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Magnetic Prospection in the Eastern Lower City of Artashat-Artaxata in the Ararat Plain of Armenia

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Abstract: In March of 2021, the Berlin-based company cmp continued geophysical prospection works at the ancient city of Artashat-Artaxata (Ararat Province, Armenia). The city was founded by Artashes-Artaxias I in the early 2nd century BC and served as his capital. First magnetic measurements were conducted by the Eastern Atlas company in September 2018. In 2021, during the 5-day survey a total surface of approximately 19.5 ha was investigated by use of the LEA MAX magnetic gradiometer array. This system was configured with seven fluxgate gradiometer probes, similar to the system used in the first survey of 2018. The investigated areas of the Eastern Lower City of Artaxata, located to the south of the investigated field of 2018, had good surface conditions with a moderate amount of sources causing disturbance. However, the general level of the magnetic gradient values measured was significantly lower compared to the 2018 data. Despite the lower magnetic field intensity, a continuation of linear structures towards the south was observed. These lines, most likely reflecting streets and pathways, criss-cross the central part of the Eastern Lower City in a NW–SE and NE–SW direction and exhibit partly positive, partly negative magnetic anomalies. Attached to them, some isolated spots with building remains were identified. The negative linear anomalies point to remains of limestone foundations, as detected in the northern part of the Lower City. The low magnetic intensity and fragmentation of the observed structures are most likely due to severe destruction of the ancient layers by 20th-century earthworks for agricultural purposes. Moreover, the southern part of the surveyed area was affected by major changes caused by modern quarries at Hills XI and XII. In general, the results of the two magnetic prospection campaigns greatly aid our understanding of the archaeological situation in the area of the Eastern Lower City of Artaxata, justifying further investigations that will surely contribute to greater contextualization of the identified archaeological structures. The full data sets are also published in open access on Zenodo.

Keywords: Artaxata, Ancient Armenia, archeology of Armenia.

Introduction

Since 2018, the Armenian-German Artaxata Project, a collaborative venture between the Institute of Archaeology and Ethnography of the National Academy of Sciences of Armenia and the Westfälische Wilhelms-Universität Münster (Germany), has undertaken archaeological fieldwork in Artashat–Artaxata in Armenia (**Fig. 1**). The aim of the project is a better understanding of the urban character of the eastern Lower City and of Hill XIII. Artaxata was a Hellenistic city of the 180s BC founded by the Armenian king Artashes-Artaxias I as the capital of his kingdom.[1] The city was situated in the Ararat valley at the confluence of the Arax and the Metsamor rivers, covering the 15 hills of the Khor Virap heights. The royal city was very large, spread over approx. 700 ha. Time and again, it assumed a prominent role in the military conflicts between Parthia and Rome, both powers striving to dominate the Armenian kingdom. The topography and archaeology of the site have been under investigation since the 1970s, with research mostly focused on the hills. The new Armenian-German project takes Hill XIII, by far the lowest hill of the city, as a starting point to investigate the lower parts of the city in the plain east of the major hills.[2] Archaeological excavations were undertaken from 2018 to 2021. The first magnetic survey was realized by the Eastern Atlas company in September 2018.[3] An area of 14 ha in the northeastern area of the Lower City was investigated in this first survey, revealing various archaeological features. It covered the area north of the road to Khor Virap, and some terraces of Hill II were also explored. The magnetic prospection of 2018 was followed by a drilling survey in spring 2020.[4] The existence of preserved building structures was confirmed on Hill XIII by the archaeological works. However, the exact characteristics of the linear structures that criss-cross the area of the eastern Lower City remain unclear. To the north of Hill XIII, a linear structure more than

[1] On the history and archaeology of Artaxata-Artashat cf. Baumgartner 1896; Xač'atryan 1981; Arakelian 1982; Arakelian 1984; Tonikian 1992; Tonikian 1996; Invernizzi 1998; Xač'atryan 1998; Xač'atryan 2005; Zardaryan 2018.

[2] On the results of the Armenian-German Artaxata Project, cf. Avagyan – Kinnaird – Lichtenberger – Sahakyan – Schreiber – Zardaryan 2018; Becker 2018/2019; Lichtenberger – Zardaryan 2018/2019; Lichtenberger – Meyer – Zardaryan 2019; Lichtenberger – Zardaryan – Schreiber 2020; Lichtenberger – Schreiber – Zardaryan 2021; Lichtenberger – Zardaryan – Schreiber 2021; Noorda – Lichtenberger – Meyer – Schreiber – Zardaryan 2022.

[3] Lichtenberger – Meyer – Zardaryan 2019.

[4] Noorda – Lichtenberger – Meyer – Schreiber – Zardaryan 2022.

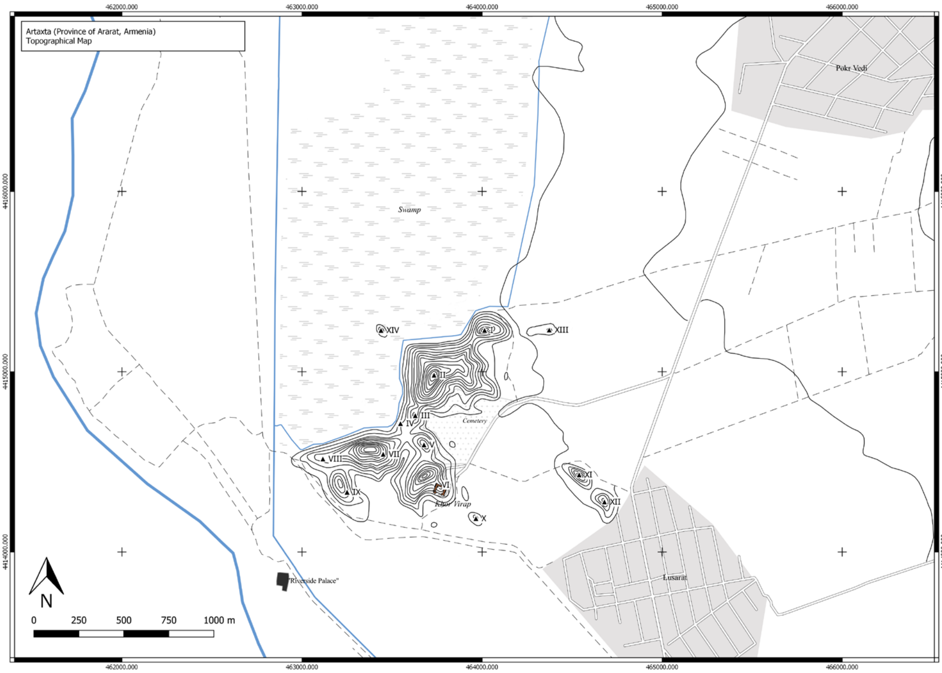

Fig. 1. Topographical map of Artaxata (© Armenian-German Artaxata Project)

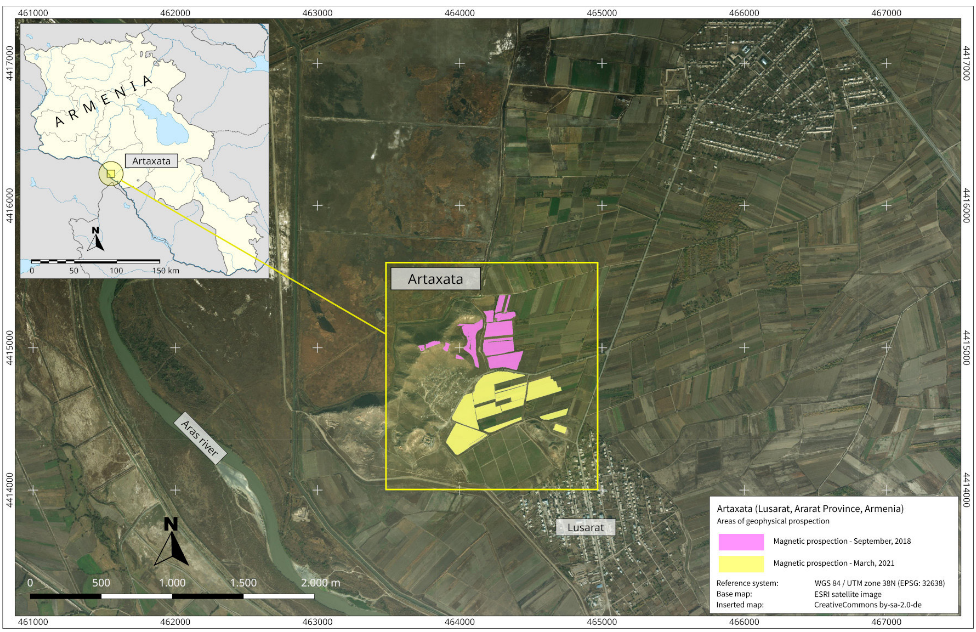

Fig. 2. Area of magnetic prospections 2018 and 2021 (© Armenian-German Artaxata Project)

Fig. 3. LEA MAX system carrying seven gradiometer probes (© Armenian-German Artaxata Project)

150 m in length running from the ENE to the WSW reflects the remains of an unfinished Roman aqueduct.[5] Another linear structure crosses the area from the NW to the SE over a distance of more than 400 m, but its details and function remain unclear. Furthermore, several more or less isolated constructions and built-up areas were located to the south of Hill XIII. It needs to be emphasized that several structures follow the same alignment and seem to have the same orientation as structures on Hill I suggesting that these constructions relate to an overall planning program in the city. During the 2019 and 2020 excavations, several areas were targeted on the eastern part of Hill XIII, with the overall results confirming the preliminary assumptions based on the magnetic anomalies relating to architectural features consisting of limestone foundations and mudbricks on top.[6] The architecture on Hill XIII stems from the 2nd century BC to the 1st century AD and displays regular planning.

The geophysical survey of March 2021 undertaken by cmprospection focused on the plains between the main chain of hillocks and the group of Hills XI and XII south of the modern asphalt road to Khor Virap monastery, where further structures of the Lower City were expected (**Fig. 2**). The area was selected because of imminent threat of new construction work. An area of about 19.5 ha was investigated. As in the survey of 2018 the magnetic measurements were realized using the LEA MAX system carrying seven gradiometer probes (**Fig. 3**).

[5] Lichtenberger – Zardaryan – Schreiber 2021.

[6] Lichtenberger – Schreiber – Zardaryan 2020.

Geology and Landscape

The ancient city of Artaxata is located in the heart of the Ararat plain (also referred to as the Ararat valley or Ararat basin), to the northeast of Mount Ararat. This fertile plain, Armenia's largest agricultural zone, is an inter-mountain depression at a height of about 800 to 900 m above sea level divided by the Arax river, situated in the central area of the Armenian plateau (or Armenian highlands).[7]

Artaxata was built on a group of 15 hillocks located near the left bank of the Arax river in the northern part of the Ararat plain, just 1 km to the northwest of the modern village of Lusarat and southeast of Pokr Vedi. Known as the Khor Virap hills (the name deriving from the famous monastery on Hill VI), these conspicuous hillocks crop out from the flat alluvial plain, being formed by tectonized Late Devonian–Early Carboniferous shallow marine carbonate and siliciclastic deposits developed in neritic facies (Famennian bioclastic limestones intercalating with thinner deposits of sandstones and quartzites and Tournaisian, slightly metamorphosed coral limestones). Several thick igneous rock (dolerites or altered basalts) sills, which most probably result from volcanic activity in the region during the Late Devonian regional volcanic period, are also present.[8]

The surrounding plain is intensively used for agricultural production and is geologically characterized by fluvial-lacustrine and alluvial-prolluvial formations (loam, clay and sandy loam) topped by cambisols, fluvial-lacustrine light brown alluvial soils poor in humus, and sandy lake deposits in the lower parts.[9] It can be assumed that the almost even plain is rather the result of intensive leveling works undertaken in the 20th century for land improvement purposes than a reflection of a natural development.

Today, the only standing construction on the hillocks is the monastery of Khor Virap on Hill VI. Connected with the expansion of a cemetery that has grown exponentially during the last few decades, it today almost entirely occupies the plain indentation between the Hills II, III, V and VI, representing a serious threat to the cultural heritage of the ancient site.

Methodology—Principles of Magnetic Prospecting

Magnetic anomalies are caused by changes in the magnetic properties of the soil. The extent of the magnetic anomalies is determined by the contrast between the different magnetic susceptibilities of objects or layers and the surrounding unaffected soil, as well as by their volume and depth. Two types of magnetization can be observed during magnetic measurements: the induced and the remanent magnetization.

Induced magnetisation is ascribed to the effect whereby elementary magnets of a specific matter are enhanced by external magnetic fields (e.g., the Earth's magnetic field) and, consequently, partly align with it. The propensity for this alignment and the en-

7 On the geology and geography of Artaxata in its regional setting cf. Noorda – Lichtenberger – Meyer –Schreiber – Zardaryan 2022.

8 Ginter – Hairapetian – Grigoryan 2011.

9 Valder – Carter – Medler – Thompson – Anderson 2018.

hancement's strength are determined and described by the magnetic susceptibility. In soils, the highest magnetic susceptibility values are observed in ferromagnetic or ferrimagnetic minerals like the iron oxides magnetite and maghaemite. These minerals occur ubiquitously in the soil, forming microscopically small grains. There are several possibilities to explain their origin and concentration in soils:

- Heating: In soils with rich organic content and in reducing conditions, iron oxides of low magnetization can be transformed into magnetite and maghemite under the influence of fire.[10]
- Microbial mediation: Microbes populating rich organic deposits can change the soil conditions sufficiently to favor the conversion of weakly magnetized iron oxides into more magnetic forms.[11]
- Magnetotactic bacteria: These bacteria are able to produce intracellular crystalline magnetite which allows them to navigate using the Earth's magnetic field. These magnetite crystals remain in the soil after the death of the bacteria.[12]
- Pedogenetic origin: The magnetic susceptibility can increase during soil formation processes in which organic material is absent.[13]

While induced magnetization requires an external magnetic field for its development, remanent magnetization permanently remains in a material after its creation. The most important type of magnetic remanence is caused by the heating of a material over its specific Curie temperature. In this process, the elementary magnets become mobile and align with the external Earth's magnetic field. During the subsequent cooling, the alignment of the magnets is conserved and, consequently, the burnt material becomes a strong magnet. Since the Curie temperature of typical soil components is between 600 and 700°C, fireplaces, kilns, layers of burned daub, accumulations of pottery and other burned materials can be detected based on this effect.[14]

In addition, other types of remanent magnetization can occur in soils. For example, small grains of magnetic minerals tend to align with the external magnetic field during sedimentary processes, producing so-called detrital or depositional remanent magnetization (DRM). This effect can also be observed in anthropological deposits, and thus remanent magnetization can be registered in the materials used to fill human-made pits or ditches.[15]

Another important magnetic phenomenon is diamagnetism. Structures mainly composed of diamagnetic materials, including quartz and calcite, cause noticeable negative anomalies. Diamagnetic materials literally repel the external magnetic field and, thus, form a strong magnetic field in the opposite direction, which results in an anomaly field with negative values. Due to this effect, both buried constructions of limestone and quartzite and infill composed of sand and calcareous sediments can be identified in the magnetic data as negative anomalies of the magnetic gradient.

[10] Le Borgne 1955.
[11] Linford 2004.
[12] Fassbinder – Stanjek – Vali 1990.
[13] Maher – Taylor 1988.
[14] Schmidt 2009.
[15] Fassbinder 2015.

Technical Data of the Magnetic Prospection and Positioning

For the magnetic measurements, a 7-probe gradiometer array moved by hand was used. This gradiometer array is a component of the convertible LEA MAX system. The Förster FEREX CON400 fluxgate gradiometer probes register the vertical gradient of the vertical component of the Earth's magnetic field with an accuracy of 0.1 nT (Nanotesla). The measured gradient (the difference between two vertically arranged sensors in the gradiometer probe) is insensitive to the typically large fluctuations of the Earth's magnetic field and is determined only by the magnetization of local subsurface objects. The technical details concerning the measurements are specified in **Table 1**.

Table 1. Technical details of 2021 measurement campaign

Method	Magnetic prospection
System	LEA MAX (Eastern Atlas)
Sensors	7 Förster Fluxgate Gradiometer FEREX CON400 (vertical separation: 40 cm)
Data logger	LEA D2 with 10 channels (Eastern Atlas)
Measurement category	Vertical gradient in nT
Configuration	7 sensors, mounted on cart
Resolution	0.5 m profile distance, max. 0.1 m point distance
Topographic measurement	2 GNSS receiver in RTK mode
Data positioning	Relative error: 0.02 m
Processing and filters	Ealdec and Ealmat, decoding program including offset and drift correction
Data format	ASCII, GeoTiff
Image resolution	0.25 m x 0.25 m

The data positioning for the magnetic survey was realized by means of differential GPS, using two GNSS receivers in RTK mode (real-time kinematic) to achieve a relative accuracy of 2 cm. The coordinate system used during the magnetic measurements was WGS84 UTM Zone 38N (EPSG: 32638). The base position was corrected by means of the fixed points, which were determined in the survey of 2018. Thus, the absolute accuracy of the data positioning is in the range of 2 to 10 cm. As a result, the magnetic data and their interpretation are presented in the coordinate system WGS84 UTM Zone 38N (EPSG: 32638).

Results of the Geophysical Prospection

The recent magnetic data shown together with the 2018 data **Fig. 4** enhance our understanding of the archaeological situation in the area of the eastern Lower City of Artaxata. Some parts of the investigation area could not be covered by magnetic measurements

Fig. 4. Magnetic data of 2018 and 2021 campaigns in Artaxata (© Armenian-German Artaxata Project)

due to the presence of vineyards with reinforced concrete posts and wires. Some fields in the southern part of the survey area were overgrown with high shrubs impeding magnetic measurements. In addition, concentrations of metal scrap, metal pipes and other sources of strong magnetic anomalies were found, especially along modern roads and paths. Detailed information on the conditions at the survey area is listed in **Table 2**.

Table 2. Measurement conditions during the 2021 campaign

Site	Artaxata
Date of measurements	15th to 19th of March, 2021
Archaeological context	Hellenistic to Late Antiquity
Terrain	Alluvial plain and hillocks
Geology	Late Devonian–Early Carboniferous shallow marine carbonate and siliciclastic deposits, Late Devonian volcanic rocks
Soil	Cambisols, fluvial-lacustrine light brown alluvial soils poor in humus, and sandy lake deposits
Surface	Plough marks
Above ground archaeological features	Construction debris
Vegetation	Grass, recently sawn crops; bushes, trees along the edges of the area
Land use	Cultivated land, pasture
Weather	Cloudy, few rain, 10 to 18 °C
Sources of disturbance	Scrap metal, fences, metal pipelines, reinforced concrete posts and wires of vineyards
Investigated area	2018: 14.0 ha (envelope)
	2021: 19.5 ha
	Total: 33.5 ha

The magnetic data images were thoroughly examined for anomalies that might indicate archaeological features. The interpretation presented here is the outcome of a subjective approach that takes both the general archaeological context as well as the environmental conditions into consideration, yet by no means claims to be exhaustive (**Fig. 5, 6**). Rather, outlined here is a cautious proposition meant to serve as a base for further archaeological research. Needless to say, the precarious nature of any interpretation has to be taken into account since the reading of magnetic results can always be subject to new or evolving hypotheses and knowledge.

The general approach to classifying magnetic anomalies is to distinguish them respectively by means of their intensity, polarization and shape. As part of the first step, anomalies of clearly modern origin, indicating ferromagnetic objects, were separated and marked in marine blue, while structures in light blue indicate magnetic anomalies reflecting traces of contemporary agricultural processing.

Fig. 5. Interpretation of magnetic data of 2018 and 2021 prospections (© Armenian-German Artaxata Project)

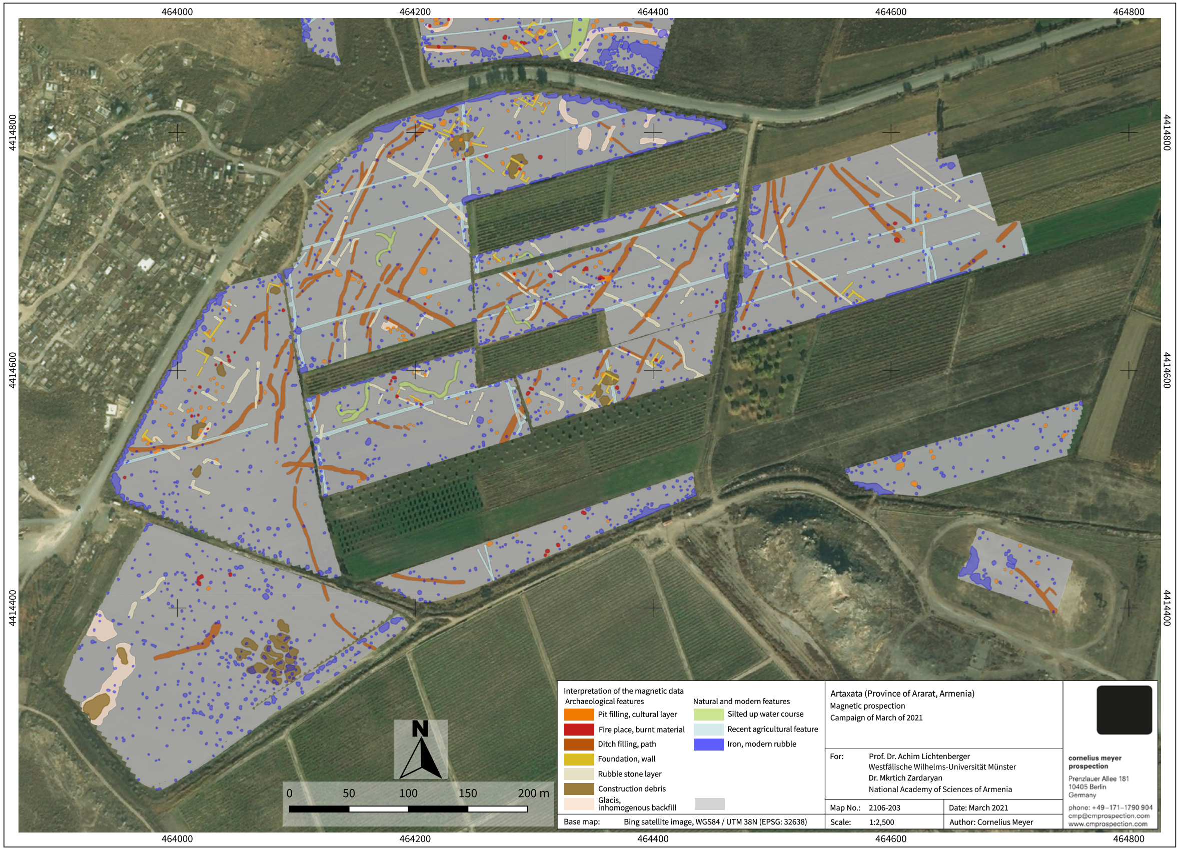

Fig. 6. Interpretation of magnetic data of 2021 prospections (© Armenian-German Artaxata Project)

The next step was to categorize the remaining anomalies that were assumed to have an archaeological background. In order to structure these anomalies, several classes were introduced with corresponding causal physical structures. In addition to the interpretation scheme used for the data of the 2018 campaign, two more classes of anomalies and structures were introduced: firstly, weak negative and linear anomalies are suspected to be caused by layers of diamagnetic rubble, which could indicate remains of ancient streets and paths, and secondly, zones of diffuse magnetic anomalies with both positive and negative values, especially found in the surroundings of ancient building complexes are ascribed to accumulations of debris composed of different materials. The specific characteristics of the anomalies, the magnetic properties of the related materials, the associated archaeological structures and the color scheme, as used in the interpretation maps, are set out in **Table 3**.

Table 3. Colour scheme of magnetic interpretation

Colour	Magnetic anomaly type	Magnetic gradient values	Type of magnetisation	Related structures and materials
	Distinct circular and oval positive anomalies	+1 to +5 nT	Induced and remanent	Fillings of pits and post holes, contain pottery fragments, burnt daub and pottery fragments
	Linear but partly irregularly shaped zones of positive anomalies	+1 to +5 nT	Induced and remanent	Organically enriched fillings of ditches, fillings of construction debris enriched with burnt daub and pottery fragments
	Distinct dipole anomalies of moderate to high intensity	±3 to ±15 nT	Predominantly remanent (thermoremanence)	Remains of kilns and fire places, accumulations of burnt clay and ashes
	Linear, negative anomalies	−2 to −5 nT	None (diamagnetism)	Foundations and walls of Upper Devonian–Lower Carboniferous limestone and quartzite

	Diffuse linear, negative anomalies	−1 to −3 nT	None (diamagnetism)	Thin layers of limestone and quartzite fragments, bases of streets or paths
	Irregularly shaped zones of diffuse positive and negative anomalies	−5 to +5 nT	Induced and remanent, and diamagnetism	Accumulation of construction debris containing limestone, quartzite, and brick fragments, mortar and ashes
	Zones of negative magnetic gradient values	−1 to −3 nT	None (diamagnetism)	Layers and backfills of sandy and calcareous material
	Linear patterns of negative and positive anomalies	±5 to ±10 nT	None, topographic effect	Plough marks, open ditches and field boundaries
	Clearly defined dipole anomalies of high intensity	>±10 nT	Induced	Scrap metal and other ferromagnetic sources

The results of the 2018 and 2021 magnetic surveys of Artaxata's Eastern Lower City are displayed on the overview **Fig. 4** (grayscale values of ±2.5 nT). More detailed maps and various grayscale values as well as different presentations of the archaeological interpretation of the magnetic data can be found in our open data publication in Zenodo.[16]

Since the level of the magnetic gradient values is generally lower in the southern part of the Lower City area, the grayscale dynamics are narrower compared to the scales used for the 2018 report. The reason for this lower intensity may be more severe damage to the ancient remains by agricultural activity. This assumption is also supported by the fact that the area south of the asphalt road leading to the monastery and cemetery is about 0.5 to 1 m lower than the area north of it, which was investigated with magnetic measurements in 2018. The altitude values were recorded by DGPS during the magnetic measurements.

Despite the lower level of the vertical magnetic gradient values, the data of the 2021 campaign reveal a complex network of linear structures, which can be observed over almost the entire survey area. These linear features run primarily in a NW–SE and NE–SW direction. Some of these structures seem to be connected to the linear features identified in the area north of the road and therefore possibly belong to a common planning phase. However, it is only possible to make assumptions about their internal structure. Two types of magnetic anomalies are observed. Firstly, 2 to 4 m wide bands of weakly positive gradient values, indicating the presence of material with remanent or induced magnetization. These layers could be caused by fillings of ditches, enriched with organic

[16] https://doi.org/10.5281/zenodo.5707542 (2018).

material, or by accumulation of cultural material along paths and streets. The second anomaly type is characterized by negative values of the magnetic gradient along bands of similar dimensions. In these cases, the presence of a layer of diamagnetic material is expected, for example, layers of limestone or quartzite rubble, which may have served as the basis for streets or pathways. None of the recognizable linear structures run completely straight, with almost all showing slight deviations along their courses.

In addition to these largely rectilinear structures, meandering features are also recognizable. They all show weakly positive values of the magnetic gradient, which suggests that they reflect silted-up watercourses. This fits well with our knowledge that the course of the Metsamor river changed several times and the anomalies might reflect such older watercourses of the Metsamor river or its tributaries.

The data give only few indications of the existence of building remains. In a few isolated locations in the central and western part of the survey area, weakly negative linear anomalies can be recognized in connection with anomaly clusters that point to accumulations of building rubble and remains of ovens or fire places. The anomaly patterns are similar to the building features located in the northern part of the eastern Lower City, the study area of the 2018 magnetic campaign. Their orientation also largely corresponds to that of the building remains further north. However, the patterns in the south are characterized by lower magnetic field intensity and great "incompleteness," indicating a poorer state of conservation. However, the fact that these remains are aligned toward the linear structures shows their structural interrelation, which is an argument to interpret both the building and linear structures as remains of ancient Artaxata.

The low intensity of the magnetic anomalies and the seeming incompleteness of the detected structures suggest that the area was severely affected by 20th century earthworks for agricultural purposes, which resulted in a substantial destruction of the ancient structures. It can be deduced that only thin layers of the bases of the assumed streets and building foundations are preserved. In fact, the magnetic data set reflects a fragment of a landscape development that has lasted for centuries or even millennia, but which certainly has large hiatuses. Thus, certain specific characteristics, such as material types and the age of the assumed ancient remains, can only be determined by future archaeological excavations.

In contrast with the dense network of linear structures with isolated remains of buildings found in the central part of the Eastern Lower City of Artaxata, there is only rare evidence of ancient structures in the southernmost parts of the survey area. In the extreme southwest, today the lowest part of the survey area in topographical terms, some indications of backfills and accumulations of debris and stones can be identified. At the western edge, close to the Khor Virap monastery, a section of a nearly circular backfill of sandy sediments and construction material can be assumed. An oral source reports from hearsay of a lake with an artificial island that still existed in the first half of the 20th century.[17] The high concentration of strong dipole anomalies located 150 m to the east of the backfill is connected with a concentration of strongly magnetic basalt fragments, but its origin and dating remain unclear. In the area opposite the cemetery and east of the modern road, several regular structures possibly correspond with both the Classical and

[17] Personal communication March 18th, 2021.

Urartian constructions of “Complex with pillars A” and “B” excavated in 1984–1988 on both sides of the road leading to Khor Virap monastery.[18]

The small fields investigated in the surroundings of the Hills XI and XII show patterns of stronger magnetic anomalies caused by scrap metal and most probably modern backfills. Since this terrain was used as a quarry, it has to be assumed that all ancient structures that may have existed were destroyed or covered by modern debris, which would make it impossible to identify them in magnetic data.

However, it must be stressed that the absence of evidence in magnetic data is not proof per se of the absence of archaeological structures. Drawing conclusions from a lack of indications is inherently problematic, not only for the analysis of magnetic data.[19] The fact that smaller structures with weaker magnetic anomalies might not be displayed in the magnetograms needs to be taken into account. To the south of the magnetic survey areas and west of Hills XI and XII, excavations in 1990 yielded extensive Early Iron Age remains and it is possible that such structures stretched into the prospected parts as well.[20]

Summary

The results of the magnetic survey carried out in March of 2021 at the site of Artaxata completed the magnetic data recorded in 2018 and contribute to our overall understanding of the ancient site and its development. Based on the magnetic data collected from an area of some 19.5 ha, which adds up to a total area of more than 30 ha of magnetic data, the following conclusions can be drawn:

- As observed in the north, the southern part of the Eastern Lower City is likewise criss-crossed by linear structures of unclear characteristics. The almost rectilinear features show two different types of magnetic anomalies: weakly positive and weakly negative ones, both of which may be related to ancient streets and pathways.
- Several isolated building complexes were identified. They are similar in orientation (NW–SE) and type to those in the northern part of the site, but are mostly only recognizable in fragment form. Since their walls are aligned along the linear features, a structural interrelation can be assumed with a high degree of certainty, as can ancient origins. The negative magnetic anomalies of the walls or foundations again suggest the presence of limestone as construction material.
- Only a few unambiguous indications of ancient structures were found in the southernmost field of the survey area. The large field located to the east of the Khor Virap monastery shows anomalies, pointing to backfills and accumulations of debris of unclear origin, while the data from the isolated field in the south and east, close to the Hills XI and XII, most probably reflect the destructive effects of using the hills as quarries in modern times.

[18] See Zardaryan – Akopian 1994; Zardaryan 2018.

[19] Wallach 2019.

[20] Zardaryan 2018.

- The level of the magnetic gradient values is generally lower in the southern part of the Eastern Lower Town. The main reason for this lower intensity is probably a more severe destruction of the ancient remains by agricultural leveling works. This assumption is also supported by the fact that the area south of the asphalt road separating the two survey areas of 2018 and 2021 is about 0.5 to 1 m lower than the area north of it.
- In order to refine the archaeological interpretation of the magnetic data and to contribute to the archaeological contextualization, features of unclear origin need to be investigated by means of direct interventions such as systematic drilling and test trenching. In particular, the origin of the network of linear structures in the Eastern Lower Town can be better elucidated in this way. This will remain a task for future archaeological work. In this paper we set out to present the magnetic data in detail to underline that the area investigated holds many archaeological features in need of protection from modern development; our aim was also to make available such data to future archaeological research of the area. In addition, therefore, we take this publication as an opportunity to publish all the magnetic data from the 2018 and the 2021 surveys in open access on Zenodo.[21]

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