Archaeologia Polona, vol. 41: 2003, 57–78
PL ISSN 0066-5924

Geophysical reconnaisance at the site of Tanais (Russia) in 1993–2003

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The paper presents the results of geophysical prospection carried out on sites in the vicinity of the Greek colony of Tanais in the course of fieldwork in 1993–2003. Included is a discussion of geoelectric resistivity survey methodology using different systems of profiling and sounding, as well as survey results verified by archaeological excavations. Activities constituting the framework for non-intrusive archaeological research in the city area and its immediate vicinity, the *chora* and cemeteries, have been described (combining analyses of aerial and satellite photography with geophysical research, field walking and archaeological testing). The results of prospecting at these multi-layered sites provided the grounds for preparing the methodology of geophysical surveying of archaeological features of a similar kind.

KEY-WORDS: archaeology, geophysics, Russia, Tanais, Greek colonies

The Greek colony of Tanais, which was situated at the mouth of the Don on the Azov Sea (Fig. 1) and which was inhabited from the 3rd century BC to the 5th century AD, is mentioned in the ancient sources, Strabo included, as the most northerly point of antique civilization. Archaeological interest in the site has practically not flagged ever since 1853 (expeditions of P.M. Leontiev, V. Tisenhausen and P.I. Hicunov) and in 1955 the Lower Don Expedition of the Institute of Archaeology of the Russian Academy of Sciences from Moscow embarked on systematic investigations, directed first by Dimitr B. Shelov and following his demise by Prof. Tatiana M. Arsen'eva. The expedition invested in international support, cooperating with Deutsches Archäologisches Institut, Eurasien-Abteilung in Berlin to form a German team which has been excavating the town since 1993, and with the Institute of Archaeology of Warsaw University in association with the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Warsaw to form a Polish group to investigate the necropolis (1996–1998) and the *chora*, the immediate hinterland of the town (since 1999).

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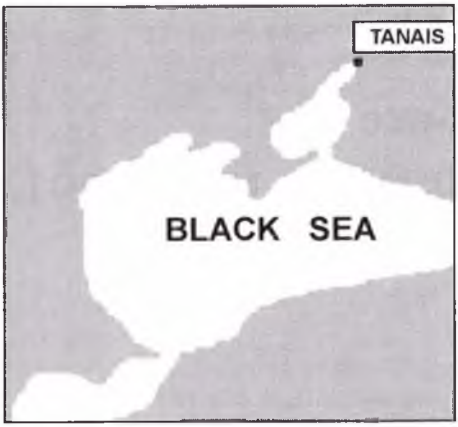


Fig. 1. Tanais. Site location.

A museum and archaeological reserve has been in operation at the site since 1961; it is a state institution run by the Ministry of Culture of the Russian Federation. The Museum is charged with coordinating archaeological research and conducting rescue excavations in the protected zone, which covers an area of over 200 ha.

Geophysical prospection on the site started with a reconnaissance in 1993, the objective of the survey being to identify the most promising places for excavation by all three teams. The central square (*agora*) and a religious enclosure in the northeastern part of the fortified area were located as a consequence (Herbich and Misiewicz 1995; Böttger, Herbich and Misiewicz 1996). The survey also traced the surviving parts of the fortifications on the south side of the town (Misiewicz 1998a) and identified the conditions for tomb location in the cemetery (Arsen'eva and Scholl 1999).

In the course of work a number of experiments were carried out with the objective of comparing the effectiveness of various research techniques (Misiewicz and Zurbickiy 1996). One was remote-sensing which was used to examine in a non-invasive way the most important surviving structures of the barrow cemetery (Garbuzov, Misiewicz and Tollochko 2001). Different techniques of taking measurements were developed and tested in practice in order to ascertain the most effective means of tracing changes of apparent resistivity on multi-layered archaeological sites (Misiewicz 2001). Field experience from Tanais served as exemplification in studies on the optimal use of geophysical prospection results in planning archaeological excavation work (Misiewicz 1998b) and for prospection carried out as part of rescue projects (Misiewicz 1999).

The conditions found at this particular site practically excluded the use of any method other than geoelectric resistivity. The site is located close to a railway line, different-voltage power transmission lines run in the immediate vicinity, water and gas mains, as well as hardened roads and a ground telephone network are to be found in the modern locality of Niedvidovka overlying the ancient site. Under these conditions any magnetic prospection, whether inside the city or on the necropolis, was bound to give negative results, recording instead substantial modern disturbances and suffering from the insufficient contrast between archaeological structures erected of the local limestone and the natural limestone surroundings. Reliable and satisfactory electromagnetic measurements were difficult to take and it was no easier to interpret the recorded anomalies (Misiewicz and Zurbickiy 1996: 163).

To be effective, resistivity method also required certain steps in order to ensure sufficiently correct readings. Measurements had to be taken repeatedly, using various electrode configurations and measuring systems. Surveying was done both in the early spring and late autumn to take full advantage of the varying humidity effect in subsurface layers, thus increasing the chances for recording anomalies triggered by extant archaeological remains.

The site in question was a multi-layered one. Ruins of architectural structures (mainly cellars) made of stone were situated at a depth of even 6 m below the present ground surface. In many places these stone features had served as foundations for later clay and stone structures superposed on them. Repeated street course changes and modifications of the architectural layout during the town's existence resulted in our resistivity maps imaging anomalies corresponding to a variety of archaeological features of varying thickness and at different depths, occasionally even heavily burned.

Satisfactory results from geophysical prospection were fostered by immediate field verification, either through archaeological testing or broad-scale excavations, of all hypotheses formulated in effect of the survey. Checking the resistivity imaging against the actual situation in the field allowed regular updating of measurement techniques and continuous improvement of interpretation skills. The outcome of these activities shall be exemplified below with a discussion first of the geophysical survey carried out in the immediate vicinity of trench XIX (which had been dug by the Germans in 1996–98 and in 2002), and then of the application of geophysical prospection in some rescue work done on the site.

The area surveyed during the first geophysical prospection of the site in 1993–1995 was contained within the borders of the ancient town (Fig. 2). Fieldwork involved a twin-electrode system for shallow prospection and a middle gradient array for deeper lying strata (Böttger, Herbich and Misiewicz 1996:456–8). It was noted that archaeological planning benefited from precise data on the depth of particular archaeological features. For this purpose, a series of vertical electrical soundings was made in a one-meter grid. The apparatus used was an alternating-current ARA03, giving readings of resistivity that could be stored in RAM memory along with measurement point coordinates and processed to construct graphic maps of resistivity distribution and apparent resistivity pseudo-sections (Herbich, Misiewicz and Mucha 1998:127 ff).

The survey north of trench XIX covered an area 35 by 20 m; a total of 450 soundings was made (Fig. 3). MN potential electrode spacing equal to 0.3 m was applied for current electrode AB spacing between 1 and 9 m and MN equal to 3 m for AB electrode spacing between 12 and 28 m. This provided data on apparent resistivity distribution changes to a depth of from 0.3 to *ca.* 5 m. The changes in resistivity were presented in 12 maps of resistivity distribution at different AB electrode

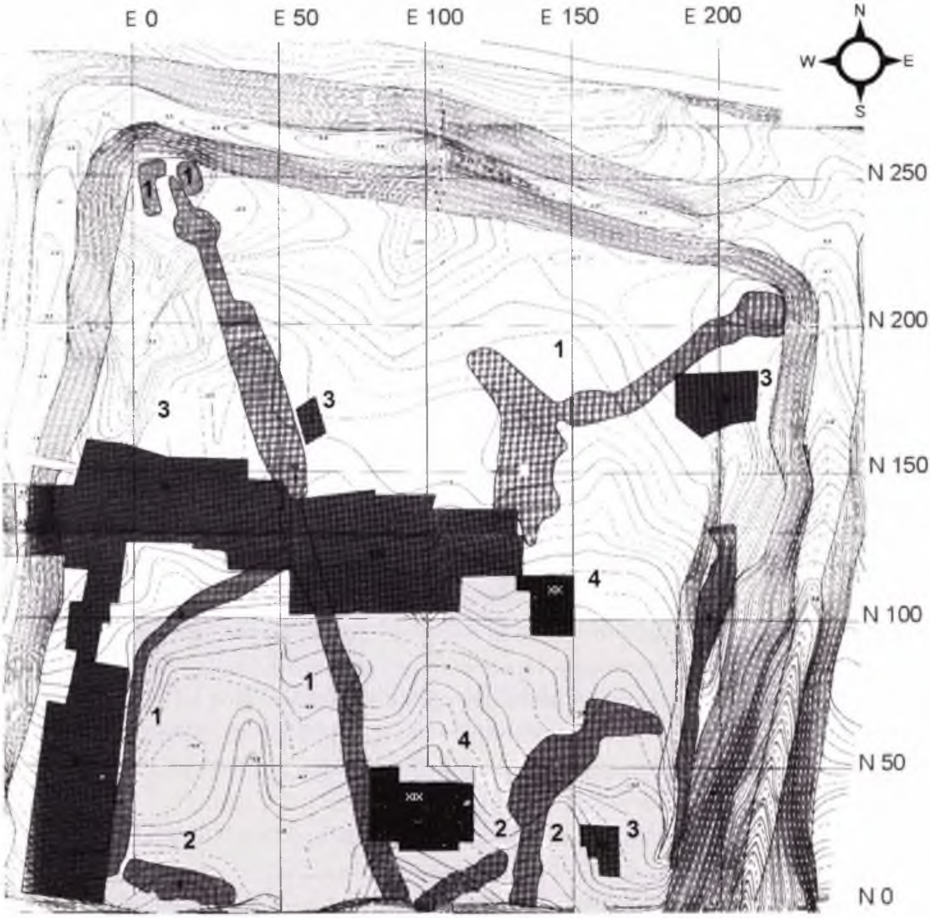


Fig. 2. Tanais. Location of areas of geophysical research (in gray) and excavation work. 1: P.M. Leontiev's trenches of 1853; 2: V. Tisenhausen's trenches of 1867; 3: trenches of the Lower Don Expedition from 1955 to 1993; 4: trenches of the Lower Don Expedition after 1993. Trench XIX, state in 1995.

spacing, that is, for different current penetration depths. Six maps of the eastern part of the surveyed area (Fig. 4) and nine maps of the northern part were analyzed in detail. Additionally, 5 apparent resistivity pseudo-sections (Fig. 5) were made along meters N 51, 52, 53, 54 and 55.

The range of recorded resistivity changes was 50–800 ohm-m. The biggest differentiation of resistivity was to be seen on maps representing the resistivity of subsurface layers measured with AB electrode spacing from 0.3 to 4 m (current penetration range from 0.3 to 1–1.5 m). A number of regularly shaped anomalies, possibly caused by archaeological features lying at this depth, came to light. Some of the recorded anomalies (*e.g.* raised resistivity at the borders of meters E 75–E 90) also continued at a deeper depth. All maps, where the current penetration reached 1.5 m, recorded a narrow low-resistivity feature between meters E 68 and E 75 in the western part of the surveyed area. This corresponded on the surface to the traces of the oldest trenches, called Leontiev's trenches, dating from the 19th century. To judge by the resistivity distribution image, the backfill of these trenches was characterized by low resistivity, indicating a natural process, that is, that the trenches had remained more or less open for a longer period of time. Additionally, narrow high-resistivity anomalies were recorded in the sections bordering the trenches to the east and west. This suggested that not all the archaeological remains had been uncovered during 19th century exploration. It was observed that with current penetration greater than 3.5 m the changes in apparent resistivity not exceeding 300 ohm-m at AB electrode spacing of 18 m are insignificant and are presumably due to changing bedrock structure, which is composed here of more or less extensively fissured limestone. It was decided that the distinctly higher resistivity recorded at this penetration depth could be related to debris-filled cellars and foundation trenches cut in bedrock. This kind of anomaly was recorded at meters E 80–E 85 and in the vicinity of meters E 90–E 100, where they form narrow, obliquely-running features. Characteristically, distinct higher-resistivity anomalies in these places appear at current penetration depths of 2.5 m below ground surface. Descriptions of the shape, course and depth of anomalous zones and analyses of the rise or fall in resistivity values within their limits were followed by hypotheses presenting their putative source. It was assumed that the most distinctive anomalies recorded with an electrode array corresponding to penetration depths of from 1.5 to 3 m (Fig. 6) include Leontiev's trench A – lowered resistivity; ruins of ancient architecture D, E, F resulting in broad ranges of raised resistivity with evident borders; finally, traces of streets B and C with surviving bedding and stone flagging, which are reflected as narrow linear high-resistivity anomalies.

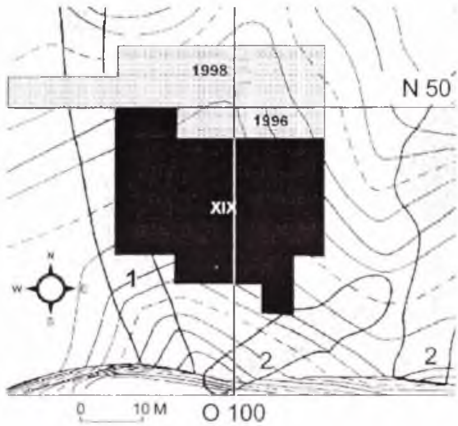
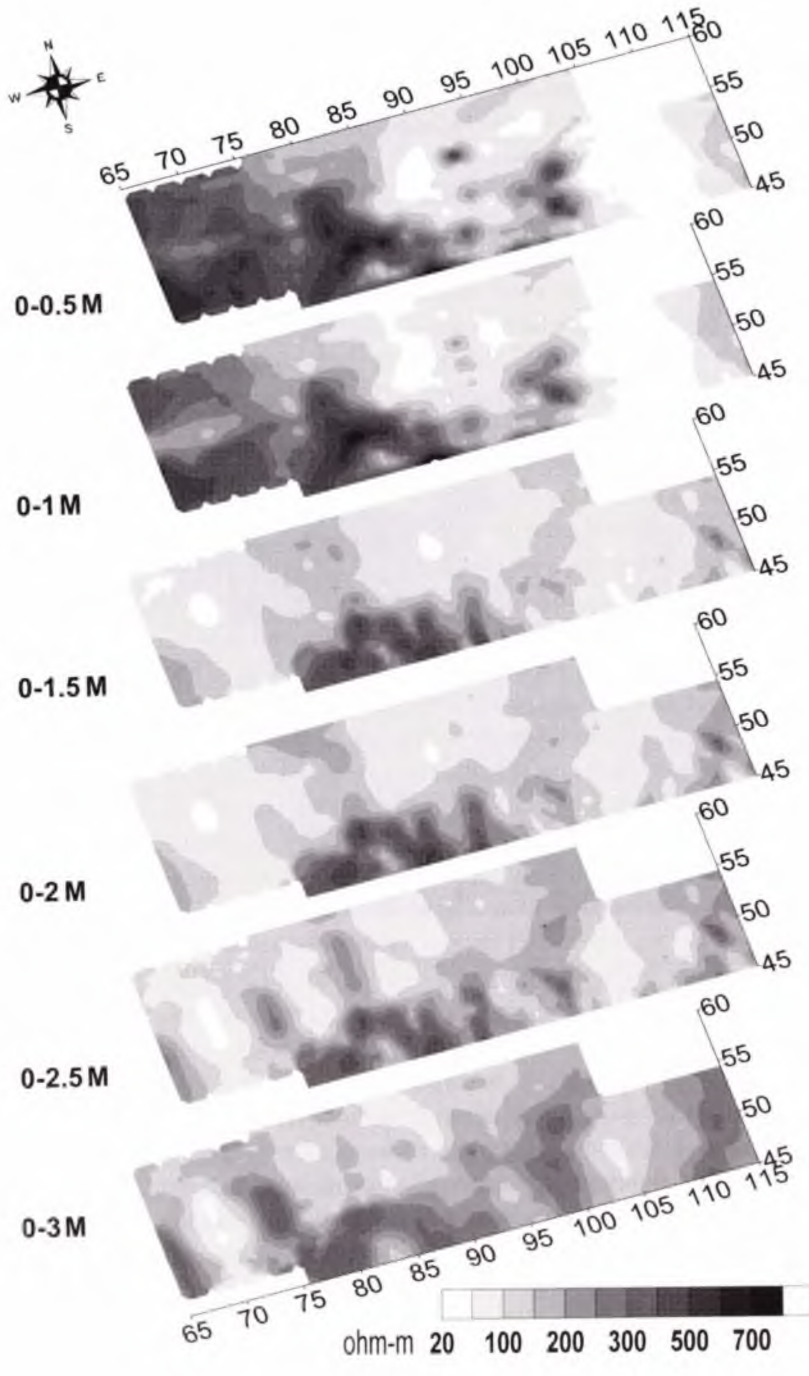


Fig. 3. Tanais. Investigations in 1996–1998. Location of excavated areas (in black) and resistivity prospection in 1996 and 1998 (in gray). Trench XIX, state for 1997.

Most hypotheses on the subject of the recorded anomalies were confirmed during the excavations in 1998 and particularly in 1999 (Arsen'eva and Böttger 2000). It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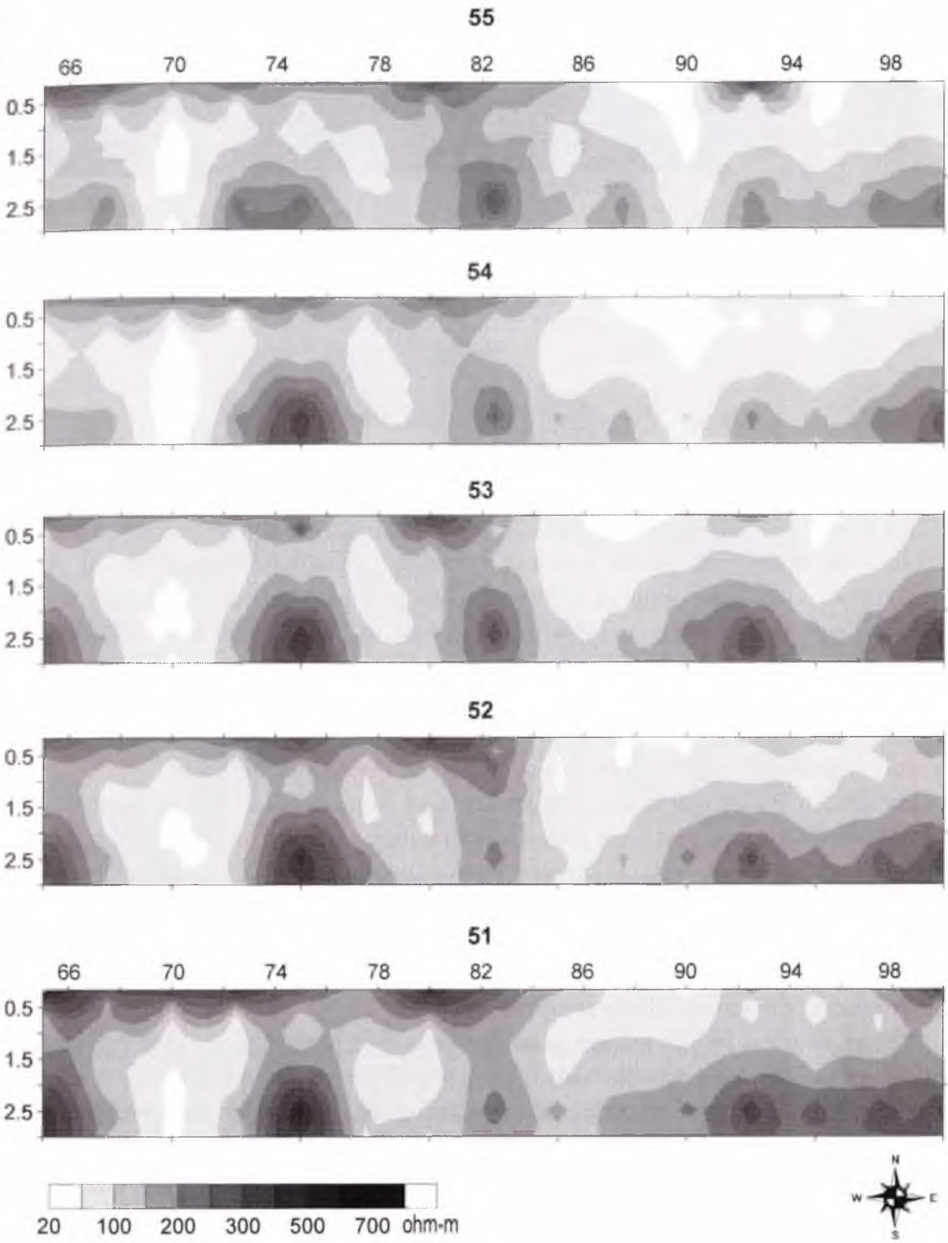


Fig. 4. Tanais. Research in 1998. Depth slices of the resistivity survey.
Fig. 5. Tanais. Research in 1998. Apparent resistivity pseudo-sections.

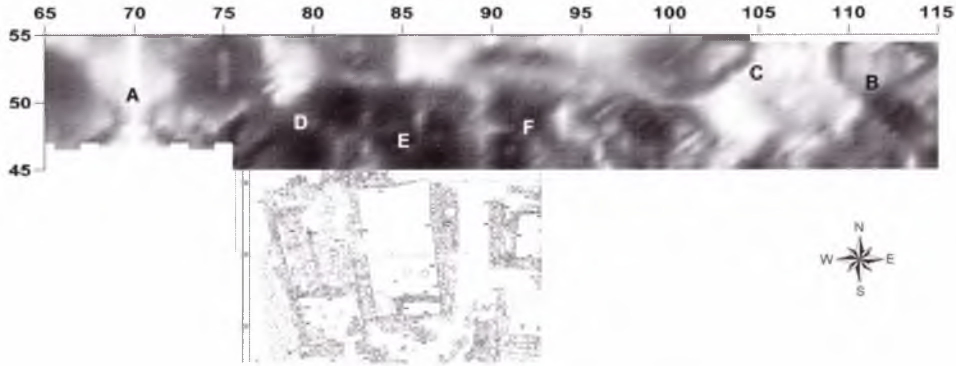


Fig. 6. Tanais. Research in 1998. Interpretative map.

was determined then that the low-resistivity zone east of meter E 90 occurs in a place where most of the youngest architectural ruins from the 4th and 5th centuries AD had been removed and the area was leveled using fairly homogeneous fill. After the traces of Leontiev's trench had been uncovered and clarified, it turned out that its limits corresponded precisely to the extent of the low-resistivity anomaly zone and that on a lower level these boundaries were delimited on one side by stones from a dump deposited here during the excavations and on the other side by the remains of stone slabs that had not been cleared and removed and which had once belonged to structures from the oldest, Hellenistic phase of the town's existence.

Further, in places where deep Hellenistic and Roman cellars had been expected, ruins were discovered that were not cleared in their entirety until 2001 (Arsen'eva, Böttger and Fornasier 2001). The information provided by the geophysical survey helped to develop a rational excavation plan by distinguishing consecutive stages of rebuilding and changes of urban layout in Roman times; this data also facilitated the clearing of features situated in areas filled with debris and relatively unclear on the ground in the course of the explorations.

The excavation results in turn provided data that helped to modify the way in which vertical soundings were made. It was found that the spacing between soundings should be decreased to 0.5 m, while retaining the one-meter distances between the sounding traverses. The resultant image of resistivity changes was much more precise, ensuring sufficient data for distinguishing anomalies corresponding to single walls and their foundations, not just defining the boundaries of ruined complexes. Every second sounding was used for the apparent resistivity pseudo-sections essential to depth analyses of recorded anomalies. The spacing between electrodes was limited to 7, that is, 1, 3, and 4 m for MN equal to 0.3 m, and 6, 10, 16 and 28 m for MN electrode spacing of 3 m. The graphic form of presentation of prospection

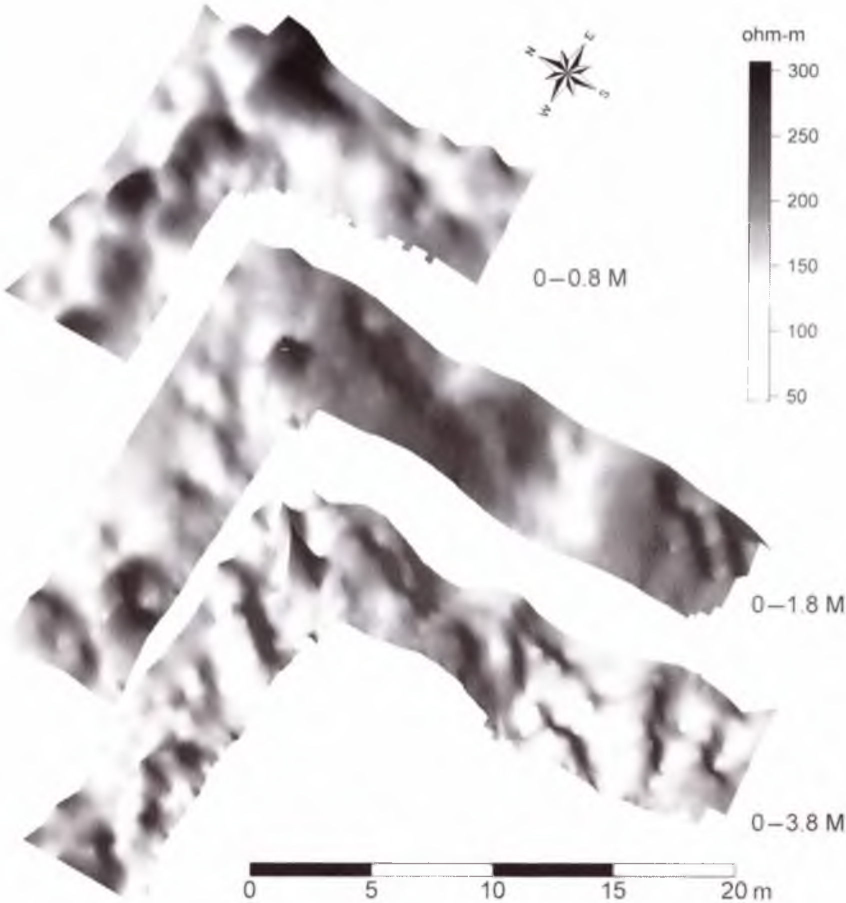


Fig. 7. Tanais. Research in 2002. Depth slices (3D) of the resistivity survey.

results was changed to a three-dimensional image of resistivity changes, this being perceived as better for representing the observed phenomena, especially in the subsurface layer. Separate maps continued to be made for each of the applied AB electrode spacings. It was assumed that the first 4 maps illustrated the changes in apparent resistivity for the youngest architecture dating from the 4^{th} and 5^{th} centuries AD, while the deeper-current-penetration maps represented anomalies corresponding to structures of Roman and Hellenistic date. In view of considerable irregularities, as well as the presence on the surface of many smaller stones from previous excavations, it was decided that a detailed analysis of 3 maps (Fig. 7) was sufficient to distinguish most of the anomalies in the surveyed area.

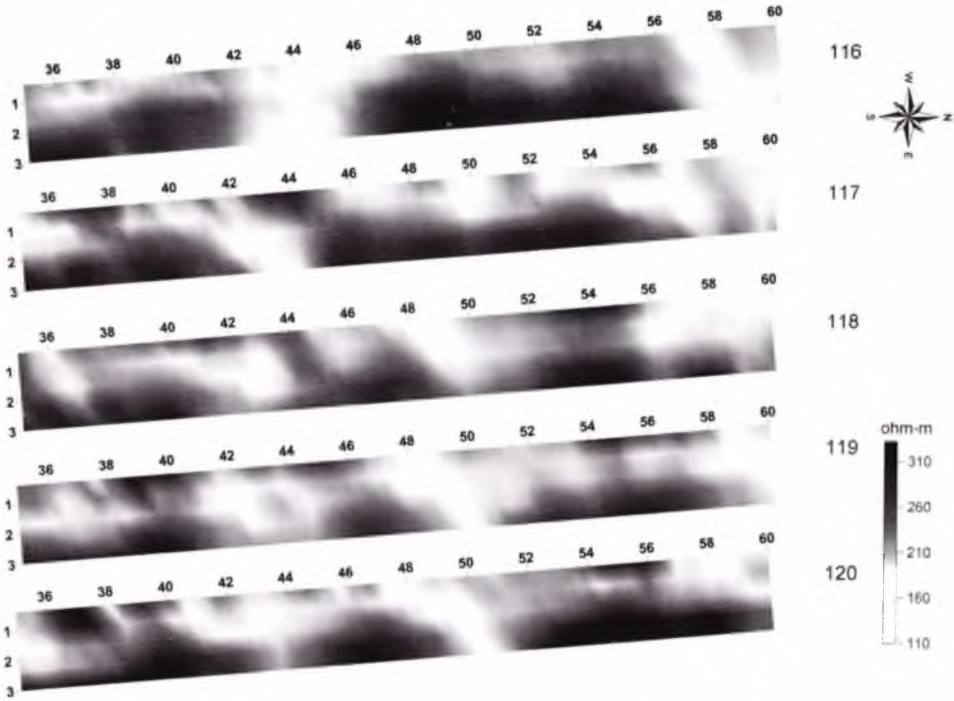


Fig. 8. Tanais. Research in 2002. Apparent resistivity pseudo-sections on N-S axis.

The reconnaissance in nine squares near trench XIX (coordinates E 100–E 120; N 56–N 60 north of the trench and E 116–E 120; N 35–N 60 east of the remains uncovered in the trench, where 225 soundings were made) was carried out in this fashion. On one hand, the survey was to determine the extent of the architecture of the *agora*, which was situated in this area to the east; on the other hand, it was supposed to provide data regarding the depth of the archaeological remains.

This last information was important for planning future explorations in this area of the ancient town. More importantly, it gave an idea as to the time factor: determining how much time was required to uncover in full, preserve and prepare for display the surviving remains of the *agora* complex. For this reason, the focus was on apparent resistivity pseudo-sections prepared for both N-S (Fig. 8) and E-W profiles (Fig. 9). Especially in the latter case, in profiles 58–60, there is clear evidence of high-resistivity anomalies in the section of meters E 100–E 102, clearly delimited on the north. It is likely that the anomalies corresponded to a filled-in cellar space, possibly belonging to the oldest, Hellenistic-phase architecture of the *agora*. Hence, the remains needed to be cleared not only to the north and east (as planned earlier),

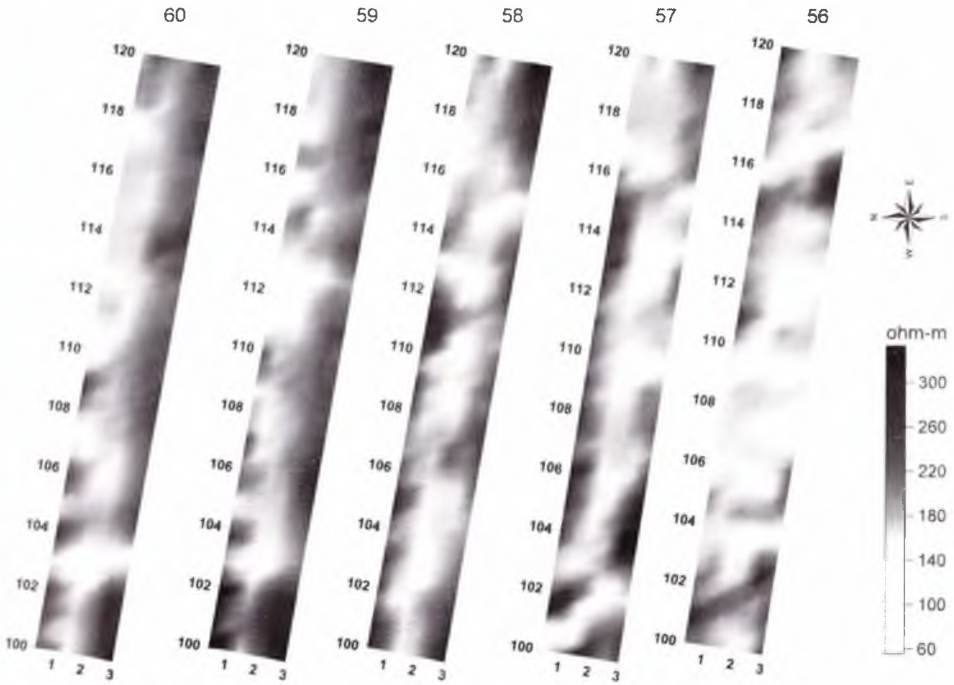


Fig. 9. Tanais. Research in 2002. Apparent resistivity pseudo-sections on E-W axis.

but also to the southeast, a decision further supported by 19th-century finds of slabs with fragments of Greek inscriptions (which added to our knowledge of the appearance of this Hellenistic and Roman complex, as well as provided interesting complementary data for the earliest history of the town).

The above-presented prospection results using series of soundings appear to be an efficient tool for obtaining data on the localization and the depth estimation of relevant remains. It should be noted, however, that these are still two-dimensional images of resistivity triggered by three-dimensional bodies deposited at different depths and characterized by varying size, differing proper resistivity and frequently complicated shape. Consequently, we need to keep in mind that the information provided by geophysical prospection is not always complete and corresponding to actual field conditions. The values referring to depth marked on maps and pseudo-sections determine the alleged maximal range of current penetration at a given spacing of the current electrodes AB, and not the actual depth of the features causing anomalies in apparent resistivity distribution. In the extant geological conditions, considering the complicated structure of layers containing material characterized by high resistivity, the calculated theoretical range of current penetration could be smaller in some places and bigger in others (where relatively homogeneous low-resistivity layers of fill were present). This fact further encumbers the interpretation of the results.

A fuller picture of the changes in apparent resistivity distribution can be obtained using techniques of resistive tomography (Szymanski and Tsourlos 1993:11), but it should be noted that our site is a multi-layered one where the archaeological features, which are the source of the observed geophysical anomalies, occur at a considerable depth. Using resistive tomography techniques in this situation, we must be aware of the fact that the extent of information on layer resistivity at this depth is disproportionately smaller than in the case of classical soundings. Besides, data obtained from soundings may be subjected to successive stages of interpretation and presented in the form of geoelectrical cross-sections, referring to the actual depth of the bodies causing the recorded anomalies to a much greater degree than the apparent resistivity pseudo-sections. However, to make a geoelectrical cross-section it is necessary to carry out a full interpretation of the soundings, which is a laborious process and not always possible under field conditions. It is essential when the reconnaissance is being made in an area of uneven surface or lying on a slope. In these cases, the profiles take into account to a greater degree the influence of the surface factor on distinguishing the depth of traced layers. At Tanais this is best evidenced by the measurements made in 1997 in the southern part of the town, outside the area enclosed by walls. This research was intended as a means of determining whether there had been a ditch on the south side resembling the one that surrounded the wall on the north, east and west. A series of soundings was helpful in reconstructing the structure of layers in antiquity and locating any potential remains of ancient structures; it was also instrumental in determining the depth at which bedrock occurs. As a comparison of the apparent resistivity pseudosection (Fig. 10A) with geoelectrical cross-section (Fig. 10B) demonstrates, the latter reflects to a greater degree the actual situation in the field, distinguishing among others the bodies causing anomalies in the apparent resistivity distribution. But it should be remembered that it is still an interpretation of measurement data, not a direct projection of the actual structure of geological and anthropogenic layers.

Despite the above described inconveniences, as well as laboriousness when taking measurements and when interpreting and presenting the results, the series-of-soundings method delivers the most information about alleged places and the depth of the relevant remains and it appears to be optimal in the case of surveys on multi-layer sites with a complicated stratigraphical structure.

More information could be provided only by a comprehensive application of a number of non-invasive methods, not just geophysical, but also aerial and satellite photography, topographical analysis of surviving archival material and surface surveying carried out on a current basis. At Tanais these kinds of activities have been undertaken successively since 1998.

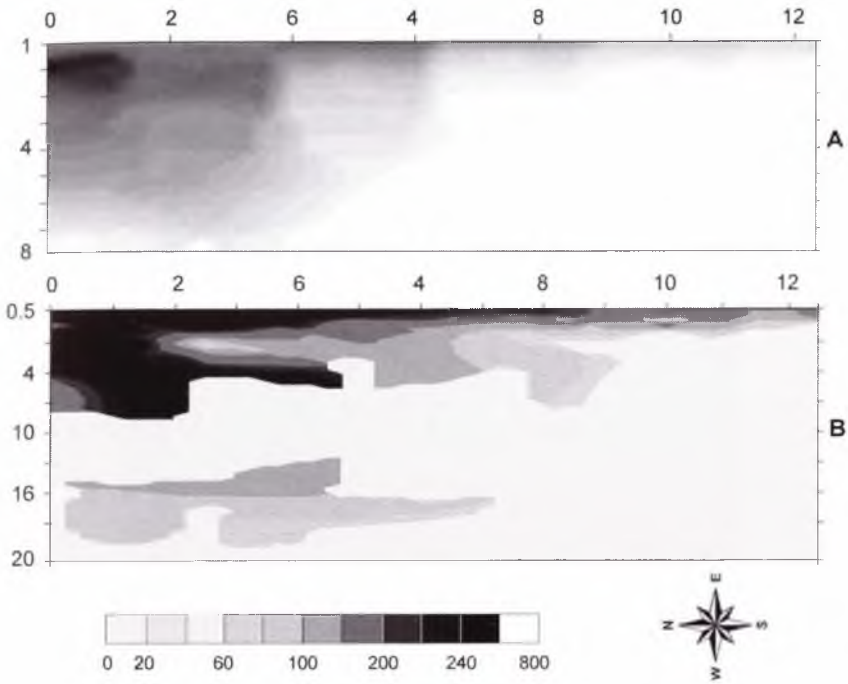


Fig. 10. Tanais. Research in 1997. A – apparent resistivity pseudo-section; B – geoelectrical cross-section.

A substantial enlargement of the range of rescue work was required in view of numerous building projects and intensified agricultural production using deep-ploughing. These activities had destroyed a number of features in the cemetery, particularly mound burials. Geophysical prospection turned out to be necessary not only in order to obtain information for a rational planning of cost-effective rescue excavations, but also in order to be able to determine the boundaries of new protection zones within the endangered part of the site.

The end objective of the project for non-invasive prospection funded by the Polish Committee for Scientific Research was to prepare a map of the archaeological remains found in a selected region of the site of Tanais, based on aerial and satellite photos. The next step was to carry out geophysical surveys and archaeological testing of the spots of selected features.

In 1999, in consequence of an agreement with the South Regional Information and Analytical Center at Rostov on the Don, it became possible to obtain and process aerial and satellite photos of the area surrounding the archaeological site (Fig. 11). Analyses of the photos led to the discovery of an ancient road that had taken its course from the general direction of the steppes toward the town. The data,

Fig. 11. Tanais. Satellite picture of the Don delta with remains of Tanais fortifications in the lower part (1).

processed as a three-dimensional reconstruction of the surface relief, allowed the putative course of this road to be traced; its remains were located with geoelectric resistivity surveying and verified by archaeological testing.

Further analyses of the satellite photos and archival aerial photos led to the locating of a number of interesting archaeological structures in the immediate vicinity of the Greek colony.[1] One of the most important of these is a complex of barrow burials (Fig. 12). Additional aerial photos were made, covering the main mound and the immediate vicinity (Fig. 13). Dark spots in the photos are the old exploratory trenches, presumably also robbers' pits. In order to obtain additional information on the archaeological features located underground here, a geoelectric resistivity survey was also conducted in the least disturbed part of the site on the northern slope of the mound.

A twin-electrode system was applied with traversing electrodes AM (spaced 1 m apart) and constant BN (5-m spacing) situated 50 m away from the extreme traverse.

[1] I am sincerely grateful to G. Garbuzov from the South Regional Information and Analytical Center for making these analyses.

Fig. 12. Tanais. Photo of the immediate vicinity of the site with evident remains of an ancient road. 1 – Tanais. 2 – Tzarski barrow.

Readings of the resistivity values were taken in a one-meter measuring grid. A number of high-resistive anomalies were located, corresponding presumably to features situated underground. With these reconnaissance results in hand, it was believed possible and purposeful to survey, using geophysical techniques, both the undisturbed part of the mound and its vicinity.

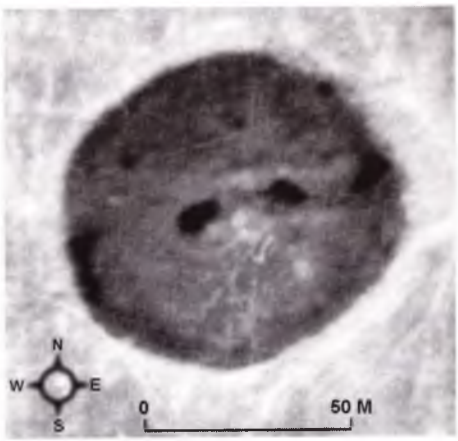


Fig. 13. Tanais.
Aerial photo of the Tzarski barrow.

The measurements generated a map of the ground resistivity distribution for layers down to a depth of *ca.* 1.5 m (Fig. 14). The recorded changes in resistivity were from 150 to 700 ohm-m. Not

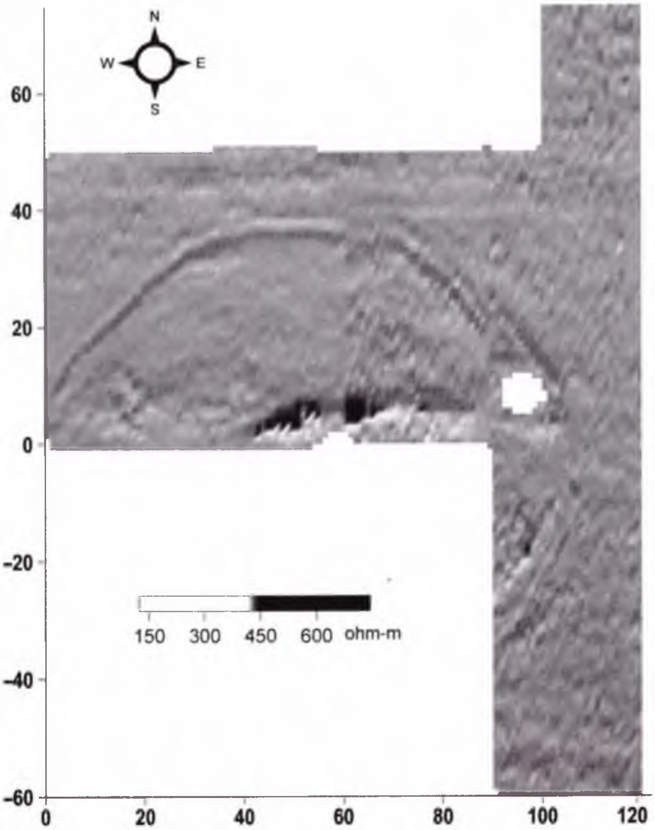


Fig. 14. Tanais. Map of apparent resistivity in the area of the Tzarski barrow.

surprisingly, the highest resistivity occurred in places, where the mound surface was dotted with pieces of stone and other materials of higher resistivity used in its construction. Also evinced, in the form of dark spots, is the initial extent of the barrow structure on the west side. A straight line can be seen from the northeast to the spot where the original mound structure has been damaged by deep-ploughing. The latter damages are particularly well visible after the results are correlated into one map. The geophysical measurements covered practically the entire relatively least disturbed part of the mound and they were carried out in conditions of varying humidity, which has an impact on the resistivity readings. Hence, the map does not constitute a homogeneous whole and one can see, for instance, a line separating particular surveyed areas in the vicinity of meter E 60. Despite this inconvenience, it is possible to isolate on the map a number of higher-resistivity anomalies occurring in places where important elements of the structure are thought to survive. It seems that of these the most important one is distinguished between meters N 5–N 15, E 10–E 20, where a rectangle is formed, 8 by 6 m, and it is not to be excluded that this rectangle corresponds to the burial chamber.

The superimposition of the geophysical map helps in a more precise interpretation of the surviving elements of the underground mound structures. It is quite evident from the map that the ancient diameter of the mound was some 8 to 10 m bigger, thus explaining the length of Leontiev's 1853 trench, which runs about 7 m to the east, beyond the present boundary of the mound.

The image of this part of the site obtained through non-invasive techniques was instrumental in arguing for regular archaeological supervision of this complex as well and primarily for excluding from agricultural use an area situated in this part of the ancient necropolis of Tanais. The local archaeological authority took appropriate steps. For them, the record of damages in recent years evoked by the geophysical prospection of the area was not without significance.

In order to see how data obtained with non-invasive techniques could be effectively combined with the results of excavation work, it was decided to work on two sites uncovered during rescue investigations: a complex of barrows at 84 Chentsova street and architectural ruins from the *chora* at the edge of the western necropolis, now at 114 Chentsova street, in the Niedvigovka area (Misiewicz and Tollochko 2002).

Geophysical research at 84 Chentsova street covered an area 30 by 42 m. Some insignificant differences of height could be seen on the surface to suggest the presence of considerably destroyed mounds (Fig. 15). The first step was to carry out a resistivity survey using a twin-electrode system with AM electrode spacing equal to 1 m. The measurements demonstrated a range of resistivity from 48 to 85 ohm-m (Fig. 16A). Thus, the resistivity differentiation was relatively insubstantial and all that could be read from it was the arrangement of the remains of the stone mound structure. There was little chance for earth-filled features to be observed. In order to obtain data on the depth of features causing the anomalies (meters E 16–E 20; N 10–N 20), the middle gradient at current electrode spacing of AB = 16 m and potential electrode spacing of MN = 1 m was also measured. The measurements were made with AB electrodes spaced on E-W and N-S axes. No univocal data on distinct anomalies in resistivity distribution were obtained, the only results being traces of minor local rises in the northern part of the surveyed area. This image suggested that the surviving archaeological remains were no deeper than 1.5–1.8 m below ground surface.

In the next stage of work, a trench was traced, covering all the remains localized with the aid of geophysical methods. Trench exploration revealed elements of two (?) or perhaps even three (?) barrow structures, retaining part of the stone facing (Figs 16B–17) and the burials in the central part and on the edges of the mounds. Three archaeological horizons were observed, two of which were connected with the forming of the mound and the third with the burial structures themselves.

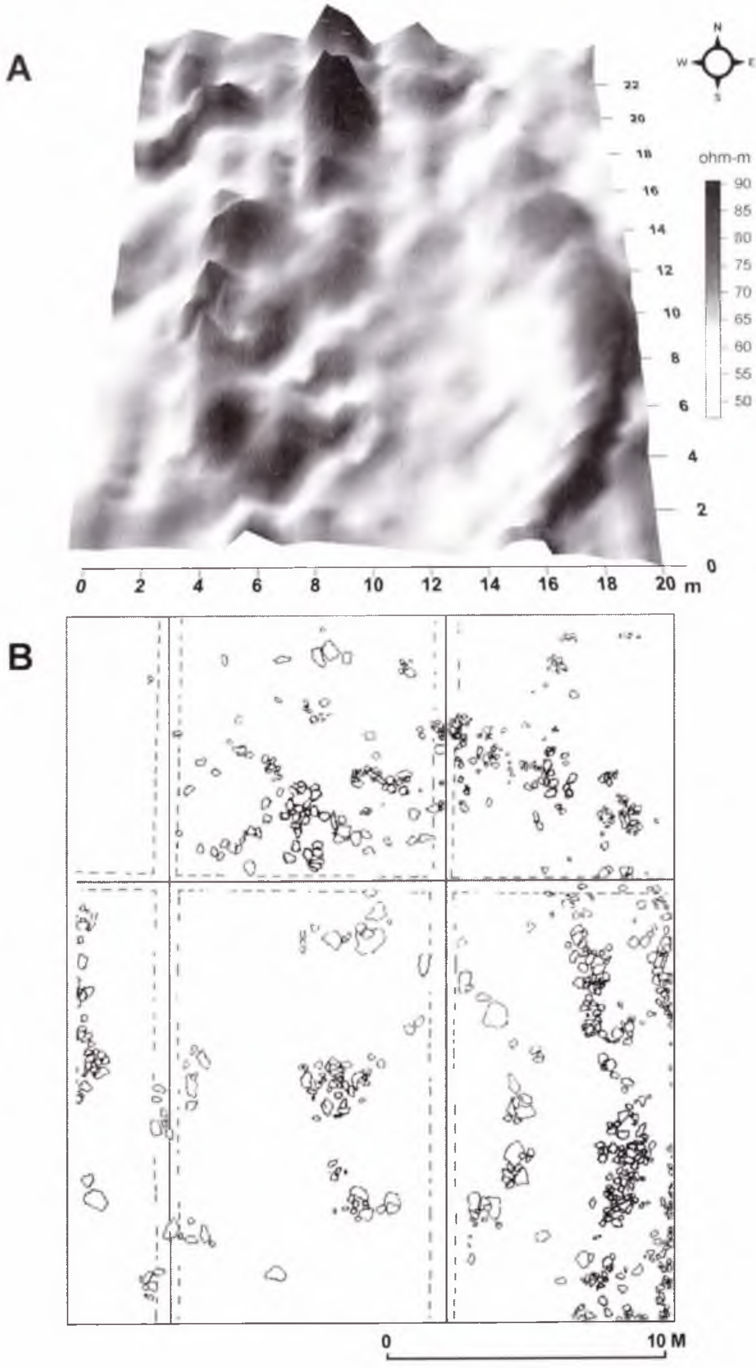
Fig. 15. Tanais, 84 Chentsova street site. Research in 2001. View of the surveyed area.

A total of 12 burials and 3 pits were uncovered. Eight of these features, located in the southern part of the trench, were dated to the Late Bronze Age. Of the five features in the northern end of the trench, two could be dated to the early 1st century BC and the remaining three to the turn of the 1st–2nd centuries AD; hence, they could all be related to the period when the Tanais colony was in existence. In the northeastern corner of the trench, traces of Leontiev's earlier pit were noted; Leontiev had explored graves from the Hellenistic period, *i.e.*, 2nd century BC, which we designated as nos 3 and 4. It was also possible to establish the presence of the remains of three barrow complexes in the excavated part of the necropolis in the southern end of our trench; of these mounds one dated from the Bronze Age and the other two from the period of the ancient Greek colony.

A comparison of the plans of the excavated structures and the results of geophysical prospection in the same area (Fig. 16) confirmed that geophysical methods could not only trace the layout of stone structures, but were also capable of isolating as separate single anomalies the surviving burial structures (outside of Leontiev's trench and covered with relatively homogenous fill). These results provided the grounds for a reinterpretation of the geophysical images and for determining the boundaries of the two other mound structures K 66 and K 67 which were practically invisible on the ground surface.

Investigations in the other area (western necropolis at 165 Chentsova street) covered an area of 20 by 20 m, immediately adjacent to trench XXIV dug in 1999 by the Lower Don Expedition team. Revealed in the trench were the remains of the architecture from the *chora* of Tanais, dated to the Hellenistic and Roman periods. The geophysical reconnaissance was a means to determine the extent of the structures to the north and to establish the border of the western necropolis, which was being explored in this sector by an expedition from Warsaw University.

Fig. 16. Tanais, 84 Chentsova street site. Research in 2001. A – map of apparent resistivity; B – plan of features uncovered in the trench.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10 M

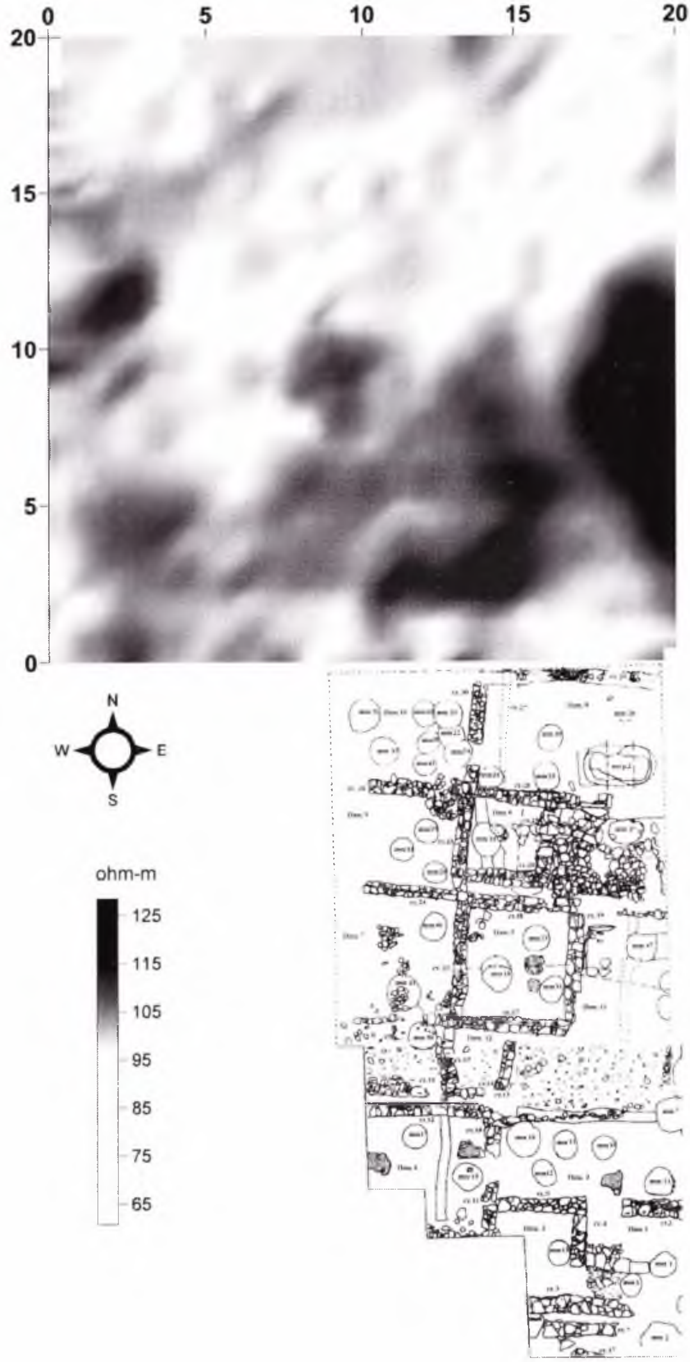
Fig. 17. Tanais, 84 Chentsova street site. Research in 2001. View of the trench with uncovered features, seen from the south.

Measurements made using a twin-electrode system (AM = 1 m) provided an image of the apparent resistivity distribution of layers down to a depth of *ca.* 1.5 m (Fig. 18). The area with resistivity between 90 and 100 ohm-m corresponds largely to the area with architectural remains. Regular "spots" within the range of meters E 15–E 20; N 4–N 10, with resistivity values of above 100 ohm-m, indicate the presence of surviving Roman-period cobbles, already uncovered in the explored southern part of this architectural complex. Single linear anomalies correspond to surviving fragments of wall foundations. An evident lowered resistivity in an E-W line within the range of meters N 1–N 2; E 10–E 15 occurs in a place where remains of a ditch, now filled with homogeneous soil, have been recognized (this ditch apparently ran around the northern side of the complex of buildings in the Roman period).

All the research objectives were achieved in consequence of the geophysical prospection. The boundaries of the western necropolis were determined and the most important elements of the architecture in the *chora* were distinguished. In consequence, there was satisfactory data for planning further essential archaeological excavations. The results of geophysical measurements will be compared in detail with the data gathered from the trenches explored in this area once the results of the excavations have been published.

Despite ten years having passed from the beginning of geophysical prospection at Tanais, the problems facing us have not all been solved as yet. The methods for conducting measurements and processing the results, which have been worked out over the years, will assuredly undergo further modifications. Repeatedly we have had to return to matters, which we had thought resolved. For example, the state of preservation of a section of the southern fortifications uncovered in the southwestern

Fig. 18. Tanais, 114 Chentsova street site. Research in 2001. Map of apparent resistivity correlated with a plan of the features uncovered in 1999–2000.


0
5
10
15
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15
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5
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W
E
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ohm-m
125
115
105
95
85
75
65

corner of trench XIX (Arsen'eva, Böttger and Fornasier 2000: 443) is much better than expected; hence, we find it advisable to re-analyze the geophysical survey data from this area (Misiewicz 1998a), possibly even to repeat measurements in a denser sounding grid applied wherever the most distinct anomalies had been recorded and the apparent resistivity distribution image obtained in the previous survey has suggested the presence of other remains beside the foundation trench of the defense wall, *i.e.*, parts of casing walls or possibly towers erected against the south face.

What is absolutely irrefutable is that the comprehensive application of non-invasive techniques has intensified the investigative process at this site, including the town as well as the surrounding cemeteries and *chora*. The opportunity for immediate archaeological verification of geophysical survey results is not without importance here, as is the systematic collaboration between geophysicists and archaeologists at each stage of the research project.

Translated by Iwona Zych

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