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The X-Tepe of Pergamon: Magnetic Investigation of an Intermediate-size Tumulus

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Introduction

The X-Tepe (figs. 1, 2) is a tumulus of intermediate size consisting of a diameter of about 85 m at its base and a height of 11 m above the surrounding plain[1] (fig. 3a, b). It is located on the alluvial fan of the Bergama Çay (Selinus) south of the acropolis of Pergamon (see fig. 1 in the contribution of F. Pirson in this volume). The terrain where the burial mound was erected is characterised by the presence of natural formations of andesite visible on the surface (figs. 1, 2). The X-Tepe tumulus is generally well preserved, but funnel-shaped holes on its top attest attempts at tomb raiding.

In its immediate vicinity four more tumuli can be found, two of which are more significant than the X-Tepe itself (see fig. 1 in the contribution of F. Pirson in this volume). These are the Maltepe tumulus, located 550 m to the northeast, and the Yığma Tepe 800 m to the east, whereas two smaller tumuli known as Tumulus 2 and Tumulus 3 lie approximately 300 m northeast of the X-Tepe tumulus. The proximity of these burial mounds indicates that the area was used as a burial ground with tumuli of considerable sizes. The X-Tepe can easily be regarded as belonging to this group of burial mounds which points to the significance of the deceased. While the Maltepe tumulus can be attributed to the Roman Imperial period due to its building technique, the Yığma Tepe and Tumuli 2 and 3 belong to the Hellenistic period (3rd–2nd century BC)[2]. In the case of the X-Tepe, the absence of typical Roman Imperial building techniques and parallels of the inner structure of the mound with Hellenistic tumuli from Macedonia (see below) tentatively point to a Hellenistic date as well. In this respect, the X-Tepe tumulus can be regarded as located in a Hellenistic funerary landscape dominated by large gravemounds, which comprised, with the Yığma Tepe, at least one burial most probably related to the Attalid family.

In the present article we present the results of two magnetic surveys of the X-Tepe that were conducted in 2019 and 2023 to explore the interior of the mound. We used the magnetic field data to determine the magnetisation distribution at the base of the mound and to map its structure near the surface. We offer a first interpretation of this data set from an archaeological perspective for further discussion.

1 W. Rabbel in Pirson et al. 2011a, 143.

2 Pirson 2017, 87–89; Kelp – Pirson 2020; Pirson in this volume. For the latest results on the dating of the Yığma Tepe, see the contribution by Meinecke et al. in this volume.

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1 X-Tepe tumulus, View from NW. Outcropping andesite in the foreground


2 X-Tepe. Aerial view from south-west

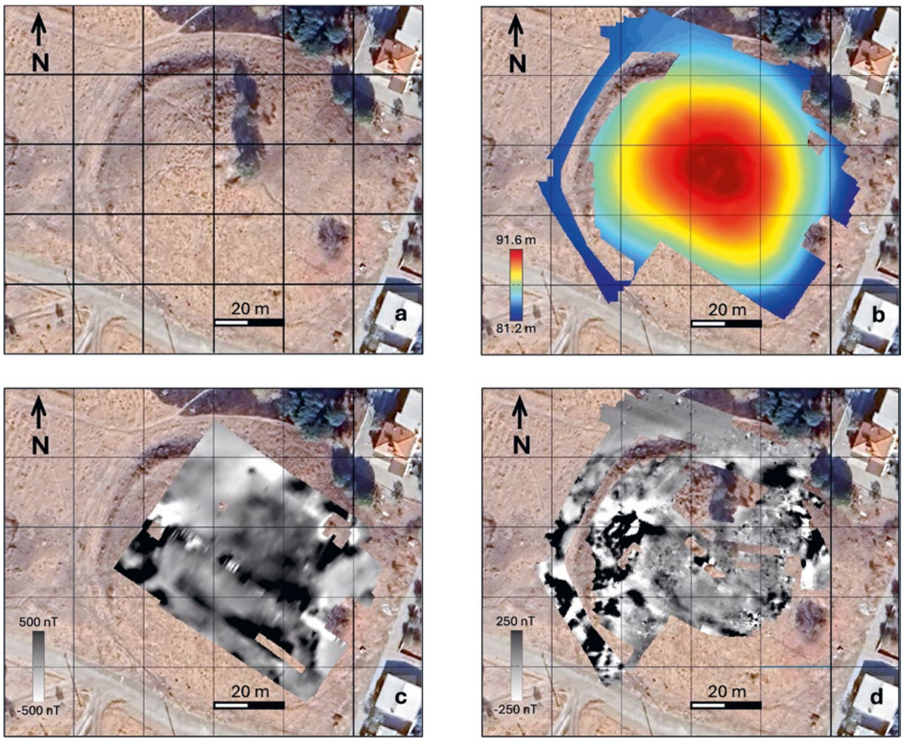
Magnetic Survey and Data Processing

The magnetic survey areas span 67 × 64 m and 80 × 80 m, respectively, each covering the X-Tepe almost entirely (figs. 3 a, b). The first survey was aimed at exploring the magnetic structure at the base, while the second survey was specifically intended to record the subsurface near the surface in higher resolution. Accordingly, the two measurements were carried out with different devices and spatial sampling densites.

During the *first survey* (2019) we measured the magnetic total field intensity along profile lines with 50 cm inline point spacing and 2 m crossline spacing using a GEM Systems GSM-19T Overhauser gradiometer. The magnetic sensors have a nominal resolution of 0.01 nT. The two gradiometer sondes were mounted at 0.5 and 2 m above ground to enable sounding depths on the order of 10 to 15 m. Positioning was performed with a differential GPS unit after the magnetic measurements.

The resulting magnetic map shows anomalies of up to ± 500 nT. The anomalies have elongated irregular shapes varying between a few meters in width or length (figs. 3 c, 4 a). Both magnitude and shape of the magnetic anomalies deserve some consideration. The magnitude is much stronger than is typical for archaeological targets. It shows that the magnetic sources must be composed of strongly magnetised rock. The volcanic andesite frequently found in the Bergama region is the most likely candidate. The large widths of the anomalies are most likely caused by the mound topography that causes distances of up to ~ 10 m between magnetic sensor and sources if the magnetic sources are concentrated at the base level of the tumulus.

To compensate for the topography effect and to determine the contours of the magnetic bodies at depth we performed an inversion computation on the magnetic field data. For the inversion we applied the mag-



3 (a) Satellite photo of X-Tepe, (b) topographic map of X-Tepe derived from DGPS measurements, (c) magnetic map derived from deep sounding Overhauser gradiometer measurements (first magnetic survey 2019), (d) magnetic map derived from fluxgate gradiometer array measurements to enhance near-surface structure (second magnetic survey 2023). Satellite images from Google Earth © Airbus 2024

netised layer concept[3], in which the magnetic sources are assumed to lie in a layer of even thickness at a constant topographic depth below the earth's surface. In order to determine realistic depth and thickness values for this layer we used the quality of the data fit and the positivity of magnetisation values of the resulting magnetisation model as an evaluation criterion. In this way test computations showed that the magnetic source zone can be confined to a layer of about 4 m thickness located at the base level of the mound. The thickness of ~ 4 m corresponds to a typical height of masoned grave chambers[4].

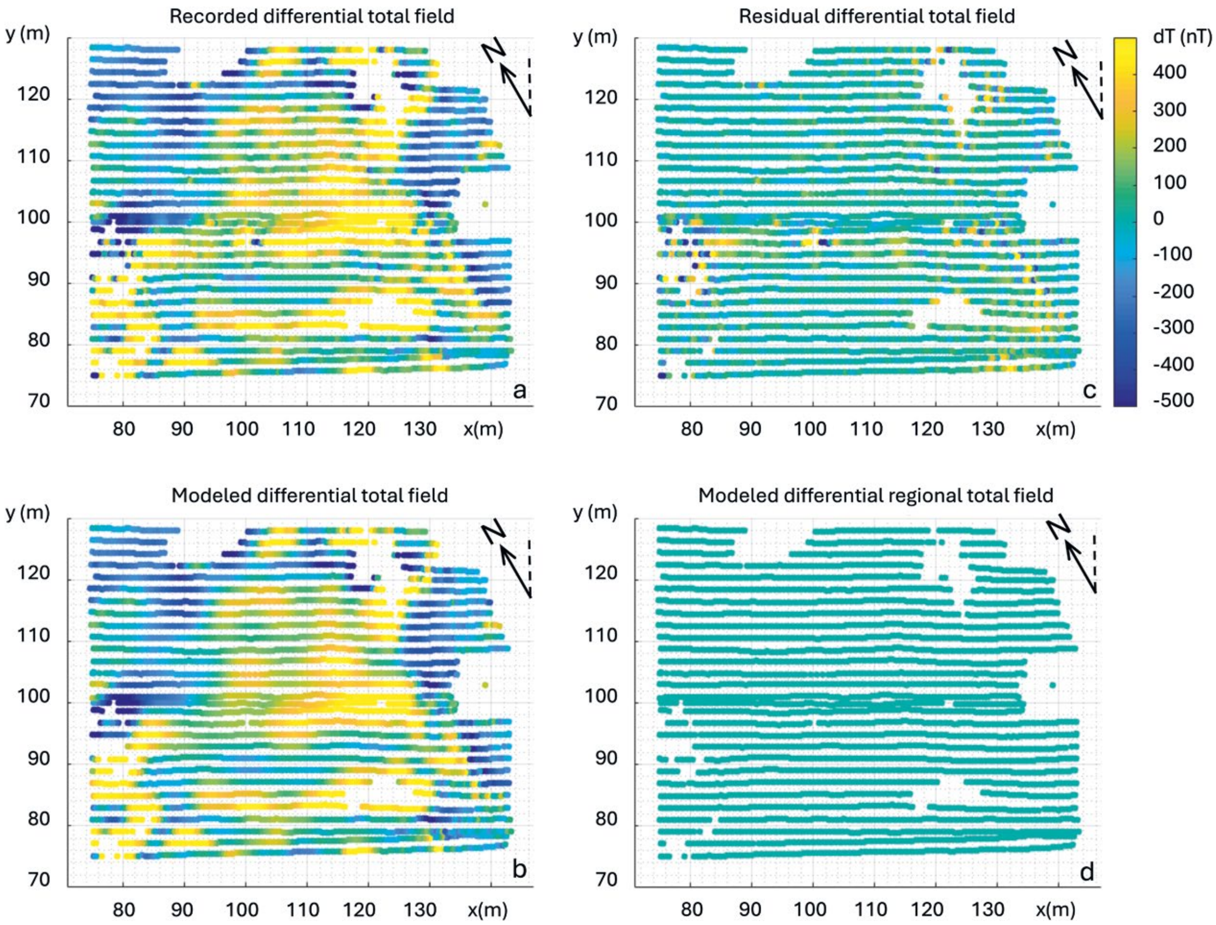
A magnetisation map computed in this way is shown in Figure 5. Taking this magnetisation distribution as a magnetic subsurface model we computed the corresponding theoretical magnetic field data for the original recording points (fig. 4 b). These show an excellent agreement with the original field data (compare fig. 4 a vs. 4 b). The difference field of recorded minus modelled magnetic data (›residuals‹, fig. 4 c) shows mainly small-scale magnetic noise caused by small magnetic objects located near to or just beneath the earth surface. Figure 4 d shows the regional linear trend that was determined together with the magnetisation model through the inversion computation. This trend is almost zero, indicating that neither the field data nor the inversion results were systematically biased through larger-scale field trends.

For the *second survey* (2023) we used a magnetometer array consisting of 6 Förster fluxgate gradiometers mounted on a handcart. Each gradiometer has two sensors measuring the vertical component of the magnetic field at 30 and 90 cm above ground. The measuring point spacing was 5 cm in the running direction (inline) and 50 cm perpendicular to it (crossline). The fluxgate sensors have a nominal resolution of 0.1 nT. Due to this configuration the sensitivity of the gradiometer-array is highest for magnetic structure in the uppermost few meters of the subsoil and decreases strongly with increasing depth. Positioning was performed with a differential GPS unit during the magnetic measurements. To create a magnetic map, the data was sorted and interpolated into a 20 × 20 cm grid.

The resulting magnetic map shows anomalies varying between a few tens nT up more than ± 2000 nT. In comparison to the deeper sounding first survey the map of the second survey reveals a multitude of partly complexly shaped near surface magnetic anomalies (cf. figs. 3 c vs. d and 6 a vs. b), which are considered in detail below.

3 E. g. Blakely 1995 chapter 10.2.1; Pickartz et al. 2019, and the references therein.

4 See many examples in Henry – Kelp 2016.



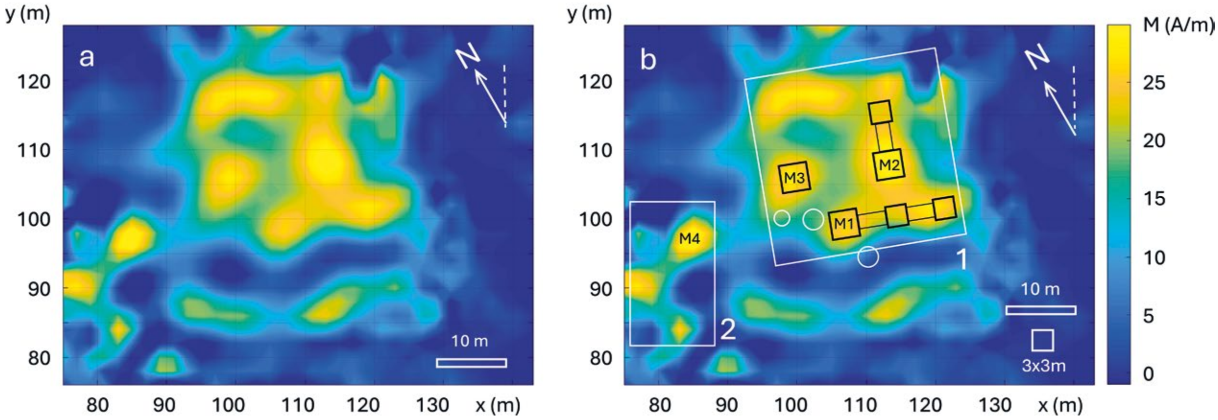
4 Measured and modelled magnetic data of the X-Tepe survey: (a) Measured differential magnetic total field (gradiometer data), local coordinates, (b) modelled differential magnetic total field according to magnetisation distribution shown in fig. 6, (c) residual differential magnetic field (›measured minus modelled‹ data), (d) regional differential total field determined by inversion computation

Magnetic Structure

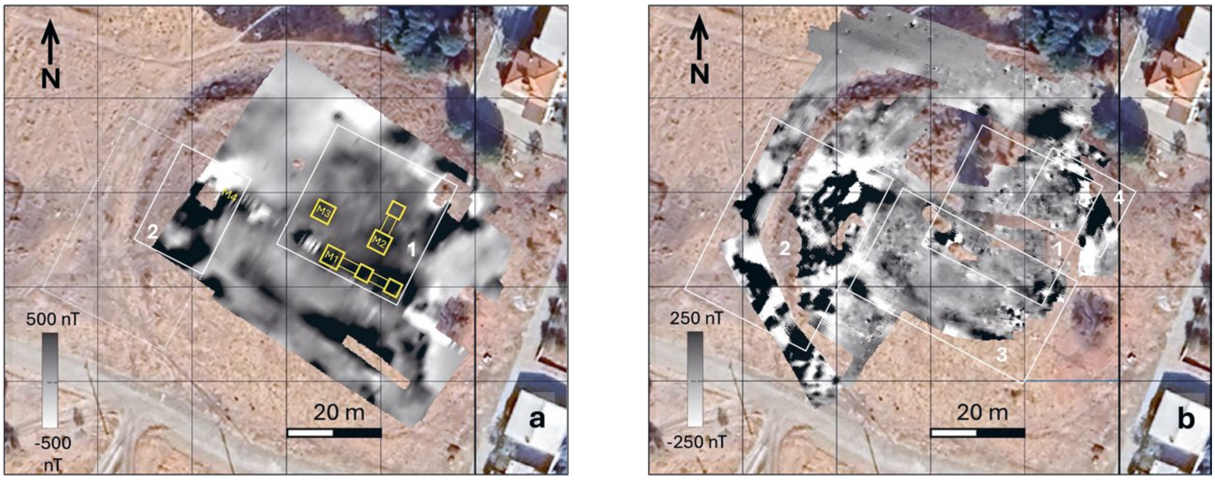
The outcome of the deep sounding magnetic investigations, based on the first survey (fig. 3 c) and described above, is a map (fig. 5) showing the magnetisation at the base level of the X-Tepe. It shows several strong positive anomalies (yellow in fig. 5) in contrast to a non-magnetic background (blue in fig. 5). The magnitude of the magnetisation maxima (up to 30 A/m) indicates that they are caused by highly magnetic rocks such as andesite and basalt, which are found frequently in the Bergama region. The low, close to zero, background magnetisation is typical for soils[5]. Outcrops of andesitic dikes are found close to the X-Tepe (foreground in fig. 1). Therefore, it is nearly certain that the detected magnetic anomalies are caused by both andesitic bedrock and anthropogenic andesite rock constructions.

The magnetisation maxima at the base of the X-Tepe can be grouped into two clusters, a larger one located in the NE quadrant and a smaller one in the SW quadrant of the burial mound (indicated 1 and 2 in fig. 5 b). The larger cluster can be contoured by a square of ~ 25 m side length. Inside this square the anomalies can be grouped into elongated sub-clusters, the axes of which are parallel to the sides of the bounding square. The square sides and anomaly axes are oriented N27°E and N116°E, respectively. The second cluster contains three isolated anomalies arranged at a right angle with NS and EW wing orientations.

5 E. g. Schön 2015, 415–436.



5 Magnetisation map of the base level of the X-Tepe: (a) magnetisation distribution determined from the field data in fig. 4 a by inversion computation for an assumed 4 m thick magnetised layer at base level, (b) tentative interpretation of figure a: clusters of magnetisation maxima (white rectangles 1 & 2), pronounced local maxima within the clusters (M1 to M4) as possible locations of chambers (black squares), linked to neighbouring maxima possibly representing antechambers (small black squares). White circles show the location of shallow pits at the mound surface, probably the remains of tomb raiding attempts

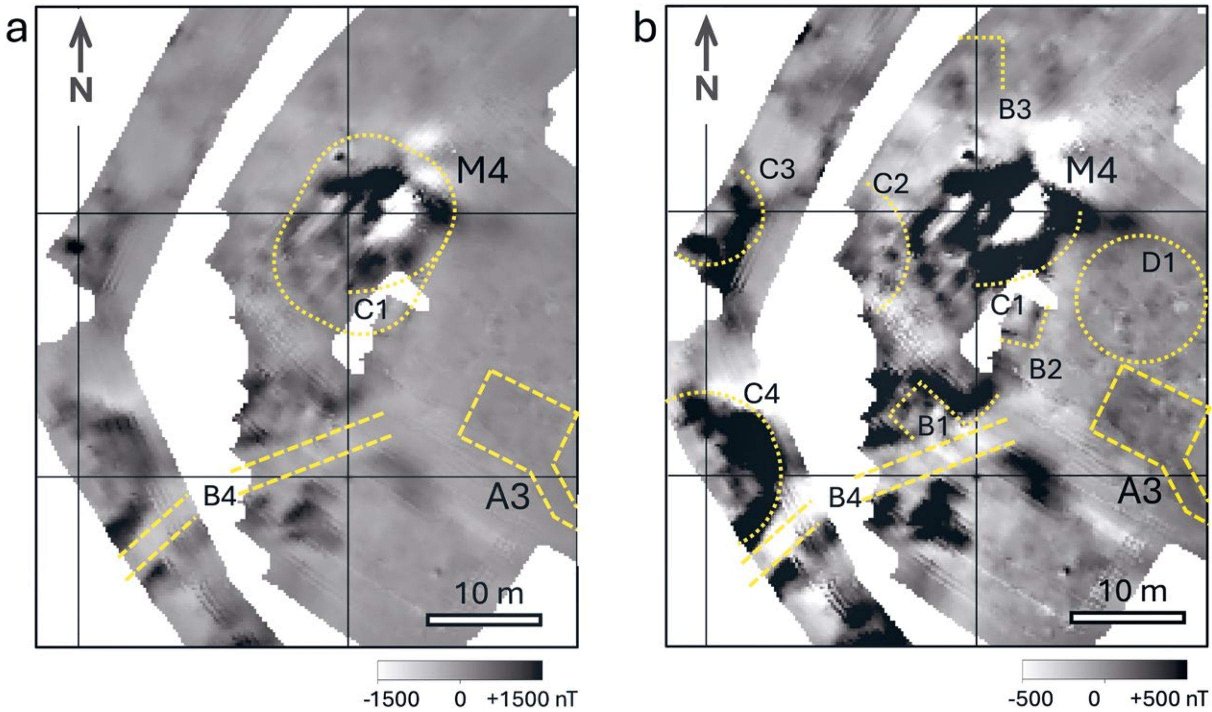


6 (a) magnetic map derived from deep sounding Overhauser gradiometer measurements (first magnetic survey 2019) with indicated clusters 1 and 2 of the magnetisation maxima determined from magnetic inversion computations (cf. fig. 5; compared to figure 5 the horizontal location of the magnetisation anomalies has been shifted 2 m to the south to compensate for the effect of the inclination of the Earth's magnetic field on the location of the anomalies at the surface). (b) magnetic map derived from fluxgate gradiometer array measurements (second magnetic survey 2023) with indicated anomaly clusters 1 to 4. Background satellite images from Google Earth © Airbus 2024

The largest magnetisation anomalies (indicated M1 to M4 in fig. 5) are gathered within a 15 m radius from the centre of the burial mound. Two of them (M1 and M3) are found close to three pits visible at the surface, which may be remains of tomb raiding attempts (pits indicated by white circles in fig. 5 b).

The locations of the magnetisation maxima M1 to M4 and the associated cluster areas 1 and 2 have been projected onto the original magnetic map (Fig. 6 a). The comparison of figure 6 a with figure 6 b shows that the magnetic anomalies corresponding to M1 to M3 are only faintly recognisable on the ›near-surface‹ magnetic map of the second investigation (Fig. 6 b) due to the changed sensor arrangement. Instead, anomalies caused by near-surface magnetic structure show up more clearly than before and in higher amplitude (signal strength). In this way magnetic anomalies of the first survey that are caused by shallow structure can be identified in hindsight.

For a closer look we group the near-surface anomalies into 4 clusters (labelled 1 to 4), of which clusters 1 and 2 are the same as before, although the area of cluster 2 has increased. Both consist of mostly very strong anomalies. Cluster 3 shows two very strong and two weaker, but well-contoured anomalies, the pattern of the latter being nearly symmetric about an



7 Magnetic anomaly cluster 2 (cf. fig. 6 b) in (a) a wider and (b) a more narrow amplitude scale. Data from fluxgate gradiometer array measurements (second survey 2023). M4: magnetic field anomaly corresponding to magnetisation maximum M4 (cf. fig. 5); B1 to B4: linear and rectangular anomaly patterns; C1 to C4: semi- and quarater-circular anomaly patterns; D1: anomaly pattern of double rows of small-amplitude spots arranged like a Mercedes-star. A3: see fig. 8

axis in N27°E direction. Cluster 4 is a group of again very strong anomalies in the northeastern part of the investigation area. Partly, the clusters overlap.

The magnetic anomaly associated with magnetisation maximum M4 (fig. 5 b) is the most prominent feature of cluster 2 (fig. 7). To visualise both its low and very high amplitude portions, we show cluster 2 in a wider (fig. 7 a) and in a more narrow amplitude scale (fig. 7 b). It turns out that the anomaly M4 contains components with high and lower amplitude, including elements of linear, roundish and rectangular shape. The highest amplitude elements can be associated with pieces of volcanic rock with edge lengths of one to a few meters, corresponding to the shape of the positive parts of the anomalies. Three partial anomalies measuring approximately 2 × 2 m each are conspicuous, which are arranged in a ~ 12 m wide quarter circle (C1 in fig. 7).

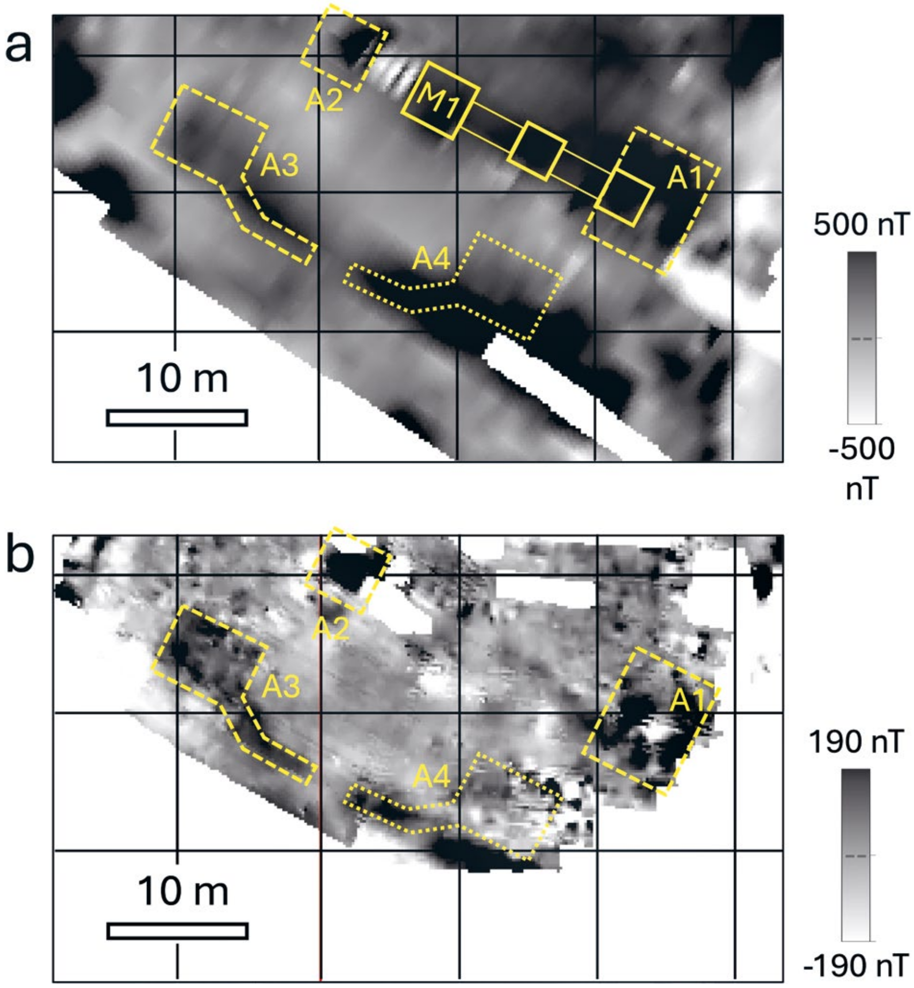
Three more half- or quarter-circular anomaly patterns are found (C2 to C4 in fig. 7 b). They are between 10 and 15 m wide, their open sides are oriented towards the western edge of the burial mound. Each of these patterns is composed of smaller, meter-scale, anomalies, which could represent pits or stone settings.

Three rectangular features (B1 to B3 in fig. 7 b) suggesting wall remains can be identified somewhat more uphill. B1 to B3 show edge lengths between 3 and 5 m. A linear blank zone in between stronger anomalies (B4 in fig. 7 a and b) is found in the lower left quadrant, possibly indicating a path or way towards the top of the mound.

Further upward, in the area labelled D1, we find 4 double rows of small-amplitude spots arranged like a Mercedes-star. The anomalies are positive only, not combined with minima, which is typical for small pits.

Cluster 3 (fig. 8) comprises four more structural element (anomalies A1 to A4 in fig. 8). These occurred somewhat blurry already in the deep sounding first measurements (fig. 8 a), but show up very clear now in the second survey. Anomalies A1 and A2 are in line with the M1 group of magnetisation anomalies (fig. 7a), A1 is located close to a stone framed indentation of the mound found on its southeastern edge. A4 is close to the looting pits on top of the mound. Therefore, A1 and A2 may be connected to the M1 group of features.

Anomalies A3 and A4 are most clearly visible in the gradiometer-array survey (fig. 8 b). The rectangular outline of A3 and its angular continuation suggest a near-surface stone construction. A4 is less clear, but the contour of the arrangement of the individual anomalies of this pattern around an almost empty (white) rectangular space suggest that the A4 pattern might be a mirrored version of A3, with the mirror axis oriented N27°E, like the edges of cluster 1.



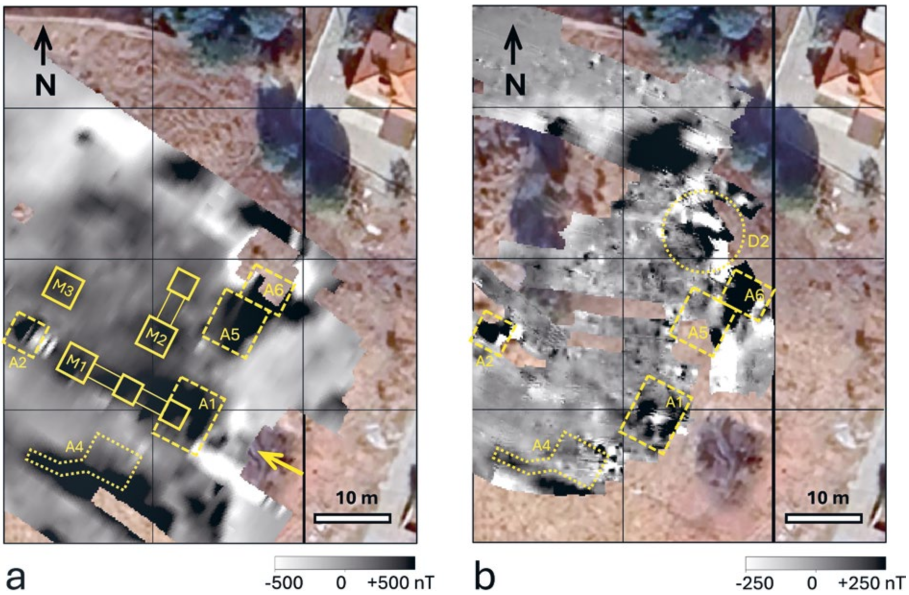
8 Magnetic anomaly cluster 3 (cf. fig. 6 a, b) as seen (a) in the deep sounding Overhauser gradiometer measurements (first magnetic survey 2019) and (b) in the fluxgate gradiometer array measurements (second survey 2023). M1: group of magnetic field anomalies corresponding to magnetisation maxima M1 in figure 5 (note comment in caption of fig. 6); A1 to A4: magnetic field anomalies of near-surface structure recognisable through the gradiometer-array survey

Cluster 4 overlaps with the northeastern corner of cluster 1 (figs. 6 and 9). It adds two new components to the structure recognised so far, anomalies A5 and A6. A5 seems to be deep feature as it is clearly visible on the map of the deep sounding survey (fig. 9 a), but only weakly on the map of the gradiometer-array survey (fig. 9 b). A5 seems to be connected to the major near-surface feature of anomaly A6. The edge orientation of A5 and A6 is roughly parallel to the edges of the central cluster 1 and the structure therein. Pattern D2 encircles a bunch of very strong anomalies in the northeastern corner of the survey area. However, the structure as a whole remains unclear because of some gaps in the measurement coverage.

We present an overview of the magnetic features found through both survey in figure 10 where the simplified pattern contours have been projected onto a satellite photo of the X-Tepe. The figure highlights the preferred approximate N27°E orientation of the major structures. For a better orientation we tried to reconstruct the original contour of the mound at base level (red line in fig. 10). It is based on the assumption that the X-Tepe was originally strictly circular with the centre of the circle located at the highest point of the mound.

Archaeological Interpretation

The magnetic anomalies of the larger cluster (»1« in fig. 5 b) show angular features which can be interpreted as architectural structures. Because of the large magnitude of bulk magnetisation it is most like-



9 Magnetic anomaly cluster 4 (cf. fig. 6 a, b) as seen (a) in the deep sounding Overhauser gradiometer measurements (first magnetic survey 2019) and (b) in the fluxgate gradiometer array measurements (second survey 2023). M1to M3: groups of magnetic field anomalies corresponding to magnetisation maxima M1 to M3 in figure 5 (note comment in caption of fig. 6); A5 & A6: coupled magnetic field anomalies of neighbouring deep and shallow magnetic structure; D2: pattern of strong magnetic anomalies of unclear origin. Background satellite images from Google Earth © Airbus 2024

ly that the grave constructions were built into the bedrock and that some part of the bedrock itself was reworked and used as construction material.

The 2023 survey revealed even more evidence of possible structures and traces under the burial mound, allowing further interpretation of the upper layers in particular. In general, the anomalies shown in yellow in Fig. 10 can be considered to be the earliest structures that can be associated with the initial burial(s) (M1, M2, M3 and A5). Apart from these, the anomalies shown in black are much more difficult to interpret. Before we comment on this, it should be noted that the following interpretations are merely plausible suggestions for interpreting the magnetic anomalies and are in no way to be understood as a definitive interpretation.

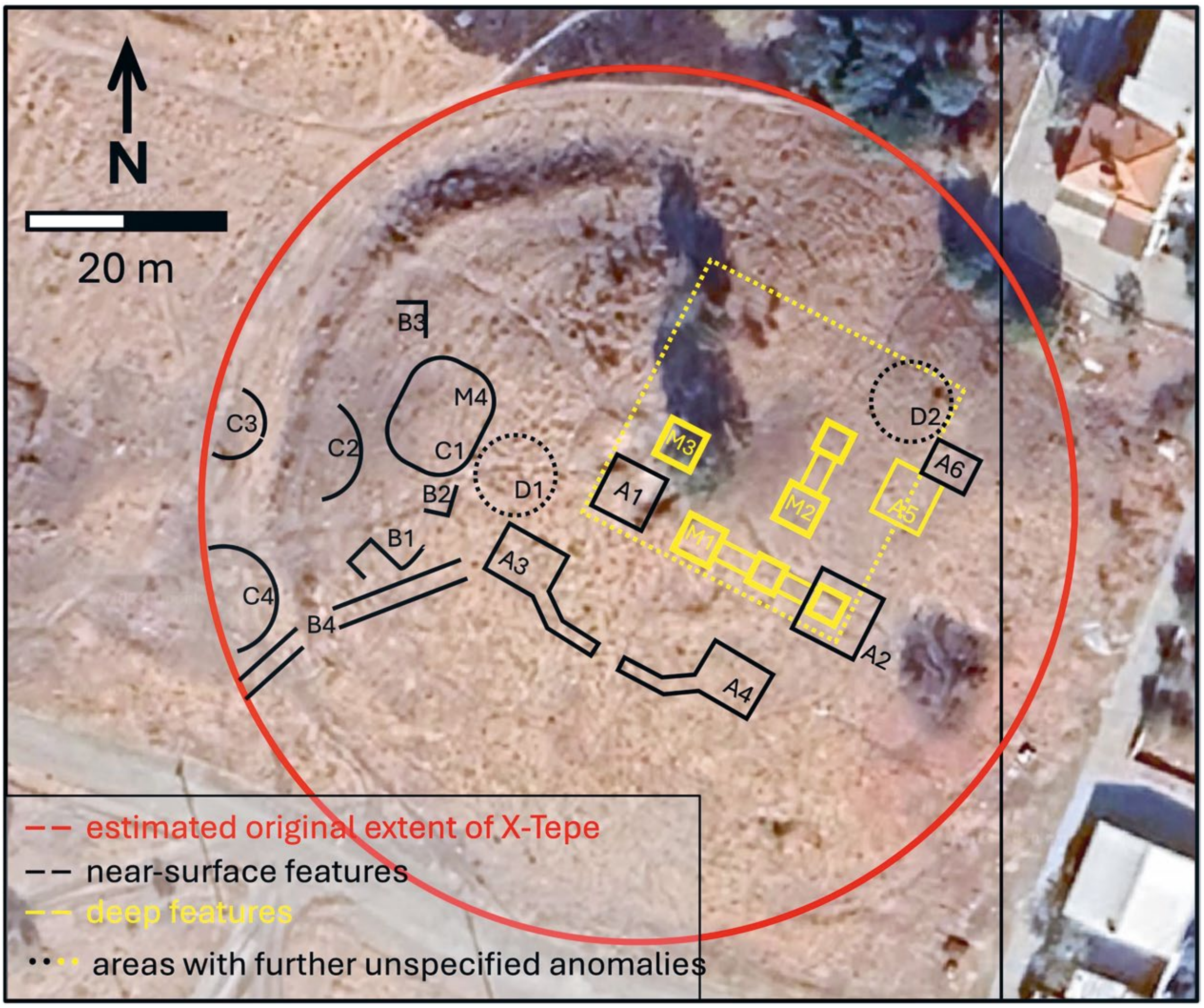
Since some of the anomalies, especially C1, C2, C3, C4 and perhaps D1, do not have a regular plan, they can be interpreted as traces of ceremonial activities during the burial rather than belonging to an architectural structural unit. On the other hand, these anomalies could also be traces of possible illegal excavation pits that were later dug on the burial mound. Anomalies B1, B2 and B3, which have a more quadrangular plan, lie close to the surface and could be the remains of burial structures associated with secondary burials.

Anomalies A1 and A2 are also closer to the surface and are noteworthy because they are oriented in the same direction as the building assemblage interpreted as burial chambers in M1. The eastern anomaly A2 may perhaps represent the entrance to the initial burial structure, while the western anomaly A1 may be considered as the northwestern continuation of the chambers in M1. However, its close proximity to the surface may also suggest that anomaly A1 may be a later addition to the initial burial structure.

A3 and A4 are the two most interesting anomalies of 2023 survey and very open to interpretation. One of the two things that make them interesting is their symmetrical arrangement, and the other is that when M1, A1 and A2 are considered as a whole, anomalies A3 and A4 lie approximately parallel to this group. Their position close to the surface may suggest that they could have been part of a structure that might have belonged to a monument on the burial mound. On the other hand, they may also indicate a secondary and later use, completely independent of the burial mound and built for another purpose. Nonetheless, it seems unlikely to be a mere coincidence that A3 and A4 are aligned in the same direction as A1, A2 and M1.

B4 resembles a long thin pathway or road that leads past C4 and B1 towards anomaly A3. Again, it is not possible to interpret the existence of such a path with certainty. Since it is close to the surface, it may be related to the recent use of the top of the burial mound for a completely different purpose. Anomaly A5, like M1, M2 and M3, demonstrates a deeper structure and may be interpreted as another chamber of the burial structure built in connection with the initial burial.

Finally, anomalies A6 and D2 also form a group close to the surface. Although anomaly D2 is depicted in the figure as having a circular plan, it is not unlikely that it also belongs to a built structure. They may also be plausibly interpreted as structures associated with secondary burials similar to C1, B1, B2 and B3.



10 Overview of the magnetic features of X-Tepe found through the 2029 and 2023 magnetic surveys, distinguished into features at base level (yellow) and located near the surface (black). Estimeted original contour of X-Tepe at base level. Background satellite images from Google Earth © Airbus 2024

Two alternative scenarios can be deduced from the magnetic prospections: 1. One single large structure represented by interconnected magnetic anomalies. 2. More than one funeral structure, represented by separate magnetic anomalies, implying the presence of several graves and/or grave structures.

According to the first scenario, a single but quite large structure that is almost square in plan is located in the NE quadrant near the centre of the burial mound. It corresponds to the whole or most of the anomalies of cluster 1 (fig. 5 b) showing a base area of 25 × 25 m and axes approximately oriented either in NE–SW or NW–SE directions. The pits found at the southwestern side may be interpreted as evidence of an entrance, but there is no clear indication of a dromos based on the magnetic anomalies alone. Burial mounds with a single burial chamber are known in the neighbouring regions of Thrace, Greece and Macedonia, but the dimensions of these tomb structures are much smaller[6]. The only close example in terms of dimensions of the burial structure is the Royal Tomb at Vergina, which measures approximately 9.6 × 8.0 m in total[7], which is still not even half of what would be expected below the X-Tepe tumulus in scenario 1. As no similar single structure with such dimensions is known, we consider scenario 1 as

6 For examples dating from the 4th cent. to the 2nd cent. BC see Pandermalis 1972, 177 f. 181; Gossel 1980, 125–134. 141 f. 154–157. 240–244. Vize A tumulus in southeastern Thrace dates to the middle of the 1st cent. AD and the burial chamber measures 4.6 × 3.12 m, see Aksan 2023.

7 Andronikos 1984, 65.

unlikely[8], and consequently regard the second scenario suggesting several separate smaller structures and/or graves as more plausible.

According to the second scenario, there would be more than one structure and/or graves below the X-Tepe tumulus. The three largest anomalies of cluster 1, labelled as M1, M2 and M3 in Figure 5, can be linked to minor anomalies in their close vicinity in such a way that they form linear two- or three-cell features. These features would be arranged in a rectangular, if not square, plan. The cells associated with M1, M2 and M3 would measure approximately 4 × 4 m in dimension, whereas the smaller squares in front of M1 and M2 are about 3 × 3 m. Although it is still difficult to find any certainty in the interpretation of these ground plans, a tentative suggestion can be made: Structure M3 could be interpreted as a single burial chamber, whereas M1 and M2 could represent burial chambers having either one or two antechambers.

As stated above, there is no certainty about the exact plans of the structures under consideration. What appears certain is that there is more than one structure and that they are all gathered in close vicinity to each other. It is possible to find resemblances with several tumuli from Macedonia dating to the Hellenistic period, where the general layout of the grave structures below the tumuli seems to be in accordance with the results of the magnetic prospection below the X-Tepe tumulus[9]. The closest example comparable to the anomalies at the X-Tepe could be the Bella tumulus, below which several graves and grave structures are found within an overall area of 25 × 30 m[10].

Finally, we put a closer focus on the azimuthal orientation of cluster 1 and the structures included (N27°E and N117°E, fig. 5 b). One of the two edges or axes is oriented N27°E, the other one orthogonal to it (N117°E). The N27°E direction is a prominent one in the following regards: First, it is oriented towards the top of the city-hill of Pergamon where important monuments of the city and the royal family such as the Altar of Zeus or the Sanctuary of Athena are located. Secondly, this orientation of an internal structure of a burial mound towards the top of the city-hill finds an equivalent in the »SOI 2« structure[11] of the Yığma Tepe. SOI 2 is an elongated massive structure detected by geophysical prospections inside the Yığma Tepe at ~ 10 m above its base level. It lies approximately on an axis with the western alignment of the Altar of Zeus, which could indicate a relation in the planning of this monument and the potential royal tumulus Yığma Tepe[12]. A similar orientation of the structures within the X-Tepe may suggest an overarching construction principle of the major tumuli of Pergamon.

Conclusions

The X-Tepe tumulus, located on the alluvial fan of the Bergama Çayı (Selinus) south of the city-hill of Pergamon, is the fourth largest burial mound of the Bergama area with an 85 m diameter at its base and a height of 11 m. It belongs to a funerary landscape that includes the largest tumuli of the region and may be related to the royal burials of ancient Pergamon. The magnetic investigations show that strong magnetisation anomalies exist at the base level of the X-Tepe, which can be interpreted as evidence of architectural structures. These potentially funeral constructions most likely involve reworked bedrock in large volumes. The clustering of magnetic anomalies suggests that there may be more than one grave chamber or structures with antechambers that are arranged at right angles to each other within an area of 25 × 25 m. However, the relation between the separate sub-structures is not yet clear. We suggest performing test excavations to verify the hypothetical interpretation and to better understand the general plan of the X-Tepe funeral construction.

8 Yıldırım 2010; Mangoldt 2012; Henry – Kelp 2016.
9 Mangoldt 2012, pl. 11; Schmidt-Dounas 2016, 124 f.
10 Schmidt-Dounas 2016, fig. 4 pl. 41.
11 Mecking et al. 2021 and Meinecke et al. this volume.
12 See Pirson – Ludwig 2024 and the contributions by Meinecke et al. in this volume.

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Abstract

The X-Tepe tumulus is located on the alluvial fan of the Bergama Çayı (Selinus) south of the city-hill of Pergamon. It belongs to a funerary landscape characterised by the largest tumuli of the region and may be related to the royal burials of ancient Pergamon. Being 85 m in diameter and 11 m high it is the fourth largest burial mound of the Bergama area. To explore the interior of the X-Tepe we conducted a magnetic survey with an Overhauser gradiometer enabling sounding depths on the order of 10 to 15 m. The resulting magnetic map shows elongated anomalies of up to ± 500 nT with irregular contours. Their comparatively large magnitudes indicate that the magnetic sources are most likely composed of strongly magnetised andesite, a rock typical of the Bergama region. To determine the contours of the magnetic bodies at depth, we performed an inversion computation on the magnetic field data using the concept of magnetised layers. The magnetic inversion computations show that strong local magnetisation anomalies exist at the base level of the X-Tepe, which can be interpreted as evidence of architectural structures. These potential funeral constructions most likely consist of reworked bedrock in large volumes. The magnetic anomalies are concentrated within an area of 25 × 25 m and display a certain rectangular ordering. Their clustering suggests that there may be more than one grave chamber or structures with antechambers that are arranged at right angles to each other.

Keywords: tumulus, funeral architecture, magnetic prospection, magnetic inversion

Illustration Credits

Fig. 1 Institute of Geosciences - Applied Geophysics, Kiel University, Kiel, Germany (Photo: Wolfgang Rabbel)
Fig. 2 Archive of the DAI Pergamongrabung (Photo: Arne Weiser)
Figs. 3–10 Institute of Geosciences – Applied Geophysics, Kiel University, Kiel, Germany; satellite images from Google Earth, © Airbus 2024 (figs. 3. 6. 9. 10)