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Onderzoeksrapport

De toepassing van geofysische prospectie methoden in de archeologie

The use of Geophysical Prospection methods in Archaeology

Agentschap
**Onroerend
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GUIDELINES FOR THE USE OF GEOPHYSICS IN ARCHAEOLOGY: SHOULD THEY BE PRESCRIPTIVE?

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Samenvatting

Zowel geofysici als archeologen voelen de nood om een houvast te hebben voor kwaliteitsgarantie bij de uitvoering van geofysische prospecties. De *Europeae Archaeologiae Consilium* (EAC) deed daarom een beroep op een team van auteurs van de *International Society for Archaeological Prospection* (ISAP), om richtlijnen terzake op te stellen. Het resulterend document legt geen rigide regels vast, maar reikt daarentegen eerder een kader aan dat bedoeld is om op efficiënte wijze een projectplan op te stellen dat kan voldoen aan specifieke vraagstellingen en archeologische 'omstandigheden'. Dankzij dit perspectief zijn de richtlijnen toepasbaar op een Europese schaal. Een belangrijke voorwaarde voor het correct inzetten van de richtlijnen, en geofysische prospectie in het algemeen, is het inzetten van de juiste expertise (ervaren archeologen en geofysici). Het is duidelijk dat er in veel landen in Europa een nood is voor de opleiding van archeologische geofysici.

Summary

Both geophysicists as archaeologists feel the need for quality control concerning the application of archaeological geophysical surveys. The *Europeae Archaeologiae Consilium* (EAC) therefore commissioned a team of authors from the *International Society for Archaeological Prospection* (ISAP) to draw up a set of guidelines. The resulting document does not rigidly define a set of rules, but rather presents a framework for the efficient design of case specific projects. Because of this perspective these guidelines can be used on the European scale. An important condition for the correct use of the guidelines, and the efficient application of archaeological geophysics in general, is the availability of the right expertise (experienced archaeologists and geophysicists). It is clear that in many countries in Europe that there is a need for education and training on the subject.

INTRODUCTION

Archaeologists are sometimes disappointed on the quality of geophysical surveys they commission. Similarly, archaeological geophysicists occasionally complain that other contractors are 'getting away' with low-price tenders because project briefs were not written sufficiently specific. Both of these groups feel the need for guidelines. Consequently, the *European Archaeological Council* (EAC; https://www.europae-archaeologiae-consilium.org/) commissioned a team of authors from the *International Society for Archaeological Prospection* (ISAP) to write such guidelines[6].

This contribution examines the choices that had to be made whilst writing these guidelines; considers how prescriptive such pan-European guidelines could be; and concludes with comments on the resulting document.

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[6] Schmidt *et al.* 2015.

THE RATIONAL FOR GUIDELINES

Subject specific guidelines are foremost useful for users of specialist services, in this case mostly for archaeologists who commission geophysical surveys. By following such guidelines they are more likely to receive good data from contractors, which in turn will allow them to obtain useful archaeological results. Ideally, by following the guidelines the best output will be obtained within the available budget. For contracting archaeological geophysicists the benefits of guidelines are that they will lead to better project briefs, which make fieldwork planning and budgeting easier and more efficient. In addition, detailed project specifications create equal conditions for all submitted tenders so that undercut pricing due to insufficient specifications can be largely avoided.

The main objection to guidelines is their perceived inflexibility. It is especially true for archaeological geophysical surveys that nearly every site is different, both in terms of the characteristics of buried archaeological features and of soil properties, which together create the measured geophysical anomalies. There is a large number of soil- and feature parameters that determine these anomalies and most of these parameters are very difficult to predict or to measure in advance. Every investigation is therefore a compromise between survey effort (i.e. cost) and potential information gain. Over-prescriptive guidelines would therefore have been problematic.

The EAC has started to create European guidelines for several archaeological specializations and has chosen as its second volume the use of geophysics in archaeology https://www.europae-archaeologiae-consilium.org/eac-guidlines. The EAC consists of representatives from national European heritage organisations. Its guidelines are drafted by a team of authors and then discussed and refined by the EAC members. Consequently, these texts have to take into account different legal systems and customary practices, which makes the creation of such a document challenging. Furthermore, guidelines issued by a pan-European body that operates outside of the European Commission, such as the EAC, are not initially legally binding. It is envisaged that the EAC's national representatives promote and implement the guidelines in their own countries to embedded them into national heritage frameworks.

The EAC Working Group on remote sensing chose a team of authors from members of the International Society for Archaeological Prospection (ISAP) to write the *Guidelines for the Use of Geophysics in Archaeology*[7]. The team realized early on in the process that it was important to base these guidelines primarily on already existing documents. The most advanced guidelines in archaeological geophysics had been written by English Heritage[8], but it was clear that the country specific views of that document had to be adjusted to a European context. It was initially planned to write a general text that would be augmented by sections related to the individual countries involved. However, it was decided that these country specific sections should be produced separately as online resources to allow for their constant updating. This ensured that the core document could be delivered in an acceptable timeframe. These country specific sections are currently being compiled and will be available from the ISAP web site at archprospection.org/eacguidelines.

THE DESIGN OF GUIDELINES

There are different perceptions as to what is meant by 'guidelines'. Some consider them to be a strict regulatory framework, others expect a set of statements that clarify terminology or workflow, and

[7] Schmidt *et al.* 2015.

[8] English Heritage 2008.

there are even other terms used to express similar concepts. For example 'standard and guidance' may mean a codified rule set (e.g. CIfA's *Standard and Guidance for Geophysical Survey*[9]) or a 'guide to good practice' may be considered to provide advice on a subject (e.g. ADS's *Geophysical Data in Archaeology: A Guide to Good Practice*[10]).

Related, but slightly different, is the distinction between procedural and discursive approaches for expressing such guidelines. In a procedural approach guidelines are formulated as a set of 'if-then' rules (e.g. "if it has been dry for a long time, earth resistance surveys may show little contrast and be less useful"). For example, the geophysics guidelines from English Heritage (2008) contain in their Table 3 a list showing the suitability of different geophysical techniques in a number of archaeological settings. The table is meant as an approximate indication, which is made clear in its accompanying caption: "*This is a rough guide only, to which there will be exceptions, depending upon the individual site circumstance and future technical developments*." (fig. 1).

Table 3 Matching survey method to feature type: survey options (see key below): the choice of geophysical survey method(s) appropriate to a range of archaeological features, based on experience from the UK. Only the most commonly used survey methods are listed. This is a rough guide only, to which there will be exceptions, depending upon individual site circumstances and future technical developments.

Feature type	*Mag area survey*	*Earth res survey*	*GPR*	*EM (cond)*	*Mag susc*
areas of occupation	Y	n	N	?	y
below artefact scatters	Y	Y	N	?	y
large pits (>2m diam)	Y	y	Y	?	N
smaller pits (<2m diam)	Y	?	y	N	N
ring gullies (prehistoric)	Y	n	N	N	N
post-holes (>0.5m diam)	y	n	y	N	N
hearths	Y	N	N	n	?
kilns/furnaces	Y	N	?	?	?
sunken-featured buildings	Y	y	?	?	N

Figure 1: Table 3 from the guidelines by English Heritage (2008) showing the suitability of different geophysical techniques.

As there are many parameters that determine the success or failure of a geophysical survey the listed types of archaeological features (e.g. "ring gullies (prehistoric)") are only weak predictors for a technique's suitability. Nevertheless, this table has been used frequently to select or prescribe the application of certain geophysical techniques for an archaeological site under investigation[11]. This shows the desire, or perceived need, for such a simple selection tool. Taking this approach further, and including more site parameters, a software tool was developed[12]: ATAGS, the *Automated Tool for Archaeo-Geophysical Survey* prompts users to enter many relevant site variables (e.g. the prevailing soil type, fig. 2) and at the end produces a detailed 'survey design' (i.e. a project brief).

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[9] CIfA 2014.

[10] Schmidt and Ernenwein 2011; Schmidt 2013.

[11] It should also be considered that prior to the planned geophysical investigations a site's archaeological features are often not well known, or only assumed and hence there may initially not be sufficient information to use the table.

[12] by Somers *et al.* 2003.

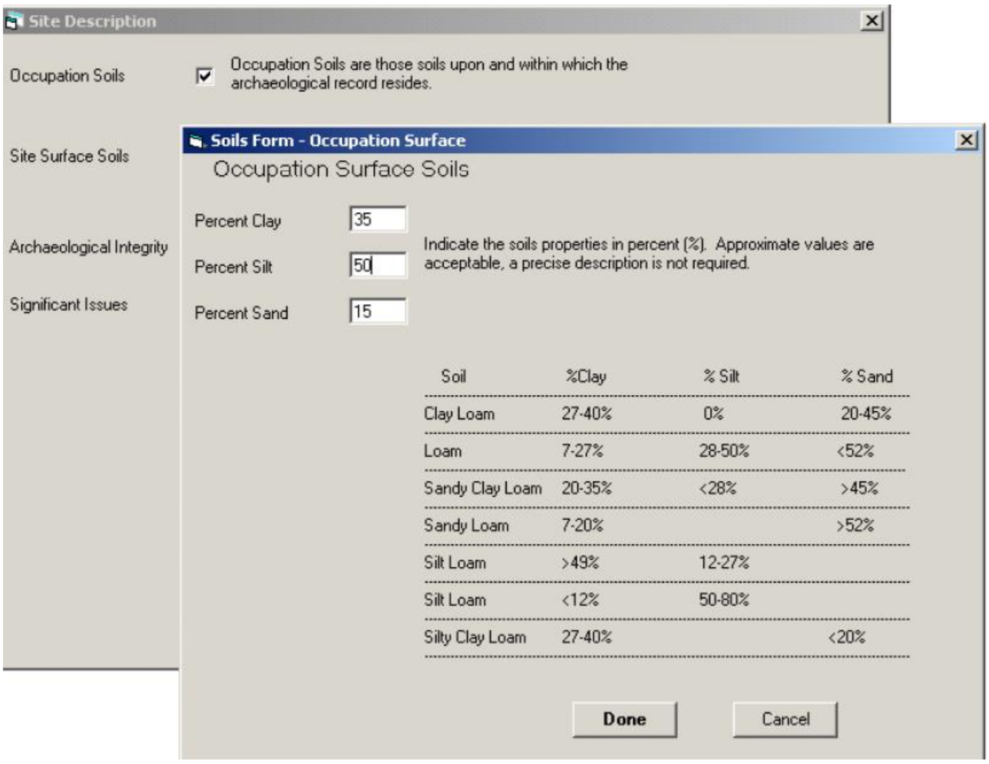


Figure 2: The 'Soils Form screen' of the ATAGS software (Somers *et al*. 2003, Figure 7)

This software formalizes the experience of its authors with the use of earth resistance and magnetometer surveys on Plains and Midcontinent archaeological sites in the USA and is hence quite specific to the conditions of this region. This approach is reminiscent of attempts to codify the experience of skilled medical practitioners through software-based diagnosis tools[13]. Interestingly, soon after the introduction of such a system for the support of nurses who answer the 'NHS direct' helpline in the UK, many nurses felt that their own experience was still superior to the software system and tried to enter data into the system such that it created the answers they wanted[14]. The construction of such medical artificial intelligence (AI) tools is primarily made possible because of the availability of a vast number of data sets for the testing and design of the algorithms. By contrast, in archaeological geophysics nearly every survey has different site parameters and only few are actually recorded, which makes an automated analysis very difficult.

An alternative is the discursive approach for expressing guidelines. It is based on the insight that the incomplete and poorly defined description of an archaeological site's properties can be addressed best by human experts. During their training they will have evaluated a range of geophysical results from known archaeological sites and will have learned about the relationship between physical properties and geophysical anomalies. Importantly, they will have discussed their insights with peers and tutors and thereby have formed a collective understanding. There is currently no automated IT system available to mirror this kind of learning and dialogue. The tasks involved can be broken down into several steps: acknowledge that there are many points to consider, attempt to list them all, discuss these with colleagues, and make overall decisions based on these facts, personal knowledge and experience. In practice these steps are usually merged into an overall workflow, but this enumeration

[13] Jiang *et al.* 2017.

[14] O'Cathain *et al.* 2004.

shows the complexity of the tasks involved and thus the difficulties for translating them into a software tool.

The authors of the EAC guidelines advocate such a discursive approach, providing a list of questions to ask and points to consider (Part I), followed by the recommendation to make the specifications for a survey project (the ‘project brief’) as detailed as possible. The project brief has to be tailored to the site under investigation and should be as specific (and prescriptive) as possible. Thereby it becomes a valuable resource for all parties involved (Part II). For some selected site categories design criteria are presented in Part III, and Part IV provides basic technical details for the geophysical techniques used most commonly in archaeology.

THE ROLE OF EXPERTS

During the campaign for the 2016 British referendum to determine whether the UK should leave the European Union (‘Brexit’), Michal Gove, a senior cabinet member and Co-Convenor of the Vote Leave organization famously exclaimed that “people in this country have had enough of experts …”[15] . Although taken out of context subsequently, this quote conveys the message that ‘the people’ with their desire to be free of unwanted regulations, usually attributed to the EU, should not have to endure the rational and complicated arguments expressed by experts who advise against leaving the EU[16]. Given such negative views of experts it is worthwhile considering their role in archaeological geophysics.

The work of archaeologists involves a large number of tools (in the widest sense of the word) to derive a narrative of the past from material evidence. It can be argued that archaeological practice would be impossible without the use of techniques developed in other disciplines. These different tools also require different levels of expertise, which can either be brought in through specialists (‘experts’) or acquired by archaeologists themselves. The main distinction between the tools is the level of interpretation that their results require. For example, digging a straight vertical section through an archaeological feature and recording the encountered soil colours mainly needs skills that can be acquired by basic training. By contrast, a detailed stratigraphic trowel excavation requires already some interpretation during the digging that is considerably more difficult to learn. Creating a 3D model of a structure or a site requires the skills of operating an instrument (camera, laser scanner) and the related software, but little interpretation has to take place during the operation of these tools, and hence simply attending a training course will mostly be sufficient. By contrast, analyzing aerial photographs (or airborne LiDAR scans) requires a thorough interpretation that is based on the archaeological understanding of landscapes. The examples show that a distinction can be made between ‘simple tools’ that slot into the existing archaeological workflow, and ‘expert tools’ that require adjustments to the hermeneutic circle of interpretation.

Much has been written about the hermeneutic circle in archaeology[17], and a simplified schematic version can be used to conceptualize the workflow within archaeological geophysics (fig. 3). Starting from an existing understanding of the past, decisions are made about the collection of geophysical data, which determine their subsequent processing and interpretation. From this interpretation new insights and a revised understanding of the past are then derived (fig. 3a). Based on such new insights

[15] Lowe 2016, 3 June.

[16] Gove’s exclamation was triggered by confronting him with the fact that there are no experts who are in favour of leaving the EU.

[17] Kelley 1983; Hodder 1986; Johnsen and Olsen 1992.

a second iteration through the circle can be made. It may start with a revised data collection strategy, for example targeting other areas of a site or using a different spatial resolution. Subsequently, data processing that is more suitable for the newly envisaged archaeological features may be used leading to new interpretations and insights. Even in projects where new data acquisition is not feasible a purely desk-based second iteration may be beneficial (fig. 3b).

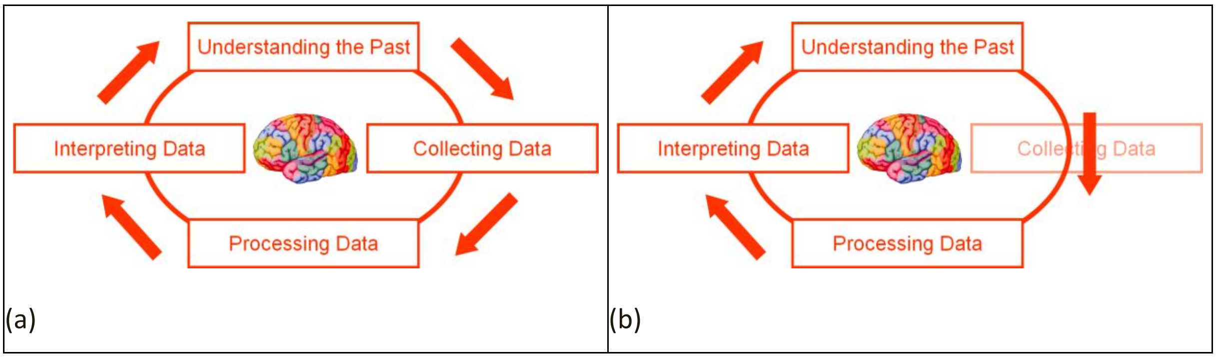


Figure 3: Archaeological geophysics in the hermeneutic circle: (a) first pass and (b) subsequent passes.

In most cases the practical skills of geophysical fieldwork can be acquired with fairly compact training and if instructions are followed conscientiously good data can be collected. The advances in satellite-based positioning (high precision GPS/GNSS systems) have made data acquisition even easier and it may appear that 'doing' a geophysical survey is not much more difficult than operating a laser scanner. This has led some to question why experts in archaeological geophysics are needed at all, when cheaper labourers following set rules might also be able to do the (field-)work. The answer to this question lies in the workflow described by the hermeneutic circle. Archaeological geophysicists use their *understanding of the past* and of sites and landscapes, and their knowledge of soil processes and geophysical properties to design *data collection strategies*. They then *process* measured data in appropriate ways (neither too much, nor too little) and, crucially, they *interpret* these data based on an understanding of their underlying geophysical nature and of the archaeological settings involved. For all these tasks considerable expertise is needed. The EAC guidelines list several important questions that should be asked when planning archaeological geophysical surveys and recommend consultations with experts to find satisfactory answers to them. This will help with the design of project briefs, the execution of surveys and the interpretation of resulting data.

THE GUIDELINES: POINTS TO CONSIDER

The following sections explain some of the points that need to be considered when designing a project brief for an archaeological geophysical survey. This text both comments and summarizes the respective sections in the guidelines.

Survey purpose (Section 3.1)

The first and most important consideration is the purpose of the geophysical survey. Why should it be undertaken and what shall be gained from it? The response to these questions will be important for many, if not all, subsequent decisions. To help with answering these questions three levels of investigation were defined:

Level 1 – Prospection: the survey identifies areas of archaeological potential and individual strong anomalies.

Level 2 – Delineation: the survey delimits and maps archaeological sites and features.

Level 3 – Characterisation: the survey characterises and analyses the shape of individual anomalies in detail.

In some cases a Level 1 survey may be sufficient. Even if not all geophysical anomalies can be interpreted archaeologically the overview provided could be enough to base decisions on the results. Where an archaeological landscape investigation is intended more detailed geophysical results may be required and hence a Level 2 survey could be desirable. If, however, the depth variation and exact shape of buried archaeological remains is of interest the investigation will need to be a Level 3 survey.

Ground coverage (Section 3.3)

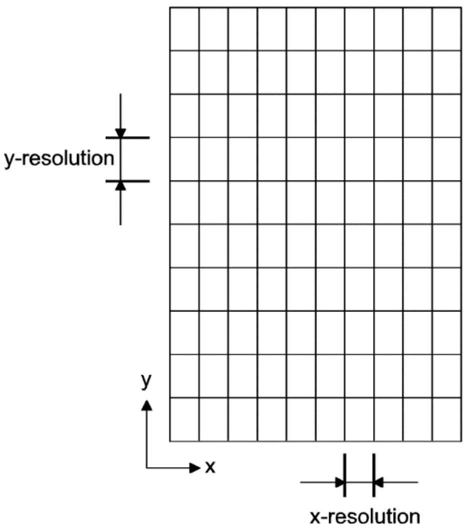
Unlike the sampling schemes often applied to trial trenching surveys and excavations in preventive archaeology, geophysical surveys should always attempt a full coverage of the areas of interest. Truncating geophysical anomalies through small survey areas can impede severely the interpretation of data. In addition, performing geophysical surveys on several small areas is always less cost-efficient due to the effort required to set up each individual area. The cost of surveys often depends not only on the total surface area under investigation, but also on the number of individual survey blocks. Only in Level 1 investigations, where mostly the presence of archaeological features is of interest, some sampling may be acceptable, but even then the cover should be at least 50%.

Spatial resolution (Section 3.4)

The necessary spatial resolution of a geophysical survey depends on the level of investigation and the expected size of features. If a broad analysis of a feature is sufficient there should be at least three readings across it (a pit of 0.5 m diameter would hence require a resolution of 0.17 m). If a more detailed analysis is required (e.g. information about shape and depth) five or more readings across such a feature may be necessary.

Geophysical surveys are mostly undertaken in a two-dimensional raster, which can have different resolutions in the two orthogonal directions (Figure 4a). For example, a magnetometer survey may be undertaken with a spacing between adjacent lines of 0.5 m and a close sampling along each line of 0.125 m. It is hence necessary to define the 'effective resolution' of such a two-dimensional survey methodology, which can be established as follows (see examples in Figure 4b and a more detailed explanation in the guidelines): "*The 'effective resolution' is the larger of the two resolutions in orthogonal directions; possibly reduced down to 2/3 of this (but not further), if the other resolution is sufficiently small.*"

The survey data are usually gridded and interpolated for processing and visualisation. The computationally increased resolution of such an interpolated dataset does not increase the information content of the collected data and is hence not relevant when determining a survey's required spatial resolution.



(a)

Survey resolution	Effective spatial resolution
1.0 m × 1.0 m	1.00 m
0.5 m × 1.0 m	0.67 m
0.125 m × 1.0 m	0.67 m
0.5 m × 0.5 m	0.50 m
0.25 m × 0.5 m	0.33 m

(b)

Figure 4: (a) visualisation of the resolution in a measurement raster and (b) examples of effective spatial resolution (Table 1 from Schmidt *et al.* (2015)).

Survey techniques (Sections 3.5-3.10)

The guidelines briefly discuss the geophysical techniques most commonly used for archaeological surveys, but there is no easy way to predict which of these techniques will lead to the best archaeological understanding of a site. The outcome depends on the type of archaeological features present, their size and shape (e.g. narrow drip ditches around Neolithic houses, defensive ditches of Roman forts, foundations, walled enclosures), the relevant geophysical properties of these features (e.g. soil washed in from topsoil, deliberate infill with soil from other areas, stone, brick) and the contrast between the features' geophysical properties and the surrounding soil (e.g. electrical resistivity of dry and wet soil, magnetic susceptibility of anthropogenically enhanced soil, sedimentary rock, igneous rock, fired bricks, air dried mud-bricks). Although there are some site conditions for which it is certain that a particular survey technique will fail (e.g. magnetometer surveys will not work well over reinforced concrete), in most cases an informed guess has to be made, for example by an experienced archaeological geophysicist, to select suitable survey techniques. Wherever possible some testing should be undertaken with different techniques to evaluate their effectiveness.

The techniques covered in the guidelines are magnetometer survey (Section 3.5), earth resistance area survey (section 3.6), electrical resistivity imaging (ERI, sometimes referred to as electrical resistivity tomography, ERT) (section 3.7), ground penetrating radar (GPR) survey (section 3.8), low frequency electromagnetic survey (LFEM, sometimes referred to as electromagnetic induction survey, EMI) (section 3.9) and magnetic susceptibility survey (section 3.10).

These techniques can be used with different survey methodologies, for example with instruments carried manually along straight lines or with several instruments mounted on a cart, the location of which is recorded continuously with satellite-based positioning systems so as to cover large areas quickly.

Data treatment (Section 4)

Data measured during a geophysical survey are processed to enhance the geophysical anomalies and improve their visualisation for subsequent archaeological interpretation. Experience is required to apply the appropriate processing steps, which should only include the minimum number required. Over-processing may introduce unwanted artefacts that would complicate data interpretation and should be avoided. All steps of the data treatment should be described in the project report so that their implications can be evaluated. Archiving the unprocessed measurement data is necessary so that new processing algorithms can be applied in the future. Moreover, the unprocessed data form the primary record of a geophysical survey and in some cases may be the only archive of an archaeological site, for example if it is destroyed during a commercial development without prior archaeological rescue excavation.

It is useful to distinguish four levels of data treatment:

- Data improvement mitigates data collection artefacts and is mostly applied to individual data blocks (e.g. to data grids).
- Data processing involves the application of spatial filters (e.g. high-pass filters), which are specific to the different survey techniques. It is usually applied to the whole dataset (e.g. to a composite).
- Image processing constitutes the visualisation of the data (e.g. after converting numerical measurement into greyscale values) and subsequent application of image processing techniques to the resulting pictures (e.g. edge enhancement).
- Numerical inversion attempts to reconstruct computationally the shape of buried features together with their geophysical properties (e.g. electrical resistivity) from the measured data.

Data interpretation (Section 5)

After the computational treatment of measurement data the subsequent process of assigning archaeological meaning to the geophysical anomalies is referred to as data interpretation. This is undertaken by human interpreters and the results depend on the skills and experience of the archaeological geophysicists involved. Ideally, they will combine a good understanding of the relationship between geophysical anomalies and causative features (e.g. distinguishing the magnetometer anomalies of deep and shallow ditches) with knowledge of the archaeological remains and site formation processes that are relevant for the investigated areas. Discussing the processed data in a team with different experts (e.g. archaeologists and geophysicists) may result in the most satisfactory interpretations. By contrast, ignoring the importance of wider subject knowledge will often lead to unsatisfactory interpretations. In this respect archaeologists ignoring the geophysical signature of anomalies ("give me your greyscale and I tell you what the lines are") are equally guilty as geophysicists claiming fanciful insights ("it is square and hence must be Roman"). It should also be remembered that interpretation is one of the most important parts of the hermeneutic circle (see above) and as such should be part of the full archaeo-geophysical cycle of analysis.

As with most other data sets, the interpretation of geophysical measurements is dependent on the people involved in the process and is hence often not easily reproducible. It is therefore advisable to complement the archaeological interpretations with relevant comments and explanations. There should also be a clear distinction between interpretations that are scientifically demonstrable and those that derive from expert speculations[18]. It is also useful to consider the level of detail that is provided in an interpretation:

- Delineation of causative features by outlining their most likely shapes based on an analysis of the geophysical anomalies[19]. This requires a geophysical understanding of the relationship between the shape of buried features and the form of geophysical anomalies.
- Indications of generic archaeological relevance by additionally categorizing the delineated features (e.g. 'an area of possible archaeological potential').
- Identification of the delineated features by also assigning specific archaeological descriptions (e.g. 'the *caldarium* of a Roman bath').

As these levels require increasingly more skills and time, it is necessary to specify in the project brief which level of interpretation is required so that the cost implications can be evaluated appropriately.

It is important to bear in mind that the absence of archaeological features cannot be inferred from the absence of geophysical anomalies; geophysical surveys cannot provide evidence for the absence of archaeology ('negative evidence'). There are many possible reasons why archaeological features may sometimes not be detectable in geophysical surveys (e.g. weather, soil conditions). In these conditions it can be advantageous to use several geophysical techniques on the same site. Although 'absence of evidence is not evidence of absence', there are cases where probabilistic statements may be possible, for example if results from similar sites are available at which geophysical survey data were compared with excavations results. Such interpretation problems are shared with all other indirect measurements and must be addressed during the planning stage. Our "impatience with ambiguity"[20] should not lead to the wholesale exclusion of geophysical surveys from the list of investigation techniques.

In contrast to such cases where archaeological features produce no geophysical anomalies, there are sometimes also geophysical anomalies for which no evidence can be found in subsequent excavations. There are several possible reasons, for example because features were only expressed in the topsoil that was removed prior to an excavation, or because the anomalies resulted from slight changes in soil composition that were not recognizable in an excavation (through colour or texture), but had sufficient geophysical contrast. Although these cases are sometimes referred to as 'false positives' it should be considered that there always must be a reason for the recording of a geophysical anomaly.

The survey report (Section 6)

All geophysical surveys must result in a report. In some cases it may be acceptable to produce a basic document that only briefly describes the work and the results. Normally, however, the survey report should contain a concise technical description and a lucid and objective analysis of the data together with a succinct summary that can also be understood by non-specialists. All required sections and some design criteria for the illustrations are described in the guidelines.

[18] Expert speculations are necessary in all data interpretations as only excavations can produce a degree of certainty.

[19] The shape of an archaeological feature is usually different from the shape of the corresponding geophysical anomaly.

[20] Sagan 1997.

Dissemination (Section 7)

A copy of the survey report (in paper and/or digital form) should be lodged with the relevant heritage organizations and responsibility for this task must be attributed clearly to either the contractor or the client so that it will not be forgotten.

Data archiving (Section 8)

All data from a geophysical survey, as well as its accompanying survey report, should be archived digitally. This allows the re-use or re-processing of data, provides material for teaching and training, and enables the inclusion into regional or national databases from which statistical evaluations can be derived (see above). As mentioned before, for sites that were removed during commercial developments the geophysical data may be the only record of the archaeological remains. The data are thus an important primary source of archaeological information.

Details of what to archive, and how, can be found in the ADS publication *Geophysical Data in Archaeology: A Guide to Good Practice*[21]. Clearly, some effort is required to compile such a digital Archive. All data have to be arranged in a logical structure, proprietary data need to be converted into forms that can be maintained in the long term, and relevant metadata have to be listed. It is therefore necessary to include sufficient resources in the survey budget. Once an Archive has been created, it should be deposited with an Archiving Body. The costs for this deposition will depend on the services required and need to be budgeted for accordingly:

- In-house archiving requires maintenance of the Archive on local storage facilities by the contractor or client. Taking sufficient measures to prevent data loss can be difficult for such systems.
- File repositories use commercial storage facility for the Archive (e.g. 'Cloud Storage') and can usually guarantee long-term preservation but offer no other services.
- Managed archiving adds additional services to a file repository, especially migration of file formats and indexing of the content.
- Accessible archiving makes a managed archive available to other users either through a web interface or via data interchange standards.

Accessible archiving for archaeological geophysics data is provided in the UK and the rest of Europe through the Archaeology Data Service (ADS) and in the USA through Digital Antiquity and the Digital Archaeological Record (tDAR).

CONCLUSION

Given the difficulties in predicting the outcome of geophysical surveys, especially in archaeology, the EAC guidelines do not prescribe generic rules for all geophysical surveys in Europe (e.g. "all survey data must be processed with method xyz"). Instead it is advised to create for every project a specification ('project brief') that is detailed and prescriptive. To help with the design of such project briefs the guidelines provide several questions through which the existing archaeological knowledge can be probed and converted into specific project requirements. It is recommended to call on the expertise of archaeological geophysicists for the design of such documents. These experts will also be able to

[21] Schmidt & Ernenwein 2011 ; Schmidt 2013.

interpret the resulting data appropriately and make the results useful for the overall archaeological workflow. Where and how this expertise can be acquired could only be discussed briefly in the guidelines, but it is clear that there is considerable need for such a training.

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Agentschap
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DE TOEPASSING VAN GEOFYSISCHE PROSPECTIE METHODEN IN DE ARCHEOLOGIE

The use of Geophysical Prospection methods in Archaeology

ERWIN MEYLEMANS EN PHILIPPE DE SMEDT (RED.)

Vlaanderen
is erfgoed

INHOUD