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Editorial

For the second time in its history, *Archaeologia Polona* dedicates an entire volume to archaeological prospection, understood as a growing range of non-invasive methods for recording archaeological structures. As in volume 41 issued in 2003, there is foremost a large set of articles documenting the application of geophysical methods in the investigation of archaeological sites. There are also articles on the GIS methods, processing and visualization, technical aspects. Recent years have witnessed a rapid development of ground-scanning technology (LiDAR), also represented in the volume. A novel element are articles from the field of the history of archaeological geophysics.

The volume accompanies the 11th International Conference on Archaeological Prospection, organized on 15–19 September 2015 in Warsaw by the journal's publisher, the Institute of Archaeology and Ethnology of the Polish Academy of Sciences (together with the Polish Centre of Mediterranean Archaeology of the University of Warsaw and the Scientific Association of Polish Archaeologists). For the past decade or so, the organizers of successive conferences have adopted the principle of publishing not the commonly accepted abstracts, limited to a few sentences, but rather brief articles including illustrations and references that give in effect a representative review of what is going on in the field, both in scientific institutes and in commercial companies around the world.

The strong representation of archaeological feedback in the volume is the effect of there being a full-day session devoted to the topic at the conference. Nine invited guest lecturers representing different centers from France, Germany, the Netherlands, Austria, Italy and Poland make up this session, the idea of which is to evaluate the effectiveness of prospection methods from the point of view of those commissioning the research, that is, the archaeologists. The objective is to popularize prospection methods among archaeologists in Poland.

The first part of the volume contains articles by Polish authors, discussing relevant research carried out in Poland (articles on research of Neolithic, Early Bronze Age and Medieval sites) and in Egypt where Polish geophysics contributed significantly to research over the past 30 years (article by Zych and Herbich on the Hellenistic/Roman harbour in Berenike). This part is rounded off with an article giving a historical overview of the development of the magnetic methods from its first application in 1958 to the late 1990s. It is only right after half a century since its inception to look up the beginnings of the field and the factors that contributed to its development. Not the least, it is practically the last moment to talk to the founders of the discipline, the authors of those first implementations of the method in the field.

The volume is also a way of paying homage to two extraordinary men, Alain Tabbagh and Helmut Becker, whose contribution to the development of archaeological geophysics has been momentous. Prof. Alain Tabbagh, a student of Albert Hesse (whose founding role in the field was acknowledged in *Archaeologia Polona* vol. 41), has dedicated a lifetime to research on the development and applications of the electromagnetic method. A lecturer at the University of Pierre et Marie Curie in Paris, he has educated a generation of researchers whose work has placed French geophysics at the top of the field. Their articles are found in this volume. As for Dr. Helmut Becker, his varied contribution to the field includes pioneering work on digital recording of measurement data, implementation of cesium magnetometry, the uses of mobile multi-sensor magnetic systems, visualization and interpretation of results and the integration of geophysical research with aerial photography, the latter in association between his laboratory in Munich and Otto Brasch. The achievements of both researchers have been presented in brief articles opening the volume.

Dedicating this volume of a journal with "Polona" in its title to these two scientists is validated also by their links with Poland. Both Alain Tabbagh and Helmut Becker have carried out research in Poland, working in cooperation with researchers from the Institute of Archaeology and Ethnology of the Polish Academy of Sciences and the Institute of Archaeology of the University of Warsaw. They have shared their immense experience as well as their equipment, which was not available by any means in Poland in those early years. Alain Tabbagh supported Polish research on early metallurgy of iron, whereas Helmut Becker provided the apparatus necessary to carry out Polish geophysical projects in Egypt in the 1990s. Our gratitude for this and much more is boundless.

Tomasz Herbich

Alain Tabbagh

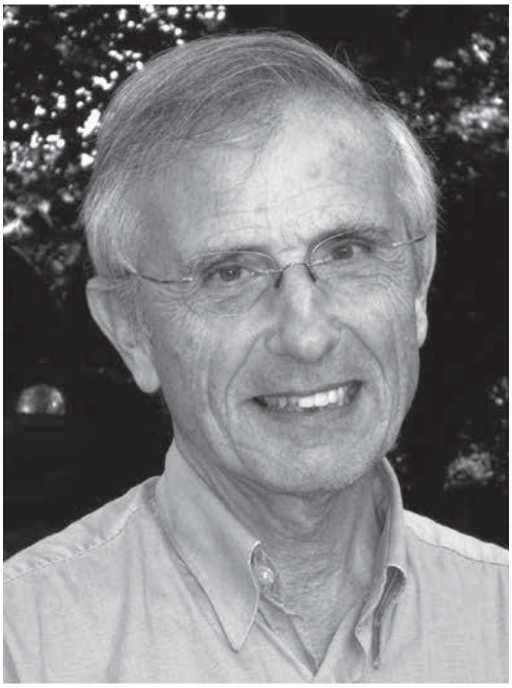

Photo: C. Tabbagh

Alain Tabbagh is one of the most eminent French geophysicists of the past 40 years. It is difficult to give an exhaustive overview of such a rich career, in which so many new avenues of research were initiated, that had barely been scratched before.

Having completed a PhD on the use of electromagnetic methods in archaeology under the direction of Albert Hesse in 1971, Alain Tabbagh became Assistant Lecturer at the University of Pierre et Marie Curie (UPMC) in 1972. He spent his entire career thereafter at the UPMC: Assistant Lecturer 1972–1978, Lecturer 1978–1984, Assistant Professor 1984–1988, Professor of applied geophysics 1988–2012, Professor Emeritus since 2012.

His research in geophysics concerns different applications, such as hydrology, soil science, civil engineering and archaeology. In the latter domain, he is one of the most eminent figures of French archaeometry. He is one of the founding members of the GMPCA in 1976 (Group for Physical and Chemical Methods in Archaeology, renamed Group for Interdisciplinary Methods Contributing to Archaeology in 1987) and presided over it from 1991 to 1995. He headed from 1988 to 1989 the Geophysical Research Center at Garchy, which was one of the pioneer institutions in Europe for the application of geophysical methods in archaeology. He was also Director of the Sisyphe laboratory (renamed METIS in 2014) from 2001 to 2008. Alain Tabbagh is also member of several international societies: European Association of Geoscientists and Engineers (EAGE), Society of Economic Geologists (SEG), International Society for Archaeological Prospection (ISAP, honorary member since 2014), American Geophysical Union (AGU), International Union of Soil Sciences (IUSS), Institute of Electrical and Electronics Engineers (IEEE), and associated editor of various international journals.

As professor at the UPMC, he was Study Director of the engineering section in geophysics and geotechnics from 1992 to 2005, and Director of the postgraduate programme 'Sciences de l'Univers, Environnement, Ecologie' from 2004 to 2011. He supervised 40 PhD theses, including several in applied geophysics in archaeology, among them theses by Michel Dabas, Christophe Benech, Julien Thiesson and François-Xavier Simon. He has published more than 130 articles, demonstrating a broad range of research in the application of geophysics in archaeology.

With his extensive experience in both theoretical and experimental approaches, Alain Tabbagh initiated important developments in the EMI domain. For small-sized dipole-dipole instruments using the slingram configuration, he was the first to make the measurement of magnetic susceptibility possible by using the in-phase response and built the first stabilized EMI device for archaeology (SH3) as well as a large series of different instruments of similar type enabling simultaneous measurement of apparent magnetic susceptibility and apparent electric conductivity. He proposed also a 3D-modelling technique based on the moment method, taking into account contrasts both in conductivity and magnetic susceptibility, and calculated the theoretical response for the different coil orientations to estimate the most pertinent configuration for the best depth of investigation. He developed also new TDEM devices to measure the magnetic viscosity of archaeological structures. All these technical and theoretical innovations were decisive for a more extensive use of EMI methods in archaeology and not just in environmental studies. The measurement and characterization of different kinds of magnetization helped considerably with the interpretation of magnetic properties of soils and their relationship with human occupation. Experiments with these instruments in the field (including the EM15 by Geonics) improved the interpretation of the physical nature of responses (anomalies) produced on survey maps by specific archaeological targets. Alain Tabbagh participated or directed many successful field surveys, including such prominent projects like the search for Bronze Age deposits in Marchezieux, delimitation of ancient metallurgic workshops as revealed by direct measurement of the magnetic susceptibility of slag deposits and the exploration of pavements of diverse churches and other buildings.

He initiated the development of electrostatic devices with the use of non-galvanic arrays, particularly useful in urban contexts and less limited than with the GPR in the case of conductive soils. He developed systems for different depths and with different array configurations and established the 1D- and 3D interpretation of the data. Such systems are particularly powerful in urban context and represent a good alternative to GPR devices when the penetration depth is limited by too conductive environments. Electrostatic systems have been used successfully for the study of the ancient topography of modern cities, like Tours in France and Alexandria in Egypt, and also for investigation inside historic buildings, like cathedrals.

As an alternative to traditional aerial archaeology, Alain Tabbagh developed new devices to measure the variations of surface temperature of the soils by using airborne and satellite infrared remote sensing as a thermal geophysical exploration method. Variation of soil temperature had already been used in aerial survey for the detection of archaeological structures like ditches, particularly when the snow is melting, which limited such investigations to a very short period during the year. By using a radiometer to measure radiation transmitted by ground soil, he carried out very impressive thermal surveys over wide areas, detecting Neolithic ring ditches and ancient land divisions. The use of the method was very limited due to the complexity of data processing and interpretation, but Alain Tabbagh computed the 3D numerical model, evaluated the thermal inertia contrasts and established the heat exchange conditions at the soil' surface favourable for surveying.

He also pursued a collaboration initiated by Albert Hesse during the 1980s with Polish colleagues Tomasz Herbich and Krzysztof Misiewicz. He participated in the publication of EM surveys with the SH3 on the sites of Słonowice and Milanówek and came back to Poland with Julien Thiesson in 2004 for the study of the pottery workshops in Stołpie.

His lifetime of work had impact on applied geophysics far beyond the specific context of archaeology that is summarised here in brief. However, it is for archaeological prospection that he invested his energy and enthusiasm and the many ways of research that he initiated are still being pursued by a younger generation of geophysicists. It is indeed a great gift to young students who are starting on their PhD to give them visionary and innovative subjects of research to help them find a place for themselves in the scientific community.

Christophe Benech and Albert Hesse

Helmut Becker

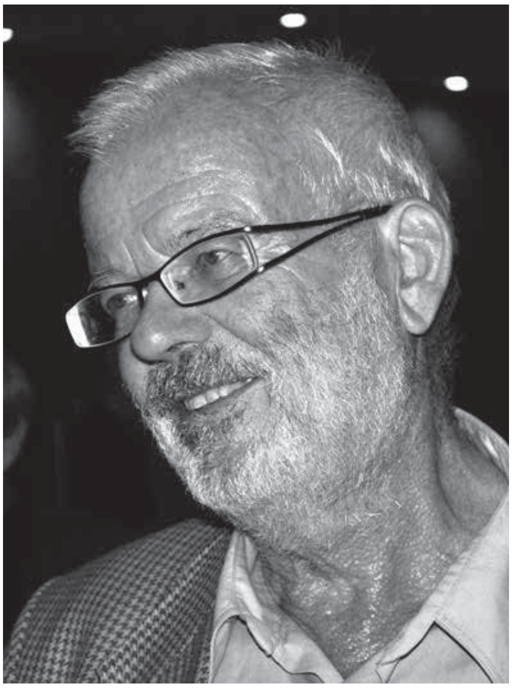

Photo: T. Herbich

Helmut Becker is one of the eminent German scientists specializing in archaeological geophysics in the past 40 years. An overview of his work in Bavaria as well as in the Near and Far East, Egypt, Eurasia and China, which was presented in the Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege (BLfD - Bavarian State Department for Monumets and Sites) in 1999 and 2001, revealing the great range and diversity of his work on archaeological sites of the Old World.

His geophysics diploma and his doctoral thesis under the direction of Heiner Soffel at the Institute for General and Applied Geophysics of the Ludwig-Maximilians-University Munich, as well as his first scientific work from 1971–1973, dealt with paleomagnetism in Iran and the verification of seafloor spreading in Iceland. But since the very beginning of his career Helmut Becker also studied archaeology and was involved in a multitude of archaeological research projects in Turkey, Greece and Iraq, where he undertook topographical measurements, archaeomagnetic studies and, last but not least, in 1976, his first magnetometer surveys in Turkey and in Greece.

Within the frame of the Volkswagen Stiftung research project in 1977–1982, he came together with Irwing Scollar (Bonn), Emile Thellier, Albert Hesse, Alain Tabbagh (Garchy) and Martin Aitken (Oxford) to establish a new research field of Archaeo-Prospection and Archaeomagnetism at the Geophysical Observatory Fürstenfeldbruck and the Geophysical Institute in Munich. These successful and promising survey and research projects helped him to convince the director of the archaeological section of the Bavarian State Department for Monuments and Sites, Dr. Rainer Christlein, to establish the Archäologische Prospektion und Luftbildarchäologie section at the Bavarian State Department. This was the first time in Germany that a geophysicist was employed in an archaeological institute for archaeological geophysics. Helmut Becker directed this department from the start.

In 1982 Helmut Becker set up a cesium magnetometer system (Varian 101) with an automatic digital data recording system. Further development yielded in 1985 a wheel-deployed magnetometer prospecting system that allowed large areas to be measured in a comparatively short time. In the laboratory of the Bavarian State Department, Helmut Becker installed and developed a highly effective and powerful computer system for digital image processing of the geophysical data, rectification of oblique air photos and combined data interpretation. Together with aerial archaeologist Otto Braasch and from 1986 with Jörg Fassbinder, Helmut Becker accomplished very successful work at the Bavarian Department, not only with the discovery of previously unknown archaeological sites in Bavaria through aerial prospection and complementary magnetometer prospection, but also with a detailed and sophisticated interpretation and mapping of these sites. It was in his department that integrated prospection with a combination and data fusion of these complementary prospecting results and methods began.

Further development of the magnetometer system at the Bavarian State Department for Monuments and Sites ("From Nano- to Picotesla") was stimulated by the discovery of the lower city of Troy and the Bronze Age fortification of Troy VI. The result was the most sensitive magnetometer system for archaeological prospection in the 1990s. Subsequently the cesium magnetometer system was enlarged to a duo-and quad-sensor system respectively. The handheld caesium duo-sensor system (Scintrex Smartmag SM4G-Special and Geometrics G-858G) is still among the most sensitive and effective prospecting systems with respect to large areas in difficult terrain; large-scale measurements in Qantir in 1996–2003 are a good example.

Helmut Becker's idea for a geophysical prospecting section within an archaeological State Department was developed from the very beginning of his work. the objective was to survey different categories of archaeological monuments and to compare survey results for the development of further archaeological research questions. His idea to ascribe Neolithic ring ditch monuments to an archaeoastronomical context was one of the major results of such a prospecting approach.

Following this idea, we now have from Bavaria geophysical survey results and interpretation of all the known Neolithic ring ditch monuments from more than 15 large early Neolithic settlements, nearly 40 enclosures from the Hallstatt period, 35 Iron Age square enclosures, as well as survey results of nearly all accessible Roman *castella* in the Bavarian part of the limes, more than 30 Roman villas and about 15 early medieval castles, many of these sites previously completely unknown.

In 2005 Helmut Becker retired from the Bavarian State Department and started a new career with his private company "Becker Archaeological Prospection". He is still active in geophysical prospection and walking hundreds of kilometres with a magnetometer, from Portugal and Spain in the west to Cornesti (Romania) in the east and places like Turkmenistan and Uzbekistan in the Far East.

Jörg W.E. Fassbinder

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Geophysical prospection in the territory of the Roman town of Aesernia, central southern Italy

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KEY-WORDS: geophysical survey, resistivity, GPR, magnetometry, Aesernia, central southern Italy, Roman period

INTRODUCTION

The geophysical prospection survey at Isernia constitutes a ground-based remote-sensing research module of the Aesernia field survey project (Stek *et al.* in press). This is a subproject of the "Landscapes of Early Roman Colonization project", funded by NWO (Netherlands Organization for Scientific Research) and based at Leiden University and the Royal Netherlands Institute in Rome, which is implemented in Molise in collaboration with the Soprintendenza per i Beni Archeologici del Molise (Stek and Pelgrom 2013). The project investigates the rural settlement organization of the Roman towns of Venusia and Aesernia through conventional surface survey techniques and remote-sensing approaches (aerial imagery and geophysical prospection).

Five different sites in the area of Isernia were prospected using an integrated strategy, namely magnetometry, soil resistance and ground penetrating (GPR) techniques. More than 16,820 m^2 were prospected with a large degree of overlap between different methods.

RESULTS

Of the five sites that were surveyed, three produced significant results. Site A205 is located in the saddle between the valley of Fonte Salomone and the plain of Perete, just north of the Fonte S. Angelo hamlet. The archaeological fieldwalking survey of the site was carried out in October 2011 and resulted in the identification of a dense scatter of pottery (including black gloss, African red slip wares, plain and coarse wares, some recognizably Late Antique in attribution,

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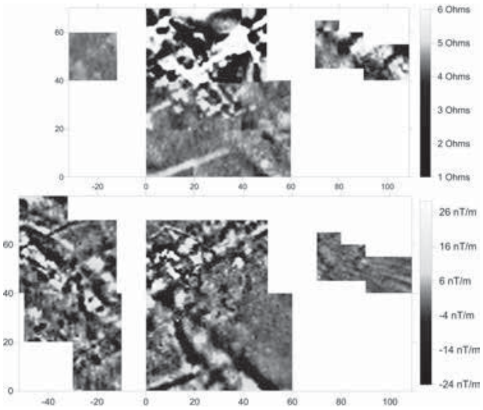

Fig. 1. Site A205. Top: results of the soil resistance survey; bottom: results of the vertical magnetic gradient survey

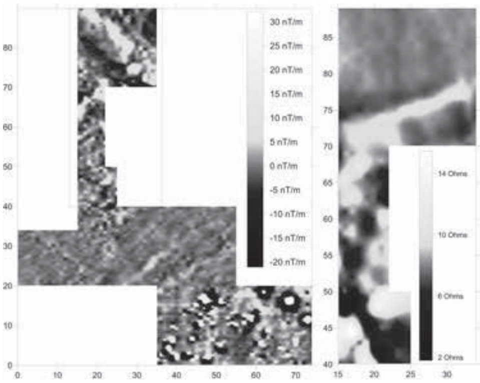

Fig. 2. Site A224. Left: results of the vertical magnetic gradient survey; right: results of the soil resistance survey limited to the upper northern part of the site

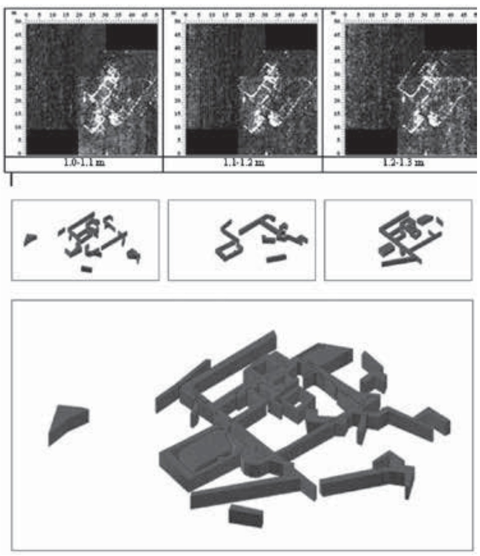

Fig. 3. Site A232. Top: GPR depth slices for depths of 1.0–1.1 m, 1.1–1.2 m and 1.2–1.3 m. The light colours indicate the intensive reflectors as registered by the NOGGIN_PLUS 250MHz GPR unit; middle: 3D reconstruction of the diagrammatic interpretation of geophysical anomalies (from left to right: GPR, magnetic, resistivity); bottom: synthesis of the 3D reconstruction indicates a clear outline of a Roman villa. The reconstruction was made as a primitive prototype, considering not so much the depth of the buried architectural remains, but traces registered by all methods, contributing in this way to a full description of the outline of the complex. The 3D reconstructions were carried out in ArcScene

amphoras and *dolia*, glazed wares) and a large quantity of roof tiles, which are ubiquitous in the field. Surface finds indicated that occupation of the site spanned a period from the Roman Republican to the late Imperial period, with some materials dating to the modern period. The geophysical results provided evidence of a number of features that could be interpreted as a large complex, 50 m (E–W) by 45 m (N–S). The clearest signals were produced by the GPR measurements, which suggested a burial depth of about 80–120 cm below the ground surface. All methods provided comparable results and their interpretation indicated that the antiquities may belong to a large installation apparently in relative good condition.

The fieldwalking surface survey in October 2012 at the cluster of sites A224/A225/A226, which is located on the top of a ridge that extends south from the village of Colle Cioffi, produced fragments of painted plaster, roof tiles, *opus spicatum* bricks and *opus caementicium* rubble. Pottery included a wide range of wares (*impasto*, *bucchero*, black gloss, Italic terra sigillata, African red slip wares, plain and coarse wares, amphoras and *dolia*, glazed wares), reflecting long occupation from the Late Iron Age/Archaic period through modern times, with the bulk of the material dating to the Roman Republican–late Imperial period. Despite the small size of the surveyed grids, geophysical techniques proved that there is substantial evidence for the presence of architectural relics possibly extending further to the central eastern and western sectors of the surveyed area. The subsurface relics seem to be buried within a depth of 1 m below the surface and strong reflectors may have been caused by collapsed building material.

The most striking data, however, were produced at site A232, which is located on the southern slopes of the Colle Facora, with a view to the south over the ridges of Campo Largo and the Cavaliere valley. Personal communication with the field owners indicated that a brick floor and marble fragments had been found in the past. The archaeological fieldwalking survey in September 2013 yielded a high sherd density (about 12 sherds per square meter despite poor ground visibility at the site), consisting mostly of roof tiles, but with some pottery (coarse wares, amphora and *dolia*). Despite the difficulties in dating the site more precisely than generically to the Hellenistic–Roman period, it was interpreted as a structure or multiple structures with possible storage function (as indicated by the *dolium* and amphora fragments).

The results of geophysical surveying verified the finds of the fieldwalking surface prospection. They showed the clear outline of a building complex consisting of multiple rooms. All three of the applied geophysical techniques (magnetometry, resistivity and GPR) resulted in complementary outcomes. GPR signals registered reflectors from 1.0–1.5 m below the surface, with the northern anomalies lying deeper than the southern ones (with respect to current ground elevation). Geophysical measurements outlined an architectural compound, 35 m by 37 m, consisting of various compartments laid out on a plan that resembles a typical Roman villa or large farmstead. At the western end of the complex there is a rectangular building, 9 m by 7 m in size, outlined as an intense reflector (possibly caused by collapsed building blocks), as a high resistance anomaly (for the same reason) and as a high magnetic anomaly (probably due to heating activities occurring inside the building). To the south-east, an aisled building is projected in front of the complex to the west. The outer diameter of it is about 5.5 m. Taking into account the continuity of the western sustaining wall to the north, the possible entrance to the compound is suggested on the southwestern side. The large open space (~18 m by 10 m) to the east of the aisled structure may belong to the inner courtyard of the house. A rectangular anomaly is outlined at the center of this suggested courtyard. To the north side of the courtyard, a long corridor is recognizable. This is not the case for the southern side of the complex, where its limits are not easily distinguished. Three internal divisions (rooms) are identified between the courtyard and the northern corridor, mainly from the GPR and the soil resistance measurements. Another elongated room is suggested on the eastern side of the complex.

FINAL REMARKS

Having a good responce from the surface surveying techniques, geophysical approaches proved extremely efficient in identifying a number of architectural structures most probably related to villas, farmsteads and agricultural installations. The geophysical survey proved a successful addition to the archaeological field survey of the territory of the Roman town of Aesernia to enhance the understanding of surface scatters of archaeological material, and the importance of applying multiple geophysical techniques (manifold approach, Sarris 2013) was clearly demonstrated. In some cases, such as site A232, the complementarity of the various techniques could be exploited in order to produce primitive 3D reconstructions of the various architectural compounds. In the next phase of the "Landscapes of Early Roman Colonization" project, a selection of sites in the research area around Aesernia (including the three examples given here) will be subject to a detailed intra-site study, using a high-resolution, gridded point sampling technique, in order to enhance the chronological and functional interpretation of the sites and to identify possible areas of internal functional zoning.

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