# The Application of Magnetic Methods for Dutch Archaeological Resource Management

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# 4 Methodology

## 4.1 Choice of sites

At the start of this project, it was intended to investigate three large sites, or rather, site related landscapes for this study. It was thought that the magnetometer survey in these three areas would identify archaeological features and possibly geological phenomena that could subsequently be sampled for laboratory investigations. In the first months of this project, two locations were investigated by means of a magnetometer survey combined with hand augering and soil sampling, the site of Broekpolder and the site of Harnaschpolder. In fact, very few archaeological features could be mapped in the magnetometer surveys in these areas, but geological features were abundant in the Harnaschpolder survey results. The reason why the archaeological features did not cause magnetic anomalies was investigated, as well as the nature of the geological anomalies in Harnaschpolder (see Chapter 5). The data collected at these initial two sites, however, did not appear to be sufficient for the overall project. The lack of identifiable archaeological features was the main reason to change the approach to site selection. On both of the sites, test trenches had been excavated before the magnetometer surveys only, which meant that archaeological features could not be sampled directly in excavation. Neither was it possible to sample the magnetically invisible features based on the magnetometer data. There was a need for better ground-truthing of the data. A practical reason for changing the approach was the difficulties with gaining access on a large set of fields with different owners.
The new approach consisted of the selection of small areas that were being or were about to be excavated. This way, magnetically invisible archaeological features could be sampled in excavation, and a direct comparison between the magnetometer and the excavation data could be made.
Criteria for site selection were:
- preferably excavation of the site after the magnetometer survey,
- archaeological features proven to be present or very likely to be present,
- archaeological features expected to be present in the top meter of the soil matrix,
- green field site.

A negative aspect of this new approach was that site selection depended on the availability of sites that were about to be excavated. In Table 4 it can be seen that for ten of the 29 sites that were investigated, it was possible to carry out a magnetometer survey before the archaeological excavation took place. Apart from Broekpolder and Harnaschpolder, two more sites were surveyed after the excavation had been carried out. The remainder of magnetometer surveys was conducted on sites that were not intended to be excavated, mainly on scheduled archaeological monuments. These sites were selected for different reasons, usually because they represent a type of site for which there were no ongoing excavations at the time of research. This set includes four so-called drowned villages (Valkenisse, Polre, Oostende and Steenbergen), a Roman road (Swalmen) and a Medieval road (Kolhorn) and one or possibly two sites with tumuli (Ossenisse) and an urnfield (Slabroek). The strategy for the magnetic susceptibility sample collection was to collect soil samples al all sites where a magnetometer survey had been carried out. This could not always be achieved. Samples for magnetic susceptibility measurements have been collected from excavation trenches where possible. Some samples have been taken by hand auger, either as a complementary dataset to the samples that were collected directly from the archaeological features, or because this was the only opportunity to collect samples, as was the case on five locations. At the bottom of Table 5 five sites are listed where no magnetometer surey took place, but which were available for sampling during excavation.

## 4.2 Inventory of sites

In Chapter 3 the variation in background magnetic susceptibility in The Netherlands was discussed, and it could be seen that magnetic susceptibility depends mainly on the type and abundance of iron minerals in the soil. The outcome of any transformation processes in the iron mineralogy is also related to the initial iron mineralogy. Thus, the iron mineralogy influences the magnetic susceptibility of a soil, as well any potential changes in magnetic susceptibility (see also § 4.3.2.3 on heating experiments). In order to cover as many soils of a different iron mineral composition as possible, the archaeological sites that were investigated for this study were also selected on their location. The selection was limited by the availability of sites where archaeological work was being carried out. The locations of the sites that have been investigated in this study are displayed in Figure 12. In this study very little attention has been given to the northern provinces of Friesland, Groningen and Drenthe. The reason for this is twofold, first, there are less ground disturbing activities in this region, and hence less archaeological projects, this is especially true for the province of Drenthe. Secondly, the archaeological remains on the sites that are excavated in Friesland and Groningen are usually not contained in the top meter of the soil matrix.

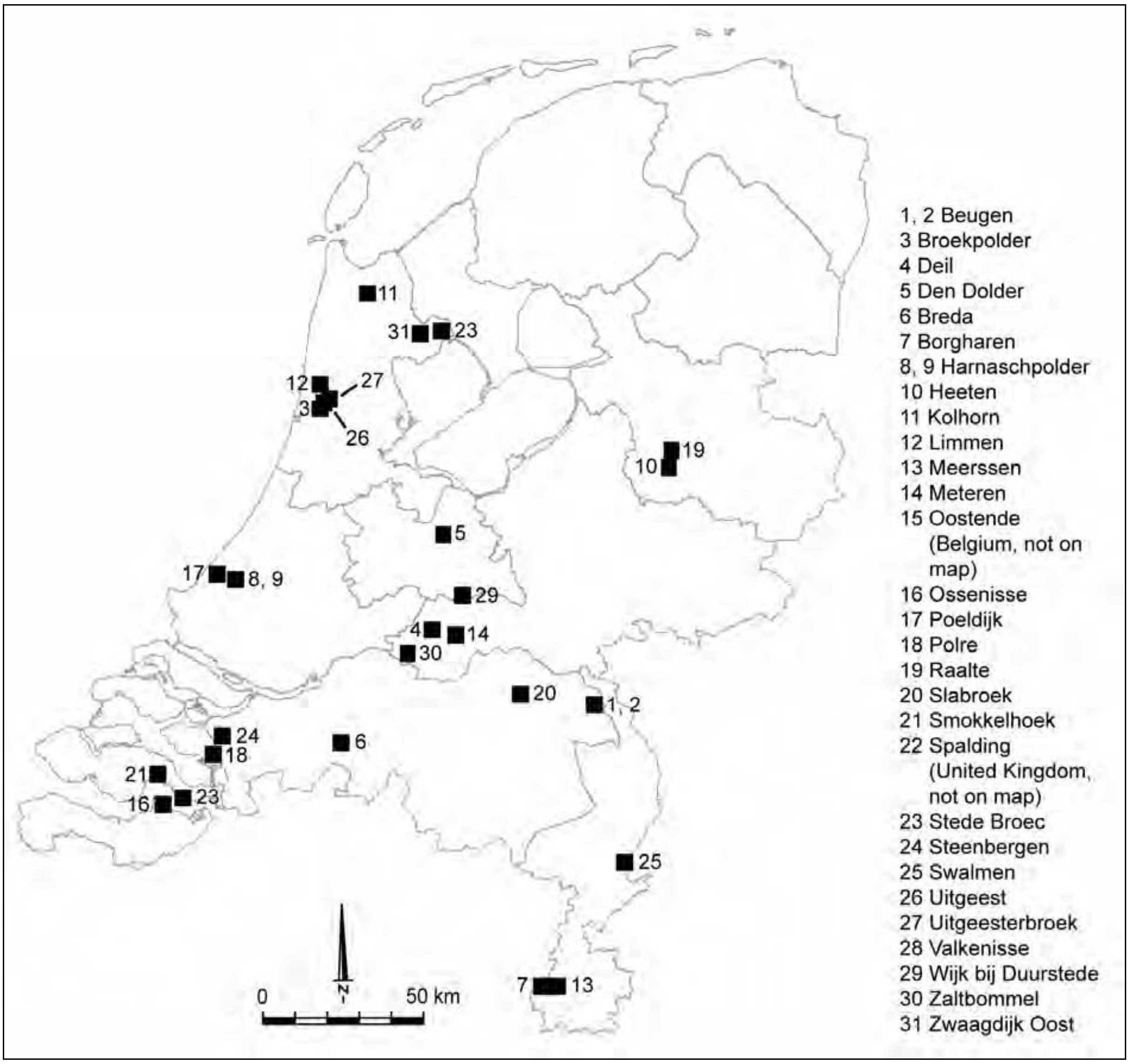


Figure 12 The location of the sites that were investigated in this study. The sites of Oostende (Belgium) and Spalding (United Kingdom) have not been displayed.

Table 4 List of archaeological sites that have been investigated in this study. The table indicates whether magnetometer surveys were conducted before or after archaeological investigations or if no excavations were carried out. Where possible, samples for magnetic susceptibility measurements were retrieved from archaeological excavations, in other cases from coring.

| site | magnetometer survey before excavation | magnetometer survey after excavation | magnetometer survey; no excavation | soil samples from excavation | soil samples from hand augering |
|---|---|---|---|---|---|
| Harnaschpolder | • | • | | • | • |
| Heeten | • | | • | • | • |
| Breda | • | | | • | |
| Limmen | • | | | • | • |
| Meersen | • | | | • | |
| Meteren | • | | | | |
| Poeldijk | • | | | | • |
| Spalding (UK) | • | | | | • |
| Wervershoof | • | | | • | |
| Zaltbommel | • | | | • | |
| Beugen Zuid | | • | | • | • |
| Broekpolder | | • | | | • |
| Borgharen | | • | | • | |
| Kolhorn | | | • | | |
| Oostende (BE) | | | • | | |
| Ossenisse | | | • | | |
| Polre | | | • | | |
| Slabroek | | | • | | |
| Smokkelhoek | | | • | | • |
| Stede Broec | | | • | | |
| Steenbergen | | | • | | |
| Swalmen | | | • | | |
| Uitgeesterbroek | | | • | | • |
| Valkenisse | | | • | | |
| Deil | | | | • | |
| Den Dolder | | | | • | |
| Raalte | | | | • | |
| Uitgeest | | | | • | |
| Wijk bij Duurstede | | | | • | |

Apart from a geographical spread, the selection of sites needed to be representative of the archaeological record - as far as this was possible - both in period and in type of site. Table 5 shows the dating for the sites that were investigated in this study. Where relevant, only the date of the features or of the section of the site that has been studied in the framework of this research is given. The dating of the actual archaeological site may be much wider. The ‘modern’ box is ticked if modern features have produced magnetic anomalies in the magnetometer data or if a modern feature has been sampled. The table shows that all archaeological periods, starting with the Bronze Age, are represented in the dataset. Sites dated before the Bronze Age have been excluded because these often lack the abundance of negative features like pits and ditches, that can be seen on the sites from later periods, and which are the targets for magnetometer surveys.

In Table 6 the type of site for the archaeological sites under investigation has been listed. Sites have been divided into five groups. Almost all of the sites that have been investigated are settlements, which may reflect the focus of current archaeological research on settlement sites. Moreover, it is likely that the majority of the archaeological sites in The Netherlands falls into the category of settlement site, as a high percentage of the current archaeological monuments do (Lauwerier & Lotte 2002). Three sites are classified as off-site because of the field systems that were excavated here (Broekpolder and Harnaschpolder) or because of off-site activities (the battlesite of Breda). Burial sites that have been investigated date from the Bronze Age (Den Dolder, Slabroek and possibly Ossenisse) and the Middle Ages (Borgharen). Attention to the magnetic expression of industrial activities has been given on sites for iron production (Heeten and Raalte), salt making (Spalding), peat extraction (Kolhorn and Smokkelhoek) and quarrying (Meerssen).

Table 5 Archaeological periods for the archaeological sites that have been investigated in this study. The 'modern' box is ticked only if modern features cause a magnetic anomaly in the data of the magnetometer survey or if a modern feature has been sampled.

| site | Bronze Age | Iron Age | Roman Period | Medieval and post Medieval | modern |
|---|---|---|---|---|---|
| Broekpolder | • | • | • | | • |
| Ossenisse | • | • | | | |
| Slabroek | • | • | | | |
| Deil | • | | | | |
| Den Dolder | • | | | • | |
| Stede Broec | • | | | | • |
| Wervershoof | • | | | | |
| Meteren | | • | • | | |
| Uitgeest | | • | • | | |
| Beugen Zuid | | • | | | • |
| Breda | | • | | • | |
| Borgharen | | | • | • | • |
| Harnaschpolder | | | • | | • |
| Heeten | | | • | | |
| Meersen | | | • | | • |
| Poeldijk | | | • | | |
| Raalte | | | • | | |
| Smokkelhoek | | | • | • | |
| Spalding (UK) | | | • | | |
| Swalmen | | | • | | |
| Uitgeesterbroek | | | • | | |
| Zaltbommel | | | • | | |
| Kolhorn | | | | • | |
| Limmen | | | | • | |
| Oostende (BE) | | | | • | |
| Polre | | | | • | |
| Steenbergen | | | | • | |
| Valkenisse | | | | • | |
| Wijk bij Duurstede | | | | • | |

Table 6 Type of archaeological site for the sites that have been investigated in this study.

| site | settlement | off-site | burial site | industrial | infrastructure |
|---|---|---|---|---|---|
| Breda | • | • | | | |
| Broekpolder | • | • | | | |
| Harnaschpolder | • | • | | | |
| Borgharen | • | | • | | |
| Den Dolder | • | | • | | |
| Ossenisse | | | • | | |
| Slabroek | | | • | | |
| Heeten | • | | | • | |
| Meersen | • | | | • | |
| Smokkelhoek | • | | | • | |
| Spalding (UK) | • | | | • | |
| Raalte | | | | • | |
| Kolhorn | | | | • | • |
| Limmen | • | | | | • |
| Poeldijk | | | | | • |
| Swalmen | | | | | • |
| Beugen Zuid | • | | | | |
| Deil | • | | | | |
| Meteren | • | | | | |
| Oostende (BE) | • | | | | |
| Polre | • | | | | |
| Stede Broec | • | | | | |
| Steenbergen | • | | | | |
| Uitgeest | • | | | | |
| Uitgeesterbroek | • | | | | |
| Valkenisse | • | | | | |
| Wervershoof | • | | | | |
| Wijk bij Duurstede | • | | | | |
| Zaltbommel | • | | | | |

## 4.3 Instruments

### *4.3.1 Magnetometer survey*

Magnetometers are instruments that can measure the magnitude of a magnetic field. In archaeological prospection, the object of interest is the earth's magnetic field. Magnetometers can either measure the magnitude of the total field, or of the horizontal or the vertical component of a magnetic field, or a combination of the horizontal and the vertical component. There are different sensors being used in ground based magnetometer surveys. For archaeological purposes, a very sensitive sensor and fast data acquisition are needed.

All the magnetometer surveys that are presented in this study have been carried out with fluxgate gradiometer instruments. This type of magnetometer is widely used in archaeological prospection. The English Heritage guideline for geophysical surveys that was published in 1995 (David 1995) assumes that a magnetometer survey for archaeological purposes is conducted with a fluxgate gradiometer, unless there are specific reasons to use another type of magnetometer. At present, however, an increasing amount of resonance magnetometers, especially caesium vapour magnetometers is used in archaeological prospection (Gafney & Gater 2003: 41). The sensitivity of these instruments is very high, up to 0.001 nT, which is 100 times more sensitive than a fluxgate sensor. Caesium magnetometers are less portable and more expensive than fluxgate magnetometers, and problems arise in the measurement of steep magnetic gradients. Because of their weight, they are often placed on carts, especially in gradiometer configuration where one caesium vapour sensor is placed above another sensor or an array of sensors. This type of magnetometer has not been used in Dutch archaeological prospection yet.

### *4.3.2 Fluxgate magnetometer*

A fluxgate sensor typically consists of a pair of parallel mumetal cores each surrounded by a primary coil, these coils are wound in opposite directions to each other. A set of secondary coils is wound around the primary coils, again in opposite directions to each other and in respect to the primary coils. An AC current through the primary coil drives the mumetal cores in and out of saturation. The magnetic field that is thus produced causes a voltage in the secondary coils that is in-phase but in opposite direction to each other, the combination of the two voltages is always zero. If the sensor is now placed in a secondary field, for example the earth's magnetic field, then a component of the external field will be parallel to the axes of the cores, resulting in an earlier saturation of this core, and a phase shift in the voltage. The combination between the two voltages is now non-zero, and this, being proportional to the field strength of the component of the magnetic field that is parallel to the axes of the mumetal cores, is the output of the fluxgate magnetometer. For a full description of the principle of the fluxgate sensor see Scollar (1990) or Reynolds (2002).

A fluxgate sensor is only sensitive to the component of the external field that is parallel to its axis. In archaeological prospection the vertical component of the earth's magnetic field is usually measured. Diurnal variations in the terrestrial magnetic field have magnitudes that are comparable to magnetic variations that can be caused by buried archaeological features. For this reason a gradiometer configuration is often preferred over a single sensor magnetometer. In a gradiometer two fluxgate sensors are placed a set distance apart, in line with each other in the sensitive direction. The sensor that is furthest away from the object of investigation, in this case the earth's surface, is mainly influenced by the earth's magnetic field and its variations. The sensor closest to the surface is influenced by both the terrestrial field and the magnetic variations in the soil matrix. Distracting the first output from the second produces a reading that is less influenced by diurnal variations.

The advantage of fluxgate sensors is that they are light and portable, relatively cheap to manufacture, and that the sensors have no problems with large gradients in the magnetic field. The resolution of the sensors is approximately 0.1 nT. A disadvantage of the fluxgate sensors is that the magnitude of only one component of the total field can be measured, resulting in the output of smaller relative changes. Because of the direction of the earth's magnetic field, this effect increases towards the equator.

#### 4.3.2.1 Geoscan FM36 fluxgate gradiometer

The Geoscan FM36 fluxgate gradiometer and earlier models of the same magnetometer are widely used in and purpose built for archaeological prospection.

Figure 13 A Geoscan fluxgate gradiometer with 0.5 meter sensor separation (left) and a Bartington fluxgate gradiometer with 1 meter sensor separation (right).

The two fluxgate sensors are placed 0.5 meter apart in a lightweight aluminum or plastic case (Fig. 13). The magnetometer is carried with the sensors in a vertical alignment, and is sensitive to the vertical component of the earth's magnetic field. The sensitivity of the instrument is 0.1 nT. The data quality strongly depends on the quality of the instrument setup, a procedure that is partly manual, partly electronic. The data that is collected is automatically displayed and recorded in the instrument's memory. For this study, sites on which a Geoscan instrument was used were divided into 20 x 20 meter grid squares. Data was usually collected every 0.25 meter on lines with a 1 meter line separation, unless stated differently in the fact sheets (Appendix I). An automated trigger was used and grids were walked in a zigzag fashion. A setup and zeroing was preformed each time before commencing a new grid, in order to optimize the data quality. The data was downloaded each day to a laptop computer with the Geoplot program.

4.3.2.2 Bartington GRAD601 fluxgate gradiometer

The Bartington GRAD601 fluxgate gradiometer is a new instrument that is becoming increasingly popular in archaeological prospection (Fig. 13). The sensor separation is 1 meter, which in theory makes the instrument more sensitive to magnetic variations at greater depths (Bartington & Chapman 2004). With this gradiometer, the vertical component of the terrestrial field is measured at a sensitivity of 0.1 nT. The setup is fully electronic, and is only preformed twice a day because the sensors are not very prone to drift. There is an option of attaching two gradiometers to the carrying harness, which increases the survey speed considerably. For this study the single gradiometer was used.
The Bartington fluxgate gradiometer has become available during the course of this study. The prototype of the instrument was tested next to the Geoscan instrument in Broekpolder and Harnaschpolder so that the results of the Geoscan and the Bartington instrument could be compared. Because the two datasets were fairly similar, they have not been displayed in this thesis. In addition, the Bartington instrument was used in this study on the site of Raalte by DW consulting (Appendix I, 19).

### *4.3.3 Magnetic susceptibility*

All magnetic susceptibility values in this study are mass related and are expressed as $m^3$/kg.

4.3.3.1 Agico KLY-2 magnetic susceptibility bridge

Soil samples for magnetic susceptibility measurements were taken by hand-auger (Boxmeer, Harnaschpolder, Heeten, Poeldijk, Smokkelhoek, Spalding, Stede Broec, and Uitgeest), directly from archaeological excavations (Beugen, Deil, Den Dolder, Ginneken, Grensmaas, Harnaschpolder, Heeten, Limmen, Meersen, Raalte, Uitgeest, Wervershoof, Wijk bij Duurstede and Zaltbommel) or without intrusion (Swalmen and Valkenisse).

For the hand augering a seven cm Dutch (screw)auger was used for top meter and a three cm gouge auger for samples deeper than a meter. Soil profiles were described and the remainder of the cores discarded after sampling.
Archaeological features in excavation were sampled by pushing sample tubes into the exposed section or surface. These small plastic lidded tubes were also used for storing and transporting the samples. The soil samples were not dried in order to prevent any chemical changes by oxidation unless stated otherwise in Appendix I, but frozen and measured within 14 days from sampling, using an Agico KLY-2 Kappabridge in the palaeomagnetic laboratory of the Universiteit van Utrecht.

4.3.3.2 Bartington MS2B susceptibility meter
On the sites of Broekpolder and Harnaschpolder, the first set of samples for magnetic susceptibility analysis were taken with a three cm gouge auger. The first five cm of topsoil were always discarded. Samples were taken from the auger with a spatula and stored in polyester ziplock bags. Samples were air dried on paper plates, and ground with a porcelain mortar and pestle.
The magnetic susceptibility of the samples was measured on a Bartington MS2B AC magnetic susceptibility bridge in the Department of Archaeological Sciences in the University of Bradford, UK. Measurements were repeated three times and the mean measurement was calculated. The AC susceptibility bridge was calibrated using a sample of high alumina cement and a sample of manganese sulphate. The samples were weighed on a top-pan balance. This was repeated twice and the mean weight of the sample was calculated.

4.3.3.3 Fractional conversion
A heat treatment was given to a selection of soil samples from Broekpolder and Harnaschpolder in order to obtain a value for maximum conversion. The procedure as described by Clark (1996) was followed.
Approximately 10 ml of each sample was weighed on a top-pan balance. The volume of the samples was measured using a 25 ml cylinder. The magnetic susceptibility of the samples was measured on a Bartington MS2B AC magnetic susceptibility bridge in the Department of Archaeological Sciences in the University of Bradford, UK. The measurement was repeated and the mean magnetic susceptibility value was calculated. One gram of plain flour was added to each sample and the samples were placed into porcelain crucibles and covered with a porcelain lid.
A Carbolite electric muffle kiln was heated up to 650 ºC with the chimney closed. Once this temperature was reached the samples were placed in the furnace and left in the furnace for an hour after the kiln had reached a temperature 650 ºC again. The furnace was switched off and left to cool for half an hour. After cooling the samples were taken out. The lids were removed and the samples were stirred with a wooden spatula. The furnace was switched on again with the chimney open. After reaching 650 ºC the samples were put back into the furnace and heated for 45 minutes after the furnace reached the temperature of 650 ºC again. The furnace was then switched off and left to cool for half an hour before taking the samples out.
After reaching room temperature, the volume of the samples was measured using a 25 ml cylinder. The samples were weighed using a top-pan balance. The magnetic susceptibility of the samples was measured on a Bartington MS2B AC magnetic susceptibility bridge. The measurement was carried out in triplicate and the mean magnetic susceptibility was calculated.

### *4.3.4 Thermomagnetic, IRM and ARM measurements*

4.3.4.1 Thermomagnetic measurements
Soil samples were obtained either by hand-augering (Harnaschpolder and Spalding) or from the sections or surfaces of archeological excavations (Harnaschpolder south, Limmen), one set of samples came from a freshly cut ditch (Broekpolder). Samples were stored in lidded plastic sample tubes, and were either freeze dried (Harnaschpolder and Spalding) or air dried (Broekpolder, Harnaschpolder south and Limmen). The Harnaschpolder and Spalding samples were taken from the reducing part of the soil section and were freeze dried in order to prevent any chemical changes in the soil samples that could possibly influence the iron mineralogy. A set of eight samples was measured for magnetic susceptibility before and after freeze drying (Table 7).

A slight change (maximum value 4.4%) can be observed. It is likely that part of the material has oxidized during the freeze drying process, probably the material on the surface of the sample that was exposed to air. It is assumed that the remaining material is chemically unchanged. The air dried samples were taken from the oxidizing part of the soil section and it was thought that further air drying would not cause any chemical changes in the soil samples. Prior to the thermomagnetic runs, the magnetic susceptibility of all samples was measured using a AGICO KLY-2 susceptibility bridge in the Palaeomagnetic Laboratory 'Fort Hoofddijk' of the Universiteit van Utrecht.

Table 7 Magnetic susceptibility before and after freeze drying of a selection of soil samples from Spalding.

| | depth | magnetic susceptibility x $10^{-8}$ $m^3$/kg wet | magnetic susceptibility x $10^{-8}$ $m^3$/kg after freeze drying | % change |
|---|---|---|---|---|
| A6 | 80 | 68 | 69 | 1.47 |
| A6 | 300 | 1138 | 1112 | -2.28 |
| A6 | 320 | 390 | 375 | -3.85 |
| A6 | 330 | 382 | 377 | -1.31 |
| A6 | 410 | 250 | 248 | -0.80 |
| A7 | 200 | 90 | 94 | 4.44 |
| A7 | 350 | 245 | 241 | -1.63 |
| A7 | 500 | 79 | 82 | 3.80 |

Thermomagnetic measurements were carried out with a modified horizontal-translation-type Curie Balance (Mullender *et al*. 1993) with a sensitivity of approximately 5 x $10^{-9}$ $Am^2$ in the Palaeomagnetic Laboratory 'Fort Hoofddijk' of the Universiteit van Utrecht. Samples were placed in a quartz glass sample holder and kept in place with quartz glass wool, and heated and cooled in air in 16 runs of 15-150, 150-50, 50-250, 250-150, 150-300, 300-200, 200-350, 350-250, 250-400, 400-300, 300-500, 500-400, 400-600, 600-500, 500-650, 650-15 °C, at a heating rate of 10 °C and a cooling rate of 15 °C per minute. The alternating field varied from 150-300 mT.

4.3.4.2 Anhysteretic remanent magnetisation (ARM) measurements

Samples from Broekpolder and Harnaschpolder were selected for ARM and IRM measurements. Approximately 0.2 gram of material was placed in a standard sized sample holder with approximately 0.2 gram of $CaCO_3$ to prevent sticking. The sample was homogenised with epoxy resin. The samples were left to dry overnight. A measurement in four directions was carried out in an Agico JR-5A spinner magnetometer. After this initial measurement the samples were demagnetised in the AF demagnetiser. An anhysteretic remanent magnetisation was impaired in the samples with a steady field of 1640 mT, and a peak alternating field in steps of increasing strength: 0, 2.15, 4.05, 6, 8, 10.1, 15, 20, 25, 30.05, 40.05, 50, 66, 80, 100, 130, 151, 176, 200, 250.05 and 260 mT. The samples were measured in four directions with the spinner magnetometer after every step.

4.3.4.3 Isothermal remanent magnetisation (IRM) measurements

The samples that were used for the ARM measurement were again demagnetised using the AF demagnetiser. Using a PM4 pulse magnetizer IRM was acquired in the samples in steps of increasing steady field strength: 0, 10, 15, 20, 25, 30, 40, 50, 65, 80, 100, 120, 150, 180, 200, 250, 300, 400, 500, 650, 800, 1000, 1200, 1400 and 1600 mT. The samples were measured with a JR-5A spinner magnetometer after every step.

## 4.4 Software

Two geophysical software packages were used for downloading the geophysical data from the instrument and for processing data, Geoplot and Archeosurveyor, the latter has become available in the course of this study.

### *4.4.1 Geoplot*

The Geoplot software package was built for use with the Geoscan instruments, like the FM36 that was used in this project.

Data is downloaded directly from the instrument in grids that generally measure 20 x 20 meter.
The grids are compiled in a so called *master grid* after which a composite dataset is obtained. The data that was collected for this study has undergone minimal processing. Generally, datasets have been *despiked* and *edge-matched*. Sometimes a *de-stagger* routine had to be applied to data that was collected in a zig-zag manner. In certain case studies *inter*- or *extrapolation* of the data was necessary for the clarity of the output picture, as directional differences in data density can give the data a 'messy' appearance. Datasets that had been collected on a 1 x 0.25 meter or a 1 x 0.5 meter spatial resolution were generally inter- and extrapolated to 0.5 x 0.5 meter.
For every dataset is has been assessed if the application of filters was beneficial for the quality of the output picture. In a few instances this was the case, if a filter has been applied, mention is made in the caption of the figure. A greyscale palette with 55 shades of grey has been used to display the data throughout this study. The graphics are exported from the program as bitmap files.
The majority of the sites that were surveyed in this study were processed with Geoplot, except for Swalmen, Heeten (2004 survey), Meteren and Ossenisse (2005 survey) for which Archeosurveyor was used.

### *4.4.2 Archeosurveyor*
The Archeosurveyor software imports directly from the instrument in grids. These grids are assembled in a *grid assembly*, the resulting dataset is a *composite*. Processing routines like *despike*, *edge match*, *destagger* and *interpolation* have been used in a similar fashion as in the Geoplot program. Filters have not been used.
A greyscale palette with 99 shades of grey has been used in Archeosurveyor to display the data. Graphic files have been exported as portable network graphics (png) files from Archeosurveyor.

### *4.4.3 Further software*
Graphics from the geophysical software have been georeferenced to the Dutch national grid (Rijksdriehoeksnet) and imported into Autocad, where the geophysical data was linked with other sources of information like archaeological data and topographical maps. The Autocad drawing has been exported as a graphic pdf file. The final lay out of the figures in this thesis has been made in Adobe Illustrator.
The Excel spreadsheet program has been used to calculate and analyze the magnetic susceptibility data. For the analysis of the Curie Balance measurements, the Cursmooth 2.03 program which was developed by the Palaeomagnetic Laboratory of the Universiteit van Utrecht was used (Mullender *et al*. 1993). From the same laboratory is the program IRM-CLG 1.0 (Kruiver *et al*. 2001, Heslop *et al*. 2002) that was used to analyze the IRM data that was obtained.