

# Processing of Geophysical Data Taken with the Long-Wire Method

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## Abstract

In this paper, we consider the development of a software module for computer analysis and interpretation of the geophysical data of the studied area of the Barobinskoe field, used in prospecting and subsequent exploration of mineral deposits.

**Keywords:** Data analysis, effective resistance, envelope graphics, pickets .

## Introduction

The use of modern methods of interpreting geological data is increasing every year. This is influenced by two factors: economic and temporal. Computer analysis and interpretation of geophysical data of the studied areas is of practical importance for the search and subsequent exploration of mineral deposits. Our goal is to reduce time input and eliminate manual processing errors thus advancing efficiency of geological prospecting. To achieve the stated goal, the following tasks were set: analyze the subject area, computerize processing field data of the long-wire method [1], and take into account ergonomic and psychological factors.

## 1 Domain Analysis

The analysis of the subject area showed that in the long-wire method for specifying an electromagnetic field a wire with a length of 1 to 10 km or more is laid. A magnetic and electric component of this field is recorded by a ferrite antenna (magnetic version) or a MN line (electric version) [2]. When passing an alternating current through a wire, the electromagnetic fields also create A and B groundings, which add up to the wire field and complicate the general picture. These complicating fields are local, most intense in places of grounding and quickly fall off to the periphery. To eliminate their influence, the working area of the survey is assumed to be equal to 0.8 of the AB line length. The "long wire" term refers to the length of the main, in which the grounding electrodes do not affect the field within the area under study. The boundaries of the section that meets the long-wire method conditions with an error of  $\leq 5\%$  are shown in Fig. 1.

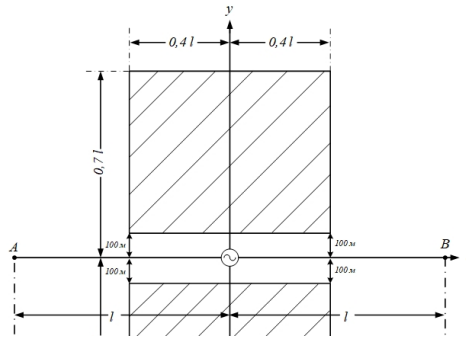


Figure 1: The range of the  $H_y$  and  $H_z$  values that meet the long-wire method conditions

## 2 Data sampling

A field survey of the magnetic field is carried out on either side of a long wire grounded at the ends, through which an alternating current of a fixed frequency is allowed. To achieve a great depth of study, a low frequency range is applied. The receiving device records the parameters in the long-wire field – horizontal  $H_y$  and vertical  $H_z$ , which make up the magnetic field, and calculates their ratio  $H_y/H_z$ , using which the effective resistance  $r_{eff}$  is defined with a pattern taking into account the operating frequency  $f$  and the spread  $r$ .  $r_{eff}$  of the electromagnetic method equipment is defined in the measuring device. These parameters as well as the picket values and power line positions are the source information, which is recorded from the equipment and stored in an Office MS Excel document. The source data contains information on more than 20 profiles. A fragment of the source numerical geophysical data is presented in Figure 2.

Date	Profile No	Picket	X	Y	P2	Hz	Hr	Hz/Hr	up to AB	ref
		7.1600	692839	5794917		69.92	226.88	0.308	0.4000	1316.0
		7.1640	692879	5794919		77.81	231.09	0.337	0.3600	864.3
		7.1680	692919	5794922		87.34	259.69	0.336	0.3200	682.9
		7.1720	692959	5794923		125.78	291.64	0.431	0.2800	317.1
		7.1760	692999	5794923		147.50	363.12	0.406	0.2400	253.8
		7.1800	693040	5794924		160.62	463.12	0.347	0.2000	253.1
		7.1840	693081	5794927		203.05	623.75	0.326	0.1600	183.1
		7.1880	693121	5794926		215.62	885.00	0.244	0.1200	215.3
		7.1920	693161	5794930						
		7.1960	693201	5794931						
	A1B1	7.2000	693242	5794933	supply line position					
		7.2040	693282	5794936						
		7.2080	693321	5794936						
06.04.2017		7.2120	693361	5794938		219.84	1032.50	0.213	0.1200	284.3
		7.2160	693400	5794938		205.23	823.75	0.249	0.1600	347.1
		7.2200	693441	5794940		200.31	692.50	0.289	0.2000	382.6
		7.2240	693481	5794943		190.47	605.00	0.315	0.2400	473.8

Figure 2: The source geophysical data

The source information is also stored graphically. For example, the graphs of the effective resistance values for profile No. 7 are shown in Fig. 3. Further over these schedules processing will be done. The graphs are presented for ease of application, and they fully correspond to the values of numerical data (Fig. 2).

The output is a geoelectric section of the study area. As a result of graphic interpretation, a section of contours of effective rock resistance is constructed, where

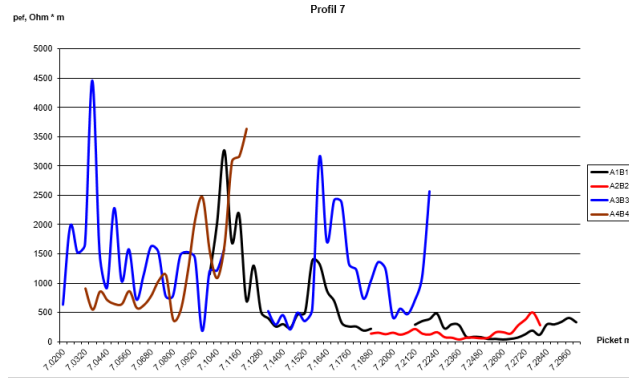


Figure 3: The graphs of the effective resistance values for profile No. 7

low and high resistance zones are distinguished with their substance prediction. To obtain the desired result, we have decided to develop a software module that would allow us to read geophysical data from the source file and automatically process it, but first we need prepare the input data. To do this we have to transfer the data shown in Figure 4 to an empty excel sheet.

Date	Profile No	Pickett	X	Y	P2	Hz	Hr	Hz/Hr	up to AB	ref
		7.1600	692839	5794917		69.92	226.88	0.308	0.4000	1316,0
		7.1640	692879	5794919		77.81	231.09	0.337	0.3600	864,3
		7.1680	692919	5794922		87.34	259.69	0.336	0.3200	682,9
		7.1720	692959	5794923		125.78	291.64	0.431	0.2800	317,1
		7.1760	692999	5794923		147.50	363.12	0.406	0.2400	253,8
		7.1800	693040	5794924		160.62	463.12	0.347	0.2000	253,1
		7.1840	693081	5794927		203.05	623.75	0.326	0.1600	183,1
		7.1880	693121	5794926		215.62	885.00	0.244	0.1200	215,3
		7.1920	693161	5794930						
		7.1960	693201	5794931						
	A1B1	7.2000	693242	5794933	supply line position					
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06.04.2017		7.2120	693361	5794938		219.84	1032.50	0.213	0.1200	284,3
		7.2160	693400	5794938		205.23	823.75	0.249	0.1600	347,1
		7.2200	693441	5794940		200.31	692.50	0.289	0.2000	382,6
		7.2240	693481	5794943		190.47	605.00	0.315	0.2400	473,8

Figure 4: Data selection for processing

The picket parameters are calculated by processing each filled cell from Excel, and then added to the two-dimensional array. The first value indicates the calculated picket position, the second – the effective resistance. Figure 5 shows an example of input parameters. Cell A1 shows the power line picket, and then the wire pickets themselves are located in Column A. Each cell contains the profile number and, for each wire position, indicates the picket position on the profile in 40-meter increments. Column B locates the wire  $r_{eff}$ . As we use several wires, data on each wire is placed on different sheets, for convenience in operation.

### 3 Plotting envelope graphics

The next step was to build an envelope of the effective resistance graph. In a conducting anomalous object under the action of an alternating magnetic field of the wire

7.2000	
7.1000	1147,7
7.1040	2021,4
7.1080	3283,3
7.1120	1698,5
7.1160	2176,3
7.1200	695,7
7.1240	1295,7
7.1280	503,6
7.1320	393,4
7.1360	253,9
7.1400	294,1
7.1440	231,7
7.1480	460,1
7.1520	494,4
7.1560	1384,7
7.1600	1316,0

Figure 5: The input parameters

eddy currents are induced, which in turn generate a secondary magnetic field. The total magnetic field from conducting anomalous objects creates an anomaly of the measured field values at the observation sites, which is displayed in the  $r_{eff}$  graphs. Figure 7 shows the program output for constructing a graph of the effective resistance  $r_{eff}$  and the envelope. The envelope in this case is the arithmetic middling of all the values of each wire in the range from 2 to  $i-2$ , where  $i$  is the number of all the wire points in the input parameters.

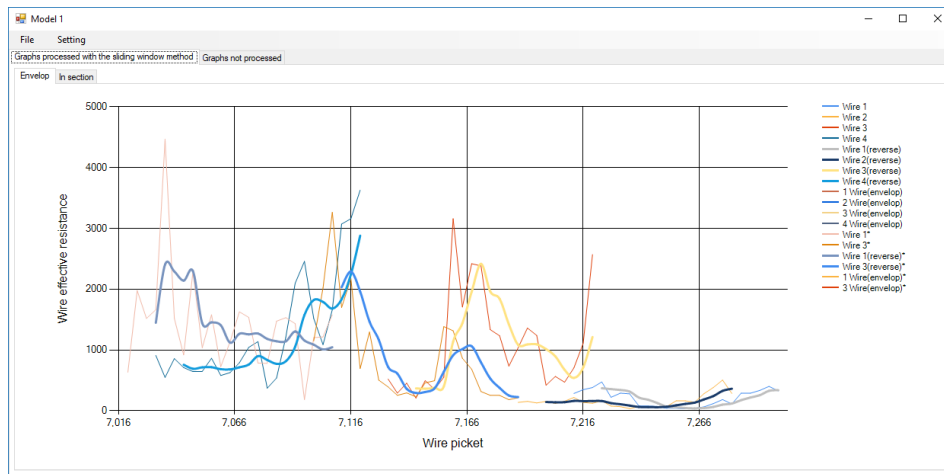


Figure 6: The program output

In this paper the calculated graph is presented for visual comprehension and is an intermediate action for the next work stages.

## 4 Plotting by method sliding window

The next step of our work was to construct a graph with the sliding window method in section conducted to eliminate the influence of near-surface heterogeneity. In the graph  $r_{eff}$  from the wire to the periphery, all the objects of shallow bedding

(tens of meters) are marked by local anomalies, which corresponds to the profiling function that solves the problem of geographic mapping of the studied area. If we remove these shallow anomalies (high-frequency background), the graph will have wide anomalies of deep-laid objects (hundreds of meters), which corresponds to the function of sounding.

The  $r_{eff}$  value at each observation site is formed depending on the magnitude and magnetic field direction  $H$  at each site of the geological environment under study, and the  $H$ , in turn, is an integral support of the eddy current caused in each conducting fragment of the environment by the primary alternating magnetic wire field and superimposed conduction and competence currents. Each elementary area (electromagnetic cell) of the lower half-space contributes to the total anomalous effect at the observation site, inversely proportional to its remoteness from current sources (wire and earth conductors) and remoteness from the observation site from the cell.

Since the geological structure of the section is individual at each wire side, then, following the semi-quantitative interpretation (containing considerable possible construction errors), the  $r_{eff}$  values calculated at the profile points are transferred to the intersection with the raypath drawn from  $K$  (wire) at an angle of  $35^\circ$  to the horizon (at provided  $h = r/3$ ). In fact, this angle depends in ratio on the conductivity response and may vary within a broad range.

The values of the calculated picket parameters are plotted on the  $z$  axis, and effective resistance is plotted on the  $y$  axis.

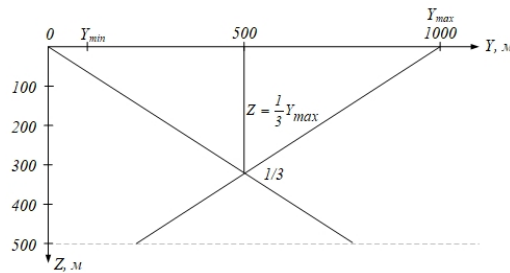


Figure 7: The calculated geometrical situation with the long-wire method (vertically). 0 – the wire position perpendicular to the drawing plane;  $Y_{min}$  and  $Y_{max}$  – minimum and maximum spread at the observation profile

To obtain the  $Z$  and  $Y$  values, the following formulas were applied:

$$Z = (Y_{min} + Y_i)/2. \quad (1)$$

$$Y = |Y_{min} - Y_i| * \frac{1}{3}. \quad (2)$$

For the value indicated in the point itself, we applied the formula (3):

$$X_i = Y_i. \quad (3)$$

The sliding window method consists in replacing the actual values of the series terms by the arithmetic mean of several terms closest to it. The set of averaged values

creates a sliding window. The term, which value is replaced with the mean with respect to the window, occupies the middle position in the window. The graph processed by the sliding window method in section can be seen in Figure 10.

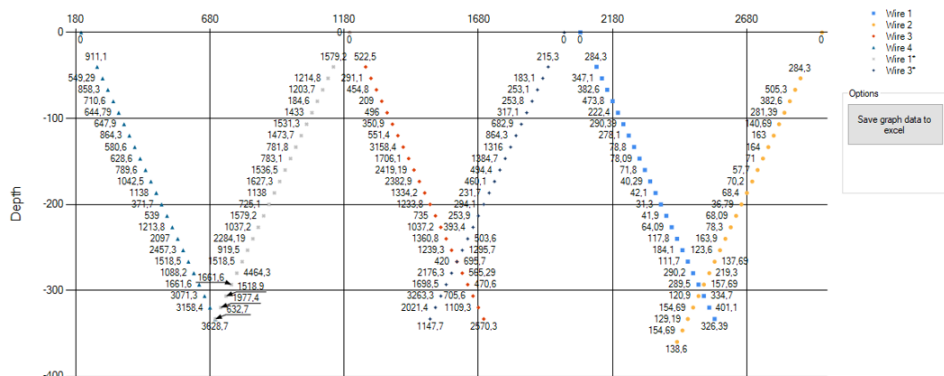


Figure 8: The graph of the values processed with the sliding window method in section

The picket parameters are calculated by processing each filled cell from Excel and added to the two-dimensional array. The first value indicates the calculated picket position, the second – the effective resistance.

The obtained values of the parameters with the sliding window method were stored in the Excel file for contouring. An example of the stored data (the sliding window method in section) is shown in Figure 11.

500	-333,333	1147,7	1000	1147,7
480	-320	2021,4	1040	2021,4
460	-306,667	3263,3	1080	3263,3
440	-293,333	1698,5	1120	1698,5
420	-280	2176,3	1160	2176,3
400	-266,667	695,7	1200	695,7
380	-253,333	1295,7	1240	1295,7
360	-240	503,6	1280	503,6
340	-226,667	393,4	1320	393,4
320	-213,333	253,9	1360	253,9
300	-200	294,1	1400	294,1
280	-186,667	231,7	1440	231,7
260	-173,333	460,1	1480	460,1
240	-160	494,4	1520	494,4
220	-146,667	1384,7	1560	1384,7
200	-133,333	1316	1600	1316
180	-120	864,3	1640	864,3
160	-106,667	682,9	1680	682,9
140	-93,3333	317,1	1720	317,1
120	-80	253,8	1760	253,8
100	-66,6667	253,1	1800	253,1
80	-53,3333	183,1	1840	183,1
60	-40	215,3	1880	215,3

Figure 9: An example of the stored data of the sliding window method in section

The columns  $E$ ,  $F$  show the input values, the columns  $A$ ,  $B$ ,  $C$  show the processed graph data. Further, the data obtained by the sliding window method are processed in the Surfer software environment. As a result of processing, the surface effective resistance values are placed in depth, and a contour section is constructed, giving an approximate idea of the geoelectric section. The processing result is shown in Fig.

12. After that, the resistance contour concentrations are analyzed and evaluated for the desired minerals in them.

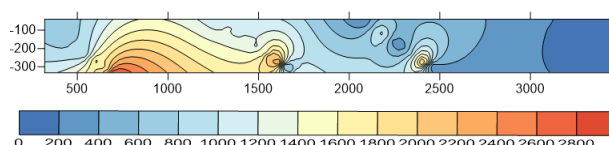


Figure 10: The resistance contours constructed in Surfer

## 5 Conclusion

High-resistance (1 and 2) and low-resistance (3) zones with their substance prediction are distinguished in this pseudosection. At the surface in the 800 - 1600 m spacing of the profile, fragments of quartz with gold were found, according to which it is assumed that we may find a series of gold-bearing quartz veins and stock work at the depth. In the 2000–3500 m spacing there is a low, marshy land, indicating the presence of salt marsh, which led to an extensive low-resistivity Zone 3, of little promise for geological prospecting and exploration. All three zones are recommended for well drilling, and when confirming the geophysical prediction Zones 1 and 2 – for prospecting. The material obtained is tentative data for the subsequent directed geological prospecting and, in general, significantly reduces its volume and cost.

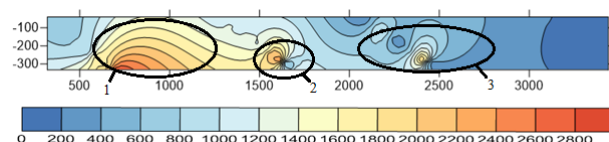


Figure 11: Substance evaluation

Figure 13 shows the fragments of quartz in selected Zones 1 and 2, as well as the predominance of wet clay (Zone 3) and the entire right-hand side.

Was developed the software module interface that allows the pickets to be calculated. When developing the interface, ergonomic factors were taken into account [3]. The interface allows easily loading data and processing it.

The graphs are navigated through the tabs located in the main program window, shown in the figure below. We can also use the manual setting buttons on the right sidebar for more precise setting. Each of these buttons will increase / decrease the height / width of the graph by the number indicated on the button being pressed.

In this paper psychological factors were taken into account. For this purpose, a user manual [4] was developed, which contains information about the program,

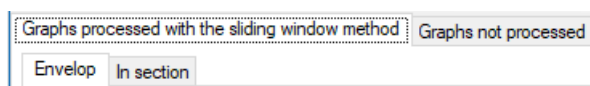


Figure 12: The main program window tabs

a detailed description of all the program features that are necessary for program authoring.

The developed software module will not only computerize processing geophysical data taken with the long-wire method, but also ensure safe storage and easy access to the information received. It also significantly reduces the time input for data processing, thereby reducing the cost of all the work done.

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