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Spatial organisation and population size of small Cucuteni-Tripolye settlements: Results of geomagnetic surveys in Baia and Adâncata, Suceava County, Bucovina, Eastern Romania

Robert Hofmann, Stanislav Ţerna, Constantin-Emil Ursu, Lennart Brandtstätter, Heiko Tiede, Wiebke Mainusch, Sabrina Autenrieth

Authors' addresses:
Robert Hofmann, Heiko Tiede
Institute of Prehistoric and Protohistoric Archaeology, Kiel University, Johanna-Mestorf Straße 2–6, 24118 Kiel
Graduate School "Human Development in Landscapes", Kiel University, Leibnitzstraße 3, 24118 Kiel.

Stanislav Ţerna
'High Anthropological School' University, Iorga Str. 5
MD-2028
Chişinău, Republic of Moldova.

Constantin-Emil Ursu
Bucovina Museum, Suceava, Str. Stefan cel Mare Nr. 33 Suceava 72003 Romania.

Lennart Brandtstätter, Wiebke Mainusch
Institute of Prehistoric and Protohistoric Archaeology, Kiel University, Johanna-Mestorf Straße 2–6, 24118 Kiel

Sabrina Autenrieth
Faculty of Archaeology, Leiden University, Postbus 9514, 2300 RA Leiden,
The Netherlands.

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Abstract

Geomagnetic research and drillings provide new results regarding settlement organisation and population size of three small settlements from the Pre-Cucuteni and the Cucuteni A-B period of Suceava County in Romanian Bucovina. In these settlements from different stages of the Cucuteni-Tripolye complex, domestic dwellings can be distinguished from clearly oversized (special?) buildings, which are situated in central locations and sometimes contain special inventories. Different principles of settlement organisation are visible, which each show far-reaching references to the Central Balkans, on the one hand, and the Bug-Dnieper interfluve on the other hand. Based on analogies with other Cucuteni-Tripolye sites, consistent populations with less than 200 inhabitants are reconstructed.

Introduction

Since the discovery of Cucuteni-Tripolye sites, researchers have sought to find out more about the internal structure of settlements in order to be able to draw conclusions about the socio-economic organisation of Chalcolithic societies (for a history of research see, for example, Sorochin, 1993; Дудкін/Відейко 2004). Three basic approaches have been used for this purpose: large-scale excavations, the study of aerial photographs and geophysical prospections. Excavations covering large areas, including the complete unearthing of burnt houses, were carried out in the 1930's by T. Passek (Пассек 1949). Aerial photographs were largely used by the military topographer V. Shishkin starting in 1964. This technique allowed him to identify a large number of sites, including the famous mega-sites from the Southern Bug Basin (Шишкін 1973; Шишкін 1985; Видейко 2012, 228–229). V. Shishkin extended his investigations to include the territory of Moldova, producing plans of several important settlements including Petreni and Stolniceni (Бикбаев 2007, 13–19).

First geomagnetic surveys on Cucuteni-Tripolye sites were performed in 1966 on the Podgorcy and Novye Bezradichi settlements in Ukraine (Даниленко et al. 1967), followed by further research in 1967 on Čapaevka and Mayaki settlements (Дудкин 1968; Дудкин 1970; Загний et al. 1971). The geomagnetic approach was first implemented to a much larger extent beginning in 1971, when the prospection of the mega-site of Maidanetske started, leading to a refinement of the methodology of prospection and the interpretation of Cucuteni-Tripolye settlements on large areas (Шмаглій et al.

1973; Видейко 2012, 231–236). Subsequently, numerous sites were scanned from 1970 to the 1990's – above all, large settlements both in Ukraine and Moldova (Кошелев 2004; Дудкін 2007).

A new stage of geomagnetic prospection of Cucuteni-Tripolye settlements ensued in 2007 with the work of a team from Kiel University (initiated by J. Müller, H. Parzinger and S. Hansen) under the direction of Carsten Mischka in Romania (Mischka 2008; Mischka 2009), followed by new prospections on mega-sites in the Ukraine (e.g. at Nebelivka from 2009–2014: Chapman et al. 2014b; Burdo/Videiko 2016; Chapman et al. 2016; at Taljanki from 2011–2012: Kruts et al. 2011; Rassmann et al. 2014; Rassmann et al. 2016a; at Maidanetske from 2011–2012: Rassmann et al. 2014; Müller/Videiko 2016; Rassmann et al. 2016a; at Dobrovody in 2011: Rassmann et al. 2014; Rassmann et al. 2016a) and Moldova (Rassmann et al. 2016b). Performed in the framework of several international cooperations, these investigations again attracted the attention of researchers to the question of detailed plans of large Tripolian settlements. Thus, new plans of the mega-sites were prepared within several years – performed this time with the technical possibilities of the 21st century, leading to more highly detailed pictures and allowing a reconsideration of results of previous prospections.

In these plans, in several cases thousands of mostly burnt houses are arranged in oval rings associated with pits. At exposed positions within these settlements, particularly large building structures were discovered, which are interpreted as communal facilities for decision-making or other purposes (Chapman et al. 2014a; Müller et al. 2016). Furthermore, numerous pottery kilns could be identified in the new plans, which provide completely new insights into the technology and organisation of the (noticeably already highly specialised) pottery production (Kruts et al. 2011; Korvin-Piotrovskiy et al. 2016). Meanwhile, several of these different features have been checked by archaeological excavations (e.g. Видейко et al. 2015; Müller et al. in print).

The focus on mega-sites and their internal structures has become a constant and developing trend of the most recent geomagnetic research of Cucuteni-Tripolye sites. This has influenced both the chronological framework of new data and their specifics. Most of the large sites and new geomagnetic plans belong to Tripolye BII and CI stages. In contrast, there is clearly a lack of geomagnetic surveys at smaller sites, on the one hand, and earlier surveys from the Pre-Cucuteni/Tripolye A, Cucuteni A/Tripolye BI and the Cucuteni A-B/Tripolye BI–BII chronological stages on the other hand. They would be useful to provide very important and unique data on settling strategies and the structure of settlement systems of Cucuteni-Tripolye communities before the formation of large sites (cf. Marinescu-Bîlcu 1974; Bodean 2001; Zbenovič 1996; Збенович 1989; Дудкін/Відейко 2004).

Due to the greater focus on late Tripolye mega-sites, the origins of the radial settlement layouts and the spatial organisation of early Cucuteni-Tripolye settlements are still an unsolved question. There are at least two basic principles of settlement organisation: the "row pattern", on the one hand, in which houses are arranged in more or less straight lines and, on the other hand, the "circular pattern", which is characterised by circular (round/oval) arrangements of houses with a centre and a periphery. The first pattern is documented by excavations. The second one is rarer and known from just four settlements, which have been excavated (Bernashevka – Збенович 1980, рис. 3; Slobodka-Zapadnaia – Патокова et al. 1989, рис.1/2) or surveyed geomagnetically (Mohilna III – Дудкін/Відейко 2004, 306; Nicolaevca V – Saile et al. 2016; Ţerna et al. 2016b). As early examples from the almost completely excavated Bernashevka (Podolje) and the geomagnetic surveyed site Iclod (Transylvania) show (Mischka 2012), we have to search for the beginnings of the circular pattern at least around the mid-5th millennium BCE. According to a case of similar settlement organisation, which has recently been discovered at the tell settlement of Borđoš (Vojvodina) and is associated with Vinča C2/D1 and classical Tisza pottery, the distribution area of this specific kind of settlement layout reached far more to the west than was previously assumed (Medović et al. 2014). It shows that there is an urgent need for further concentrated research on the problem of Neolithic and Chalcolithic settlement organisation and the problem of megastructures and special buildings.

As a contribution to the mentioned problems, a cooperation project was launched between the Museum of the Bucovina in Suceava, on the one hand, and the University of Kiel, on the other hand, which aimed at the performance of geomagnetic surveys of selected sites in the Suceava region. The results of the fieldwork that took place between the 2nd and 6th of March, 2015 are presented here for the first time.

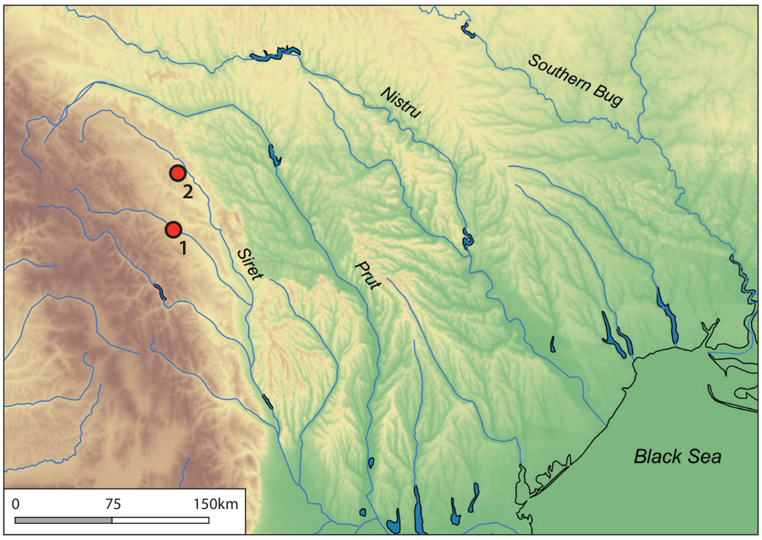


Fig. 1 Map of Southeast Europe with investigated sites. 1 – Baia, 2 – Adâncata.

The surveys focused, on the one hand, on the site of Baia, which belongs to the earliest (Pre-Cucuteni-I) stage of the Cucuteni-Tripolye complex (Fig. 1). Here, excavations have been conducted since 2012, during which – among other things – an extraordinary large building with special inventory was discovered. Thus, the opportunity arose to clarify the general settlement layout of a very early Cucuteni-Tripolye settlement and also to contribute to the problem of special buildings in corresponding sites. In Adâncata, on the other hand, we could survey a fortified settlement of the Cucuteni A-B stage as well, which remains a matter of ongoing fieldwork carried out by the Bucovina Museum.

General information about the settlements and the history of their research

Baia-În Muchie

The settlement of Baia-*În Muchie* is located in Suceava County, 2 km north of the modern village of Baia (Romania). It lies at an altitude of 370–375 m above sea level on the first floodable terrace of the large valley of the Moldova River (part of the Siret basin) in the sub-Carpathian region (Fig. 2 and 3) and is located between the Şomuzul Mocirlos and the Şomuzul Mare Rivers on a territory with many drainage channels which were artificially dug in the 20th century. The settlement is situated on the very edge of the terrace on a semi-circular foreland.

Baia-*În Muchie* was discovered in 1998 by Bogdan-Petru Niculică and Mugur Andronic (Niculică/Andronic 2000). Beginning in 2012, investigations have been started by Constantin-Emil Ursu from Bucovina Museum in Suceava. In 2013, the team was joined by the researcher Stanislav Ţerna (High Anthropological School, Chişinău).

During three archaeological campaigns (2012–2014), a total area of 524 m² was unearthed. The stratigraphical sequence of the site includes complexes and/or finds from the Early and the Late Copper Age (late Pre-Cucuteni I and Horodiştea), the Bronze Age and the

Fig. 2 Baia. View on the site from the south-east. The arrow indicates the position of the settlement on the first flooded terrace of the Moldova River within the river's valley.

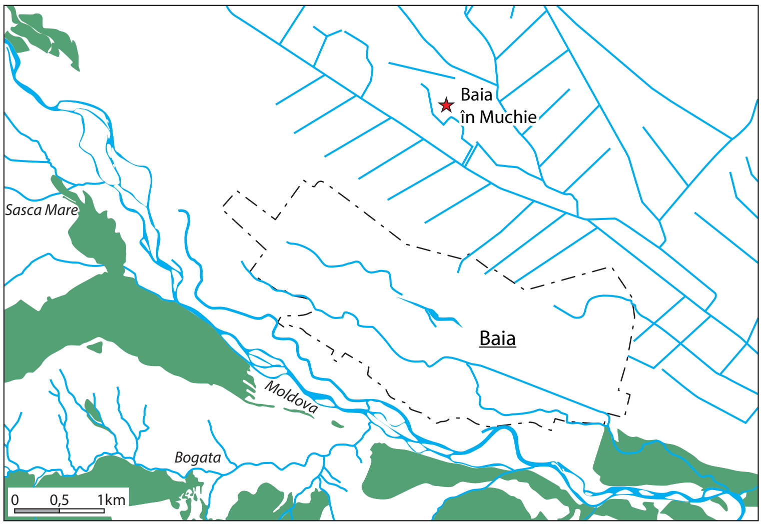


Fig. 3 Baia. Position of the site within its micro-region. Rivers are labelled with italic font, the modern village is underlined, the settlement is marked with a star.

first centuries AD. The two most consistent occupational layers documented so far belong to the Pre-Cucuteni period and the first centuries AD.

Four dwellings and a number of other complexes belonging to the Pre-Cucuteni sequence were excavated. Dwellings 1, 2 and 4 (the latter unearthed just partially) are of typical size for this early stage with dimensions not exceeding 25 m². A real surprise and a major archae-

Fig. 4a Baia. Building no. 3 (middle–lower part of the plan).

ological discovery turned out to be construction no. 3. Excavations on this structure started in 2013 and continued in 2014 (the investigation of this building shall be completed in the next years). With its exceptional dimensions (at least 11.1 × 17.6 m), building no. 3 from Baia is one of the largest burnt clay assemblages (if not the largest of these assemblages) from the late 6th–early 5th millennia BC in Southeastern Europe (Fig. 4a).

Apart from its huge dimensions, two other characteristics of building no. 3 are remarkable. First, its architecture is significant. A complex system of five parallel-segmented foundation trenches (53–63 cm wide and 90–130 cm deep) with postholes ensured the stability of the large building (Fig. 4b). The burnt clay from collapsed walls and the ceiling was investigated using a complex methodology, applied for the first time on the territory of Romania. All of the wooden imprints on clay were recorded using special sheets and a graphical system of symbols. Such an approach allowed us to trace the internal division of the space within the dwelling, including at least 8 rectangular rooms measuring 10–30 m². The rooms were oriented in alignment with the main axis of the building. Moreover, some internal architectural elements were documented, including heating and clay installations (Ursu/Ţerna 2014; Ursu/Ţerna 2015; Урсу/Церна 2015).

The inventory of the building is as remarkable as its dimensions and architecture. The building contained a huge quantity of ceramic vessels (at least 200), grinding tools and chipped stone implements. The most striking element of the ceramic assemblage is the special pottery with stylized anthropomorphic representations (Fig. 5). Before Baia, such vessels were known from other settlements of the Pre-Cucuteni/Tripolye A chronological horizon, but in all of the cases only 1–2 vessels and/or several fragments were recovered. In building no. 3 from Baia, at least 33 vessels with stylized anthropomorphic representations have been discovered thus far and 68 such finds have been recovered at the settlement (Ursu et al. in print; Урсу/Апараскивей 2014). Such a concentration is unique for the entire Pre-Cucuteni-Cucuteni/Tripolye complex. In contrast, only two anthropomorphic figurines were found in the building. Such a low number is also quite unusual for Pre-Cucuteni-/Tripolye A complexes.

A detailed analysis of the distribution of postholes and foundation trenches together with field records and observations allowed us to make some assumptions on the microstratigraphy of the settlement and building no. 3. It is possible that the building existed during an earlier phase with the same orientation but smaller dimensions. This phase is contoured by the distribution of postholes. A second phase would be the one with foundation trenches and the dimensions that we recorded. Another micro-phase is represented by a complex of pits and clay ovens, which cut one of the foundation trenches of the building.

The pottery found in the excavations dates to the Early Copper Age horizon with the final Pre-Cucuteni I stage, which could roughly correspond to the turn of 6th and 5th millennia BC.

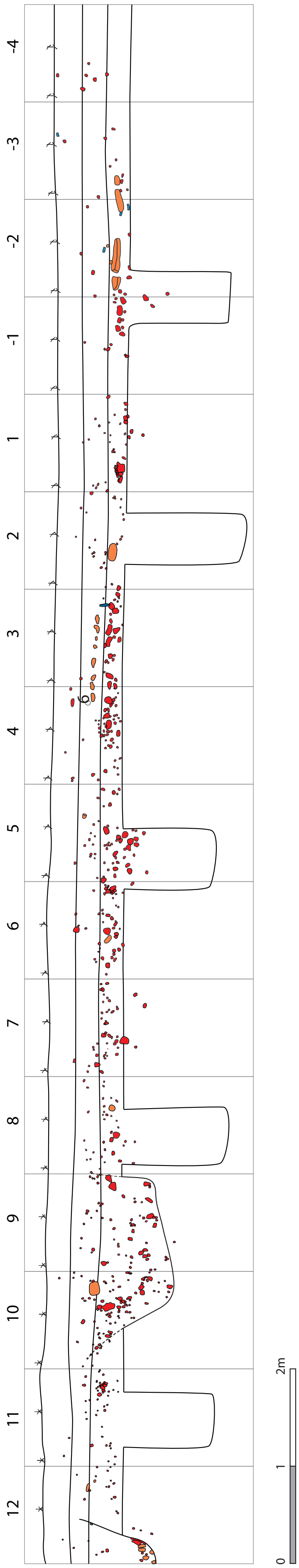


Fig. 4b Baia. Building no 3. Transversal profile through the building with the section of burnt daub layer, foundation trenches and post–Copper Age interventions. Red represents the burnt clay, light-brown the stones.

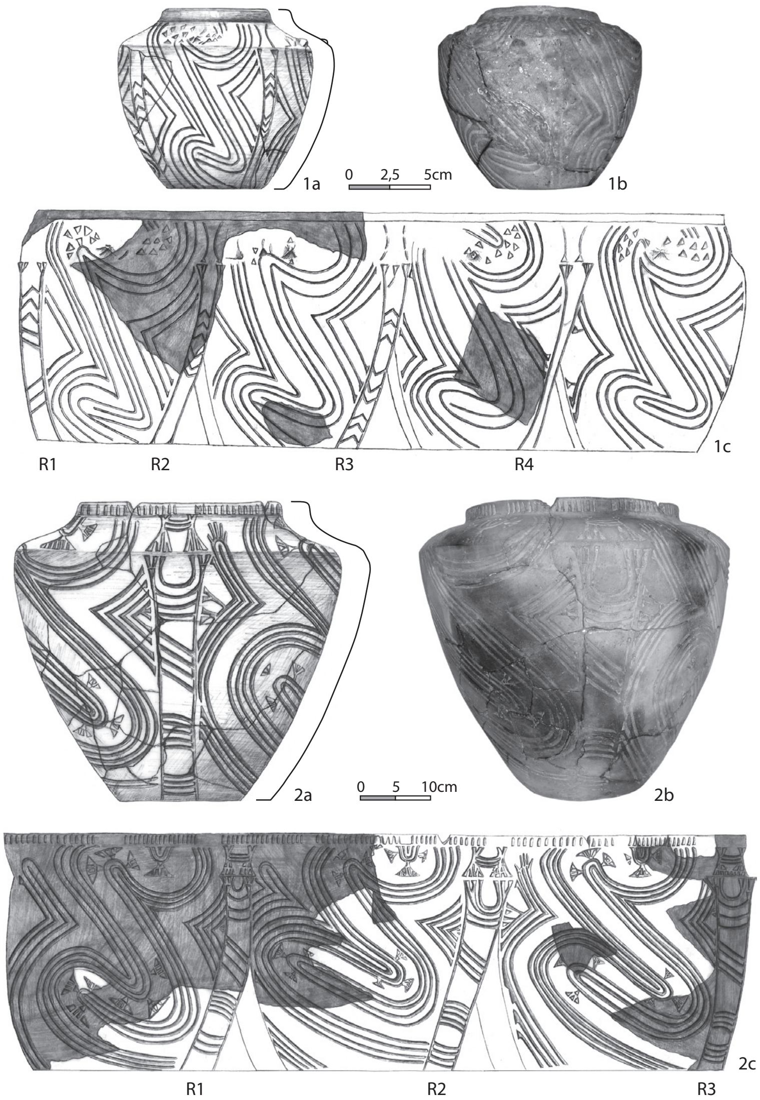


Fig. 5 Baia. Building no 3. Pottery with stylized anthropomorphic representations.

Adâncata-Dealul Lipovanului

The Copper Age site of Adâncata-*Dealul Lipovanului* is located in Suceava County near the Adâncata commune (Romania). The settlement lies on the northern headland of a plateau located circa 1 km to the north of the village on the left side of the Adâncata-Călugăreni road (Fig. 6). The rectangular promontory has a south-north orientation. From three sides, its high slopes are steep, which provided the settlement with natural protection. Thus, the only accessible side is the southern slope (Fig. 7). The Şipot River (part of Siret Basin) runs along the western side of the hill (Fig. 8).

The settlement was discovered in 1984 by an amateur and has since been successively checked by specialists from Suceava (Niculică 2001). The surface find assemblage included pottery, flints, multiple figurines, a small "altar"-table and the fragment of a copper axe of Jászladány type (Mareş 2012, 248).

Archaeological investigations, conducted by Ion Mareş from the Bucovina Museum, started in 2013 and continued in 2014 on the northern part of the site (Mareş 2013; Mareş 2015; Mareş/Aparaschivei 2014a; Mareş/Aparaschivei 2014b; Mareş/Aparaschivei 2014c). The excavations led to the partial investigation of two burnt houses, several pits, a fireplace and a small and narrow ditch, interpreted as a "foundation ditch". The ditch contained many finds, including 21 fragmented anthropomorphic figurines (regarded by the authors of

Fig. 6 Adâncata. View on the site from the north. Letters mark the three zones from the geomagnetic plot.

the excavation as a cultic assemblage), pottery, stone tools, flint arrows, a miniature chair and fragments from technical pottery of *briquetage* type. The bottom of the ditch presented traces of burning; a lid turned upside down was deposited on the bottom. Notable is also the presence of a fragment of a human femur in a pit under the fireplace. As the very location of the site suggested the presence of at least one ditch on the southern unprotected side, an archaeological trench has been opened there, but no indications for a fortification system have been encountered. The *briquetage* fragments indicate that the site was integrated into the system of salt exchange and its provision from extraction sources located in the mountains (ca. 30–40 km away) further to the east to the sites in the Botoşani region and the Prut Basin (Mareş/Aparaschivei 2014c).

The pottery from archaeological complexes allows the site to be dated to the Cucuteni A-B_1 phase (Mareş 2015, 13–14), which corresponds to the late 5^{th}/early 4^{th} millennium BC (Harper 2013; Манзура 2000, 272).

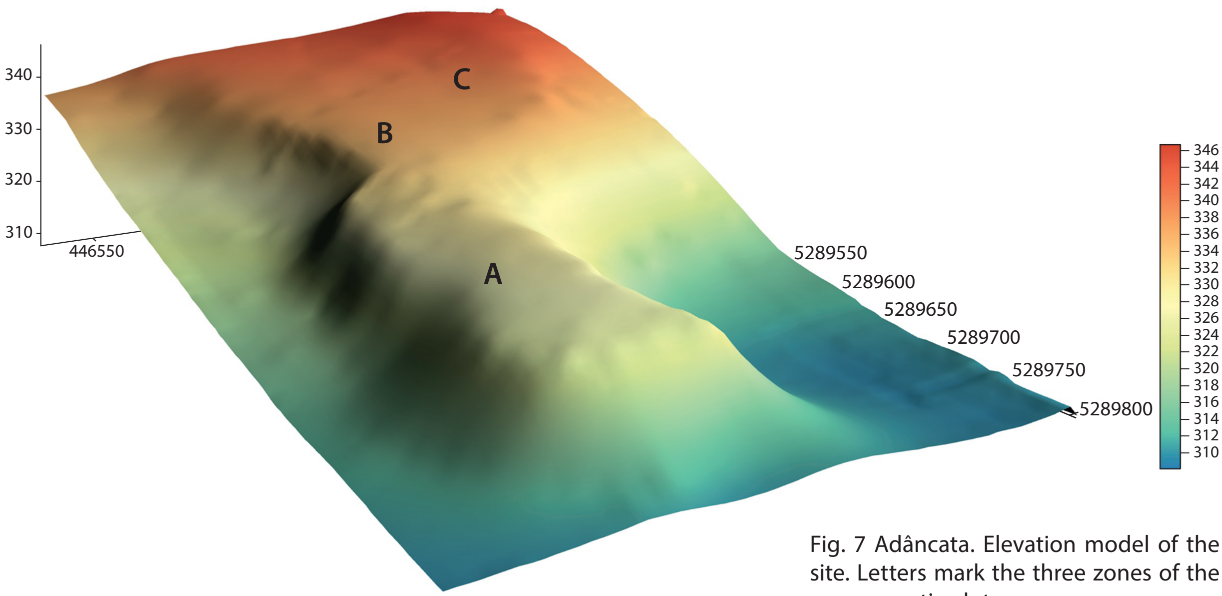


Fig. 7 Adâncata. Elevation model of the site. Letters mark the three zones of the geomagnetic plot.

Fig. 8 Adâncata. Photo of the excavation trenches 2014 (after Mareş/Aparaschivei 2014, fig. 4)

Methods

For the geomagnetic measurements, the MAGNETO® MX V3 Survey System of the company SENSYS Sensorik & Systemtechnologie GmbH Bad Saarow (Germany) was used, which can be utilised in various configurations with up to 16 channels (sensors) (Fig. 9). The instrument is the property of the Graduate School "Human Development in Landscapes" of Kiel University. During the field work in Romania, the device was installed on a wheel cart pushed by two persons (Fig. 1). At the time when the surveys were performed, only 11 sensors were available. In order to utilise the most possible width, only 8 sensors were installed with intervals of 0.5 m and a total width of 3.5 m. The geomagnetic device is coupled with a GPS-system (Leica, GNSS/GPS systems Viva GS 10), enabling continuous grid measurements (zig-zag) in a short amount of time.

Fig. 9 The geomagnetic device of the Kiel Graduate School "Human Development in Landscapes" during its use in Baia.

In the case of both surveyed locations, fix-marked measurement points are available, which were used to locate the measurements precisely within the national and world coordinate systems (Tab. 1 and 2). The measurements themselves were performed in the UTM coordinate system (zone 35N) and WGS 84 ellipsoid.

Data acquisition, primary data processing, interpolation and data export were performed using the SENSYS software package MonMX (v. 4.0), DLMGPS (v. 4.01) and MAGNETO®- ARCH (V3). During data exports from DLMGPS, the automatic track offset correction was turned

	Stereo70		UTM35		longitude/latitude (decimal)		
point name	x	y	x	y	long	lat	z
Borna10	660894.639	591779.791	440837.31	5254471.48	47.4409806	26.215325	374.6
Borna11	660953.729	591817.702	440876.667	5254529.53	47.4415056	26.2158389	374.889

Tab. 1 Baia. Coordinates of fix-marked measurement points in different coordinate systems.

	Stereo70		UTM 35		
point name	x	y	x	y	z
B1	696308.47	596521.77	446482.912	5289737.96	324.96
B2	696366.04	596519.67	446482.268	5289795.55	311.98
FIX_02			446422.773	5289681.01	327.714
FIX_03			446486.517	5289592.66	329.403

Tab. 2 Adâncata. Coordinates of fix-marked measurement points in different coordinate systems.

on. For data export from MAGNETO ARCH, we chose the format Surfer grid 7, which delivers raster maps that can be used in GIS-applications and enables us to modify thresholds and the colour scale. The standard setting was used, which interpolates the measurement results to 0.2 m x 0.2 m raster cells.

For the analysis of the geomagnetic maps, the GIS application QGIS v. 2.6.1. (Brighton) was used. We performed the interpretation of the geomagnetic maps in two different ways. On the one hand, anomalies which could be interpreted more or less undoubtedly as ditches, as (rectangular) remains of burnt houses, or as modern disturbances (e.g. from power poles) were distinguished and redrawn directly. On the other hand, in order to also interpret anomalies of less obvious character, an automatic classification of the features was performed. Therefore, vector polygons have been generated using the threshold value of 2 nT and the GRASS algorithm *r.countour level* based on the raster grid. For these vector objects, different statistical values, such as average, mean and maximum flux density, were calculated. Subsequently, it was tested to what extent correlations were present between shape and surface area of the objects.

To present the data, we chose the mean-nT-value since the same variables were used for object classifications of Tripolye CI mega-sites in the Bug-Dniepr interfluve (Ohlrau 2015). However, since a calibration of the device is usually performed for each individual site, the values from the different sites cannot be compared.

In order to prove the character of selected anomalies, in some cases drillings took place using a Pürckhauer. In 10 cm-steps, the soil substrates were classified and non-plastic admixtures described. For interpretation, the drilling profile rows have been plotted against the flux density values. Further interpretation is drawn from the results of excavations, which were performed in three campaigns between 2012 and 2014 and initiated by the Museum of Bucovina, Suceava.

In order to ensure maximal transparency and considering that somebody might be able to read more out of our measurements, the raw data of the geomagnetic surveys are available under the URL [https://www.jma.uni-kiel.de/en/research-projects/data-exchange-platform] in two different file formats (GeoTIFF and ASCII).

Results

Baia-În Muchie

Description and interpretation of the features

At the site of Baia-*În Muchie*, three areas with a total size of 5.66 ha have been geomagnetically surveyed (Fig. 10). The prospection was focused on the central area, which extends spur-like into the flood-plain southwest of the settlement. The excavations took place at the highest elevated part between 2012 and 2014. Surveys in two small-

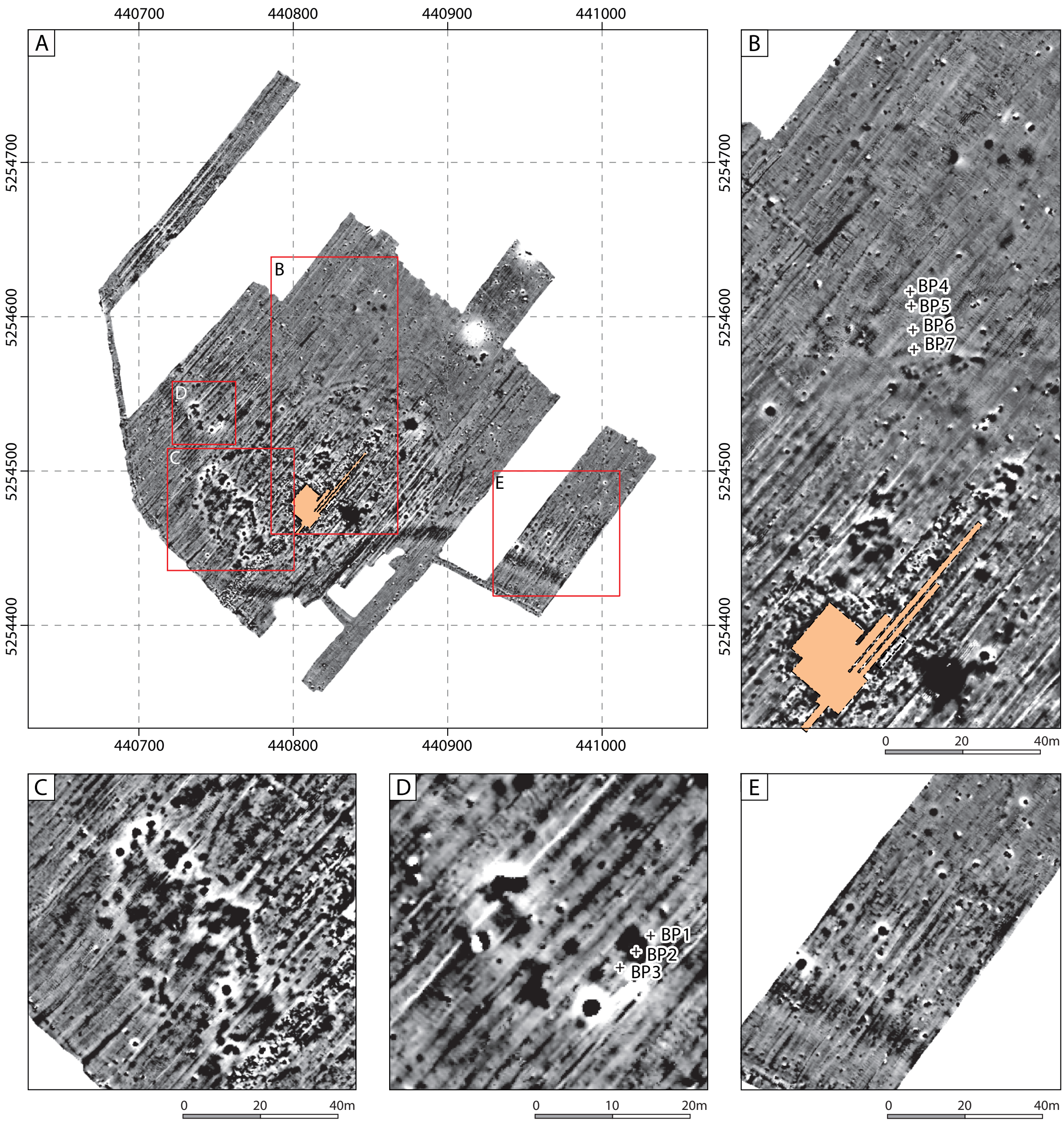


Fig. 10 Baia. Plan of the geomagnetic survey. A) Overview. B) Detail with excavation area, anomalies of burnt domestic house remnants, and position of the drilling points BP04–BP07 through the faintly visible ditch system. C) Large-scale anomaly in the south-western part of the central surveyed area, which is flanked by small strong anomalies that are interpreted as possible pottery kilns. D) Group of rectangular anomalies at the western periphery of the central surveyed area with the position of the drilling points BP01–BP03 and a further round kiln-like (?) anomaly. E) Kiln-like anomalies in the eastern surveyed area.

er areas northwest and southeast of the central part aimed at the localisation of a late antiquity settlement core. Its existence is suggested by the distribution of surface finds.

In the entire surveyed area, anomalies of different strength, size and density are visible. They are concentrated in the central part of the settlement. Relatively large areas of the site have been disturbed in modern times. On the one hand, there is a row of large anomalies

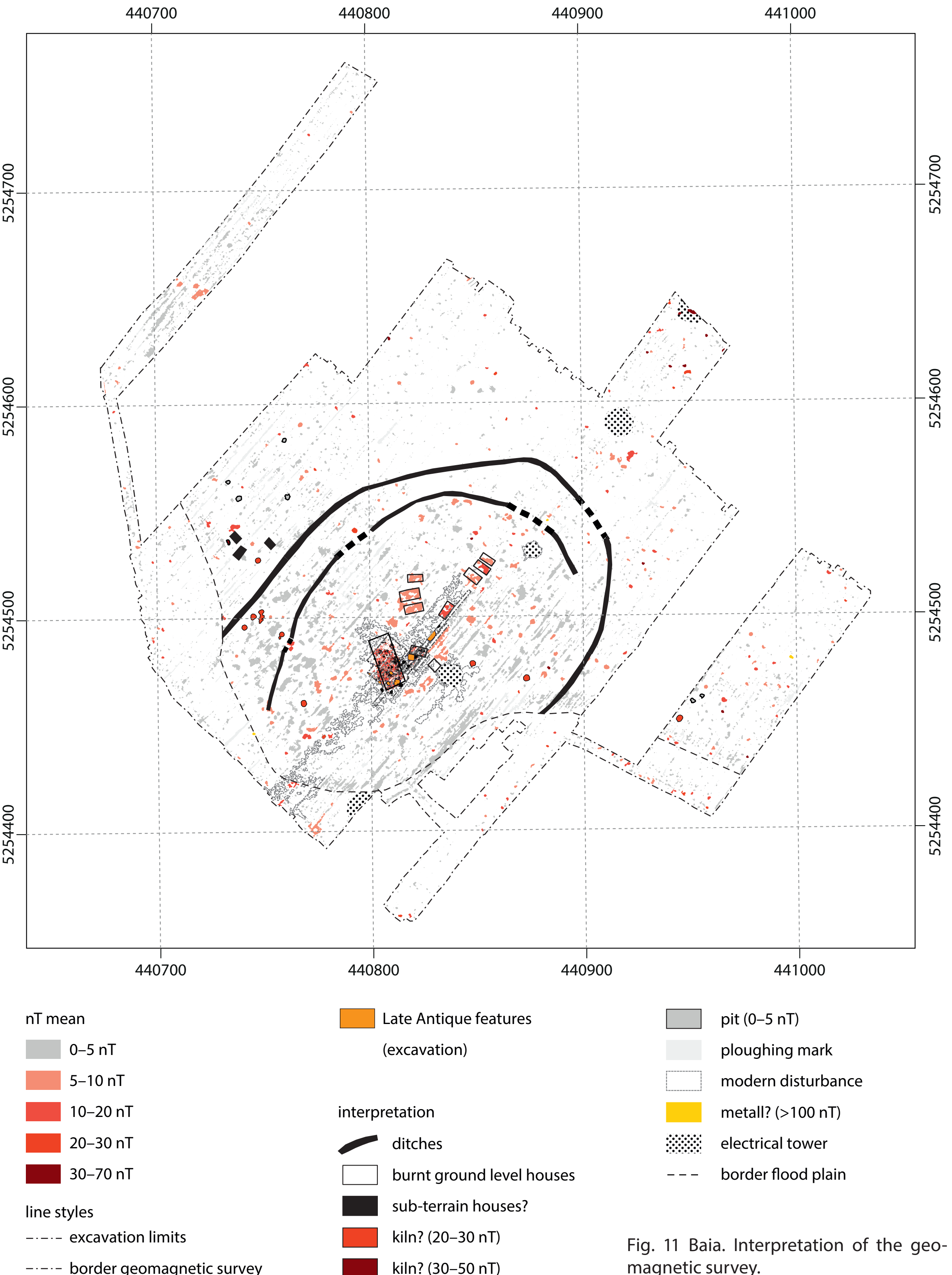


Fig. 11 Baia. Interpretation of the geomagnetic survey.

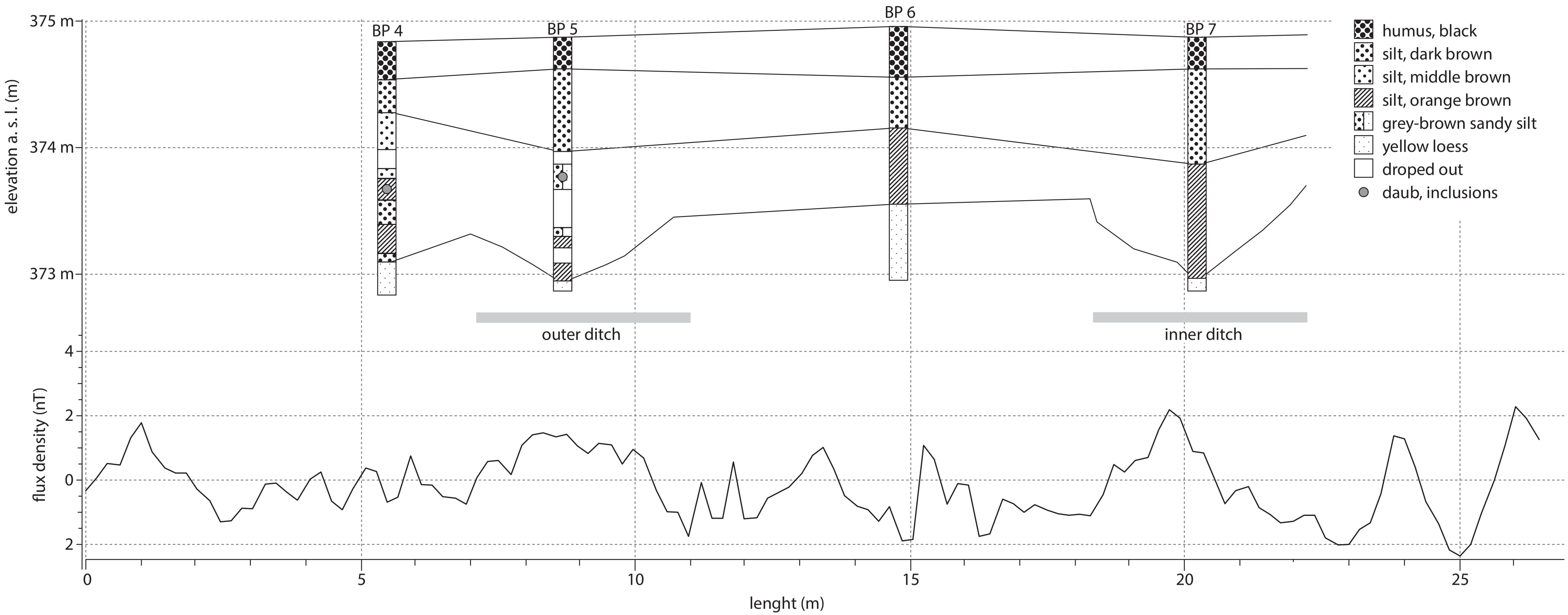


Fig. 12 Baia. Drilling profile BP04–BP07 through the ditch system combined with the geomagnetic profile line.

from electrical towers with diameters of 8–10 m, which cross the surveyed area from northeast to southwest. On the other hand, there are large areas around the excavation trenches and from there in an about 20 m wide stripe down to the flood plain, which are probably caused by dispersion of daub from the excavated areas due to ploughing.

In the central part of the surveyed area, two weak (2 nT) linear anomalies encircle an oval settlement area of 190 by 140 m or 1.95 ha running parallel to each other at a distance between 10 and 20 m (Fig. 11). Towards the flood plain side, this oval area is open. The dimensions of the smaller inner circle measure 170 by 125 m, which correlate with an area of 1.45 ha. By the drilling cores BP 04–BP 07, it could be confirmed that these linear anomalies are most likely the remains of completely backfilled shallow ditches with widths of at least 2.5 m (Fig. 12).

To the north-east of the central excavation area, there are seven more or less rectangular visible anomalies with average magnetic flux densities between 5 and 20 nT and sizes in a range between 19 and 45 m² (Tab. 3). In analogy to the results of other geomagnetic surveys and since these anomalies partly represent continuations of daub packages from the excavated area, they are interpreted as the remains of burnt houses.

Although these anomalies form short rows in two cases, there is no clearly recognisable settlement layout. However, we can see distinct differences in size between smaller houses, on the one hand, and the huge building structure that was uncovered during the excavations in the centre of the settlement on the other hand.

Clearly concentrated within the area encircled by ditches, there are several visible anomalies, which are in most cases smaller and amorphous. They show the same nT range as the features interpreted as burnt houses. These might be strongly eroded house remnants; but could, however, at least partly also represent other kinds of objects, for example, burnt stone concentrations – remains of hearths from first centuries AD since they were uncovered in big numbers during excavations (Fig. 13).

In a much lower number, relatively small anomalies also occur both inside and outside of the ditches, which show significantly higher average flux density values between 20 and 70 nT. In the southwest area of the enclosure, five such round anomalies with area sizes between 4 and 5 m² and diameters between 2 and 2.5 m are grouped around an area which is characterised by a particularly large area (>15 m²) of anomalies. However, the character of these anomalies is currently unknown (Fig. 10 C, 10 D und 11). Several other anomalies with very high flux density values are distributed in the eastern part of the enclosure (2), east of the enclosure (1) and west of the enclosure (1). Shape, flux density and size of these anomalies correspond to similar objects in Tripolye mega-sites of the Bug-Dnieper interfluve, which are interpreted there as remnants of pottery kilns (Rassmann et al. 2014; Kruts et al. 2014; Korvin-Piotrovskiy et al. 2016).

Immediately west of the fortified settlement about 20 m above the floodplain border, a group of three rectangular anomalies is slightly visible. They each have lengths between 5 and 6.5 m, an almost identical width of 4 m and surface areas between 18 to 25 m² (Fig. 10 D). The magnetic flux density of these structures amounts up to 10 nT. By means of the core drillings BP 01–BP 03, we could clari-

floor space m²
19.19
20.97
24.25
26.57
30.59
30.67
32.88
35.60
45.74
238.97

Tab. 3 Baia. List of house sizes.

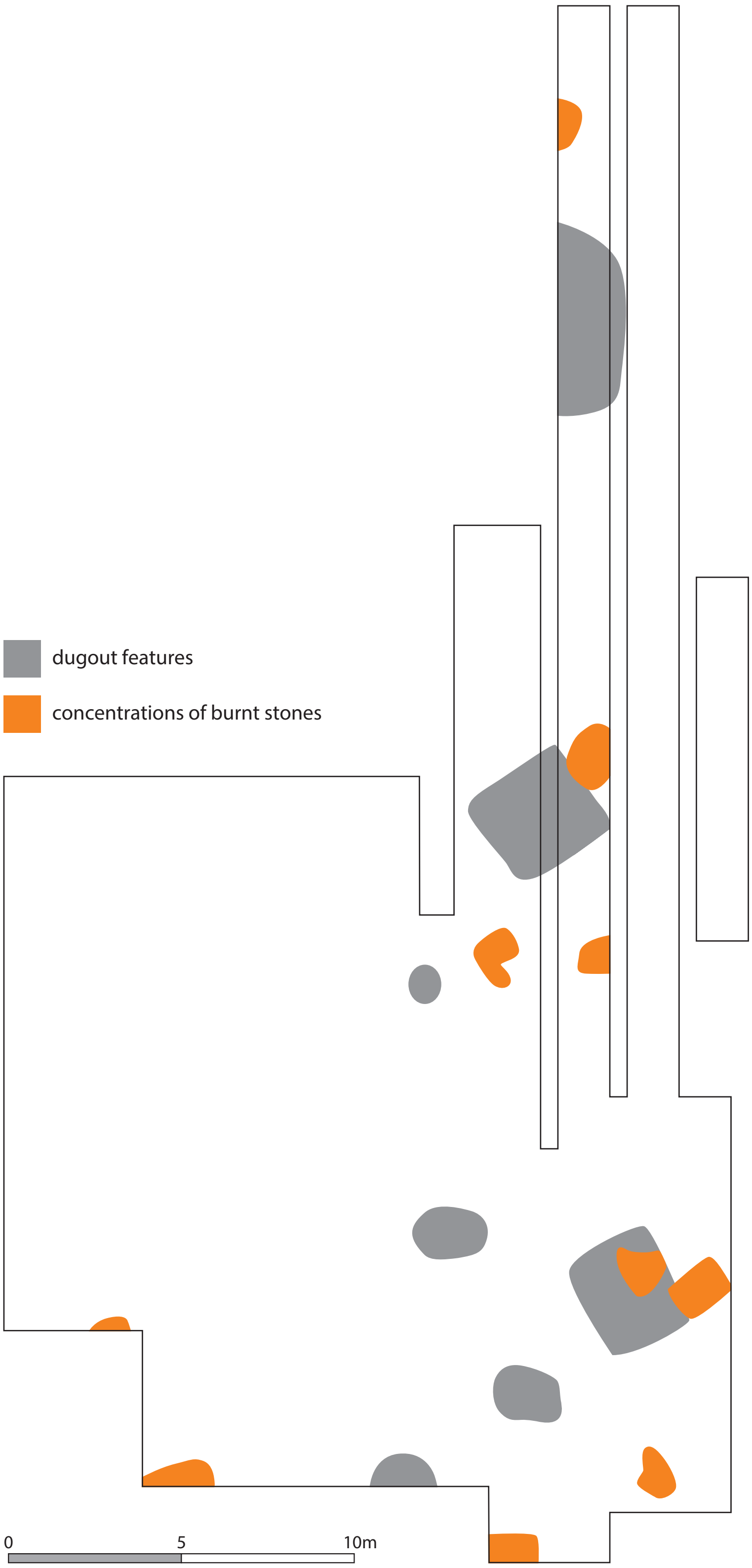


Fig. 13 Baia. Post–Copper Age complexes (Roman and Early Medieval times) in the excavated part of the site.

fy in the case of one such object that is was a structure dug into the ground at about 0.8 m depth (Fig. 14). Taking the rectangular shape and the size of the objects into consideration, they can be preliminarily interpreted as some sort of semi-subterranean building structures. However, their location outside of the enclosure system as well as the high content of dark soil might be an indicator for their post-Neolithic age.

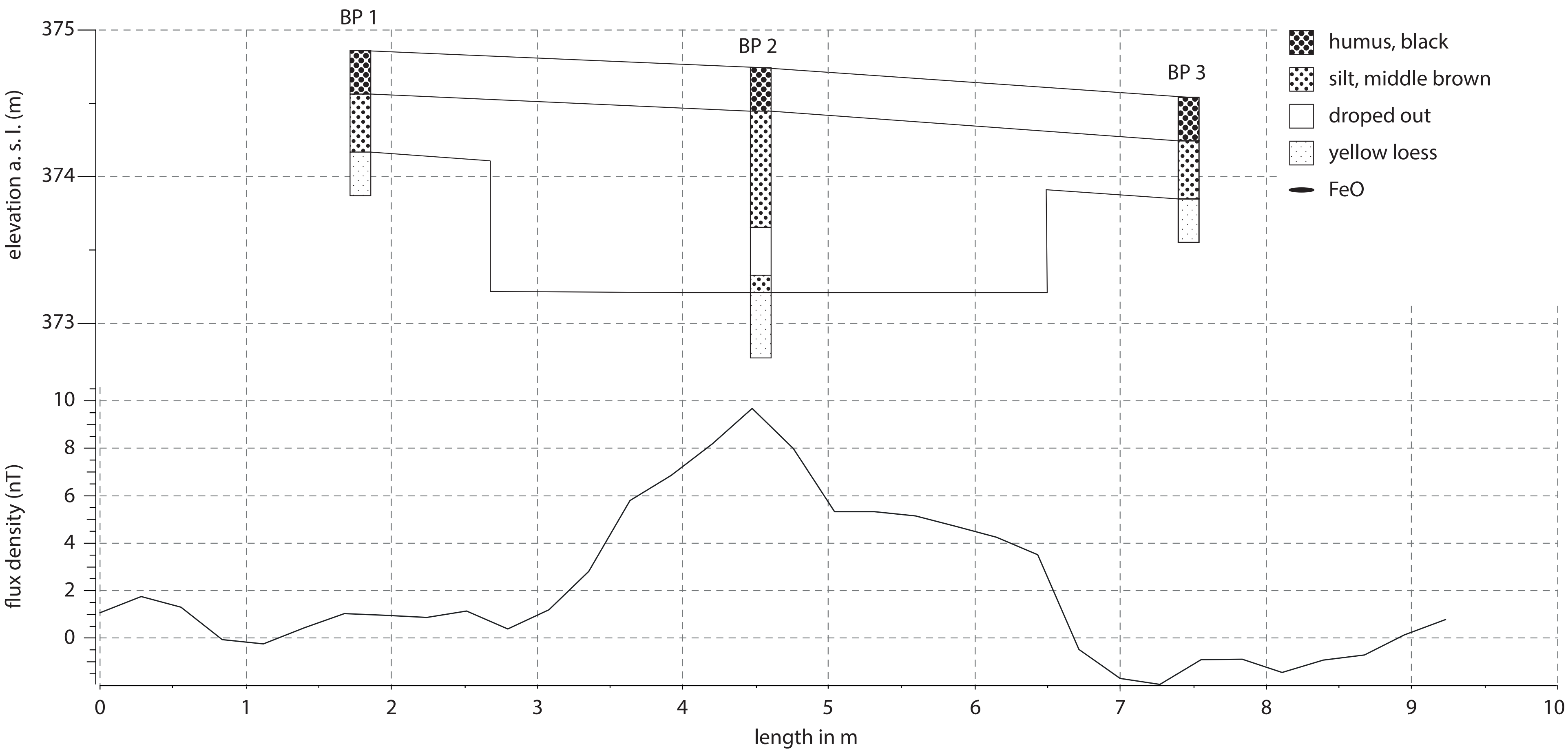


Fig. 14 Baia. Drilling profile BP01–BP03 through one of the rectangular structures in the west of the central surveyed area combined with the geomagnetic profile line.

Discussion

Based on the recent geomagnetic survey, the shape, size and partly also the spatial layout, the Pre-Cucuteni settlement of Baia can be reconstructed, although a considerable part of the site is not accessible by geomagnetic measurements due to modern disturbances and pollution by daub originating from recent excavations. Two parallel ditches possibly demarked two settlements, which had oval shapes and sizes of 1.5 and 2 ha. Since the site was occupied during the Late Copper Age and Roman times as well, it seems at least questionable if the anomalies outside of these ditches represent remains of Pre-Cucuteni settlement activities.

It is hard to evaluate why the ditches are interrupted at the edge of the flood plain. Since the destructive potential and dynamics of river systems tend to be underestimated, it seems most plausible that the settlement area was reduced in size due to lateral erosion of the adjacent river in post-Neolithic times[1]. It seems rather unlikely that an ancient river bank situation was present in Baia.

In Baia, the visibility of features in the image of the geomagnetic survey is clearly not as good as, for example, those of the B2 and C1 settlements from Ukraine and Moldova, although the thickness of the cultural layer and the character of the features seems quite comparable, even if we take into account the lack of two-storey houses represented by massive piles of daub at Baia. Most likely, the scope for interpretation is limited due to the use of the place in several Chalcolithic and other periods, the resulting overlaps of features, and relief-related slope erosion.

The features in the northern part of the settlement area are not as strongly affected by erosion as those which are situated on the slope facing the floodplain (Fig. 15). This is probably the reason why several rectangular anomalies are preserved here. These are interpreted as the remains of burnt houses of the Pre-Cucuteni period. The size of these buildings, ranging between 20 and 45 m^2, contrasts significantly with the size of the central building of about 220–230 m^2, which was uncovered by excavations. The dimensions of the smaller dwellings correspond to the size of other known Pre-Cucuteni constructions (Burdo et. al. 2013, fig. 5.3 a) and to the "regular" dwellings of this time from South-Eeastern Europe (Lichter 1993, Tab. 1).

By proving the enormous differences in the size of buildings in Baia, our geomagnetic investigations confirm the special character of the central building, which is also suggested by the extraordinary find assemblage (see above). Similar large-scale building structures, for which special functions seem obvious, have also been recently verified in other Cucuteni-Tripolye settlements by high-resolution geomagnetic surveys and partly by excavations. Notable are, for example, the building in the centre of Petreni (Rassmann et al. 2014; Rassmann et al. 2016b), larger buildings in the central part of the investigated area at Stolniceni I (Ţerna et al. 2016a), the so-called mega-structures at Tripolye mega-sites of the Bug-Dnieper interfluve (Chapman et al. 2014a, Rassmann et al. 2014; Ohlrau 2015; Chapman et al. 2016) and also the two central buildings of the radially-structured Cucuteni A-B Corlăteni settlement, each of them much larger than the other dwellings on the site (Nestor et al. 1951). Recently, oversized buildings have been encountered geomagnetically on the Cucuteni A-B settlement of Ripiceni-*Holm* (Botoșani County, Romania)[2].

[1] High post-Neolithic dynamics of rivers have been observed, for example, in microregional case studies in Central Bosnia and the Serbian Vojvodina (cf. Dreibrodt et al. 2013; Medović et al. 2014).
[2] Prospections of Andrei Asăndulesei (Arheoinvest Iași).

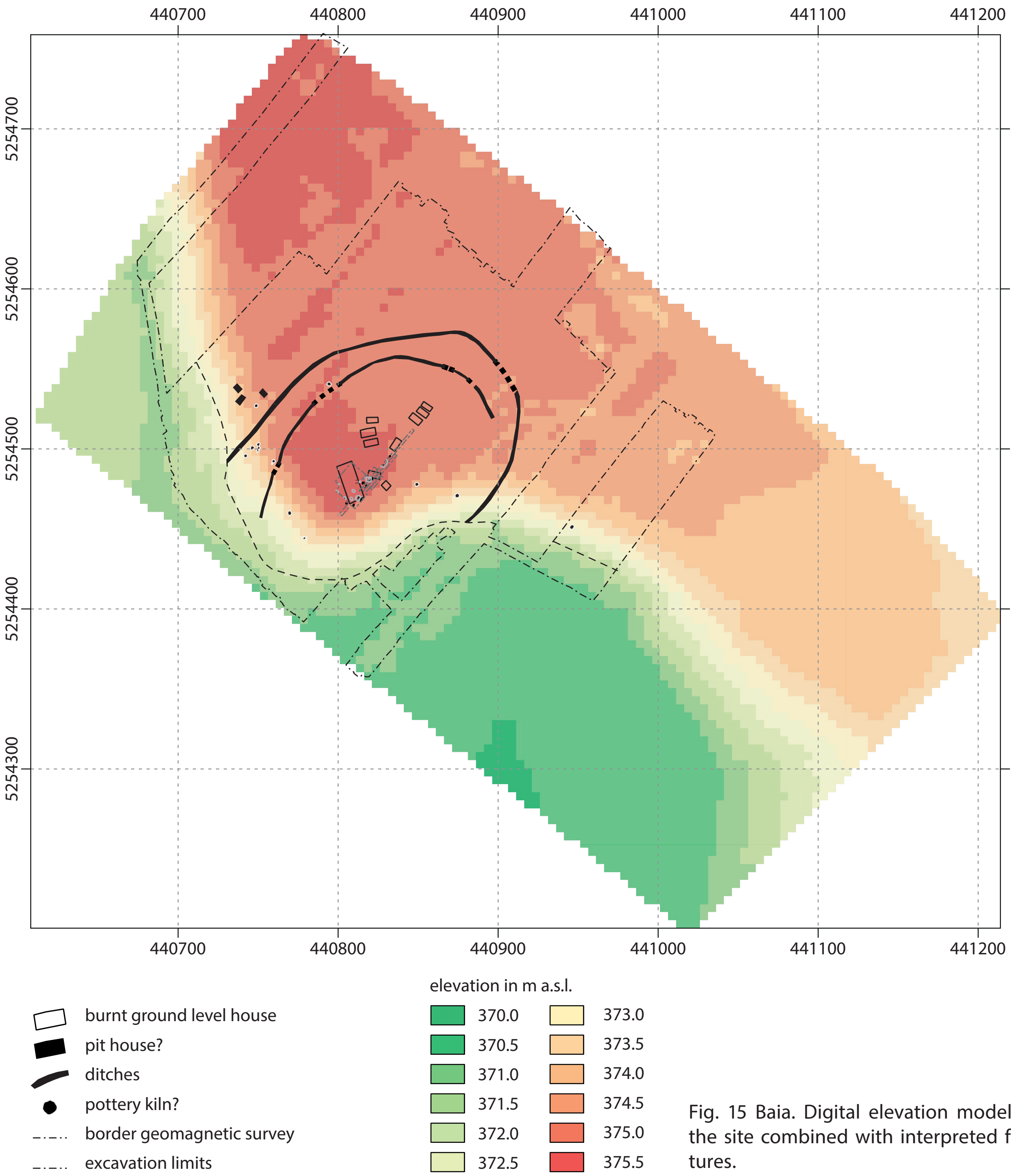


Fig. 15 Baia. Digital elevation model of the site combined with interpreted features.

In addition to Baia, the case of Alexandrovka in Ukraine (Відейко 2004, 324) also shows that corresponding dwellings of unusual large size already occurred in the Pre-Cucuteni/Tripolye A horizon. Currently, the question on how to identify, delimit, and interpret such oversized buildings is under intensive discussion. Considering the rarity of other indications for distinct hierarchies, most authors tentatively agree not to suspect elite residences in such structures, but communal buildings with special functions such as decision-making and collective religious and ritual practices (Chapman et al. 2014a; Burdo/Videiko 2016; Müller et al. 2016). This is supported, among other things, by cross-cultural research, which indicates that the majority of non-stratified tribal societies have used integrative facilities in the form of special multifunctional buildings or other communal institutions (Adler/Wilshusen 1990). However, Clemens Lichter's (2014) statement should be affirmed that functional interpretations should not only refer to size but also consider additional explanatory criteria such as the spatial integration of the buildings in the settlements and find inventories.

In the case of Baia, the central position of the oversized building within the settlement is certainly an additional argument for its special importance. Furthermore, the remarkably large number of vessels with specific pillar-like anthropomorphic representations, which were discovered during the excavations, should be emphasized. Ultimately, the interpretation of this building will also only be possible after finishing field investigations and the assessment of all its finds.

The much smaller buildings from Baia most likely represent normal dwellings. If we assume a permanent and sedentary occupation of the site and if we accept the empirically documented relationship between the size of houses, on the one hand, and the number of inhabitants, on the other hand, we have to expect 3–7 persons per house considering floor spaces between 20 and 45 m^2 (e.g. Naroll 1962; Brown 1987; Porčić 2010).

The layout of the settlement of Baia cannot be reconstructed due to the limited number of houses which are visible in the plan of the geomagnetic prospection. The few houses are arranged in short lines. Since numerous geomagnetic surveys in Moldavia and Ukraine show that linear arrangements can be combined with circular layouts (e.g. Sorochin 1993; Кошелев 2004; Ţerna et al. 2016a), based on the plan of the geomagnetic survey it cannot be currently decided whether the houses were generally arranged in straight lines or that parts of the settlement had a circular layout, as is widely common in later Cucuteni-Tripolye settlements and as also seems plausible for Baia due to the oval shape of the settlement plan.

In view of the incomplete picture of the settlement layout, considerations regarding the population size of the Pre-Cucuteni settlements from Baia are highly speculative. Nevertheless, we can explore at least the possible range based on contemporaneous analogies. In doing so, it is assumed that the Chalcolithic settlement activities have been limited to the enclosed area. Since no indications of tell accumulation are observed in the stratigraphy of the site, we do not expect such a high overall building density in the small areas where houses are visible.

Geomagnetic research provides data concerning population estimations for Cucuteni-Tripolye sites in the form of density of habitation coefficients: Several cases which, however, date to the 4th millennium BCE and concern much bigger sites with different spatial layouts resulted in population estimates of about 80–100 persons/ha (e.g. Rassmann et al. 2016b; Ohlrau 2015, 87 f.). Accordingly, for the two Copper Age settlements from Baia we would have to expect populations in dimensions of 120–150 for the smaller and 160–200 inhabitants for the larger settlement enclosed by the outer ditch.

A lower number of inhabitants is obtained if we use the estimations of A. Diachenko (2012, 121; 2016, 188 f. Tab. 6) concerning the number of houses per hectare settlement area. Accordingly, in small settlements building densities have been determined between 7 and 13 houses per hectare. The application of these data to the case of Baia result in 31–136 individuals for the small settlement and 42–182 persons for the large settlement if we assume a range of 3–7 individuals per house.

Adâncata – Dealul Lipovanului

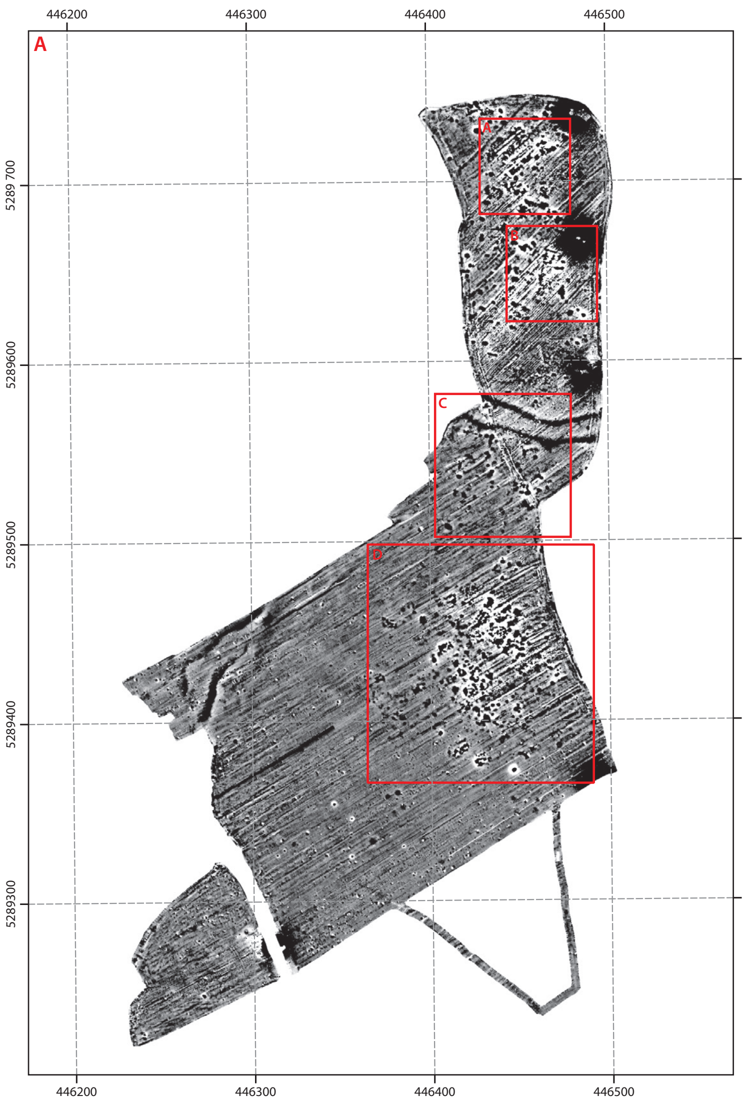
Description and interpretation of the features

At the site *Adâncata – Dealul Lipovanului*, an area with a total size of 6.43 ha has been surveyed (Fig. 16–18). Our prospection included both the spur naturally protected from three sides (1.5 ha) and a large piece of the plateau, which is located behind it (4.93 ha). Features are concentrated in two areas of the surveyed area: Area A on the elongated spur itself and area B on the eastern part of the plateau in front of the edge to a small river valley. In contrast, in the western and southern parts of the plateau features are almost absent.

Zone A

A large part of the spur is separated from the hinterland by two linear anomalies, which run parallel to each other at a distance of 8–10 m. Their width measures on average three meters; they only occasionally show higher flux densities than 10 nT. The bottom of these anomalies has not been reached in drilling profiles. Nevertheless, it is most likely that these anomalies result from backfilled deep fortification trenches. The inner ditch encloses an area of 1.425 ha; the outer ditch 1.5 ha.

In zone A, apart from the ditches, only a limited number of features can be clearly addressed: In two or four cases, such anomalies



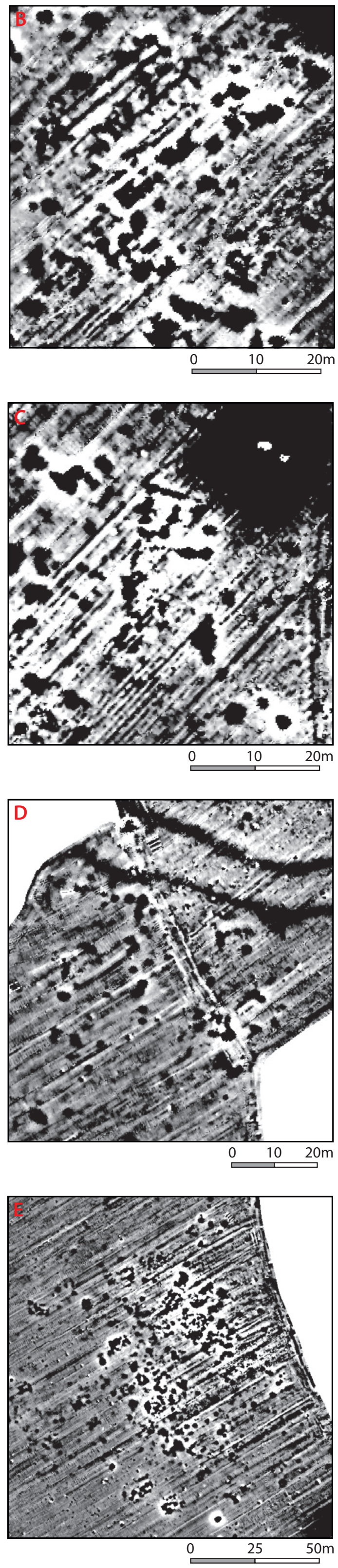


Fig. 16 Adâncata. Plan of the geomagnetic survey with the position of the drilling points BP1–BP9 and excavation areas. A) Overview. B) Burnt domestic structures in the northern part of zone A. C) Large building structure in the centre of zone A. D) Geomagnetic anomalies outside of the fortification ditches in zone A. E) Detailed map of zone B.

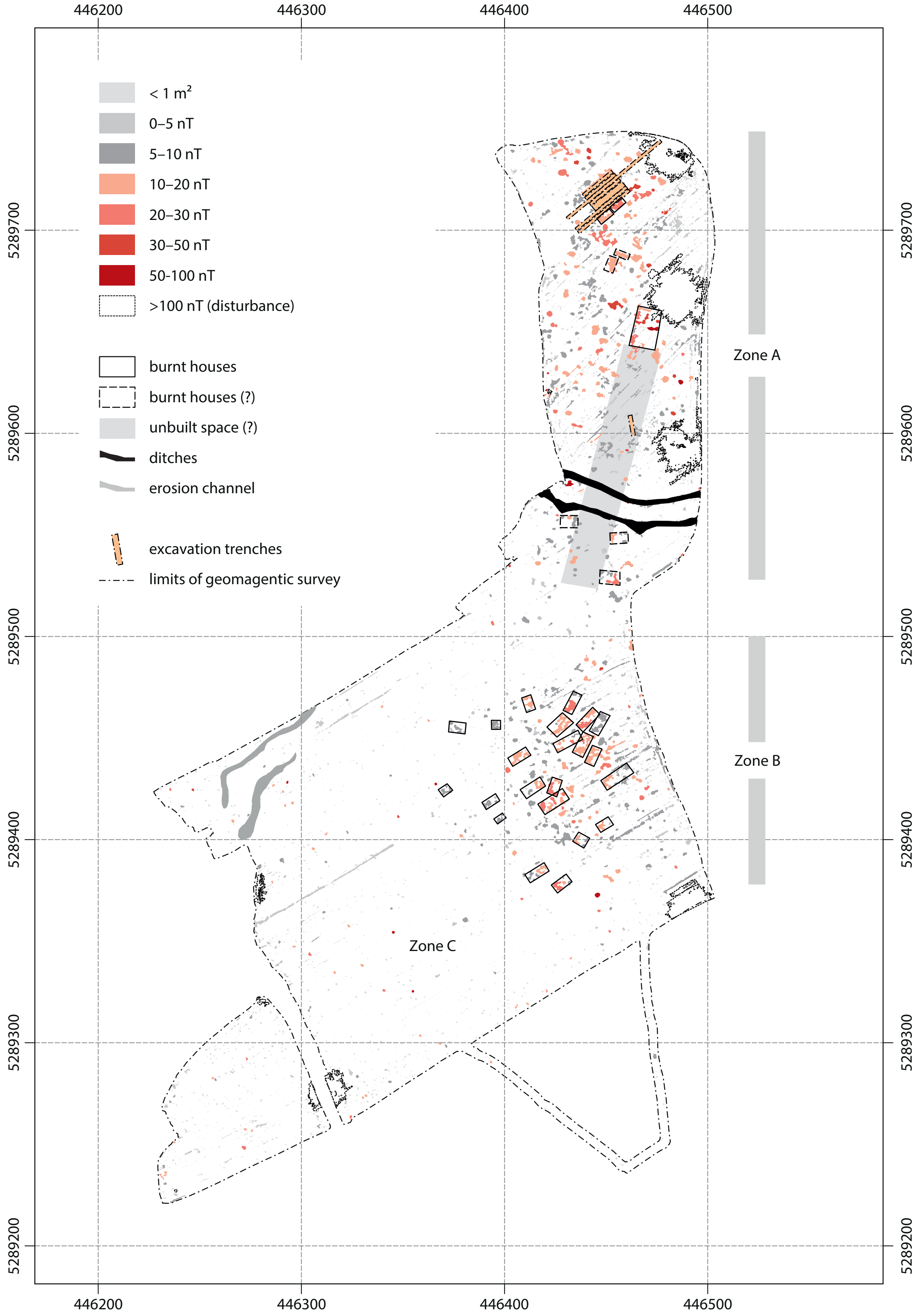


Fig. 17 Adâncata. Interpretation of the geomagnetic survey.

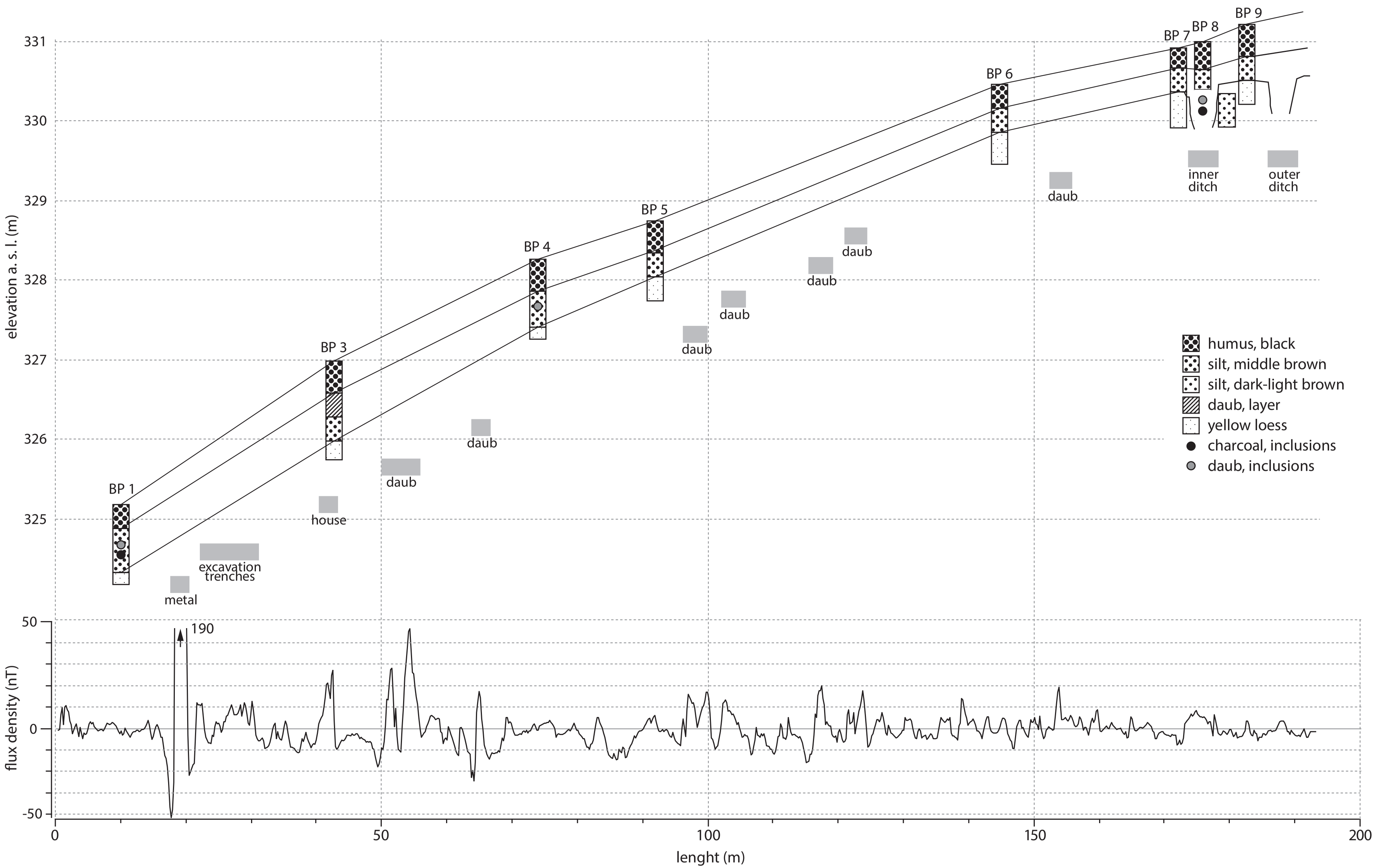


Fig. 18 Adâncata. Drilling profile BP1–BP9 through zone A of the site with the geomagnetic profile line.

with average flux densities between 10 and 30 nT show almost rectangular shapes and can, thus, be identified with high probability as the remains of burnt houses (Tab. 4). Numerous smaller, amorphous features show similar or lower flux densities. At least in part, these anomalies might represent stronger eroded remains of houses. However, the spatial layout and the building of the settlement cannot be estimated from the plan.

Directly to the southeast of trench 4 (from campaign 2013), two 7.5 m long and about 3 m wide rectangular house anomalies are situated. If we add 1 m to the stripe, which was uncovered in the 2013 excavation and subsequently destroyed, we can reconstruct two houses with a size of about 30 m² (cf. Mareș 2013, fig. 6). A similar range between 25 and 35 m² is also shown by two other anomalies, which are situated 20 m further south.

Almost in the centre of the enclosed area, the remains of a built structure with completely different character and size are visible (Fig. 16C). This NNE–SSW directed structure seems to have an overall size of about 20 x 12 m. The 10 m wide northern part is divided from the open southern part by an internal wall and contains a further internal division.

Important is the fact that the built space also includes the area beyond (outside of) the ditches. Without further investigations, it is difficult to evaluate if this indicates a kind of "suburb" or if it is the result of an occupation phase without additional fortification (Fig. 16D). It may be argued for the latter scenario that stronger anomalies are concentrated on both sides of a 12–15 m wide more or less feature-free zone, which also seems to continue on the other side of the ditches within the enclosed area. There, this zone continues until the large building structure, which is described above.

Zone B

In general, the features in zone B are better preserved. Here, anomalies of different sizes, shapes and magnitudes are distributed on an almost round area of 110 x 90 m (Fig. 16E and 17). Towards the centre of the zone, the magnitude and density of features increase. In the central part of zone B, 9–12 more or less rectangular features with mean magnetic flux densities between 10–30 nT are arranged around a long oval empty space measuring 20 x 60 m. Most likely, the mentioned geomagnetic features belonged to two short parallel lines of houses that were destroyed in a settlement fire.

Since house features show different alignments in several cases even though they are situated immediately adjacent to each other, there is a certain probability that the house remains represent more than only one phase. This is also indicated by the character of several other house features, which are located at the northern and western periphery of zone B. Here, several radially arranged anomalies form an outer ring of the settlement. With mean flux densities between 5–20 nT, they are clearly weaker than those in the centre of the settlement. The assumed asynchronicity of the houses in the centre, on the one hand, and the periphery of the settlement, on the other hand, could also be manifested in differences in sizes between 15 and 90 m² floor space (see below). The house remnants of the outer ring are on average clearly smaller than those at the centre of the site.

Our preliminary interpretation of the described situation is that the outer (weaker) ring of the settlement could represent a first phase and the two rows of houses a second phase of this settlement. However, this scenario urgently requires further verification.

Geomagnetic anomalies are also sporadically found outside of the zones A and B. Several weak anomalies are visible in Zone C, 40 m

zone	floor space m²
A	28.57
A	26.01
A	21.87
A	47.92
A	64.99
A	23.48
A	35.68
A	240.00
B	44.08
B	49.76
B	35.07
B	75.67
B	43.59
B	61.14
B	88.94
B	34.20
B	44.02
B	53.45
B	36.06
B	32.64
B	59.13
B	50.67
B	90.74
B	23.31
B	15.64
B	20.45
B	57.64
B	46.95
B	65.19
B	70.61

Tab. 4 Adâncata. List of house sizes.

southwest of Zone B. These round anomalies have diameters between 2 and 4 m and maximum flux densities ranging from 2–7 nT. Most likely, these are remains of pits, which might have been used for activities outside of the two settlements.

Discussion

The spatial distribution of features indicates that the geomagnetic survey at the site of *Adâncata-Dealul Lipovanului* in fact encompasses the remains of at least two settlements: A) A settlement with a size of 1.85 ha is situated on a naturally protected and additionally fortified spur, and B) an unfortified flat settlement of about 1 ha size is located on the edge of the plateau above a small tributary of the Șipot River. In the latter case, probably the remains of two phases can be distinguished.

By typo-chronology, the pottery of settlement A has been classified stylistically as Cucuteni A–B_1, which dates absolute chronological in the period around 4000 BCE (cf. Harper 2013; Манзура 2000, 272). The dating of the second settlement B is still an open question. However, surface finds and the “radial” layout indicate Chalcolithic Cucuteni-Tripolye affiliation as well (see the concluding remarks below).

Although the Chalcolithic remains in area A seem to be already badly eroded, our survey provided important knowledge regarding the settlement layout. There is, on the one hand, the finding of a fortification composed of two parallel ditches. However, since geomagnetic anomalies occur on both sides of the ditches, it is unclear to which extent they are connected to the Cucuteni-Tripolye settlement – either they were backfilled when the settlement was growing in size or they belong to another occupation phase of the spur. On the other hand, there is a certain probability that an unbuilt area (square) could have existed close to the entrance side of the settlement. Similar open space or squares are also verified in other settlements of the same type (see, for example, the classic example from Trușești, Cucuteni A, Romania – Petrescu-Dîmbovița et al. 1999).

On the analytical level of architecture, there is a clear dichotomy between smaller buildings, which in no case exceed the size of 50 m², and the remains of a much larger built structure of 240 m² size (Tab. 4). The latter might have been situated at a prominent place close to the mentioned open space or access axis.

The spatial layout is more highly visible in zone B, where houses are radially arranged around a small open square. The specific arrangement of the house remnants and the variability in house size could indicate that possibly two phases are represented in the settlement plan.

In the case of the spur settlement (zone A), due to hard erosion, reconstructions of the population size, again, are only possible based on analogies, for example, to Ukrainian Cucuteni-Tripolye settlements. Assuming between 80–100 persons per hectare as an estimate, which was determined by K. Rassmann and R. Ohlrau for mega-sites of Northern Moldova and the Bug-Dniester interfluve, a population of 150–185 persons is determined for zone A. For settlement B, a population of 80–100 persons is estimated. Using 7–13 houses per hectare, which was determined by A. Diachenko, and 3–7 persons per house, the reconstruction ends up with only half of the population in the case of zone A: Eighteen houses with an average size of 27 m² could have been used by a population of about 39–168 persons. In the case of the settlement in zone B, we would expect ten houses with an average size (median) of 50 m², three to seven

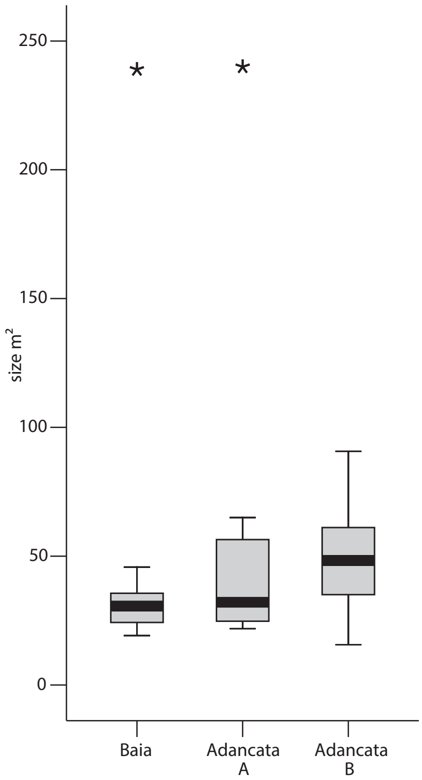


Fig. 19 Boxplot diagram which shows the floor area of houses in Baia and Adâncata.

inhabitants and a population of 21–90 individuals. Actually, at least 25 houses can be identified in the plan of the geomagnetic survey, which, however, do not need to have existed at the same time. If this would have been the case, we would have to expect a population on a scale between 75 and 175 inhabitants (25*7). If the house remnants belong to two successive phases, the population could be halved (12*3–7 = 36–84).

Concluding remarks on the spatial organisation and population structure

Our prospections provided two new settlement plans for Pre-Cucuteni and Cucuteni A-B stages. Despite the erosion of dwellings and certain uncertainties in defining the exact outlines of some of them, this result is very significant since there have not been many previous insights into the structure of sites from these two particular chronological horizons, neither from excavations nor from geomagnetic plots.

For Pre-Cucuteni/Tripolye A, the available settlement plans display both circular and linear internal organisation. The former is encountered on such settlements as Bernashevka (Збенович 1980, рис. 3), Mohilna III (Дудкін/Відейко 2004, 306), Slobodka-Zapadnaia (Патокова et al. 1989, рис.1/2) and Nicolaevca V (Saile et al. 2016; Ţerna et al. 2016b). The latter is known from Luka-Vrublevetskaia, Bernovo-Luka, and Alexandrovka (Sorochin 1993, 75) and from sites located in Romania – Târgu Frumos and Isaiia (Ursulescu 2008). For several settlements, a dispersed or group-like pattern is known: Lenkovcy, Traian – Dealul Viei, Floreşti I, and Târpeşti (Sorochin 1993, 75). It appears that from the very beginning of the Cucuteni-Tripolye cultural development, namely from Pre-Cucuteni I and II stages, there has been a certain variety in the internal organisation of settlements, when several distinctive patterns coexisted. These patterns evolve further into the middle and late Cucuteni-Tripolye stages; in particular, the radial organisation of settlements will find its maximal expression in the famous mega-sites of the Tripolye CI stage. In order to understand the reasons behind such diversity in the organisation of settlements, one should take into account, both the information from Late Neolithic cultures across the Balkans and the Carpathian Basin as well as perform further geomagnetic prospections on Pre-Cucuteni settlements from different areas.

Pre-Cucuteni ditches have also been identified on several sites – all from the territory of Romania: Târpeşti, Târgu Frumos and Traian – Dealul Viei (Lazarovici/Lazarovici 2006, 566–567). They could have had both a delimitation function and a defensive one, although the first variant seems more plausible (Bem 2001). It is very possible that the number of Pre-Cucuteni ditches is actually much higher – the problem is that they can very seldom be observed on the surface and are exclusively traceable from excavations and geomagnetic investigations. The continuation of geomagnetic prospections on Pre-Cucuteni sites will surely shed more light on the problem of Pre-Cucuteni ditches, including their numbers, dimensions and configurations.

For the Cucuteni A-B/Tripolye BI–BII chronological stage, the available data on settlement organisation reflects the persistence of the same variety in the patterns of arrangement of houses (Bem 2007; Chitic 2008; Melniciuc 2011; Sorochin 1993). The sites of the Ariuşd group from Transylvania, partially contemporaneous to the Cucuteni A-B stage, display an internal structure consisting primarily of rows and groups of houses. Several ditches have been also investigated (Sztáncsuj 2015, 134–135).

There is a certain difference concerning the location of settlements in comparison with the preceding Cucuteni A stage – most of the Cucuteni A–B settlements are no longer located on hardly-accessible and naturally protected promontories, rather they are shifted down to valleys or are located on open spaces, where the principles of internal organisation were no longer constrained by the natural limits of forelands. The location of Cucuteni A sites on high narrow protected promontories, additionally enforced by massive ditches, is related to a certain stress situation within the Cucuteni A stage, already pointed out by several researchers (Manzura 2005; Дергачев 2000; Манзура 2000). Here, we will not go into too much detail on the cause of this stress situation – it is usually linked with the invasion of horse-riders from the steppe or with internal conflicts caused by climatic changes as well as social and demographic tensions (see the articles cited above with further literature). By the end of the Cucuteni A-B period, large concentric sites start to develop, marking the beginning of the mega-site formation process (Sorochin 1993).

Going back to Adâncata, the presence of two different patterns of site organisation is notable – the northern part of the site lies on the naturally protected promontory and access is possibly restrained by two massive ditches, whereas the southern part is on an open flat field without any natural or artificial spatial constraints. The northern part displays a probable row-like structure and the southern part a circular structure. The drillings show the presence of a cultural layer above the fill of the inner ditch (BP 8); the thickness of this layer is similar to the one from the space near the ditch and between the two ditches (BP 7 and BP 9). Thus, at least the inner ditch could have been backfilled during the life of the settlement. If we presume that the site extended from north to south, this could reflect the changing organisation of settlements during the transition from Cucuteni A to Cucuteni A-B stages, as described above. The excavations on the northern part of the settlement produced Cucuteni A-B_1 material, attributed by the author of investigations to the Drăguşeni-Jura local variant (Mareş 2015). This local variant, as defined by V. Sorochin (2002), is considered to be the one behind the formation of the Cucuteni A-B stage in the Prut and Nistru Basins and would belong to the late Cucuteni A phases (A_3 and A_4), for which the location of sites on naturally protected promontories remains characteristic. Therefore, the situation from Adâncata reflects both traditions – a naturally and artificially protected site with a row-like structure and an open site with a circular structure. Most probably, this is a unique case, where the shift between these two traditions is to be recorded at a single settlement. Future excavations in the southern part of the site and the comparison of the inventory with the material obtained from its northern part should show whether our hypothesis is correct; at this moment, it seems to be the most plausible interpretation. At a general level, further geomagnetic prospection of Cucuteni A-B settlements shall provide extremely valuable data to understand the formation of both large and huge sites of later periods.

Despite major uncertainties, which result primarily from the incomplete visibility of houses, it is possible to evaluate the scale of population sizes in the examined settlements. This is insofar of great importance as the determination of the group size potentially allows an estimate of the degree of socio-political integration within a community from a sociological perspective and with regard to decision making processes (Johnson 1982). While according to Hassan (1981, 51 ff.) groups of 20–30 people represent an optimum in forager societies with regard to internal decision-making processes, group sizes in agrarian societies are often significantly larger and more variable. Conversely, there is a cognitive limit to the number of people with whom one can maintain stable social relationships, which is quantified between 150 and maximally 250 persons (Dunbar 1992). Beyond this, additional political institutions are necessary to tackle social complexity.

With regard to settlement and population sizes, Cucuteni-Tripolye mega-sites of the first half of the 4th millennium with up to 15.000 inhabitants represent an extreme case, whose genesis and functionality has not been sufficiently understood so far. Recent studies assume that these large settlements were organised in decentralised patterns with house groups and neighbourhoods or quarters. House groups represent on average between 24–42 persons, but could reach in exceptional cases up to 180 (Maidanetske) and 246 (Talianki) persons (Ohlrau 2015). Neighbourhoods or quarters represent much larger units with at least 500–600, but frequently between 1000 and 2000 persons.

For the settlements investigated in this study, none of the reconstructed populations exceeded the threshold of 250 people and was usually clearly lower (Tab. 5). Accordingly, we are dealing with relatively small communities, whose social complexity could likely be regulated within the framework of kinship groups and the neighbourhood. For corresponding communities (at least at the local scale), no marked hierarchies should be assumed, but rather mechanisms which maintained social equality.

The mega-structures, which could be detected in at least two of the three surveyed settlements, could have served decision making, ritual and other communal purposes. Such mega-structures are

	Baia A	Baia B	Adâncata A	Adâncata B
settlement size (ha)	1.5	2.0	1.85	1.0
number of houses (geomagnetic survey)	>9		>2	22
range of house size (m^2)	19–46		26.0–28.57	15.6–90.74
average house size (m^2)	30		27	48
mega-structure (size)*	1 (239 m^2)		1 (240 m^2)	–
100 persons / ha*	150	200	150–185	80–100
7–13 houses / ha (3–7 persons/house)*	31–136	42–182	39–168	21–90
geomagnetic survey	–	–	–	90–175

Tab. 5 Summary of parameters and results of population estimations of the investigated settlements. *Due to assumed special communal functions, oversized buildings should generally be excluded from the calculations of population estimations. In the presented cases, the results are not influenced significantly by the exclusion of such areas.

clearly not a phenomenon, which is exclusively related to certain phases or sizes of settlements, but rather they occur at small sites and already during earliest phases of the Cucuteni-Tripolye complex.

The idea, which was developed in connection with the mega-sites of the Bug-Dnieper interfluve, continue to be very plausible in light of our new results from Baia and Adâncata: These large mega-structures could have represented multifunctional focal points and integrative facilities of smaller (basal) population units within the huge population agglomerations. However, the dimensions of the population, which is assumed to be integrated in the organisational unit of such a mega-structure, appear significantly larger in Ukrainian mega-sites than in the much smaller settlements discussed in this contribution. According to the cross-cultural empirical evidence of Adler/Wilshusen (1990), in the case of the Ukrainian mega-structures we should therefore consider a higher degree of ritual specialisation, which is theorised to enable a more effective communication flow

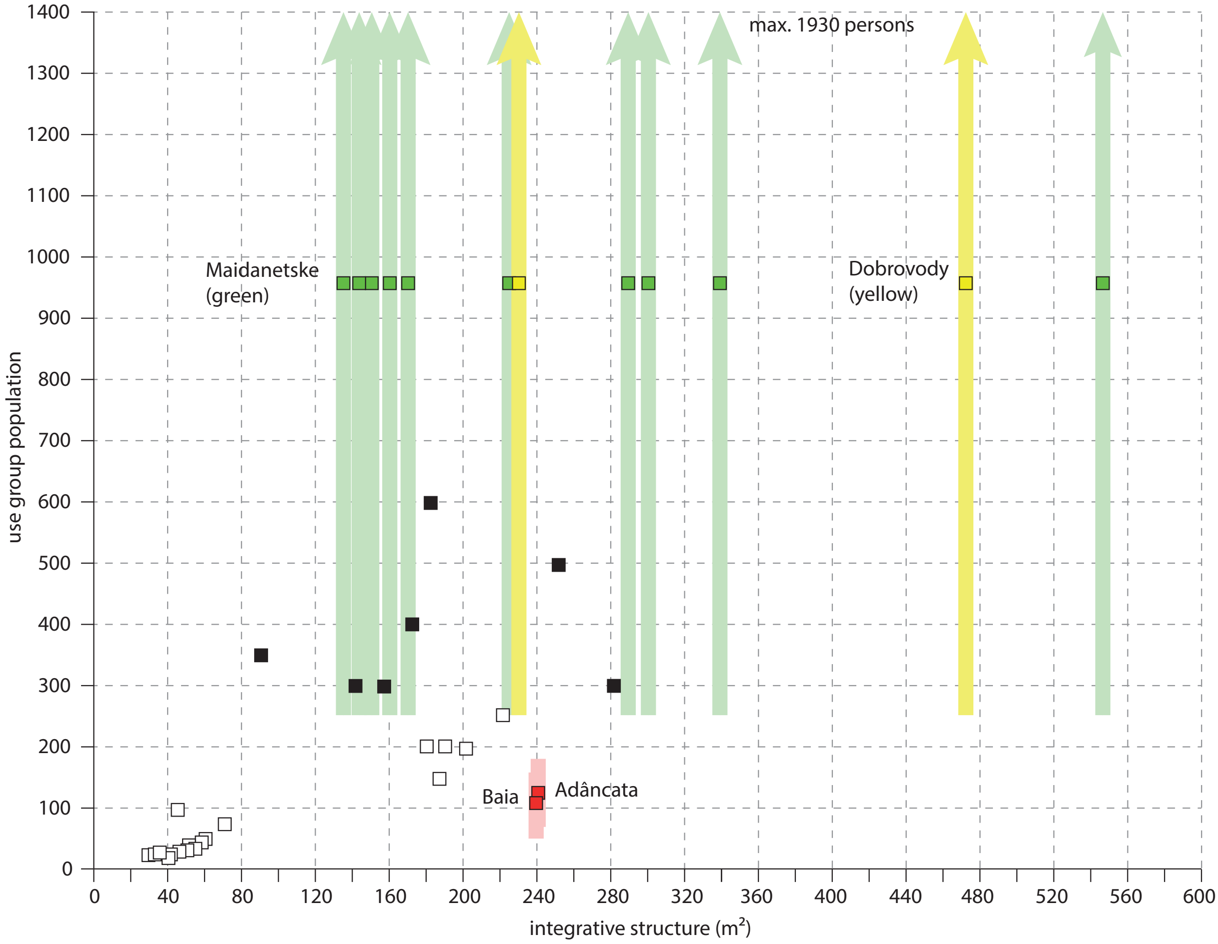


Fig. 20 Comparison of use group population and size of integrative facilities for built low-level (empty quadrat: used by a certain part of the local population) and high-level integrative facilities (solid quadrat: used by the whole community or additionally by members of other communities) after Adler/Wilshusen 1990, fig. 1. Added are cases from the Ukrainian mega-sites Maidanetske and Dobrovody (after Rassmann et al. 2014; Ohlrau 2015; Rassmann et al. 2016a) and the oversized buildings from Baia and Adâncata. Determination of the use group population in the case of Maidanetske and Dobrovody is based on the minimal, average, and maximal count of houses belonging to such neighbourhoods (after Ohlrau 2015, 62, tab. 8). The number of inhabitants per houses was assumed to be 4–5 which is borrowed from Diachenko (2016, 182).

under conditions of larger group sizes. According to ethnographic observations there is, in contrast, a certain correlation between the size of such facilities and the size of the use group population (Adler/Wilshusen 1990). The oversized buildings in Baia and Adâncata are located in the upper size range of such ethnographically observed facilities. Compared to their use group population, they seem clearly too large in the light of the cross-cultural sample (Fig. 20). This applies even more since the mega-structures at mega-sites of the Southern Bug-Dnieper interfluve are in many cases smaller or only slightly larger than the buildings from Baia and Adâncata, although they were potentially used by much larger population groups. This raises the question if the discussed buildings from small settlements could have played a role not only at a local level but also for integration on a regional scale? To obtain answers to this question, further investigations particularly on a micro-regional scale and more settlement plans of small sites are needed.

Literature

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