Archaeological Prospection
Archaeol. Prospect. **19**, 141–145 (2012)
Published online 21 February 2012 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/arp.1418

Short Report

Towards an Integrated Methodology for Assessing Rural Settlement Landscapes in the Belgian Lowlands

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ABSTRACT Although the Belgian lowlands witnessed a dense rural occupation in Roman and especially in medieval times, the exact nature of the settlement patterns, the farms and the interaction with the landscape is still poorly understood archaeologically, both scientifically and from a heritage curatorship point of view. Archaeogeophysical research has remained relatively limited in this area. However, other prospection techniques such as aerial photography provide ample evidence of historic rural settlement. The main aim of this research is to develop an efficient and integrated approach for the characterization of these rural landscapes, by combining and mutually evaluating data from geophysical methods including magnetometer, electromagnetic induction and ground-penetrating radar, aerial photography, fieldwalking, historic accounts and test-pitting. Copyright © 2012 John Wiley & Sons, Ltd.

Key words: Aerial photography; rural settlement; fluxgate gradiometer; electromagnetic induction; electrical conductivity; magnetic susceptibility

Introduction

The northwestern part of modern day Belgium is made up of lowlands that were densely occupied throughout history, with a considerable development during the Roman and medieval periods. With important towns such as Ghent, Ypres and Bruges, the region was in medieval times amongst the most densely populated in Europe between the eleventh and the fifteenth century. This high density of city dwellers had a profound impact on the landscape surrounding the cities, as is testified by historic text-sources and maps (Verhulst, 1995, 1999), resulting in the creation of farms and the reclamation of forests and waste lands to develop agriculture. Unfortunately the exact morphology and evolution of this rural settlement pattern as well as the wider natural and cultural landscape in which it was integrated, have remained poorly understood archaeologically. Similarly, earlier forms of rural settlement (e.g. dating from the Roman period) have also remained largely unknown until recently.

More and more information on parts of these historical landscapes has emerged during the past decade, allowing a first synthesis of the Roman period (De Clercq, 2011). However, scientific archaeological study of these landscapes still remains rare and important questions relating to their landscape context and structural evolution remain largely unanswered. From a heritage point of view, assessing and defining

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Received 29 November 2011
Revised 3 January 2012
Accepted 6 January 2012

settlement areas, and making scientifically based choices as to the strategies needed to map and understand the farm complexes is often problematic, especially in the framework of making choices for *ex situ* preservation by excavation. Moreover, a danger of circular reasoning and the loss of an important part of information emerges when evaluation strategies remain almost solemnly based on densities of features and not on an integrated evaluation of the landscape context, structure, density and quality of the features detected, leaving low-density farm complexes undiscovered.

An academic as well as a heritage management challenge therefore lies at the basis of our research. In combining different datasets and methods, our main goal is to develop an efficient integrated archaeo-geophysical approach towards the evaluation and characterization of these rural landscapes, and to reconstruct the evolution of their reclamation and use. This paper discusses the methodological aspects and the first results, based on a case study.

Methods and research strategy

Previous archaeo-geophysical studies in the Belgian lowlands focused on small phenomena such as burial mounds or small castles (Simpson *et al*., 2009b, 2010; Verdonck *et al*., 2009) or on large-scale landscape assessment (De Smedt *et al*., 2011). Geophysical techniques such as electromagnetic induction (EMI) and ground-penetrating radar (GPR), often applied in characterizing soil variability, are now deployed more frequently on archaeological sites. Electromagnetic induction especially adds to the understanding of these rural environments as it enables a detailed and straightforward analysis of the pedological context (McNeill, 1980).

An important asset for the knowledge of rural landscapes in historic Flanders and also for the interpretation of geophysical data is a dataset of 70,000 aerial photographs, mostly of crop marks, gathered since the 1970s and which is still being updated at the University of Ghent's Archaeology Department (Bourgeois *et al*., 2002, 2005). This dataset offers a wide coverage of the northwest Flemish landscape, especially in the area between Ghent, Ypres and Bruges, the historic heart of medieval Flanders. Data from these photopraphs as well as from different geophysical methods, historic sources (e.g. maps and written documents) and detailed fieldwalking will be gathered to develop a large-scale archaeo-geophysical methodology stepping beyond previous small-scale or monodisciplinary approaches. This will lead to a combined multilayered image of the natural and human landscape, also allowing comparison with excavated data and evaluation of the methods used. In a further stage, trial trenching will be used for evaluation of the methods applied.

For our test-case, a region of some 50 ha was selected west of the village of Maldegem-Kleit, in the northwestern part of Belgium (Figure 1). The study area is made up of Tertiary clay partially covered with Quaternary sand deposits. This slightly undulating landscape was once part of the 'Maldegemvelt', a large area of wasteland lying in between Ghent and Bruges, which was only extensively cultivated in the eighteenth century but contains important Roman and medieval reclamation phases. The first archaeological features in this test-region were discovered in 1987 during an aerial photographic survey. A systematic

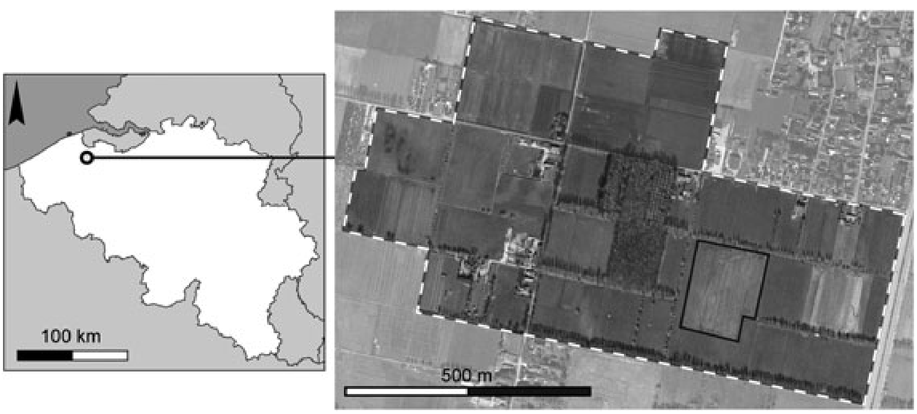

Figure 1. Location of the study area in Belgium (left) and an orthophotograph of the study area (AGIV, 2003). The white dashed line delineates the entire study area and the field discussed here is delineated by the black line.

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DOI: 10.1002/arp

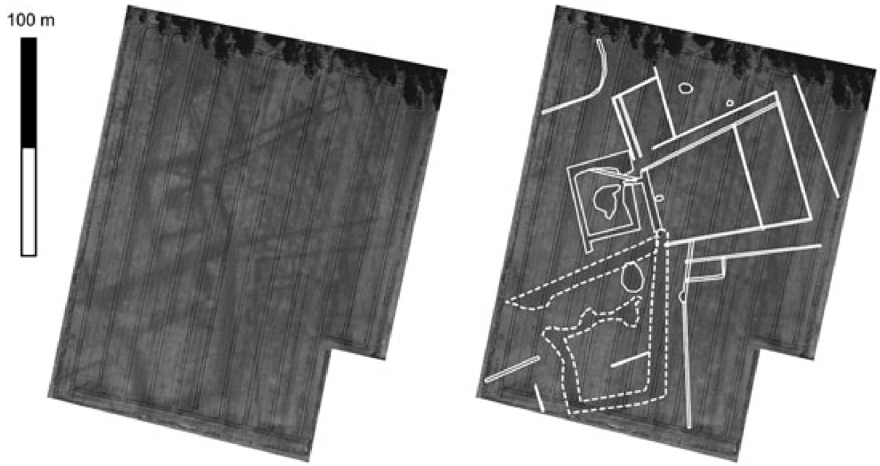

Figure 2. Aerial photograph of the field studied. In the picture on the right, the visible archaeological features are delineated by the white lines. The feature delineated in the dashed line is referred to as the 'main enclosure'. (Aerial photograph 553546, Department of Archaeology, Ghent University)

follow-up of the site led to a dataset of 205 images taken under varying conditions. These images revealed several enclosures, individual features and linear structures, visible as crop or soil marks, which were vectorized in a GIS environment. On a 3 ha field a particularly high density of crop marks was observed, revealing enclosures, ditches and possible pits and wells (Figures 1 and 2).

In a second stage, these data were compared with the results from two different geophysical methods (fluxgate gradiometer and EMI), to produce a broader insight into the detected features as well as to provide a mutual calibration of the observations made. An important objective is to gain insight into the landscape setting of the features observed and to examine the relationship between the pedology of the site and the visibility of features on aerial photographs.

Initially a geophysical survey was performed using a Bartington Grad 601–2 fluxgate gradiometer (Bartington and Chapman, 2004). The zigzag traverse method of survey was used with readings taken at 0.25 m intervals along lines spaced 1 m wide in grid squares of 30 × 30 m. The data were then processed using Archeosurveyor v. 2. The data has been enhanced by clipping to remove extreme data point values, destriped due to the directional effects that are inherent in magnetic instruments and interpolated in the X and Y direction to provide a smoother graphical appearance.

In a second phase, a detailed multireceiver EMI survey was conducted using a Dualem-21 s sensor in a mobile configuration. This instrument allows simultaneous measurement of the apparent electrical conductivity (EC_a) and the apparent magnetic susceptibility (MS_a) of four different soil volumes (Simpson *et al*., 2009a). Measurements were taken along parallel lines, 0.75 m apart, with an in-line resolution of 0.25 m. For the EC_a measurements, the depth of penetration of the different coil pairs varies from approximately 0.5 to 3.2 m below the sensor. In this paper, only the shallow measurements of the soil volume between 0 and 0.5 m will be discussed. For the MS_a data, the focus will also be on the shallow measurements, which have a penetration depth of approximately 0.5 m (Simpson *et al*., 2010). These data were corrected for instrument drift and interpolated using ordinary kriging. A more detailed overview of the data processing procedure can be found in Simpson *et al*. (2009b).

Preliminary results

The fluxgate gradiometer survey revealed an overall low magnetic variability, ranging from −0.43 to +0.43 nT (Figure 3A) . Here, a number of small ditches were detected. The most prominent features in the magnetometer data could be related to the main enclosure seen on the aerial photographs (Figure 2). However, based on these data it was not possible to further reconstruct the site's layout.

The multireceiver EMI data showed a clearer image of the features in the southern part of the field. The EC_a maps revealed the large structures visible on the aerial photographs (Figure 3B). Furthermore, a number of different ditches and other features that did not show up on the aerial photographs were detected, indicating another physical layer or varying depth of these anomalies. Saey *et al*. (in press) indicate that further processing, for example EC slicing, may allow a clearer delineation of the archaeological

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DOI: 10.1002/arp

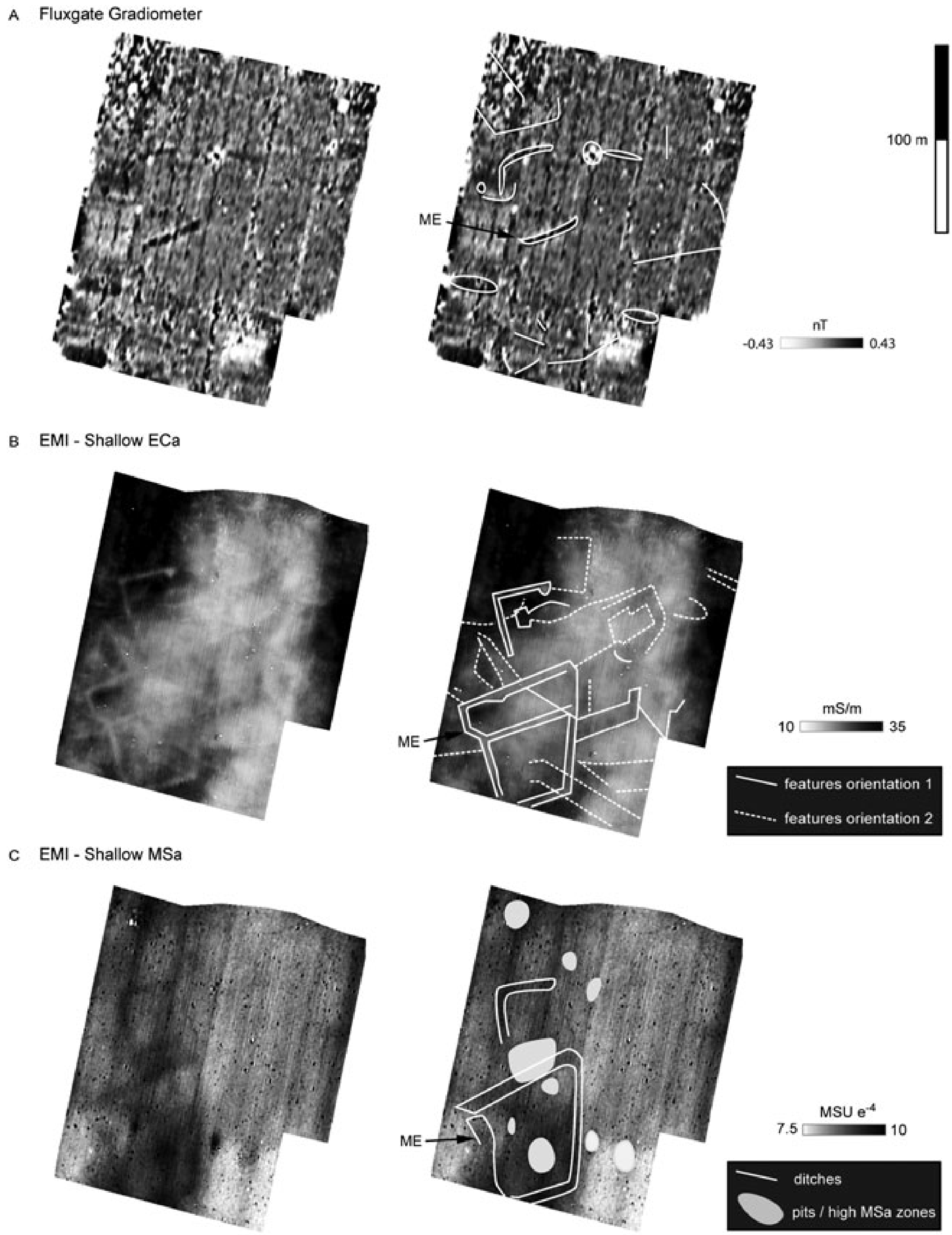

Figure 3. Geophysical data of the field studied without (left) and with indication of the main anomalies and traces of the main enclosure (ME) seen in Figure 2 (right): (A) fluxgate gradiometer data, (B) shallow EC_a data and (C) shallow MS_a data.

features and facilitate a more detailed interpretation. This type of data analysis will be investigated in a later stage of the project.

The MS_a data (Figure 3C) clearly show the structures and the main enclosure in the southern part of the site, visible as broad traces. Apart from these main ditches, a number of high MS_a zones could be distinguished that may be attributed to occupation zones, wells or pits. Furthermore, a large number of small anomalies with an elevated MS_a were detected scattered over the field. The clear visualization of these main ditches in the MS_a data illustrates the difference in detection potential between magnetic susceptibility measurements and the passive

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DOI: 10.1002/arp

magnetometer survey. Whereas mainly abrupt changes in magnetization are recorded with the fluxgate gradiometer, the EMI based MS_a measurements allow detecting magnetic features with more diffuse boundaries (Dalan, 2008). When dealing with subtle archaeological soil variability and not with stone architecture, MSa measurements especially can be a valuable addition to the survey dataset.

Discussion, future work and conclusion

The first results of the combined analysis of aerial photographs and geophysical surveys are promising. Geophysical methods affirm the high density of archaeological features seen in the aerial imagery. Although magnetometer survey did not provide significant insight, the EMI data suggested different occupation phases, based on the differing orientation of the features detected. Moreover, these data revealed features different to those rendered by the crop and soil marks.

A preliminary interpretation of the features suggests the presence of a multiperiod settlement area. The complex structure of the site is unknown in the region, which makes it hard to interpret the site functionally and chronology, being based solely on aerial photographs or geophysical data. Therefore, it requires a comprehensive approach to understand its role in the rural exploitation of the landscape. Based on recently excavated sites in the wider region, a late medieval date can be suggested for the large enclosure. However, the rectilinear narrow ditches, shaping a trapezoidal enclosed area, suggest a Roman date as known from other regions (e.g. northern France; Agache, 1978). During the following months additional geophysical surveys will be conducted in the area. First we will include a GPR survey using a stepped frequency radar with a 13 antenna array from three-dimensional radar (Linford *et al*., 2010). In addition, tests will be performed measuring the MS_a with the EMI sensor in different orientations. These results will be combined with recently revealed detailed historic cartographic data and with the results of detailed fieldwalking.

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