98/17.

# GRANTHAM PIPELINE (HACEBY), LINCOLNSHIRE

*Topsoil Magnetic Susceptibility & Gradiometer Survey*

( Survey Ref : 1610998/GRL/APS )

SEPTEMBER 1998

Produced by

**OXFORD ARCHAEOTECHNICS LIMITED**

under the direction of

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Commissioned by

Archaeological Project Services

on behalf of

Anglian Water Services Limited

OXFORD ARCHAEOTECHNICS

EVENTS L43276 L43277

SOURCE L18002

62505 L83156 Roman.

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# Specialist Archaeological Field Evaluation

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## *SUMMARY*

*A geophysical evaluation programme comprising topsoil magnetic susceptibility mapping and gradiometer survey was carried out within a 180 x 40 m corridor (0.72 ha area) on land situated immediately north of the A52 at Dembleby Gorse, Haceby, c.10 km east of Grantham, Lincolnshire (centred on NGR TF 01950 37050) in advance of pipeline construction.*

*The survey corridor lies in close proximity to two known Roman sites, a villa situated 100 m to the south, and the findspot of Romano-British pottery and building debris from Dembleby Gorse 100 m to the northwest.*

*The survey was based upon the principle that past human activity and its associated debris usually creates slight but persistent changes in the local magnetic environment which can be sensed from the surface (using magnetic susceptibility measurement and magnetometry).*

*Topsoil magnetic susceptibility mapping (on a 10 m grid) showed a dynamic range and patterning indicative of anthropogenic activity.*

*Detailed gridded magnetometer (gradiometer) survey revealed several substantial anomalies suggestive of large pit forms, a number of (mostly weak) linear intrusions, and clusters of anomalies indicative of disturbed ground with what are probably pockets of buried structural debris represented either by burnt or fired (brick or tile) debris. Areas of magnetic activity are separated by broad zones which appear remarkably 'quiet' magnetically. At least one area of in situ burning is also suggested.*

# 1. INTRODUCTION

1.1 Geophysical survey was commissioned by Archaeological Project Services (APS) on behalf of Anglian Water Services Limited on land immediately north of the A52 at Dembleby Gorse, Haceby, c.10 km east of Grantham, Lincolnshire in advance of pipeline construction. The fieldwork was carried out in September 1998.

1.2 The survey area (centred on TF 01950 37050) comprised a 180 x 40 m corridor (0.72 ha in area) along the north side of the A52 Salter's Way, a probable Roman route which may have adopted the line of a prehistoric trackway. The location is shown on Fig. 1.

1.3 The survey area lies between 70.5 and 63.5 m AOD, sloping uniformly to the east to within 70 m of the pond shown on the OS 1:2500 sheet at TF 02100 37050, where the field becomes relatively flat. The land lies on the Jurassic limestone ridge which forms the first raised escarpment the fen edge, which lies some 12 km to the east. The soils are mapped as belonging to the Aswarby Association over interbedded Jurassic limestone and clays. The land was under corn stubble at the time of survey.

1.4 The survey corridor lies almost equidistant between two known Romano-British buildings. Less than 100 m to the south, lies the site of Haceby villa, which was originally discovered (together with a mosaic floor) in 1818 (Whitwell 1970). Partial excavation in 1929 by cadets and officers of the RAF College at Cranwell revealed part of a bath-suite; no dating evidence was recovered during this work (Taylor & Collingwood 1929, de la Bere 1935, Lane 1995). The site is a Scheduled Ancient Monument. Less than 100 m to the northwest, within an area of woodland known as Dembleby Gorse, the County Sites and Monuments Record (SMR) records the discovery of Romano-British pottery and building debris. The objectives of the geophysical survey were to determine the extent and possible geometry of archaeological features located during a recent trial trenching evaluation programme carried out by APS, which located Roman material including building rubble overlying a dump of burnt material within a 10 m square trench sited almost central to the survey area (centred on NGR TF 01978 37018), but found no archaeological evidence within trenches spaced at 100 m intervals to both east and west (pers. comm. G. Taylor, APS). The location of the APS trenches in relation to the geophysical survey corridor is shown on Fig. 2.

1.5 The geophysical survey comprised a combination of topsoil magnetic susceptibility field sensing and magnetometer (gradiometer) survey. An explanation of the techniques used, and the rationale behind their selection, is included in an Appendix to the present report.

## 2. MAGNETIC SURVEY DESIGN

2.1 Survey control was established to a local grid based on a 40 m offset into the field from an existing wooden survey marker (at approximately NGR TF 02060 37020) sited at the southern edge of the survey corridor between the two APS evaluation trenches. Further control was established to the corners of the square evaluation trenches and the end of hedgebank situated 125 m west of the survey corridor (further survey details are available if required).

2.2 The equipment used for the direct topsoil magnetic susceptibility survey was a Bartington Instruments MS2 meter with an 18.5 cm loop.

2.3 *In situ* magnetic susceptibility readings were taken on a 10 m grid, an interval known to give a high probability of intersecting with dispersed horizons from a wide range of archaeological sites, particularly those associated with occupation and industrial activity from the later prehistoric period onwards. Soils over former occupation and industrial sites usually register as stronger patterning, frequently showing a marked focus. Agricultural activity helps to both generate (by ploughing casting up underlying deposits), and ultimately disperses the more magnetic soils over a wider area. Patterns recorded by 10 m magnetic susceptibility mapping tend to define zones of former activity rather than locate individual elements. Nevertheless, in some contexts, a focus of markedly stronger soil magnetic susceptibility (or markedly magnetically lower soils indicative of ploughed down earthworks) is occasionally found to relate to material dispersed from specific underlying features.

2.4 The whole of the survey corridor was also investigated by detailed gridded gradiometer survey with a Geoscan Research FM 36 Fluxgate Gradiometer (sampling 4 readings per metre at 1 metre traverse intervals in the 0.1 nT range). The nanotesla (nT) is the standard unit of magnetic flux (expressed as the current density), here used to indicate positive and negative deviations from the Earth's normal magnetic field.

2.5 The topsoil magnetic susceptibility colour shade plot (Fig. 5) shows contours at 5 SI intervals. Magnetometer data have been presented as grey scale and stacked trace (raw data) plots (Figs. 3 & 4), an interpretation of results is shown on Fig. 3 and an overview on Fig. 6.

## 3. SURVEY RESULTS

### TOPSOIL MAGNETIC SUSCEPTIBILITY MAPPING (Fig. 5)

3.1 84 *in situ* magnetic susceptibility readings were recorded. Susceptibility is reported in SI: volume susceptibility units (x $10^{-5}$), a dimensionless measure of the relative ease with which a sample can be magnetized in a given magnetic field.

3.2 *In situ* topsoil susceptibility measurements showed a dynamic range between 17 and 85 (x $10^{-5}$) SI units. The mean for the survey was 41 SI units and the standard deviation calculated against the mean was 16.6 SI units.

3.3 Almost three quarters of the survey corridor displays relatively low levels of topsoil magnetic susceptibility (15 - 45 SI), showing evidence for quite subtle east-west patterning, whilst the topsoil susceptibility increases dramatically (up to 85 SI) within a 40 m wide band along the eastern edge of the survey corridor. This abrupt interface, which runs parallel with the extant modern field boundaries, is probably attributable to a former boundary between cultivation blocks.

3.4 Within the magnetically weaker zone lies one small focus showing slight enhancement, situated between 100 and 110 m from the western edge of the survey corridor, close to the hedgeline, where an APS evaluation trench (see 1.4 above) has revealed archaeological features of Romano-British date, and close to an area in which subsequent gradiometer survey suggested some local activity, including an area containing burnt deposits (see 3.7 below).

3.5 No corresponding magnetic anomalies were revealed by subsequent gradiometer survey to account for the strong topsoil magnetic susceptibility patterning within the relatively easternmost quarter of the survey corridor. It is probable that the marked contrasts represent differential activity within this area (formerly a separate field) which has locally modified the magnetic identity of the topsoils; the incorporation of locally burnt horizons may provide an alternative explanation. On present evidence, the pattern is difficult to interpret within the relatively narrow corridor. However, as this zone of high topsoil magnetic susceptibility levels corresponds with a topographically low area, it is possible that the magnetically stronger soils represent the presence of colluvial deposits derived from anthropogenically modified horizons immediately upslope to the west.

### MAGNETOMETER (GRADIOMETER) SURVEY (Figs. 3 & 4)

3.6 The gradiometer plot shows two distinct patterns of magnetic anomalies, a number of discrete and for the most part pit-like features, and secondly, broad erratic zones which represent magnetically confused horizons, probably incorporating structural elements and dispersed structural debris. It is difficult to determine any clear geometry within these zones, although the nucleus of such activity can be clearly recognised. The principal focus covers an area 20 m in diameter lying close to the hedge, some 45 - 60 m from the western edge of the survey corridor. Romano-British roofing material (tile and diamond-shaped slates) together with a number of dressed limestone blocks were noted during the course of the survey along the hedgeline at this location. There is a slight suggestion that this area may be enclosed by a rectilinear enclosure on an alignment at 45 degrees to the survey corridor. The substantial anomalies representing probable pit forms, ranging in size between 1- 2 and up to 4 - 5 m in diameter, appear generally as more isolated features situated mainly west and north of this area of disturbance.

3.7 Beyond this area to both the northwest and east, extending for a distance of some 30 m, the background is generally stable and magnetically 'quiet'. Further magnetic activity is visible in the vicinity of the APS evaluation trench, where a cluster of anomalies indicative of intrusive features are visible; included within this group, lying immediately northwest of the evaluation trench is a zone measuring some 3-4 x 5 m, which may include *in situ* burnt material, or concentrations of brick and tile; a group of pits is clustered immediately to the east of the trench. A substantial intrusion, which may also include magnetically enhanced burnt/fired material, and measuring some 8 x 4 m, lies 35 m northeast of the trench.

3.8 The northeastern angle of the survey corridor is crossed by a linear anomaly, probably a ditch, which is visible for a distance of 10 m running on a eastnortheast-westsouthwest alignment. Other linears are suggested on the interpretation plot (Fig. 3). These appear, for the most part, to be agricultural in origin, although there are suggestions of others on a southwest-northeast alignment, one being visible for a distance of 70 m, which cannot be readily explained by modern agricultural activity.

3.9 Very little ferrous debris was recorded.

## 4. CONCLUSIONS

4.1 Within areas of archaeological potential, stronger patterns of topsoil magnetic enhancement tend to reflect anthropogenic activity, particularly in proximity to a building where it might be expected that subsequent cultivation would have incorporated particles of burnt/fired material and habitation debris into the topsoil. There is, curiously, however, very little correspondence within the survey corridor between the magnetic anomalies recorded by magnetometer (gradiometer) survey, and the patterns revealed by the topsoil magnetic susceptibility map: where there is strong topsoil magnetic susceptibility patterning close to the eastern edge of the survey corridor, only one corresponding 'cut' feature was found, whilst topsoils within the western part of the corridor, which yielded much weaker and more subtle magnetic susceptibility patterning, have been demonstrated by gradiometer survey to overlie archaeological horizons and substantial 'cut' features. Seen within such a relatively narrow corridor, the reasons for this apparent inversion are difficult to explain, although it is possible that the increased enhancement has been derived from an anthropogenic source further upslope.

4.2 Gradiometer survey has identified a number of features with clear archaeological potential generally dispersed within the survey corridor, but with a significant concentration of activity probably indicative of underlying structural material along the southernmost (roadside) boundary, at a location in which Romano-British structural debris was noted alongside the modern hedgeline.

4.3 Probable features of archaeological significance detected by the gradiometer comprise areas of disturbance and structural remains/debris and probable areas of burning or concentrations of fired material. The general absence of magnetic anomalies suggesting substantial ditches (with the exception of a clear linear crossing the northeastern angle of the survey corridor), is unusual, although it is possible that linears infilled with low susceptibility material may not have been visible to the magnetometer.

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Topsoil magnetic susceptibility mapping and magnetometer survey by Oxford Archaeotechnics Limited under the direction of A.E. Johnson *BA*, with: M. Tomkins *BA, MA*..

## APPENDIX - MAGNETIC TECHNIQUES: GENERAL PRINCIPLES

A1.1 It is possible to define areas of human activity (particularly soils spread from occupation sites and the fills of cut features such as pits or ditches) by means of *magnetic survey* (Clark 1990; Scollar et al. 1990). The results will vary, according to the local geology and soils (Thompson & Oldfield 1986; Gale & Hoare 1991), as modified by past and present agricultural practices. Under favourable conditions, areas of suspected archaeological activity can be accurately located and targeted for further investigative work (if required) without the necessity for extensive random exploratory trenching. Magnetic survey has the added advantages of enabling large areas to be assessed relatively quickly, and is non-destructive.

A1.2 Topsoil is normally more magnetic than the subsoil or bedrock from which it is derived. Human activity further locally enhances the magnetic properties of soils, and amplifies the contrast with the geological background. The main enhancement effect is the increase of *magnetic susceptibility*, by fire and, to a lesser extent, by the bacterial activity associated with rubbish decomposition; the introduction of materials such as fired clay and ceramics - and, of course, iron and many industrial residues - may also be important in some cases. Other agencies include the addition and redistribution of naturally magnetic rock such as basalt or ironstone, either locally derived or imported.

A1.3 The tendency of most human activity is to increase soil magnetic susceptibility locally. In some cases, however, features such as traces of former mounds or banks, or imported soil/subsoil or non-magnetic bedrock (such as most limestones), will show as zones of lower susceptibility in comparison with the surrounding topsoil.

A1.4 Archaeologically magnetically enhanced soils are therefore a response of the parent geological material to a series of events which make up the total domestic, agricultural and industrial history of a site, usually over a prolonged period. Climatic factors may subsequently further modify the susceptibility of soils but, in the absence of strong chemical alteration (e.g. during the process of podzolisation or extreme reduction), magnetic characteristics may persist over millions of years.

A1.5 Both the magnetic contrast between archaeological features and the subsoil into which they are dug, and the magnetic susceptibility of topsoil spreads associated with occupation horizons, can be measured in the field.

A1.6 There are several highly sensitive instruments available which can be used to measure these magnetic variations. Some are capable, under favourable conditions, of producing extraordinarily detailed plots of subsurface features. The detection of these features is usually by means of a *magnetometer* (normally a fluxgate gradiometer). These are defined as passive instruments which respond to the magnetic anomalies produced by buried features in the presence of the Earth's magnetic field. The gradiometer uses two sensors mounted vertically, often 50 cm apart. The bottom sensor is carried some 30 cm above the ground, and registers local magnetic anomalies with respect to the top sensor. As both sensors are affected equally by gross magnetic effects these are cancelled out. In order to produce good results, the magnetic susceptibility contrast between features and their surroundings must be reasonably high, thereby creating good local anomalies; a generally raised background, even if due to human occupation within a settlement context, will sometimes preclude meaningful magnetometer results. The sensitive nature of magnetometers makes them suitable for detailed work, logging measurements at a closely spaced (less than 1 metre) sample interval, particularly in areas where an archaeological site is already suspected. Magnetometers may also be used for rapid 'prospecting' ('scanning') of larger areas (where the operator directly monitors the changing magnetic field and pinpoints specific anomalies).

A1.7 *Magnetic susceptibility measuring systems*, whilst responding to basically the same magnetic component in the soil, are 'active' instruments which subject the sample area being measured (according to the size of the sensor used) to a low intensity alternating magnetic field. Magnetically susceptible material within the influence of this field can be measured by means of changes which are induced in oscillator frequency. For general work, measuring topsoil susceptibility *in situ*, a sensor loop of around 20 cm diameter is convenient, and responds to the concentration of magnetic (especially ferrimagnetic) minerals mostly in the top 10 cm of the soil. Magnetically enhanced horizons which have been reached by the plough, and even those from which material has been transported by soil biological activity, can thus be recognised.

A1.8 Whilst only rarely encountering anomalies as graphically defined as those detected by magnetometers, magnetic susceptibility systems are ideal for detecting magnetic spreads and thin archaeological horizons not seen by magnetometers. Using a 10 m interval grid, large areas of landscape can be covered relatively quickly. The resulting plot can frequently determine the general pattern of activity and define the nuclei of any occupation or industrial areas. As the intervals between susceptibility readings generally exceed the parameters of most individual archaeological features (but not of the general spread of enhancement around features), the resulting plots should be used as a guide to areas of archaeological potential and to suggest the general form of major activity areas; further refinement is possible using a finer mesh grid or, more usually, by detailing underlying features using a gradiometer.

A1.9 Magnetic survey is not successful on all geological and pedological substrates. As a rule of thumb, in the lowland zone of Britain, the more sandy/stony a deposit, the less magnetic material is likely to be present, so that a greater magnetic contrast in soil materials will be needed to locate archaeological features; in practice, this means that only stronger magnetic anomalies (e.g. larger accumulations of burnt material) will be visible, with weaker signals (e.g. from the fillings of simple agricultural ditches) disappearing into the background. Similar problems can arise when the natural background itself is very high or very variable (e.g. in the presence of sediments partially derived from magnetic volcanic rocks).

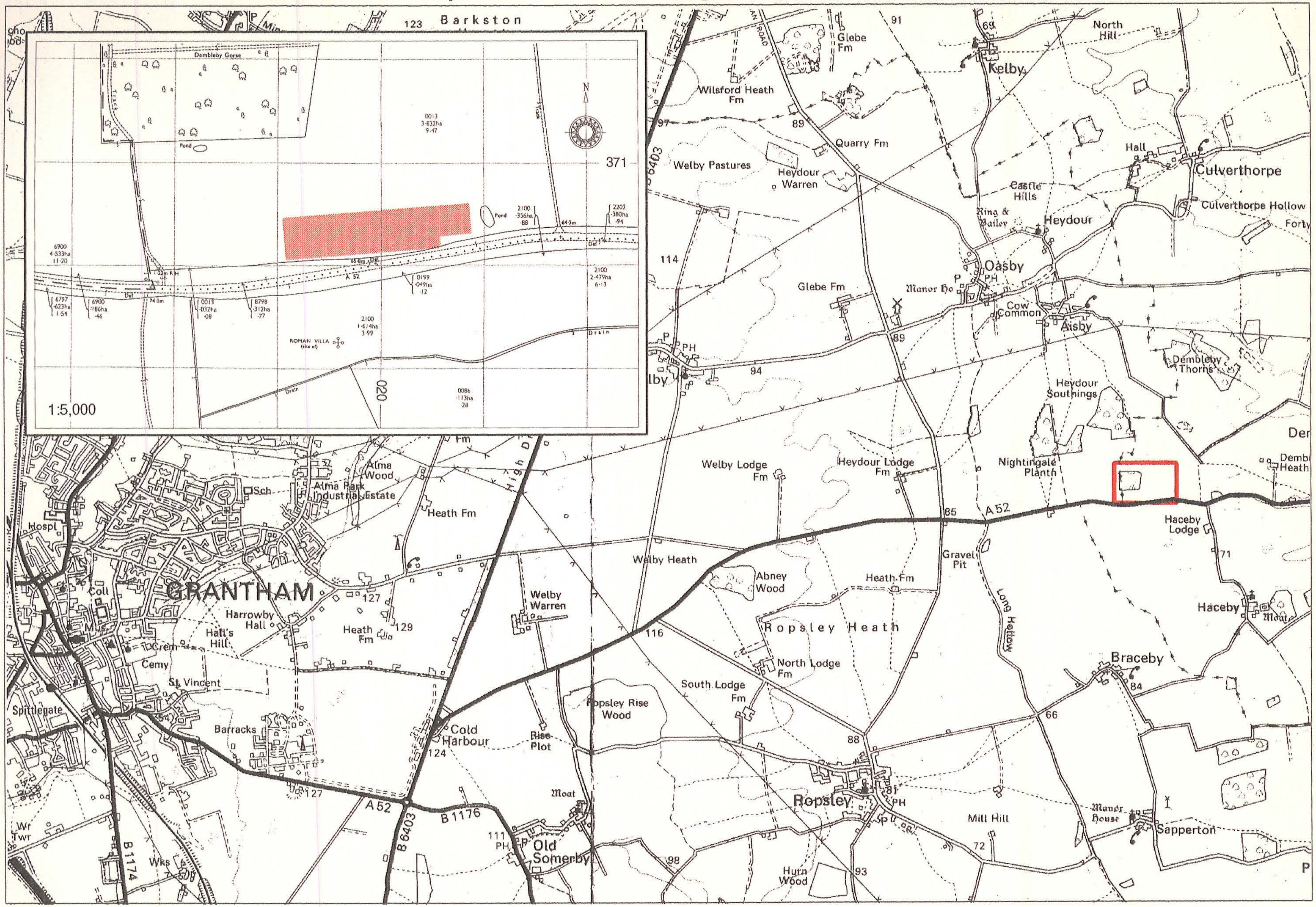
A1.10 The precise physical and chemical processes of changing soil magnetism are extremely complex and subject to innumerable variations. In general terms, however, there is no doubt that magnetic enhancement of soils by human activity provides valuable archaeological information.

A1.11 As well as locating specific sites, topsoil magnetic susceptibility survey frequently provides information relating to former landuse. Variations in the soils and subsoils, both natural and those enhanced by anthropogenic agencies, when modified by agriculture, give rise to distinctive patterns of topsoil susceptibility. The containment of these spreads by either natural or man-made features (streams, hedgerows, etc.) gives rise to a characteristic chequerboard or strip pattern of varying enhancement, often showing the location of former field systems, which persist even after the physical barriers have been removed. These patterns are often further amplified in fields containing underlying archaeological features within reach of the plough. More subtle landuse boundaries and indications of former cultivation regimes are often suggested by topsoil magnetic susceptibility plots.

A1.12 Where a general spread of magnetically enhanced soils contained within a long-established boundary becomes admixed over a long period by constant ploughing, it can be diffused to such a point that the original source is masked altogether. Magnetically enhanced material may also be moved or masked by natural agencies such as colluviation or alluviation. Generally, it appears that the longer a parcel of land has been under arable cultivation, the greater is the tendency for topsoil susceptibility to increase; at the same time there is increasing homogeneity of the magnetic signal within the soils owing to continuous agricultural mixing of the material. Some patterns of soil enhancement derived from underlying archaeological features are, however, apparently capable of resisting agricultural dispersal for thousands of years (Clark 1990).

# FIGURE CAPTIONS

# Grantham Pipeline: archaeological geophysical survey

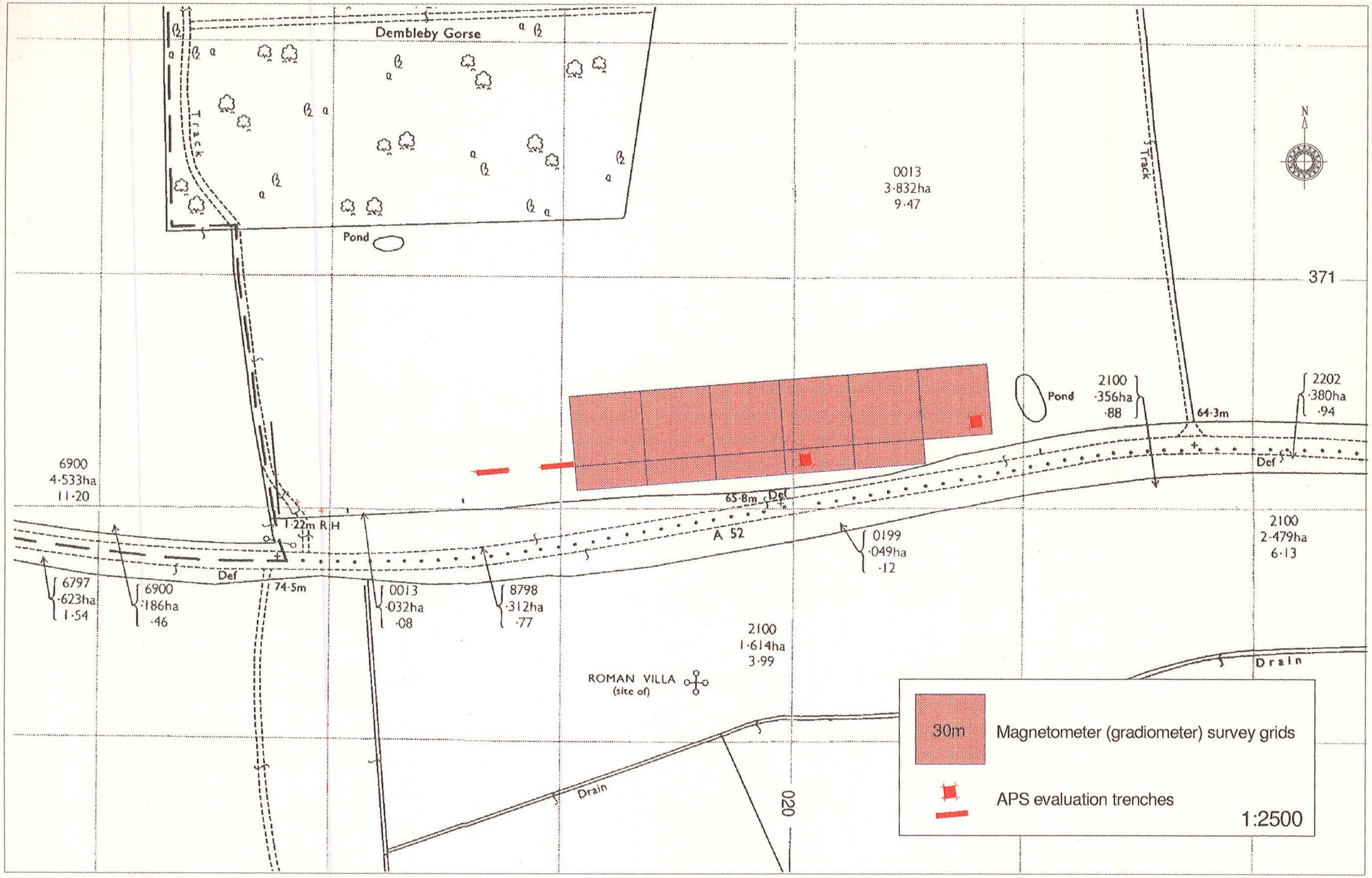



1:50,000

Location

OXFORD ARCHAEOTECHNICS FIG. 1

# Grantham Pipeline: archaeological geophysical survey




Location of survey grids

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FIG.2

# Grantham Pipeline: archaeological geophysical survey

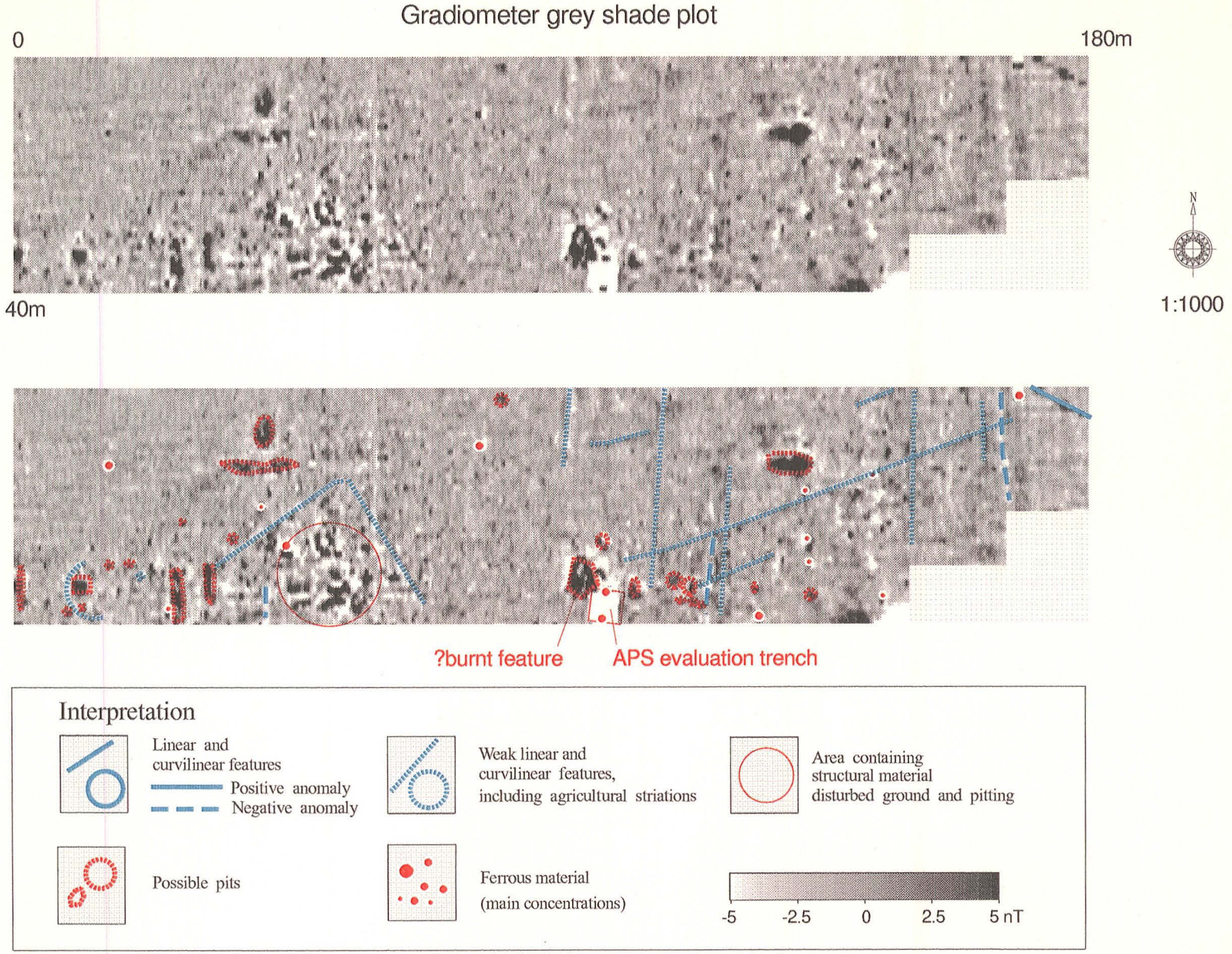


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FIG. 3

# Grantham Pipeline: archaeological geophysical survey

Gradiometer stacked trace plot (raw data)

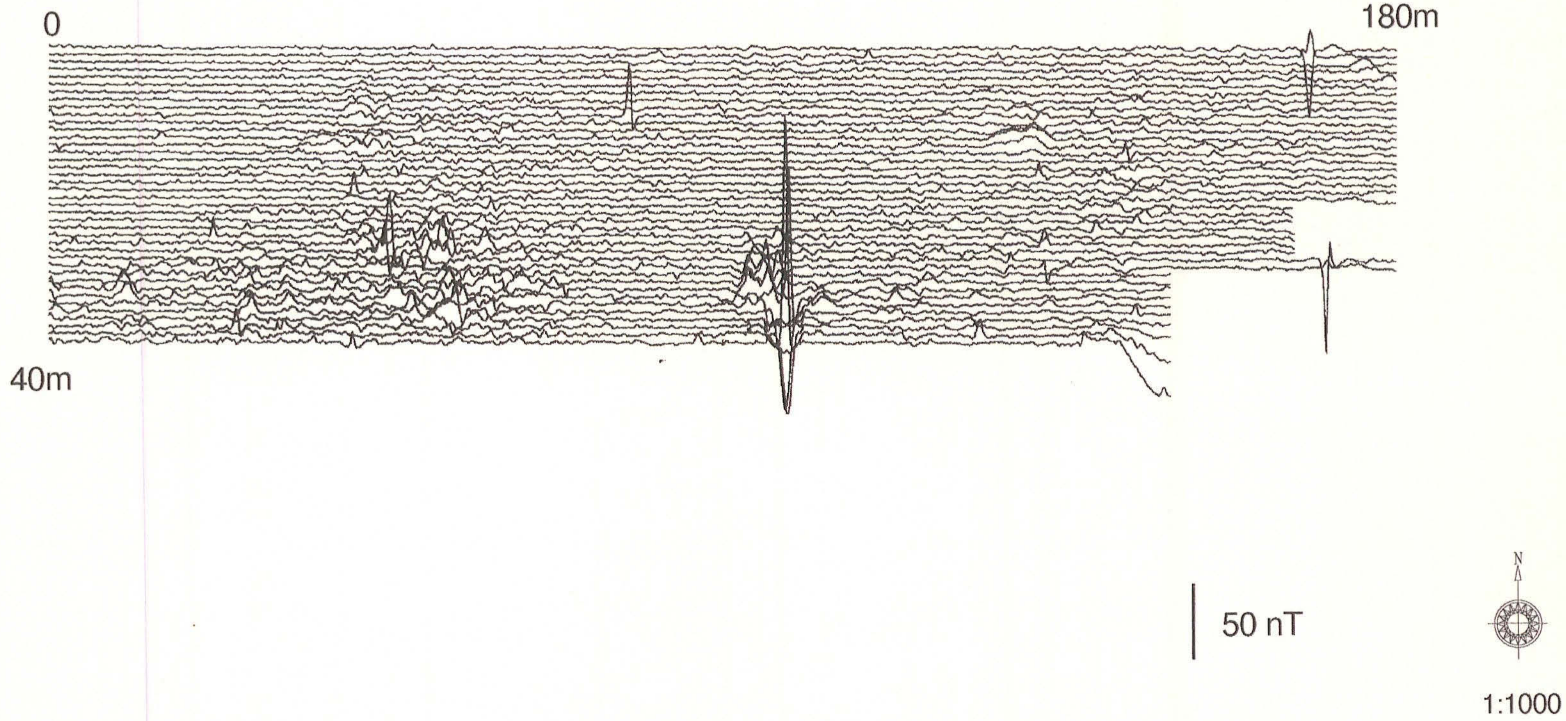


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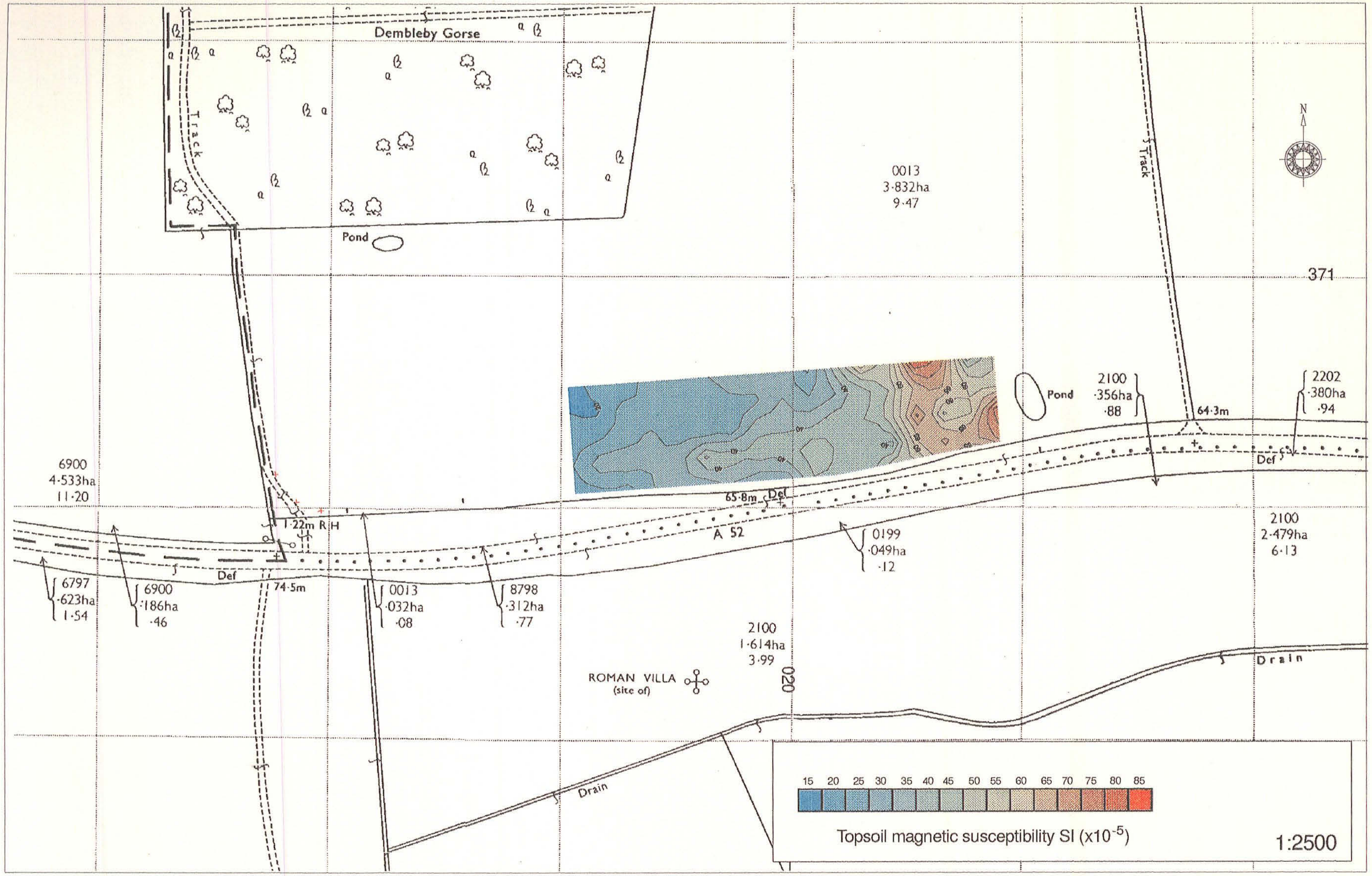
FIG. 4

# Grantham Pipeline: archaeological geophysical survey




Topsoil magnetic susceptibility

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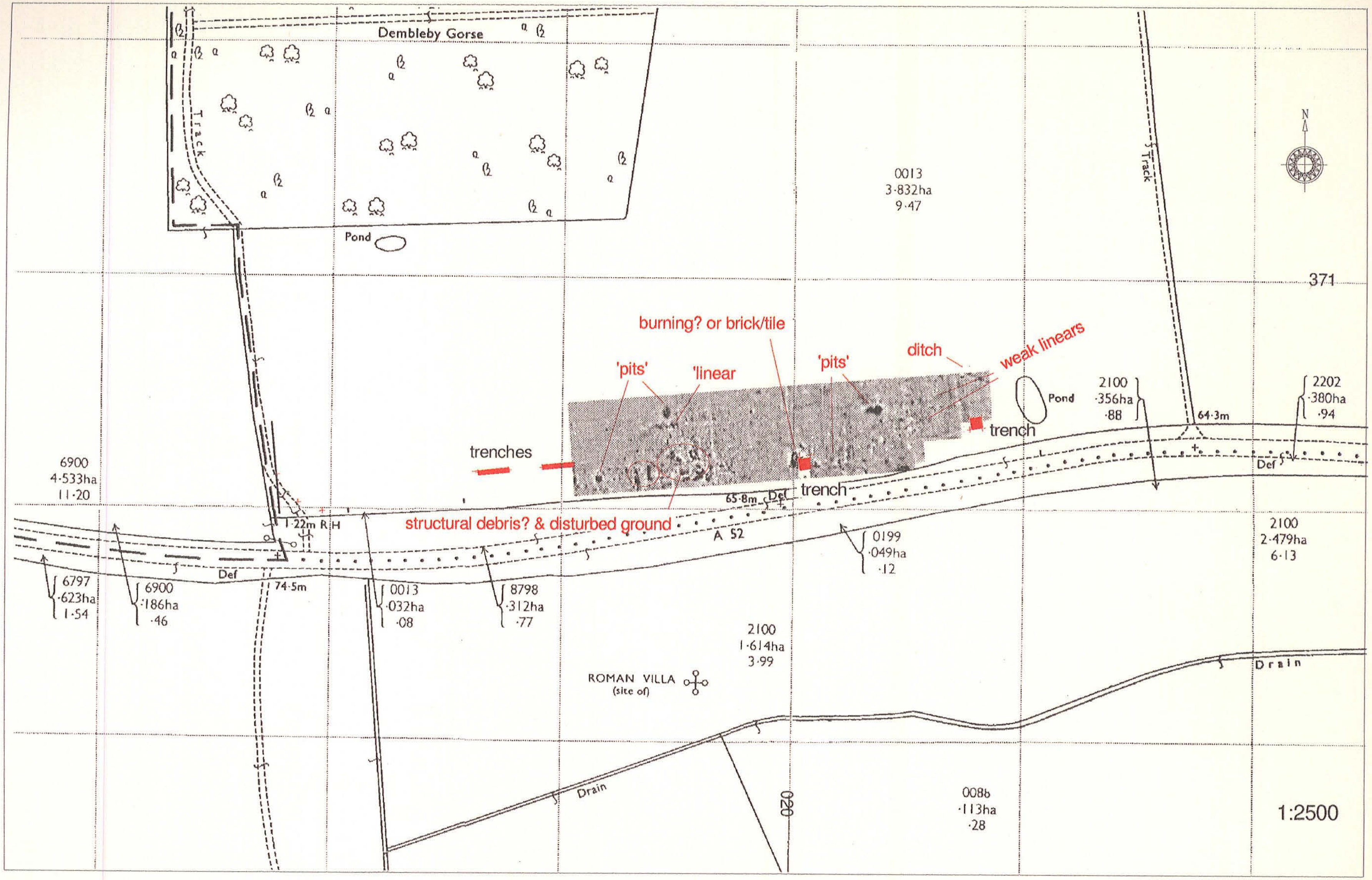
FIG.5

# Grantham Pipeline: archaeological geophysical survey




Gradiometer survey: overview

FIG.6

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Specialist Archaeological Field Evaluation

## INTERNAL QUALITY CHECK

| | | |
|---|---|---|
| Survey Reference | 1610998 / GRL / APS | |
| Primary Author | [signature] | Date 30/9/98 |
| Checked By | APJ | Date 30-9-98 |
| Checked By | | Date |
| Further Corrections | | Date |

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