The Application of Magnetic Methods for Dutch Archaeological Resource Management

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1 Introduction

1.1 A magical method?

This study is about a method that has long since been used in archaeological prospection. For the last 30 years, magnetic methods have been frequently employed in both the archaeological academic and commercial world, on the one hand to map unknown archaeological sites and on the other to investigate known archaeological sites (see for example Clark 1996, Gaffney & Gater 2003, Linford 2006 for an overview). A good example of a magnetometer survey on a known archaeological site is the mapping of the site of the Standing Stones of Stenness on Orkney in the United Kingdom, which was one of the early magnetometer surveys with an archaeological purpose (Fig. 1). The plotted magnetometer data clearly shows the partly buried ditch surrounding the megalithic monument, and a number of pits in the centre of the circle. On the northern edge of the monument lies a double linear anomaly that is, for the moment, interpreted as being post Neolithic ditches, as they appear to over cut the monument.

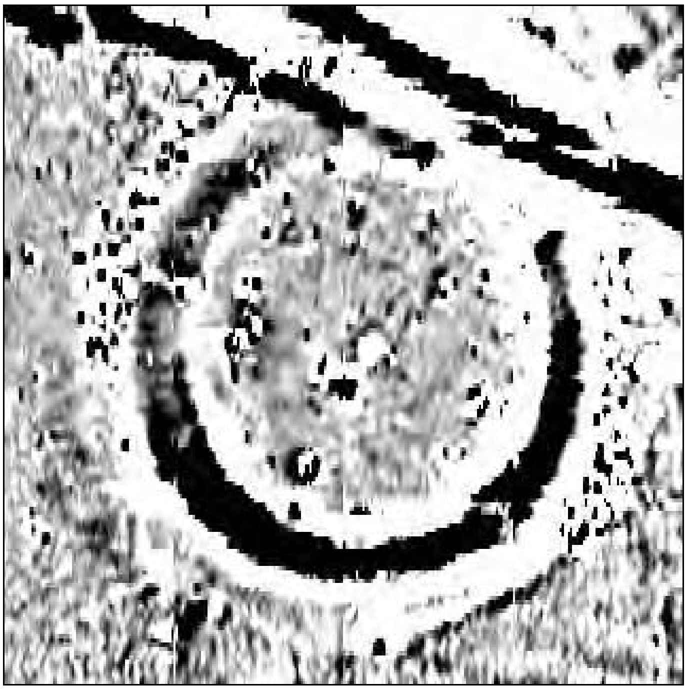

Figure 1 Magnetometer dataplot of the survey that was conducted by GSB Prospection at the Neolithic site the Standing Stones of Stenness, Orkney, United Kingdom. This is not the original dataset but the result of a repeated survey 25 years later. Extend 80 x 80 meter, range 0 (white) to 20 nT (black). Figure has been reproduced with kind permission.

Another megalithic monument, probably the most famous of all, is the site of Stonehenge in Wiltshire in the United Kingdom. From an archaeologist's point of view, not only the monument itself, but also the way that man has shaped the landscape around it is of major scientific interest. The proposed tunneling of the A303 road, running through Stonehenge's valley, and the development of a new visitor centre has sparked the need to investigate the area around the megalithic monument (Fig. 2).

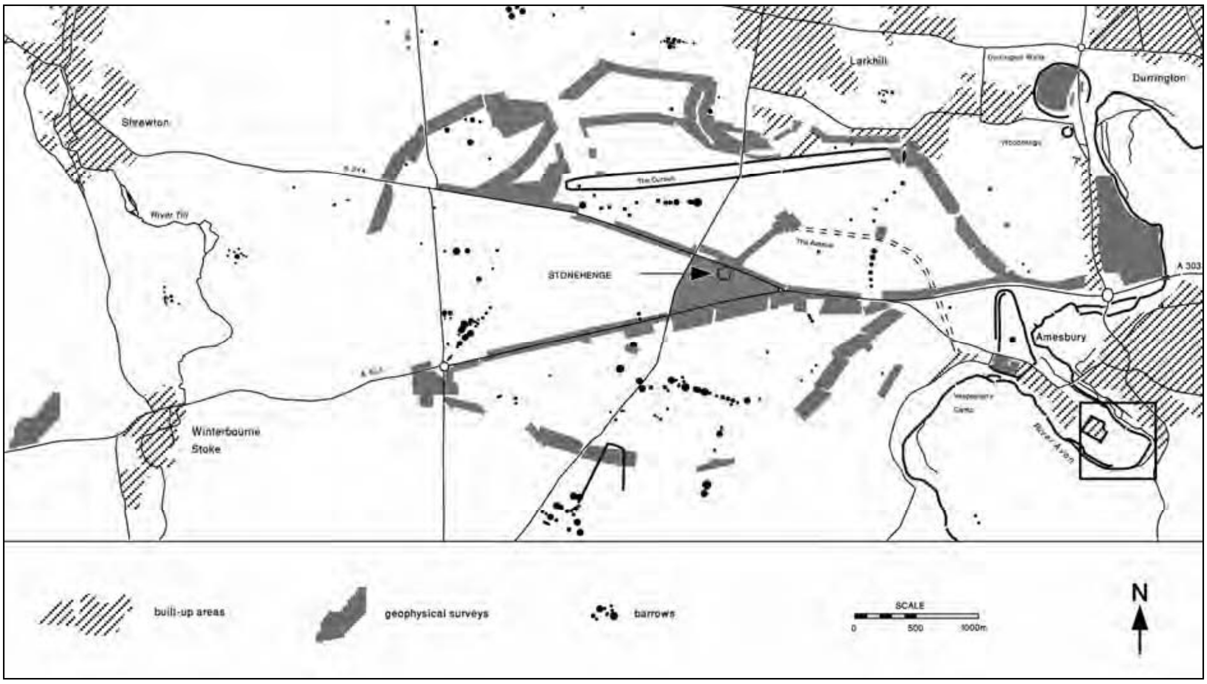

Figure 2 The distribution of geophysical survey, almost all of it fluxgate gradiometer survey, in the Stonehenge area. Figure reproduced from David and Payne (1997) with kind permission.

The method of choice was the magnetometer, and an area of 183 hectares was investigated (David & Payne 1997). This magnetic mapping on a landscape scale can be appreciated as a modern approach to an established method. As the focus of archaeology changes from the archaeological site to the archaeological landscape, the way that archaeological methods are employed changes accordingly. In the survey many features that were previously known to exist from old maps or from aerial photographs were rediscovered and some new elements were added (see for example Fig. 3 for the results in the area directly around the monument). Most importantly, it is now much clearer what damage - if any - the infrastructural works are going to do to the monument in an entirely non-destructive way. Not all archaeological features can be mapped magnetically, however, and on some archaeological sites there is a general lack of magnetic contrast between the archaeological deposits and the undisturbed subsoil, making the site unsuitable for magnetic prospection. The site of Easingwold in the United Kingdom, where none of the features that were excavated after the magnetometer survey had caused a detectable magnetic response, is an example (Weston 2004).

This study is about the application of magnetic methods in The Netherlands, where the physical evidence of past societies can not be compared to that of the British Isles. And which is geologically different from the sedimentary rocks of Orkney, and from the chalk plain of Wiltshire. But there are examples of 'successful' magnetometer surveys on archaeological sites that approach the Dutch situation very well. The early Mediaeval site of Haithabu in Northern Germany for example. It has several 'typical Dutch' qualities. It was built out of wooden posts on a sandy spur next to the sea. Part of it has been waterlogged for a considerable length of time. And the results of the magnetometer surveys are excellent for giving information about the street pattern and the remains of individual buildings that are still present underneath the topsoil.
During the last 30 years, in a time when archaeological geophysics was a 'hot topic' in universities in Germany, Austria, France, Italy, the USA, Japan and the United Kingdom, Dutch universities have never embraced the subject. In commercial archaeology, less than 20 magnetometer surveys have been carried out. But were the universities right not to participate in the research into these new methods? Or has Dutch archaeology missed out and are there opportunities for the successful application of geophysical methods in the Dutch situation?

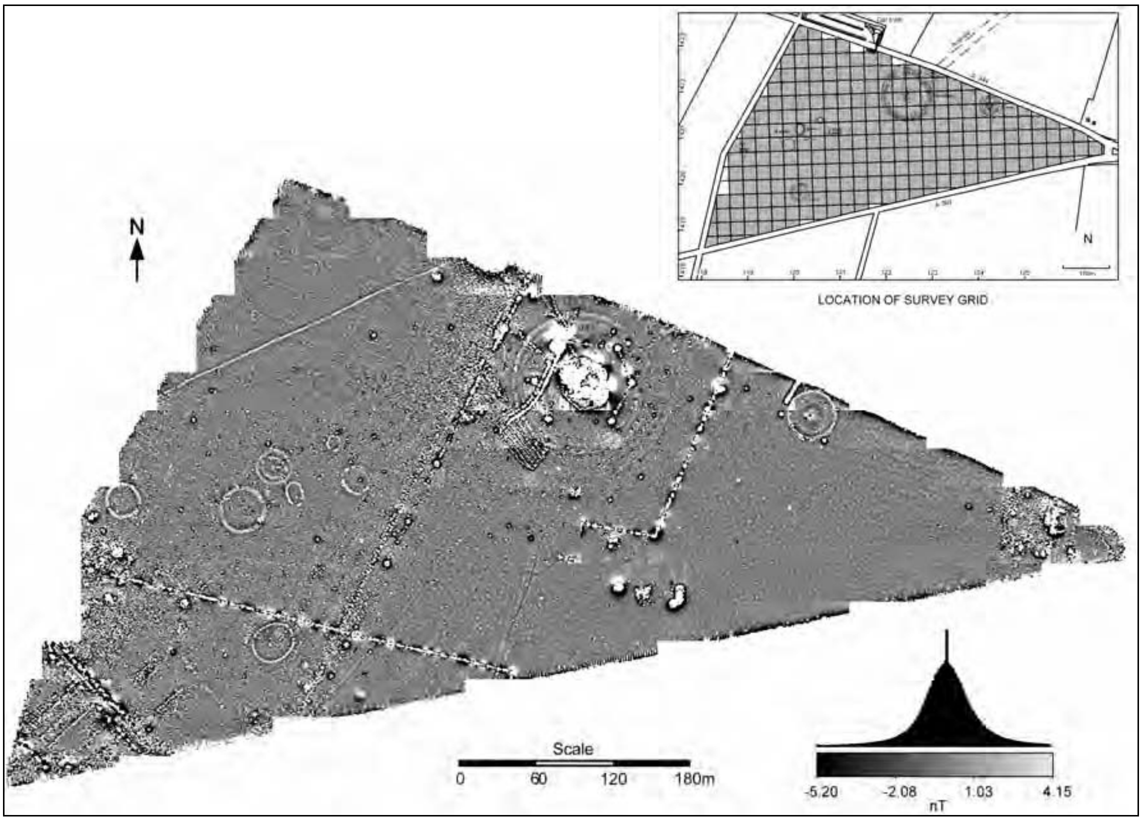

Figure 3 Greytone plot of the entire magnetometer survey of the Stonehenge 'Triangle'. Figure reproduced from David and Payne (1997) with kind permission.

1.2 Aims and objectives

The aim of this project is to assess the possibilities of the application of magnetic methods for mapping and evaluating archaeological remains in The Netherlands. The objectives of the project are:

- To assess the use of magnetic methods in The Netherlands for mapping archaeological features and sites.
- To assess the use of magnetic methods in The Netherlands for archaeological landscape prospection.
- To define areas within The Netherlands where magnetic methods can and cannot be used within the framework of Archaeological Resource Management.
- To develop a quick soil sample based method to predict whether a magnetometer survey can provide information about archaeological remains.

1.3 A Dutch perspective

The interpretation of magnetic data presupposes a local geological knowledge, and the possibilities for the application of magnetic methods depend largely on the underlying geology. It is sometimes difficult to distinguish magnetic signals caused by archaeological features from geological variations, and archaeological responses can in some cases be overshadowed by geologically caused magnetic variations. For example, the linear magnetic anomalies at the Standing Stones of Stenness, that were tentatively interpreted as post Neolithic ditches at the start of this introduction, have in fact been caused by a - pre Neolithic!- volcanic dyke. Geological magnetic variations are common in igneous geological settings, but they occur in karstic and sedimentary landscapes as well.

On the other hand, the properties of the soil matrix in which archaeological features are shaped and preserved partly determine the magnetic properties of these features and their fills. Magnetic susceptibility enhancement depends on the presence of iron in the soil matrix. Archaeological activities on a hypothetical soil devoid of iron would not cause magnetic susceptibility enhancement. Apart from the presence of iron, other variables like the grain size, organic matter content and the hydrological situation make a soil more or less suited for magnetic enhancement and subsequent magnetic prospection.

Because of the close relation between the successful magnetic mapping of archaeological sites and background geology, the core of this thesis is organized around the Dutch geological regions.
As the magnetic properties of the soil depend largely on the lithological and organic composition of the soil, as well as on depositional, soil formation and post depositional processes, The Netherlands has been divided into three sections based on depositional environment; estuarine, wind blown and fluvial deposits. By using the depositional environment as discriminating factor, sites that have a similar lithological composition, and have depositional processes, soil formation processes and post depositional processes in common can be discussed as a group. Twenty-nine archaeological sites which are spread over these three groups have been investigated for their suitability for a magnetometer survey. Moreover, soil samples have been collected on most of these sites in order to assess why certain sites are and others are not suitable for magnetometer surveys, in other words why certain sites do and others do not have a magnetic contrast. Investigations of archaeological and non-archaeological deposits for their magnetic susceptibility and for other magnetic properties aim to make that this thesis is more than a collection of survey results.
Along side this geological approach, a number of typically Dutch themes have been investigated. A group of drowned village sites in the southwestern part of the country has been researched because their buried structures are difficult to map with traditional prospection methods like hand augering and surface collection. Off-site structures, field systems for example, pose similar problems, and the possibilities for a magnetometer survey on field systems in the western part of The Netherlands have been investigated. Other scattered sites include a battlefield, an extensive iron production site and a series of small dwelling mounds. Moreover, it has been assessed if magnetic prospection can be an additional method to aid the problematic prospection under plaggen soils, and in areas where peat extraction has taken place.

1.4 This study

This introduction forms the first chapter of this study. The second chapter describes the history and the framework of archaeological prospection in The Netherlands. Prospection plays a crucial role in the cycle of archaeological resource management (ARM), which is why there is much interest to improve and add to current prospection techniques, this study is one of the examples of this trend. This chapter will explain the importance of non-destructive techniques for ARM and will set out what the current role for geophysical methods is. Additionally, archaeological prospection will be positioned in the current archaeological practice and it will be investigated how the quality of (commercial) prospection activities is protected in the Kwaliteitsnorm Nederlandse Archeologie[1] (KNA), and how the Nationale Onderzoeksagenda Archeologie[2] (NOaA) sets the agenda for the future with respect to the scientific research into archaeological prospection.
An introduction to magnetic methods is given in Chapter 3. Relatively much attention is given to the principles that underlie magnetic prospection, because it may not be possible to follow the argument in later chapters without understanding these principles. Most importantly, without an understanding about the way that magnetic susceptibility is related to induced magnetic anomalies, and how induced and remanent anomalies differ, this thesis can not be read.

[1] Quality Norm for Dutch Archaeology.
[2] National Research Agenda Archaeology.

Chapter 4 describes the methodology of this study, and starts with the way the approach to site selection has changed during the course of the work. The choices that have been made with respect to the field and the laboratory equipment and sampling strategy are justified in the remainder of this chapter.
The data of all the archaeological sites that have been investigated can be found in Appendix I, the sites have been ordered according to the list shown in Figure 12 (Chapter 4).
The core of the study is laid down in Chapter 5 and 6, where the results of all the individual surveys are synthesized by depositional environment, the estuarine deposits (Chapter 5), and the wind blown and fluvial deposits (Chapter 6). The investigations in these chapters work towards answering the question in which areas in The Netherlands magnetic methods can be successfully used within the framework of ARM and why.
Chapter 7 aims to be a catalogue of examples of the magnetic responses of different types of archaeological features that were encountered in this study.
The aims and objectives of the current study are related to ARM on the one hand, the importance of which is set out in the second chapter, and to the development of methods for archaeological prospection in general and to the methodological research into magnetic methods on the other hand. The importance of this study has to be appreciated on these three levels. The core of the book is concerned mainly with the basic level, the methodological research. The relevance of the results to the two other levels is discussed in the discussion (Chapter 8) and the conclusion (Chapter 9).