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Non-destructive geophysical-archaeological investigations of the site at Tablada de Lurin (Peru)

Krzysztof Misiewicz[a] and Krzysztof Makowski[b]

The paper presents the results of resistivity surveying carried out in 2001–2002 at the Tablada de Lurin cemetery near Lima in Peru. The research was conducted in association with the Catholic Pontifical University in Lima as part of an intervention and conservation program. The chief objective was to identify the spatial extent of the burial ground and the location of concentrations of two main types of tombs occurring at this site: cist graves and shaft-and-chamber tombs. Geoelectric measurements covered an area of *ca.* 3 ha, using twin-probe and Wenner arrangements on a meter grid. A test was made of the usefulness of the magnetic method applied as gradient measurements taken with a proton magnetometer. The results provided the grounds for planning further archaeological excavations. Simultaneously, they served to record the actual condition of various features and the potential threats to the ancient substance.

KEY-WORDS: archaeology, geophysics, Peru, Lima Culture, Tablada de Lurin

The cemetery of Tablada de Lurin (Fig. 1), south of Lima (Peru), is one of the most important archaeological sites of the so-called Formative Period of the Lima Culture. It occupies an area of more than 20 ha. Here more than 1500 intact burials dating to the transition from the Early Horizon to the Early Intermediate Period (200 BC – 300 AD) were recorded during systematic and salvage excavations (Balbuena 1996). These burials are shared by two cemeteries located on the river's left bank. Since 1991 systematic excavations were begun in the eastern cemetery (Makowski 2002:4), which is called San Francisco de Tablada or Tablada de Lurin (*Proyecto Arqueológico-Taller de Campo "Lomas de Lurin", convenio PUCP-Cementos Lima S.A.*). Thus far, 437 burials in shaft tombs with side chambers, and 4 subterranean chambers with multiple burials – called *cistas* in Spanish – have been found. To date 22220 sq. m of the cemetery have been uncovered, 1700 sq. m of which

[a] Institute of Archaeology and Ethnology, Polish Academy of Sciences, Warsaw, Poland
[b] Catholic Pontifical University, Lima, Peru

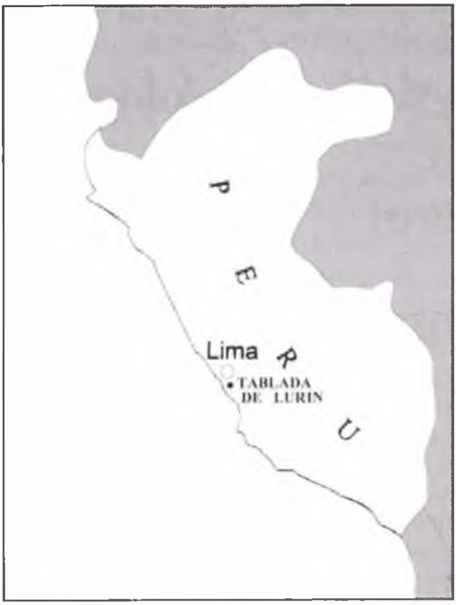

Fig. 1. Location of the Tablada de Lurín site.

were excavated. The area excavated using a different methodology by Ramos de Cox and Cárdenas between 1958 and 1988 comes to about 3000 sq. m. The total area explored is thus over 0.5 hectares, *i.e.*, 3.13% of the minimum area estimated for the cemetery. We therefore have enough data not just to study social differentiation and its symbolic representation in the burial ritual, but also to try and understand the principles that guided the organisation of the area exclusively set aside for use as a burial ground (Makowski *et al.* 1994).

As it was described above only a small part of the cemetery has been investigated, and revealed the existence of two types of burials – shallow stone-built cist graves and shaft tombs. The cemetery formed by subterranean stone structures (Fig. 2) is slightly later than the shaft tombs, and this is reflected in its stratigraphic position, as well as in that the latter are frequently disturbed by the pits, at the bottom of which the structures were built. The shape of the structures is varied. Most are quadrangular in shape (20 out of a total of 34, including those with a curved far wall), but there also are some polygonal (5) and oval- or circular-shaped ones (9). Size and entryways also vary. Some structures have doorways with outer vestibules, others vestibules with stairways, and still others are simple openings with a roof on top. The structures were built some time before the first burial and were left unroofed until the first bodies were placed inside. These were placed with their back against the back wall, seated on a mat or inside a basket. Their position was the same as in the shaft tombs. In the big structures, the people in charge of the burial moved the skeletons previously placed to the sides. When the building was of small size (*e.g.*, the circular structures), the old bones had to be removed and were then packed in the empty spaces once new occupants had been placed inside the chamber. The burial could involve more than one individual. The number of times the tombs were reopened is hard to establish, but it usually comprised more than 4 consecutive events. A limited number of secondary burials is possible (Makowski *et al.* 1994: 112).

The second type consists of deeper chamber graves (from 1.5 m to 3 m deep) with shafts of diameter 0.8 m – 1.2 m (Fig. 3). The deep shafts of up to 3.40 m were dug in the sand. The area meant for the burial is at the bottom of each shaft. Usually the shaft narrows in this part and the chamber is partially excavated in one of the walls, so that a comfortable step is formed that helped place the bundle and its paraphernalia inside. However, the step often vanished due to successive expansions made to bury other individuals after the shaft had been intentionally reopened. In individual burials the chamber was often sealed with horizontal or diagonal flagstones (Makowski 2002).

Fig. 2. Tablada de Lurin.
Remains of a stone-built cist grave.

Near the site is a large open air mine belonging to the mining company "Cementos de Lima S.A.", the operation of which has for several years constituted a severe threat to the archaeological remains. This has given rise to the need for rescue excavations and the preservation of the surviving archaeological remains. The mining company has financed a considerable part of the excavation, but the size of the site and the density of the graves, sometimes forming complex multi-layer structures, has hindered this work. It was decided to employ geophysical survey methods in order to increase the effectiveness of the investigations, and at the same time obtain by non-destructive means and in a comparatively short time data allowing the examination of the layout of the cemetery in order to plan further excavation work on the site.

In 2001 initial geophysical measurements were made using the geoelectrical resistivity method applying the version of profiling with a twin-probe system with mobile AM electrodes fixed in a frame a metre apart and permanent BN electrodes situated 5 m apart and 50 m from the nearest point of measurement. This allowed the measurement of apparent resistivity (the average resistance of the surface layers measured along the ground surface) to a depth of 1.5 m. Such a system of measurement allowed the location of remains of the stone structures of cist graves as well as the fillings of the shafts of chamber graves which differ markedly from the surrounding soil (Fig. 4). An additional factor which facilitated the identification of anthropogenic changes in the structure of the site was the fact that there was a layer of relatively

Fig. 3. Tablada de Lurin. Remains of shaft tombs.

unporous alluvial layer (*lomas*) lying just below the ground surface. This had the greatest influence on the resistance of the layers of the site which were recorded, because any discontinuities in this layer were registered as clear resistance anomalies.

In order to obtain data on the deeper lying features, the middle gradient method with the distance between the AB current electrodes of 16 m and the MN potential electrodes at a distance of a metre was used. This gave the possibility of obtaining information on layers to a depth of even 3 m, but a hindrance to the use of this system was the necessity to repeat the measurements with different settings of the AB electrodes. The middle gradient system is also very time consuming, because it forces the work to take place within 10 m by 10 m squares. This is a result of the fact that, with a 16 metre distance between the AB electrodes, in the measurement points situated in the vicinity of these electrodes, if the distance between the electrodes is less than 3 m, an apparent increase of resistivity occurs which is later very difficult to eliminate in the interpretation of the results.

During the testing of the possibilities of different geophysical methods a proton magnetometer was also used, working in a gradient mode with the probes at heights of 0.7 m and 1.5 m. Due to the presence of haematite deposits in the vicinity it was not possible to stabilize the measurements from the lower probe. Suitable measurements were only obtained with it at a height of 1 m from the ground surface. In such a situation it was not possible to discover anomalies caused by small features or objects whose magnetic susceptibility did not differ much from the surroundings

Fig. 4. Tablada de Lurin. Filling of a shaft (marked with arrow) visible in the profile of archaeological trench.

(the filling of graves, layers of rubble, *etc.*). This is why it was decided to concentrate on the resistivity method as this guaranteed more reliable results.

The measurements were taken with an ARA03 resistivity meter using alternating current at frequency 128 Hz with an internal memory capable of storing 10 000 measurements together with their XY coordinates (Herbich, Misiewicz and Mucha 1998).

The grid within which the measurements were taken was the same as that used in the course of the excavation. The measurement were taken at 1 metre intervals, that is, a measurement profile every metre with the same distance between the measurement points in the profiles. In the course of the test 7600 measurements were made covering an area of 0.7 ha in total, in different parts of the site.

As a result of the measurements carried out we obtained a relatively varied picture of the apparent resistivity of the layers of the site which ranged from 25 to 120 ohm-m. A key factor allowing the interpretation of these results was the conducting of measurements in the vicinity of where the excavations which had previously taken place had removed the upper *lomas* layer without digging into the archaeological features (merely mapping their position) in the region of the metre squares E75-E90; S80-S100 (Fig. 5). In the grid within which the geophysical measurements were taken, this was the area E262-E282; N45-N63. Fig. 6 presents the results of investigations in this area and one may observe a clear lowering of the

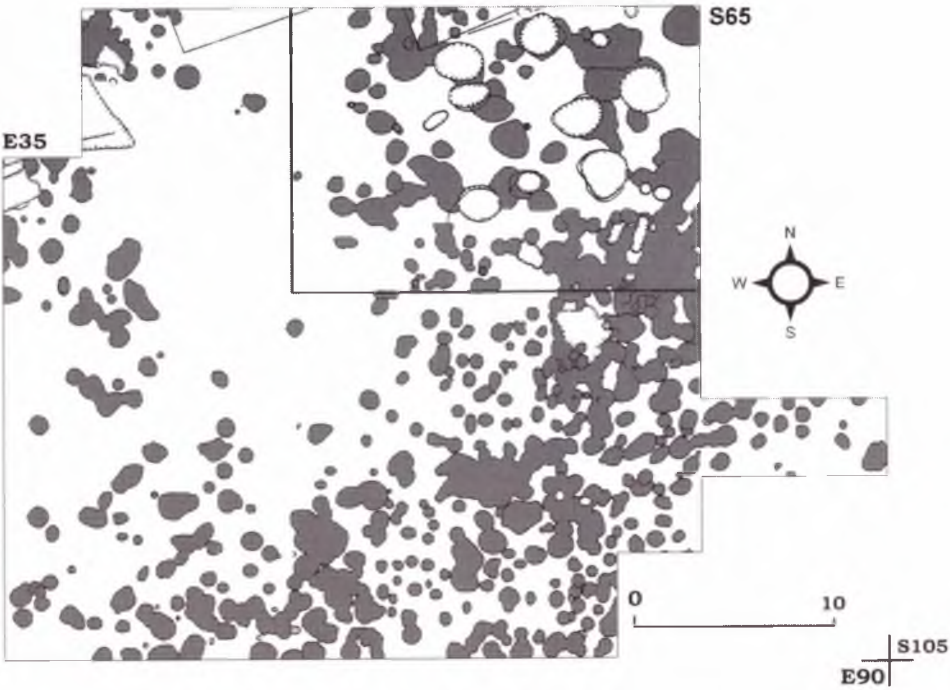

Fig. 5. Tablada de Lurin. Upper part of the remains discovered in archaeological trench.

resistivity measurements. In the places where archaeological features were recorded there is an increase in resistivity. It is clear also that the shape of the resistivity anomaly does not always exactly correspond to the shape of the archaeological features. This is probably caused by the fact that the shape of the feature in the upper *lomas* layer may change on excavation and, especially in shallow features the difference in resistivity between the fill of the grave and the surroundings is often small and therefore produces only slight differences in the apparent resistivity measured on the ground surface.

It is a different situation in the case of deep features. These will create anomalies with considerable dynamic qualities when the values of resistivity rise to above 100 ohm-m. It is possible to predict that the position of these anomalies will correspond more closely to their real position.

Valuable information obtained in the survey of this area included the observation that the recent creation of discontinuities in the upper layer is characterized by a lowered resistivity. Relatively homogeneous low-resistivity areas appear in the vicinity of old archaeological trenches (metres N60-N62; E268-E276 in Fig. 6). An additional difficulty in the unequivocal interpretation of the results was the presence

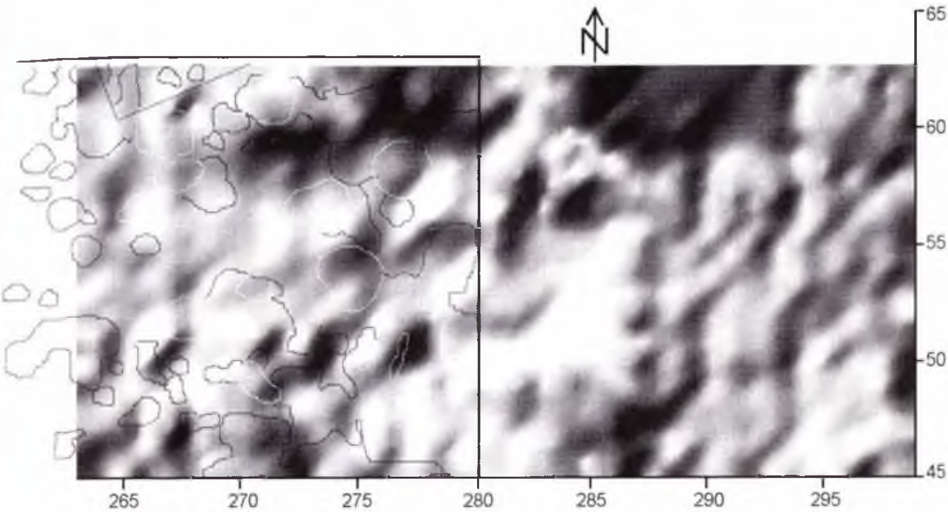

Fig. 6. Tablada de Lurin. Survey of 2001. Map of the apparent resistivity superimposed on the plan of excavated remains.

of anomalies caused by recent looters' pits which were not always dug in the areas where the graves (which were being sought by the robbers) were located.

Being in possession of the above-mentioned data it was possible to attempt to interpret the results obtained from other areas which were deliberately selected in different areas of the site. Using this method of interpretation it was possible to define clusters of archaeological features as well as the sites of old archaeological trenches. Even as a result of such fragmentary investigations it was clear that it was possible to define areas where the anomalies formed regular shapes, defining concentrations of graves and differentiate places where archaeological features occur sporadically.

It appears that the resistivity method carried out by the twin-electrode method applied here is fully effective and may be used to investigate the area of the site (about 3 hectares) most threatened with destruction. It should be noted that these measurements were carried out in March after a dry summer which caused difficulties in the form of the drying out of the surface layers which hindered the probe-to-soil contact and made it difficult to take correct and reliable resistivity measurements. Another problem connected with the use of measurements by the twin-probe system was the need to change the location of the stationary electrodes which was connected with the appearance of artefactual linear anomalies at the edges of the measurement grids. Such anomalies which are not so disruptive and relatively easy to eliminate in the investigation of small areas can become a problem in the case of the investigation of more extensive areas of the site.

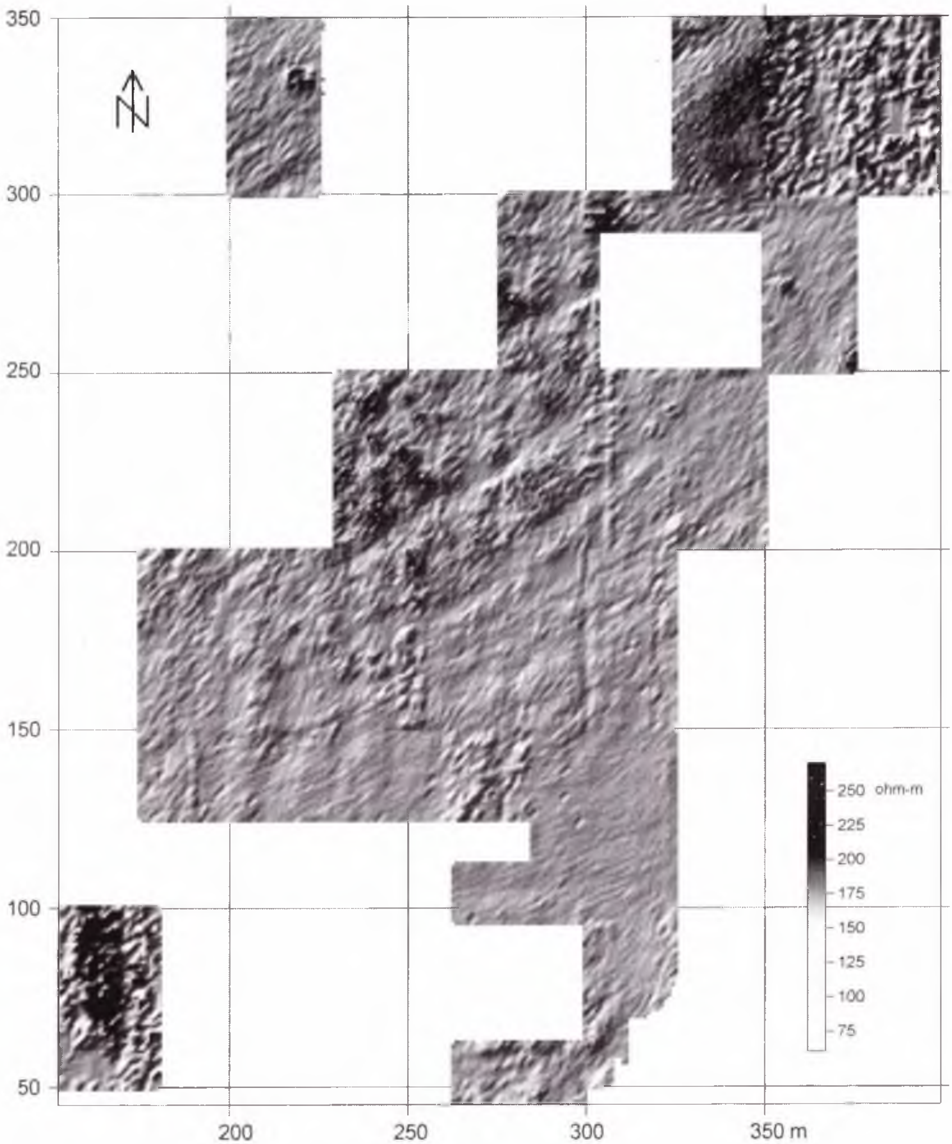

Fig. 7. Tablada de Lurin. Survey of 2002. Map of the apparent resistivity of the entire investigated area.

For these reasons in the preparation of such a project:

– the survey should be undertaken at the turn of September and October in order to have the best chances of the most suitable soil conditions for resistivity measurements (high soil humidity) after the damp winter season;

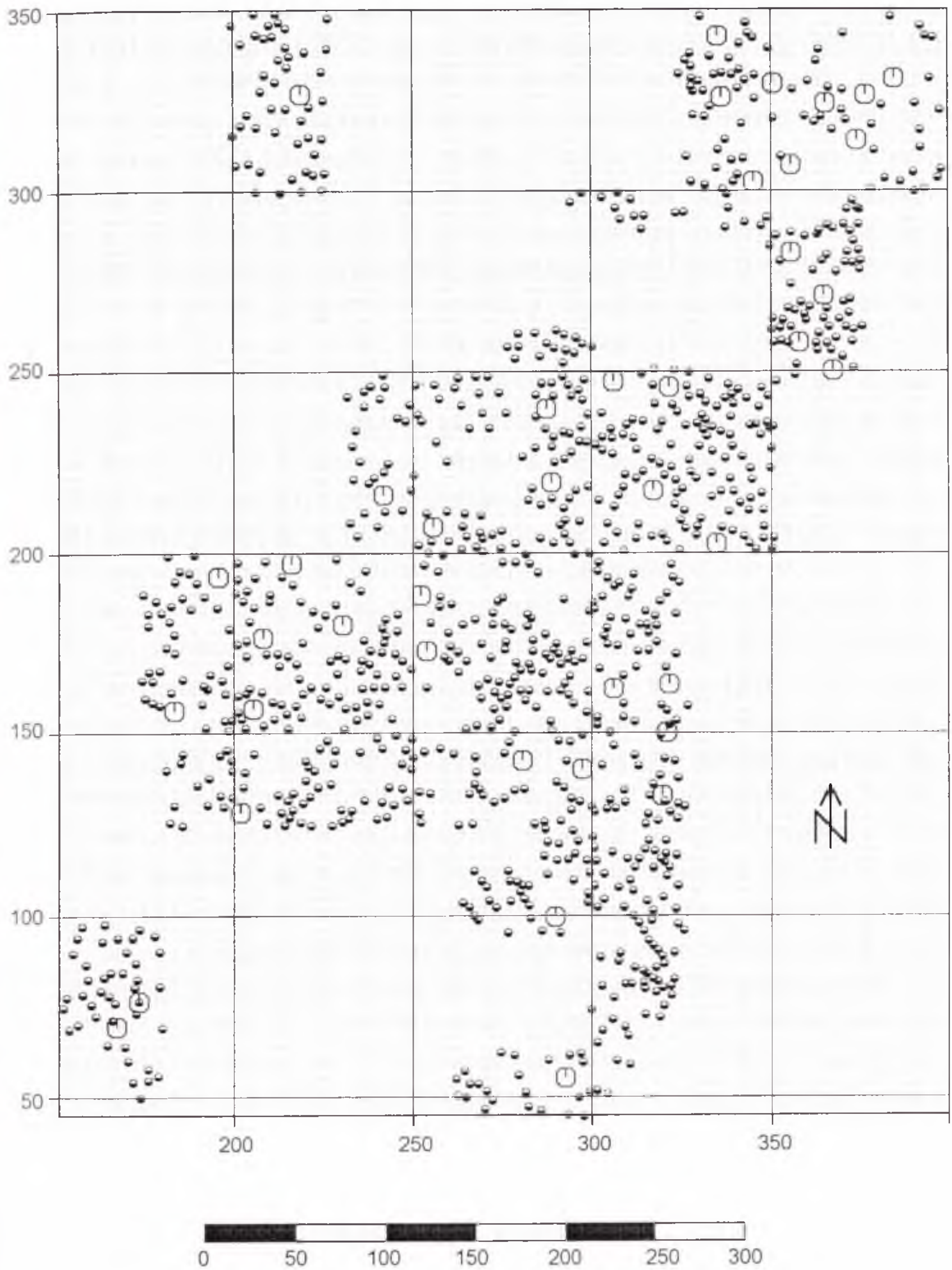

Fig. 8. Tablada de Lurin. Interpretation of the survey results. Chamber graves are designated by a circle, remains of cist graves by a square.

– the measurements should be taken using the Wenner array with the electrode spacing equal to 1 metre, giving a similar extent of measurement as the twin-probe array, but avoiding the formation of apparent linear anomalies.

The correctness of the above assumptions was confirmed by the appearance of the site itself. Instead of the yellowish-grey colour of the *lomas* observed during the investigations of 2001, we were dealing with a relatively damp surface covered with green and violet flowering vegetation. In the whole of the investigated area no difficulty was experienced with the probe-to-soil contact. The use of a symmetrical array on a rigid aluminium frame allowed the taking of the same number of measurements as in the case of the twin-electrode array.

Using the metre grid, it was possible to investigate the whole area of the site lying between the excavated sectors in its northern and southern parts. The resistivity map (Fig. 7), which was created on the basis of 32000 measurements in a metre grid, allowed the graphical representation of the recorded changes of resistivity from 70 to 300 ohm-m. As an effect of the measurements being carried out under conditions of relatively high humidity of the surface layers, there is greater contrast in the picture of the distribution of the apparent resistivity together with a lower value for the background and increase of values of the resistivity in the zones of higher value anomalies (clusters of graves), as well as in the case of individual features. The clear zones of lower resistivity visible on the map appear where there were local paths and wider communication routes.

Next to the concentrations of features on the map are also visible irregular areas of increased resistivity on the sites of "illegal" dumping of waste products of the "Cementos de Lima" production facility. This information allowed, if not the halting of this activity, then its limitation.

A detailed interpretation of the obtained results is presented in Fig. 8 where the shaft-chamber graves are designated by a circle and the remains of cist graves by a square. This shows the layout characteristic of the site – the cist graves form "avenues", while the shaft-chamber graves form overlapping circular and semicircular clusters. The smaller number of cist graves results from the fact that they contained multiple burials and as structures on the ground surface could serve for a longer time, as had been determined in the earlier excavations (Makowski 2002). The interpretation plan based on the resistivity map which our work produced allows the supplementation of the picture of the site which had emerged from earlier excavations. It is also possible to use it in the planning of further excavation trenches within the bounds of the site.

In a section of the resistivity map (Fig. 9), one can clearly see the places where the remains of both square and rectangular cist graves are situated (the region of N 266-268, E 357-360; N 288-290, E 365-367 and N 292-294, E 372-374) as well as the circular and smaller areas of the filling of the shafts of chamber graves. It is

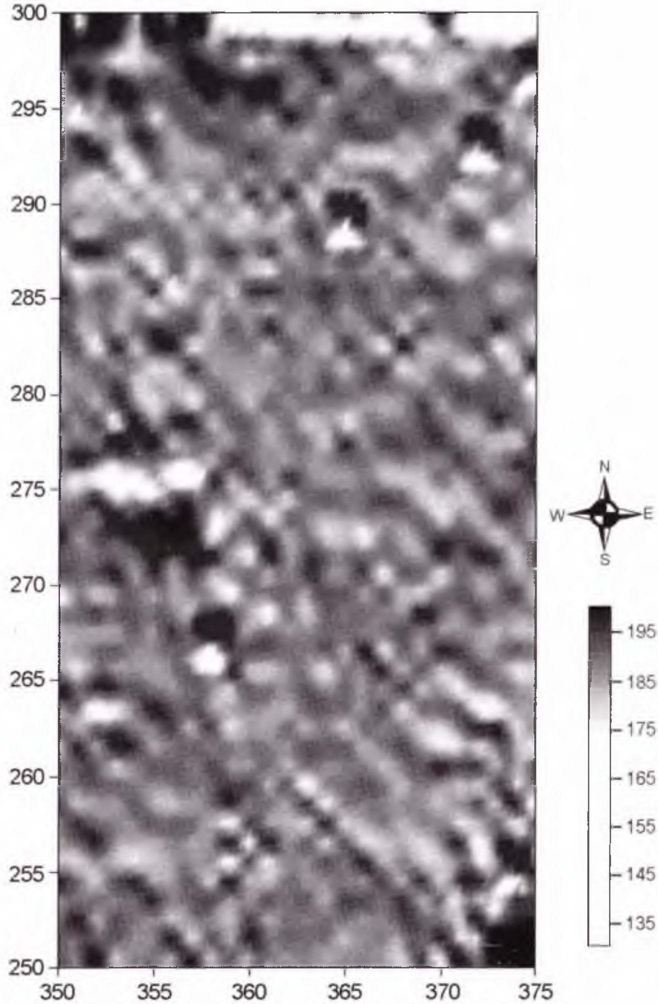

Fig. 9. Tablada de Lurin. Map of the apparent resistivity in squares N250-300; E 350-375.

characteristic that one can differentiate the remains of undisturbed grave constructions and robbed tombs (such as the two graves in the region N 273-276; E 351-360). In the latter situation the differentiating feature is the presence in their vicinity of higher-resistance material situated as a rule on one side of the tomb construction. We present here an example of the analysis of one of the investigated portions of the site, but a similar analysis could have been carried out in any other part of the site, also in higher-resistivity surroundings.

The results of the method of prospection described above confirm the usefulness and wide possibilities of the chosen method of investigation for work on archaeological sites of this type. First of all, it is a rapid method, much cheaper than excavation and – what is most important – it does not disturb the stratigraphy of the site.

The partial investigation of the north-west part of the Tablada de Lurin cemetery (metre squares N300-350; E 200-225), where trenches were dug to only a relatively limited degree, has allowed the confirmation of the usefulness of the applied method not only for the supplementing of information recovered by excavation, but also for the surveying of a site before excavation. We must be aware that in the case of a site directly threatened with destruction, such as in the case of the cemetery at Tablada, rescue excavations are necessary, but due to earlier geophysical investigation, they can be cheaper and more effective.

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