The Application of Magnetic Methods for Dutch Archaeological Resource Management

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2 Archaeological prospection in The Netherlands

2.1 Introduction

Archaeology is the scientific study of the physical evidence of past societies. It is thought that the buildings, features, objects and the way people have used and altered the landscape is a reflection of the way that they perceived the world and of the society that they were part of. The physical evidence of the past consists of visible archaeological features, e.g. tumuli, of invisible but known archaeological sites, but largely of unknown, buried archaeological remains. In this respect, Deeben *et al.* (2005) have introduced the useful concept of archaeological stock, which is illustrated in Figure 4. The original stock is the total of all the archaeological remains that have been deposited, at any moment in time, in or on top of the ground. It is a fictitious stock, that has never existed at one moment in time and which has been and is being altered by biotic, anthropogenic and abiotic post-depositional processes, for example by human alteration of the objects or features that were deposited earlier, or by excavation. Hence part of this original stock is lost, another part has been gained because it has been excavated and recorded. The actual archaeological stock is what is left of the original stock after taking off the lost and the gained stock. Part of the properties of the actual stock is known through earlier research, but it is the unknown part of the actual archaeological stock that is the main object of archaeological research. This part of the soil archive consists of unknown archaeological remains on unknown locations. Knowledge about this unknown stock is usually generated through archaeological excavation. Archaeological resources, however, are finite, and the activity of archaeological excavation destroys its own object of interest, by transferring part of the unknown stock to the gained stock; archaeologists kill their informants (Flannery 1982).

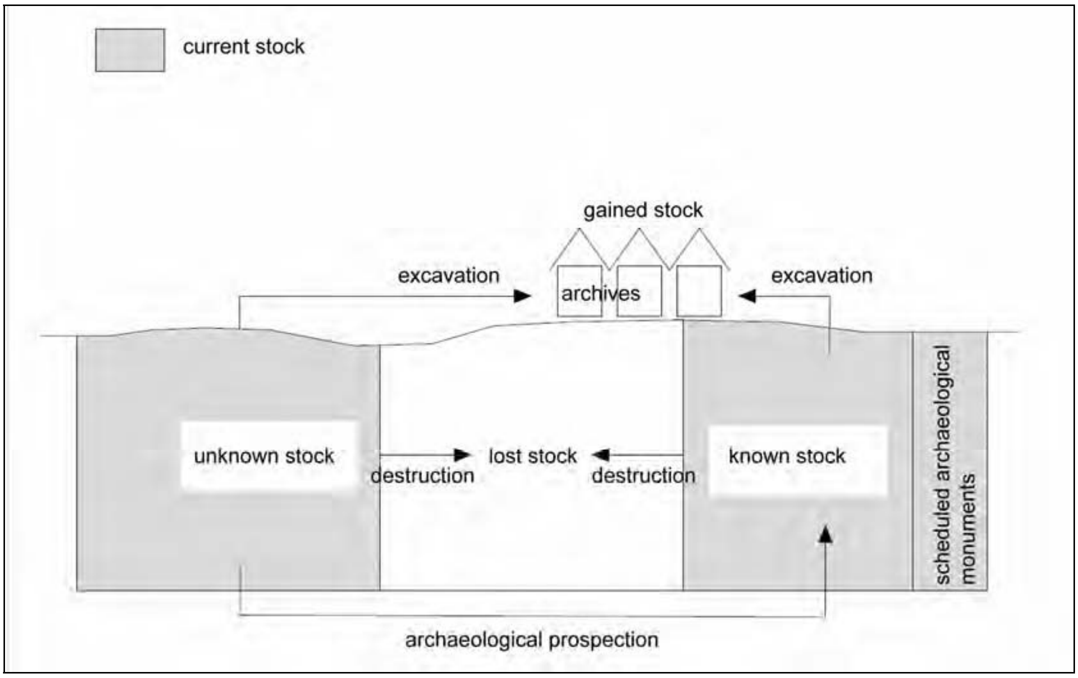

Figure 4 The relation between the known and the lost archaeological stock, and the unknown stock, which is the main object of archaeological research. After the text of Deeben *et al.* (2005).

A small part of the known stock is therefore preserved *in situ* as scheduled archaeological monuments. The first Dutch Monuments Act which provided a legal framework for the protection of archaeological sites came into effect in 1961. Not only scheduled sites were protected, but part of the unknown stock as well, as from this moment it was prohibited to carry out excavations without permission. The Act was replaced in 1988, in the new Monuments and Historic Buildings Act, in which under water archaeology was included. Before 1991, only designated parties could obtain a licence for archaeological excavation; universities, councils, provinces and the state service. From 1991, commercial archaeological companies could apply for an excavation licence. With a growing number of parties, the need to implement a quality system increased. At present, the Quality Norm Dutch Archaeology (Kwaliteitsnorm Nederlandse Archeologie (KNA)) is used to control the quality of the archaeological work that is carried out by all parties. A new Archaeological Monuments Act has been established in September 2007 for the implementation of the guidelines of the Malta Convention (1992). In this European Convention on the protection of the archaeological heritage of Europe, it is agreed that funding should be reserved for archaeological work in major private of public development. Further, the unknown stock will be better protected as the care of the archaeological heritage is integrated into the urban and regional planning. The changes in the Monument Acts reflect a policy shift from protecting individual archaeological monuments as a representation of the past, to future oriented archaeological heritage management (AHM), or archaeological resource management (ARM). Choices that are made today, determine what is left of the archaeological 'resource' in the future. ARM is often visualized as a cyclical process (Fig. 5).

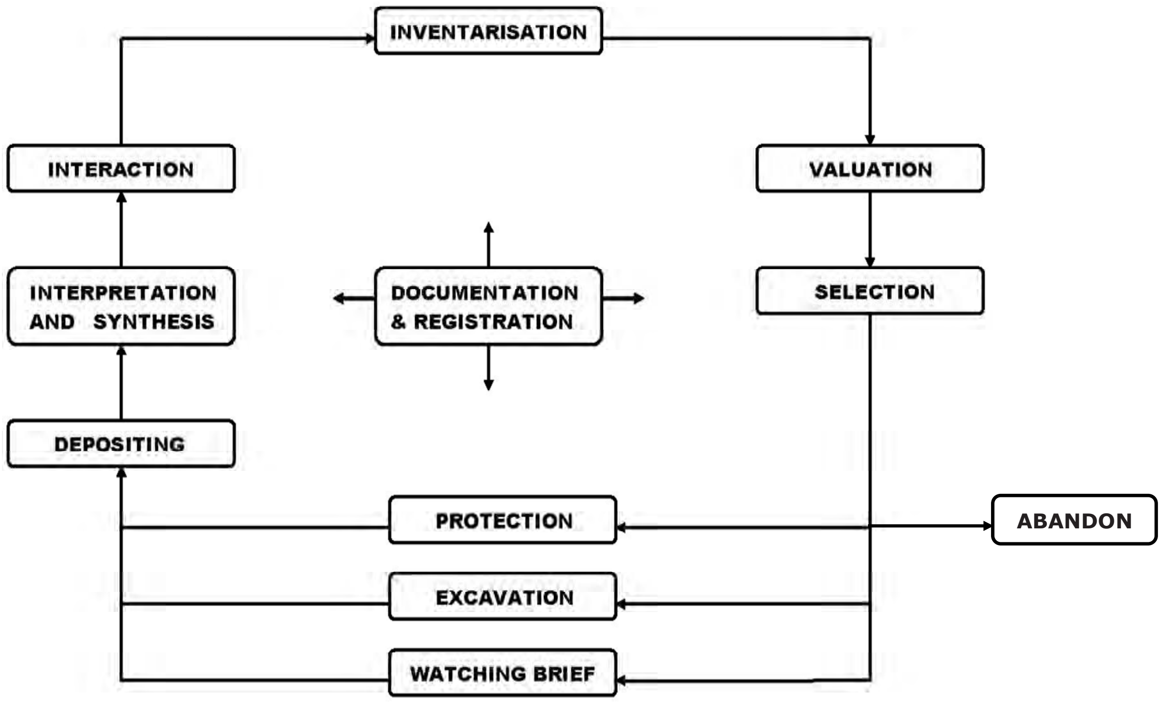

Figure 5 The cyclical process of Archaeological Resource Management. Archaeological prospection plays a key role in the assessment and valuation of archaeological resources. See Willems (1997, 2008).

Figure 5 is a schematic representation of this process, of the way choices are being made about the future management of archaeological resources. Whether an archaeological site is preserved or excavated, for example, can depend on the information that has been collected during the assessment and the valuation process. In these two steps, knowledge is generated about the unknown archaeological stock. It is in this domain that archaeological prospection must be introduced.

Archaeological prospection can be defined as the scientific study of the spatial component of the physical evidence of past societies, which has been collected using techniques other than excavation. It broadly poses the same questions as, for example, excavating archaeology, but the way the answers are generated is different.

Most of the techniques that are used in archaeological prospection are practically non-destructive, which is a prerequisite in the process of ARM. The choices that have to be made about archaeological remains have to be based on information about these sites or objects, but extracting the information while destroying the carrier, as would be the case during archaeological excavation, could create a paradox. The archaeological heritage can not be managed without investigation, but investigation may lead to destruction, and by destroying the object of interest, the resource needs no longer be managed. Deeben *et al*. (2005) see a similar paradox in the known archaeological stock: the more knowledge there is about this part of the stock, the more damaged it is. Non-destructive techniques are needed to close the cycle of ARM. In terms of archaeological stock, unknown stock can become known stock through archaeological prospection (Fig. 4).

This chapter will introduce the history of archaeological prospection in The Netherlands and in an international framework. Special attention is given to the development of geophysical techniques and to past experiences in the use of magnetometry as an archaeological prospection method. The chapter ends with a description of the framework in which archaeological prospection is currently embedded in The Netherlands.

2.2 The history of archaeological prospection in The Netherlands

Aerial photography and surface collection

The first decades of archaeological prospection in The Netherlands were entirely dominated by the investigation of manifestations of the buried archaeological record on the surface, i.e. by aerial photography and surface collection. The fist aerial photograph of an archaeological site was taken in England in 1906 and depicted Stonehenge. A growing amount of air traffic in and after the First World War led to an increase in interest in archaeology from the air. In the late 1940s and early 1950s, Von Frijtag Drabbe published a number of papers (e.g. Von Frijtag Drabbe 1947) devoted to the use of aerial photography for Dutch archaeology. A detailed description of the history of aerial photography in The Netherlands falls outside the scope of this study and can be found in Sueur (2006). In the same period, Stiboka[3] was undertaking large scale soil mapping projects, during which archaeological surface finds were collected. These first accidental surface collection surveys were soon followed by more scientific surveys that were undertaken to solve a specific archaeological problem. Example of these surface collection programs are the surveys of Texel and West-Friesland which were initiated by the ROB.[4] In the 1960s, archaeology was embraced by not formally trained or amateur archaeologists, who initially concentrated on surface collection too.

Aerial photography generally provides information about archaeological remains that are buried at shallow depth in the form of crop marks or shadow marks, for example the so called Celtic fields (Brongers 1976) or visible at the surface (in the case of soil marks), although the aerial photography section of the Universiteit Gent has demonstrated that crop marks can originate from archaeological features that are buried under up to one meter depth of soil (J. Bourgeois, pers. comm.). In general, however, archaeological remains that are buried under deep deposits, both natural and anthropogenic, as well as earlier phases of multi-phase sites can not be seen in aerial photographs. This means that part of the archaeological stock will always be invisible to this technique (Fig. 4), and, in fact, most crop mark features are only visible at certain times of the year.

Surface collection has similar limitations, this prospection technique can provide information about superficial sites and about sites that are buried at shallow depth and are damaged by post depositional biotic, anthropogenic or abiotic processes. Moreover, the relationship between the manifestations of the archaeological record on the surface and the buried actual archaeological stock is unclear (Flannery 1976). Rather than interpreting for example surface material as being a reflection of sub-surface remains, both classes of evidence should be appreciated as different and complementary sets of data (Haselgrove 1985).

[3] Stichting Bodem Kartering, Dutch Soil Survey Institute, now renamed Staring Centrum.

[4] Rijksdienst voor Oudheidkundig Bodemonderzoek, the State Service for Archaeology, now renamed to Rijksdienst voor Archeologie, Cultuurlandschap en Monumenten (RACM), the State Service for Archaeology, Cultural Landscapes and Monuments.

In order to investigate the archaeological record more fully, a shift from surface oriented investigations to sub-surface prospection was required.

Sub-surface techniques

How to gain knowledge of the subsoil without excavation, in a non-destructive way? The first incidental geophysical surveys were carried out in The Netherlands in the 1970s. Van der Kley (1968, 1970) investigated two Roman castellae by means of an earth resistance survey. At the time of introduction, the rate of data collection of this technique was very slow, but these surveys proved to be the first Dutch examples of the successful and non-destructive investigation of structural remains. In order to map buried archaeological sites that could not be detected with the surface oriented techniques, nor with electrical methods, a hand auger was first introduced in the Assendelver Polder project in 1980 (Terkorn 1991). By using this equipment, which was originally developed for soil scientific purposes, buried archaeological deposits could be mapped, investigated and related to their geological and chronological environment.

In 1985 RAAP[5] came into existence, originally a non-profit organization connected to the Universiteit van Amsterdam, which concentrated entirely on archaeological prospection. RAAP has been the main institution concerned with prospective archaeology in The Netherlands in the past 20 years. Initially the surveys consisted of a combination of surface collection, aerial photography and hand augering, and by employing this combination of methods, many new archaeological sites were discovered. Another part of the unknown archaeology stock was being made visible. Earth resistance and magnetometer surveys were selectively employed, and research into the applicability of these techniques was carried out from within RAAP.

Magnetometry

Because of the subject of this study, this section is concerned with the results of earlier magnetometer surveys. The first set of magnetometer surveys in the Netherlands was collected by Anderson (1996/ unpublished) for RAAP. In her study, that consisted both of magnetometer surveys and earth resistance surveys, 13 archaeological sites were magnetically surveyed. The work was conducted within the constraints of a commercial company, and the choice of sites that were investigated was undoubtedly influenced by commercial constraints. Most of RAAP's assignments for commercial work were for the investigation of castle sites; four of Anderson's sites were castles. On these sites the magnetics are generally noisy due to ex-situ bricks and metal, and the fact that most of the castle sites now lie in an urban environment. In two cases (Entinge and Merckenburg) walls, foundations and a well can be recognized in the magnetic data. On two furnace sites, a set of pottery furnaces (Holdeurn) and a set of roof tile furnaces (Swalmen) structures could be mapped in great detail due to the thermoremanent nature of the objects under investigation. Anderson's magnetic datasets are generally dominated by objects and features with a remanent magnetization. The excavation Canisiuscollege in Nijmegen was situated in an urban setting, which, again, created a lot of magnetic noise. Some objects, stone, metal and a volcanic millstone caused magnetic anomalies due to their remanent magnetic properties. Much quieter is the data of the magnetometer survey on three prehistoric sites on wind blown sand deposits in the eastern and southern part of The Netherlands. A suspected hearth on a flint site (Borkeld and Elsenerveld) could not be mapped, and the features on two prehistoric burial sites (the urnfield of Someren and the tumuli group of Weert Boshoverheide) did not create any detectable magnetic anomalies.

The Roman settlement on Kops Plateau, a terminal moraine, was first surveyed and excavated afterwards, but none of the magnetic anomalies seemed to correspond to the features that were excavated, but rather to the more recent paths and ditches. In Gennep, however, pits, ditches and an oven could be seen in the magnetometer data. This 4th/5th century site was located on deposits of the river Meuse, and it is the only example in Anderson's study where non-remanent archaeological features have a detectable magnetic anomaly due to an induced magnetization.

After Anderson's study, a small number of magnetometer surveys has been conducted by RAAP, De Steekproef and DW Consulting, most of them on historical sites.

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5 Originally an abbreviation for Regionaal Archeologisch Archiverings Project, Regional Archaeological Archiving Project. Now renamed RAAP Archeologisch Adviesbureau, RAAP Archaeological Consultancy.

A brick church in Sexbierum in a matrix of clay caused a strong anomaly. In Neede Borculo the moat surrounding a small stronghold could be mapped because it was filled with brick from the demolished building. In Baaium the foundations of a church, built with tufa, caused a detectable magnetic anomaly. An exception to the anomalies caused by remanent magnetization was the survey of a Michelsberg culture settlement (Schelsberg, Heerlen), here, a substantial ditch caused a negative magnetic anomaly.
In 1998, one of the Neolithic farms in the experimental archaeology centre Archeon caught fire and burned down. A magnetometer survey was conducted over the remains before carefully excavating the features that remained after the fire. Unfortunately, the results of the survey were dominated by magnetic anomalies that were caused by pieces of metal building material (Orbons 1998).

Hand augering
Gradually, because of its success rate, hand augering became the preferred archaeological prospection method in The Netherlands, and not only in those areas where the surface oriented methods failed, i.e. the areas where archaeological sites were likely to be covered with Holocene deposits, but also in areas where surface collection and aerial photography had been successful, on the Pleistocene deposits in the east and the south. Groenewoudt (1996) investigated the instrumental variables that influence the discovery of an archaeological site by hand augering; grid spacing, type and size of auger and developed a triangular grid for hand augering. Almost ten years later, RAAP Archeologisch Adviesbureau, still the largest, but no longer the only archaeological prospector in The Netherlands, has continued the research of Groenewoudt, now including research into the effectiveness of mechanical drills (Tol *et al*. 2004). The increasing interest in the use of mechanical augers is also reflected a further report on the subject by the Universiteit van Amsterdam (Hissel & Van Londen 1994) on the qualitative comparison of mechanical and manual augering.
During the 1980s and 1990s the methodological focus in Dutch archaeological prospection had shifted to hand augering, with relatively limited attention for established techniques like aerial photography or novel techniques like geophysical methods. An exception was the work of De Vries-Metz (1993) who investigated the application of remote sensing for mapping a prehistoric landscape in West-Friesland. Not only did she use novel remote sensing techniques, but she also propagated the use of remote sensing in ARM for the monitoring of scheduled archaeological monuments.

Expanding the suite of prospection methods
In recent years, the attention and funding for research into novel prospection techniques in Dutch archaeology has increased. This study into the application of magnetic methods in Dutch ARM is an example of the renewed interest in the methodological development of archaeological prospection, which has developed from the notion that prospection plays such an important role in the cycle of ARM. Alongside this project, there are two other lines of research in which the possibilities for chemical prospection (Oonk 2006) and the structural use of remote sensing (Sueur 2006) in Dutch archaeological prospection (and ARM) are being investigated. The first focus of the chemical prospection project is the development of novel extraction techniques for soil phosphate samples. Whereas soil phosphate determination as an archaeological prospection technique has been in use for a long time, better extraction techniques can increase the data quality and possibly refine the archaeological interpretation of phosphate distributions in the soil. A second branch of Oonk's research entails the investigation of the use of proteinaceous biomarkers in archaeological prospection, a topic which needs further research before it can be integrated into the current suite of prospection methods.
Sueur's work has shown that there is a good potential for the use of remote sensing techniques in ARM in The Netherlands. There appear to be only few technical reservations, but the implementation of the techniques in policy and guidelines, most noticeably in the Quality Norm Dutch Archaeology (KNA), is lacking. One of the novel techniques that are advocated in his study is LIDAR. In the *Technologie & Samenleving* (Technology & Society) program for the innovative use of existing techniques and datasets, the Dutch Ministry of Economic Affairs for has funded a project on the archaeological use of the LIDAR dataset (Waldus & Van der Velde 2006), that was collected over The Netherlands for other purposes.

Two geophysical projects received funding in this same program, a project for the development of a portable sensor for in situ sediment characterization by measuring the concentration of γ-ray emitting radionuclides (van Wijngaarden *et al.* 2002) and a project for the adaptation of the phased array technique that is used for telescopes to use in archaeological subsoil prospection.
For the non-destructive prospection of archaeological remains in the water bottom (IMAGO 2003), for example ship wrecks, Rijkswaterstaat has conducted a comprehensive study using acoustic sub-bottom profiling, and ground penetrating radar (GPR) techniques.

2.3 The history of archaeological prospection from an international perspective

Whereas Dutch prospective archaeology moved from the surface to the subsurface by focusing on hand augering, archaeological prospection in the United Kingdom and other European countries developed in a different way. Here, too, the first activities in the field of archaeological prospection were employed in aerial photography (e.g. Crawford 1928) and surface collection (e.g. Jenness 1930), but soon geophysical techniques were introduced for subsurface investigations in archaeological prospection. The earth resistance survey of Dorchester is generally considered to be the first scientific geophysical survey for archaeological purposes (Atkinson 1953). The success of this survey encouraged archaeological institutions outside the United Kingdom to start using and developing electrical methods. This was soon followed by the development of the first magnetometer that was suitable for archaeological prospection in the 1950s. The development of a lightweight, high resolution magnetometer created the opportunity to map large areas in limited time. At this point in time, archaeological geophysics was embedded into academic and public institutions in the United Kingdom,[6] the United States,[7] Italy,[8] France[9] and Germany[10]. In the 1960s the scientific community started to publish papers on the subject of geophysical prospection in archaeology (e.g. Aitken 1961, Lerici 1961, Black & Johnston 1962, Decker & Scollar 1962, Hesse 1962), first in journals dedicated to archaeology and archaeological sciences, from 1966 in the Italian periodical *Prospezioni Archeo-logiche*, and currently in *Archaeological Prospection*. Dutch archaeologists did not participate in this explosion of interest in archaeological geophysics. Although the first two geophysical surveys, which were carried in 1968 and 1970, were successful, geophysical methods did not get embedded in the research of academic or governmental institutions.
In most European countries and the United States, geophysical techniques are and have often been employed alongside superficial prospection techniques like aerial photography and surface collection. The methodology focuses on the discovery and mapping of archaeological remains by superficial techniques, and the investigation and evaluation of the subsurface component of these remains by means of geophysical methods. Satellite imagery is the most recent addition to conventional aerial photography. Satellite images can be taken in the visual light or in any other electromagnetic spectrum, of which infrared is the most used for archaeological purposes. In the United Kingdom, Germany, Austria, Ireland and the United States the combination of remote sensing (including conventional aerial photography) and geophysical techniques has become a standard methodology for the archaeological prospection of 'blank' areas prior to development and in academia. An excellent example from Britain is the work that has been carried out in the Salisbury Plain Training Area (McOmish *et al*. 2002).
In Germany, the *Bayerischen Landesamtes für Denkmalpflege* has surveyed extensive areas with a combined methodology and mapped many new archaeological sites (Becker *et al*. 1996), whereas in Austria, the *Vienna Institute for Archaeological Science* has concentrated on the development of methods to combine the data of aerial photography and geophysical surveys (Doneus *et al*. 1997).

[6] The Ancient Monuments Laboratory and the Research Laboratory of the University of Oxford.
[7] Museum Applied Science Center for Archaeology (MASCA), Pennsylvania.
[8] The Lerici Foundation, Rome.
[9] Centre National de la Recherche Scientifique (CNRS), Garchy.
[10] Rheinisches Landesmuseum, Bonn.

Commercial companies started to carry out geophysical surveys for archaeological prospection after 1980, when the methodological development of the equipment allowed faster and more accurate surveys than in the first decennia of geophysical prospection for archaeology. This happened at a time when the amount of large scale, potentially disturbing infrastructural and housing projects was on the increase. Geophysical, and primarily magnetometer surveys are important tools for archaeological prospection in Archaeological Resource Management in many European countries and the United States. In the United Kingdom alone, the approximately 100 persons employed in archaeological geophysics have conducted hundreds of geophysical surveys.
A new suite of methods, the electromagnetic methods, most notably the ground penetrating radar (Conyers & Goodman 1997, Leckebusch 2003) were added to the toolbox of archaeological prospection. Outside of The Netherlands, there are very few examples of coring being used as an archaeological prospection method (examples are Dockrill & Gater 1992 and Bates & Bates 2000), although a few early studies on shovel test sampling, which is comparable to hand augering, were carried out in the United States (e.g. Krakker *et al*. 1983, Kintigh 1988).
During the years that were discussed in this paragraph, the focus of archaeological research gradually changed from the archaeological site to the archaeological landscape. In 1987, Heron and Gaffney announced that archaeological geophysics should change the object of its focus accordingly, 'Archaeologists do not follow walls these days, so why should archaeogeophysicists?' (Heron & Gaffney 1987:.78). This development is on-going, and at present individual archaeological sites are often investigated within their wider geological and archaeological framework. Still, research programmes often lack the integration of a geophysical component (Gaffney *et al*. 1998).

2.4 Archaeological prospection in The Netherlands

At the time of writing, archaeological prospection in The Netherlands has recently become embedded in the Quality Norm Archaeology (KNA)[11] and the National Research Agenda (NOaA).[12] As a result, companies, universities and other parties that carry out archaeological prospection work have to comply with a set of rules (the KNA) in order to ensure a minimal quality of the research. Most activities in the field of archaeological prospection are carried out in the cycle of archaeological resource management (ARM) (Fig. 5), and rarely without the urgency of the possible destruction of archaeological remains that may be present. In the field, archaeological work within ARM can be characterized by three phases:

- reconnaissance, extensive, usually large scale,
- mapping, semi-intensive, on the scale of groups of archaeological sites,
- evaluation, intensive, on the scale of individual archaeological sites.

Reconnaissance in The Netherlands is the domain of widely spaced (usually 40 x 50 meter) hand augering surveys and pick up surveys, whereas the second phase, mapping, is also conducted by hand auger, but on a more narrowly spaced grid (usually 20 x 25 meter). The most detailed phase of archaeological prospection is the evaluation, in this phase test trenching, narrow grid hand augering[13] and geophysical methods are the techniques that are used to generate archaeological information. Whereas in other European countries geophysical methods are employed in all three phases of archaeological prospection, in the Netherlands geophysical techniques are only used in the evaluation phase, and rarely so.

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[11] Quality Norm for Dutch Archaeology. This text refers to KNA version 3.1. See www.sikb.nl for the full text.
[12] National Research Agenda Archaeology, published on the internet only by the RACM. See www.noaa.nl for currently available chapters.
[13] Test trenching and hand augering are both semi-destructive methods. Some definitions of archaeological prospection only include non-destructive methods, but Dutch archaeological practice has a focus on hand augering and to a lesser extend test trenching as prospection methods. The choice of the definition of prospection that was used at the start of this chapter, in which excavation is the only archaeological activity that is excluded, was directed by this focus on semi-destructive methods.

This discrepancy can possibly be explained by three factors; the historical development of archaeological prospection in The Netherlands as was outlined above, the lack of interest in geophysical methods from academia and governmental institutions and the absence of a clear place for archaeological geophysics in daily archaeological resource management work.
Only recently, archaeological geophysics has obtained a place in one of the universities that teach archaeology,[14] but not in the archaeology department. Only for the small group of students that attend the Geoarchaeology course at this university geophysical techniques are part of the curriculum. In other archaeology courses, students are not educated in geophysical techniques for archaeology, neither is there any research in this subject. The State Service for Archaeology, Culture and Monuments (the RACM) lacks a section for archaeological prospection in general, or more specifically for geophysical prospection.
The establishment of the Kwaliteitsnorm Nederlandse Archeologie has reinforced the dominancy of hand augering and test trenching over alternative prospection methods. In the reconnaisance phase, the latter two are the only recommended methods. In the two later phases, according to the KNA, it is possible to use geophysical methods. In practice, the prospection method that will be used in a certain project is laid down in a Statement of Requirement (Programma van Eisen (PvE)) and whether or not geophysical methods are included depends on the individual. A general lack of university education on the subject in combination with a lack of experience with and exposure to geophysical methods has led to the virtual absence of geophysical methods in recent Statements of Requirement.
Another framework defining document is being made available, the Nationale Onderzoeksagenda Archeologie. The aim of this agenda is to define the framework for the questions that are being asked in the Statements of Requirement, and to form the scientific base for the day-to-day (commercial) archaeological work. The chapter about archaeological prospection is mainly methodological with relatively much attention for geophysical methods. Although addressing these questions is important, the type of methodological questions that are being posed will not aid in integrating geophysical techniques into daily archaeological practice. If the rather large document of the NOaA will, in practice be used for Statements of Requirement remains to be seen.

2.5 Conclusion

- The different sections of physical evidence of the past can be represented as different types of archaeological stock.
- The unknown stock is the object of interest for archaeology.
- Archaeological prospection is the study of the spatial component of the unknown stock with non- or semi-destructive methods. Non-destructive techniques are needed in the cycle of ARM.
- In The Netherlands, archaeological prospection developed from aerial photography and surface collection to sub-surface prospection in the form of hand augering and limited application of geophysical techniques and remote sensing.
- Other European countries and the United States developed differently and focused on geophysical techniques for subsurface testing. The scale of geophysical investigations has changed from site to landscape.
- This discrepancy can be explained by the historical development of archaeological prospection, by the lack of academic and governmental interest in geophysical techniques and by the absence of a well-defined place for archaeological geophysics in the framework of ARM.

[14] At the Institute for Geo- and Bioarchaeology in the Faculty of Earth and Life Sciences of VU University, Amsterdam.