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Comparison of the results of magnetic and gradient surveys with the real situation in the field on the basis of excavations at Akrai/Acrae, south-eastern Sicily. New possibilities for the interpretation of geophysical maps

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The archaeological site of Akrai (Greek Ἄκραι, Latin Acrae, Agris, Acrenses) is situated to the south-west of the modern town of Palazzolo Acreide, in south-eastern Sicily. The colony Ἄκραι was founded around 664/663 BC by Dorian colonists from Syracuse. The town emerged and developed in the shadow of the metropolis of Syracuse. Intensive development began in the 3rd century BC as attested by buildings: a theatre, bouleuterion, agora, stoa (Chowaniec 2013; 2015).

Research on the urban centre of Akrai concentrated on the public part of the town, only sporadically touching private architecture. The archaeological evidence has confirmed the functioning of the city in the time of the Roman Republic and the Empire. The town re-emerged in Late Antiquity, when the stone quarries were turned into early Christian necropolises with inscriptions carved therein, dated to the 4th and 5th century AD.

The city may have occupied approx. 35 ha, but its exact extent is still unknown. Unfamiliarity with the nature of the town and its history after the fall of Syracuse led to new archaeological investigations being undertaken. In cooperation with the Soprintendenza dei Beni Culturali e Ambientali di Siracusa, the University of Warsaw began research in 2009, starting with non-invasive investigations (survey, aerial photography, geophysical prospection). Archaeological excavations by different teams, off and on since 1816, have demonstrated that ancient ruins can be found directly beneath the surface.

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Fig. 1. Akrai. Results of magnetic caesium Geometrics 858 G (left) and gradient Bartington dual-Grad602 (right) measurements. Measurements K. Misiewicz

A preliminary analysis of the Warsaw team's first results, archaeological and geophysical (Chowaniec *et al.* 2010), confirmed the situation, indicating as well that the rubble ensconcing most of the standing remains consisted of the same stone building material as used in wall construction. Therefore, the general maps of magnetic and gradiometric surveys (Fig. 1) typically present values corresponding to what is described as magnetic debris; multi-layered features also result in similar registered values. Linear features, which are the most important for planning excavations, most probably represent architectural remains. These are narrow anomalies, showing in most cases higher values of magnetic susceptibility, either ferrous-induced, if the sources have traces of magnetite, or thermoremanent, if they are igneous in origin. Additionally, linear anomalies can form regular, parallel structures, sometimes with right angles. The disposition of recorded values (both in magnetic and gradient measurement) was described in a preliminary report as being typical of a multi-layer site containing architectural remains (Chowaniec and Misiewicz 2010). Remains can be expected to lie at different depths and to vary in their degree of preservation; moreover, entire buildings, mostly filled with rubble may be expected next to fragments of building foundations. Linear anomalies that were similar to those detected in the area of a street exposed during earlier excavations were also present. Their perpendicular arrangement to the known street suggests that the anomalies may reflect a street grid.

Excavations in Trench I confirmed the preliminary interpretations of the geophysical results (Fig. 2). The main anomaly detected here was a narrow linear feature aligned SE–NW, running through the southern part of the surveyed area, corresponding to nothing visible on the ground (Chowaniec, Misiewicz 2010). Earlier testing in a trial pit near Trench I uncovered a stone-paved street, 0.20–0.25 m beneath the surface (766.70–766.45 a.s.l.), and architectural remains to the west of this road (already in Trench I) (Fig. 3). The first layer (766.45 to 765.98 m a.s.l.) was formed mainly of small loose stones, making it difficult to recognize the source of the detected magnetic anomalies. The first feature capable of producing changes in magnetic field intensity was wall 2,

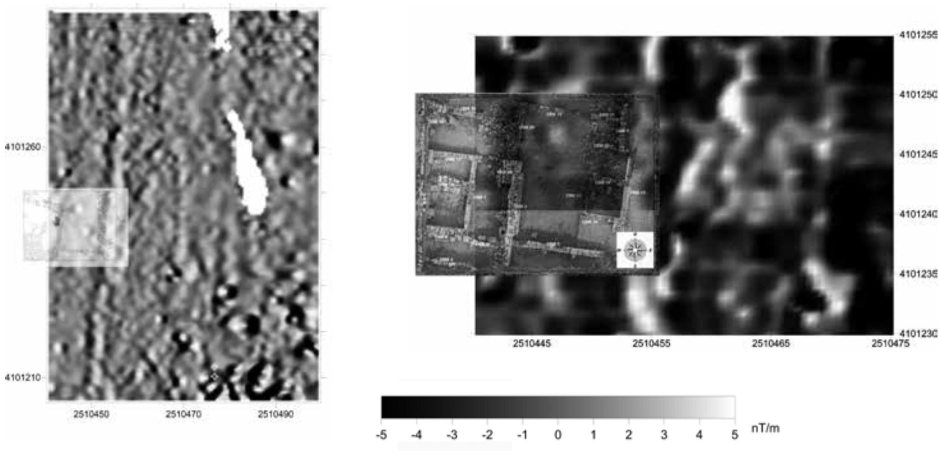

Fig. 2. Akrai. Comparison of geophysical map with the result of excavations in Trench I. Measurements and processing K. Misiewicz

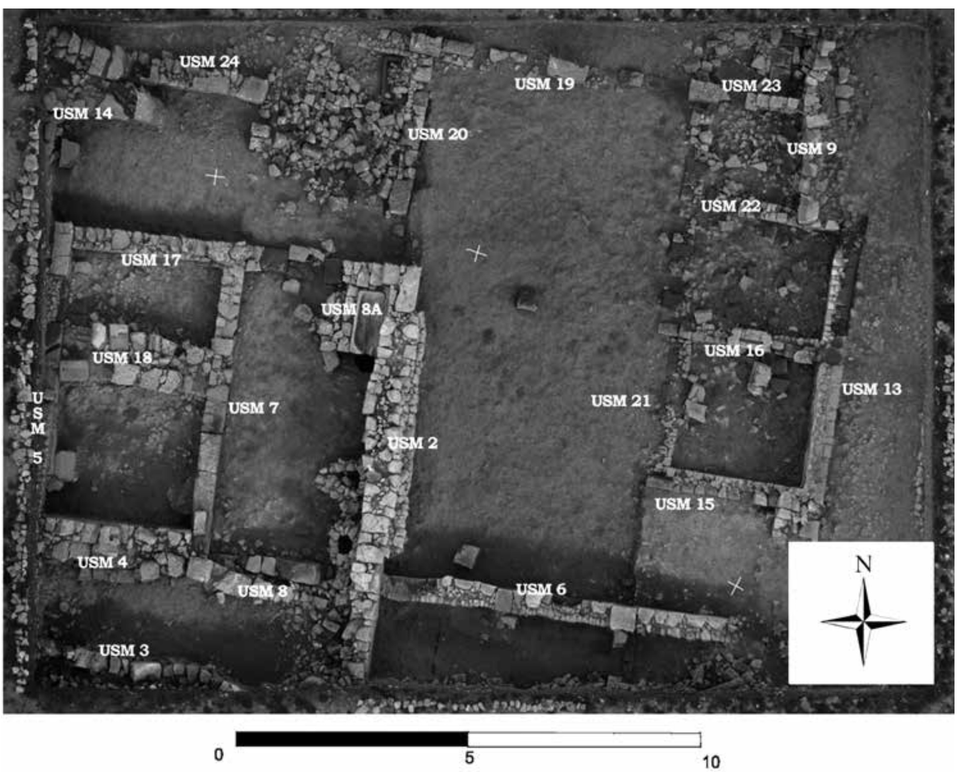

Fig. 3. Akrai. Orthophotomap of Trench I. Measurements and processing M. Bogacki and R. Chowaniec

found at a depth of 766.09–765.15 m a.s.l., surrounded by collapsed stone. A stone sarcophagus stood on top of the wall, directly under the surface (766.05–765.98 m a.s.l.). The wall and the sarcophagus were evidently later than the layer of small stones. However, the most distinct negative anomaly (from –4.6 to –5.9 nT/m) was caused by large stone slabs deposited close to the surface; it was observed on both the gradient and the magnetic maps. Similar loose stones, taken from the surface while plowing here decades ago, also shaped a subsurface layer in the western part of the excavated Trench I. In a layer about 0.9 m thick (766.30–765.28 m a.s.l.), there were the remains of walls aligned N–S, lying on the western border of the trench at 765.51 m a.s.l.

More walls were discovered in the trench: an E–W one at the southern border of the trench, its highest point being at 765.70 m a.s.l. (wall 3), and others, parallel to the first, 2.5 m further to the north, at a depth of 765.70–765.50 m a.s.l. (walls 4 and 8). Magnetic field intensity values for this part of the trench were generally lower and the contrast between the walls and their surroundings was too small to produce distinctive anomalies. The same could be said of the eastern part of Trench I, where another two walls were excavated, one aligned E–W at a depth of 766.00–765.59 m a.s.l. (wall 6) and the other N–S at a depth of 766.27–766.04 m a.s.l. (wall 9). The first wall could be the source of a dipole–dipole anomaly with values between -2 and -5nT/m on the north and from 1.5 to 2nT/m on the south. A linear anomaly with values from -1.5 to -2nT/m on the eastern side and from 3.5 to 5nT/m on the western side of wall 2 was also registered.

The results of the detailed analysis presented above should be a key to understanding the magnetic map prepared for the whole site.

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