METHODS AND RESULTS OF GEOPHYSICAL INVESTIGATIONS OF THRACIAN MOUNDS

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ABSTRACT

Thracian mounds are widely spread over the territory of Bulgaria. The paper presents data on the geophysical and geometrical characteristics of the mounds and vaults discovered in some of them. The possibilities provided by the geophysical methods, for serching vault structure under the given circumstances, are being discussed. It is found out that vault structure can cause well expressed anomalies in the apparent resistivity along circular concentric towards the top of the mound profiles. The results of the geophysical survey of the Ginina mound near the village of Sveshtari in NE Bulgaria are indicative in this respect. A highly important archeological site, the Thracian King's sepulchre from the 3rd century B.C., was discovered there by using geophysical data.

Mounds are very important objects of geophysical investigations in archeology. Only on the territory of Bulgaria their number is over 10000. A certain number of these cover vault constructions and burials which provide rich sources of information in archeological studies of the ancient culture on the Balkan Peninsula. In order to direct the archeological excavations in the right way, it is necessary to determine in advance the presence of a vault and its location. This problem can be solved effectively by applying geophysical methods which permit a remote investigation of the site without impairing its integrity.

Burial mounds are specific objects of geophysical investigations. The comparatively small volume, depth and physical contrast of the vault structures determine geophysical effects commensurable with those of the mound shape. The mounds reach up to 18-20 m in height though most of them do not exceed 10m. The mound diameter varies from several metres to 100 m. Vaults ranging from 2 to 32 m in length, 1 to 3,5 m in width and 1.2

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to 4.5 m in height have been discovered in these mounds (Guetov, 1970). The vaults are built of stone or brick, first covered up with rough stone and then with earthen mass which shapes up the mound. Therefore the physical model of the space under investigation contains three basic elements, i.e. the domelike earthen mass, the building material and the void space of the vault.

The investigations carried out on the physical properties of materials from mounds and discivered vaults, as well as model studies on the respective geophysical effects, have yielded the following results:

- The earthen mass has low specific electrical resistance - up to 70 Ωm; the building material is usually limestone with high resistivity - up to 10^3 Ωm. The resistivity methods make it possible to observe the effect caused by the vault, but only after relevant data processing with the purpose of eleminating the influence of the mound shape;

- The magnetic susceptibility of the earthen mass is up to 10^{-3} SI. That of the building material is about 1 order lower. In these cases the amplitude of the magnetic anomaly on the mound surface is below 10 nT. The anomalous effect created by the mound shape and the natural vertical gradient of the geomagnetic field is of the same order;

- The density contrast between the vault hollow and the surrounding mass is more than 2000 kg/m^3. However, the gravitational effect calculated at the height of 1 m above the top of a vault of a maximum size is less than 0.08 mGal. The precise taking of measurements and separating of the small gravity anomalies from the searched objects, encounter considerable methodical difficulties;

- The elastic properties of the main mound's elements differ significantly, but the peculiarities pointed out below complicate the applications of the seismic methods. The sites are not of a big size, they are covered by earthen mass at a low wave velocity and with a high coefficient of absorption; contrastive seismic boundaries do not exist - earthen mass does not differ from the mound's substratum and the vaults have initially been covered with rough stones;The surface of observations is of a specific shape and this complicates the wave picture and its interpretation.

The geophysical investigations of more than 15 mounds have proved that the electric and magnetic methods are the most appropriate ones for solving the problems of determining the presence and location of vault constructions in the mounds. The basic method is the electric resistivity method of the direct or low frequency current. The measurements are made by a four-electrode circuit along radial profiles through the mound top and along concentric peripheral circular profiles. The distance AB between the current electrodes is determined in relation to the mound diameter d, to its height and the depth of the bedrock, respectively. The ralation found experimentally is AB/d = 0.5 ÷ 0.6 for the radial profiles, and AB/d' = 0.25 for circular profiles with diameter d' > d/2. The measurements are made by a megger with a meansquare error of the order of ± 1 Ωm, thus determining the relative error not greater than ±5 %. The magnetic method plays an ad-

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ditional role in the overall investigation. The sites searched usually manifest themselves with negative magnetic anomalies. The measurements are to be performed with highly susceptible proton magnetometers with a meansquare error below ± 1 nT and density of the measurement network from 0.25 to 1 points per square metre. A precise topographic survey of the mound is needed for the adequate processing and interpretation of the data from the electric and magnetic measurements.

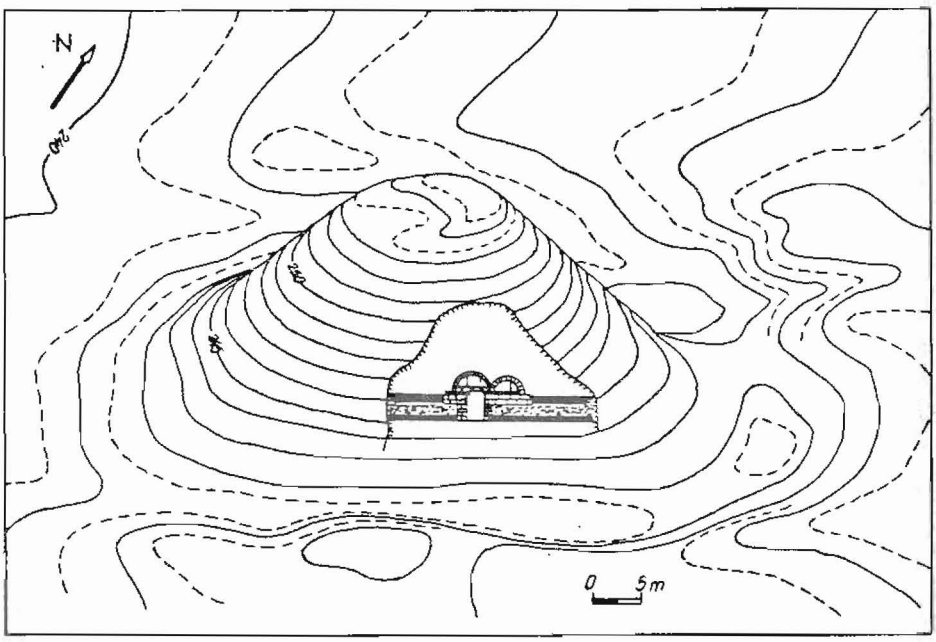

Fig. 1. Panoramic picture of the Ginina mound with an open vault entrance, the village of Sveshtari, NE Bulgaria. The solid lines are basic horizontals at intervals of 1 m, the broken ones are auxiliary horizontals at intervals of 0.5 m

The results from the symmetric electroprofiling along the radial profiles are presented on an apparent resistivity map. In order to eliminate the effect of the mound shape, the mean values of the apparent resisitivity are calculated along circumferences with centres coinciding with the mound apex. The anomalous effect in the points of each circumference is obtained as a difference between the measured value of the apparent resisitivity and the mean value (Radkov et al, 1978). The zones of positive higher intensity anomalies show the points under which it is possible to find a vault. Symmetric electroprofiling along circular concentric profiles and more detailed survey of the magnetic field are carried out in order to confirm the anomalous effect and specify the position

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of the site. The efficiency of this investigation method depends on the size and position of the anomalous object. The disposition of the vault construction, being peripheral in most cases, is favourable for the search.

The concrete results from the preliminary geophysical investigation of the Ginina mound in the vicinity of the village of Sveshtari near the town of Isperih in Northeast Bulgaria are indicative. Exavations were made according to geophysical data and the entrance of a large Thracian King's sepulchre from the 3rd century B.C. (Chichikova, 1983) was discovered on the spot exactly determined by the authors. The panoramic picture of the Ginina mound and the vault entrance are shown in Fig.1 according to topographic survey results (P. Valev). The mound is 14 m high and 80 m in diameter. The vault, including the entrance, is 12 m long, from 1.85 up to 3.50 m wide and from 2.15 m (in the corridor) up to 4.58 m (in the central part) high. The total volume of the void space is about 100 m^3.

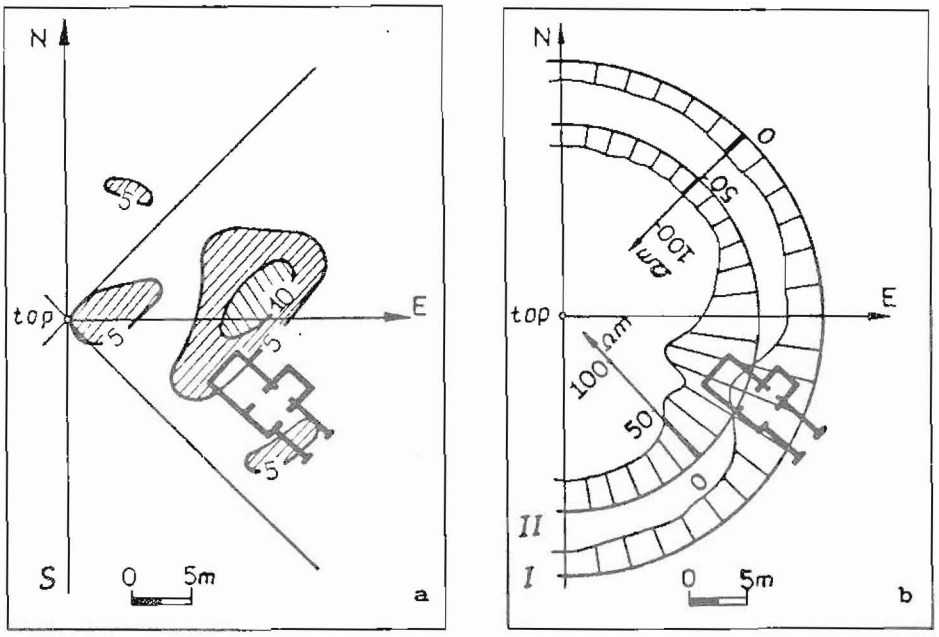

Fig. 2. Layout of the vault and results of electric profiling along radial profiles (a) and circular profiles (b) of the Ginina mound

The comparison between the archeological site already known and the geophysical anomalies which it causes, is of particular interest. The projection of the vault structure located in the east-southeastern section of the mound and the zones of intensive positive anomalies of the apparent resistivity are shown in Fig.2,a. The results of the electroprofiling

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along the peripheral circular profiles (Fig.2,b) are considerably more expressive. Along the first profile passing low over the vault entrance, an anomaly of 30 Ωm intensity and 10 m width has been registered. The second profile lies higher above the larger central part of the vault and records its presence by a 40 Ωm anomaly at about 20 m width. A noticeable magnetic effect in these sections was not recorded. The location of the site and the place for starting the excavations were determined in advance according to the extremes of the electric anomalies.

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