Newbridge Quarry Extension
Pickering
North Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering 19 hectares was carried out on arable farmland north of Newbridge Quarry in advance of a proposed northward extension to the current quarrying operation. The survey has clarified the extent and morphology of the system of fields, trackways and enclosures that had previously been identified as cropmarks. The survey also clearly demonstrates the continuation of the pattern of settlement and enclosure revealed immediately to the south during the several excavations undertaken in advance of the quarries phased northward expansion. The survey shows that archaeological activity seems to be confined to the western half of the proposed extension area with little or no evidence of activity in the eastern part of the site.

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Report Information

Client:	Cemex UK, Cemex House, Coldharbour Lane, Thorpe, Surrey TW20 8TD
Report Type:	Geophysical survey
Location:	Pickering
County:	North Yorkshire
Grid Reference:	SE 7990 8670
Period(s) of activity represented:	Iron Age/Romano-British, post-medieval
Report Number:	1770
Project Number:	3143
Site Code:	NQE07
Planning Application No.:	Pre-determination
Museum Accession No.:	-
Date of fieldwork:	September 2007
Date of report:	February 2008
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Authorisation for distribution: ---

ISOQAR ISO 9001:2000
Certificate No. 125/93

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1 Introduction and archaeological background

Archaeological Services WYAS was commissioned by Stewart Mitchell, Principal Planner at Cemex UK to carry out a geophysical (magnetic) survey on agricultural land north of Newbridge Quarry, near Pickering in advance of a proposed northward extension to the operating limestone quarry.

Newbridge Quarry lies approximately 1 km north-east of Pickering close to the southern edge of the North York Moors National Park (see Fig. 1). The proposed extension site lies at a height of between 90 and 105m OD, overlooking the Vale of Pickering to the south, and is centred at SE 7990 8670. It is located to the west and north of the listed structure of New Hambleton farm. The site comprised three fields bounded to the west by Swainsea Lane and the disused Old Hag Quarry, Haugh Wood to the east and north-east with open agricultural fields to the north-west and is approximately 220m north of the current quarry site.

The soils of the area are classified in the Elmton 2 association being described as shallow, well-drained, brashy calcareous fine loams over limestone. The solid geology is exposed in the quarry and is comprised of Upper Calcareous Grit (Upper Oxfordian Stage).

The survey was carried out in September/October 2007, following the harvest, when ground conditions were ideal. No problems were encountered during the survey.

Between 1999-2006 the limestone extraction at Newbridge Quarry has been preceded by a series of extensive archaeological excavations. The open–area excavations, largely carried out by Archaeological Services WYAS, have covered a total area of about 7.5 hectares in a long north-south linear strip approximately 500m long and 150m wide (see Fig. 2). These investigations have identified several phases of occupation dating from at least the earlier Iron Age to the early post-Roman period. The activity in all periods seems to have focussed upon a meandering trackway, defined by parallel ditches, which ran longitudinally north/south through the quarry extraction area (Signorelli and Roberts 2006).

The earliest activity takes the form of an open settlement comprising round houses and more enigmatic sub-circular and square enclosures. These were succeeded by a series of later Iron Age and Romano-British rectangular ditched settlement enclosures appended to the trackway ditches at different places, to form what has been termed a ‘ladder settlement’, although strictly not all the enclosures were co-existant.

Post-Roman activity is represented by the post-holes of a palisade enclosure, but moreover by the presence of some 30 cremation burials and three inhumations. The cremated remains were not found in urns and had all been inserted into holes cut in the fills of the trackway ditches. The inhumations, which are probably of a different period, were within stone-lined graves. A stone-lined crop drier cut into the trackway ditch fill may well be contemporary with the graves.

2 Methodology and presentation

The general aims of the survey were to obtain information that would contribute to an evaluation of the archaeological significance of the proposed extension area. This information would then enable further evaluation and/or mitigation measures to be designed in advance of the proposed quarry extension.

More specifically the aims of the survey were to:-

- provide information about the nature and possible interpretation of any geophysical anomalies identified by the survey;
- determine the presence or absence of buried archaeological remains in the areas that would be affected by the proposed quarrying.

In order to achieve these aims Gail Falkingham at the Heritage Unit of the North Yorkshire County Council advised that a geophysical survey be undertaken across the whole of the proposed extension area, including areas of topsoil storage and bunds, in advance of the determination of the planning application. This comprised an area of 19 hectares.

Detailed survey employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on traverses 1m apart. These readings are stored in the memory of the instrument and are later downloaded to computer for processing and interpretation. Further details are given in Appendix 1. Detailed survey allows the visualisation of weaker anomalies that may not be readily identifiable by less rigorous evaluation techniques such as magnetic scanning.

A Bartington Grad601 magnetic gradiometer was used during the survey with readings being taken at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m grids. The readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation using Geoplot 3 software.

The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David 1995) and by the IFA (Gaffney, Gater and Ovenden 2002). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figure 2 shows the processed magnetometer data superimposed onto an Ordnance Survey map base at a scale of 1:5000. The processed (greyscale) data and a composite showing the interpreted archaeological features are presented in Figures 3 and 4 respectively. The processed and unprocessed (XY traceplot) data, together with accompanying interpretation diagrams, are presented at a much larger scale (1:1000) in Figures 5 to 22 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive.

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

3 Results and discussion

Summary

The site has been split into five sectors for presentation purposes. From Figure 4 it can be seen that the eastern part of the site is virtually devoid of archaeological anomalies. However, to the western edge of the site five enclosures can be quite clearly seen, inside one of which is a very strong rectangular anomaly indicative of a structure, perhaps burned *in situ*. The trackway identified in the excavations to the south can also be seen continuing through the survey area. Other linear anomalies define the boundaries of former fields. A circular ring ditch anomaly can also be seen.

Field 1 and Field 2 (Figs 5 to 13 inclusive)

Non-archaeological anomalies

To the north of Field 2, as well as (but to a lesser extent) in Field 1 numerous parallel, linear trend anomalies can be seen aligned north-north-west/south-south-east parallel with the existing, western, field boundary. These anomalies are caused by modern ploughing.

In Field 1 numerous 'iron spike' anomalies can be seen throughout the field with several more extensive areas of magnetic disturbance noted particularly towards the southern end of the field. These anomalies are thought to be due to modern activity associated with New Hambleton Farm.

Several vague, ephemeral, linear anomalies have also been identified in both these fields and in Field 3 to the west. The linearity might suggest an anthropogenic cause but examination of first edition and later mapping, as well as earlier tithe maps, has not identified any boundary features on these alignments. Consequently these anomalies are interpreted as probably being geological in nature, possibly due to fissures in the bedrock being filled with sub-soil.

Archaeological anomalies

Only a single archaeological anomaly has been identified in either of these two fields, this being the continuation of an east/west aligned linear anomaly due to a former field boundary ditch described in more detail below.

Field 3 (Figs 14 – 22 inclusive)

As in Fields 1 and 2 linear, ploughing anomalies can be seen across all parts of the field – those to the south-eastern corner are particularly prominent.

In the western half of the field a series of linear, conjoining, anomalies can be clearly discerned. These anomalies are caused by infilled, cut ditch features that together form a coherent system of fields, trackways and enclosures.

Five enclosures of varying size and shape have been identified. At the northern end of the field three sides of a square enclosure (Enclosure 1) measuring 40m by 40m can be seen. A single linear ditch extending northwards from the north-western corner of the enclosure suggests that the complex extends beyond the bounds of the current site.

Twenty metres to the south of Enclosure 1 a rectangular enclosure (Enclosure 2), measuring 45m by 30m, has been identified and this is linked to Enclosures 3, 4 and 5 by other linear field boundaries, one of which extends due east and is the only archaeological anomaly identified in Field 2 (see above). All the enclosures are aligned on the cardinal points of the compass.

Both Enclosure 1 and Enclosure 2 are bisected by vague linear anomalies aligned broadly north-west/south-east. As the alignment of both these anomalies is at variance with the archaeological anomalies (see below) with no obvious connection it is difficult to give a confident interpretation but on balance non-archaeological causes are considered most likely.

Inside Enclosure 4, which is itself contained within a much larger enclosure (Enclosure 5), is a distinctly rectangular anomaly (15m by 8m) in the north-west corner. The size and shape of this anomaly could suggest the presence of a building.

Linked to the south-west corners of Enclosures 4 and 5 are two parallel linear anomalies that are caused by ditches either side of a trackway. This trackway is the same feature that has been seen in all the phases of excavation undertaken in advance of previous phases of quarry expansion. Extending west from the trackway are two ditched boundaries delineating three sides of a large field, in the middle of which is circular anomaly, approximately 8m in diameter. This feature is possibly a ring barrow. Extending east from the trackway is another linear ditch type anomaly that demonstrates that the field system also extends to the eastern side of the trackway.

4 Conclusions

The magnetometer survey has confirmed and clarified the extent and morphology of the system of fields, trackways and enclosures that had previously been identified as cropmarks following analysis of air photographs of the area. This archaeological activity seems to be confined to the western half of the current survey area with little or no evidence of activity in the eastern part of the site.

These features clearly demonstrate the continuation of the pattern of settlement and enclosure revealed following the several phases of excavations undertaken in advance of the quarry's continued northward expansion over the last five years. Activity seems to be focussed on the trackway that meanders from broadly north/south through the site with enclosures appended to the eastern side to form a 'ladder settlement' that is thought to date to the late Iron Age/Romano-British period. Possible earlier activity may be inferred from the identification of a possible round barrow towards the western edge of the site.

Intrusive trial trench investigation of similar sites on limestone geologies following geophysical survey suggests that there are likely to be more archaeological features present, particularly discrete features such as pits or post-holes, than have been identified by the current survey.

The survey has confirmed that about half of the proposed extraction area is located in an area of high archaeological potential. The remaining eastern part of the site would seem to have little obvious potential.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

Appendix 1: Magnetic survey: technical information

Magnetic Susceptibility and Soil Magnetism

Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

Types of Magnetic Anomaly

In the majority of instances anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geological substrates.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic ‘spiky’ trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. An agricultural origin, either ploughing or land drains is a common cause.

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an ‘iron spike’ anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

Methodology: Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

Methodology: Gradiometer Survey

There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as ***magnetic scanning*** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey.

The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect. The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected. If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features. The possible drawbacks mentioned above mean that a 'negative' scanning result should be validated by sample detailed magnetic survey (see below).

The second method is referred to as ***detailed survey*** and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.25m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 20m by 20m square grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

An XY plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a ‘stacked’ plot. A hidden line algorithm has been employed to block out lines behind major ‘spikes’ and the data has been clipped. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the ‘shape’ of individual anomalies can be discerned and potentially archaeological anomalies differentiated from ‘iron spikes’. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2: Survey location information

The site grid was laid out using a Geodimeter 600s total station theodolite and tied in to the corners of buildings and other permanent landscape features and to temporary reference points (survey marker stakes) that were established and left in place following completion of the fieldwork for accurate geo-referencing. The locations of the temporary reference points are shown on Figure 2 and the Ordnance Survey grid co-ordinates tabulated below. The internal accuracy of the survey grid relative to these markers is better than 0.05m. The survey grids were then superimposed onto a map base provided by the client as a 'best fit' to produce the displayed block locations. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than ±1.5m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes.

Station	**Easting**	**Northing**
A	479924.1	486672.0
B	479664.5	486535.4
C	479887.9	486828.6
D	480076.9	486791.4

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator, CorelDraw6 and AutoCAD 2000) files.
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the relevant Sites and Monument Record Office).

Bibliography

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