



GROUND PENETRATING RADAR PROSPECTIONS IN ROMANIA. MĂRIUȚA-LA MOVILĂ NECROPOLIS, A CASE STUDY

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ABSTRACT

In the last decades, ground-penetrating radar (GPR) has been successfully used in archaeological and forensic anthropological applications to locate relatively shallow features, even though the technique can also probe deeper into the ground. GPR is a non-destructive method based on the propagation of electromagnetic waves in soil, rocks or other media. This prospection method has rarely been used previously in Romanian archaeology and never for a necropolis. GPR surveys of the Măriuța - La Movilă necropolis (Călărași county, southeastern Romania) led to the identification of several new structures: a prehistoric pit belonging to the Kodjadermen-Gumelnița-Karanovo VI culture (Complex 1/2008), a grave from the IVth century A.D. (Complex 2/2009) and a modern burrowing pit (Complex 1/2009).

KEYWORDS: Archaeology, ground-penetrating radar, interdisciplinary research, necropolis

INTRODUCTION

In the past decades, ground-penetrating radar (GPR) has been successfully used in archaeological and forensic anthropological applications to locate relatively shallow features, even though the technique can also probe deeper into the ground. GPR prospection represents a modern method for quasi-continuous, rapid and non-destructive investigation. The method is based on the propagation of electromagnetic waves in soils, rocks or other media (Elliott, 2006; Jol, 2009). GPR was rarely applied in Romanian archaeology, as compared to other methods of geophysical prospection (such as magnetometry and electrical resistivity of soils). When used on archaeological sites (e.g. Rotbav, Băneasa, Luncavița), the GPR method was applied in settlements and habitation spaces (Vulpe et al., 2007; Micu et al., 2010). Măriuța-La Movilă represents the first instance in Romanian archaeology where GPR is applied in a necropolis. The expensive cost of application notwithstanding, this represents a step forward in the implementation of modern methods in Romanian archaeology.



Fig (1): Location of Măriuța-La Movilă archaeological site

The Măriuța-La Movilă archaeological site

The prehistoric site Măriuța-La Movilă is located on the right bank of the old Mostișteea River (which has been converted into several artificial lakes), just northwest of the village of Măriuța, in Călărași County, southeastern Romania. This location is ca. 31 km north-northeast of Bucharest, and ca. 56 km north of the Danube River (Fig. 1). The prehistoric site

consists of a *tell*-type settlement and a necropolis, both dated to the Eneolithic period (the second half of the fifth millennium, 4550-3900 B.C.) and belonging to the Kodjadermen-Gumelnița-Karanovo VI culture, one of the most important prehistoric civilizations of southeastern Europe.

Research on the site started in the mid-twentieth century, in the form of field surveys (Trohani and Șerbănescu, 1978). Systematic research at the site was conducted in 1984-1990 by Mihai Șimon. In 2000 excavations were resumed by The Lower Danube Museum Călărași (Lazăr and Parnic, 2007). This phase of archaeological research is characterized by a strongly interdisciplinary approach that integrates participation of researchers representing several disciplines (archaeozoology, archaeoethnology, sedimentology, micromorphology, anthropology) (Parnic and Chiriac, 2001; Parnic et al., 2003). In 2004 we started excavations in a new area, on the old river terrace in the vicinity of the *tell* settlement. The aim of these excavations was to detect the putative necropolis associated with the *tell*, a goal achieved in the same year (Lazăr, 2005). Following the identification of the prehistoric necropolis, in 2008 we opted for the application of non-intrusive exploration methods in the area of the site, under the *Archaeological Research and Prospection with Optoelectronic recourses – CARPO* program.

The Mostișteea Valley (about 92 km long) is located in the southeast of the Romanian Plain. A suite of lakes formed along the valley either by natural processes or as a result of anthropogenic interventions (Gâșteanu, 1963). On the right side of the valley lies the high plain of the Bărăgan Cornulesei Mostișteea Plain that ends at the south to the Danube, with large terraces, fragmented by valleys formed by the north tributaries of the Mostișteea river. The right side of the valley makes the transition to the Bărăgan itself through a fragmented valley plain (Mihailescu, 1925).

In terms of geomorphological setting the site of Măriuța-La Movilă is positioned at the intersecting area of the Vlăsiei, Mostișteea and Bărăganul Lehliului Plains, a zone characterized by the extent of loess and crowd “crov” fields (Coteț, 1973).

Table 1 contains the geographic coordinates of the 27.1 hectare area where the *tell* and necropolis are located. The corresponding absolute altitude of the *tell* settlement is at least 46.321 m and maximum 53.259 m, while the cemetery is appropriate at least 53.181 m and maximum 63.227 m. All data are reported in the projecting system of coordinates STEREO-70 and 1975 Black Sea elevation system reference.

Table (1): The geographical coordinates (Latitude / Longitude) of the Măriuța-La Movilă site.

North Latitude	East Longitude
44°32'20.00"	26°29'20.00"
44°32'20.00"	26°29'40.00"
44°32'00.00"	26°29'20.00"
44°32'00.00"	26°29'40.00"

The prehistoric site covers a ca. 11.67 hectare area, oriented approximately north-south and surrounded on three sides by water representing a meander of the Mostiștea River (Fig. 1). The prehistoric settlement occupies the northern headland and the cemetery is located ca. 200 m northeast of the settlement, on the terrace formed by the confluence of the Mostiștea and Colgeacu valleys (Coteț, 1973, 1976).

Archaeological background

Necropolis research is an important source of information about societies of the past. The discovery in 2004 of the necropolis at Măriuța-La Movilă was a major step forward in the knowledge of Eneolithic communities from Romania and southeastern Europe. Currently, more than 30 necropolises belonging to the Kodjadermen-Gumelnita-Karanovo VI culture are known.

In Bulgaria 17 extramural (Vinica, Goljamo Delčevo, Durankulak, Devnja, Radingrad, Var-na I, Tărgoviște, Liljak, Omurtag, Demir Baba Teke-Sboryanovo, Pomoștica, Kosharna, Smyadovo-Gorlomova koria, Poljanita, Ovčarovo, Stara Zagora-Bereketska Mogila, Stara Zagora-Rupki) and three intramural (Kubrat, Ruse, Yunatsite) Eneolithic cemeteries have been partially or completely studied (Georgiev and Angelov, 1957; Todorova, 1971, 2002; Radunčeva

1976; Ivanov, 1982, 1989; Angelova, 1991; Kalčev, 2002; Băčvarov, 2003; Boyadžiev, 2006). In Romania only 11 extramural cemeteries belonging to this culture are known – Vărăști-Grădiștea Ulmilor, Gumelnița I, Gumelnița II (Valea Mare), Chirnogi I (Terasa Rudarilor), Chirnogi II (Șuvița Iorgulescu), Cetatea Veche-Grădiștea, Căscioarele-D'aia Parte, Radovanu, Dridu, Sultana-Malu Roșu I, Măriuța-La Movilă, along with four other hypothetical cemeteries (Pietrele-Gorgana, Hârșova, Palazu Mare, Sultana-Malu Roșu II) (Comșa, 1960, 1974, 1980, 1995; Șerbănescu 1985; Bălțeanu and Cantemir, 1990; Hașotti, 1997; Lazăr, 2001a, 2001b; Hansen et al., 2005; Lazăr and Parnic, 2007; Lazăr et al., 2008, 2009; Toderăș et al., 2009).

The Măriuța-La Movilă necropolis is located on the high terrace of the old Mostiștea river, aprox. 200 m ENE of the *tell* settlement, and expands also on the terrace slopes.

This situation is similar to that observed in other Kodjadermen-Gumelnița-Karanovo VI *tell*-settlements north and south of the Danube. Most of the known cemeteries are found near the *tell* type settlements in high, unfloodable areas (usually on terraces and their slopes): Căscioarele-D'aia parte – 300 m NW of the D'aia parte *tell*, on the terrace and slopes (Șerbănescu and Șandric, 1998); Durankulak – 300 m SW of the settlement, on the Dobrudja plateau, on Lake Durankulak, graves are located on slopes (Todorova and Dimov, 1989); Goljamo Delcevo – on the high terrace west of the *tell*, at ca. 200 m (Todorova et al., 1975); Gumelnița – on the high terrace of the Danube, 250 m E of the *tell* and on the slopes of the settlement (Lazăr, 2001b); Sultana-Malu Roșu – on the high terrace of the old Mostiștea river, about 150 m W of settlement and on the slopes of the settlement (Lazăr et al., 2008, 2009); Radingrad – on the high terrace near the settlement, ca 100 m W of the *tell* (Ivanov, 1982); Vărăști-Grădiștea Ulmilor – 150 m NW of the Boian B *tell*, on the shore of the old lake Boian (Comșa, 1960, 1974, 1995); Vinica – approx. 50 m SSE of the settlement, on the high terrace of the Kamčija River (Radunčeva, 1976).

Table (2): Characteristics of the grave excavated between 2004 and 2006.

Grave	1	2	3	4	5
Year	2004	2004	2005	2005	2006
Section	S4	S5	S13	S19	S22
Altimetry	-0.94 m	-1.59 m	-0.95 m	-1.40 m	-0.97 m
Position	contracted on the right side	backwards lying	contracted on the left side	contracted on the left side	contracted on the left side
Orientation	ESE-WNW	NNE-SSW	E-W	ENE-WSW	E-W
Inventory	animal bone, sherds	ceramic pot, bone bead	-	flint blade, copper pin, stone chisel, red ochre	flint blade
Chronology	V th millennium B.C.	I-II century A.D.	V th millennium B.C.	V th millennium B.C.	V th millennium B.C.

Between 2004 and 2006 we found five inhumation graves in the Măriuța-La Movilă necropolis (Table 2). Four of the graves are prehistoric (Kodjadermen-Gumelnița-Karanovo VI culture) and one dates to the I – II centuries A.D. The presence of a grave from another chronological period is not a new phenomenon. Such situations are known in other prehistoric cemeteries (e.g. Durankulak, Goljamo Delcevo, Sultana- Malu Roșu, Chirnoği I and II etc) (Todorova et al., 1975; Todorova, 2002; Lazăr, 2001a; Lazăr and Parnic, 2007; Lazăr et al., 2008, 2009). In the current stage of research we do not have a relevant explanation about this phenomenon – the reusing of previous funerary areas by communities from different historical periods.

New investigations of the Măriuța-La Movilă necropolis carried out in 2008 and 2009 aimed at non-intrusive prospection as part of the CARPO project and led to the identification of new archaeological complexes.

METHODS

The methods used in the Măriuța-La Movilă necropolis are adapted to the specifics of the site, taking into account the size of the terrace (ca. 27.1 hectares), the particular aspects involved in the investigation of prehistoric cemeteries and the specific characteristics of the GPR method. In these circumstances, the cemetery was approached by applying techniques of interdisciplinary research.

Archaeological methods

The investigated area was divided into a grid of 20 x 20 m units for the easier manage-

ment of the excavation (Fig. 2). The grid was set using as reference the topographic landmark located on the village side of the terrace. Altimetry measures were reported to a reference point (P0) represented by a tagger located on the terrace at an elevation of 61.374 m above sea level.

A total of 27 archaeological sections were investigated between 2004 and 2009 (Table 3). Initially, 3 x 1 m sections were dug 10-20 m from each other, in order to cover as much surface area as possible.

After the first graves were discovered, bigger sections were cut (8 x 1 m, 8 x 2 m, 10 x 2 m), and areas overlain with a 2 x 2 m grid were excavated for systematic and comprehensive study. The microstratigraphic method, consisting of in-depth study of individual stratigraphic units (s.u.), was used to record the stratigraphic data.

Following GPR prospecting in 2008, five sections were excavated to verify the result of the prospection: S1/2008 (3 x 2 m) in square C1; S2/2008 (3 x 2 m) in square C3; S3/2008 (3 x 2 m) in square C4; S1/2009 (6 x 2 m) in square A1; S2/2009 (3 x 1 m) in square A2. GPR survey in the Măriuța-La Movilă necropolis led to the identification of anomalies at depths between -0.20 m and -1.20 m and with sizes ranging 1-2 m (Fig. 3).

These features have the same characteristics as the prehistoric graves previously studied at this locality. The existence of these anomalies shows that the Măriuța-La Movilă necropolis occupies an area much larger than the one studied to date.

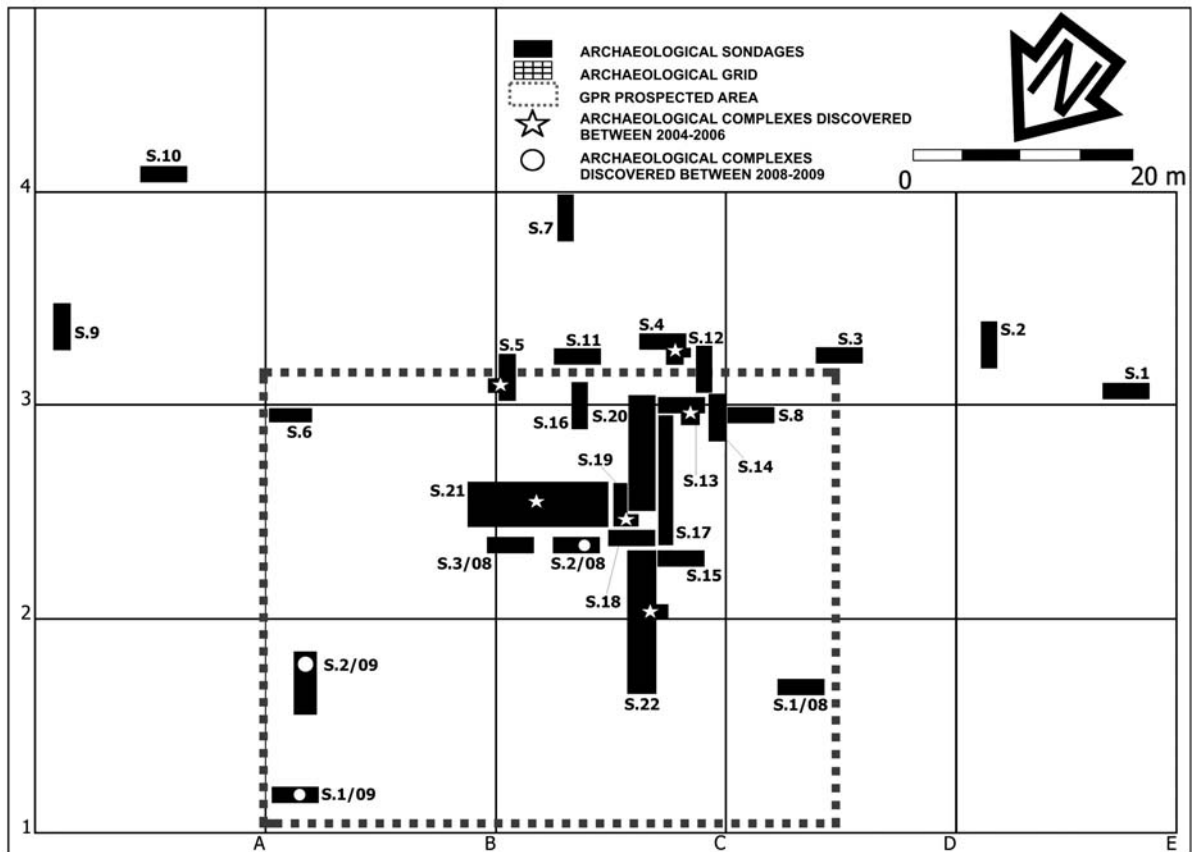


Fig (2): Plan of the archaeological excavations from Măriuța-La Movilă necropolis

GPR methods

The surface area chosen for exploration was a 50 x 50 m square (Fig. 2). We used a commercially available GPR system. Since most of the previous excavations revealed objects buried at depths of up to 2.00 m, the antennas, 500 MHz and 800 MHz were chosen to be suited to this depth. (Grasmueck et al, 2005). The temporal acquisition window of the two antennas was 64 and 52 nanoseconds respectively, with sampling frequencies of 8.6 GHz and 9.8 GHz. Transmitter/receiver antenna separation was 18 and 14 cm for 500 and 800 MHz respectively, and the distance interval sampling 11 and 8 cm respectively. Measurement triggering was done using a mounted wheel.

The prospection was carried out in the spring, following two weeks of heavy rain that introduced important quantities of water into the ground. In these circumstances the humidity strongly affected the measurements (Huisman et al. 2003).

Another major factor was represented by the previous diggings or sections. These, in the time

of acquisition, were covered with the same excavated ground, but the level of compactness gave a different shape of the signal. These areas were mapped, so during the prospections were not taken into consideration, but given the shape of electromagnetic waves propagates in ground under a cone some noise was given by these areas. This problem was not affected just the diggings / sections, but also the area that was considered for temporary storing of the excavated ground, temporary storing that was not mapped.

Table (3): Characteristics of the sondages excavated between 2004 and 2009

Sondages no.	Year	Square	Dimensions	Orientation
1	2004	A3	3 x 1 m	NW-SE
2	2004	A3	3 x 1 m	NE-SW
3	2004	B3	3 x 1 m	NE-SW
4	2004	C3	3 x 1 m	NE-SW
5	2004	C3	3 x 1 m	NW-SE
6	2004	D2	3 x 1 m	NE-SW
7	2004	C3	3 x 1 m	NW-SE
8	2004	B2	3 x 1 m	NE-SV

9	2004	E3	3 x 1 m	NW-SE
10	2004	E4	3 x 1 m	NE-SW
11	2004	C3	3 x 1 m	NE-SW
12	2005	C3	3 x 1 m	NW-SE
13	2005	C3	3 x 1 m	NE-SW
14	2005	C2	3 x 1 m	NW-SE
15	2005	C2	3 x 1 m	NE-SW
16	2005	C3	3 x 1 m	NW-SE
17	2005	C2	8 x 1 m	NW-SE
18	2005	C2	3 x 1 m	NE-SW
19	2005	C2	3 x 1 m	NW-SE
20	2006	C3	8 x 2 m	NW-SE
21	2006	C2	10 x 2 m	NE-SW
22	2006	C2	10 x 2 m	NW-SE
S1/08	2008	C1	3 x 2 m	NE-SW
S2/08	2008	C3	3 x 2 m	NE-SW
S3/08	2008	C4	3 x 2 m	NE-SW
S1/09	2009	A1	6 x 2 m	NE-SW
S2/09	2009	A2	3 x 1 m	NW-SE

RESULTS AND DISCUSSIONS

The depth of interest during processing was represented up to 2 meters, with anomalies larger than 1 meter. Even though for this subsurface prospection the best results are given by an 800 MHz antenna, the signal were too dispersed, being unreliable to interpret. In total were identified 16 possible interested areas.

After prospections was discovered one grave of 1x2 m, at a depth of 1 meter, with the height of the grave of 0.3 meters. The shape on radargram was an ellipse with the semimajor axis of 4 meters (including common midpoint effect), at a depth of 0.70 m, with a given electric constant of 14 (Fig. 4). Also the prospections led to the identification of two pits. One of them had a length of 2 meters on the image, at a depth of 50 cm, with 3 several distinguishable echoes (Fig. 5).

The archaeological sections made in order to verify the result of the GPR prospection led to the identification of the following archaeological features (Table 4).

In sondage S3/08, square C2, a pit was found at a depth of 1.20 m. This feature was noted as Complex 1/2008 and has a diameter of 0.94 x 0.79 m. The pit contained many prehistoric pottery fragments belonging to the Kodjadermen-Gumelnița-Karanovo VI culture (Vth millennium B.C.) (Fig. 2).

In sondage S1/09, square B1, at a depth of 1.40 m was found another pit, noted as Com-

plex 1/2009. This feature has a circular shape (diameter of 1.05 m), without archaeological materials. This was probably a pit for the extraction of clay and is dated in the modern period (XXth century A.D.) (Fig. 2).

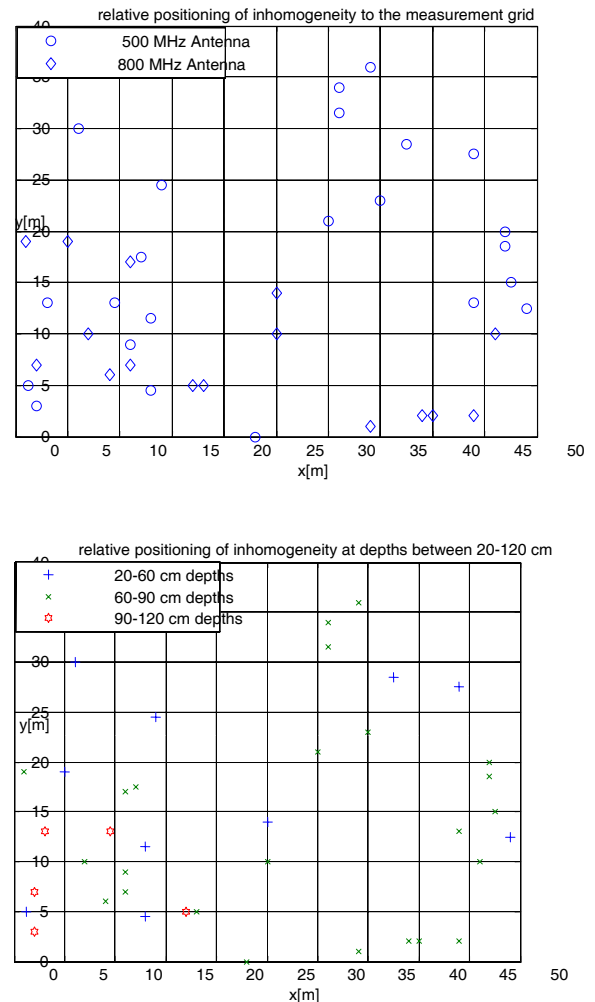


Fig 3): Inhomogeneity relative positioning: depending on the antenna that was made sounding (left); the depth at which irregularities were discovered with a value of relative permittivity of 14 (right).

In sondage S2/09, square B1, at a depth of 1.54 m was found a new inhumation grave (Complex 2/2009) (Fig. 2). This complex is the most important archaeological discovery made after GPR prospecting from Măriuța-La Movilă necropolis.

The funeral pit had an oval shape (1.62 x 0.56 m), oriented NNE–SSW. The filling of the funeral pit was yellowish-brown, homogenous, medium granulated, less compact than the surrounding sediment. It contained carbonates and it was disturbed by a few burrows.

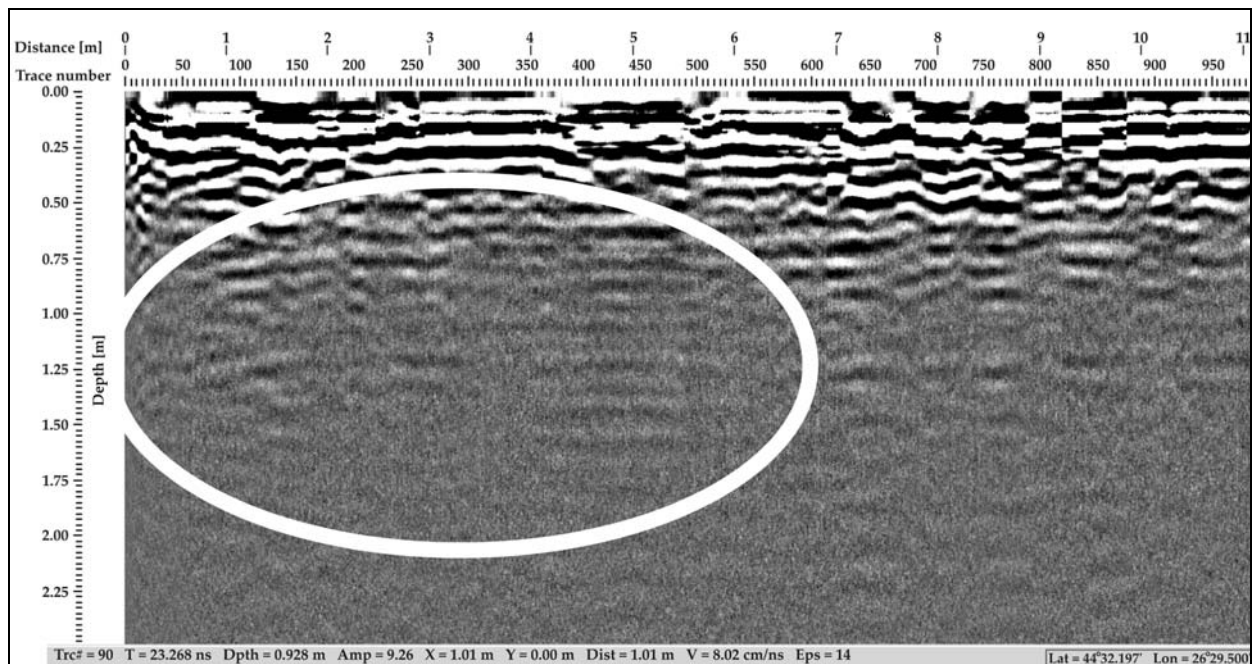


Fig (4): Grave explored image, it may be seen the echoes generated by the grave's layers (Complex 2/2009).

The grave contained the disturbed remains of an adult individual, the skeleton being de-ranged due to an intervention pit. Most of the bones were no longer in anatomical connection, being moved and disturbed (only the long bones were partially connected). Giving these

circumstances, it was possible to note that the skeleton was in backwards lying position, oriented N-S. Probably the left arm was rested aside the body and the right arm was bent with the hand towards the skull.

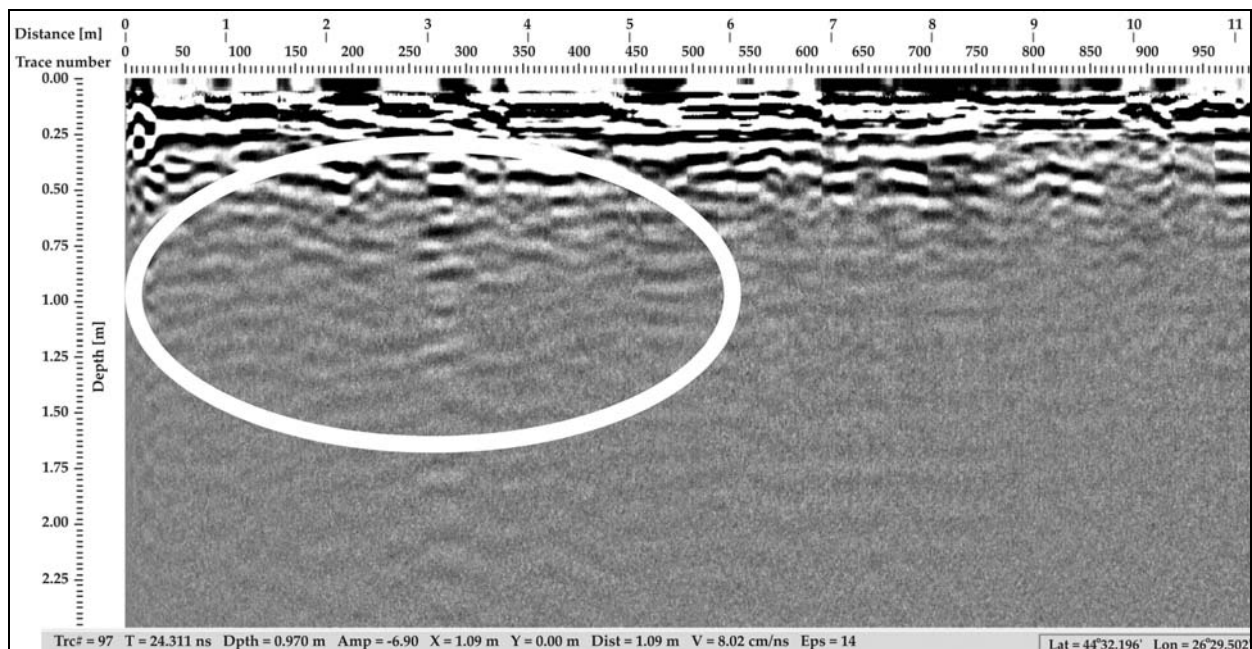


Fig (5): Grave pit explored image (Complex 2/2009).



Fig (6): Complex 2/2009: the ceramic bowl found in the grave (right) and detailed view of the grave (left).

Table (4): Characteristics of the complexes excavated between 2008 and 2009.

Complexes	1/2008	1/2009	2/2009
Year	2008	2009	2009
Section	S1/08	S1/09	S2/09
Square	C2	B1	B1
Altimetry	-1.20 m	-1.40 m	-1.54 m
Type	storage pit	pit for the extraction of clay	grave
Inventory	ceramic sherds	-	ceramic pot, glass bead
Chronology	V th millennium B.C.	XX th century A.C.	IV th century A.D.

The funeral inventory consists of a ceramic bowl (cup), placed near the skull. The ceramic bowl had spherical shape, with raised and slightly flaring rim (Fig. 6). Its dimensions are: h = 11.5 cm, Ø lip = 8.0 cm, Ø base = 5.3 cm. In the area of the

legs, thighs and neck were found more glass beads. They probably formed three necklaces and ornaments were to embellish the body of the defunct. Based on the funeral inventory the grave can be dated in the IVth century A.D.

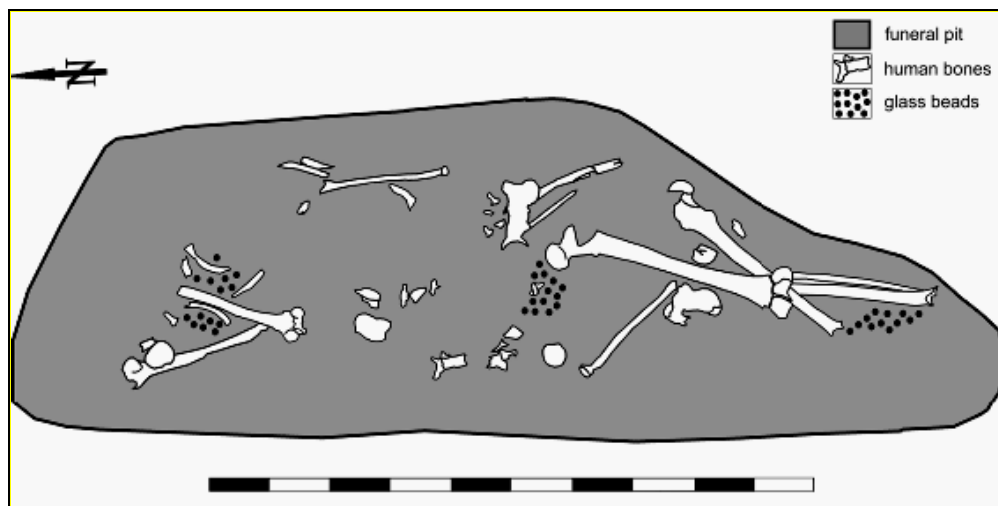


Fig (7): Complex 2/2009: the plan of the grave.

CONCLUSIONS

A short analysis of the Romanian Archaeological in the last period (2007-2009) indicates that from 581 researched sites, only in 17 cases were used geophysical prospecting methods (only 3%). In most of the cases magnetometry and electrical resistivity of soils methods were used (12 cases). Only five cases were using GPR surveying (e.g. Rotbav, Băneasa, Luncavița, Saveni and Măriuța sites) and most of them were made in the CARPO project (3 cases).

In conclusion, applications of the GPR methods in Romanian archaeology are still at the beginning and Măriuța-La Movilă site represents the first case in Romanian archaeology where GPR method has been applied to a necropolis. GPR prospecting led to the identification of more complexes, which correspond to the characteristics of the identified archaeological complexes studied previously. Moreover, verification methods using archaeological GPR results

confirmed the data obtained, identifying three archaeological complexes: one prehistoric pit (Complex 1/2008), one grave from the IVth century A.D. (Complex 2/2009) and a borrowing pit from the modern period (Complex 1/2009). However, archaeological research in the Măriuța-La Movilă necropolis should continue to check all the anomalies obtained from GPR prospecting.

Using GPR method in the necropolis of Măriuța-La Movilă has opened a new page of interdisciplinary research in Romania. This proved that applying geophysical methods in archaeology leads to good quality results. Under these circumstances, we believe that the use of GPR in archaeological prospecting is recommended in future, especially if we consider the time required to achieve this leaflet (much shorter than the achievement of archaeological excavations) and high accuracy especially for identifying archaeological complexes.

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