NON-DESTRUCTIVE METHODS IN FIELD ARCHAEOLOGY IN LITHUANIA: THE FIRST RESULTS OF A GERMAN-LITHUANIAN PROJECT

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Abstract

Since 2010, several archaeological sites in Lithuania have been geomagnetically surveyed, as part of a German-Lithuanian cooperation project. Within the framework of this cooperation, the Ėgliškiai/Anduliai cemetery, the Taurapilis barrow site, Taurapilis and Opstainiai/Vilkyškiai (outer settlements), and Jakai/Sudmantai (the enclosure) have been investigated. In almost all the sites, features and structures were detected that enable us to make some initial statements about the structure and dimensions of the archaeological monuments. For some sites, the surveys also provided very precise and hitherto unknown information about the context of the settlement. These new results show clearly the potential of non-invasive, especially geomagnetic, methods for archaeological purposes. However, it should be admitted that only a combination of several methods and tools enables a maximum level of knowledge and information on the scientific value and potential of archaeological sites and landscapes. The task for the coming years must therefore focus on the application and combination of further non-invasive geophysical (ground penetrating radar, electrical resistivity) and remote sensing methods in archaeological surveys.

Key words: geomagnetic investigations, Lithuania, archaeological sites, German-Lithuanian cooperation.

Introduction

Interdisciplinary investigations of ancient sites enable the archaeological community to answer numerous questions concerning social and religious structures, the economy, the everyday life, and the living conditions of former populations. A method which will be applied more frequently within this diversified spectrum of historical and natural science subjects is geomagnetic survey. Geomagnetic surveys have been used in archaeological research since the late 1950s (Aitken 1959; Neubauer 2001; Lueck 2005; Casten 2008). This non-invasive method enables the detection and investigation of various kinds of structures caused by human, geological and even climatic impacts within large areas in a relatively short period of time, and without the need to interfere in the ground. In the case of archaeological issues, in particular the remains of human activity, traces of settlements, fortifications, cemeteries, and so on, are the focus of investigation. Geomagnetic surveys therefore permit the acquisition of detailed data concerning the structure, expansion and preservation of archaeological sites, which will then usually be used as a basis for specific archaeological and geological investigations.

The aim to start using modern methods and technology in Lithuanian archaeological research was the reason why the Institute of Baltic Sea Region History and Archaeology of Klaipėda University launched a cooperation project with the German Archaeological Institute to conduct initial geomagnetic investigations on various sites in Lithuania. The main objectives were the discussion of geophysical methods and the development of new projects using non-invasive methods. Another important aim was to impart geomagnetic knowledge to Lithuanian students, who were able to participate in surveys and summer schools (e.g. Klaipėda, 27-31 August 2012).

Altogether, 11 sites have been surveyed to various extents since 2010 (Fig. 1).[1] The sites are predominantly located in west Lithuania; only Taurapilis and Tauragnai are in the eastern part. The selection of the sites was primarily based on archaeological issues (see below), but it was also intended that the surveys should be con-

[1] The geomagnetic surveys were carried out using a multi-channel-magnetometer from Sensorik&Systemtechnologie GmbH (Sensys). Two systems were used, consisting of five and 16 (vehicle-towed) fluxgate vertical gradiometer magnetometer (Förster probes, Type FGM-650A); the channel spacing was 25 centimetres.

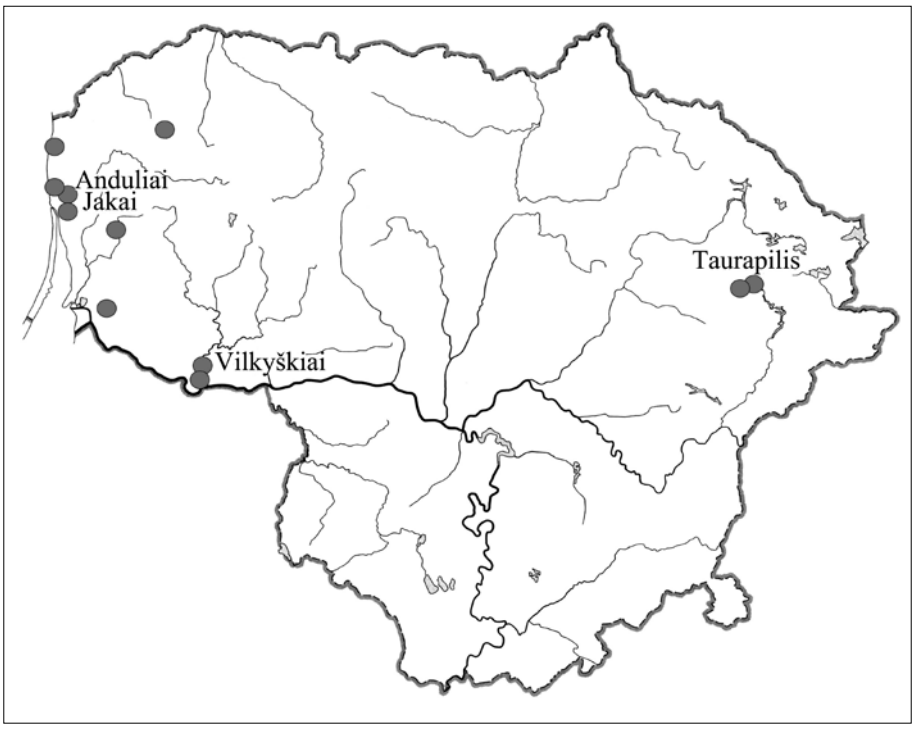

Fig. 1. Geomagnetic surveys in Lithuania. The archaeological sites which are discussed in the article are marked.

ducted under different conditions, especially geomorphological, like soil types. This recorded data will then be used for the development and improvement of the software for analysis.

The German-Lithuanian project has already achieved some very interesting and exciting results, of which the most important are presented in this article.[2]

Ėgliškiai-Anduliai

Ėgliškiai-Anduliai cemetery in southwest Lithuania is one of the largest Curonian stone circle burial sites, and has been researched since the end of the 19th century (Bitner-Wrólewska *et al.* 2008). Since archaeological investigations started on the site, about 800 graves altogether have been excavated, dating from the end of the second century AD to the first half of the 13th century. However, complex investigation, for instance, allows us to argue that the Ėgliškiai-Anduliai cemetery vanished at the end of the 12th century. Anyhow, only a few artefacts and some inventorial books, descriptions of graves and schematic artefact drawings have survived from the pre-Second World War research, so only a fragmentary reconstruction of the burial site features and grave complexes was possible. Therefore, new investigations, including archive as well as archaeological studies, were conducted recently, in order to collect all surviving data scattered throughout various national and international institutes, and set up a database which enables a more detailed reconstruction of the development of the Ėgliškiai-Anduliai cemetery site.

These efforts to collect data also included non-destructive research methods. With the help of geomagnetic investigation, the internal structure and dimensions of the cemetery, as well as the type, location and orientation of the burials if possible, should be clarified. Furthermore, it was important to gain information about the former late 19th and early 20th-century infrastructure, because no farmsteads or field roads have survived from that time to serve as reference points for the preserved excavation maps (Bitner-Wrólewska *et al.* 2008). It was therefore assumed that the detection of former buildings or roads may help to relocate excavated areas and plots.

The first trial geomagnetic surveys were conducted in 2006 (Bitner-Wrólewska *et al.* 2008, p.87, Table 1), but since 2010 further surveys have been carried out by the German Archaeological Institute (Fig. 2). Altogether, 3.5 hectares had been mapped by geomagnetic methods by 2014 (Fig. 3). These initial surveys have revealed a lot of new information about the structure and dimensions of the cemetery. One result is that the boundaries of the burial ground can be detected in the

[2] The authors would like to thank all their colleagues, students and friends who have participated in the project in recent years.

Fig. 2. Ėgliškiai-Anduliai. Geomagnetic survey with a five-channel magnetometer.

eastern, and probably also in the southern part, which is indicated by the significant decrease in the number of anomalies. Also remarkable is the possible internal structure of the cemetery. This is indicated by separate groups of presumed burial features within the cemetery, which seem to be isolated by open spaces. This observation is probably related to the cemetery's horizontal stratigraphy, which seems to spread from south to north (Bitner-Wrólewska *et al.* 2008, p.84).

An evaluation of the survey data also resulted in the detection of various graves and burial features. Numerous indications of stone circle graves were recorded especially in the southern part of the cemetery. This type of burial was already known in this area from excavations by A. Götze in 1895, and a recent small-scale excavation by A. Bliujienė in 2002 (2005, p.94ff.), who investigated one grave with a stone circle dating from the turn of the third century AD (Bitner-Wrólewska *et al.* 2008, p.82). The stones from the later investigation remained in the ground, and can therefore be used as geomagnetic reference data (Fig. 4). Based on this data, at least nine more stone circles can be assumed within a surveyed area of about 100 by 30 metres in size. These presumed stone circles consist of both stones and pits (stone marks), which are arranged in an almost circular shape; the diameters reach up to nine metres. In some cases, possible central grave pits can even be detected within the stone circle. The distribution of stone circles as the geomagnetic record indicates seems to be limited to the southern part; in other areas of the cemetery, no evidence of this burial type could be recorded. Therefore, it is quite likely that the Roman Iron Age part of the cemetery was located only in the south and close to the hill-fort, while later graves were further north.

Detecting other burial types like inhumation and cremation pit graves without any construction features is more difficult. Such graves, dating from the tenth to the end of the 12th century, were investigated in the middle part of the study area. Geomagnetic prospection in this area revealed a few minor accumulations of anomalies in the central eastern and the western part of the survey plot. Based on the already-mentioned small-scale investigations south of the plot, a preliminary interpretation of the anomalies detected as presumed burials (inhumation and cremation pits) is very conceivable. This interpretation may also be confirmed by numerous artefacts dating from the Late Migration and Pre-Viking Age that have been found within the survey plot by metal detector surveys, and which can be used as indicators of burials.

In addition to the archaeological data, new information about former development and land use in the 19th and 20th centuries could also be obtained. For-

Fig. 3. Ėgliškiai-Anduliai. The 2010–2012 geomagnetic surveys; areas of investigation (-10/+10 nT).

mer field boundaries, still partly visible in the fields as small embankments, and presumed paths, are especially well displayed as linear structures in the magnetometer-record. In addition, several anomalies also reveal some evidence of former settlements, which are known from historical sources (e.g. maps). Anyhow, distinct evidence of buildings was not discovered, but huge anomalies and accumulations of numerous anomalies, dipoles and positive anomalies, indicate former settlements.

Opstainiai/Vilkyškiai

The hill-fort complex is situated in southwest Lithuania, in the present-day Vilkyškiai ward of Pagėgiai (Jarockis, Messal 2013). The site is attributed to the Iron Age ethnic and cultural area of the lower part of the River Nemunas and the Scalvians (Tautavičius 1996, p.81ff.). The fortification is on a ridge on the left bank of the Apsta rivulet (Fig. 5). The plateau is trapezium-shaped, and fortified by an earth rampart, 40 metres long and four metres high, and a nine-metre-wide and one-metre-deep moat on the northern edge of the plateau (Baubonis, Zabiela 2005, vol. II, p.148ff.). Two outer settlements were known according to surface finds, small-scale excavations and geomagnetic data. One settlement is located east of the hill-fort; the second is to the north and northwest of the hill-fort.

Geomagnetic surveys have been conducted at Opstainiai/Vilkyškiai since 2010, to gain more information

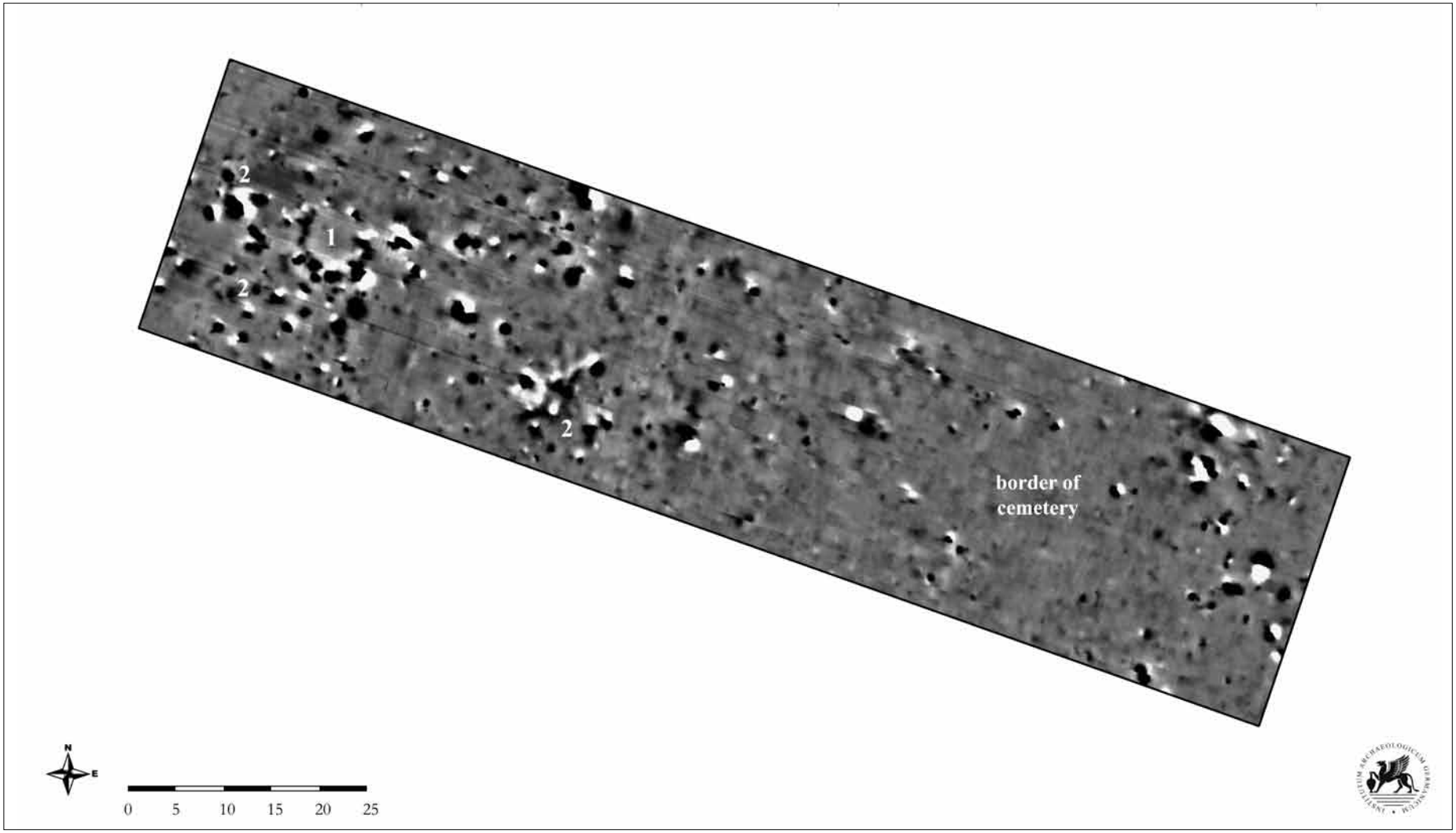

Fig. 4. Ėgliškiai-Anduliai. The area of stone circle graves: 1 excavated stone circle grave; 2 presumed stone circle graves (-10/+10 nT).

Fig. 5. Opstainiai/Vilkyškiai. Aerial photograph of the Iron Age hill-fort/settlement complex from the northwest (photograph by G. Zabiela, 1 March 2009).

about the dimensions, structure and possible fortifications of the site, especially the outer settlements. A total area of 3.9 hectares is currently being investigated by geomagnetic survey in all parts of the site (Fig. 6).

The hill-fort plateau

Measurements on the hill-fort plateau revealed only a scattered distribution of anomalies (Fig. 7). This may be explained by processes of erosion, and also by the different kinds of building types (such as log buildings), which do not usually leave any traces in the ground. The use of the plateau during the Second World War also led to the mass destruction of archaeological features.

Nevertheless, the geomagnetic survey confirmed several anomalies which may indicate settlement activity on the site. These anomalies are distributed all over the plateau, and should be interpreted as archaeological features, like pits for various functions, and hearths. The distribution of the features confirms the habitation of the entire plateau. In addition, several elongated anomalies could be detected along the edges of the plateau. The interpretation of these anomalies as traces of a former fortification of the hill-fort, or as trenches from the Second World War, cannot currently be confirmed, and should be verified by further investigation.

The eastern settlement (lower settlement)

Surveys within the outer settlement to the east and northeast of the hill-fort covered a 320-metre-long and 110-metre-wide field, which rises slightly from south to north. The hilltop is located in the northwest of the field (Fig. 6). Due to vegetation, the areas close to the hill-fort could not be investigated.

An evaluation of the survey data provides much evidence of archaeological features within the eastern settlement; however, indications of a presumed fortification could not be detected. Many anomalies located within or close to the known ‘black earth’ area of the settlement, especially in the southern part of the survey plot, can be interpreted as archaeological features. Initial archaeological excavations of selected anomalies have confirmed this interpretation; during these investigations, semi-pit houses and storage pits could be verified (Jarockis, Messal 2013, p.358ff.).

Fig. 6. Opstainiai/Vilkyškiai. The 2010–2012 geomagnetic surveys: areas of investigation (5-/16-channel magnetometer; -6/+6 nT).

In a few cases, linear arrangements of anomalies can also be observed, but clear structures indicating a clear settlement pattern (buildings, fences) could not be made out. Only in the northernmost part of the survey plot was a rectangular structure consisting of at least 20 small rounded and oval anomalies detected. The structure is about 19 metres long, and seven to nine metres wide; the average distance between single anomalies is between 1.8 and two metres. The interpretation of this structure remains open, but the rectangular plot and the size of the structure may indicate the location of a post building.

The northern settlement (upper settlement)

The geomagnetic survey within the northern settlement revealed numerous anomalies indicating settlement activity. A rectangular structure with dimensions of six by four metres, which is interpreted, according to numerous analogies (Batora *et al.* 2009, p.9ff.; Burdo *et al.* 2012), as the remains of a burnt building (Fig. 7), is remarkable. Other larger accumulations of anomalies to the south and east of this structure may therefore indicate similar structures. Smaller anomalies surrounding the presumed buildings may be interpreted as pits, postholes or hearths/fireplaces.

Unlike the eastern settlement, the northern part was fortified. This is indicated by a linear structure, with a recorded length of about 70.5 metres, and a width of about six metres, which runs roughly from the eastern slope of the hill in a western direction, and then bends to the south (Fig. 7). Even if the southern end was not detected, we can assume that the structure extends further south towards the hill-fort. An interpretation as a moat is very likely, indicating the border of the settlement. This is confirmed by the fact that to the north of the presumed moat, very few anomalies could be detected; while to the south of it, most of the archaeologically interpreted anomalies could be observed. Also, the existence of a former earth rampart can be supposed, because the closest settlement traces were

Fig. 7. Opstainiai/Vilkyškiai. Geomagnetic survey: details of the hill-fort plateau and northern settlement, with probable ditch and burnt houses (5-/16-channel magnetometer; -6/+6 nT).

detected about ten metres behind the moat. This may well suggest a now levelled rampart behind the ditch; the buildings were then constructed immediately behind the fortification.

Jakai/Sudmantai

About six kilometres east of Klaipėda, in a vast lowland landscape close to the village of Jakai, is a small, rather level enclosure; flattened walls up to 60 centimetres high are preserved (Baubonis, Zabiela vol. I, p.418ff.). The site has been known since the beginning of the 20th century, and was already recorded in the Königliche-Preussische Landesaufnahme in 1910/1912 as 'Alte Schanze', as well as being mentioned by Hans Crome in 1937 (1937, p.125, No. 26). Initial excavations were conducted by R. Banytė and V. Žulkus to verify the character of the enclosure in 1993, when several small test pits were excavated within and outside the monument (Banytė, Žulkus 1994) (Fig. 8). However, the interpretation, construction, and the date of the enclosure remained largely unknown. A preliminary chronology according to analogies in Scandinavia and Estonia varied between the first millennium BC and the Viking Age (Zabiela 1995, p.230; 2008, p.143ff.).

Because of these open questions, a geomagnetic survey was conducted, primarily to obtain more insights into the construction of the assumed fortification. Moreover, the inner structure of the enclosure should be clarified. Based on the results, initial excavations in order to answer issues concerning the interpretation and the date of the site will be conducted. A survey in 2012 covered the whole monument, and comprises 1.1 hectares; only a 12 by seven-metre spot within the enclosure, currently used as a rubbish dump, had to be excluded from the survey (Fig. 9).

The construction of the enclosure is clearly recognisable within the geomagnetic record. The monument

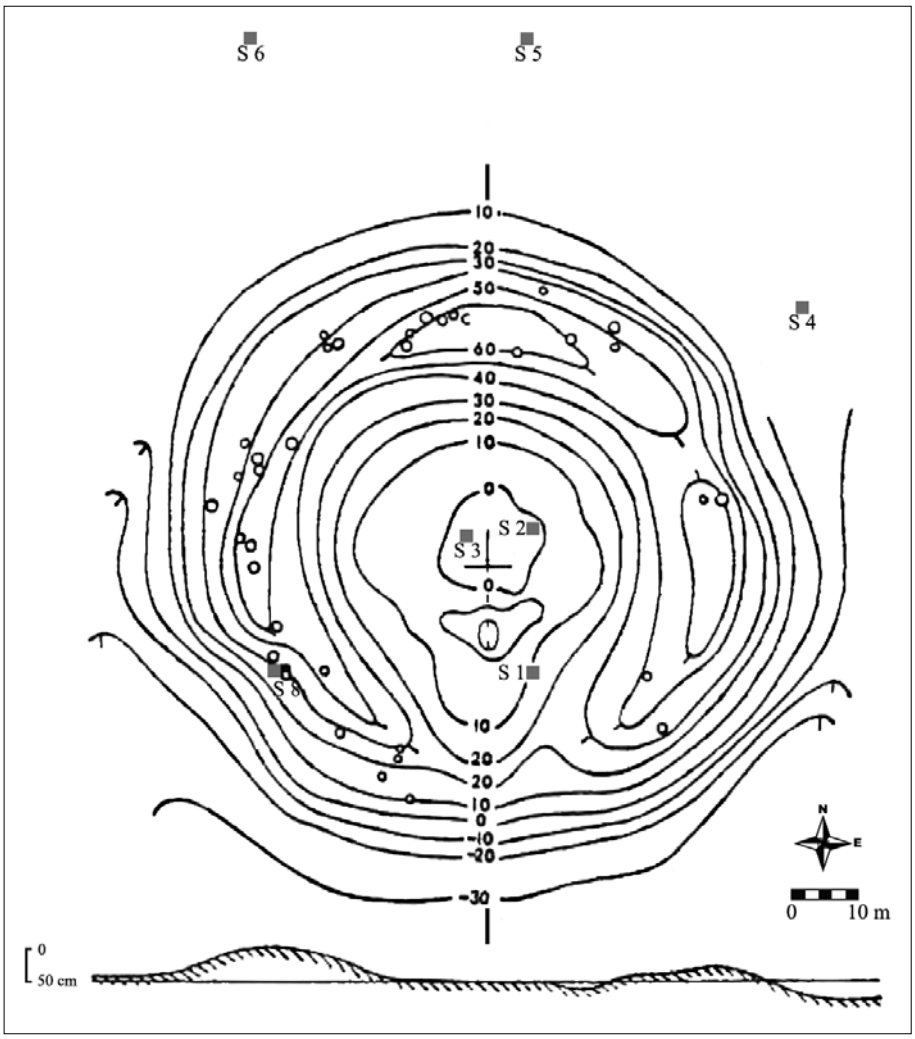

Fig. 8. Jakai/Sudmantai. Schematic plan of the fortification and excavation trenches of 1993 (after Banytė, Žulkus 1994, Fig. 4).

consists of a circular stone rampart, almost round in shape; the outer diameter is about 75 to 78 metres, the inner one about 53 to 56 metres. The inner length of the rampart is about 185 metres, enclosing an area of about 2,500 to 2,600 square metres. The state of preservation is mostly good, only the southern and western parts of the rampart have experienced greater destruction by the removal of stones. Moreover, a huge disturbance, probably one of the test pits (No 8), could be detected along the southwest course of the rampart.

The rampart was constructed, as the geomagnetic record indicates, by at least two rows of stones/boulders on the inside and outside; the width is about seven to eight metres. Along the northern part of the rampart, a third, inner row of stones can also be detected, perhaps indicating two rampart sections (three to four metres each), or even two stages of construction. The stones are displayed in the record as positive anomalies with a partially white periphery, and dipoles indicating the use of non-magnetic and magnetic stones. Based on this, the rampart may be described as dry stone masonry with an inner and outer wall shell. The wall space was probably filled with soil, since a clear stone filling is not detectable.

The location of gates cannot be determined exactly. Along the southern and western course of the rampart, some gaps can be recognised, which may indicate former gates. But since this part of the rampart is already severely damaged by the removal of stones, the question remains open.

The interior of the enclosure is characterised by numerous small, almost uniformly distributed anomalies, which in most cases may have been caused by stones (non-magnetic and magnetic stones), and less frequently by pits and post holes. A few larger anomalies were probably caused by the initial test pits Nos 1 to 3 in 1993. Moreover, some modern metal objects with high nT-values buried close to or on the surface can be detected, as well as one presumed modern metal post in the centre. An accumulation of several larger anomalies in the southwest part of the plateau cannot

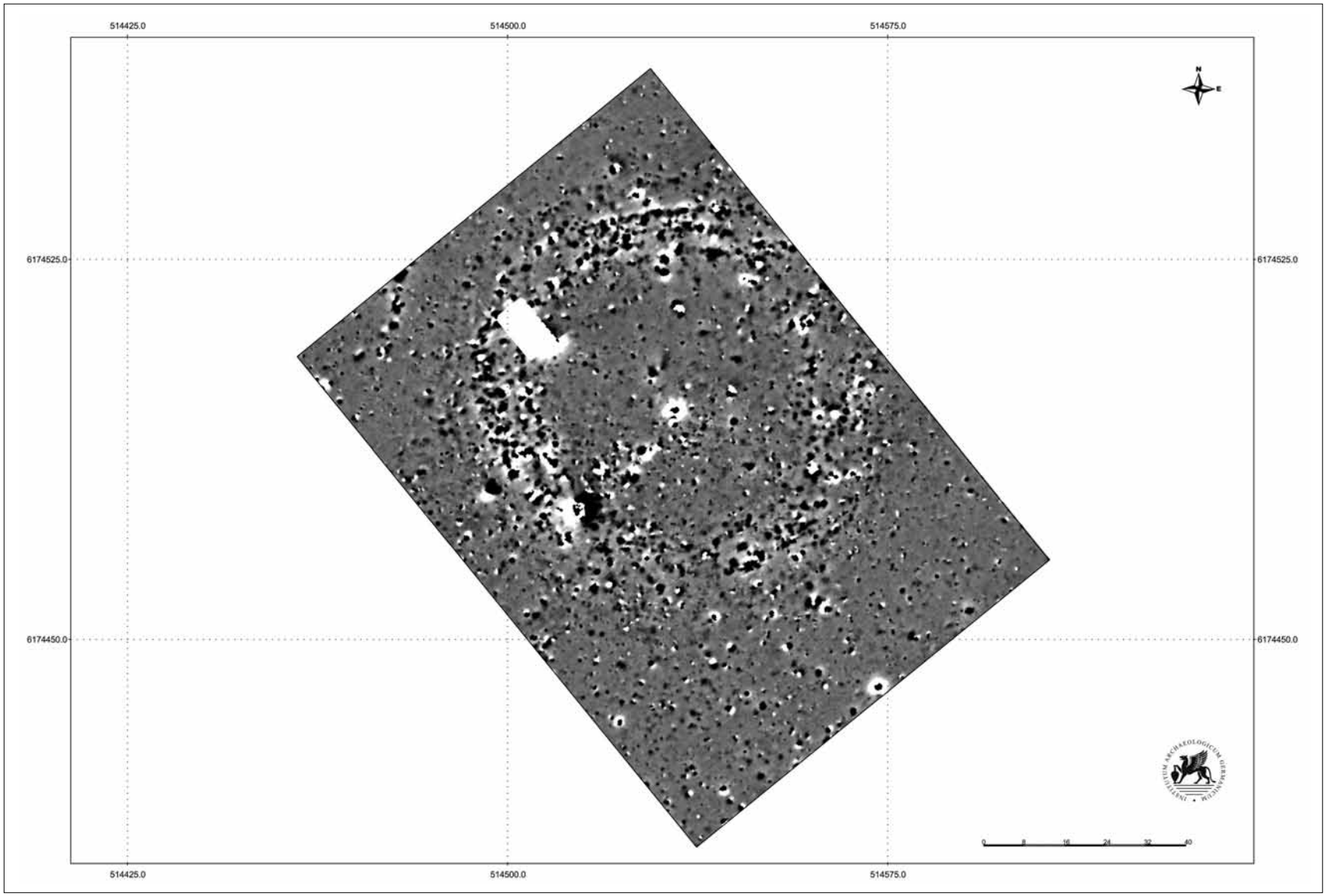

Fig. 9. Jakai/Sudmantai. The 2012 geomagnetic survey (-12/+12 nT).

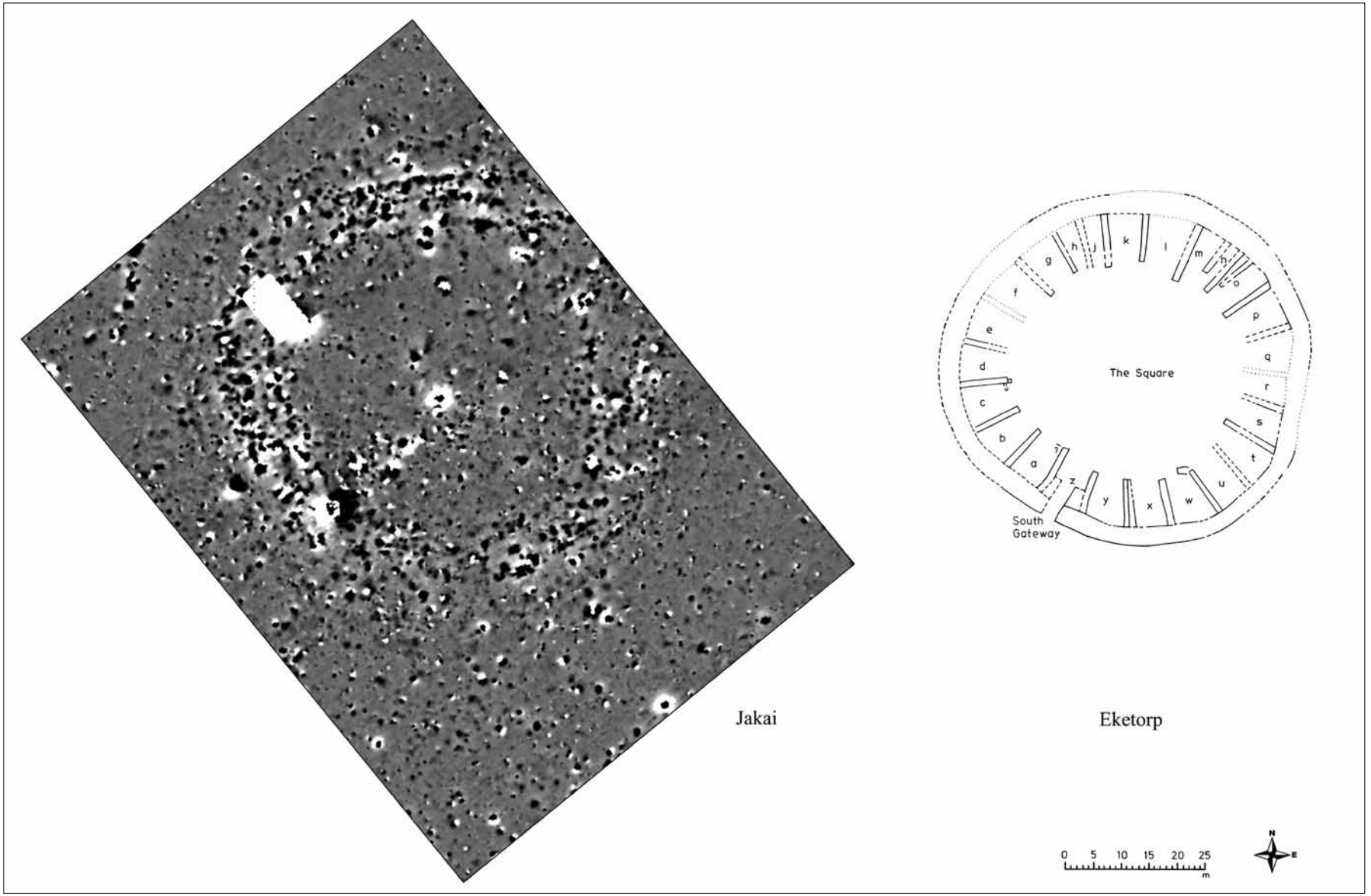

Fig. 10. Jakai/Sudmantai and Eketorp (after Weber 1976, Fig. 58).

Fig. 11. Taurapilis. Aerial photograph of the hill-fort from the south. In the foreground the moat of the settlement is very weakly recognisable as linear green discoloration/crop mark (Photo by Z. Baubonis, 28 July 2006).

currently be explained, a modern origin (stone heap of excavation No 8, rubbish, etc) may be assumed.

Clear archaeological structures as indicators of a permanent settlement inside the enclosure cannot be observed within the geomagnetic record. However, it is remarkable that numerous anomalies were accumulated behind the inner wall shell, which may indicate house construction immediately behind the wall, but also relocated stones from the rampart.

The enclosure is apparently surrounded by another circular structure, which is only slightly visible within the geomagnetic record and in aerial pictures. This structure extends around the entire rampart, and is shown as faint grey discoloration, which is characteristic of weak-magnetic anomalies. The width cannot always be determined; it varies between six and nine metres. The inner side joins directly to the wall; along the outside, several single anomalies (stones, posts?) can be detected, indicating an outer boundary. The location in front of the rampart allows a preliminary interpretation of the structure as a moat, but another outer earthen construction (a further construction phase?) may also be considered.

Numerous anomalies could also be detected outside the monument. These are quite uniformly distributed, but more to the south and east of the enclosure. The interpretation of these anomalies remains open, but settlement traces cannot be excluded. Another interesting structure, consisting of several larger anomalies, was partly detected along the northwest edge of the plot. The orientation of this structure seems to be similar to the course of the rampart, and it probably also extends west of the enclosure, as at least five huge single anomalies indicate. An archaeological context to the wall may be assumed (an outer fortification?), but cannot currently be proved.

After an initial geomagnetic survey, the enclosure at Jakai can be interpreted as a fortification; and since no settlement traces within the inner plateau can currently be proven, the fortification may have functioned as an outpost of the surrounding micro-region. It is remarkable, however, that the rampart was built as dry stone masonry, with an inner and outer wall shell. This type of construction is not typical in present-day Lithuania. Only two other enclosures of a similar type are known, at Auksūdis and Arsla (Baubonis, Zabiela 2005, vol. I, p.438ff., vol. II, p.366ff.). Such fortifications are typical of Scandinavian enclosures, as V. Žulkus has already suggested (Žulkus 2000, p.103ff.), but they are also known in southeast and east Baltic regions (Tvauri 2012, pp.47ff, 53ff.; Figs. 10, 11; Bliujienė 2013, p.195ff., Fig. 109). Interestingly, the fortification at Jakai/Sudmantai bears very close similarities

Fig. 12. Taurapilis. Geomagnetic surveys 2011-2012, areas of investigation (-20/+20 nT); 1-2 archaeological trenches 2012.

to the oldest fortification at Eketorp on Öland/Sweden: the similar dimensions and the same stone wall construction are more than apparent (Weber 1976, p.61ff.; see also: Näsman 1989) (Fig. 10). Even if the results of the geomagnetic survey are preliminary and need to be verified, the construction and dimensions seem too similar to be accidental. The only differences occur concerning the settlement structures within the fortification, which at Jakai/Sudmantai is not as clearly detectable as at Eketorp. However, based on a preliminary hypothesis as a Scandinavian fortification, information on the possible dating of the site at Jakai/Sudmantai can also be obtained. The oldest fortification at Eketorp (Eketorp I) is dated to the Early Roman Iron Age (fourth century AD). A similar date can also be supposed for Jakai/Sudmantai.

The archaeological background of a fortification of possible 'Scandinavian type' in west Lithuania should not be discussed here. Of course, possible migrations by Scandinavians are possible, as well as cultural contacts and general communication, but without further investigation, the context remains only speculative. Therefore, further interdisciplinary studies should be conducted at Jakai/Sudmantai to obtain more information about the date, construction and settlement structure of the site, and also about the surrounding landscape (settlements and cemeteries). Moreover, the enclosures of Auksūdis and Arsla, which seem to be in a comparable context, also need to be included in these studies, to verify the character of the sites in terms of interpretation, date and context.

Taurapilis

Taurapilis is one of the most famous sites in Lithuania. It is located in northeast Lithuania, and consists of a huge hill-fort with a surrounding settlement, and two nearby barrow cemeteries (Fig. 11). The west barrow group was partly excavated in 1970 and 1971 (Tautavičius 1981). At least eight barrows were investigated, and several rich burials from the end of the fifth to the first half of the sixth century AD were documented, including the burial of the 'Taurapilis duke'. No research has taken place within the hill-fort and the settlement; the dating, internal structure and dimensions of the site therefore remain unknown.

New interdisciplinary investigations were conducted recently in order to enable a more detailed reconstruction of the settlement history of the Taurapilis site. These investigations currently involve comprehensive geomagnetic and drilling surveys, and small-scale excavations (Stankevičiūtė *et al.* 2013; Zabiela, Messal 2014). Moreover, isotope analyses of bone material from the former excavation are planned.

Geomagnetic surveys

Geomagnetic investigations were conducted at Taurapilis in 2011 and 2012. Altogether, about five hectares were surveyed (Fig. 12). The surveys covered the hill-fort plateau and parts of the outer settlement, and part of the western cemetery, which is currently covered by trees. In addition, some fields in the vicinity of the site, especially to the west of the cemetery, were partly surveyed, to obtain data on possible archaeological structures outside the settlement.

The hill-fort

The Taurapilis hill-fort is on a single hill with steep 13 to 14-metre-high slopes, situated on the southern shore of Lake Tauragnai. The plateau lies in a long west-east direction, 90 by 14 to 22 metres, with the remains of walls up to one metre at both ends (Baubonis, Zabiela 2005, vol. III, p.270ff.). Almost all the hill-fort was surveyed; only small areas were excluded, due to vegetation and a north-south running ditch separating the western part of the plateau (Fig. 13). Numerous dipole anomalies were detected in the eastern part of the plateau close to the modern stairway. These dipoles display modern metal objects. However, the survey data also provides some new information about the development structure of the hill-fort. Two larger structures may be interpreted as the remains of former buildings. The first is located in the western part of the plateau, and consists of several rectangular arranged anomalies; the size is about 7.3 by 5.3 metres. The other structure was recorded on the northern edge of the plateau. Several positive anomalies, partly rectangular in shape, form an approximately six by three-metre ground plan of a possible former building. It is known from written sources that the hill-fort burned down in February 1433: the anomalies may therefore be interpreted as the remains of burnt wooden floors, or the frames of buildings which provide strong signals in the geomagnetic record. Smaller anomalies surrounding the presumed buildings may also be interpreted as associated pits and hearths.

Along the edges of the plateau, several linear or large anomalies could be detected. These anomalies may be interpreted as the remains of a former, now levelled fortification of the plateau, which is also burnt, and therefore very recognisable in the geomagnetic evidence.

Fig. 13. Taurapilis. Geomagnetic survey, detailed map of hill-fort and settlement area (-20/+20 nT).

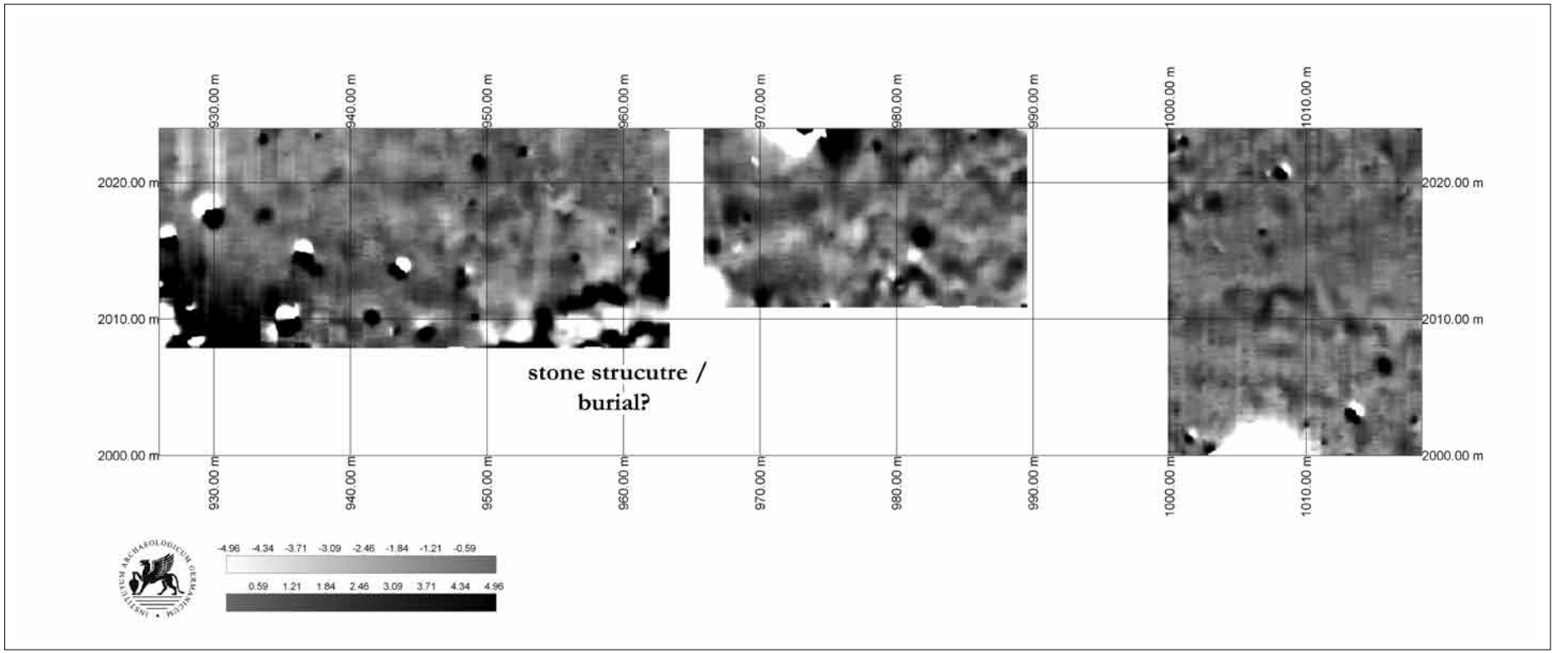

Fig. 14. Taurapilis. Geomagnetic survey, detailed map of cemetery area (-5/+5 nT). The presumed stone chamber burial is marked.

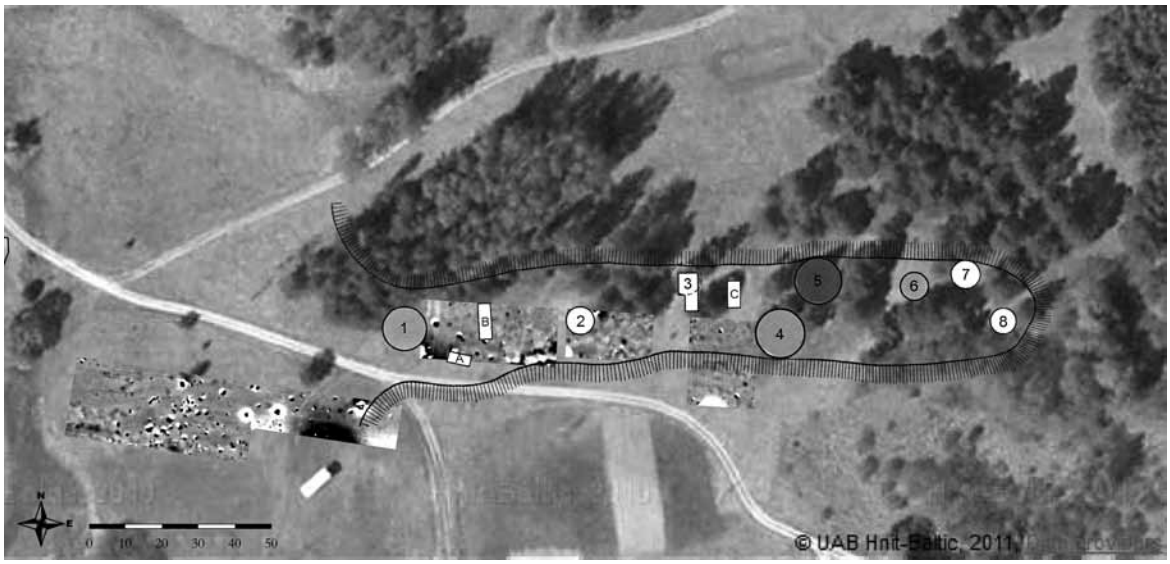

Fig. 15. Taurapilis. Western cemetery, combined map of geomagnetic survey and excavated burials (1970/71; No 5 "Duke" of Taurapilis; after Tautavičius 1981).

The settlement

Surveys within the settlement also revealed new information of various kinds (Fig. 13). Numerous dipole anomalies were caused by modern objects, mainly iron objects or bricks, in the agricultural layer. Especially in the southern parts of the surveyed areas, which are characterised by modern farmsteads and currently cultivated fields, huge concentrations of dipoles were recorded. Also former field systems, shown as white linear structures, can be detected, as well as underground pipes or power lines. Other extensive anomalies, disturbing the record, are caused by the modern infrastructure, like concrete posts, information panels and buildings or containers.

The most important archaeological result in the geomagnetic record is the detection of a previously unknown moat which fortified the settlement (Fig. 13). The remains of a rampart could not be geophysically detected, but are proven by initial archaeological investigations (Stankevičiūtė *et al.* 2013). The moat curves slightly from the west in a northeast direction into Lake Tauragnai, and could be proven, with a gap of 32 metres, over a length of about 190 metres. The course to the west is disturbed by a modern farmstead, but it probably coincides with a horseshoe-shaped earthwork in the west of the site. The steep and deep walls of that ditch seem to be of a fairly modern shape, the further course of both ends into the lake is assured by the geomagnetics. However, it is possible that the ditch may be oriented to the course of the older moat. This is also indicated by the little evidence of possible settlement activities west of this ditch.

The detection of the moat clearly simplifies the interpretation of anomalies recorded within the enclosed settlement as archaeological features. These are distributed over the whole settlement area, and indicate intense building density within the settlement. The archaeological features are interpreted mainly, for example, as pits and post holes, and hearths and ovens. Former residential areas are therefore usually characterised by accumulations of anomalies of various types and sizes. Buildings are, however, more difficult to determine; in only a few cases can indications of supposed post buildings be observed.

The west barrow cemetery

Eight barrows were excavated in 1970 and 1971, but it remains unknown whether the whole cemetery was investigated at that time. A geomagnetic survey was therefore conducted to verify the supposed existence of more burials, like flat graves and ploughed barrows.

The survey revealed clear results. Between the investigated barrows, no further graves were detected; only at the southern edge of the barrow group, an almost rectangular structure made of several positive anomalies was discovered (Fig. 14). The length of the structure is about 6.5 metres, the width 3.5 metres. The interpretation remains unclear, but another grave can surely be considered. The rectangular layout of the anomalies indicates a stone construction, suggested by analogies such as Eitulionys in southeast Lithuania (Kurila 2007, p.293). It can therefore be assumed that the geomagnetic survey discovered at least one unknown and unexcavated grave in the cemetery (Fig. 15).

Fig. 16. Taurapilis. Geomagnetic survey with 16-channel-magnetometer within the settlement area.

Summary and conclusions

Since 2010, several archaeological sites in Lithuania have been geomagnetically surveyed through German-Lithuanian cooperation (Fig. 16). The objectives of these surveys were in general a discussion of non-invasive methods in Lithuanian archaeology, and in particular archaeological issues of the various sites.

These geomagnetic surveys revealed in many cases very interesting and exciting results. In almost all the sites, features and structures could be detected that enable some initial statements on the structure and dimensions of the archaeological monuments. For some sites, the surveys also provided very precise and hitherto unknown information about the settlement context, as in Taurapilis and Opstainiai/Vilkyškiai (fortification ditches), or Jakai/Sudmantai (stone wall fortifications). These new results show clearly the potential of non-invasive, especially geomagnetic, methods for archaeological purposes; not just for archaeological research, but also for cultural heritage management. The geomagnetic data can be used differently: for example, as a basis for specific archaeological investigations, which have already been conducted in Taurapilis (Stankevičiūtė *et al.* 2013; Zabiela, Messal 2014), or for the development of future concepts and strategies for the protection and preservation of these sites.

However, only the combination of several methods and tools enables a maximum level of knowledge and information of the scientific value and potential of archaeological sites and landscapes. The task of the coming years must therefore be to focus on the application and combination of further non-invasive geophysical (ground penetrating radar, electrical resistivity) and remote sensing methods in archaeological surveys.

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NEARDANTYS METODAI LIETUVOS ARCHEOLOGINIUOSE LAUKO TYRIMUOSE. PIRMIEJI VOKIETIJOS IR LIETUVOS BENDRADARBIAVIMO REZULTATAI

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Santrauka

Nuo 2010 m. keliolika Lietuvos archeologinių paminklų buvo žvalgyti naudojant magnetometrą (1–2; 16 pav.,). Šių žvalgymų tikslas buvo neardančių tyrimo metodų taikymas skirtinguose Lietuvos archeologijos paminkluose. Daugeliu atvejų šis metodas pateikė labai įdomių rezultatų. Beveik visuose tirtuose paminkluose buvo identifikuoti įvairūs objektai ir struktūros, kurie įgalina daryti kai kurias pradines prielaidas apie archeologinių paminklų sąrangą ir dydį. Be to, kai kurių iš žvalgytų paminklų geomagnetiniai tyrimai pateikė labai tikslią ir iki tol nežinotą informaciją apie gyvenviečių struktūrą. Tokie pavyzdžiai gali būti Taurapilio ir Opstainių (Vilkyškių) piliakalnių papėdės gyvenvietės ir Jakų (Sudmantų) žiedinis įtvirtinimas,

suręstas iš akmenų (5–15 pav.). Taip pat buvo gauta naujų duomenų apie Ėgliškių-Andulių kapinyno struktūrą, ypač apie kapus su akmenų vainikais (3–7 pav.). Šie nauji duomenys rodo akivaizdžią neardančių tyrimų svarbą ir yra naudingi ne tik archeologinių žvalgymų ir platesnių tyrimų, bet ir paminklų tvarkymo srityje. Pažymėtina, kad geomagnetinio tyrimo metodu gauti duomenys gali būti naudojami skirtingai. Jie gali padėti renkantis žvalgymų metu išryškėjusių struktūrų ar didesnės apimties archeologinių tyrimų vietas. Be to, tokie tyrimai įgalina numatyti tolesnę paminklo tyrimų ir apsaugos strategiją. Šių dienų archeologijoje tampa akivaizdu, kad tik kelių neardančių tyrimo metodų (georadaras, elektros varžos matavimo metodas ir kt.) taikymas įgalina gauti mokslui vertingų žinių apie patį paminklą ir kraštovaizdį.