GEOPHYSICAL MAPPING OF THE RUDABÁNYA MINE WASTE ROCK PILES AND HÁMOR LAKE

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1. Introduction

Ore and mineral mining at Rudabánya dates back to ancient times. Initially, sulphide ores and materials of surface oxidation zone were utilized. Later carbonate iron ore was produced here, with additional silver, copper and lead ores. Large-scale iron ore mining began in 1880 and lasted for a century. During the mining activity, millions of tonnes of waste rock material were deposited on the surface near the villages of Rudabánya and Felsőtelekes. Because of technological developments and new ideas the material of the spoil tips - iron oxides and remaining sulphides, barite – can be utilised. Due to Háromkő ' - s previous successful investigations on the Toka- Creek region [1] and refuse damp near Miskolc [2], the company was requested to take part in the project of „ Rudabánya Ore Occurrences Research Development Program for Geological Studies". The task was: general geological mapping of the area and identifying the site boundary and the inner structure on the heaps. The four areas are the following: Rudabánya No. 1. heap – a "Baritmix" landfill and three areas near Felsőtelekes. The area No. 1 and no. 3 were studied in detail and only exploratory measurements were performed on other two heaps.

Considering the extent of fields and quality of materials in the subsurface we combined four geophysical surveying methods: multielectrode profiling, VES sounding, IP sounding, total magnetic field and gradient measurements and GPR. These methods have been successfully applied abroad [3, 4].

During the processing of data measured we determined near-surface resistivity distribution of multi-electrode section and the real resistivity distribution from the VES data as well. From the IP data the types of contamination were determined. The earliest IP sounding, Turai interpreted corrected electric conductivity [5] was introduced for the mapping of contamination. Measuring the total magnetic field and magnetic gradient were successful.

As a second example of geophysical mapping, we briefly discuss the resistivity profiling of Hámor Lake. A floating Schlumberger array probe was used on Lake Hámor's water surfaces and sonar measurement with so-called "fish radar" was utilised within the project of "Diagnostic and Research Work of Miskolc's Endangered Karst Aquifer".

2. Measurements and interpretation

Vertical electrical soundings, and multielectrode measurements were carried out with Hungarian Diapir-10 instrument made by ELGI, using traditional Schlumberger array, $AB_{max.}$= 200 m supply electrode distance reaching a penetration depth of approx. 40 m-s.

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For the profiling 5-5-5 m-s… Wenner-arrangement was used along a 160 m line. VES curves were processed, then calculated by Marquardt 1D inversion, and the multielectrode profiling’s data were evaluated by Res2D inversion. This way real specific resistivity sections were made and finally interpreted as (geological) sections.

Magnetic field mapping was performed with a G-856 GEOMETRICS Proton Precession Magnetometer.

As for the GPR; - on the ground surface a GSSI instrument with 100 MHz and 270 MHz antennae (Radan-6 software) was used, and in the water LOWRANCE LMS-240 sonar.

Large quantities of measurements were taken in the first area (No. 1.) which is waste rock full of dry ferromagnetic material, next to the ore-dressing factory. Fig. 1 shows the resistivity section based on the VES data. Close to the surface among points RB101-102, 103-104 and 105-107 one can observe a high anomaly zone with 200-1000 ohm-meters. The result suggests a dry and solid material. Between points RB102 and 104 there is a landfill of looser structure. At a depth between 8 and 10 m-s the material of the heap changes into a reactive material. The anomalous IP data interpreted at the RB101 and 104 points reflects on a strong oxidation-reduction zone with good electrical conductivity; simply put, it is a highly polluted area. Between RB 103 to 105 points under the depth of 20 meters a large imbedding with high resistivity can be seen. This resistive anomaly is not due to the waste rock, it is believed to be the limestone basement.

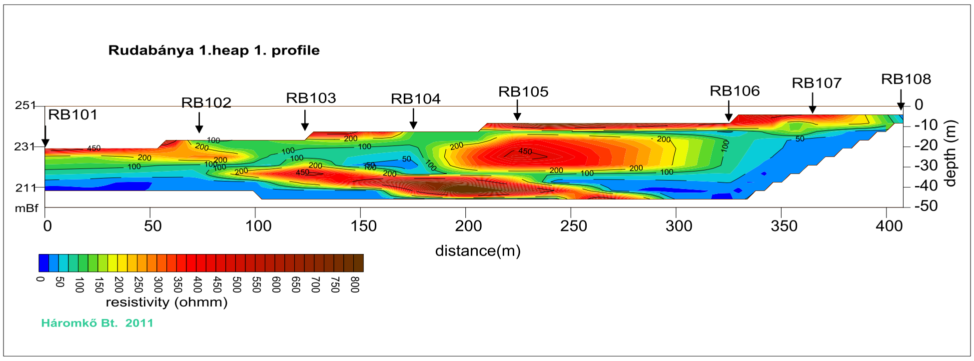

Figure 1. Resistivity section

Figure. 2 shows the results of IP measurements –for two stations of the first profile. Surprisingly at several points high values appeared. This type of pollution is substantial in terms of the metal and redox – polarization. Induced polarization is a very useful geophysical method in general, and especially in the detection of environmental contamination.

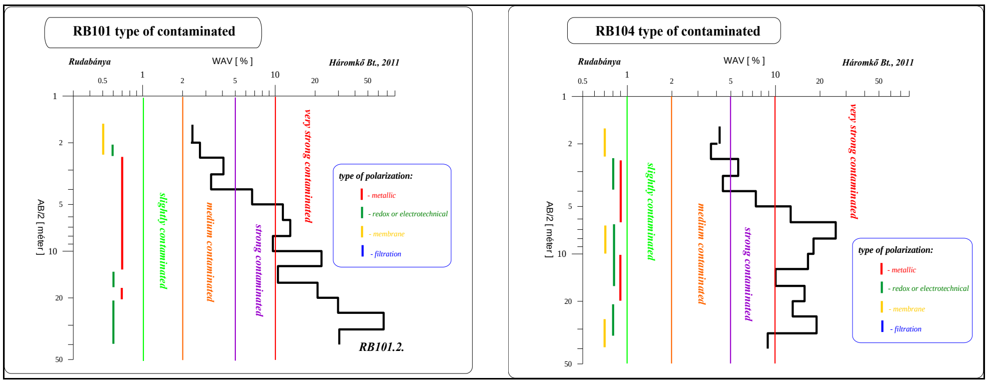

Figure 2. Type of polarization and contamination

Figure. 3 presents a magnetic profile measured along a profile parallel to the first geoelectric profile. This part of the magnetic field indicates a very high level, a 2000-3000 nT surplus to the natural background. At the same place this zone is very heavily polluted as is shown by the IP measurements: metallic and electrochemical polarizations are assumed and the reactive material relates to a ferromagnetic metal content.

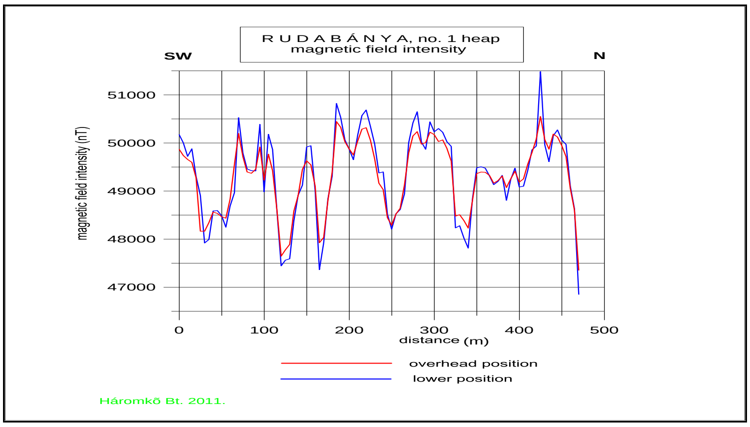

Figure 3. Magnetic profile

In the next example Fig. 4 describes measurements on the Felsőtelekes No. 3 heap: the geoeletric section No.1 is parallel to the multielectrode and the IP profile. This profile started with a “virgin site” on a meadow surface. Low resistivity can be observed in the vicinity of the FT101 point on the western part of the profile, due to the clay sediments. FT103 measuring point is displayed in the ore material landfill. According to the calculated data of point FT 104 there are 10 meters of dry and solid spoil material. At the end of the section of the FT108 point there is the high - greater than 500 ohm-meters – resistivity. This is partly due to a concrete spot on the surface, but it is mainly the result of the underlying Triassic bedrock. Between FT103 and FT106 points below the massive spoil there are low resistivity Pannonian sediment layers. In the course of IP measurements a highly contaminated zone was detected in which both redox and metal polarization occures. The pollution is not only in the upper part, we detected it at the depth of 10 meters as well.

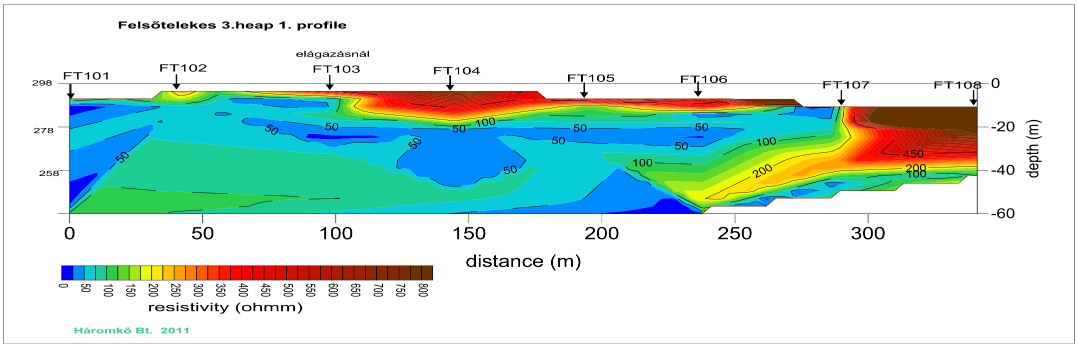

Figure 4. Resistivity section

Figure. 5 is a multielectrode section where you can see that the first part of the section does not contain reactive material; however, between 80m and 320m the resistivity of the spoil mass is more than 200 ohm-meters on the surface and beneath to the depth of 7-9 m.

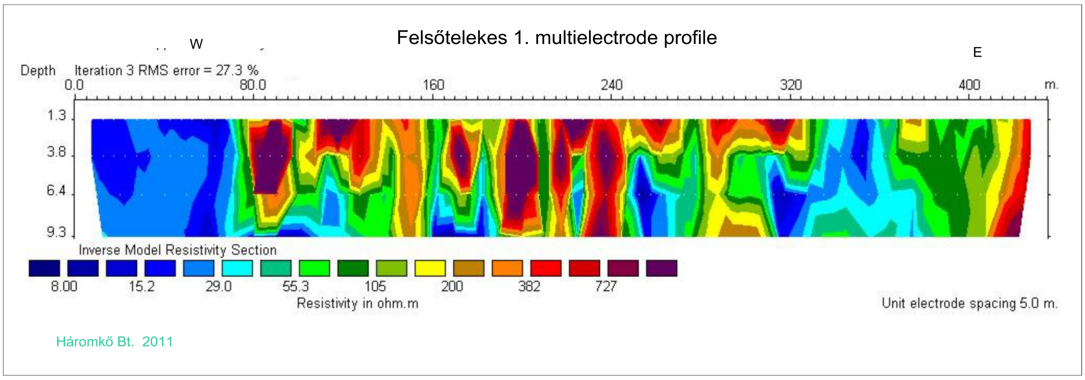

Figure 5. Multielectrode section at Felsőtelekes

3. The Lake Hámor hydro-physical measurements

Resistivity surveys were carried out to characterize the lake sediment in order to determine the sludge (mud) thickness and the bottom of the basement, performed with a 100 metre long floating probe (made by A. Madarasi). The radar measurements were continuously performed during towing (measuring the depth, time, temperature and coordinates).

During water radar measurements sonic wave packets are reflected from the solid basement, thus we could identify the depth of the substrate and we also could obtain a relief of the bottom of the lake. The difference in physical terms of the two methods allows us to separate the loose muddy part from the substrate based on the discrepancy of measured data. The mud is not the first reflective layer but behaves like a more resistive substratum than the water. This fact allows us to determine the sediment thickness. Figure. 6 presents the sediment thickness distribution. The sediment becomes thicker near the shore (a few metres only), in the south-eastern part sometimes the thickness is about 6-8 m.

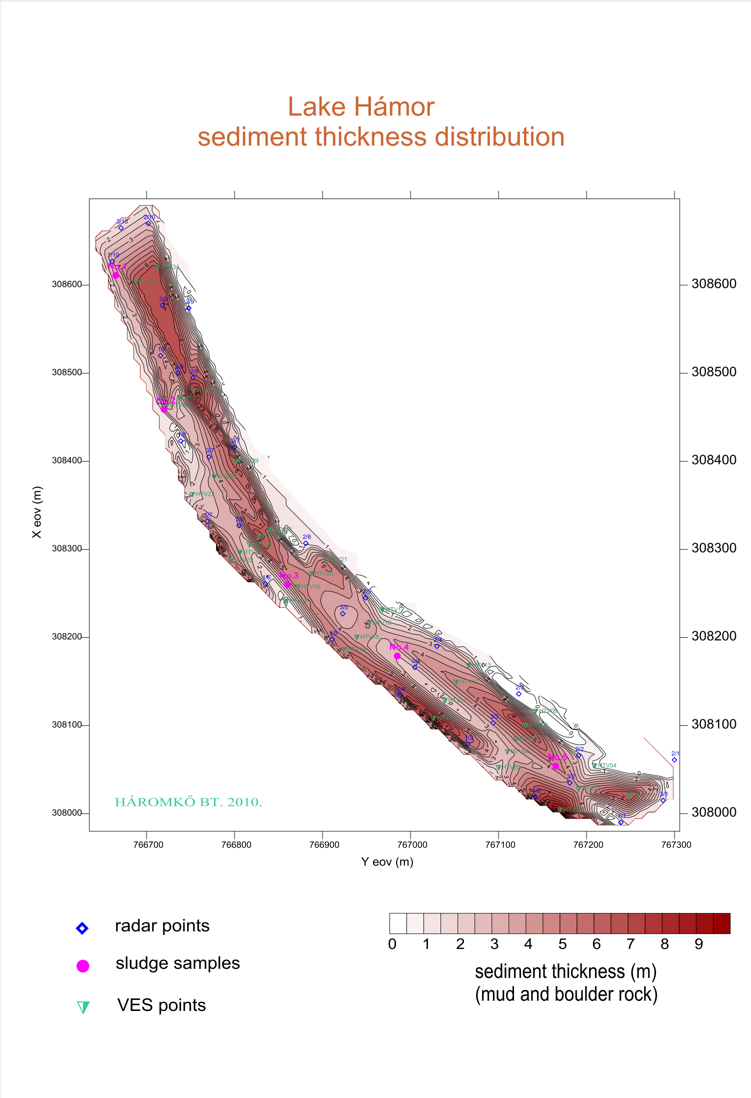

Figure 6. Sediment thickness at Lake Hámor

4. Conclusions

Based on the geophysical measurements described here we were able to provide information on the boundary of mining waste heaps, theirs inner structure/stratification and in some cases the types of deeper layers.

IP sounding clearly indicates the polluted zones and allows us to estimate the kinds of pollutants. Geophysical mapping techniques were also used to provide estimates of sediment depth in a small lake and a relief map of the lake bottom.

Acknowledgement

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