and limestones in the central part of the province, being used as the raw materials for cement production. In spite of existence of only two cement plants nowadays, the number of plants in the past was much greater, up to eleven at the beginning of the 20th century.

As it was proven in former studies, raw materials, fuels, and particularly additives used in cement production, as well as production method (dry or wet), highly influence the magnetic susceptibility of cement dusts and soils in the vicinity of plants, causing wide variation in its values.

Still open is a question, if any new ferromagnetic minerals can be forming during the cement production as a result of mineralogical changes in existing iron compounds. Statistically important linear correlations between magnetic susceptibility and total amount of iron in cement dusts and clinkers suggest, that it is possible in the process of clinker burning. The investigations show, that the amount of ferrimagnetic minerals occurring in clinker is strongly influenced by the conditions of its burning. The model studies comprising burning the mixture of limestone (as the raw material) and fly ash (as the additive) in laboratory kiln at three different contents of carbon monoxide in kiln gas, proved that mineralogical changes of iron, leading to the increase in magnetic susceptibility of dusts, are possible. The greater the content of carbon monoxide, the better the conditions for the creation of strongly magnetic iron minerals.

Soil investigations carried out in the province of Opole nature reserves, being under the influence of cement industry, proved technological derivation of their magnetic susceptibility, which was highly correlated with heavy metals. So magnetic susceptibility can be used in soil environment monitoring, allowing to designate changes in soil chemical composition generated by accumulation of industry pollutants.

MAGNETIC PARTICLES AS SOURCE MARKERS OF STEEL-WORKS CONTRIBUTION TO PM10 IN ATMOSPHERE AT INDUSTRIAL MONITORING SITE

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Atmospheric particulate matter of anthropogenic origin contains significant portion of minerals with pronounced ferrimagnetic properties. These minerals, mostly (metal-substituted) iron oxides with typically spherical shape, can serve as tracers of industrial pollutants at the sites of PM10 collection. These particles can be detected and characterized with very high sensitivity. Furthermore, depending on the pollution sources and sampling site, concentration of these particles may show significant correlation with the total PM10 concentration and several heavy metals. Although this relationship has no general validity and is site-characteristic, fast and sensitive magnetic measurements can be used for monitoring purposes and/or source identification (e.g. in case of major steel works dominating the nearby monitoring site).

In this contribution, we will show results obtained on PM10 samples collected at industrial site, located close to major steel works. The data on PM10 concentration and concentration of ferrimagnetic phase are compared with wind direction and intensity. Our results show that daily variations in concentration of magnetic particles within PM10 at industrial site, observed over 1 week and normalized to weekly average, show pattern similar to that of PM10. However, while PM10 concentrations vary within ±25% with respect to the weekly average, magnetic particles show much larger variations, from some 10% up to almost 300% of the weekly average. Using the wind diagrams, related to the sampling periods, magnetic data can be interpreted in terms of meteorological control of the contribution of industrial PM10, emitted by the steel works. While concentration of magnetic particles reached their maximum during the days with prevailing weak wind (no more than 2-3 m/s) blowing from the steel works, they were at the minimum level during the days with wind blowing towards the steel works. Even winds from the steel works, if moderate to strong (> 4 m/s) caused decrease in concentration of magnetic particles, most probably due to “overblowing” effect. Similar results were obtained for both August and December 2007 sampling campaigns.

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MAGNETIC PROPERTIES OF ROAD DUSTS AND IMPLICATIONS FOR URBAN ENVIRONMENTAL EVALUATION: A CASE STUDY FROM THE EAST LAKE, WUHAN CITY, CHINA

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Ninety-seven road dust samples were collected within a period of about one week around the East Lake landscape area, Wuhan city, Hubei Province, China. The aims are to delineate the distribution and concentration of contaminants (heavy metal) in street dust and to trace the sources of contamination by using magnetic methods. In order to compare the spatial variations in magnetic properties of the street dust, sampling area was divided into four segments, which are signed east section, south section, west section and north section, respectively.

Results indicate that a magnetite-like phase should be responsible for the enhanced magnetic signal in road dust. In addition, another magnetic phase (may be sulfides-bearing Fe) was identified in most samples except some samples from western segment. The χ_{LF}, SIRM and ARM values indicate that the high concentration of magnetic minerals in dusts is located in the northern segment.

The chemical analysis reveal that the concentrations of heavy metals in road dust from the northern segment are much higher than the other three segments, except for Zn, Cu and Ba elements. However, the concentration of Ba is the highest in the western segment. The Zn and Cu have little difference in each segment. Consequently, the northern segment is the heavy polluted area. Correlation analysis, factor analysis and cluster analysis were applied to investigate relationships between element concentrations. The results suggest mixed contributions of heavy metals from the fly-ash produced by coal combustion, soil and vehicle emission, probably mainly from the fly-ash. For the eleven heavy metal elements, Fe, Cu, V, Ni, Cr, Mn, Co mainly are from fly-ash; Zn and Ti are from fly-ash and soil; Ba is from soil and vehicle emission.

The correlation analysis between magnetic parameters and heavy metal contents suggest that the parameters which mainly reflect the concentration of the magnetic minerals (χ_{LF}, SIRM and ARM) have close correlations with Fe, Cu, V, Ni, Cr, Mn, Co and PLI but have no correlation with Zn and Ti, and negative correlation with Ba. Therefore, we proposed that the magnetic minerals in street dusts mainly came from fly-ash. These results suggest a possible approach for source identification in pollution studies and the validity of magnetic measurements for pollution mapping.

MAGNETIC MINERALS IN INDUSTRIAL DUSTS FROM POWER PLANTS, COKING PLANTS AND CEMENT PLANT IN SOUTHERN POLAND

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The aim of the study was to investigate mineral composition of dust samples collected in different industrial plants (power plants, coking and cement plants) in southern Poland. A special estimates was paid to magnetic phases of industrial dust. Semi-quantitative analysis of magnetic phase were attempted by measurement of mass-specific magnetic susceptibility (κ) on MS2B "BARTINGTON" magnetic sensor. In samples with high magnetic κ values magnetic particles were separated from the bulk sample by hand magnet placed in ultrasonic cleaner in isopropanol. Measured κ values ranged from between 2000 – 9000 $\times 10^{-8}$ m^3kg^{-1} in case of power dust,100 to 1100 $\times 10^{-8}$ m^3kg^{-1} in case of coke dust and between 30 to 500 $\times 10^{-8}$ m^3kg^{-1} in case of cement dust. The magnetic and non-magnetic mineral fractions were examined by x-ray powder diffraction and scanning electron microscope equipped with EDS detector. Most of magnetic particulates have varied forms some of them are spherical, other are angular shape. In addition to predominant magnetite and maghaemite minerals with ferrite structure $MeFe_2O_3$, were observed in magnetic fraction. Fe in those ferrites was sometimes with Zn, Mg or Mn. That phases occupy from 15% vol. in dust of cement plant up to 40 % vol. in samples of coking plant. Middle capacity about 30 % vol. contains industrial dusts from power stations. Samples from power and coking plants contain also a few % vol. α-iron. Sulfides of Fe, Pb and Zn were also observed. Non-magnetic fraction consisted mainly of coke, quartz, mullite, gypsum, anhydrite, feldspars, sylvine and clay minerals, but they quantity is different and depend of industrial processes. High concentrations of magnetic minerals from industrial dust accumulated in atmospheric particles and also an uppermost layer of forest topsoil in many areas in southern Poland. Magnetic particles are good tracers of industrial and urban dust deposition and their occurrence correlates well with to anthropogenic trace element concentrations in forest topsoil.

ENVIRONMENTAL MAGNETISM OF AIRBORNE PARTICULATE MATTER IN THE CITY OF ROME

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Classical rock magnetic techniques may be applied to characterize the magnetic fraction of airborne particulate matter (PM). In recent years, a variety of environmental magnetic studies on PM have been carried out in the city of Rome and the Latium Region (Itay), using either tree leaves as natural and widespread collectors of PM, or paper filters specifically designed to collect PM_{10} (or $PM_{2.5}$) and employed in automated stations for the monitoring of air quality.
These studies indicated that the main source of magnetic PM in the study region is represented by circulating motor vehicles and demonstrated that the environmental magnetic monitoring is a powerful tool to delineate the capillary distribution of magnetic (anthropogenic) PM in urban environments. The detailed magnetic characterization of airborne PM provide air pollution proxies for the identification and the tracing of the time and space changes in variable mixtures of PM populations originated from distinct natural and anthropogenic sources. The environmental magnetic data provide original and valuable indications that may support the planning and the designing of an efficient network of air quality monitoring stations.
In this talk, the achievements reached up to date on these subjects will be reviewed, briefly pointing out the open problems and the possible future developments. I will also discuss the laboratory treatments and analytical tools that are presently recommended in order to establish a sound and shared protocol for the application of conventional rock magnetic techniques to the study of airborne PM pollution.

MAGNETIC PARAMETERS OF MEMBRANE FILTERS OF THE AIR- AS THE CONTROL FACTORS OF THE IRON COMPOUNDS AIR POLLUTION IN WARSAW

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The collection of filters gathered in the central meteorological station of Institute of Meteorology and Water Management in Warsaw during two years: 1977 and 1980 has been used to check the possibility of proposed monitoring method for an atmosphere pollution.

The samples measured in the present work were the membrane, paper filters (previously used during the study of air radioactivity). An atmospheric air was pumped through the following filters, every day in 24 hour cycles and the volume of the air passed was measured.

The magnetic susceptibility of each, single filter contaminated by the dust and aerosols present in the air has been measured, using the Kappa-bridge KLY-2. The obtained values of magnetic susceptibility has been normalized by the volume of the air pumped through the each filter.

Summarized monthly values of magnetic susceptibility of the air-polluted filters for the above mentioned two years from Warsaw were compared with the following average monthly meteorological parameters: temperature T , relative humidity H and absolute humidity h.

It appeared that the observed differences of magnetic susceptibility values for the following months were connected with the seasonal characteristic of mentioned meteorological factors.

Thanks the measurements of all single filters it was possible to observe also the details of magnetic susceptibility changes during every month and to find the days with very rapid jumps of its value, present almost in all studied months. The revealed jumping, anomaly high or strongly lowered values of magnetic susceptibility of single polluted filters seem to be connected with a fast exchange of the air masses over Warsaw . Such masses of air could be differently polluted. The observed abnormal pollution of some filters could be also caused by an extraordinary activity of heat and power plants or ironworks in Warsaw, changing from day to day.

The additional experiments has been performed for the chosen filters. Parameters of magnetic hysteresis, anhysteretic magnetic remanence ARM has been measured and thermal treatment of pollution has been used to identify the magnetic minerals present on contaminated filters.

The preliminary results of this study indicate that the application of proposed measurements of magnetic parameters seems to be convenient, fast and non-expensive method for the current control of polluted by iron-compounds atmosphere.

MAGNETISM OF DUSTS ORIGINATED FROM VEHICLE EMISSIONS IN ROME, ITALY

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Environmental magnetic study on airborne particulate matter (PM) demonstrated that in Rome, Italy, circulating vehicles are the main source of magnetic PM. Magnetic PM was characterized by means of analyses on the magnetic properties of tree leaves and air filters as prevalently composed of low coercivity, magnetite-like particles.

To further constrain the nature and origin of such magnetic particles, we carried out coupled field-emission scanning electron microscopy and a variety of rock magnetic analyses on PM specimens from *Quercus ilex* leaves and from potential PM sources in circulating motor vehicles in Rome. Particles from disk brakes and diesel and gasoline exhaust pipes have shown distinct compositional and magnetic hysteresis signatures, suggesting that the magnetic PM on tree leaves consists of a mixture of magnetic particles deriving from the abrasion of disk brakes and, to a lesser extent, from fuel combustion residuals emitted by diesel and gasoline exhausts.

Specific rock magnetism techniques have been applied to determine the contribution of fine superparamagnetic particles to the overall magnetic PM assemblage. The combined magnetic and microtextural-compositional analyses provide an effective and original tool to characterize urban PM air pollution.

SPATIAL AND TEMPORAL VARIATIONS IN MAGNETIC PROPERTIES OF STREET DUSTS IN THE OLYMPIC PARK, BEJING AND ITS ENVIRONMENTAL SIGNIFICANCE

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In this work, we carried out a preliminary study of spatial and temporal variations in magnetic properties for street dusts and topsoils collected from the road of the Olympic Park in Beijing. Samples were studied by integrated rock magnetic and microscopic methods. Measurements of magnetic susceptibility, acquisition of remanence, and thermomagnetic analysis were carried out for bulk samples. Morphological features, including size and shape of magnetic spherules for magnetic extracts were studied by scanning electron microscopy (SEM). Their elemental composition was determined by EDX analysis.

Results of rock magnetic measurements suggest that the source of mineral magnetic particles in the urban environment is particulates derived from vehicles. Magnetic mineralogy of the samples is dominated by pseudo-single domain magnetite. SEM images for the extracted magnetic particles reveal a complex internal structure, showing an agglomeration of smaller grains. Magnetic spherules have a variety of surface and internal structures, mostly dominated by granular and dendritic structures. On the other hand, the EDX analyses on magnetic extracts show that Fe, Si and O are the most common elements, whereas, the chemical composition of the samples for heating period also contain S. Noting that the magnetic susceptibility of samples during the heating period is higher than that of non heating period, it is very likely that the domestic combustion process (mainly coal burning) during the heating period has increased magnetic particle input, and its contribution to the source of mineral magnetic particles in urban environment cannot be ignored.

MAGNETIC, GEOCHEMICAL AND MICROSTRUCTURAL CHARACTERISTICS OF ROAD DUST ON ROADSIDES WITH DIFFERENT TRAFFIC VOLUMES- CASE STUDY FROM FINLAND

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The importance of road traffic as a source of anthropogenic pollution in urban areas significantly increased over the last decade. The anthropogenic processes related to traffic activity (e.g. vehicle exhaust emissions, cycling of dust in suspension due to vehicular movement, dispersion of road construction materials, abrasion of tires, brake linings and road surface) lead to the emission of magnetic particles into the environment. Regarding their anthropogenic origin and association to heavy metals, magnetic particles seem to be one of the main objectives for current and future environmental research, especially if they become a health issue.
In this study the combination of magnetic, geochemical and microstructural methods was used to characterize road dust properties in roadside soils of two sites in southern Finland: a highway (Tuusula no. 45, high traffic volume) and a local road (Mikkeli no. 13, low traffic volume). Significant differences in horizontal (κ) and vertical (χ) distribution of magnetic susceptibility were observed in the investigated roadside soils. These variations were concluded to be mostly associated with traffic volume, a major factor which determines the degree of particle emissions derived from vehicle traffic. Magnetic parameters of hysteresis, isothermal remanence magnetization (IRM) acquisition curves and thermomagnetic data indicated coarse-grained (PSD/MD) magnetite as the primary magnetic carrier. Scanning electron microscope (SEM) and energy dispersive X-ray spectroscopy (EDX) analyses identified two groups of magnetic materials: angular/aggregate particles (diameter ~2-100 μm) derived from vehicle activity and magnetic spherules (d ~3-15 μm) possibly originating from industrial and domestic heating systems. Concentrations of selected trace elements Cu, Zn and Pb in highway roadside soils were significantly higher than those in local roadside soils.

STUDY OF FOREST SOILS ON AREA OF MAGNETIC ANOMALY OF THE KOLNENSKA PLATEAU

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The Kolnenska Plateau is an area of wide soil magnetic anomaly (Magiera et al., 2002). Up to now the origin of this anomaly was not reliable recognized. The aim of the study was an explanation of the anomaly origin. The magnetic and geochemical investigations were carried out only on forest areas, because the forest soil profile enables a sampling and measurement in each individual soil organic subhorizon (mostly Oe and Oa if were developed). The field measurements of magnetic susceptibility (κ) were performed in small forest areas as they were more or less regularly distributed on the whole study area. The vertical distribution of κ value in 34 topsoil profiles (30 cm) was measured. Additionally to these measurements, 7 deep (1.5 m) soil pits were excavated and selectively sampled from each genetic horizon for chemical analysis.

The soil study proved that rusty-soils developed in sandy and/or gravelly parent rock are main soil type occurring under the study forest. The topsoil magnetic screening exhibited very low values of κ between 2 and 11 $x10^{-5}$ SI units. These values together with the pattern of their vertical distribution in soil profiles suggest that the measured κ are of pedogenic or geogenic origin. In soil profile the maximum of κ value as well as maximum of total Fe content were observed mostly in Ap and Bw horizons. The κ value in topsoil is rather stable on the depth between 5 and 20 cm that was commonly observed in arable soils. This observation was also confirmed by morphological observation of studied profiles, where in many cases the formerly ploughed Ap horizon was distinguished. These observations revealed the post-agricultural origin of the forest soils on study areas. The increased values of heavy metals in the Oe/Oa subhorizons, that usually indicate their anthropogenic origin as an effect of industrial and urban dust deposition was not observed in studied forest soil profiles. The maximal content of iron was observed in Ap and Bw horizons which is natural effect of soil-forming process in rusty soils.

The results of magnetic measurements obtained during this study indicated the geogenic origin of observed magnetic anomaly that could be connected with high Fe-bearing mineral content in glacial tills of northern Poland (Gworek, 1985, Brożek, Zwydak 2003) and also revealed the post-agricultural origin of most forest soils of the Kolenska Plateau.