

## **2003 GRADIOMETRIC RESEARCH AT MURIGHIOL, ROMANIA**

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This paper reports on the first time that magnetic prospection utilizing gradiometry has been used to produce maps of a Romanian Danube archaeological site. First, gradiometry will be briefly described, and then its use at Halmyris, a Roman fort near present day Murighiol, Tulcea County, will be discussed and selected features highlighted.

A gradiometer measures slight deviations in the earth's magnetic field which can be as little as a few parts in a million down to a depth of about 2 meters under the proper conditions. The sensitivity is so great that even very small amounts of ferrous or magnetic material can affect a reading. However, for a gradiometer to detect archaeological features, those features must have different magnetic properties than the surrounding material.

The earth's magnetic field is distorted either by the concentration of iron molecules or by clay (including pottery and bricks) and some stone when heated above the Curie point. Deviations, or anomalies, of archaeological interest are caused by iron objects such as weapons, armor, and nails or the concentration of iron in decomposed and compacted organic material such as is found at bottoms of wells and in trenches, pits, post holes, and kitchen middens. Magnetic features due to fire altered materials include hearths, ovens, furnaces and kilns, or even burned dwellings. On the other hand, some stone, especially limestone, has less magnetic susceptibility than the surrounding soil.

At Halmyris, 20 x 20 meter grids oriented to magnetic north by compass were traversed with a Geoscan FM256 dual fluxgate gradiometer in parallel northerly traverses one meter apart. Eight data readings were collected per meter traversed. Data editing and mapping were done with the use of Geoplot and Surfer 8 software.

Halmyris is located near present-day Murighiol, where the southern (Sf. Gheorghe) branch of the Danube River emptied into the Black Sea during Roman times (see Figure 1). It was occupied by the Getae perhaps as early as the 5<sup>th</sup> Century BC and then by the Romans as late as the early 7<sup>th</sup> Century AD when

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the site was abandoned. At its height, Halmyris comprised a fortification of ca. 2.5 hectares, was a bishopric, and was one of the 15 important towns of Scythia Minor. During its Roman occupation the site suffered at least two major fires and four devastations at the hands of barbarians, shows signs of damage due to seismic quakes, and was extensively rebuilt at various times by the Romans. Gradiometry can detect magnetic anomalies related to these events but only traditional archaeological excavation can provide an exact answer as to what is seen and when it occurred.

At various times, aerial photographs have been taken of Halmyris. A 1977 aerial photograph (Figure 2) shows the site and the remains of some of the random and largely unreported excavations carried out at the site by Expectatus Bujor in the mid-1950's. Based especially on this photograph, Alexandru Stefan, in a 1984 publication, reached conclusions about the nature of the fort and its defensive towers. Stefan reported that the southern corner towers of Halmyris were fan-shaped and that, with one exception, the others were U or horseshoe shaped (Figure 3). Stefan also concluded that there were defensive ditches and earthen ramparts that circled the fort to the water line of the Danube. Dr. Mihail Zahariade, in systematic on-going excavations since 1981, has found that the tower to the north of the western gate is in fact a bastion and that the northern tower is two towers flanking a gate. He has also determined that the northeastern tower is, in fact, a gate which was later sealed. Additionally, the current gradiometric examination (Figure 4) shows that the southern corner towers were, in fact, trapezoidal—partly within and partly extending outside the fortress walls. The data on the eastern side of the fort (Figure 6) also raise doubts that the earthworks outside the fort extended as far as the waterline, at least not during the later phases of occupation.

In the gradiometric maps, areas to the north and east of the fort were once Danube River and the harbor of the fort—now occupied by cornfields. To the south of the fort and harbor was a civilian community—now occupied by a sunflower field. The area of no data in the northwestern part of the fort, *Insula I*, has been excavated extensively by Zahariade. It was in this area that the basilica was located with the crypt containing the remains of the martyrs, Astion and Epictet. Blank areas in the southern and eastern part of the fort are where there are piles of excavated stone and brick or deleted readings determined to be due to modern iron.

The white (negative) areas are either stone which contains less iron than the surrounding material, or the negative poles of strong magnetic features. The black (positive) areas indicate either iron or iron molecule concentrations or areas which were subjected to high heat. There are extremely high positive and negative readings in the tower west of the southeast corner tower of the fort (Figure 4), probably due to the intense heat of the inferno when this tower was destroyed. Excavation down to 2 meters in this 10-meter high tower revealed large quantities of melted clay and remains of roof tiles that had curled and melted. The iron spikes found were too few and too deep to have caused the strong magnetic readings.

In Figure 4, one can see buildings within the fort, including those which were previously excavated; streets leading up to the tower areas; and a broad

relatively open area where the *Cardo Maximus* would have been. The lack of buildings around the southern *Cardo Maximus* is puzzling and may be a result of destruction of buildings to be used elsewhere in the fort or the purposeful creation of an open area. The often faint, extensive building consisting of many rooms in the southeast is in a higher than usual mound which was probably the *Principia*. These fainter than usual walls may be buried more deeply or may have been constructed more with native stone than with limestone. This building has what appears to be a large atrium at its southern entrance. Leading to the eastern tower which is third from the bottom is a portion of the *Decumanus Maximus*. The dark interiors of the buildings are due perhaps to a combination of organic material and the fire which swept the fort. The *Principia* seems perhaps to have not burned as severely as other buildings on the western side and against the eastern wall. It is also possible that some strong readings are due in part to the removal of modern soil from archaeological features during Bujor's excavations. The tower to the north of the southeastern corner of the fort is of interest due to its apparent complexity and large size, suggesting that it may have served as a gate to the harbor area. At approximately N170, E135, immediately southwest of the northeastern gate of the fort, there is what is believed to be a chapel approximately 10 meters in length. It has a distinctive street leading from it parallel to the outer fortress wall to the building believed to be the *Principia*.

Figure 5 is a close-up view of the feature that may be a chapel. In spite of the scatter of the fallen walls, it is possible to see an attached room to the left. It also appears that there were at least two columns in the central area, one still in place where it fell. Just before the apse, on the right there appears to be significant debris; from another angle one can see either a door or a breach in the wall at this point. By far the highest readings in this grid are those of the apse which was perhaps sheltered from destruction by the adjacent tower wall (just outside the grid).

Figure 6 shows the southern port area that could be surveyed. The area east of the southeastern fortress tower and just left of center which exhibits the numerous extreme bipolar values (N90-100, E34-49) was previously excavated and has been used as a dump; therefore, these bipolar spikes are mostly, if not all, modern iron—bottle caps and rusted iron. The dark line running in an east-southeasterly direction from this point is a ridge, possibly for defensive purposes. Usually one would expect a ditch, rather than a ridge of this type, to give this positive reading—perhaps this signifies a palisade or organic material which collected against a wall. Many of the light and dark bipolar spots on the map are probably signatures of Roman nails, or possibly fired tiles. In some areas these spots appear to form circles. The possibility exists that some linear or circular lines of bipolar points represent wooden structures which now may be detected only by the existence of the nail signatures. The two large dark features at approximately N89 and N97 and E84 on the map were perhaps kilns or a kiln and its dump. The dark area near the southeastern fort wall at N113, E33 is probably a building or central room in a larger building which burned. The eastern wall of this structure was probably confused by Stefan to be one of his proposed defensive ramparts. The double line stretching across the lower map from east to west (E69 – E58) is the current horse cart road which has negative tracks due to the compacted soil, with the adjacent ditches being darker (positive) due to the concentration of organic matter. The features in the southeast showing very

strong positive and negative poles are near, or in the edge of, what appears to be an Iron Age necropolis (not on the map). An exposed grave with a gradiometric signature like the feature at N49, E115 was identified by recovered pottery as being an Iron Age grave. The extreme located in this area may indicate grave goods or the tiles surrounding interments, or modern iron.

The Figure 7 relief map has all positive values converted to zero and negative values transformed. Near the fort, there appears to be an enclosure or platform with a building in the center, or a room within a larger room—this is the feature (N113, E33) with a dark center in the previous map. There are straight lines consisting of stone, brick, or negative poles of iron nails roughly parallel to or at right angles to the ridge noted in Figure 6. When straight lines run parallel to and at right angles to each other, one can theorize that there are buildings, but this needs to be tested by „ground truthing” or excavation.

Figure 8 shows the northern harbor area east of the fort. The strong positive and negative feature at the upper left (N94-104, E20-25) is part of a tower at the northeastern gate. A faint road leads in a northeasterly direction from the gate. To the left of this road is a circle of nine dark spots (N128-136, E9-17); they are each about two meters in diameter—perhaps dolia or ovens. Between the two towers is a building just outside the walls (N67-75, E34-42) with six or more small rooms and a similar building at an angle to the right of it. Also, immediately to the north, one can see a faint round feature consisting of small dots with a larger dark dot in the middle. The ring of dots, at least in part, may be caused by iron nails—perhaps a livestock corral, perhaps just a coincidence in location of unrelated items. It is significant that this oval is large—about 13 meters in length. The central dark dot has a positive area surrounded by a negative one; the size (1 meter diameter) and readings (which are weaker than one would expect of iron) suggest that this may be a well. These suggested features all require ground truthing.

Figure 9 is a 30 x 30 meter grid over a Bronze Age tumulus on the ridge above the fort, with modern iron spikes deleted and geologic features truncated. It was the only tumulus in a series on the ridge that had not been excavated or plundered. The dark and light parallel lines running from the northwest to the southeast are geologic strata of the bedrock on which the tomb rests. These geologic features are almost as strong as the strongest archaeological features in this grid. In the center of the grid, you can see the very faint traces of a stone circle. There is little contrast between the circle and the surrounding area probably because the circle was constructed of native stone from a pit near the tumulus and offered little magnetic contrast. In the western side of the circle are two negative features, perhaps grave goods or two burials. On the northern side is a feature with a negative center surrounded by four ordinally-oriented positive areas. Is this perhaps offerings or the actual Bronze Age grave? Or is this an Iron Age grave? Figure 11 is a three-dimensional edited map with the geologic features muted, demonstrating the relatively weak absolute intensity of the archaeological features of interest in comparison to a small piece of modern iron on the surface in the lower right. While strength of the archaeological features in this grid are reduced due to the higher magnetic susceptibility of the background, the fact remains that they are weak *vis-à-vis* an also diminished standard.

These maps demonstrate the utility of gradiometry in rapidly and economically determining site plans of previously undescribed excavations, developing hypotheses concerning layout and function of features not yet excavated, targeting features for possible excavation, and informing the archaeologist of features to look for during excavation. However, a final word of caution is in order. While one can identify features in these maps and imagine what they are, one can only definitely know what is there through traditional archaeological excavation. Due to a lack of time and resources, only limited ground truthing has been possible at Halmyris. Excavations in Insula I have supported the gradiometric location of walls and Roman iron, but much more ground truthing is needed in the harbor area to verify what now can only be hypothesized.

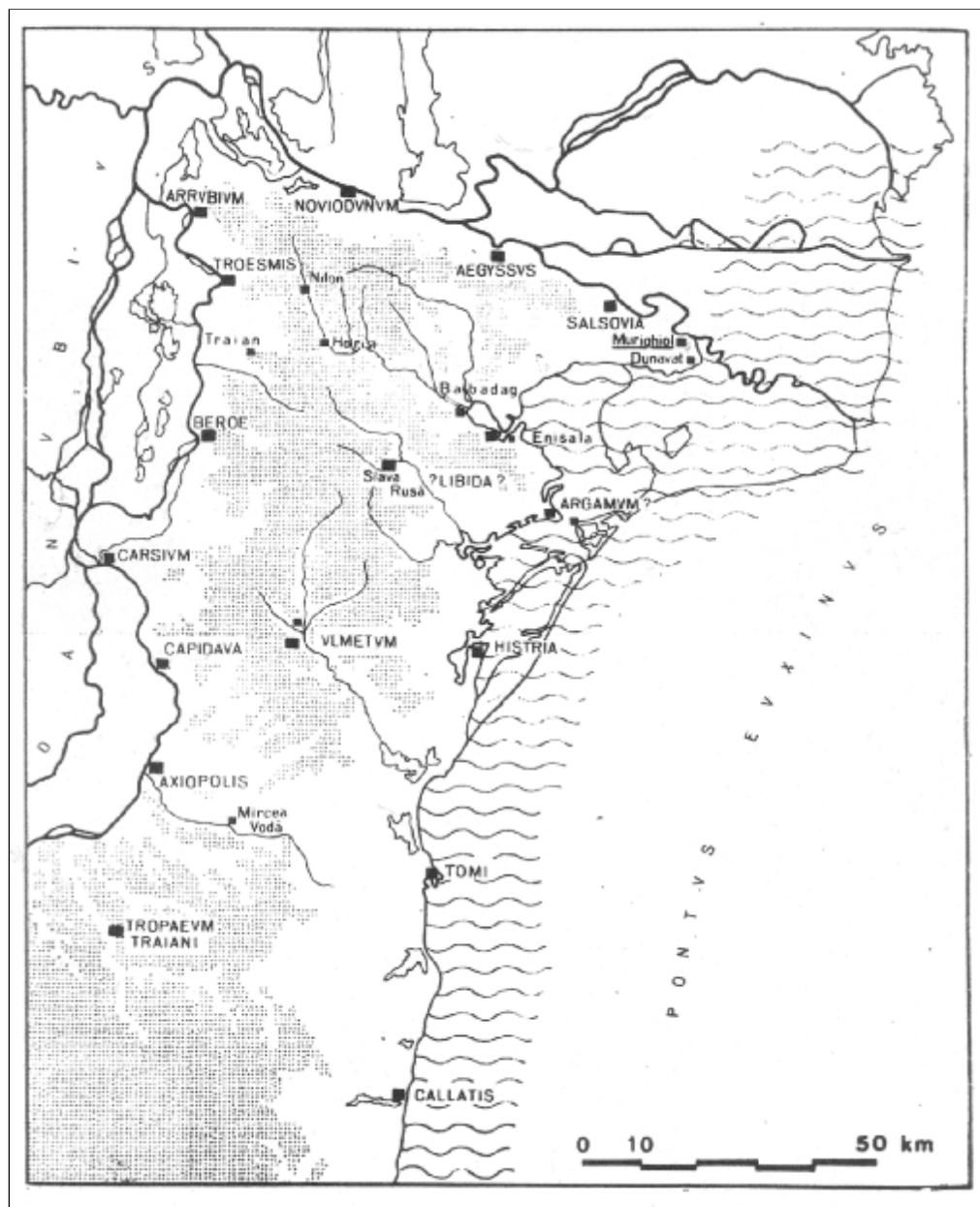


Fig. 1 - Map showing location of Murighiol (Halmyris) and other main 4<sup>th</sup>–5<sup>th</sup> Century fortresses in Dobrugea, Romania



Fig. 2 - 1977 vertical air photograph of Halmyris

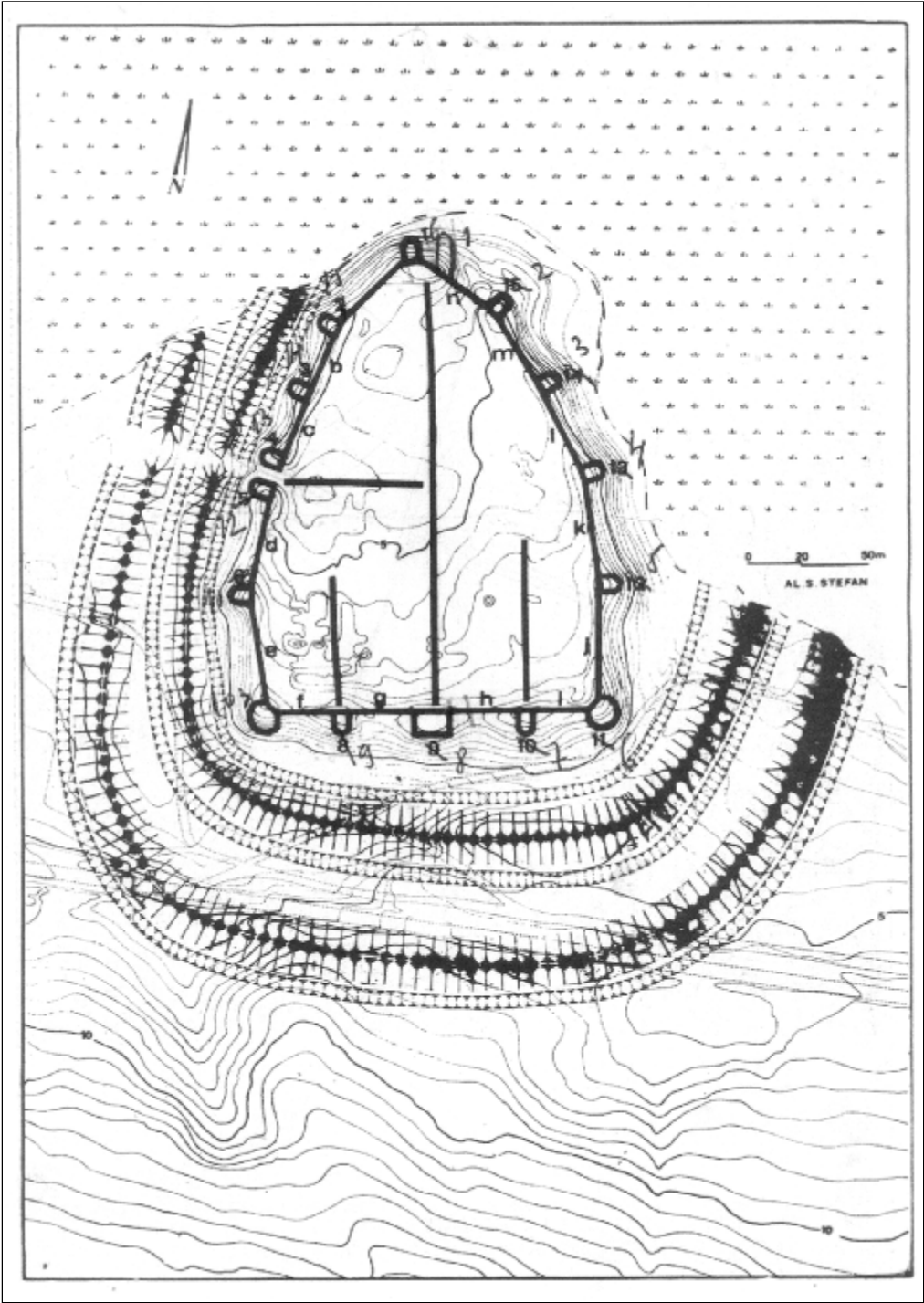


Fig. 3 - A. Stephan photogrammetric plan of Halmyris

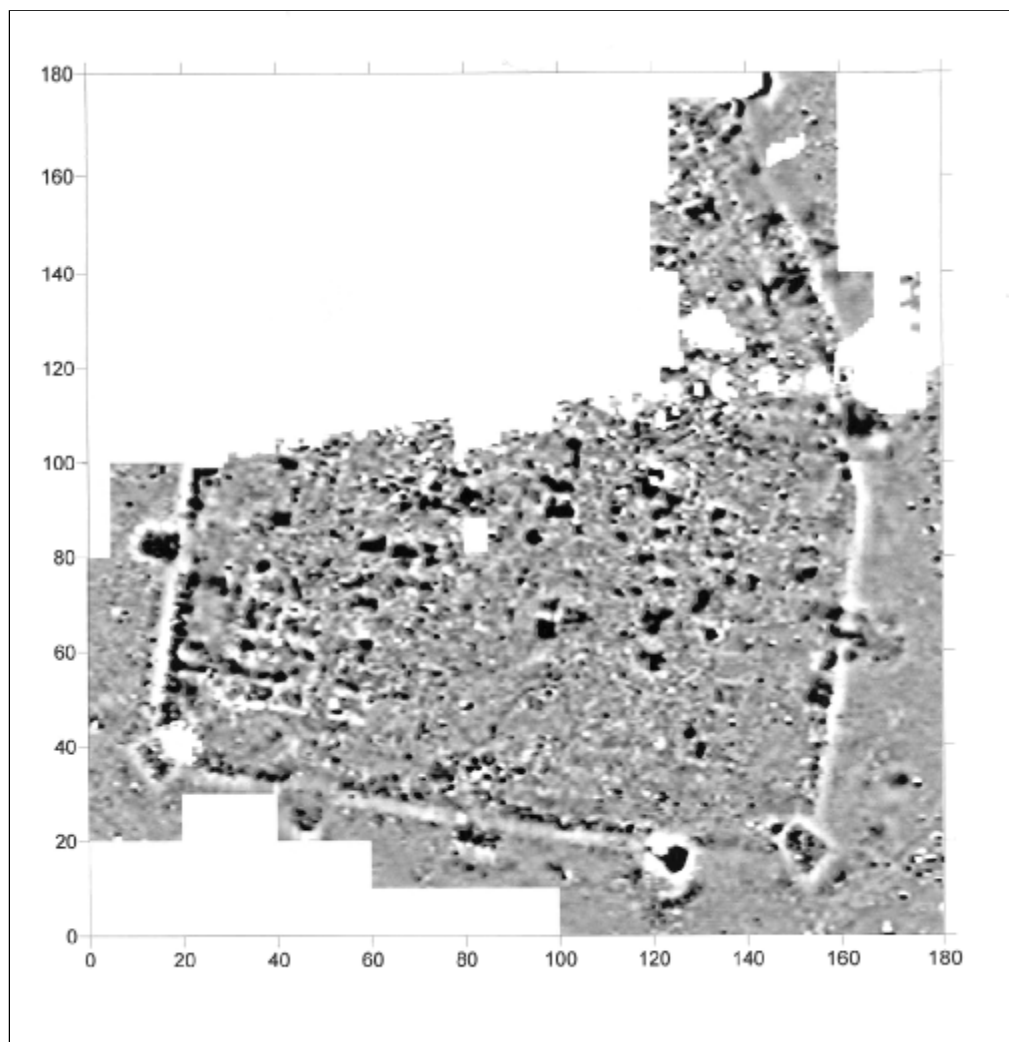
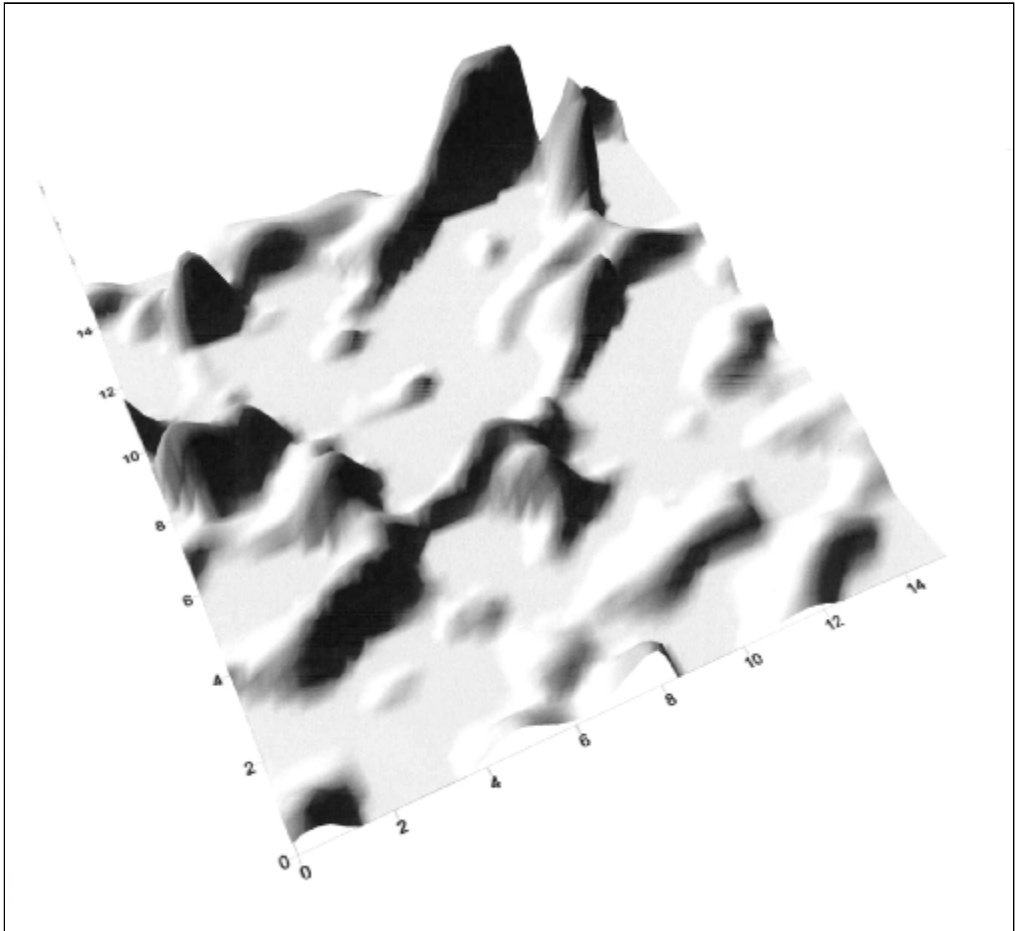


Fig. 4 - Gradiometric map of the accessible fortress area, Halmyris



**Fig. 5 - Gradiometric relief map of the possible chapel, Halmyris**

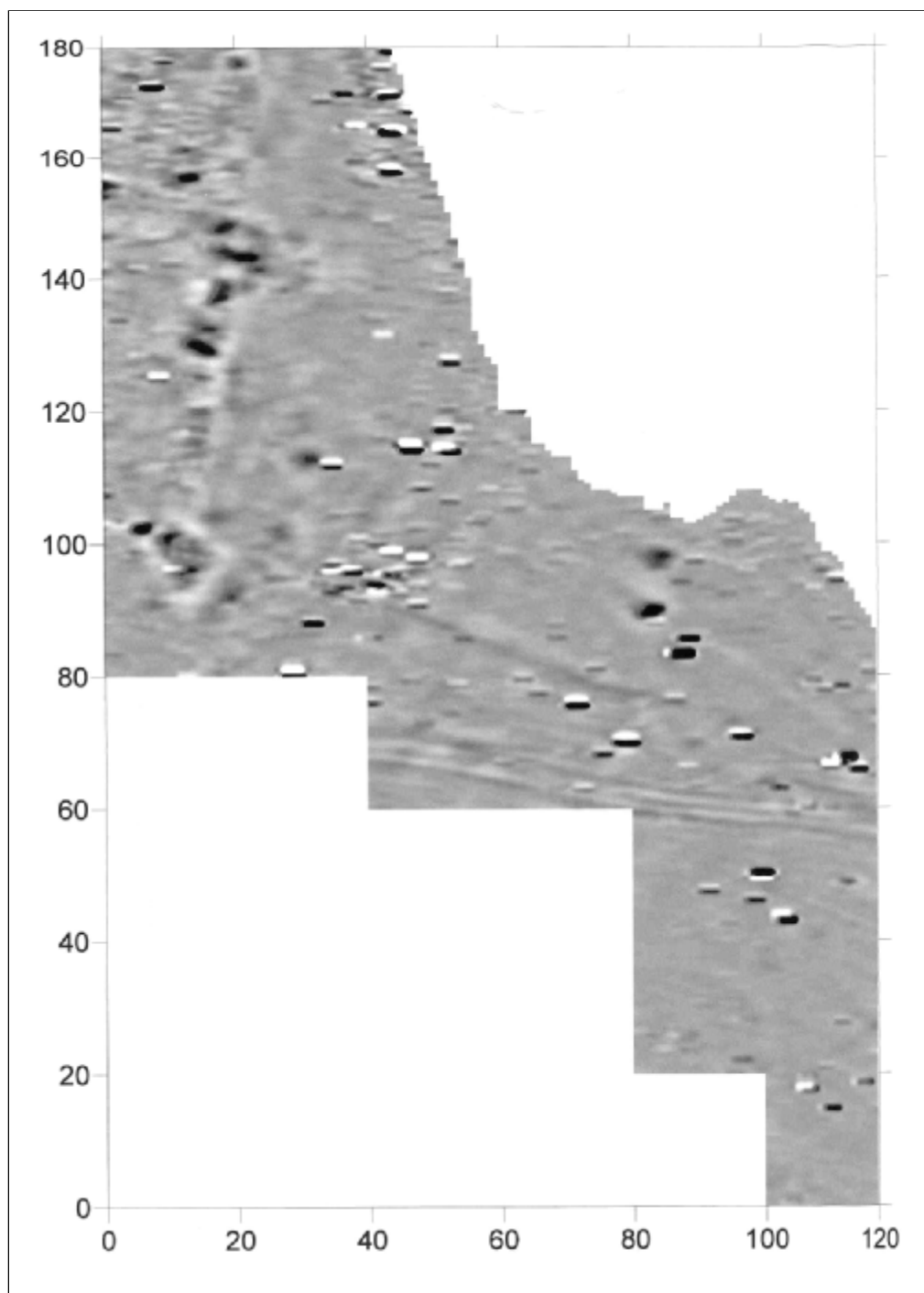


Fig. 6 - Gradiometric map of the accessible southern harbor area, Halmyris

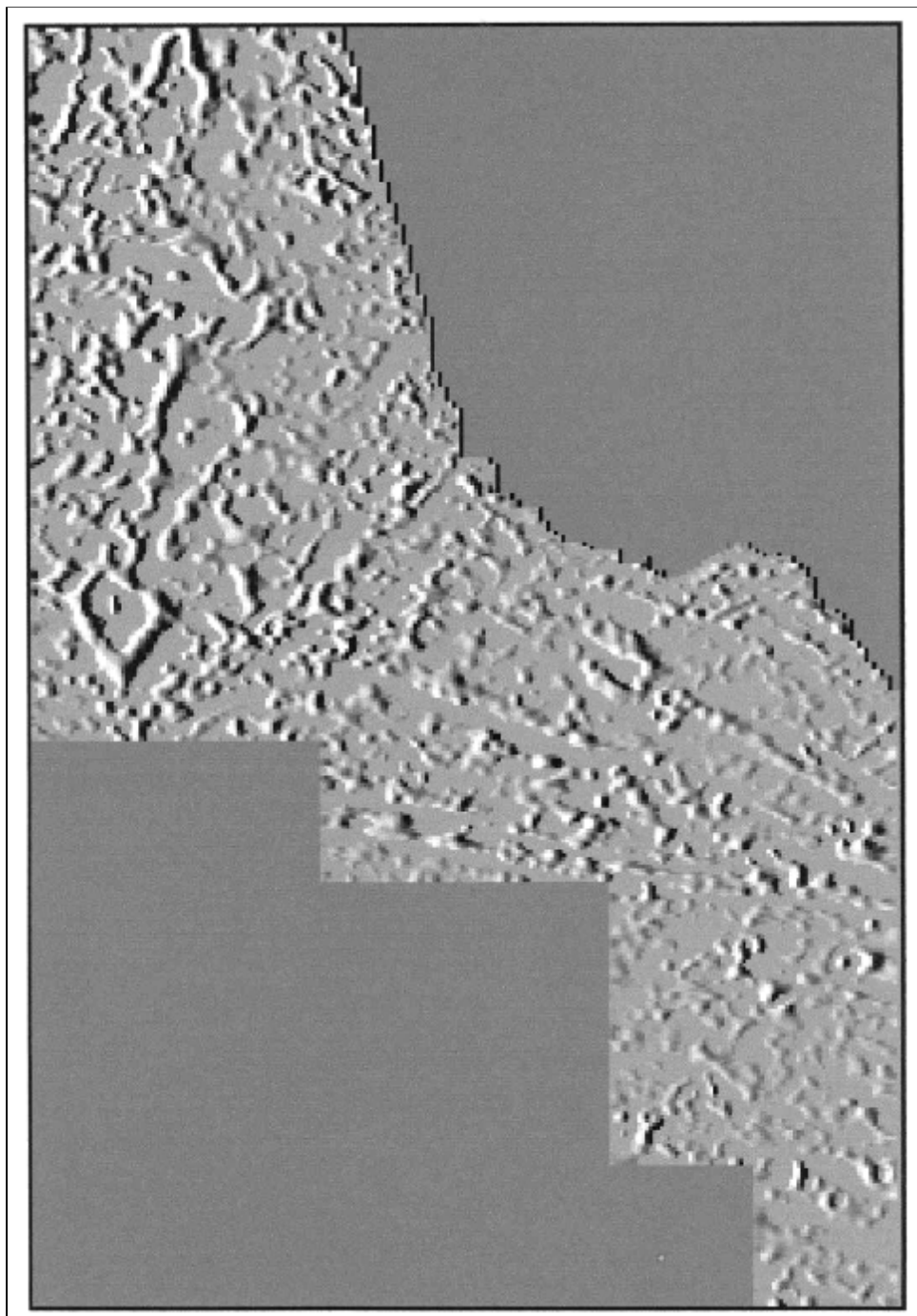


Fig. 7 - Gradiometric relief map of negative anomalies  
in the southern harbor area, Halmyris

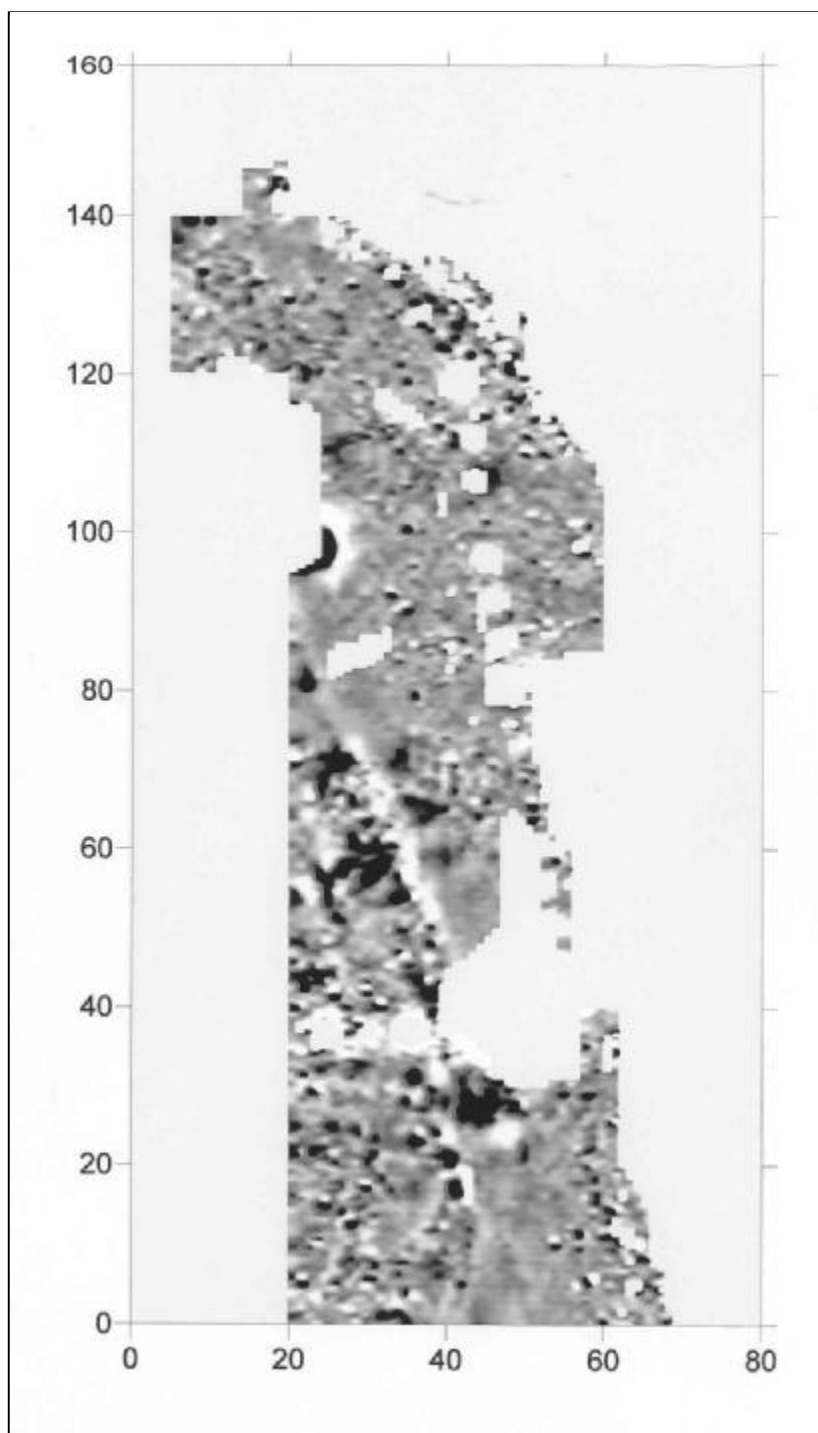
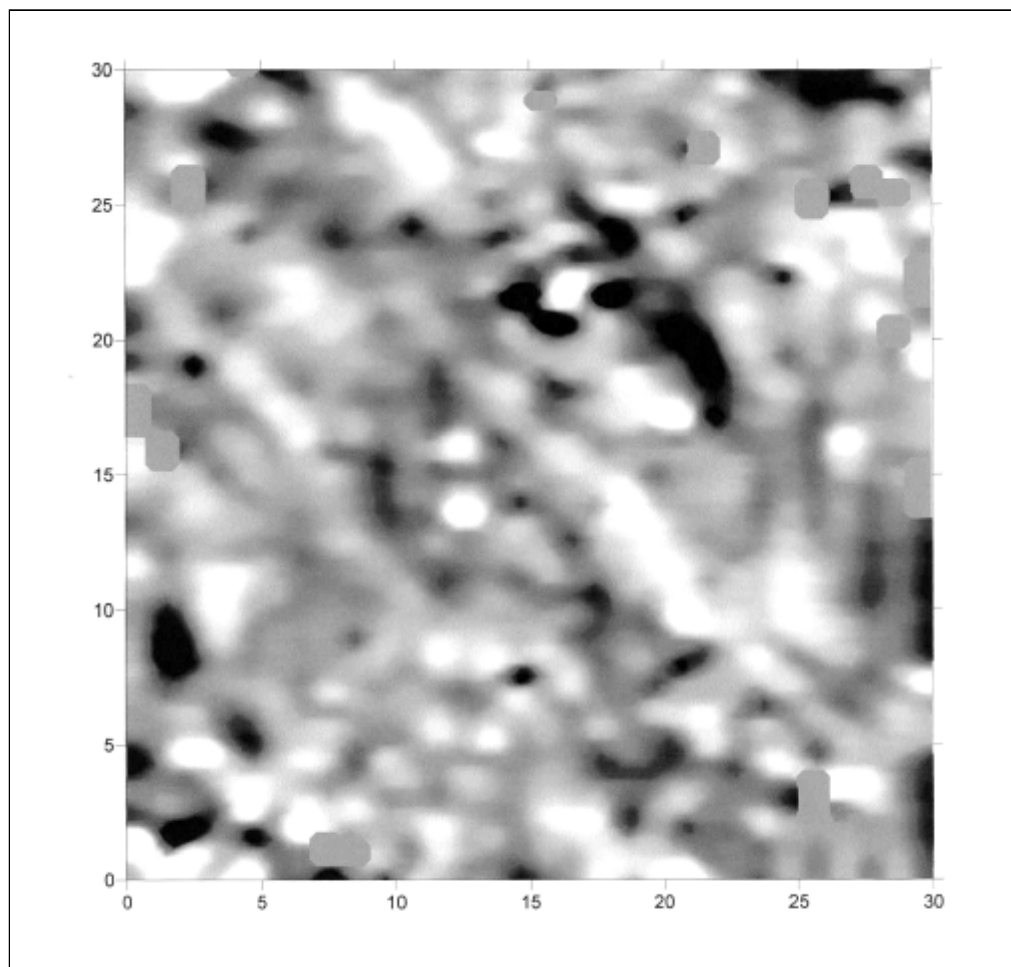


Fig 8 - Gradiometric map of the northern harbor area, Halmyris



**Fig. 9 - Gradiometric map of Bronze Age tumulus,  
Murighiol, Tulcea County, Romania**

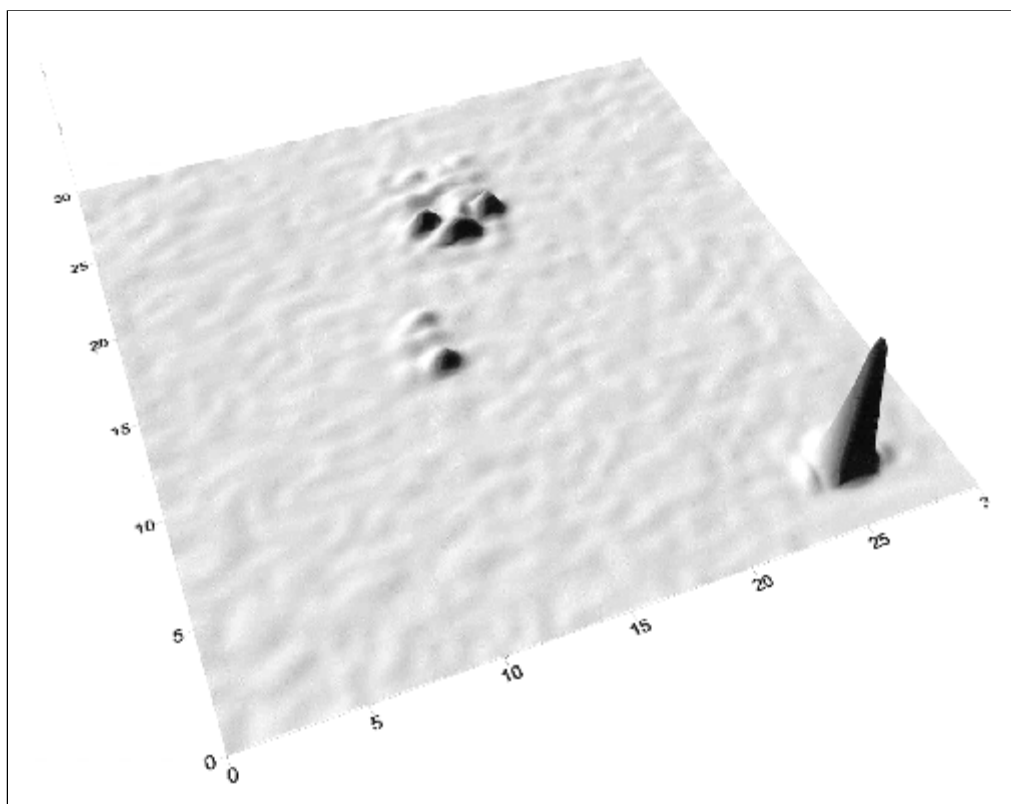


Fig. 10 - Edited relief map of absolute values of key archaeological features in the tumulus compared to a modern iron signal