

# MAGNETIC PROSPECTION OF A TUMULUS IN THE ANCIENT HISTRIA NECROPOLIS

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**Abstract.** Near surface geophysical investigations are employed in archaeology in order to estimate the location, depth, shape and physical properties of buried ancient structures. The geophysical study initiated in 2008 on tumuli located in the Histria necropolis was based on magnetics, the measurements being carried out with a proton precession magnetometer / gradientmeter. The networks where measurements of total magnetic field and magnetic vertical gradient were performed covered each tumulus and small adjacent areas. The magnetic measurement points situated at 2 m interval represented detailed rectangular networks. The necropolis is situated at ca 2 km north-west of Histria ancient Greek city and includes a great number of tumuli of various dimensions and trends. Previous archaeological studies evidenced different rituals of burial for the ca 1300 years of continuous inhabitation during Greek colonization and Roman / Byzantine empires. The magnetic data obtained for the tumulus analyzed in this paper, located toward the north-western limit of the Histria necropolis, suggest quite complex archaeological features, similar to those observed in the excavations. Generally, metallic artifacts, a clay layer affected by fire or active magnetic rocks employed in the buried infrastructures may represent sources of high magnetic anomalies. The magnetic total field and vertical gradient anomalies are interpreted as being here mainly due to burnt materials and buried greenshist structure (high anomalies), or to an outer stone belt made of limestone boulders (low anomalies).

**Key words:** Histria, necropolis, tumulus, magnetic method, magnetic anomalies

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## INTRODUCTION

Non-destructive geophysical methods are used nowadays in archaeological studies to provide important information on the form, size, spatial arrangement and certain physical properties of the buried features in order to guide excavation works. Among these methods, high resolution magnetics was adopted in the last two decades in archaeological prospection being able to detect shallow archaeological targets at depths of a few meters. The effectiveness of the magnetic surveys, many times employing vertical gradient measurements, depends on the contrast between the magnetic properties of archaeological infrastructure and artifacts and those of the environment (soil and near-surface rocks).

The archaeological targets usually generate small magnetic anomalies in the range of a few tens of nT, for total field anomalies, or nT/m, for vertical gradient anomalies. Usually, magnetic archaeological remains are represented by kilns, bricks, pottery and obviously, artifacts made from iron, all

being characterized by high magnetic susceptibility and/or remanent magnetization.

## HISTRIA ANCIENT NECROPOLIS

Histria is the oldest ancient Greek city in Romania, established on the Black Sea by Greek colonists from Milet during the seventh century B.C. The city was inhabited continuously about 1300 years, since ancient Greek times until Roman-Byzantine ones. During the Greek period (VII<sup>th</sup> century B.C to I<sup>st</sup> century B.C.), the city had two distinct parts, the acropolis and the civil settlement, following a widespread model of the ancient world.

This structure was preserved until the city was abandoned during the VII<sup>th</sup> century A.D., following probably the closure of the bay where the city port was constructed. Presently, the excavated remains of Histria are situated on the western shore of Sinoe Lake, separated by the sea by the Chituc sandy bank.



Fig. 1. Tumuli in Histria ancient necropolis

The necropolis is located outside the ancient city walls and includes a large number of tumuli displaying different sizes and trends (Fig. 1). Archaeological excavations carried out during the XX<sup>th</sup> century showed that often the encountered burial rite was incineration and the tumuli infrastructure consisted in a circular peripheral ditch, a funeral platform and a stone belt (Fig. 2 - Alexandrescu, 1982).

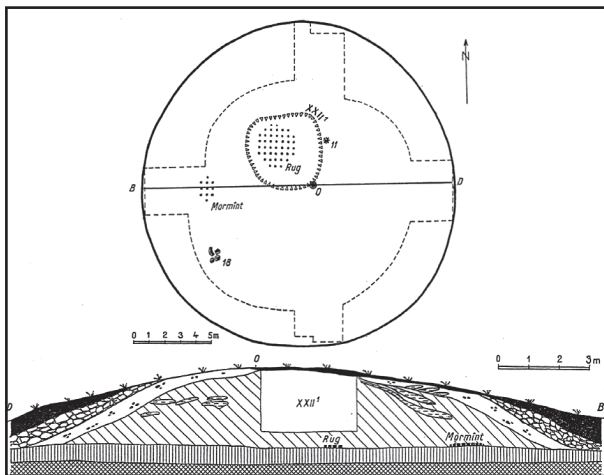


Fig. 2 Sketch of an excavated tumulus in Histria necropolis (Alexandrescu, 1982)

## GEOPHYSICAL DATA

The magnetic measurements were carried out using a Geometrics G-856 proton magnetometer/gradiometer device in a 2m interval rectangular grid overlapping the investigated tumulus. The tumulus elliptical shape extends on 40m (N-S) and respectively 30m (E-W).

The readings of total magnetic field, taken with an accuracy of 0.1 nT, were subsequently corrected for diurnal variation effect in order to obtain the magnetic anomalies. The two magnetic sensors of the gradiometer system are positioned at the heights of 0.75m and 2.00m above the ground.

The magnetic data were processed using Oasis Montaj<sup>TM</sup> software, three maps being obtained for the investigated tumulus:

- total field magnetic map at height 0.75m (Fig. 3);
- total field magnetic map at height 2.00m (Fig. 4);
- map of magnetic vertical gradient (Fig. 5).

## MAGNETIC DATA INTERPRETATION

The interpretation of the geophysical maps of magnetic total field and vertical gradient should be based on information of the magnetic properties of loess in the necropolis area, (since this is the material the tumulus was constructed) as well as other types of rocks that might be parts of the buried infrastructure.

Magnetic susceptibility measurements on rocks and soils in the Histria excavated city and inside the necropolis, taken during the geophysical observations using a KT-3 instrument, showed the following situation:

- the lowest magnetic properties were observed on monuments exhibited in the Histria Museum that made of marble and limestone (lowest values on lumachellic limestone);
- greenschists within the city inner walls are highly magnetic, but they may not be characteristic for this area, being possibly brought from remote areas during restoration;
- greenschists that outcrop at the eastern limit of Histria city display higher magnetic properties than limestone and slightly higher than loess.

Considering these qualitative observations, due to weak magnetic contrasts between rocks and loess, low magnetic anomalies might detect buried structures made of limestone, while high magnetic anomalies might be associated with structures where greenschists are dominant. Locally, high magnetic anomalies should be related to burnt structures or pottery.

The analysis of total field anomalies measured at lower height above the tumulus (0.75m – Fig. 3) showed important magnetic variations on a quite small area, the difference between the highest and the lowest value being 163.7 nT. An elongated central high anomaly trending N-S (north is toward right in the figure) is contoured by a circular to ellipsoidal low anomaly. Considering the magnetic properties discussed above, the magnetic high may be determined by greenschist boulders utilized in the tumulus inner structure and possibly, by burnt materials in a central burial platform (as suggested in Fig. 2). The large low magnetic anomaly is considered to be related to the outer stone belt made of limestone boulders.

The map with total field anomalies measured at higher height above the tumulus (2.00m – Fig. 4) displays similar aspects as described above, the increased distance from the ground diminishing the difference between the highest and lowest value (139.4 nT). Another consequence that may be observed is the smoothing of the magnetic anomalies

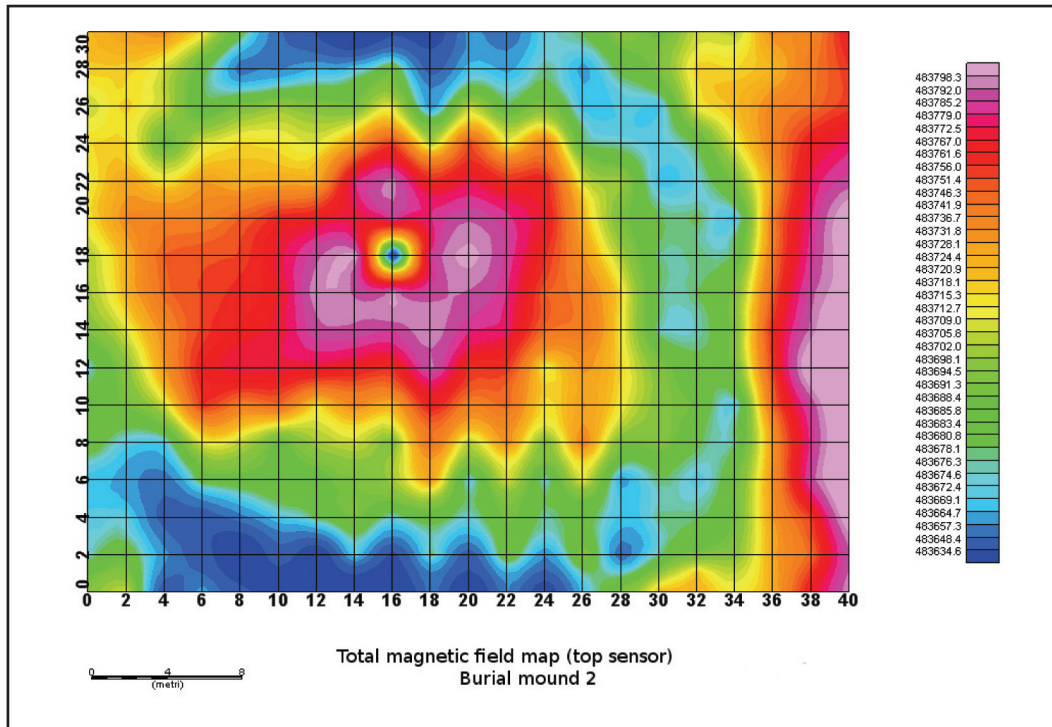


Fig. 3 Map of total field magnetic map at height 0.75m

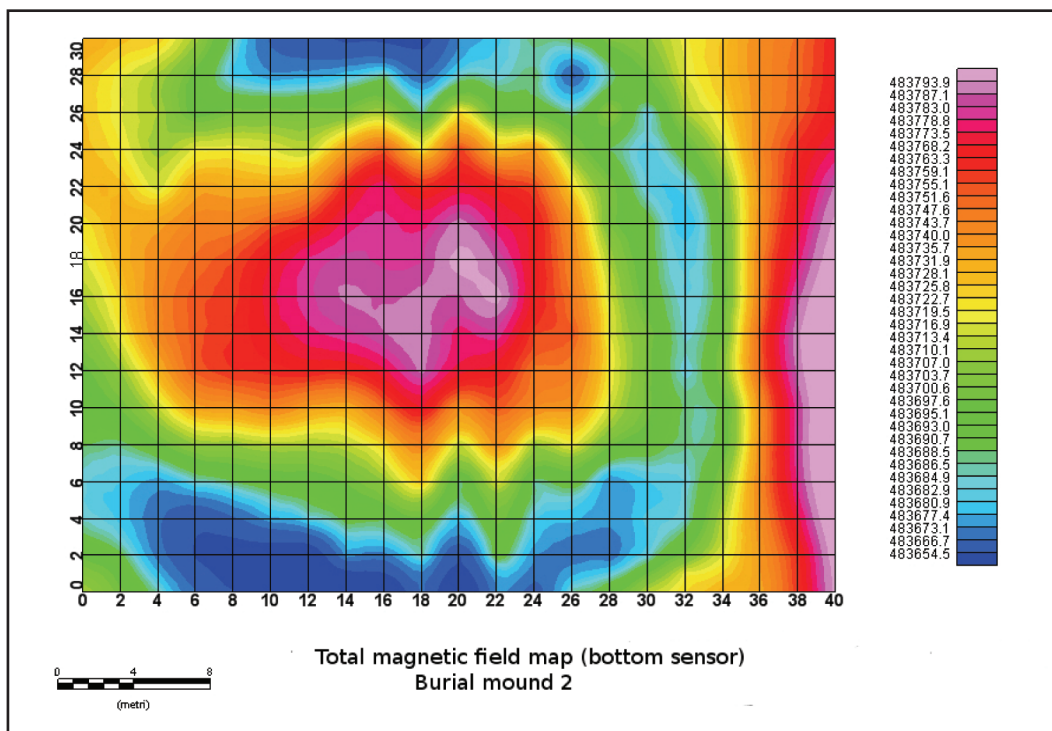
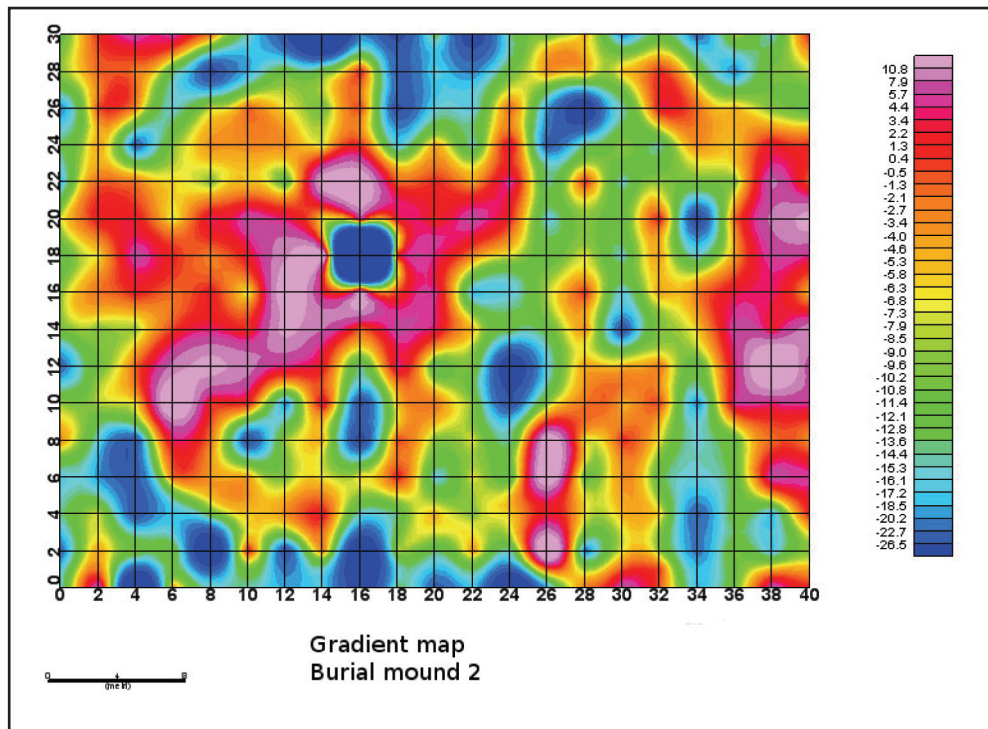


Fig. 4 Map of total magnetic field at height 2.00m



**Fig. 5** Map of magnetic vertical gradient

as compared to the previous map. The two local anomalies trending NE-SW situated at the high magnetic apex might reflect a more complex structure of the hypothetical burial platform.

The map of the magnetic vertical gradient (Fig. 5) presents large variations of this quantity, ranging between +10.8 and -26.6 nT/m. The vertical gradient anomalies are determined by shallower variations of magnetic properties as compared to the total field anomalies, and that is why they are so popular in archaeological prospection. From the main high total field magnetic anomaly is preserved here only a half, a feature that may be interpreted as a prolongation toward the tumulus upper part of the actively magnetic central structure. The other half, which is characterized by lower magnetic values, may represent an corridor toward the inner structure created by ancient "archeologists", presently filled with loess. The outer main low magnetic anomaly is still seen in this map, but especially on the tumulus flanks, where measurements were taken at the topography height, closer to the buried stone belt.

## CONCLUSIONS

A magnetic prospection carried out in August 2008 within the Histria ancient necropolis aimed at testing the capability of this geophysical method to investigate the tumuli infrastructure in this area.

Two magnetic total field maps were computed at heights above the tumulus (0.75m and 2.00m, respectively), while the magnetic vertical gradient map was computed for half of the distance between sensors.

The interpretation of total field magnetic data correlated the central high magnetic anomaly with a complex buried burial platform, possibly including burnt materials and a structure made of greenschist boulders. The large circular low magnetic anomaly is interpreted as the effect of an outer stone belt made of limestone boulders.

The magnetic vertical gradient data suggest that half of the central buried structure is developed upward at depths where this magnetic quantity is able to bring useful information. For the other half of the high magnetic anomaly, the interpretation favors a partial destruction of the central buried structure performed by ancient "archeologists".

The authors consider that this geophysical test showed good possibilities for a future magnetic detailed prospection of the Histria necropolis.

Better results with clearer archaeological meaning may be obtained by a closer cooperation between geophysicists and archeologists before, during and after excavation works.



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