Journal homepage: https://jmr.uaic.ro/

JOURNAL OF MULTIDISCIPLINARY RESEARCH
NEW APPROACHES AND DATA

Volume 1, Issue 1 (2024): 51 – 68

# Geophysical Investigations of the Antique Sites of Olbian *Chora*

Roman Kozlenko[1], Kseniia Bondar[2], Iryna Sheiko[2*]

[1] National Historical-Archaeological Reserve "Olbia", National Academy of Sciences of Ukraine, Olviiska St., 47A, Parutyne village, Mykolaiv Region, 57540, Ukraine.
[2] Institute of Geophysics, Polish Academy of Sciences, Księcia Janusza 64, Warsaw, 01-452, Poland.
[3] Institute of Archaeology, National Academy of Sciences of Ukraine, Volodymyra Ivasiuka Av., 12, Kyiv, 04210, Ukraine.
* Corresponding author: ira.sheiko@gmail.com

**Abstract**

The *chora* of the antique city of Olbia is full of synchronous settlements that ensured the polis existence at different stages of its functioning. In the paper new data on the sanctuary-ashmound structure of the 5th – 4th centuries BC near Katalyne village, a fortified settlement of the 1st – 3rd centuries AD Kozyrka I, as well as the Roman fort Kamianka V, which in the first century AD was located on the northwestern border of the Olbian state, is presented. At the Katalyne ashmound, anomalies in the centre of the embankment are associated with anthropogenic activity of the antique period. The embankment is located next to a modern road, which, in turn, crosses a prominent rectangular structure, which probably is also dated to the Antiquity. The magnetic map of the hillfort Kozyrka I shows advanced stone building, and materials with a high content of ferromagnets, such as clay and brick, were also used in the construction. The structure of the geomagnetic field on the hills of the lower terrace of the settlement indicates the presence of a cultural layer here. The geomagnetic survey of the eastern part of the Kamianka V fort revealed the presence of double fortified moats and allowed us to clearly establish the geometry of the inner eastern fortification of the fort. The work carried out has shown the need to

expand the scope of geophysical surveys, including the periphery of the Roman fort and the nearby burial mound.

**Keywords:** sanctuary, Roman fort, hillfort, residential areas, magnetometer survey.

## 1. Introduction

The main source of our evidence on the city planning, architecture, and construction of antique settlements of the Northern Black Sea region in general, and the Lower Buh region in particular, is the remains of buildings and structures discovered during archaeological excavations. Despite the existence of a comprehensive source base obtained through many years of research on the monuments of the region, the issues of urban development of antique city-states and the stages of their formation remain open.

Special attention of researchers is focused on the antique polis of Olbia Pontica (N46.69°; E31.90°), which has been studied for more than 100 years. Equally important are the settlements of the Olbian *chora*, which formed a single economic unit with the city at different stages of its existence (Bujskich 2006, 116, 122, 129, 132-134). However, the historical information that can be obtained by analysing the spatial structure of the settlements is obtained very slowly during excavations.

In 2023, under the project "Social and Natural Factors of Early Urbanisation Processes in the North-Western Black Sea Region (on the Example of Antique Centres)", we had the opportunity to expand our knowledge of certain monuments of the *chora* of Olbia Pontica using magnetometer survey as a highly-productive geophysical technique.

Although it was the first time geophysics was used in the Olbian *chora*, the non-invasive methods have shown high efficiency on Olbia itself being implemented in 2014 and 2017, within the project "Antike Stadtentwicklungander Grenzedergriechischen Oikumene. Archäologische Untersuchungenim Vorstadtareal Olbia Pontikes." In particular, the construction of dugouts in the suburbs of Olbia Pontica was discovered and confirmed through archaeological excavations, an ancient moat was found, which apparently delimited the area of the suburbs and the city during the early antique period, and a system of slope strengthening was discovered. A large-scale magnetometer survey has shown that the ancient suburbs covered a much larger area than it was previously believed (Patzelt et al. 2016, 3-6; Fornasier et al. 2017, 31; Patzelt 2019, 8; Patzelt and Waldhör 2021; Buiskikh et al. 2020, 130-133).

Olbia Pontica, like other antique city-states, was not developing in isolation, but for centuries had remained at the centre of a complex interweaving of political, administrative, economic and logistical ties with the settlements of its own periphery (Kryzhytsky et al. 1990, 120). Thus, the choice of monuments for the study is not accidental. Chronologically, they cover the period from the 5th century BC to the 3rd century AD representing typical sites of Olbian *chora* – ashmound-sanctuary, hillfort and Roman fort. Unfortunately, the proximity of the front line significantly reduced the

planned number of archaeological sites to be surveyed. This paper is focused on geophysical results from the sites where an unambiguous interpretation of geophysical data was possible or those had been partially excavated in the past, which gives grounds for archaeological considerations (Fig. 1).

A special attention in this paper is paid to magnetometer survey results from the Roman fort Kamianka V. In Europe, Roman camps are not only actively studied, but also become testing grounds for new non-invasive technologies and equipment (Fassbinder 2015; Fassbinder and Gorka 2009; Fassbinder 2010; Țentea and Popa 2017; Costa-García and Gago 2019; Stewart et al. 2020; Stele et al. 2023). Magnetometry has become a tool for chronological analysis of multi-layered monuments, this technique was called "magnetic stratigraphy" (Fassbinder 2015). For example, at the Roman camp of Burgsalach in Bavaria, at least two phases of construction were identified (Fassbinder and Gorka 2009; Fassbinder 2015), and at the Roman fort at Lake Farm, near Wimborne Minster in Dorset, the interior layout of the fortress was identified along with evidence for an earlier phase of the site as a marching camp (Stewart et al. 2020).

This case study not only provides valuable insights into the unique challenges confronted by archaeologists doing research on antique monuments in the Northern Black Sea region, but also serves as a compelling illustration of how geophysical practices can be harnessed to elevate excavation efficiency and enhance overall understanding of human occupation.

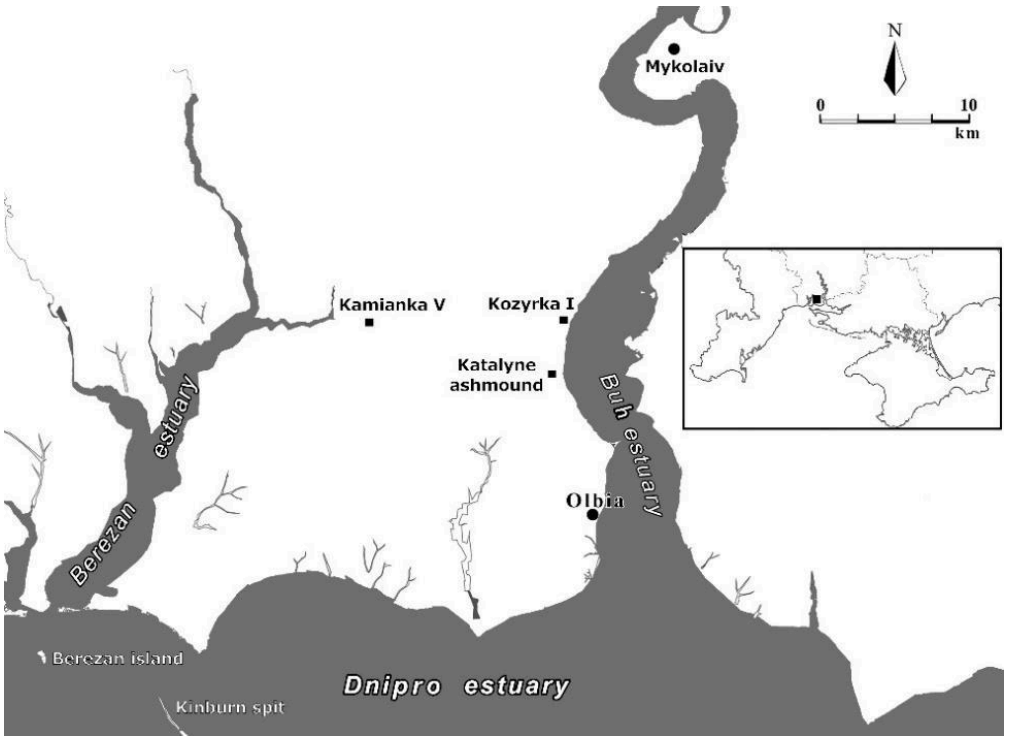


Fig 1. Map of studied sites in the *chora* of Olbia Pontica

Today, 45 of the Hallstatt enclosures are documented using magnetometer prospecting. Two of them were surveyed in the 2022 season: the enclosures at Oberstimm (Obs22) south of Ingolstadt and at Hartkirchen (Hkn22) in the lower Vils

valley (Fig. 1). These two enclosures shall serve as examples of some methodological conspicuities that prospectors may be confronted with during interpreting magnetic survey data of such archaeological structures.

## 2. Materials and methods

### *2.1 Characterisation of the study area*

During the existence of the Olbian polis (6th century BC – 3rd century AD), it included the *chora*, an agricultural suburb consisting of several hundred settlements and towns in the Lower Buh region (Kryzhytsky et al. 1990), the first of which began to appear in the second half of the 6th century BC and reached the peak of its development together with the city in the 5th – 4th centuries BC (Bujskich 2006, 116, 122-123). The *chora* of Olbia extended along the Berezan, Buh and Dnipro-Buh estuaries, in the north reaching the peninsula at the confluence of the Southern Buh and Inhul rivers, and consisted of agricultural settlements, villas, hillforts, sanctuaries located outside the city, etc. Despite the stages of reduction and decline, its boundaries were generally unchanged throughout the existence of the Olbian polis (Bujskich 2006, 134).

At the beginning of the 1st century AD, after decades of desolation of the Olbian *chora* associated with the destruction of Olbia in the middle of the 1st century BC by the Getae, a complex of hillforts was formed around Olbia (Buiskikh 1991, 48-78). The Olbian defence system of Roman times, which consisted of the polis's fortifications, and a complex of settlements along the Buh, Dnipro, and Berezan estuaries, is unique in its kind. Taking maximum advantage of the geographical location and landscape conditions, the fortifications were a serious obstacle against the invasion of the Lower Buh region from the outside. Among them are the few Roman military field camps (Ruban and Buiskikh 1976; Buiskikh 1991, 67-68; Gudea 2005, 472-475). The debate about these monuments has been continuing for several decades, as some researchers have been extremely critical of this interpretation (Zubar 1998, 48-50; Sarnowski 2006, 122-123; Karasiewicz-Szczypiorski 2015, 141). One such fortification of the Olbian *chora* was investigated with a magnetometer.

### *2.2 A brief description of the studied monuments:*

*Katalyne ashmound* (N46.76°; E31.85°) is one of the earthen ashmound-sanctuaries of antique times on the territory of the Olbian state. It is located in the northwestern part of the antique settlement of Katalyne I, dated to the 6th – 3rd centuries BC (Kryzhytsky et al. 1990, 11, fig. 4/48; 28, 58). The mound has a diameter of 50 m and a height of about 1 m (Fig. 2). It is an eschara (ἐσχάρα) – a sanctuary probably associated with the worship of Heracles, as indicated by the findings of lead votive figurines on it (Snytko 2021, 208-212). In addition, a limestone altar, a terracotta statuette of a seated

goddess, coins, a fragment of a limestone anthropomorphic stele were also found on its surface. The site suffered from many years of ploughing the farmland on which it is located, as well as constant interference by robbers.

*Fort Kamianka V*. In 2011 a new fortified site of Roman time, which was named Kamianka V, was discovered. According to the results of visual inspection and excavations, it can be interpreted as a Roman military field camp (castellum) or fort ("numeruskastell") (Kozlenko 2016, 80-81). The site covers an area of 7 hectares, and is located near Kamianka village, Mykolaiv district, Mykolaiv region (N46.79°; E31.70°) (Fig. 3).

The fortification is surrounded on four sides by a 10-15 m wide rampart, which has become very eroded due to many years of ploughing, and a moat. The fort is rectangular in plan (260 × 270 m), with a gap in the northwestern part. Inside, the fort has two additional fortifications measuring 65 × 65 m.[1]

Fig. 2. Katalyne ashmound. View from the east (photo after R. O. Kozlenko).

In the process of archaeological research, four trenches were laid that cut the outer defensive line, as well as the western and eastern internal fortifications of the fort. The section of the moat of the eastern inner fortification showed that its depth from the mainland level was 2.6 m, its width at the top was 6.5 m, and at the bottom – 2 m.

The shape of the moat of the western inner fortification differs from the eastern one. The width of the moat at the top, from the mainland edge of the first scarp, is 7.6 m, along the edges of the sides – 4.8 m, at the bottom – 3.3 m, and the depth from the mainland level – 2.1 m. A section of the outer defensive line near the main fort's gate showed that its moat shape is not similar to any of the moats of the inner fortifications.

[1] Forts of the Flavian and Trajan dynasties, similar in size and layout, intended for the location of auxiliary units of the Roman army, are known in the Roman provinces (see for example: Farkas 2015, 79-90).

The width of the moat is 5.3 m at the top, 0.6 m at the bottom, and 1.8 m deep from the mainland level.

Fig. 3. Roman fort Kamianka V. View from the north (after R. O. Kozlenko).

The stratigraphy of all the moats is the same: humus, brown layer, buried humus, dark grey ashy layer, dark brown layer, light clay layer, and the mainland. The ramparts of the fortifications have been significantly ploughed up, but their preserved height of about 0.3 m is still visible on the surface. No berms can be traced in the fortification cross-sections, and several processed stone blocks were found in the moats' fillings, which may indicate the existence of crepidomas that protected the ramparts from flooding.

According to the ceramic and numismatic material, the construction of fort Kamianka V can be dated to the third quarter of the 1st century AD, which coincides with the introduction of the Olbian era, the end of the Roman-Bosporan war, the military and political activities in the Northern Black Sea of the governor of the Roman province of Moesia, T. Plautius Sylvanus Elianus, and the close relationship between Olbia and the Sarmatians (with references: Kozlenko 2018).

*Hillfort Kozyrka I.* One of the most researched settlements of the Olbian *chora* of the Roman period is the hillfort Kozyrka I (Fig 4), located 12 km to the north from Olbia in a favourable landscape position on the right bank of the Buh estuary (N46.79°; E31.87°). It has the shape of an irregular trapezoid, covering an area of about 6 hectares, and served as a stronghold (burgus), whose task was to signal in case of danger to the surrounding settlements and Olbia itself, and to hold the siege until the arrival of help (Buiskikh 1991, 85). From the highest point in the area, where a steep slope and defences protected the settlement, the surrounding area was clearly visible. At the time of the invasion, the inhabitants of the surrounding unfortified settlements could take

refuge in a separate southern part of the settlement. The convenient location of the fortress near the Buh estuary may indicate the presence of a harbour or a pier on its lower terrace. In the general context, hillfort Kozyrka functioned as a military and economic stronghold, which was responsible for protecting the northeastern border of the Olbian state (Zubar 1994, 79).

During 1954-1967, as a result of archaeological excavations by A. V. Burakov in the southeastern part of the hillfort, a residential quarter consisting of a series of premises and alleys was investigated (Kryzhitsky and Burakov 1975; Burakov 1976, 16-63). Field research had revealed developed stone construction, with techniques of the Roman building tradition (Burakov 1976, 50-63; Son and Buiskikh 2014, 48-54).

The excavations of the hillfort Kozyrka have provided a large number of fired bricks, which is a typical feature of provincial Roman construction techniques. The use of the fired brick masonry system with limestone solution (opus caementicium) is generally typical for Roman construction techniques. In addition, a semi-dugout of the Cherniakhiv culture, measuring 4.5 × 3 m, was investigated on the territory of the hillfort, in the urban area (Burakov 1976, 46).

The study of the fortifications of the settlement revealed the presence of a wide moat and a stone fortress wall. In the northern part of the hillfort, a passage can be traced in the defensive system, on both sides of which elevated platforms - the remains of the hillfort's defensive towers - are recorded on the modern surface.

Fig 4. Hillfort Kozyrka I. View from the southeast (after R. O. Kozlenko).

*Lower terrace of the hillfort Kozyrka I*. On the lower unfortified slope of the hillfort there are a number of natural hills (Fig. 5), where a cultural layer was discovered, synchronous with the time of the settlement's existence on the upper steppe plateau (1st – 3rd centuries AD). The elongated hills orientated along the coast of the Buh

estuary were formed as a result of a landslide of the edge part of the hillfort (Burakov 1976).

In 2019 a 4 × 6 m excavation (R-1) was laid out on the extreme northern hill (Fig 9A). It revealed a stone overlay consisting of small and medium-sized limestones, laid with four to seven rows of stones in the form of a carapace (Fig 9B). The stones were laid on an ashy layer, which contained hearths, charcoal and large pieces of fired fragments of clay, mainly located under the central part of the overlay. Fragments of amphorae of the 1st – 3rd centuries AD, as well as fragments of limestone columns, bones of cattle and small cattle were found during the clearing of the "stone foundation." Under the "stone foundation" (overlay) there was a foundation pit over 3 m deep. The stratigraphy of the foundation pit has nine different, sometimes inconsistent, layers: topsoil, ancient dark humus, light brown layer, light ashy layer, red clay layer, light brown loam, red clay layer with inclusions of a dark ashy layer, dark yellow sand, limestone colour sand, and mainland clay. This allows us to conclude that it was formed in stages, which is confirmed by extensive dating of archaeological materials. The nature of this object enables us to preliminarily define it as an ashmound or a sub-urban sanctuary (Bujskikh 2005), which was located outside the fortified part of the settlement and is associated with the ritual and ceremonial activities of the local population in the Roman period. The terminus ante quem of the ashmound functioning can be preliminarily determined as the middle of the 3rd century AD, as indicated by fragments of amphorae of the Zeest 75 and Shelov D types from its filling (Kozlenko 2020, 174-176).

Fig. 5. The lower terrace of the hillfort Kozyrka I. View from the north (after R. O. Kozlenko).

### *2.3 Magnetometer survey*

Magnetometer survey is a well-known rapid tool for mapping subsurface features (Aspinall et al. 2008; Fassbinder 2015). The survey was conducted with cesium total field magnetometers PKM-1 (Geologorazvedka, Russia). The instrument records 10 measurements per second, providing a spatial resolution of about 10 cm on the profile by normal walking speed. With traverse interval of 0.5 m, the total intensity of geomagnetic field was acquired with a spatial resolution of 50 × 10 cm. The procedure of profile median withdrawal from the measured values allows the exclusion of the normal field and diurnal variation (Becker 1999; Tabbagh 2003). The obtained magnetic map therefore reflected archaeological structures, pieces of magnetic rubbish and ploughing effects. Magnetometer surveys were conducted in September 2023. Survey polygons were georeferenced by measuring coordinates using GPS in RTK mode.

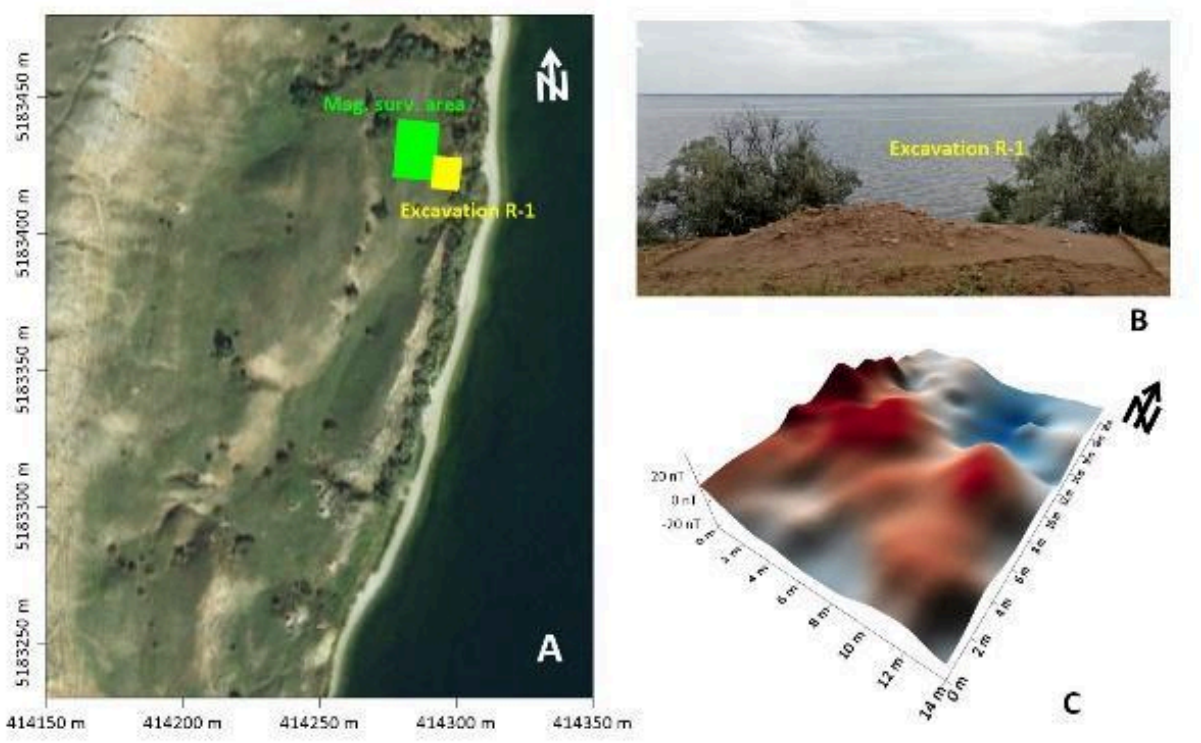


Fig. 9. Hillfort Kozyrka I, lower terrace. (A) location plan; (B) – photograph of the excavation R-1. Stone overlap of the ashmound. View from the west (after R. O. Kozlenko); (C) – magnetogram in dynamics of the total magnetic field ± 20.0 nT, red is high (after K. M. Bondar).

## 3. Results and interpretation

### *3.1 Katalyne ashmound*

The surveyed area includes several types of magnetic anomalies (Fig. 6). The semi-circular negative anomaly A in the east is caused by electric power line slab.

Weak linear ones in the west are typical for old roads (B), some of which appear on Shubert's 3-verst maps (three-versts map, sheet XXX-10), and, probably, cattle pen border (C). Two spot-like positive magnetic anomalies D and E with approx. diameter of 15 and 5 m and maximum intensity of 8.5 and 5.4 nT are shown in the centre of the hill, and presumably correspond to foundation pits similar to those excavated on other ashmounds in Olbian *chora* (Golovacheva and Rogov 2002; Nosova 2002; Kozlenko 2020; Bondarenko and Smyrnov 2021). They have a difficult stratigraphy, which indicates that they were formed in a stepwise manner, not simultaneously. Due to scanty historical information available on the site it is not clear about a source of positive anomaly F in the southeastern part of survey area. It may be a separate part of the ashmound (another foundation pit), or may belong to the building structures of the nearby antique settlement Katalyne I.


Fig. 6. Katalyne ashmound. (A) – magnetogram in greyscale and dynamics of the total magnetic field ± 4.0 nT, black is high, placed on a satellite image; (B) – interpretation scheme explained in the text (after K. M. Bondar).

### *3.2 Roman fort Kamianka V*

The magnetometer survey covered the eastern part of the fort with a total area of 32900 m2. The magnetic anomaly map looks extremely illustrative (Fig. 7A), and allows a fairly accurate archaeological interpretation (Fig. 7B).

According to magnetometer survey results, the outer line of the fortifications consists of a double moat that frames the remains of the ramparts visible on the surface. The anomaly from the outer moat has a maximum intensity of 12.5 nT, the width of the moat corresponds to the size of the anomaly and is 3.5-5.0 m. At a distance of 3-4 m from it, there is another, inner ditch, the width of which does not exceed 2 m.

The magnetic map reveals the geometry of the fort's eastern inner fortification. It has a rounded outer moat and a square-like inner ditch. Between them, in the middle of the rampart remains, a linear anomaly is partially observed, probably from the palisade. On the southern side there are gaps in the moats – the entrance to the

fortification. The internal dimensions of the free surface of the eastern fortification are 34 × 34 m.


Fig. 7. Fort Kamianka V. (A) – magnetogram in greyscale and dynamics of the total magnetic field ± 2.0 nT, black is high, placed on a satellite image; (B) - interpretation scheme: 1 – moats, 2 – dugouts, 3 – limestone structures, 4 – modern road, 5 – objects interpreted from the satellite image (after K. M. Bondar).

On the northern side of the eastern fortification, between it and the outer moat, there are small positive anomalies that may be associated with residential or household constructions, probably slightly deepened to the natural/sterile layer. On the southern side of the eastern fortification, weak negative anomalies are recorded, probably associated with stone structures made of local limestone. A modern road is laid through the fort, covered with gravel. It can be seen as a linear positive anomaly on the southern edge of the fort.

In situ magnetic susceptibility (k) topsoil measurements were taken using a handheld KM-7 SatisGeo kappameter at several points inside and around the fort. The magnetic susceptibility of the topsoil out of the fort and inside the outer rampart was in the range of 0.85–1.00*10-3 SI. At the slightly elevated ramparts, both of outer and inner fortifications, the magnetic susceptibility dropped to 0.48–0.65 *10-3 SI as the ramparts were constructed of the subsoil loess material extracted from moats.

### *3.3 Hillfort Kozyrka I*

Magnetometer survey was carried out in the eastern part of the upper plateau of the hillfort with an area of 9 600 m2 (Fig. 8 A–B). The magnetic field of the hillfort Kozyrka shows a large number of different anomalies. If we exclude the anomalies caused by natural processes, as well as those that may be traces of robbery digs, modern stone

quarrying dumps, and magnetic garbage, we will get a suggested layout of the antique structures on the site.

The interpretation scheme (Fig. 8 B) assumes that positive linear anomalies (1) can be sourced by walls made of burnt/mud brick or, alternatively, by small moats; positive "spots" (2) can mark moats and ramparts, dumps from excavations and pits, pits that have been gradually re-filled with soil, dugouts and semi-dugouts, etc; negative linear anomalies (3) are walls constructed of limestone, and may also be robbery trenches; negative isometric anomalies (4) are usually associated with robbery pits.

As we can see, the largest concentration of "archaeological" anomalies is observed in the central part of the site, although they are also present in the northern and southern edge parts. In the central part, linear negative anomalies are mainly associated with the walls of buildings made of stone-limestone. The brick walls caused weak linear positive anomalies. In the northern part of the hillfort, to the east of the gate, near the excavation trench no. 13, the magnetometer recorded type 2 anomalies - probably the contours of a defensive moat and wall, and possibly one of the towers that flanked the passage. The distance between them is about 8 m.

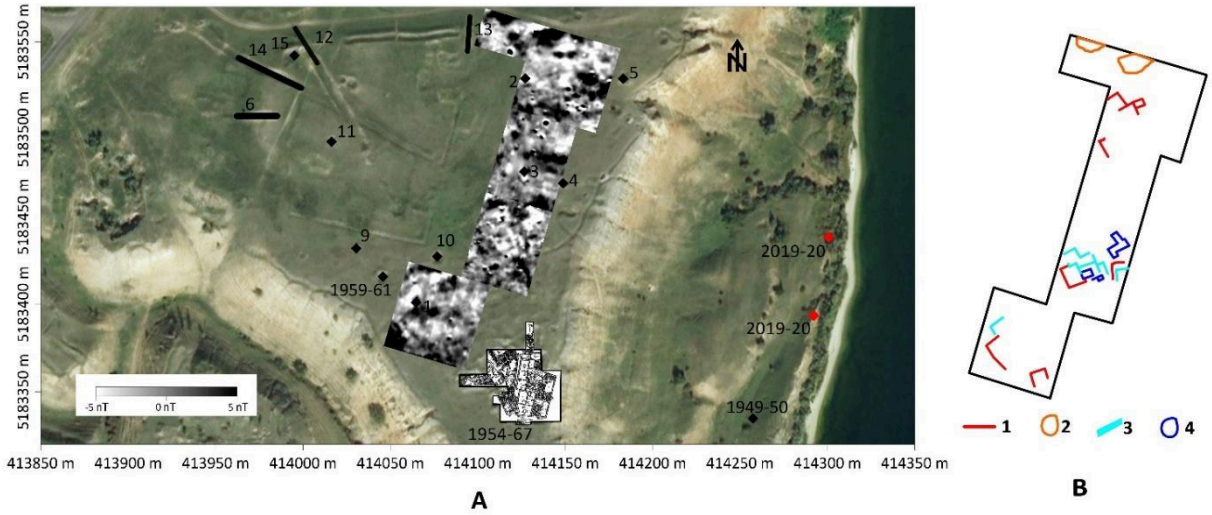


Fig. 8. Hillfort Kozyrka I. (A) – magnetogram in greyscale and dynamics of the total magnetic field ± 4.0 nT, black is high, placed on a satellite image, black rhombuses, lines and polygon mark pits, trenches and excavations by A. V. Burakov; (B) – interpretation scheme explained in the text (after K. M. Bondar).

### *3.4 Lower terrace of the hillfort Kozyrka I*

As a result of magnetometer survey on the hill, where the sanctuary-ashmound with a stone overlay was partially investigated (Kozlenko 2020, 175-176), the boundaries of the object along the N-S axis were revealed with the help of a magnetometer, and its significant length to the west of R-1 was confirmed, which can be traced de visu on the microrelief of the landscape due to the differences in the solid stone foundation. The magnetometer survey recorded a complex positive anomaly with several local maximums (Fig 9C), which indicates the significant size of the sanctuary – approximately 18 × 20 m within the defined square, including the already investigated

eastern part of the ashmound. However, its western boundary has not yet been determined, as the remains of the stone overlay and burnt soil continue to extend further. A 3 m deep foundation pit filled with burnt soil and broken ceramics found under the stone foundation, became the source of the magnetic anomaly.

## 4. Discussion

Among the investigated sites, we have two sanctuaries: an ashmound near Katalyne village and an ashmound on the lower terrace of the hillfort Kozyrka I. The chronological interval between these monuments is several centuries, but they have common features of formation and purpose. The earthen hill with a stone overlay at the hillfort Kozyrka I is the unique object of this kind of the first centuries AD in the Lower Buh region. The similarity of these sub-urban sanctuaries, i.e. those located outside the direct boundaries of settlements, may indicate the centuries-long preservation of the traditions of using and constructing sanctuaries of this type on the territory of Olbian *chora*.

Magnetometer surveys of the eastern part of the fort Kamianka V revealed that the outer and inner defensive lines of the latter consisted of double defensive moats[2]. Roman field forts with double moats are known on the territory of the Roman limes, but such fortification techniques are known on the fortifications of the Roman period on the territory of the Olbian polis at the settlements of Mys and Skelka, the shape of one of the moats of which is similar to the cross-section of the moat of the western inner fortification of the fort Kamianka V (Buiskikh 1991, 56-57, 69-71). This further indicates the significant danger posed by some of the surrounding nomadic tribes, from whose possible encroachments the double moats of this fortification were built.

Usually, on the territory adjacent to Roman forts, there were auxiliary economic or religious buildings and field roads, the remains of which can be identified by non-invasive research methods, namely magnetometer surveys of the ground surface.

The magnetometer survey of the fort Kamianka V is not complete. This site should be investigated in the future together with its periphery, the surrounding space outside the outer fortification, which must have been used by the Romans as it was at similar sites on the Iberian Peninsula (Costa-García and Gago 2019), or, as an example, the castellum 'Iciacum' Theilenhofen, whose periphery is full of many synchronous and asynchronous objects (Fassbinder 2010).

In addition, when analysing satellite images of the area, we noticed that 1.9 km southeast of the fort Kamianka V is a structure similar in shape and size to the fort's internal fortifications (Fig. 10). This newly discovered fort is located near the large

[2] The magnetometer survey confirms the presence of a well-defined outer moat that enclosed the inner fortifications along the surrounding perimeter. It is directly related to the fort's defence system, and cannot be related to modern construction works (Sapozhnikov and Sinelnikov 2021, 383), as the rampart in the southern part of the fort was partially leveled during the construction of the irrigation channel. This can be clearly seen de visu, in the microrelief of the wooden and earthwork fortifications' remains, and is evidenced by the stratigraphy of the outer moat. In addition, fragments of Pontic amphorae were found in an excavation trench in the outer moat (Kozlenko 2016, 80).

burial mound Dovha Mohyla and along the field road to Olbia, near which fort Kamianka V was located (Sapozhnikov and Sinelnikov 2021, 382-384). Undoubtedly, the two described complexes should be investigated using a single methodological approach, and, above all, non-destructive methods – geophysical and geoinformational.

Magnetometer survey of the hillfort Kozyrka I, carried out in the eastern part of the upper plateau, showed the outlines of new residential buildings to the north and northwest of the already investigated part of the hillfort with the remains of a residential quarter.

Thus, the clear outlines of another residential quarter can be traced to the north of the Burakov's excavation. At least one dwelling with outbuildings in the eastern part, orientated along the northwest-southeast axis, and alleys can be seen. The area of urban development is also recorded near the northern entrance to the hillfort with the same orientation to the cardinal points.

A fragment of a marble profiled base of a column or altar, with a total diameter of about 65 cm, which was found in the central part of the stone floor of the ashmound, on the lower terrace of the hillfort Kozyrka I (Kozlenko 2020: 175-176, Fig. 5, 7), may indicate the existence of a monumental building of administrative or religious purpose on the upper plateau of the settlement, since a marble architectural detail of the Roman period in the Olbian district is an extremely rare find.

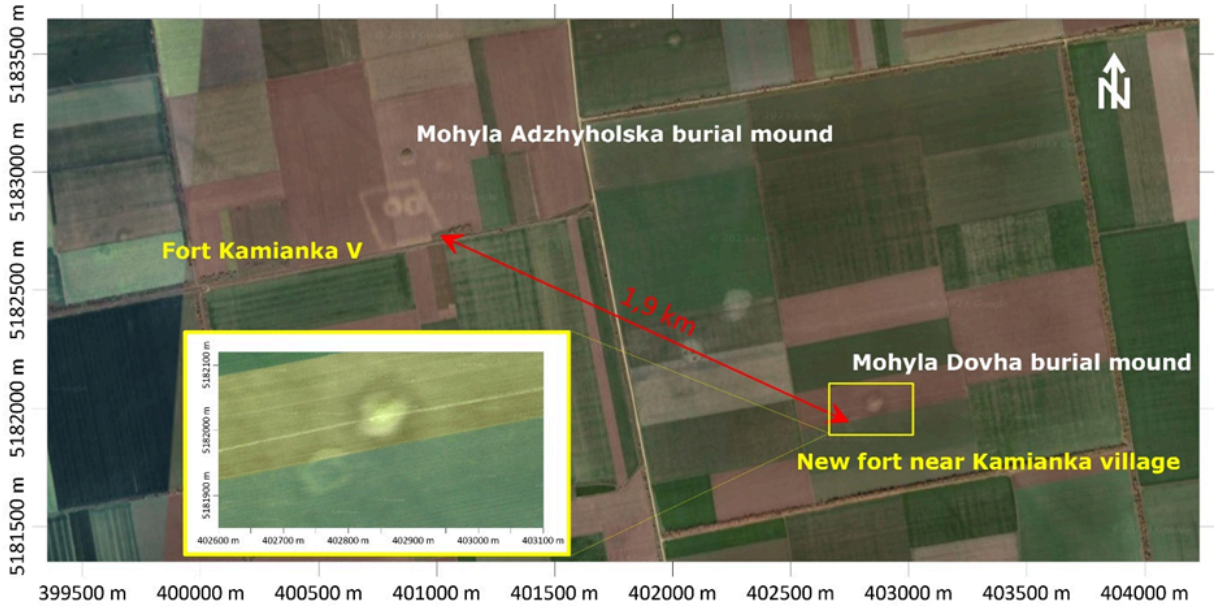


Fig. 10. Location of two Roman forts next to burial mounds (after K. M. Bondar).

In addition to the inner perimeter of the fortress, the surrounding area of the hillfort is promising for further geomagnetic research. In general, the magnetometer surveys revealed several areas with stone structures and confirmed the settlement's construction density.

The lower terrace part of the hillfort Kozyrka I requires further conservation and rescue research, as it is closely adjacent to the Buh estuary, which results in its cultural

layers being slowly destroyed by coastal abrasion and suffers from constant interference by robbers.

## 5. Conclusions

As a result of the magnetometer surveys, new data on the structure of the antique monuments of the Olbian *chora*, namely the hillfort Kozyrka I and its lower terrace, the Katalyne ashmound, and the fort Kamianka V, were obtained. In particular, at the Katalyne ashmound, the map of geomagnetic field anomalies reflects the overlap of different economic presence of humans in this area. The anomalies located in the centre of the visible ashmound embankment may be associated with archaeological objects of the antique period.

On the upper plateau of the hillfort Kozyrka I, the largest concentration of anomalies, the sources of which are linear structures – limestone walls, walls made of burnt or mud brick, small moats – is observed in the central part of the site, although they are also present in the northern and southern edge parts. In the central part of the monument, the anomalies are mainly associated with the walls of limestone buildings, although there is probably a building completely paved with limestone slabs, as well as walls made of brick. The magnetic map also shows the elements of the settlement's defensive system – a rampart and a moat.

On one of the hills of the lower terrace of the hillfort Kozyrka I, there was investigated an object – a sanctuary of antique times, similar to the Katalyne ashmound. It is recorded on the magnetic map as a series of positive anomalies up to 20 nT, stretching in the West-East direction and marking the ashmound embankment.

A map of geomagnetic field anomalies in the eastern part of the fort Kamianka V was also obtained. The interpretation of the magnetic data revealed that the outer line of the fortifications consists of a double moat that frames the remains of the ramparts visible on the surface. The geometry of the eastern inner fortification of the fort has been established. It has a rounded outer contour (moat), as well as a subsquare inner moat. On the southern side there are gaps in the moats – the entrance to the fortification. On the northern side of the eastern fortification there are small positive anomalies that may be associated with residential or household buildings, and on the southern side there are areas of a weak negative field, probably associated with stone structures made of local limestone. Prospects for further research of the fort and its periphery are outlined. The results of this case study emphasise the pivotal role of non-invasive techniques such as magnetometry in demonstrating the particulars of Roman earth fortification.

## References

Aspinall A., Gaffney C.F., Schmidt A. 2008. *Magnetometry for Archaeologists*. Lanham, MD: Altamira Press.

Becker H. 1999. Duo- and Quadro- Sensor Configuration for High-Speed/High-Resolution Magnetic Prospecting with Caesium Magnetometer. In: Jörg W.E. Fassbinder, Waltr E. Irlinger (Hrsg.) *Archaeological Prospection (Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege)*. Band 108, München: 100–105.

Bondarenko D., Smyrnov O. 2021. Ash Pit no. 2 of Ancient Sanctuary Viktorivka-1: General Characteristics. *Eminak*. 1: 132–143.

Buiskikh A.V., Fornasier J., Sheiko I.M., Chechulina I.O. 2020. New studies of the Terraced City of Olbia. In: Boltrik Yu.V., ed. Archaeological research in Ukraine in 2018. Kyiv: IA NAS of Ukraine: 130–133 (in Ukrainian).

Buiskikh S.B. 1991. *Fortification of the Olbian state (first centuries AD)*. Kyiv: Naukova Dumka (in Russian).

Bujskikh S.B. 2005. Les sanctuaires extra-urbains à l'époque de la colonisation grecque dans le Bug méridional. In: Kacharava D., Faudot M., Geny E., eds. *Pont-Euxin et polis: polis hellenis et polis barbaron. Actes du Xe Symposium de Vani, 23-26 septembre 2002: Hommage à Otar Lordkipanidzé et Pierre Lévêque*. Besançon: Presses Univ. Franche-Comté: 181–202.

Bujskich S.B. 2006. Die *Chora* des pontischen Olbia: Die Hauptetappen der räumlich-strukturellen Entwicklung. In: Guldager Bilde P., Stolba V.F., eds. *Surveying the Greek Chora. Black Sea Region in a Comparative Perspective*. Black Sea Studies, 4. Aarhus: 115–139.

Burakov A.V. 1976. *Kozyrka Settlement of the Turn of the Century and the First Centuries of our Era*. Kyiv: Naukova Dumka (in Russian).

Costa-García J.M., Fonte J., Gago M. 2019. The Reassessment of the Roman Military Presence in Galicia and Northern Portugal Through Digital Tools: Archaeological Diversity and Historical Problems. *Mediterranean Archaeology and Archaeometry*. 19(3): 17–49. https://doi.org/10.5281/zenodo.3457524

Farkas I.G. 2015. *The Dislocation of the Roman Army in Raetia*. Oxford: BAR International Series, 2723.

Fassbinder J.W.E. 2010. Geophysical Prospection of the Frontiers of the Roman Empire in Southern Germany, UNESCO world heritage site. *Archaeological Prospection*. 18(1): 129–139. https://doi.org/10.1002/arp.387

Fassbinder J.W.E. 2015. Seeing Beneath the Farmland, Steppe and Desert Soil: Magnetic Prospecting and Soil Magnetism. *Journal of Archaeological Science*. 56: 85–95. https://doi.org/10.1016/j.jas.2015.02.023

Fassbinder J.W.E., Gorka T. 2009. Vermessen? Das Römerkastell burgsalach, Landkreis Weißenburg-Gunzenhausen, Mittelfranken. *Das archäologische Jahr in Bayern 2008*: 76–79.

Fornasier J., Bujskich A.V., Kuz'miščev A.G., Patzelt A., Helfert M., Kratzsch N. 2017. Vor den Toren der Stadt. Deutsch-ukrainische Forschungen in der Virstadt von Olbia Pontike. *Archäologischer Anzeiger*. 1: 19–61.

Golovacheva N.V., Rogov Ye.Ya. 2002. Rural Temple and Ash Pit at the Settlement Kozyrka II on the *chora* of Olbia. In: Vakhtina M.Yu., Zuev V.Yu., Kashaev S.V., Khrshanovskiy V.A. eds. *The Bosporan Phenomenon. Burial Monuments and Sanctuaries*. Part 2. St. Petersburg: State Hermitage Publishing House: 41–44. (in Russian).

Gudea N. 2005. *Der untermoesische Donaulimes und die Verteidigung der moesischen Nord-und Westküste des Schwarzen Meers. Limes et litus Moesiae Inferioris (86-275 n. Chr.)*. Jahrbuch des Römisch-Germanischen Zentralmuseums. 52 (2). Mainz: Verlag des Römisch-Germanischen Zentralmuseums.

Karasiewicz-Szczypiorski R. 2015. *Forty i posterunki rzymskie w Scytii i Taurydzie w okresie pryncypatu*. Światowit Supplement Series A: Antiquity, XV. Warszawa: Instytut Archeologii Uniwersytetu Warszawskiego.

Kozlenko R.O. 2016. Roman Forts on the Territory of Olbian State. *Arheologia*. 2: 78–87.

Kozlenko R.O. 2018. Olbia, the Sarmatians and the Roman Limes. In: Burgunder, P. ed., *Actualité archéologique ukrainienne: Olbia Pontique, le limes et les Barbares*; Lausanne, Switzerland: Etudes Bosporanes: 79–90.

Kozlenko R.O. 2020. Research of the Kozyrka I Settlement. In: Boltryk Yu.V., ed. *Archaeological Research in Ukraine 2020*. Kyiv: IA NAS of Ukraine: 174–178 (in Ukrainian).

Kryzhytskiy S.D., Burakov A.V. 1975. Experience of Reconstruction of Dwelling Houses of the Settlement in the Olbian Periphery of the First Centuries AD Near Kozyrka Village. In: Kryzhytsky S.D., ed. *Olvia*. Kyiv: Naukova Dumka: 192–219 (in Russian).

Kryzhytskiy S.D., Buiskikh S.B., Otreshko V.M. 1990. *Antique Settlements of the Lower Buh Region (Archaeological Map)*. Kyiv: Naukova dumka (in Russian).

Nosova L.V. 2002. About the Cult Ash Pits of Ancient Settlements of the North-Western Black Sea Region (in Connection with the Excavations of the Koshar Archaeological Complex). In: Vakhtina M.Yu., Zuev V.Yu., Kashaev S.V., Khrshanovskiy V.A., eds. *The Bosporan Phenomenon. Burial Monuments and Sanctuaries*. Part 2. St. Petersburg: State Hermitage Publishing House: 62–68 (in Russian).

Patzelt A., Fornasier J., Buyskikh A., Ivtchentko A., Kuzmischev A. 2016. Geomagnetic prospections in the suburb of Olbia Pontike – an ancient Greek Colony in the Northern Black Sea Area, Ukraine. *ISAP News.* 45: 3–6.

Patzelt A. 2019. Geophysikalische Untersuchungen in Olbia. In: Fornasier A. *An den Ufern des Bugs. Internationale Fachtagunganlässkich des Jubiläums: FünfJahr e deutsch-ukrainische Ausgrabungen in Olbia Pontike, 7-9 Oktober 2019, Goethe-Universität, Frankfurt am Main, Deutschland; Zusammenfassungen der Vorträge*: 8.

Patzelt A., Waldhör M. 2021. Geomagnetische Prospektionen in der sogenannten Vorstadt Olbia Pontikes. In: Fornasier J., Bujskich A.V., eds. *An den Ufern des Bug. Deutsch-ukrainische Ausgrabungen in Olbia Pontike im Kontext internationaler Forschungen zu antiken Migrations prozessen*. Bonn: Verlag Dr. Rudolf Habelt GmbH, Frankfurt Archaeological Studies, 42: 137–154.

Ruban V.V., Buiskikh S.B. 1976. Research in the Didova Khata tract. In: Rybakov B.A., ed. *Archaeological Discoveries of 1975*. Moscow: Nauka: 386 (in Russian).

Sapozhnikov I.V., Sinelnikov A.S. 2021. On the Roman Earthen Linear Fortifications and the Road of the Barbarians Near Olbia. *Starodavnie Prichornomoria*. 13: 381–392. (in Russian)

Sarnowski T. 2006. Ti. Plautius Silvanus and the "Phantom Squadron" on the Black Sea in the 1st Century AD. *Vestnik Drevnei Istorii*. 1: 117–131 (in Russian).

Snytko I.A. 2021. Sanctuaries and Sacral Territories of the Olbian Polis of Antiquity. *Tyragetia*. 15 (1): 199–218 (in Russian).

Son N.A., Buiskikh A.V. 2014. Tegula Romana from Kozyrka Settlement near Olbia (to the Question of the Roman Building Tradition in the North-Western Black Sea Region). *Archaeology and Ancient History of Ukraine*. 1 (12): 48–54 (in Russian).

Stele A., Kaub L., Linck R., Schikorra M., Fassbinder J.W.E. 2023. Drone-based magnetometer prospection for archaeology. *Journal of Archaeological Science*. 158: 105818. https://doi.org/10.1016/j.jas.2023.105818.

Stewart D., Cheetham P., Russell M. 2020. A Magnetometry Survey of the Second Augustan Legionary Fortress at Lake Farm, Dorset. *Britannia*. 51: 307–317. https://doi.org/10.1017/S0068113X20000082

Tabbagh J. 2003. Total Field Magnetic Prospection: Are Vertical Gradiometer Measurements Preferable to Single Sensor Survey? *Archaeological Prospection*. 10 (2): 75–81. https://doi.org/10.1002/arp.193

Țentea O., Popa A. 2017. Castrul și băile romane de la Hoghiz – rezultatete recente ale prospecțiunilor geofizice. *Cercetări Arheologice*. 24: 135–141.

Zubar V.M. 1994. *Tauric Chersonesos and the Roman Empire. Sketches of military and political history*. Kyiv: Kyiv Academy of Eurobusiness (in Russian).

Zubar V.M. 1998. *North Pontus and the Roman Empire*. Kyiv: National Academy of Sciences of Ukraine, Institute of Archaeology (in Russian).