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NEW GEOPHYSICAL SURVEYS AND ARCHAEOLOGICAL RESEARCH AT SUCEAG (CLUJ COUNTY, ROMANIA)*

Coriolan Horațiu Opreanu[1], Vlad-Andrei Lăzărescu[2]

Abstract: *The settlement at Suceag I situated at approximately 15 km from Cluj-Napoca (former Roman colony Napoca) in the immediately nearby of the Roman road running from Napoca to Porolissum. It was in Roman time probably a rural settlement, or a villa. After the abandoning of Roman Dacia on top of the former Roman habitation, a new settlement dating between the second half of the 4th and the first half of the 5th centuries AD developed. Despite the fact that the settlements were archaeologically investigated for more than 10 years, a new approach was necessary in order to fully understand both the extent, the character of the habitation and the relationships between the two chronological stages. The main unknown of the archaeological landscape was the extent of the habitation. Taking this challenge, a comprehensive ground and aerial-based set of physical sensing techniques has been proposed. Within this new approach a large area in the southern part of the settlement was explored in 2012 by the means of geophysical techniques. Large scale low altitude remote sensing data acquisitions for the entire micro region, as well as the geophysical exploration of the northern part of the settlement are scheduled to be completed in the spring of 2014. Regarding the possible interpretation of the geophysical survey, a series of anomalies can be identified after the processing of the data, having both archaeological significance or being either of recent origin or geologic nature. The results point to the fact that all the investigated area is composed of numerous archaeological features, having a certain tendency of disappears towards the northern part. The soil seems to be abundant in highly remnant magnetized materials, out of which some could be interpreted as destroyed pottery kilns as for instance anomaly no. 8 possibly affected by the actual road that touches the archaeological feature.*

Keywords*:* *rural settlement, geophysical surveys, pottery kilns, Roman Dacia, Early Migration Period*

The geographical zone where the site at Suceagu is situated belongs to the bigger geographical unit of the Transylvanian Plateau, namely the Cluj and Dej Hills, at the confluence

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with the Huedin Plateau[3] and to be more precisely, on the Nadăș River valley (Fig. 1). This geographical micro-region called Căpușului Hills is positioned right in the south-east of the Someș Hills being separated by the Almaș River to the west, by the Gârbou Hills to the north and north-west, by the Someșul Mic River to the east and by the Căpuș and Crișul Repede rivers towards the south. From a geological point of view, the area is characterized by the presence of different types of grit stones and clays of diorite sand origin but most of all by the so called Dej volcanic tuff which determines the hilly aspect of the relief[4] (Fig. 1).

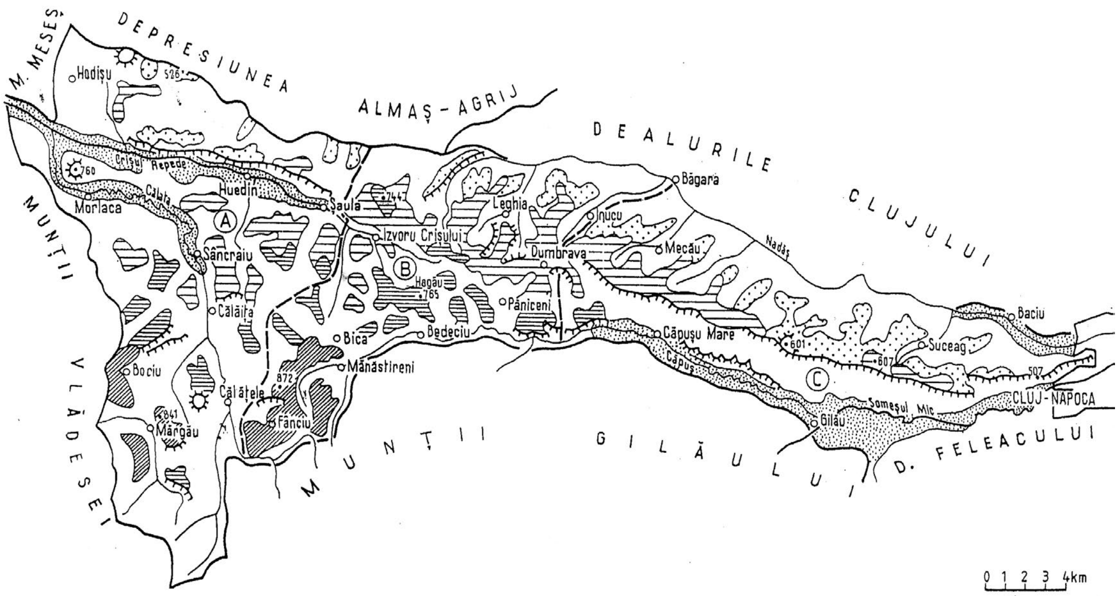

Fig. 1. The Huedin Plateau region (after BADEA 2006, 105, Fig. 8)

Because of the favourable natural conditions, the area was inhabited since prehistoric times[5]. During the Roman period, a rural settlement (or a *villa) emerged in close connection with the Roman imperial road situated in its close vicinity, linking the town of Napoca with Porolissum*[6]. After the ending of the Roman rule in Dacia, on top of the former Roman habitation, a new settlement dating between the second half of the 4th and the first half of the 5th centuries AD developed. Despite the fact that the settlements were archaeologically investigated for more than 10 years, a new approach was necessary in order to fully understand both the extent, the character of the habitation and the relationships between the two chronological stages (Pl. 1).

The Roman site seems to be spread over a wide area near the Roman road. On top of the „Orat" hill, several Roman votive inscriptions were discovered in the past[7]. It is possible that the ruins still visible today to be in close connection with these inscriptions. Right across the modern road, where the above mentioned excavations have taken place, several stone structures and lots of Roman small finds and pottery were uncovered[8]. The chronology of this settlement starts during the first decades of the 2nd century AD[9] and lasts until at least the

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[3] BADEA 2006, 102–106.
[4] SAVU 1963, 84–86; SAVU 1987, 528–536; POP 2001, 125; BADEA 2006, 85.
[5] COCIȘ/OPREANU 1994.
[6] DAICOVICIU 1928–1932; FODOREAN 2006, 68–71; 134–139; PISO 2011, 321–323.
[7] MACREA 1928–1932; FERENCZI 1972, 402.
[8] OPREANU/COCIȘ 1994; OPREANU/COCIȘ 1995.
[9] COCIȘ 2001.

first half of the 3rd century AD[10]. As the area comprising all the Roman structures and finds is quite large, it possible to formulate the hypothesis of a rural settlement as opposed to the older theory presuming the existence of a *villa rustica*[11]. Beside the local topography another argument supporting the existence of a settlement consists in the identification of several stone walls belonging to different large stone buildings[12]. The pattern of rural habitation in Roman Dacia is little known, many isolated finds being arbitrary considered as evidence for villas[13], but only extensive research programs will succeed to gather enough data for a realistic background[14].

During the Early Migration Period, among the former Roman buildings, a new group of population built other dwellings which developed in time into a significant settlement. The chronology of this new habitation was established based on several metal artefacts and pottery[15] showing that there is no direct link between the Roman and Early Migration settlements. As far as we know, the settlement at Suceagu represents a self-supported type of community being a pottery production centre[16] and having at least one antler manufacturing workshop[17].

The main unknown of the archaeological landscape was the extent of the habitation. Taking this challenge, a comprehensive ground and aerial-based set of physical sensing techniques has been proposed. Within this new approach a large area in the southern part of the settlement was explored in 2012 by the means of geophysical techniques. Large scale low altitude remote sensing data acquisitions for the entire micro region, as well as the geophysical exploration of the northern part of the settlement are scheduled to be completed in the spring of 2014. The preliminary results of the geophysical investigation carried out in 2012 will be presented in the following lines[18.]

The site area is highly disturbed by modern human activities. That is why only a part of the site was available for geophysical investigation. This clean area, with a total surface of 1.6 hectares, was mapped using geophysical magnetic techniques, while ERT (Electrical Resistivity Tomography) measurements were performed in order to reveal the main stratigraphic sequences.

Within the clean area, a grid consisting of 10 cells was drawn. The grid cells measured 40 m × 40 m each. The magnetic survey was carried out using a Bartington GRAD 601–2 dual sensor Gradiometer. The reason behind such a data acquisition strategy was the fact that the archaeological excavations carried out within the site in 1989 and1994 revealed the existence of 3 pottery kilns. Beside the extent of the site, a second goal of the non-invasive surveys was to determine whether some other pottery kilns could be identified. Because of this, the magnetometric analysis was thought to be the best solution for a quick investigation and data acquisition technique in the field. The Bartington GRAD 601–2 dual sensor Gradiometer with 2 fixed measuring units, each containing 2 separate fluxgate type sensors at a distance of 1 m on the vertical scale, allowed for a quicker survey by eliminating the need of a remote sensor for the measuring of the earth's magnetic field variations caused by the time and temperature variations during the day. On the other hand, using such equipment, diminished the exterior lateral perturbations of the measurements, recording only the vertical component of the magnetic field and thus identifying and mapping with high precision only the influences caused to the earth's

[10] A silver coin issued by Septimius Severus was found during the archaeological excavations in 2012.

[11] MACREA 1928–1932; FERENCZI 1972, 402.

[12] OPREANU ET ALII 2013, 122.

[13] POPA 2000.

[14] A good example is the recently identified rural settlement at Șibot, see BÂLTÂC 2013.

[15] See the contribution of C. H. Opreanu in the same volume (OPREANU 2013).

[16] OPREANU/COCIȘ 2002.

[17] OPREANU 1992.

[18] Geophysical investigations were conducted by Dan Ștefan. The other members in the geophysical team were Vlad-Andrei Lăzărescu and Constantin Ștefan. Processing and interpretation of the geophysical and topographical data-sets were performed by Dan Ștefan and Maria-Magdalena Ștefan.

magnetic field by the buried archaeological features. The acquired datasets were processed using specially designed algorithms the results being afterwards georeferenced and integrated into a GIS platform for a better understanding of the archaeological situation.

Out of the entire investigated area of 1600 m^2, a total of 64000 vertical magnetic gradient measurements were performed and collected. The equipment was programmed to record the values of 4 measurements per meter on 40 m profile. The cells composing the newly created grid system, located towards the eastern side of the PlantExtrakt industrial facility, was covered in a zigzag manner towards the north (a direction consistent with the natural slope of the terrain) (Pl. 2a). A coverage using the natural contour lines, even though much more easy to perform, would have led to errors and measuring inaccuracies because one of the sensors would have been placed closer to the surface than the other. The gradiometric measurements performed in parallel rows but with different orientation generated on the magnetic map a series of stripes in oriented in the direction in which the traverses were performed because of the calibration differences, position and orientation of the sensors, but after a series of filtering processes as part of the post-processing of the data, all these issues were resolved (Pl. 2b).

The method of collecting data in the field followed a well-established plan described below:

a. The on-site assessment of the main characteristics of the terrain such as surface, vegetation, elevation patterns and the identification of the areas with the highest archaeological potential for such an analysis;

b. Defining the data acquisition strategy;

c. Establishing the position and pattern of the gridding system;

d. The on-site cleaning of the area to be investigated (collecting all the metallic wastes that could interfere with the survey);

e. The calibration of the gradiometer;

f. Random surveying of the area for a better assessment of the local magnetic response;

g. Creating the gridding system;

h. Georeferencing the magnetometric gridding system by GPS means;

i. Magnetometric survey.

The magnetometric survey was accompanied by a series of 5 Electrical Resistivity Tomography (ERT) profiles destined to point out the inner stratigraphic sequence of the site. The ERT profiles were positioned over one of the biggest magnetic anomaly recorded by the magnetometric survey (Pl. 6).

The magnetic datasets were processed by means of mathematical algorithms and digital filtering in order to highlight archaeological structures underneath and diminish useless details and unwanted background noise[19]. In this way the differences between the zigzag traverses resulted as part of the acquisition process were eliminated using the de-stripe filter (zero mean traverse algorithm), the unwanted offset between the traverses was corrected through the application of the de-stagger filter while the equalization of the acquisition density of the data on the x-y axis was obtained using the mathematical interpolation of the measured values. The magnetic anomalies were highlighted employing different manipulation techniques of the dynamic range of the geophysical signal. Thus, the most extreme values were clipped between a 2SD (standard deviation) interval. In the same time the variation of the recorded values was modified for each case that needed it either by logarithmic compression or by different Locally Adaptive Contrast Enhancement techniques.

The electrical dataset was initially visualized as *pseudo-cross-sections of apparent resistivity. For obtaining the 2D electrical resistivity tomography profiles as well as for the complete 3D solution*

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19 SCOLLAR 1986; ȘTEFAN 2012.

the rapid least-squares inversion of apparent resistivity pseudo-sections using quasi-Newton method was used[20]. The direct and inverse model of the electrical data was obtained using the software solutions DC_2DRO and DC_3DPRO[21] (Pl. 6–8).

Regarding the possible interpretation of the geophysical survey, a series of anomalies can be identified after the processing of the data, having both archaeological significance or being either of recent origin or geologic nature. The results point to the fact that all the investigated area is composed of numerous archaeological features, having a certain tendency of disappears towards the northern part (Pl. 3). The soil seems to be abundant in highly remnant magnetized materials, out of which some could be interpreted as destroyed pottery kilns as for instance anomaly no. 8 possibly affected by the actual road that touches the archaeological feature (Pl. 4). The anthropic anomalies of recent origin are caused by the actual roads covering the area (1, 2 and 3) as we can easily document by overlapping the magnetic map with the satellite image of the site. The magnetic survey also highlights a series of linear anomalies marked on the map using a solid green line (4, 5 and 6) which can possibly be associated to some elements of the sites' micro-topography and/or morphology of the area (possible natural terraces). The most important magnetic anomaly is the one marked with no. 7 having a strong dipole character, such magnetic signature being typical to the pottery kilns in general, the diameter of the anomaly measuring approximately 4.5 meters. Anomalies 8, 9 and 10 might also be interpreted as pottery kilns, out of these, anomaly no. 9 representing probably a discarded kiln. Anomaly no. 11, situated in the 3D grid refers to a group of consistent magnetic pits while anomalies 12, 13, 14 and 15 can be definitely interpreted as archaeological structures, their exact nature and function being at the moment unknown, the need of an archaeological excavation that could clarify both the stratigraphy and nature of these structures being recommended by the intensity, nature and abundance of anomalies with archaeological potential documented by this large scale survey (Pl. 5).

The electrometric analysis covered the area where a magnetic anomaly typical for the presence of a pottery kiln was observed, the anomaly marked on the map with no. 13 (Pl. 8). A very good correspondence and complementarity between the results obtained through the two geophysical surveying methods used. The electrometric analysis provides new data regarding the stratigraphic details. The analysis of the ERT profiles (Pl. 6) along with the full 3D inversion of the electrical dataset (Pl. 7) allows for a better view of the groupof anomalies no. 13. They form immediately under the topsoil (at an approximate depth of 0.15 cm) and develop until -0.65 cm and then up to a maximum depth of 1.5 m. The archaeological nature of these anomalies is quite evident, while their functional and typological identification is quite risky even after a combined analysis of the two datasets mentioned above. The high values of the vertical magnetic gradient points towards some areas that suffered a thermic alteration, a situation that points to the interpretation of these features as either pottery kilns or features that suffered an intense firing process. The low values of the electrical resistivity illustrates the fact that we are dealing with sunken features, but the fact that these features are visible right under the topsoil indicates that they might have suffered alterations in time. This post-depositional evolution, highly marked by erosion and modern anthropic activities, characterises in fact the entire archaeological site at Suceagu, an observation that explains the lack of clear patterns and the tendency to decay of the anomalies showed by the surveys.

The geophysical surveys at Suceagu showed once more, the complexity of this archaeological site bringing new complex information regarding the unexcavated archaeological structures. The main groups of features identified will be the subject of future targeted

[20] TSOURLOS 1995; LOKE/BARKER 1996; LOKE/BARKER 1996a.

[21] Through the kind permission of the software application's author, Dr. Jung-Ho Kim; see also YI ET ALII 2001.

archaeological investigations, a situation that will allow for a better understanding of the correspondences between the different types of geophysical anomalies and the archaeological structures, making also possible a better understanding of the future geophysical surveys.

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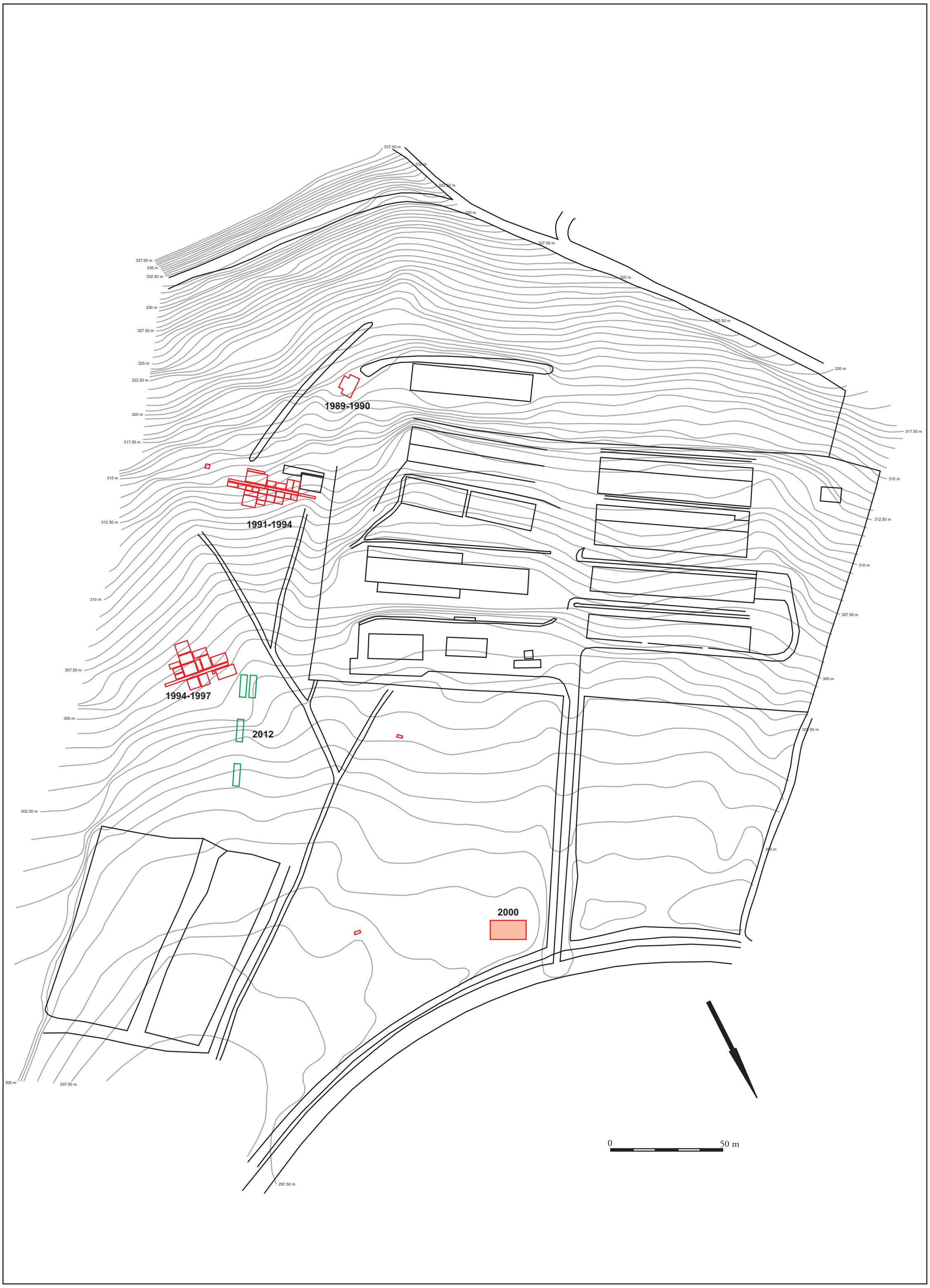
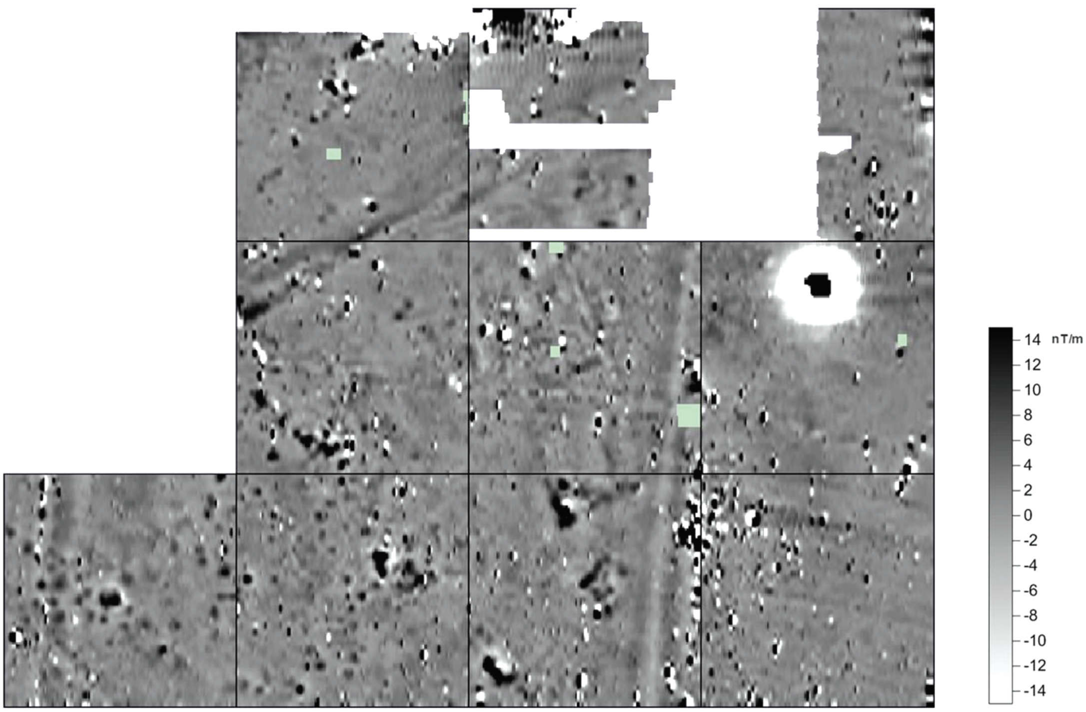


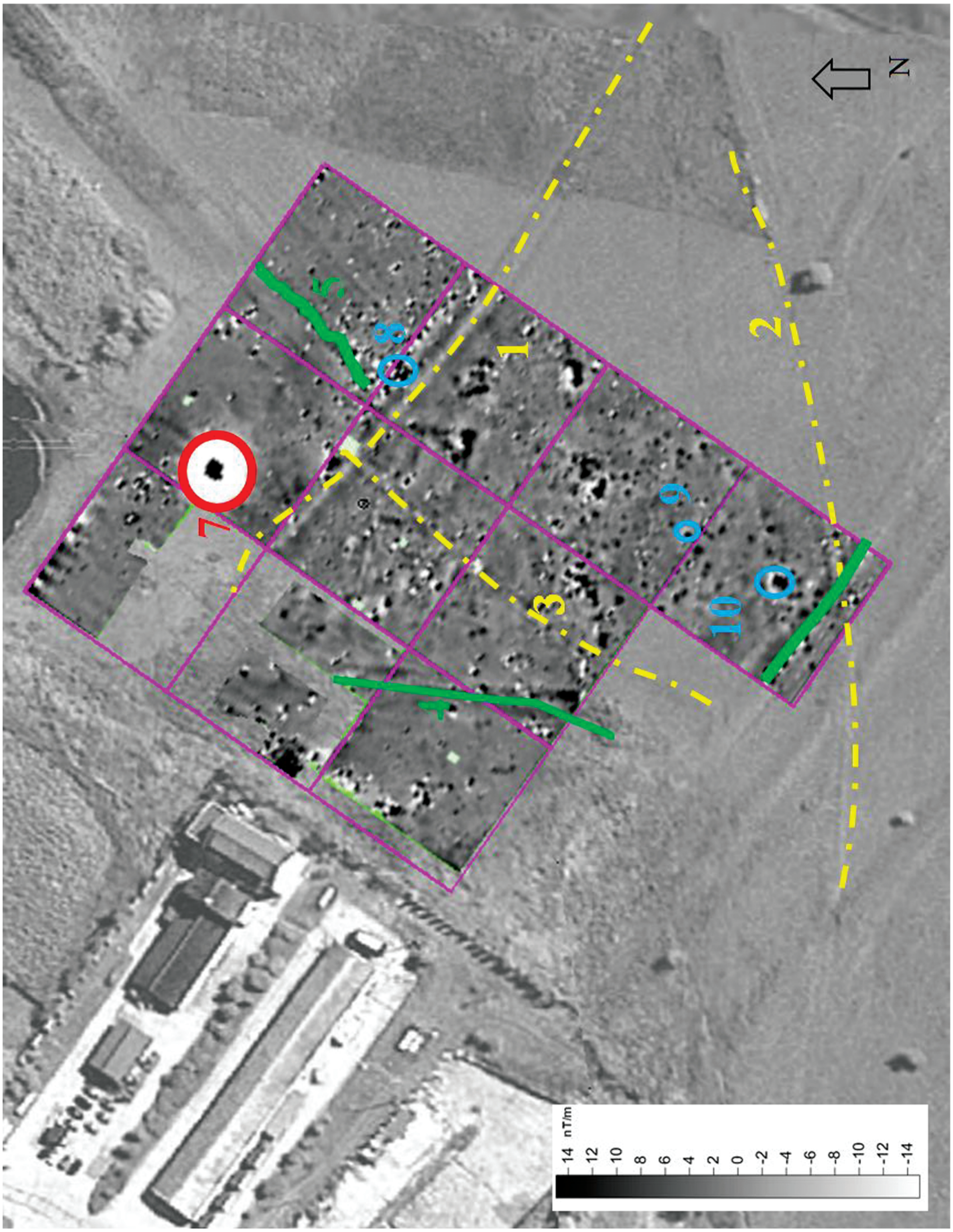
Pl. 1. General plan of the site at Suceagu.

a.

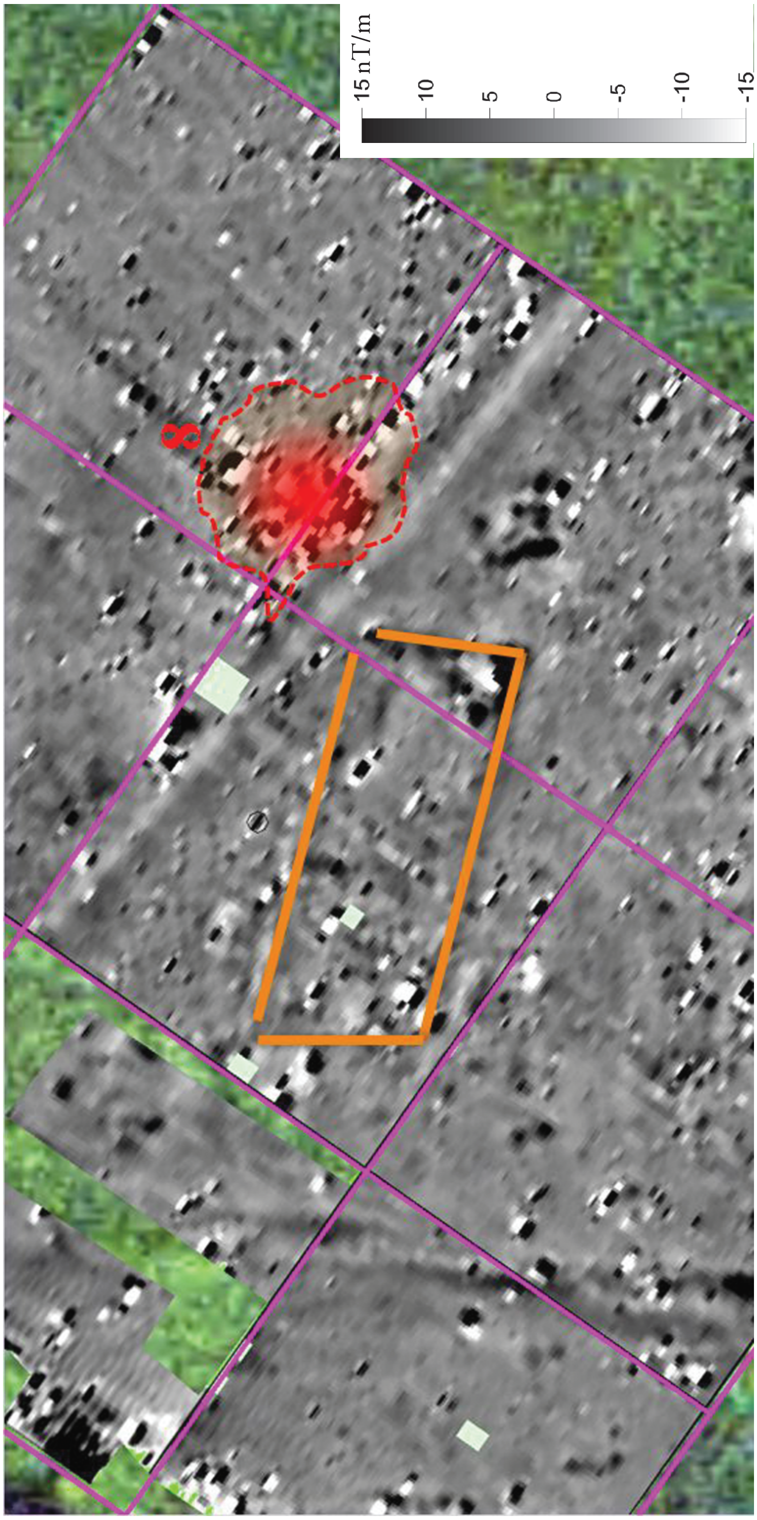


b.

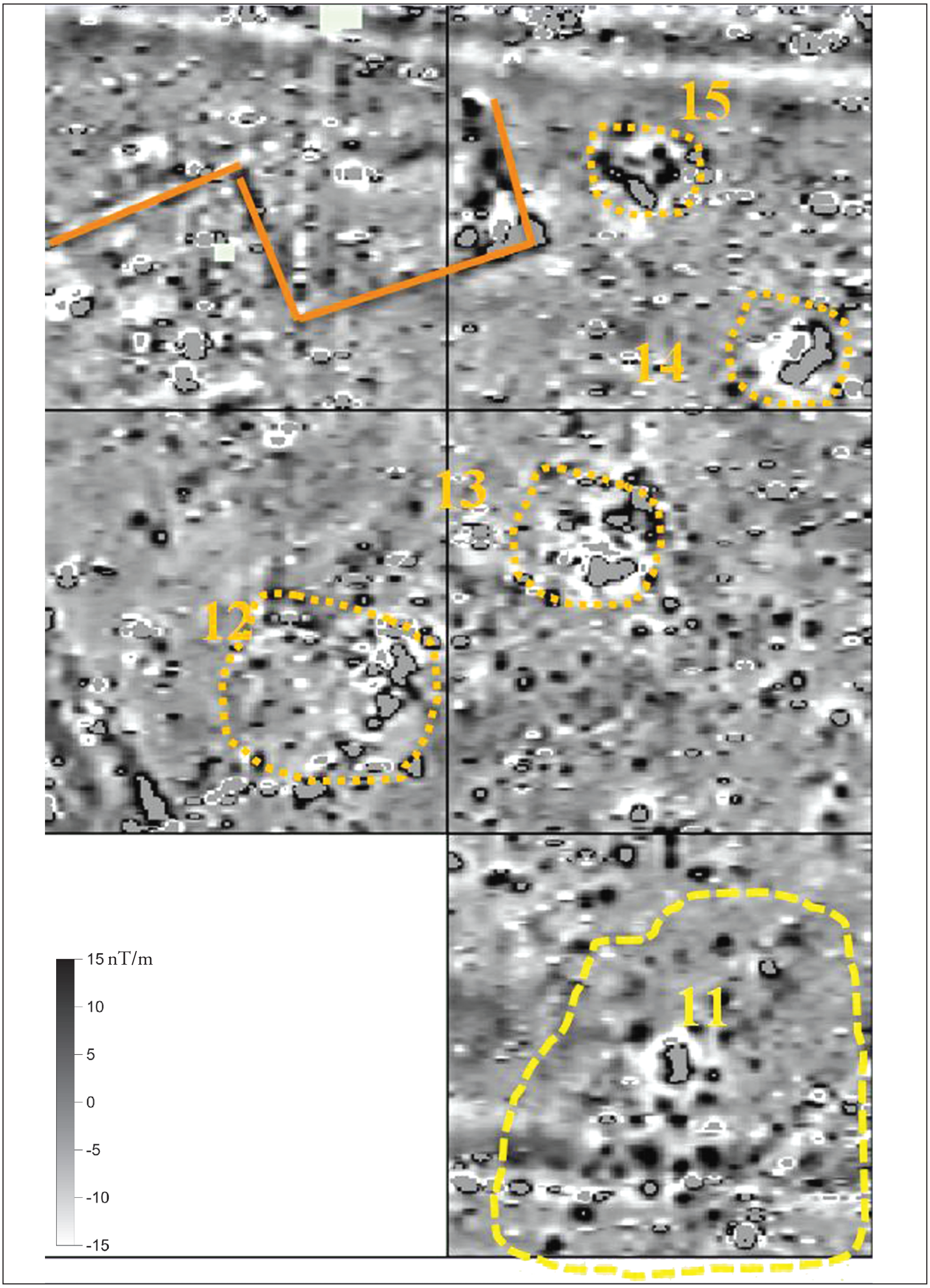
Pl. 2. a. The grid system used for the geophysical survey; b. The magnetic map obtained after processing the aquired dataset.



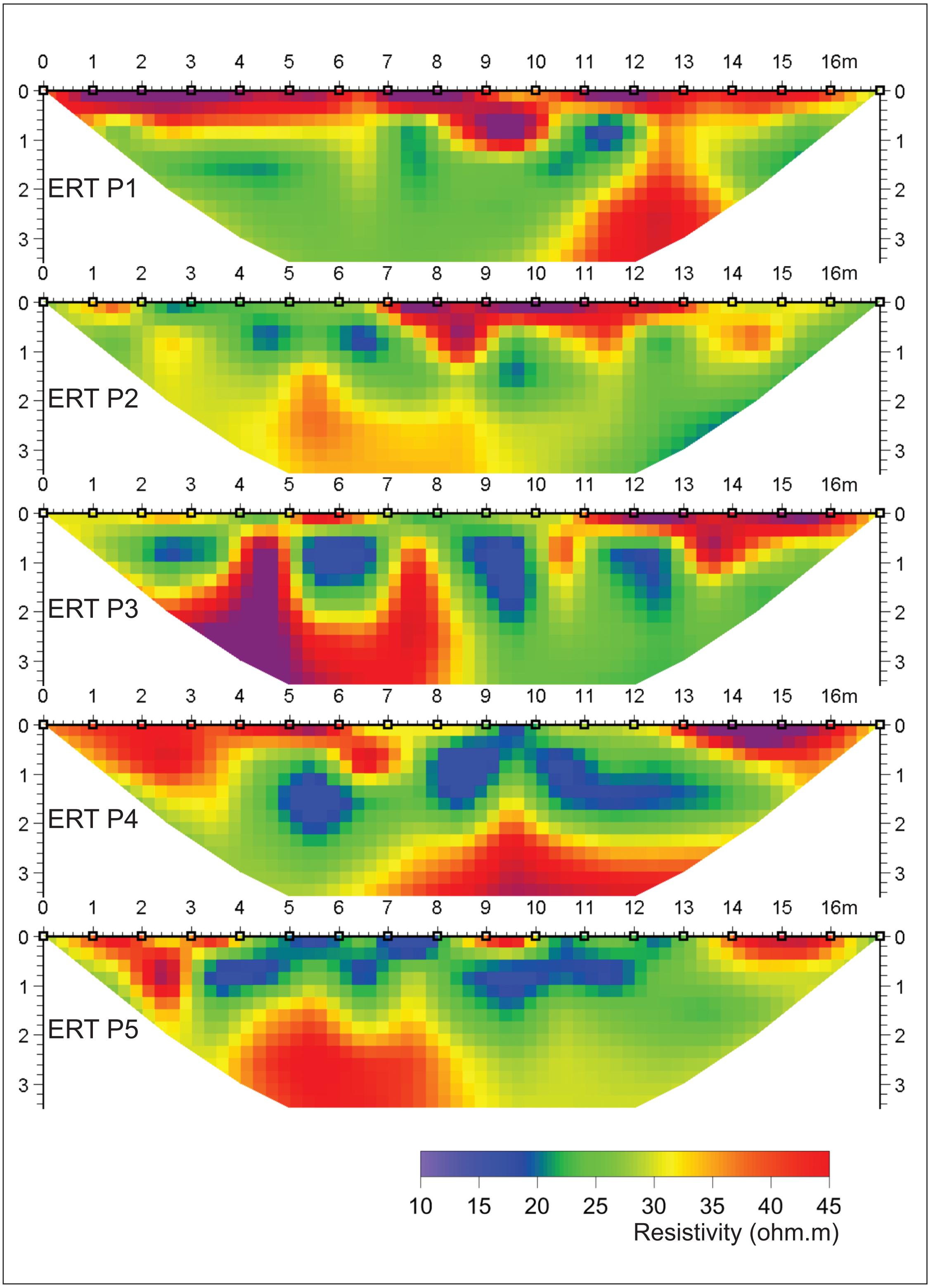
Pl. 3. The interpreted magnetic map showing anomalies no. 1-10.



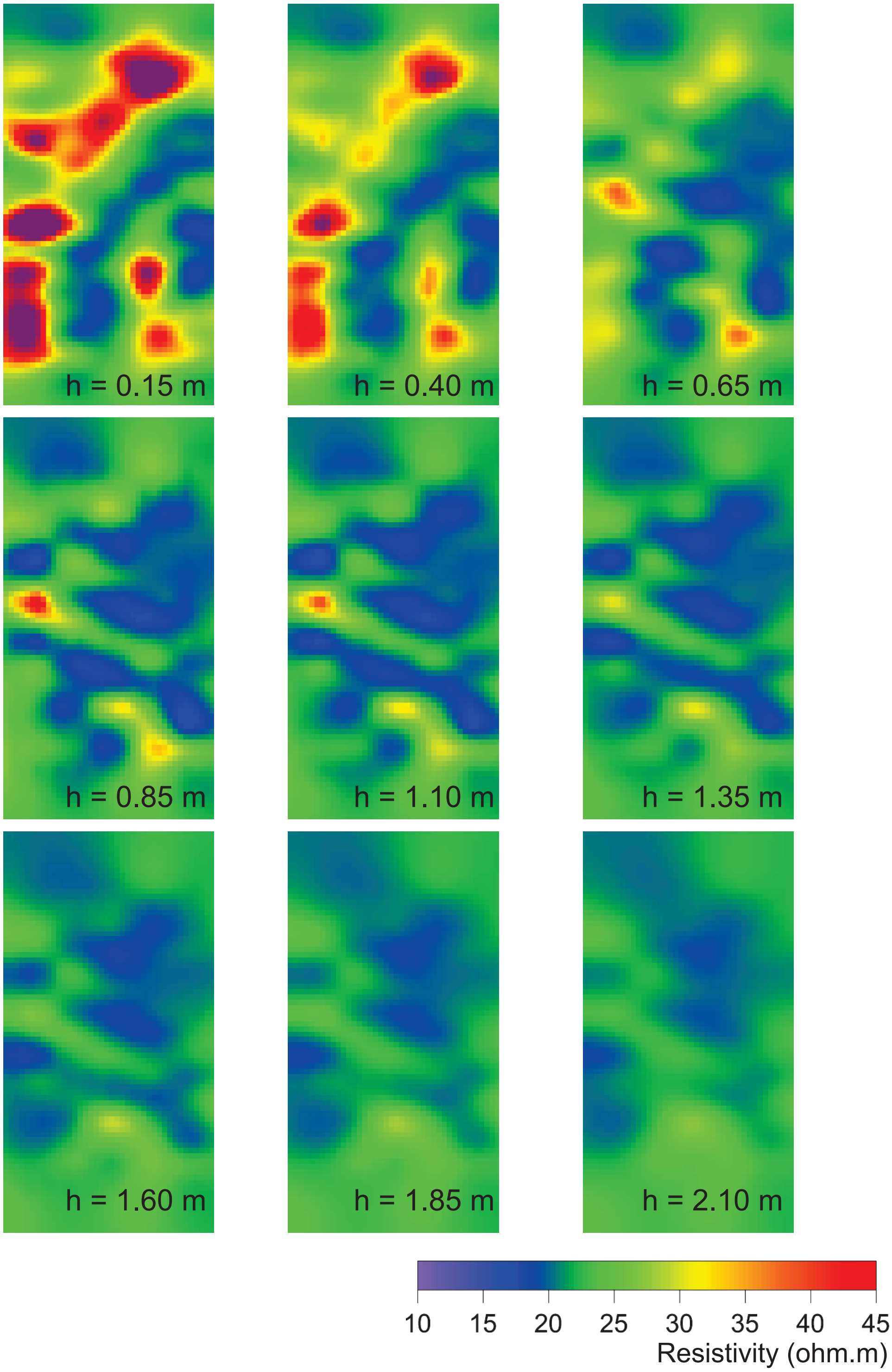
Pl. 4. The interpreted magnetic map showing anomalies no. 8.



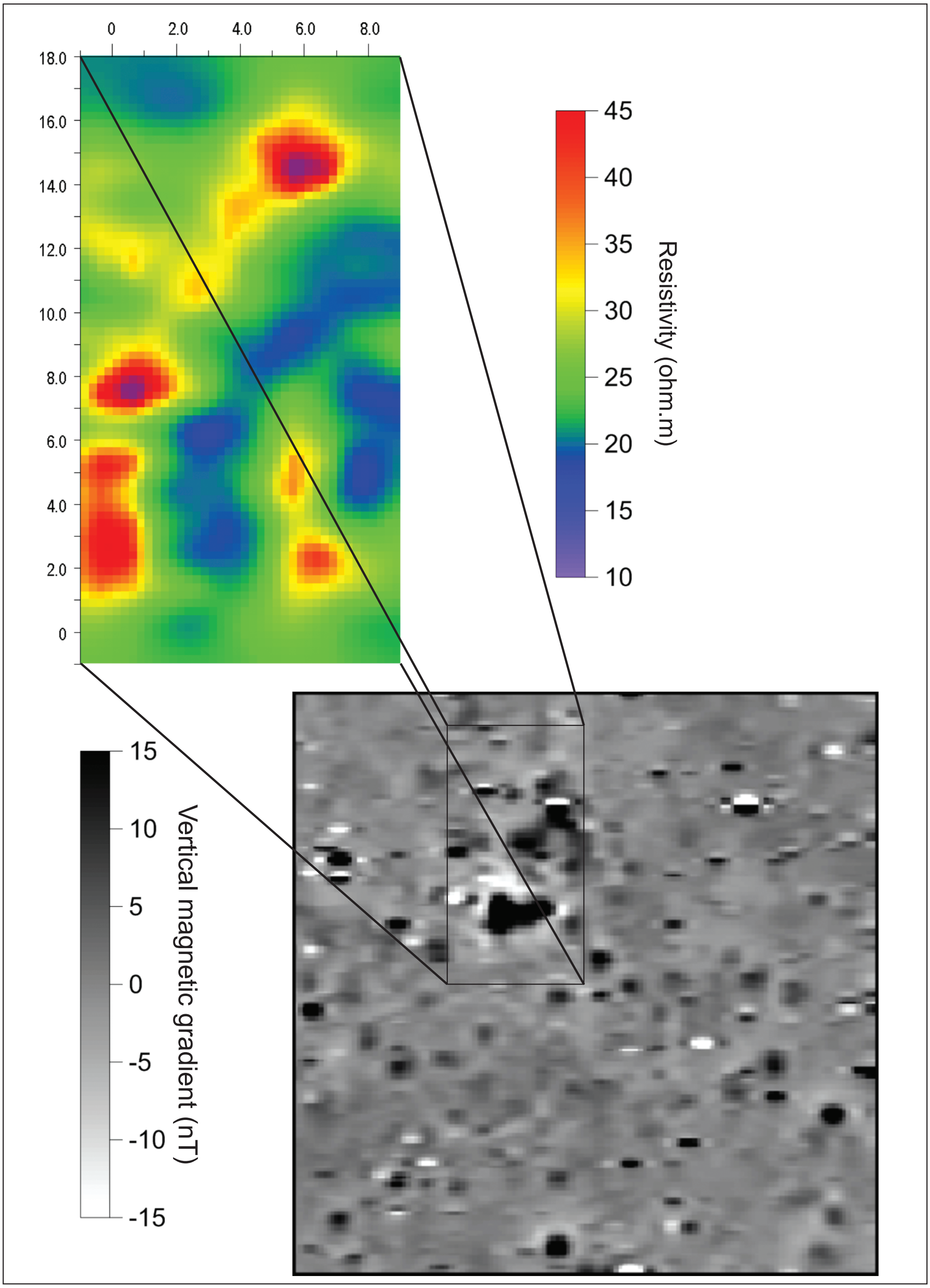
Pl. 5. The interpreted magnetic map showing anomalies no. 11-15.



Pl. 6. Electrical resistivity tomography profiles (P1 ÷ P5).



Pl. 7. Electrical resistivity tomography. 3D Inversion of the P1 ÷ P5 profiles.



Pl. 8. Electrical resistivity tomography; a. – 3D Inversion of the P1 ÷ P5 profiles at 0.40 m depth; b. – location of the 3D ERT slice on the magnetic map.