

LEA MAX – multi-purpose gradiometer array in the fields of the Kaikos valley (Bergama, Turkey)

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During the past decade magnetic surveys using multi-gradiometer arrays have proven to be an eminently suitable tool for the investigation of extensive archaeological sites and landscapes. By means of vehicle-driven devices areas of 10 to 40 ha can be surveyed at high data density in one day. However, in archaeological practice many factual constraints lurk not only beneath the surface.

Mediterranean landscapes with long human settlement history are especially often characterised by intensive agricultural use and sprawling industrial and construction activity. In many cases, archaeological sites are already half-destroyed or in danger of imminent total destruction. Thus, archaeologists must not lose time to survey whatever still remains of these records of history. Investigation areas vary in size and in surface conditions. Additionally, in these archaeological landscapes many sites are still hidden in remote places, hardly accessible to motor vehicles.

Geophysical prospection projects under these preconditions also require versatile measuring equipment and case-by-case approaches. The geophysical investigations in the Kaikos valley (Bakırçay), the archaeologically very rich landscape between the ancient Greek city of Pergamon in Aeolis and its port Elaea, are textbook examples.

Between 2009 and 2011 a number of Classical sites were investigated within the frame of the DFG-funded SPP (priority program) “The Hellenistic polis as a manner of life”. The fieldwork was directed by Dr. Albrecht Matthaei from LMU Munich University (Zimmermann 2012; Matthaei 2014). Parallel to it, a survey program of prehistoric sites in the environs of Pergamon started in 2010. In this case, six prehistoric sites, partly recorded earlier (Driehaus 1957) and partly newly discovered, were surveyed with geophysical methods. The main objective of the survey was to study

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Fig. 1. The LEA MAX magnetic gradiometer array in the olive groves at Yeni Yeldeğirmentepe



Fig. 2. Results of the magnetic survey at the site of Teuthrania 114

the settlement patterns and lifestyles of the late 4th and 3rd millennium BC in a region that may have served as a link between the Troas in the north and the central parts of western Anatolia. This project was initiated and directed by Dr. Barbara Horejs from the Institute of Oriental and European Archaeology of the Austrian Academy of Sciences in Vienna (Horejs 2010; 2013).

Magnetic prospection was the main survey method. A LEA MAX gradiometer array, an in-house development, was applied in all the investigations. The positioning of the data was supplied by both a DGPS RTK system and an odometer. Arrays of three to six sensors were used, both on wheels and carried by hand, corresponding to specific site conditions (Fig. 1).

Constraints were set not only by the general conditions on the ground. Since the area of investigation is located in a region of intensive agriculture today, complete sites or parts of them were covered by crops or plantations of olive or pomegranate trees. Postponement of the surveys was not possible, as government license for archaeological fieldwork in the region of Pergamon is usually restricted to the months of August to October, that is, at the height of the harvest season and, in any case, the time flexibility of survey teams and equipment is limited to a short time window of a few weeks due to economic considerations. These additional constraints can be compensated for to some extent by resourcefulness.

Additionally, all datasets are characterised by very high magnetic anomalies complicating the archaeological interpretation. The reason for that is the high magnetisation of andesitic rock, a Miocene volcanic rock forming the landscape of the Kaikos plains, a Pliocene rift valley. A further peculiarity is that the residual soil over andesitic rock shows very high electrical conductivity values, which means that the conditions for both electrical resistivity methods and GPR are highly unfavourable.

THE CHORA OF PERGAMON

Three classical sites are presented in the poster. First is the fortified settlement of Atarneus, a Greek settlement that was inhabited from the 6th century BC to the 1st century AD and is characterised by settlement structures on mostly narrow terraces surrounded by steep slopes conditioning special measures to conduct the geophysical prospection. The next site is Teuthrania II4, located about 1.5 km to the northeast of Kalerga Tepe, in the plain of the Kaikos river. To trace the architectural remains in an area of intensive agricultural use, it was necessary to investigate several fields, including a pomegranate plantation (Schneider *et al.* 2014). The third site, Taşlari Tepe, containing the remains of a rural site of Roman date, like a villa or hamlet, was covered with sunflowers at the time of the survey. To map all three sites magnetically, the gradiometer array had to be converted to ensure optimal coverage and data of sufficient density and quality. The magnetic data revealed evidence of monumental structures, as at the site of Teuthrania II4 (Fig. 2), or settlement patterns, as was the case at Atarneus and Taşlari Tepe.

PREHISTORIC SURVEY IN THE ENVIRONS OF PERGAMON

The same variability of measuring conditions characterized the sites of prehistoric date in the Kaikos plain. The geophysical survey started at the site of Yeni Yeldeğirmen Tepe, a late Chalcolithic and early Bronze Age settlement. Surface finds indicated a relatively large perimeter, which

magnetic measurements and additional electrical resistivity tomography (ERT) were supposed to trace. A small part of the site was located on an outcrop of andesitic rock in the river plain. The main area, however, is buried under intensively used croplands. It must be assumed that archaeologically interesting layers have already been levelled out of existence.

The second site, Bağlı Tepe, was located on the left riverbank of a tributary of the Kaikos river in the Gümüşova valley. The site was covered by dense olive groves and brushwood, so that even the more easily accessible areas were challenging to say the least. Magnetic surveys were carried out both with a wheeled and a carried array. Together with additional GPR data, the geophysical results gave numerous indications of preserved archaeological structures in the ground.

One of the most spectacular prehistoric sites in the region is the settlement at Çiftlik Höyük. Parts of a tell are still preserved, today forming the base of a modern farmstead. The fields surrounding the farm offered a number of prehistoric finds, advising the implementation of an extensive magnetic survey. Farmland levelling in the past few decades does not seem to have been particularly destructive, leaving open the chance for recording the deepest and hence potentially the oldest layers of the prehistoric settlement. The magnetic data give reason to assume that early stages of settlement development can be discerned at this site.

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