Magnetic susceptibility surveys of the sequence layers within remains of Rich Stalls in Main Market Square in Krakow

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1. Summary

This work is concentrated on the use of magnetic susceptibility surveys in a near-surface sediments study. The researches were carried out in the area of Main Market Square in Krakow. Magnetic susceptibility surveys were applied in investigation of historical sequence layers. In the field magnetic susceptibility has been measured using kappameter KT-6. Samples of soil and deposits have been examined by means of MS Bartington Instrument in Petrophysics Laboratory in Department of Geophysics (Faculty of Geology, Geophysics and Environmental Protection, AGH). The natural layer of sand in the bottom of the profiles is characterized by the lowest values of magnetic susceptibility. Local enhancements of magnetic susceptibility are connected with the presence of brick pieces in the sequence layers. Moreover, materials present in pits show a little higher values of magnetic susceptibility in the comparison with magnetic susceptibility of sand.

2. Introduction

A susceptibility study can provide useful information in near-surface investigation of soil and deposits. An increase of magnetic susceptibility of sediment sequence layers can be caused by both natural and anthropogenic processes. Concentration of magnetic particles created in natural way can be connected with oxidation of Fe^{2+}, weathering of magnetic minerals and biological activity of bacteria. Magnetic susceptibility surveys provide also information on minerals of anthropogenic origin. Those minerals are formed in high temperature processes for example in fires or waste burning. A susceptibility study can provide information on the influence of a human activity on the environment in the past.

3. Theory and Method

One of the quantities determining the magnetic properties of a matter is magnetic susceptibility. Magnetic susceptibility is an ability of matter to be magnetized. Because of the fact that this property determines response of a matter to a weak magnetic field its full name is low field magnetic susceptibility. During measurements a bulk (volume) magnetic susceptibility κ [dimensionless] is obtained. It is defined as a ratio of induced magnetization J_i [A/m] and magnetic field intensity H [A/m]. In environmental research a specific (mass) magnetic susceptibility χ [m^3kg^{-1}] is commonly used. This parameter takes account of sample density. Mass magnetic susceptibility is defined as a ratio of volume magnetic susceptibility and density of a sample.

Magnetic susceptibility can be measured by means of kappabridge, kappameter or MS Bartington Instrument.

4. Examples

The study was performed under the ground level, in the eastern part of Main Market Square in Krakow, close to Cloth Hall. Sequence layers had been formed in this place on sand deposit by human activity (mainly economic activity). The aim of the study was to obtain magnetic description of soil and deposits of sequence layers within mediaeval sediments. Researches were carried out in four measurement sites using kappameter KT-6 (AGICO Company). This device has a maximum sensitivity of $1 \cdot 10^{-5}$ SI units and can measure very low level of susceptibility. Data are gathered mostly from 20mm depth.

In the first measurement site researches were done in three depth profiles: lower (I), middle (II) and upper profile (III). Magnetic susceptibility surveys have been started more than 500 cm below ground level and were done in lower and upper profile in 5 cm distance. The results are presented in Fig. 1.

The bottom of the layers being sand deposit (natural layer) possesses the lowest values of magnetic susceptibility. The higher values are observed ca. 4 meters below the ground level. The enhancement of a magnetic susceptibility is probably connected with the pieces of brick which were presented in this part of the profile. The similar situation has been observed in the upper profile (III).

Magnetic susceptibility surveys

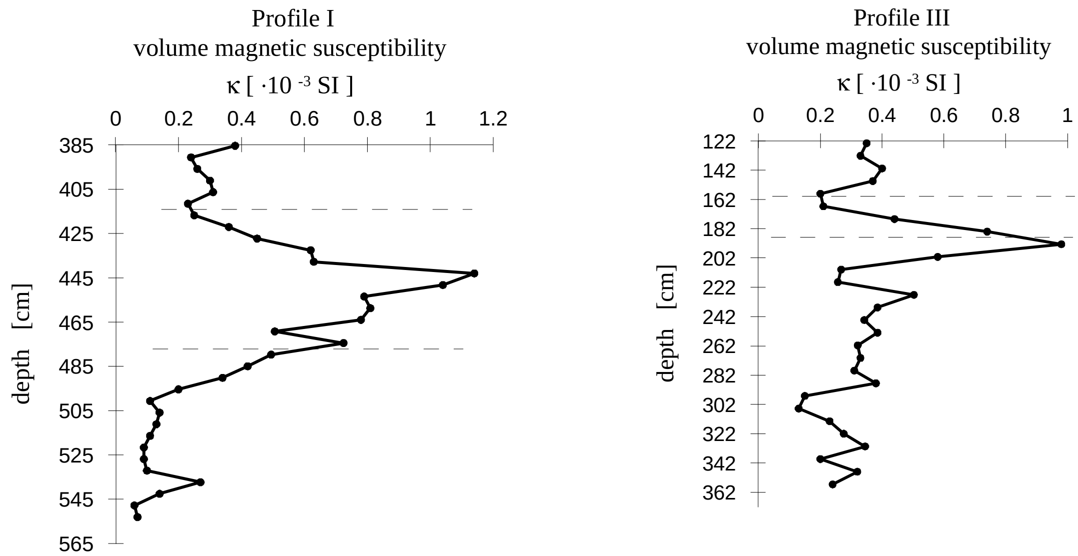


Figure 1. Magnetic susceptibility surveys in one of the measurement sites.

Researches of sediments sequence layers in other measurement sites have been shown also low values of magnetic susceptibility (Fig. 2.).

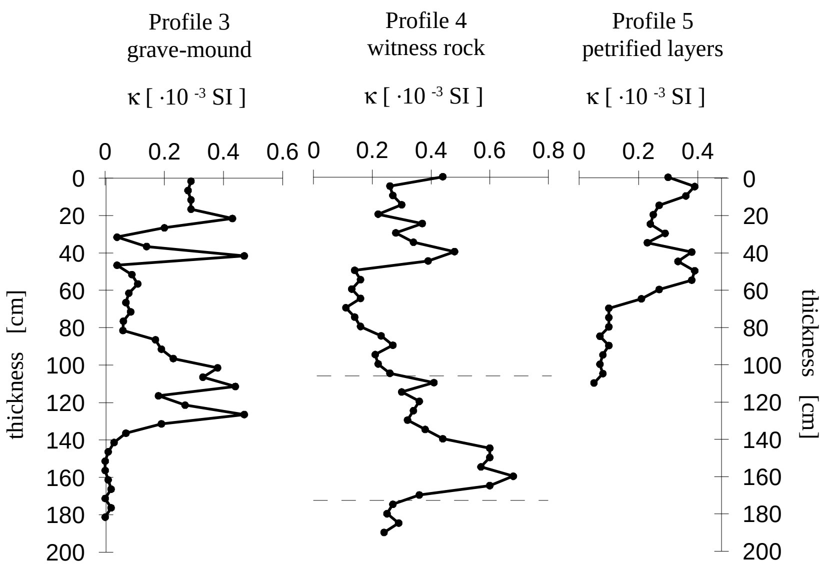


Figure 2. Bulk magnetic susceptibility measured by means of kappameter indicates low magnetic properties of sediments in other places.

A laboratory study has been performed in Petrophysics Laboratory in Department of Geophysics (Faculty of Geology, Geophysics and Environmental Protection, AGH). The samples collection was representative of each level of sequence layers. Volume magnetic susceptibility of soil and deposits has been examined by means of MS Bartington Instrument. The samples were weight and mass magnetic susceptibility was calculated. The results are showed in Fig. 3.

Magnetic susceptibility surveys

The layers in which a brick pieces were presented have often shown an increase of magnetic susceptibility. Samples from the pits indicate a little higher values of magnetic susceptibility than deposit in the bottom (Fig. 4).

Depth [cm bgl]	Description of the samples collected in the upper profile (III)	Mass magnetic susceptibility $\chi \cdot 10^{-8}$ m^3kg^{-1}
ROOF 122-142	loose, fine-grained, sandy material, dark brown-brown colour, includes fragments of brick	23,2
142-152	a little humid, fine-grained material, dark brown colour, includes large fragments of sedimentary rocks, mostly dark ingredients	101,0
152-157	fine-grained material, red colour, presence of dark ingredients with powdered brick	30,2
157-167	fine-grained material with powdered brick and medium fragments of brown-red rock with light ingredients	53,4
167-192	fine-grained material, light black colour, includes light ingredients and fragments of trick	50,3
192-212	fine-grained material, grey-dark brown colour, includes light ingredients and fragments of brick	15,5
212-230	fine-grained material with fragments of rock, the red-dark brown colour comes from the presence of brick fragments	51,9
230-254	fine-grained material, light brown colour, mostly light ingredients	10,4
254-304	fine-grained material, from dark brown to light black colour, includes fragments of light ingredients and bricks with different size	32,2
304-332	fine-grained material with coarse-grained elements, from grey to dark brown colour	4,3
BOTTOM 332-372	dry, different-grained material, light brown colour, mosty light ingredients	2,0

Figure 3. Mass magnetic susceptibility $\chi \cdot 10^{-8}$ m^3kg^{-1} of the samples setting against geological description (Niemczykiewicz M. 2010 Historyczne źródła zanieczyszczenia ołowiem i jego obecny wpływ na środowisko infrastruktury podziemnej Krakowa, WGGiOŚ, AGH).

Depth [cm bgl]	Description of the samples collected in the lower profile (I)	Mass magnetic susceptibility $\chi \cdot 10^{-8}$ m^3kg^{-1}
BOTTOM 535-565	fine-grained material, light brown, sands includes quartz and feldspars	0,3
PIT 535-565	coarse-grained sands with light, different size ingredients and fine-, medium-, coarse-grained material, yellow-brown	0,8
PIT 535-565	humid fine-grained sand, brown-yellow colour, includes quartz and light ingredients	9,2

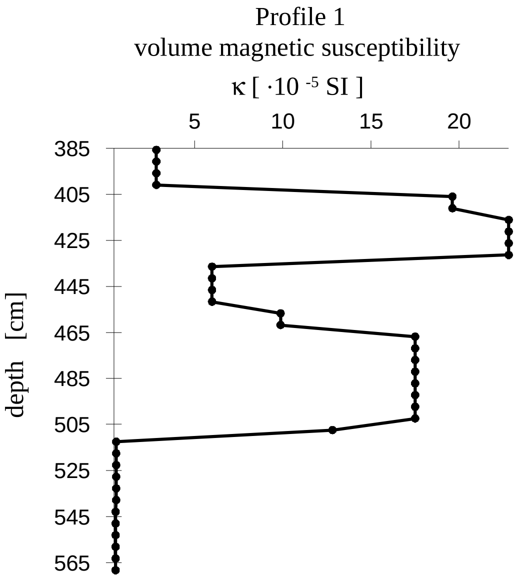
Depth [cm bgl]	Description of the samples from the lower profile (III)	Mass magnetic susceptibility $\chi \cdot 10^{-8}$ m^3kg^{-1}
PIT 372-412	uniform fine-grained, black material	18,5

Magnetic susceptibility surveys

Figure 4. Mass magnetic susceptibility $\chi \cdot 10^{-8}\ m^3kg^{-1}$ of material collected from pits in setting against geological description (Niemczykiewicz M. 2010 Historyczne źródła zanieczyszczenia ołowiem i jego obecny wpływ na środowisko infrastruktury podziemnej Krakowa, WGGiOŚ, AGH).

Measurements carried out by means of Bartington Instrument and kappameter have been given comparable results (Fig. 5).

a.



b.

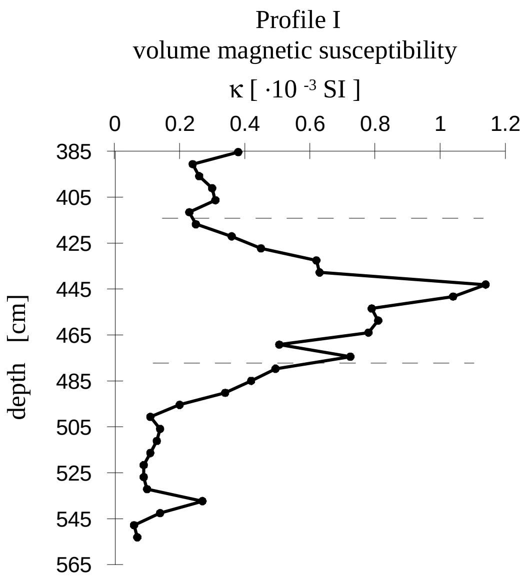


Figure 5. The results of laboratory measurements (a) are showed in comparison with the field results (b).

Magnetic susceptibility variations with depth are similar in both cases. The lowest value of magnetic susceptibility in field and laboratory studies has been responded to sediments in the bottom layer. A little higher susceptibility characterizes material in the depth of 385 cm. However in the middle part of the profile (445 cm) the maximum of a magnetic susceptibility was shifted. It can be connected with a methodology of measurements. A gradual change of susceptibility with depth in field investigations and sudden change of susceptibility in laboratory study are clearly visible.

5. Conclusions

1. Historical sequence layers have been characterized by very weak and weak magnetic properties. The average value of bulk magnetic susceptibility in the field is $29 \cdot 10^{-5}$ (dimensionless) and the average specific magnetic susceptibility is $18 \cdot 10^{-8}\ m^3kg^{-1}$.
2. The results of magnetic susceptibility surveys clearly show contrast in magnetic susceptibility between natural sediments and overlying cultural sequence layers.
3. Layers which are consisted of brick pieces often possess higher values of magnetic susceptibility.
4. Material filling pits have been indicated as more magnetic than surrounding.
5. Measurements by means of Bartington Instrument and kappameter have been given comparable results.
6. To confirm results of this study more sites should be investigated.

6. Acknowledgments

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