PROCESSING OF THE RESULTS OF RESISTIVITY PROSPECTING OF ARCHAEOLOGICAL SITES

Abstract

Geophysical methods find wide application for prospecting of archaeological sites. A system for accumulation, storage, formation and computer processing of the information obtained in these investigations is being created at the Archaeometry Laboratory This is achieved by means of software facilitating the loading and storage of the primary data. Another group of programs allow preliminary processing and visualization of the results of the measurements.

The possibilities offered by some of the described programs are illustrated with the results of the electrical resistivity measurements of various archaeological sites: fortification walls, settlements, buildings, etc.

The use of different geophysical methods for discovering and exploration of archaeological objects faces researchers with some serious problems. One of them is connected with accumulation, storage and processing of the information obtained. Specialists working in this field are familiar with the abundance of information obtained from relatively small areas, as well as the problems involved in the processing of this information.

One of the major tasks of the Archaeometry Laboratory in this direction is to create a system for accumulation, storage, formation and processing of the information obtained during exploration of archaeological sites. This is a very labor consuming and difficult task, in view of the specificities of this type of measurements. In our opinion, personal computers should be used for solving this task. In spite of their increasing sophistication, they still have some limitations concerning the memory and speed of operation, which additionally complicates the problem, but nevertheless they offer an opportunity of express information being obtained in situ, so as to guide subsequent investigations or archaeological excavations, and last but not least their low cost compensates these difficulties.

The processing of the results of the measurements can be presented as consisting of the following major elements:

- Collecting and loading of data;
- Storage of primary information, accumulation and maintenance of a primary data base;
- Processing and analysis of the measurements;
- Storage of the results obtained from the processing and analysis of the data, formation and maintenance of a data base;
- Shaping and presentation of the results of all stages of the processing.

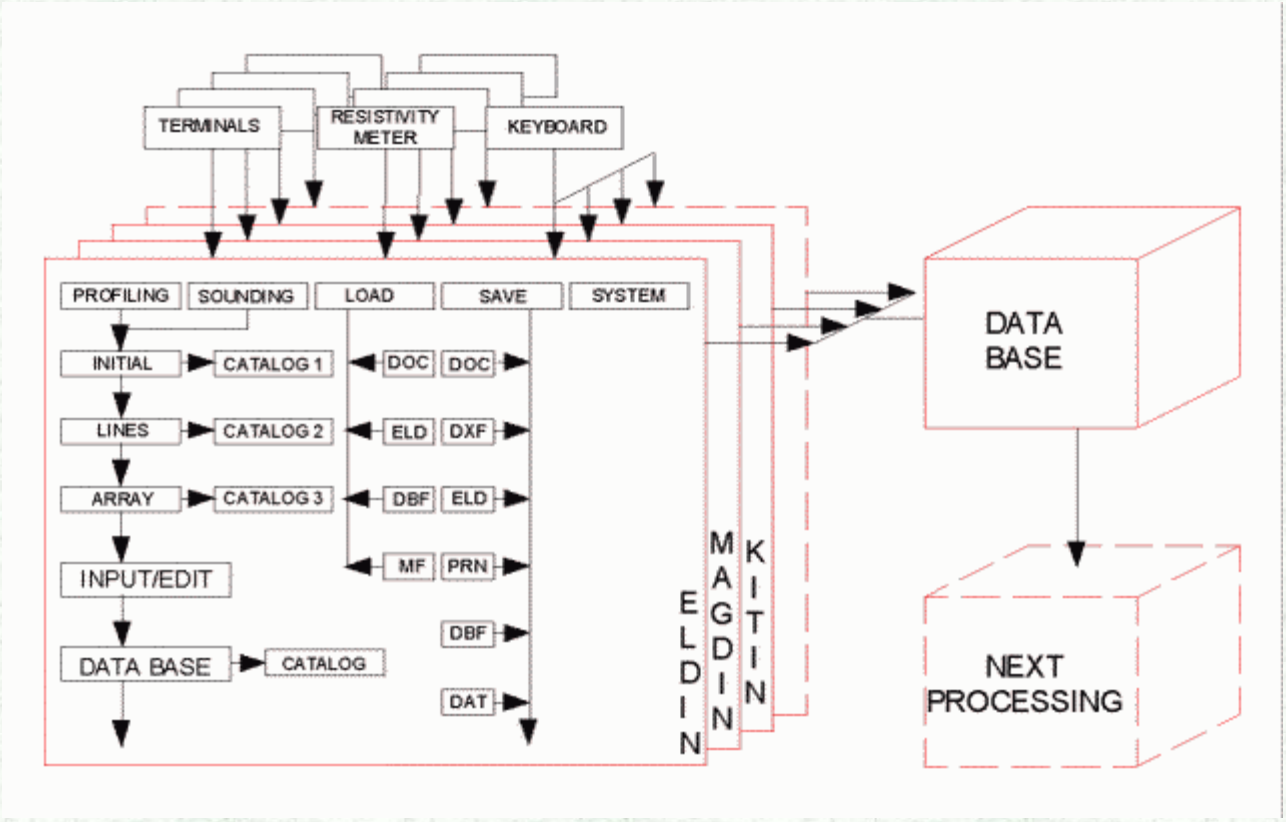

Fig. 1. Block diagram of the system for loading, storage and processing of geophysical information and of the ELDIN program.

The system consists of separate programs and modules performing different stages of the comprehensive processing of the results (Figure 1).

The program ELDIN is one of the basic programs in the system. It is intended for introducing the results of the resistivity measurements performed using profiling or sounding methods. Its block diagram is shown on Figure 1. The program is elaborated in TURBO BASIC and it works in dialogue mode with the operator. The program can be used to load into the computer the results obtained from:

- automated and computerized resistivity meters with built in memory. In the course of the measurements the data obtained are stored in a certain way in the memory of the device;
- ordinary resistivity meters, the results being registered in terminal devices or electronic notebooks;
- manually recorded results.

An opportunity is also envisaged to load data recorded in text files or in DBF files.

When data are loaded using the keyboard, the program operates in dialogue mode and requires the introducing of all additional necessary data: the type and the dimensions of the configuration applied, profile grid, commutation parameters, device used, object, etc. In

order to facilitate the operator in this dialogue, the program maintains three catalogues:

- "devices" catalogue which stores data on the devices used and the respective apparatus coefficients needed to correct the measurement results;
- "lines" catalogue describing ten types of lines (linear and radial), as well as the necessary parameters for their localization in space and calculation of the coordinates of the measurement points;
- "configurations" catalogue including 16 types of electrical prospecting configurations and the parameters needed to determine their size and coefficient.

After loading the data, the program calculates the coordinates of the points of measurement with respect to the chosen system of coordinates, the coefficient of the configuration and the apparent resistivity. If necessary, the program can perform transformation and/or shifting of the coordinates.

The loaded data, formatted and arranged in a definite way, are stored in the primary data base, which is built according to the principles and criteria described by Dr. M. Kanarchev (Kanarchev, 1986, and Kanarchev, Butchvarov and Georgiev, 1988). To this data base there is a catalogue containing generalized information about the sites studied, about the type and conditions of the measurements, which facilitates the search of the required information.

The following opportunities are envisaged in the output part of the program:

- drawing of the map of the investigated area and of the line grid in the system of coordinates chosen;
- printing of a brief report on the investigations carried out on the site, the line grid, the configuration used, its dimensions and some other conditions of the measurement;
- printing of the loaded data;
- recording of the loaded data in formats suitable for applying commercial software products for drawing, shaping and processing (Surfer, Acad, etc.).

Similar in structure and opportunities offered are the programs MAGDIN and KITIN, included in the system and intended for loading the results of the magnetic and geodesic measurements accordingly.

The programs STATMAP and PIXMAP are included in the system for preliminary analyses, shaping and visualization of the results of the measurements.

The program STATMAP is intended for statistical calculations and screen display of the results obtained. It is used to determine the maximum and the minimum value of the parameter measured, it calculates its mean value, the mean square root deviation, the interval width and it plots the histogram of the distribution of the data. These statistical calculations are performed according to formulae described in many literary sources. Strictly speaking, at this stage of the processing these parameters are more of a provisional nature and should not be considered as statistically correct values. From the type of the

histogram obtained, it is possible to evaluate the character of the investigated area with respect to its homogeneity the presence of anomalous zones and sections, their division and the determination of their properties.

The program PIXMAP is intended for pixel visualization of the results of the measurements or of the processing of the geophysical information. It offers big opportunities for operative change of the parameters of visualization, which allows maximum contrast in the presentation of the anomalous areas and presentation of the results in a way that is accessible and understood by the user.

The following two examples illustrate some of the opportunities offered by the program STATMAP and PIXMAP for processing results of electrical resistivity prospecting of archaeological sites.

Considerable amount of ceramic fragments and traces of ancient building activity have been found over an area of about 5000 m2 in the Tsarichina locality, near the village of Golemo Selo, Kyustendil district. These finds and some written data directed archaeologists to seek buried objects and sites in this region. The task was to perform a preliminary prospecting of this region with the aim of guiding archaeological excavations to the most promising areas.

The area is characterized by the following specificities: homogeneous section consisting of a thick soil layer with apparent resistivity of 3040 Ohm.m; assumed depth of the objects sought between 0.5 and 2 m; the localization, shape, spread, mutual positioning and the apparent resistivity are unknown; presence of powerful sources of strong electromagnetic disturbances.

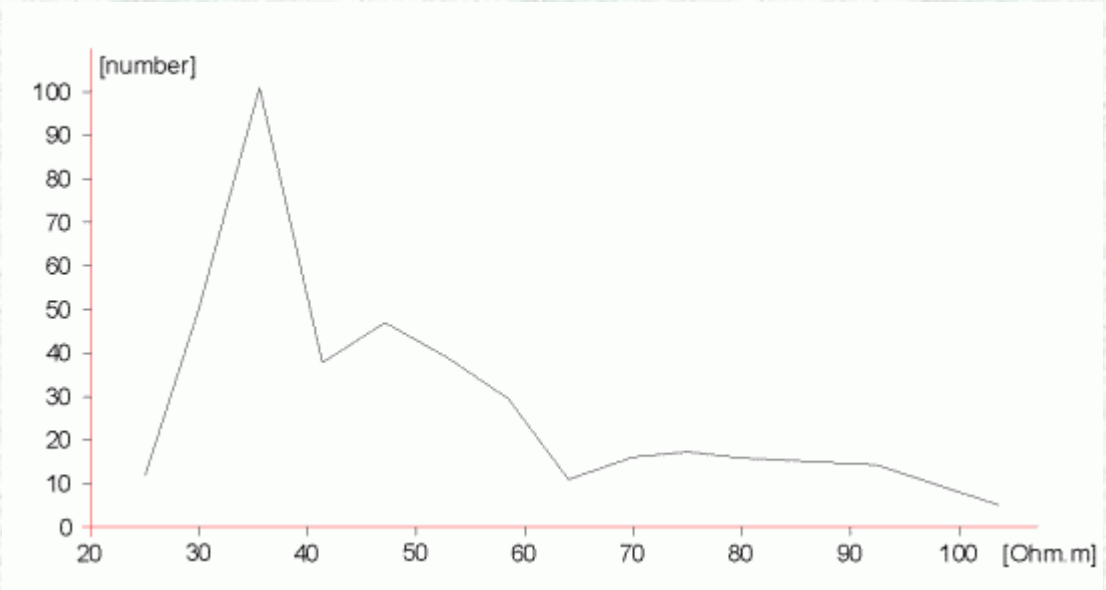

Fig. 2. Histogram of the apparent resistivity

The measurements were made using the profiling method with symmetrical four electrode

configuration A2M1N2B along a system of mutually perpendicular profiles. An area of 650 m2 was investigated. The map of the apparent resistivity is shown on Figure 3.After statistical processing of the results

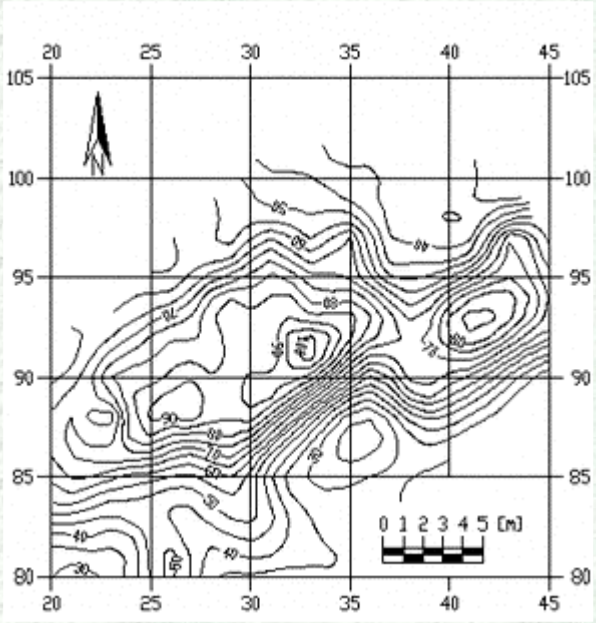

Fig. 3. Contour map of the apparent resistivity, the site of Golemo Selo.

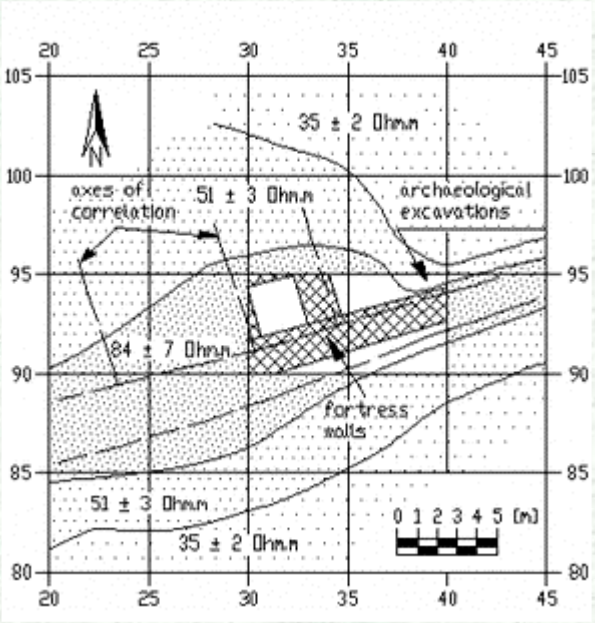

Fig. 4. Result of the statistical processing of the data and archaeological excavations.

of the measurements, three zones can be distinguished within the limits of the area under investigation (Figures 2 and 4):

- zone with normal (background) values of the apparent resistivity 35 ¸ 2 Ohm.m;
- anomalous zone with resistivity 84 ¸ 7 Ohm.m.
- transitional zone with resistivity of 51 ¸ 3 Ohm.m.

Two groups of correlation axes of the maximum values can be clearly distinguished from the apparent resistivity graphs along the profiles, one group with azimuth 70° 2', t he other one 160° 4'.

After analyzing the results of the statistical processing and of the measurement results, our hypothesis about the character of the disturbance was that the anomalous zone was induced by remains of a settlement or a fortress whose basic construction directions coincide with the correlation axes. The profiles cross at acute angles the principal disturbing bodies probably walls with a width of 180 ¸ 0.3 m. In the anomalous zone there are many linear anomalies induced by small objects with a length of about 2.5 m and a width ranging from 0.2 to 0.6 m. The transitional zone is induced by destroyed materials.

Archaeological excavations in two 5 x 5 m squares started immediately after the geophysical prospecting, revealing a 2 m thick fortress wall and two 1.5 m wide walls transverse to it (Figure 4). Excavations continued during subsequent years and fully

confirmed our hypothesis.

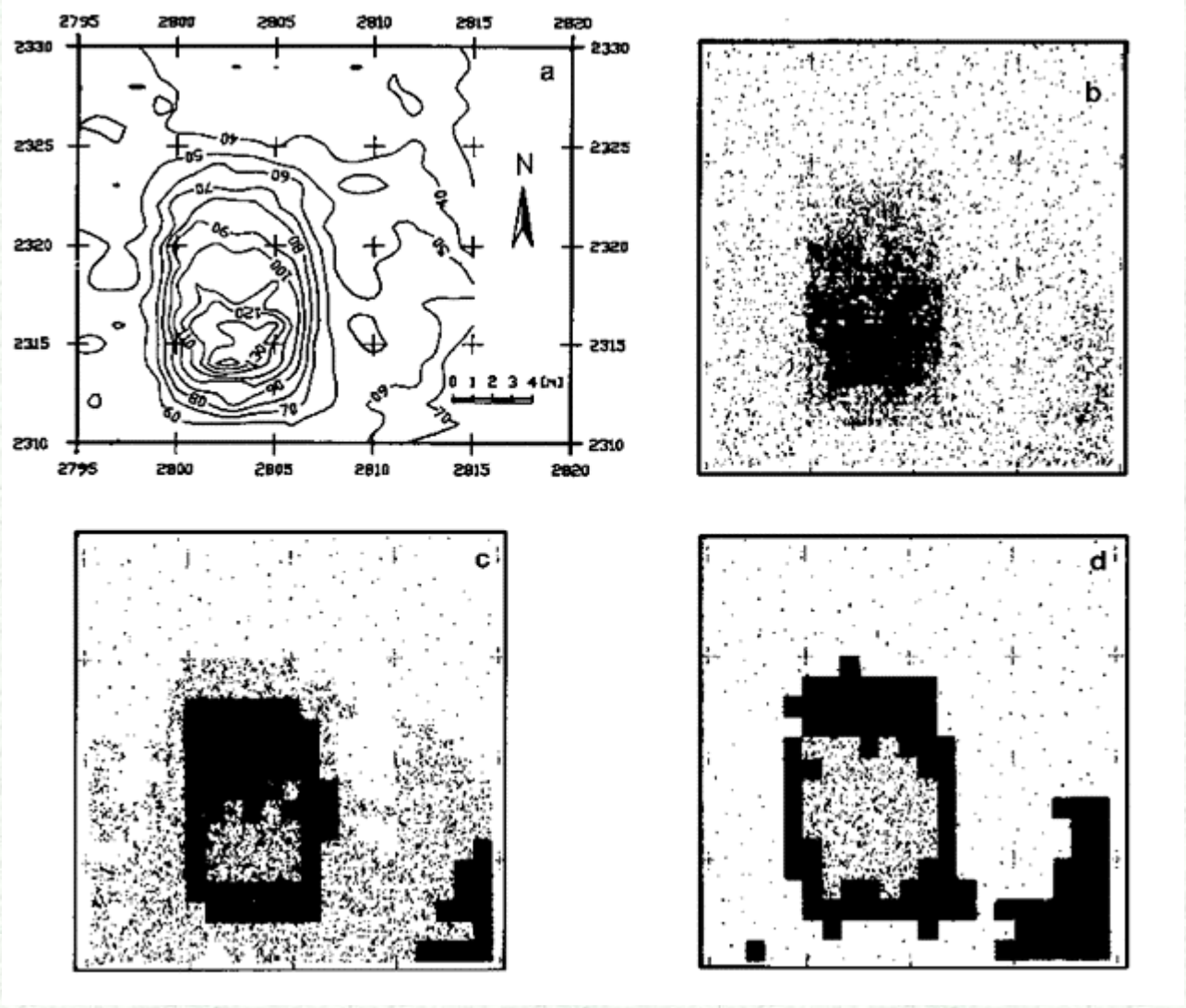

Fig. 5. Map of the apparent resistivity in iso-lines (a) and its pixel image (b, c, d).

An interesting site was discovered on the basis of the photographs obtained in the course of aerial observations in the region of the archaeological reservation Deultum near Debelt village, Bourgas district, at about 100 m to the north of the discovered Roman city. Electrical and magnetic geophysical prospecting was performed after precise geodesic fixing of this terrain. The electrical profiling measurements were made using a system of mutually perpendicular profiles with a four electrode configuration A1M1N1B. The measurement grid was 1 x 1 m. Figure 5 presents the primary results of the measurements: in iso-lines (a) and through pixels (b). The next two figures (5c and 5d) present the same results, but after changing the parameters of the pixel image. The intense contrast in the figures is apparent. In our opinion, this newlydiscovered site is a building for religious purposes, i.e. a chapel or a church. Its archaeological investigation is forthcoming.

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