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SILBURY HILL ENVIRONS, AVEBURY, WILTSHIRE. Report on Geophysical Survey, February 2005

A Payne, N Linford, P Linford and L Martin

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Summary

A geophysical survey was carried out immediately east of Silbury Hill in an attempt to identify any significant archaeological activity in this area and assist the wider interpretation of the monument within a landscape context, in advance of ongoing conservation works to stabilise the mound. An extensive caesium magnetometer survey was conducted and successfully recorded a wide range of anomalies. Many of these anomalies appear to result from the variable geology of the river valley location on the floodplain of the Winterbourne stream (or river Kennet). However, immediately east of Silbury Hill a series of linear magnetic anomalies indicate the presence of a complex of ditched enclosures and associated occupation activity. More weakly defined anomalies suggest the presence of further enclosures extending under deposits of alluvium running up to the present course of the Winterbourne stream. These results suggest that the Romano-British activity previously recorded beyond the survey area, directly east of the Winterbourne, may extend up to the external quarry ditch around Silbury Hill. A more limited earth resistance survey provides additional evidence for possible structural features within the enclosures identified by the magnetic survey.

Keywords

Geophysical Survey
Magnetometer
Caesium Vapour
Fluxgate
Gradiometer
Earth Resistance

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SILBURY HILL ENVIRONS, AVEBURY, WILTSHIRE

Report on Geophysical Survey, February 2005

Introduction

A geophysical survey was carried out to the east of Silbury Hill (NGR SU 100685, SAM 21707) in an attempt to identify any significant archaeological activity in the area. It was hoped that the results would contribute to the wider interpretation of the monument within a landscape context and help to mitigate any possible damage to surviving archaeological remains, should further works be required to assist with the conservation of the monument. In addition, the survey would contribute to one of the aims of the Avebury World Heritage Site Archaeological Research Agenda to explore the environs of Silbury Hill for contemporary and later features by the use of non-invasive techniques (David 2001).

The survey area is divided into two pasture fields (Areas 1 and 2; Figure 2) and extends from the eastern ditch or quarry of Silbury Hill across the alluvial floodplain of the Winterbourne (the upper part of the river Kennet) up to the modern course of the river. The floodplain area is crossed by a number of drainage channels, consisting of open ditches and gullies (dry at the time of the survey) in the northern of the two fields, but filled-in and levelled over where they continue into the southern field. The drift geology in the south and western part of the survey area bordering the hill consists of valley gravels, overlain by an increasing depth of alluvium to the north and east towards the river. The underlying solid geology consists of Cretaceous middle chalk (Institute of Geological Sciences 1974). Local soils are of the Frome association consisting of shallow loamy soils over flint gravel or over chalky and gravelly river alluvium (Soil Survey of England and Wales 1983).

Immediately beyond Area 2, directly north-east of the Winterbourne on the western flank of Waden Hill, parch-marks interpreted as Roman settlement remains were identified from aerial photography in 1995 (Chadburn and Pomeroy-Kellinger 2001; Pollard and Reynolds 2002, Fig.70). Archaeological evidence was also recorded in this area during the construction of a sewer pipeline in 1993 (Corney 1997; Powell *et al.* 1996). Remains of at least 5 separate Roman buildings were uncovered in the pipeline easement, located at regularly spaced intervals in a line running north from the A4 road along the eastern bank of the Winterbourne up to the area containing the parch-marks. It was hoped that the current geophysical survey might reveal whether this Roman activity continued to the west of the Winterbourne, where cropmarks are unlikely to appear through the overlying alluvium.

Due to the presence of significant alluvial overburden a further methodological goal of the survey was to test the application of high sensitivity caesium vapour magnetometers under conditions where traditional fluxgate instruments are often compromised.

Method

The survey of Areas 1 and 2 was conducted with an array of four specially-modified high sensitivity Scintrex SM4 caesium vapour magnetometer sensors mounted on a non-magnetic cart system (Figure 1). Readings were collected at a sample interval of 0.5m x 0.125m based on a 100m grid set out using a differential Global Positioning System (GPS).

Figure 1
The cart-mounted array of caesium magnetometer sensors in Area 1 with Silbury Hill in the background.

The combined caesium magnetometer data is presented as linear grey tone images in Figures 3 and 6 and traceplots (employing different vertical scales to emphasize stronger and weaker anomalies respectively) in Figures 4 and 5. A one-dimensional (1D) high-pass median filter was employed orientated parallel to the traverse direction to correct for drift caused primarily by short timescale changes in the strength of the Earth's magnetic field, using a window width of either 20m or 30m depending on the rate of drift evident in the data. In addition, a cross-line 1D median filter of window width 5m or 10m was simultaneously used to preserve linear anomalies running parallel to the north-south traverse direction (P Linford *pers. comm*.). Any remaining mis-match between adjacent blocks of survey data was corrected by applying a 1D high-pass median filter of window width 10m parallel to the direction of the mismatched edge. Only areas of data in each block near to the common edge were processed in this way. The output values were a weighted combination of the original data and the median filtered data with the weighting being modified linearly to favour the original data with increasing distance from the edge in question.

The total field caesium magnetometer data was augmented by a narrow strip of fluxgate gradiometer survey at the southern extremity of Area 1, adjacent to the A4 road (Figure 2). This area was left un-surveyed by the caesium system due to the ferrous interference from the boundary fence and passing traffic on the road. This effect may be minimised by using a differential gradiometer configuration and data was acquired using a Bartington Grad601 dual sensor fluxgate gradiometer. Readings were collected on a 30m grid using the 200 nanotesla per metre (nT/m) range setting of the magnetometer (recording data to the nearest 0.1 nT/m). Measurement points were at 0.25m intervals along north-south orientated traverses spaced 1.0m apart. Subsequent processing of the data involved initial truncation of

the recorded data range to remove extreme readings (values above and below 100 nT/m) caused by the ferrous disturbance. Drift correction was then applied to the truncated data using a zero mean traverse processing method.

An additional earth resistance survey was carried out in Area 1 over a 60m x 60m square containing negative linear anomalies in the magnetic data, possibly indicative of buried masonry structures (Figures 2 and 7). This area of raised ground is also located near to the position of a well first recorded in the late nineteenth century (Brooke and Cunnington 1896) and believed to be of Roman date (*cf* Pollard and Reynolds 2002, Fig. 70; Corney 2001).

The earth resistance survey was conducted with a Geoscan RM15 resistivity meter using a twin electrode array with a 0.5m mobile probe spacing. Readings were recorded at 1.0m intervals over a 30m grid. Plots of the raw data and the data after the application of a 3m radius Gaussian high-pass filter are presented on Figures 8 and 9. The high pass filter was applied to remove large scale variation in background resistance due to geological effects, giving greater emphasis to smaller scale variation of earth resistance more likely to be associated with buried archaeological features.

Results

i) Caesium total field magnetometer survey

The results of the caesium magnetometer survey present a rather confusing picture having been influenced by natural soil changes (linked to the variable geology of the river valley location) and man-made disturbance of recent origin associated with modern drainage as well as responses to buried archaeological features.

Anomalies of uncertain origin

In the western half of the survey, over the area of gravel terrace, the magnetic background is very variable. The gravel terrace is characterised by broad rectilinear areas of increased magnetic response [**m1-7** on Figure 7] flanked in some places by reduced or negative magnetic anomalies [**m7 and m8**]. Within and around these broader regions of varying magnetic background response are numerous smaller but more pronounced positive magnetic anomalies [**m9**]. Although smaller, these positive anomalies [**m9**] still suggest the presence of substantial causative features.

The broad areas of heightened and reduced magnetic response are most probably a result of natural variations in soil magnetism linked to the depositional environment of the floodplain location - possibly representing simple changes in soil type or natural undulations in the former land surface that have filled up differentially with river borne sediments. However their archaeological potential should not be dismissed entirely as they do exhibit some symmetry of form (in particular anomaly [**m1**] and to a lesser extent [**m2**]). If anthropogenic, one possible explanation of these anomalies could be that they correspond with slight traces of earthwork features (such as platforms or perhaps even barrows) associated with occupation activity.

The material from which the central core of Silbury Hill was constructed may also provide a further possible clue to the origin of some of the anomalies in the survey. Previous excavation of the original central turf mound at the core of Silbury Hill (explored by the 1849 Merewether tunnel) showed that it contained fresh water mollusc shells (McOmish *et al.* 2005, p26) indicating that the material was obtained from the neighbouring floodplain environment (Geddes and Walkington 2005, p65). The extraction of the original material used in the construction of the hill may have left traces of ground disturbance in the fields between the Winterbourne and Silbury Hill recorded by the magnetic survey.

Anomalies of probable archaeological origin

The south-western part of Area 1 also contains a number of linear magnetic anomalies [**m11-13**], perhaps superimposed on the broader background magnetic variations described above. These linear anomalies display a regular arrangement suggestive of a group of rectilinear ditched enclosures and are particularly concentrated in Area 1 along-side the course of the Mildenhall to Bath Roman road, close to the route now followed by the modern A4. A further probable enclosure [**m14**] lies further out on the floodplain nearer the Winterbourne to the east over an area of fairly uniform background response and appears to contain a weakly defined semi-circular positive anomaly [**m15**]. Numerous localised positive magnetic anomalies in the areas within and adjacent to the enclosure features [for example **m16-18**] may also indicate associated occupation features, such as pits and quarries.

Further more diffuse linear anomalies are present over the floodplain where the background magnetic response is far more uniform and less disturbed due to the alluvial overburden. These anomalies [**m19-23**] may represent further ditched enclosures and boundaries closer to the course of the river and their weak response suggests that the causative features are overlain by considerable alluvial deposits. One of the two magnetic anomalies directly west of the Winterbourne, either [**m19**] or [**m20**], is a probable continuation of a similar response mapped in 1992 running into the east bank of the stream on an east-west alignment (Geophysical Surveys of Bradford 1992a; Geophysical Surveys of Bradford 1992b; Powell *et al.* 1996, pp28-9, Figs. 9 and 10). Subsequent excavation by Wessex Archaeology in advance of replacement of the Kennet Valley Foul Sewer Pipeline in 1993 showed that this anomaly corresponded with a wide ditch (Ditch 164, 9.5m wide at the top and 2m deep) of Romano-British date (Powell *et al.* 1996, p37, Plate 6) containing late 1st - early 2nd century AD pottery.

The linear anomaly at [**m21**] in the present survey may also represent the continuation of a ditch previously excavated along the route of the foul sewer directly east of the river (Ditch 189, Powell *et al.* 1996, Figs. 9 and 10). This feature was recorded as a substantial east-west ditch 6m wide and 1.12m deep sealed by deep hill-wash 1.1m thick but was not detected by the initial gradiometer survey, presumably because of the thickness of the overlying colluvium. The detection of this feature in the current survey immediately west of river may be due to a combination of either the greater sensitivity of the caesium sensors or a considerable decrease in the soil depth overlying the ditch on the western side of the stream. A further ditch feature, Ditch 253, recorded running longitudinally along

the pipe trench on the opposite side of the stream, follows a very similar alignment to the linear response forming the central strut of the 'H'-shaped anomalies at [**m23**]. Ditch 253 was sealed by a 0.3m deep layer of brown silt loam hill-wash and the finds from the upper fill included late Roman pottery forms dated to the 4th and 5th centuries AD. Both the excavated ditch and the group of anomalies at [**m23**] also share a similar orientation to the Waden Hill parchmarks (Chadburn and Pomeroy-Kellinger 2001, Fig. 14; Pollard and Reynolds 2002, Fig. 70).

Two further possible ditch type anomalies [**m24** and **m25**] are present in the smaller detached area of the survey south of the drainage channel in Area 2, both aligned northeast to southwest.

Between the two enclosure ditches [**m13**] and [**m14**] a rectilinear arrangement of negative linear anomalies [**m26**] may indicate the presence of masonry building remains in the vicinity of a probable Roman well (Pollard and Reynolds 2002, p178).

Riverine and geological anomalies

A narrow linear negative magnetic response [**m27**] running through Area 1 close to the enclosure anomalies [**m13**] and [**m14**] appears to correspond with the boundary between the valley gravel or chalk deposits nearer the hill and the alluvium over the floodplain to the east. This transition is more clearly marked in the resistivity survey (see below).

In Area 2, the background magnetic response is generally extremely quiet (+/- 1.5nT) and uniformly undisturbed, reflecting the presence of alluvial soils. The weak magnetic response in this area is, however, interrupted by a strong positive and negative linear anomaly at [**m28**], that may well represent the course of a palaeochannel or other geomorphological feature formed by the migration of the Winterbourne stream. A number of even weaker linear responses [**m29**] are also evident and may represent banding in the alluvial sediments deposited parallel to the course of the river.

Modern disturbance associated with the drainage channels

Extensive spreads of intense magnetic disturbance have been recorded in Area 1 coinciding with the course of a former drainage channel marked on the Ordnance Survey mapping (see Figures 2, 3, 4 and 7). The intense response of these anomalies is probably due to infilling of the ditch with magnetic rubble to create a level surface or otherwise modify the drainage.

Two weak narrow negative linear magnetic anomalies [**m30**] in Area 2 relate to further extant drainage channels consisting of slight linear depressions on the ground not mapped by the Ordnance Survey.

ii) Fluxgate gradiometer survey

The fluxgate gradiometer survey proved an effective means of extending the magnetic coverage as far as the southern fenced boundary of Area 1 with the A4 road. The additional fluxgate data lacks any further evidence for archaeological

activity, although to the east there is a weak linear anomaly [**g1**] that probably forms a continuation of a curvilinear anomaly [**m31**] mapped by the caesium survey. This anomaly may well be geomorphological in origin, perhaps representing a palaeochannel or banding in the alluvial or gravel deposits of the river valley.

iii) Earth resistance survey

The earth resistance survey straddles the change from river gravels along the edge of the valley and the alluvial deposits of the river floodplain (Figures 2, 8, 9c-e and 10). This geological division is marked in the data as an abrupt change in background resistance from high values over the gravel to much lower values recorded over the alluvium to the east. Superimposed over this background variation are some areas of high resistance [Figure 10; **r1**] and a number of fragmented linear anomalies [**r2**]. These correlate with the slight negative linear anomalies [**m26**] found in the magnetometer data and may possibly indicate the presence of building remains (Figures 7 and 10).

One of a series of probable Roman wells discovered by the Wiltshire Archaeological and Natural History Society, lies within Area 1 of the current survey (Pollard and Reynolds 2002; Powell *et al.* 1996) in a central position in the grouping of ditched enclosures [**m11-14**] identified by the magnetic survey and approximately 20m to the southwest of the tentative masonry buildings suggested by the earth resistance data. The position of the well (see Figures 8 and 10) might lend further weight to the possible presence of a Romano British building complex situated towards the centre of the enclosure system revealed by the magnetic survey.

Although a settlement context for the wells is now established, Pollard and Reynolds (2002) suggest that a purely domestic function is unlikely, given their proximity to Swallow Head Springs (the source of the River Kennet) and the Winterbourne along which the Roman settlement lay, and that “a religious ritual function was served by these shafts fitting a known tradition of ritual practice both during the Roman period and earlier in the Iron Age”.

Of the four known wells, two have been excavated, both on the south side of the modern A4 road outside the geophysical survey area (Brooke 1910; Brooke and Cunnington 1896; Corney 2001, p29). Besides their rather odd positioning in a radius around the hill, the contents of the excavated wells are of considerable interest. One was about 9m deep and contained, amongst other finds, dressed stone blocks and the base of a stone column along with a bronze finger ring, an iron stylus, an iron hook and half a pair of shears and some coins. The dating of the coins is of great significance for the duration of the Roman activity at Silbury, (one is of the emperor Arcadius (AD 383-95) and another of Theodosius (AD 378-95), suggesting activity into the fifth century in agreement with the more recent archaeological evidence from the adjacent Silbury settlement. The other excavated well had been deliberately back-filled and capped with undressed sarsen (Brooke 1910). Potential votive activity, including the coins and other material found in Atkinson’s excavations on the south side of the hill (Atkinson 1978; Whittle 1997) parallels the dating of the filling of the well-shafts indicating late Roman interest in the mound from a religious ritual perspective (Pollard and Reynolds 2002, p179).

Conclusions

The alluvial soils and variable drift geology at the site have resulted in a complex set of magnetic results and a contrast between the response recorded over the river terrace deposits to the west and the alluvial deposits closer to the course of the Winterbourne to the north and east. The rather ambiguous nature of these magnetic anomalies is difficult to interpret with confidence, as either an archaeological or geomorphological origin may be equally ascribed to many of these responses. However, an area of reasonably certain archaeological activity containing a probable group of enclosures and associated occupation activity has been detected in the southernmost portion of the site adjacent to the route of the A4 and the former Roman road. These enclosures possibly suggest a continuation of the Romano-British activity to the east of the Winterbourne previously identified from aerial photography and recorded along the course of the foul sewer pipeline in 1993.

The enclosures extend to within 20m of the eastern quarry of Silbury Hill and it is possible that the presence of the earlier monument as well as the Roman road from *Cunetio* (Mildenhall) east of Marlborough to *Aquae Sulis* (Bath) was a significant factor in the siting of the Romano-British activity.

The magnetic response over the heavily alluviated flood plain has, as expected, been extremely weak. However, despite such unfavourable conditions a number of linear and curvilinear responses have been detected by the caesium vapour magnetometer that may well indicate further ditched enclosure features covered by a considerable alluvial overburden.

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L Martin
A Payne

Date of survey: 21-25 February 2005

Reported by: A Payne
N Linford
P Linford
L Martin

Date of report: 24 February 2006

Geophysics Team, English Heritage.

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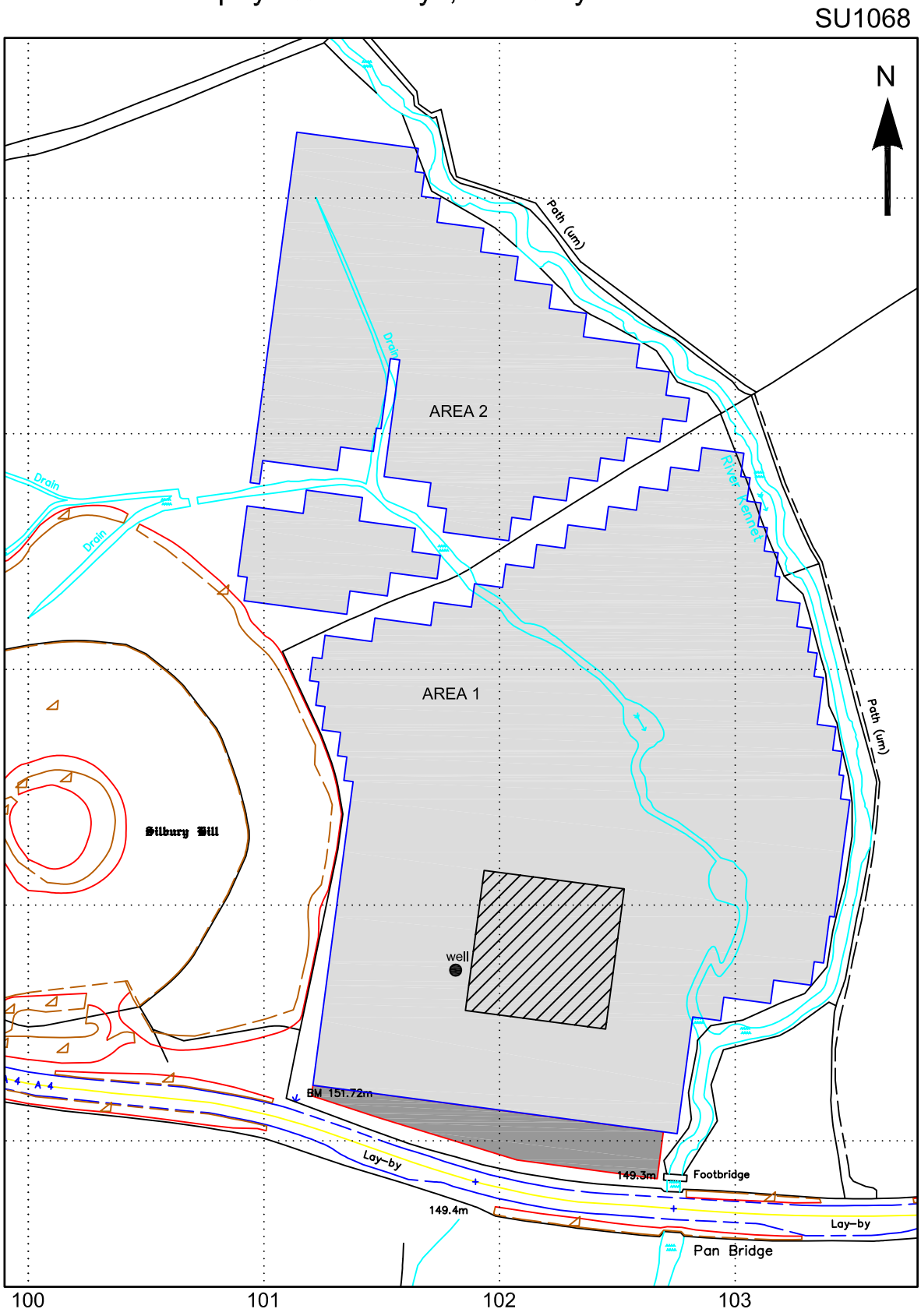
List of enclosed figures

FIGURE 2

SILBURY HILL, WILTSHIRE

Location of Geophysical Surveys, February 2005



SURVEY AREAS

Caesium magnetometer

Fluxgate magnetometer

Resistivity survey

1:2500

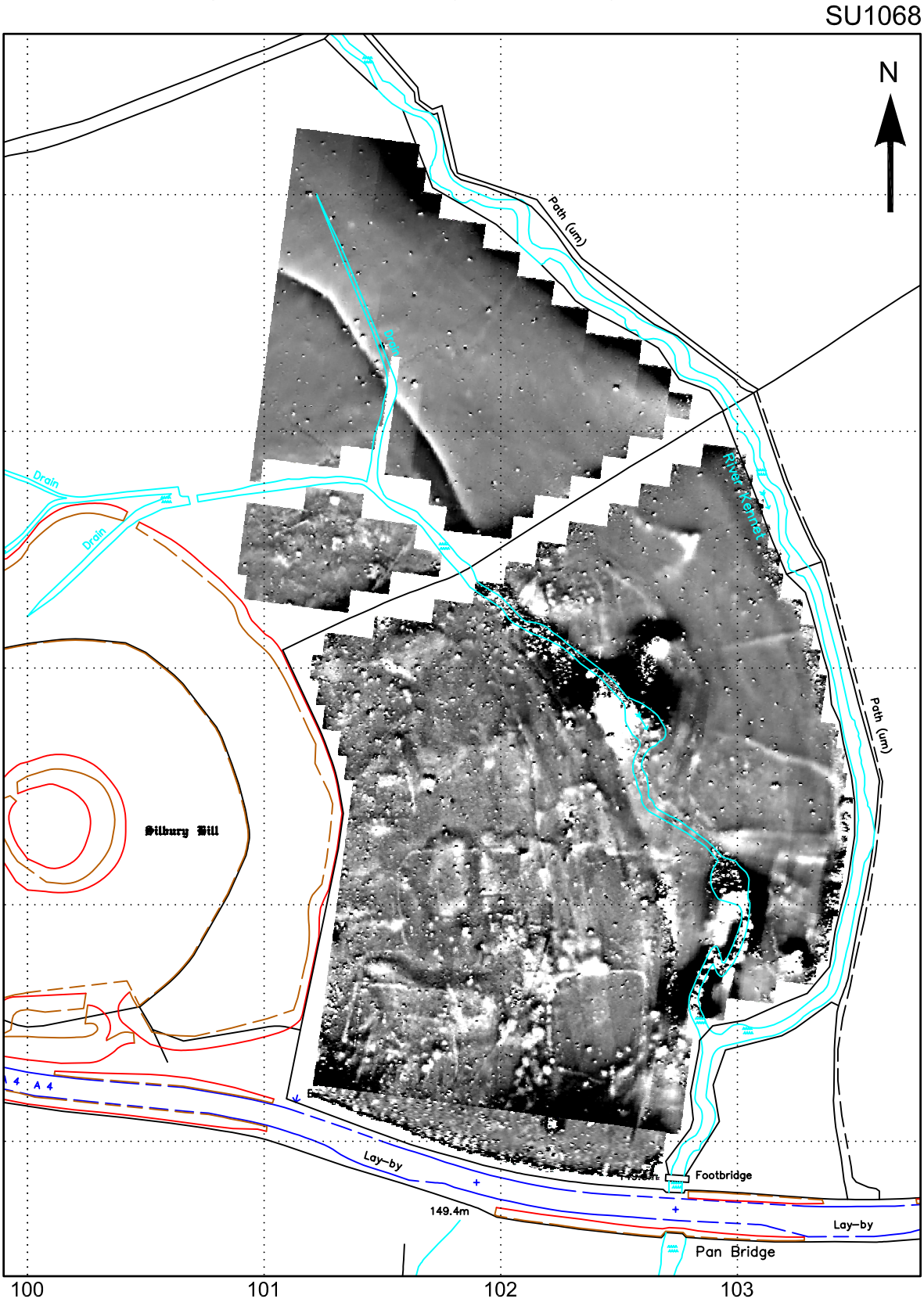
0 30 60 90m

English Heritage 2005

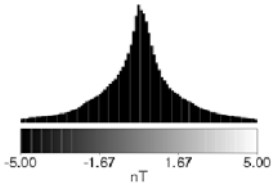
FIGURE 3

SILBURY HILL, WILTSHIRE

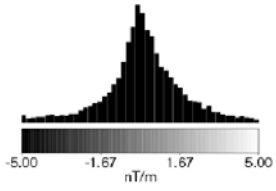
Location of Magnetometer Surveys, February 2005



Caesium



Fluxgate



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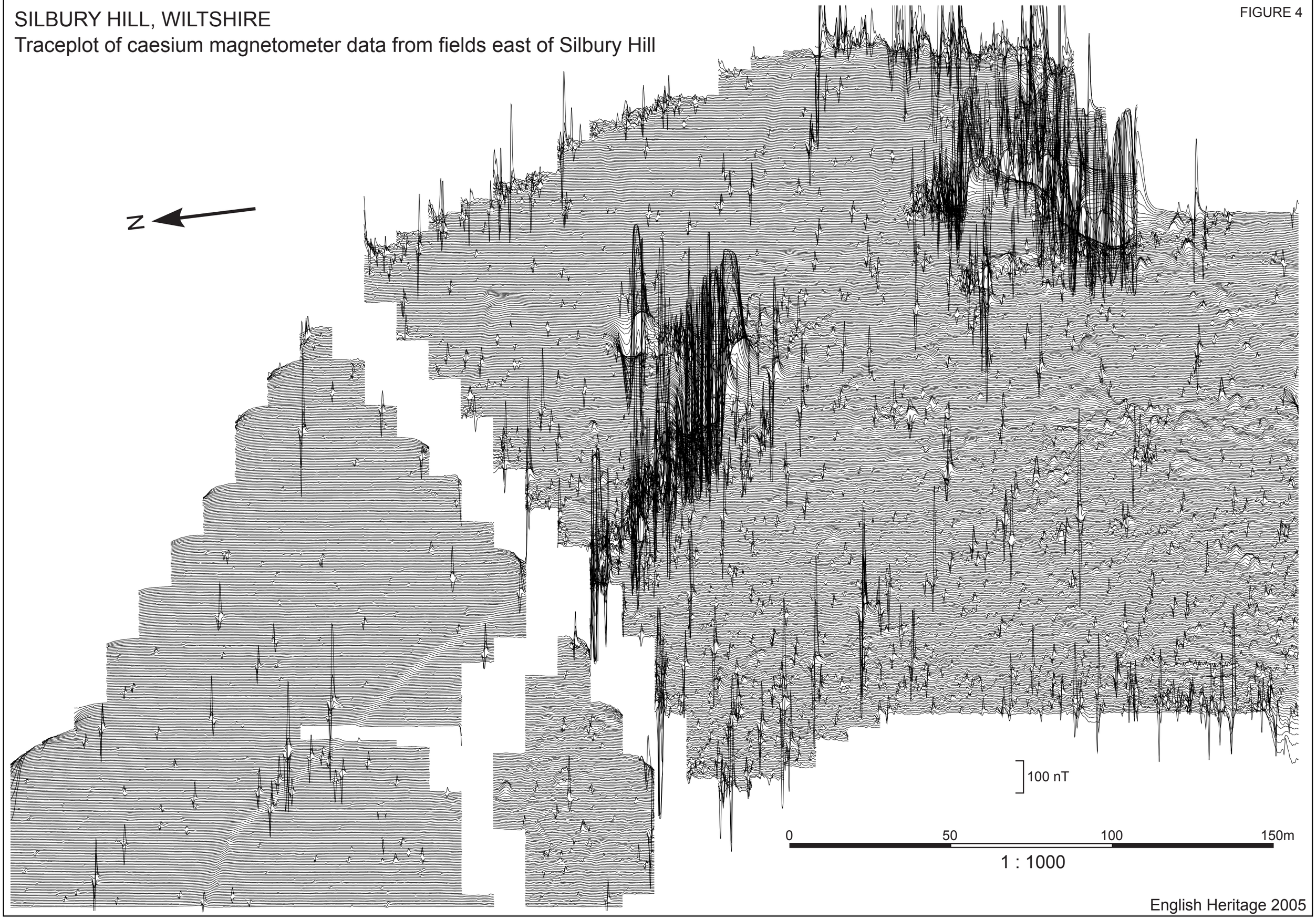
0 30 60 90m

SILBURY HILL, WILTSHIRE

Traceplot of caesium magnetometer data from fields east of Silbury Hill

FIGURE 4



English Heritage 2005

FIGURE 5

SILBURY HILL, WILTSHIRE

Traceplot of caesium magnetometer data from fields east of Silbury Hill after range-truncation (values outside +/- 15 nT) to emphasize more significant archaeological responses over extreme ferrous signals

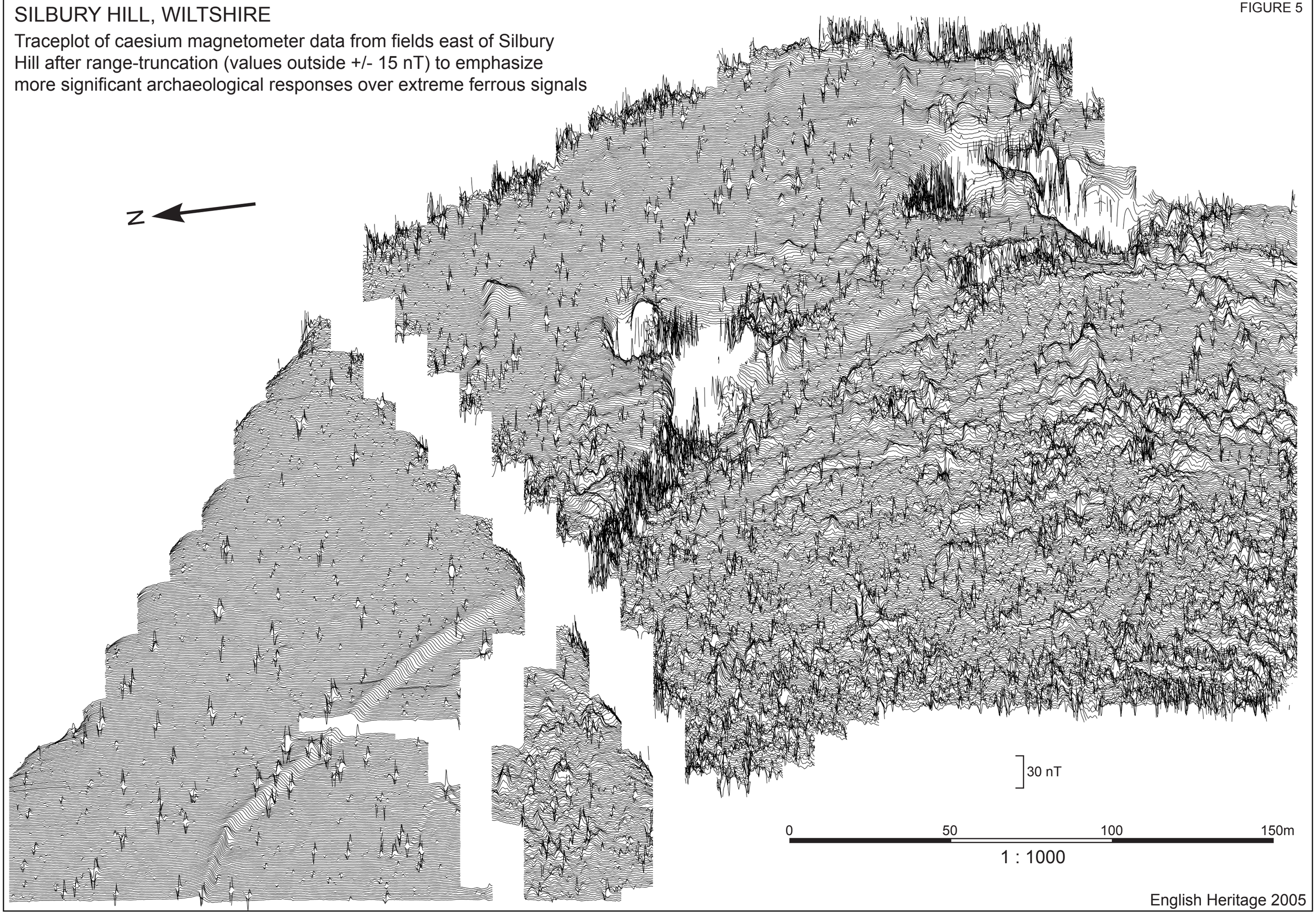
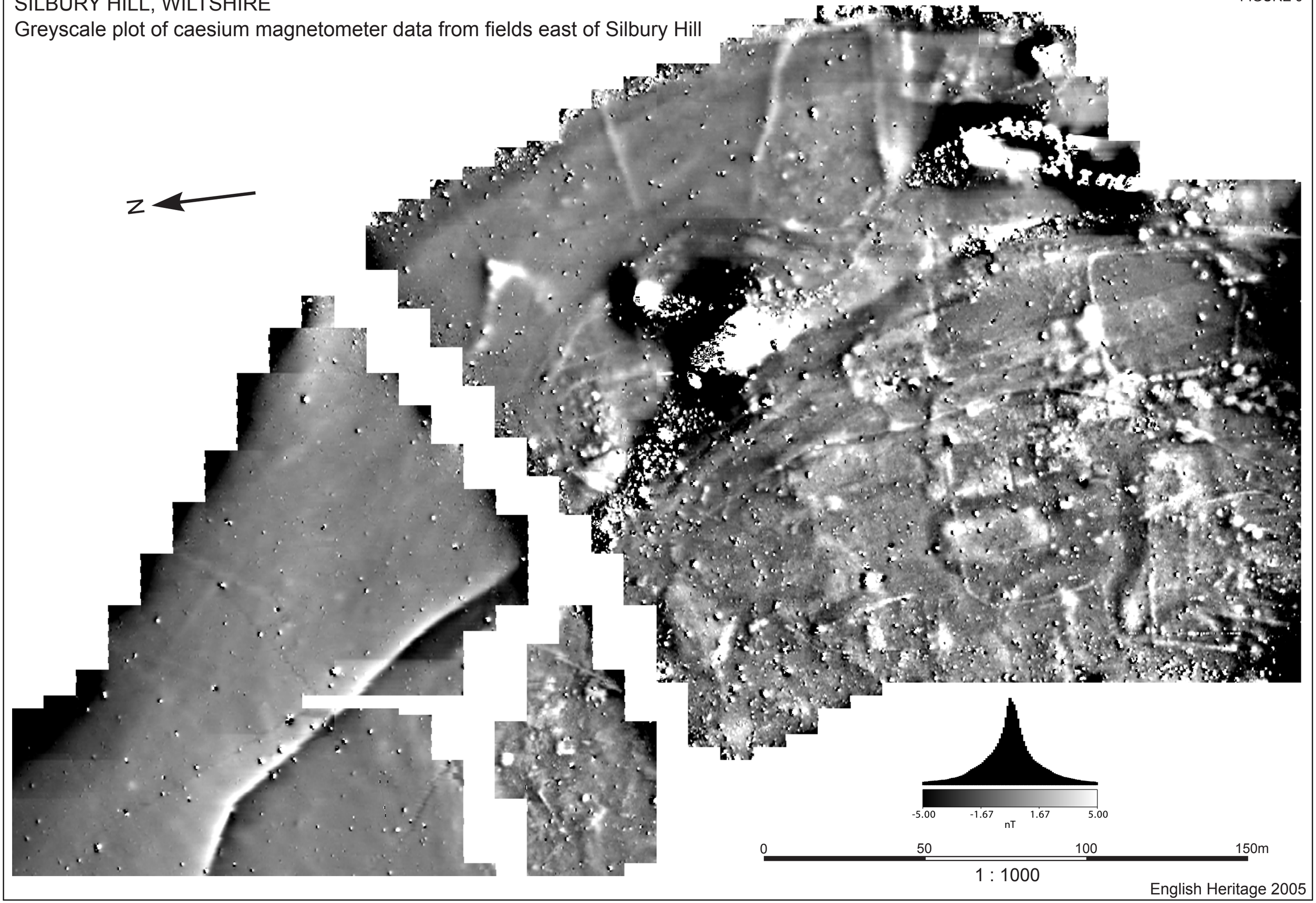


FIGURE 6

SILBURY HILL, WILTSHIRE

Greyscale plot of caesium magnetometer data from fields east of Silbury Hill

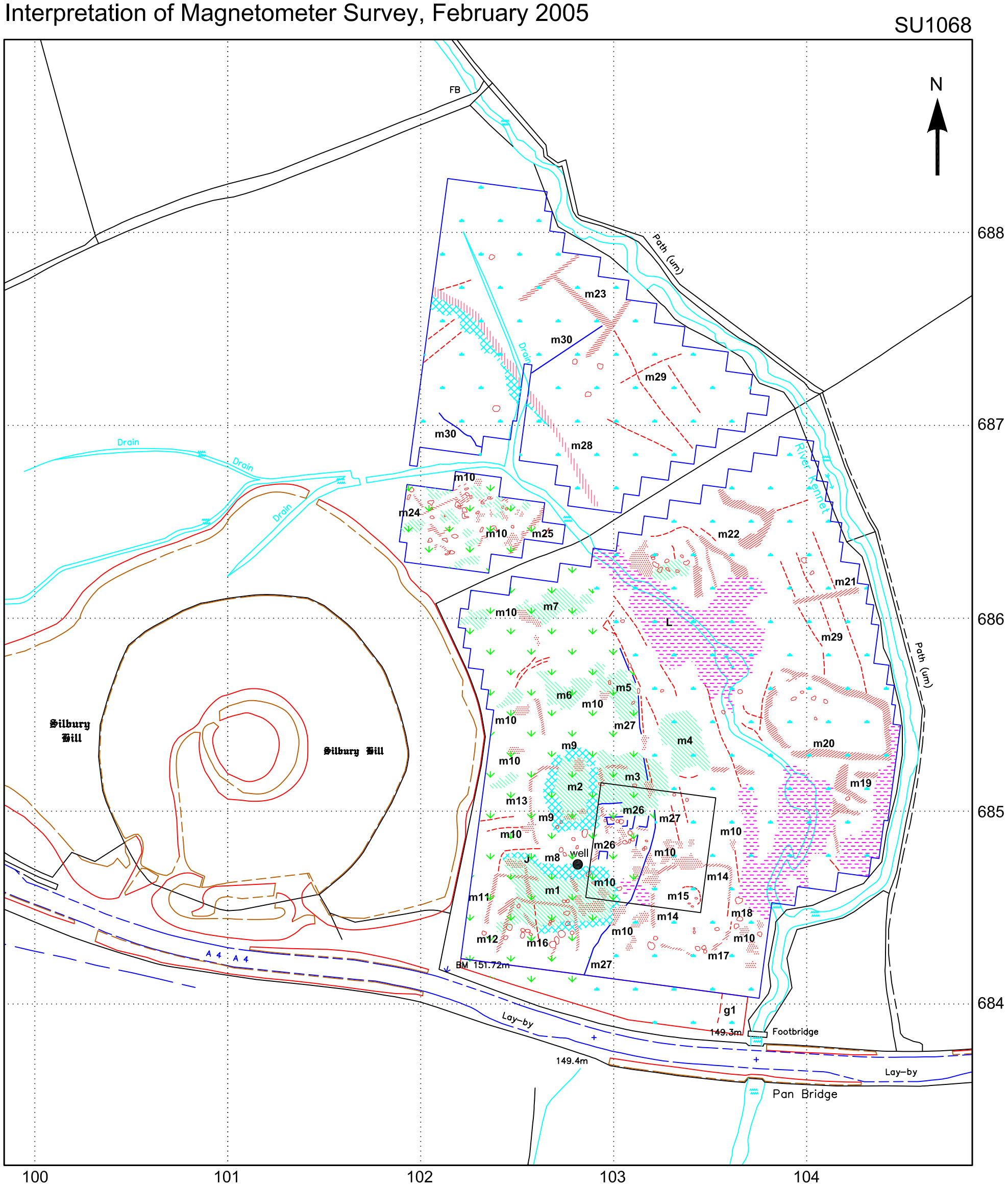


English Heritage 2005

FIGURE 7

SILBURY HILL, WILTSHIRE

Interpretation of Magnetometer Survey, February 2005



INTERPRETATION

- positive linear magnetic anomalies - probable ditches
- tentative positive linear magnetic anomalies - possible ditches, cultivation or riverine features
- large amorphous positive magnetic anomalies - possible quarry features or natural disturbances in the subsoil
- other localised positive magnetic anomalies - pits or natural disturbances in the subsoil
- areas of intense magnetic disturbance
- areas of increased background magnetic response
- areas of reduced background magnetic response
- Riverine feature associated with the migration of the course of the river Kennet
- negative linear magnetic anomalies
- area of river terrace/valley gravel subsoil
- area of alluvial subsoils
- **m1 - 30** specific anomalies referred to in the report

SURVEY AREAS

- Caesium total field magnetometer
- Fluxgate gradiometer
- Twin electrode resistivity

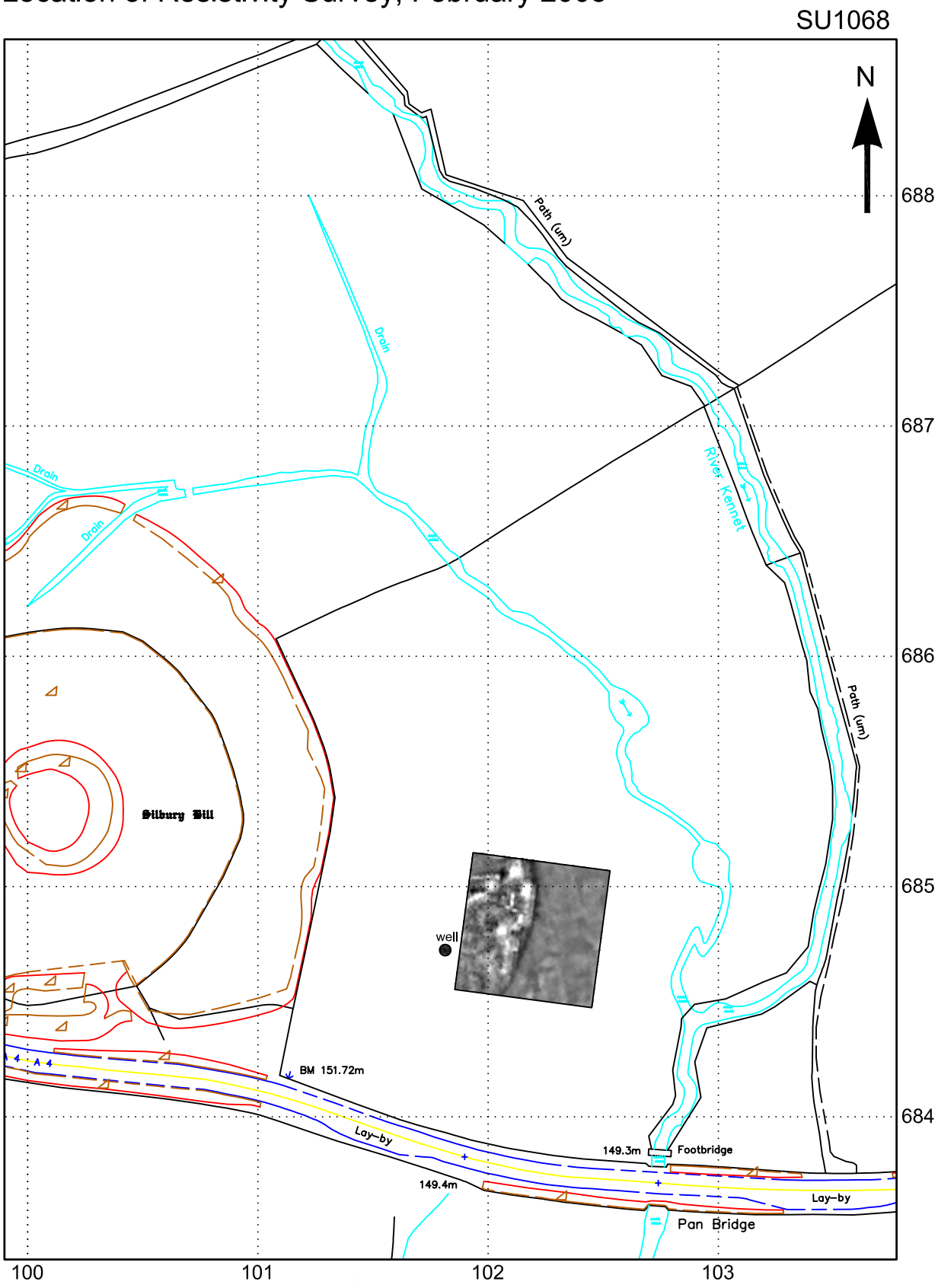
1:2000

0 30 60 90m

FIGURE 8

SILBURY HILL, WILTSHIRE

Location of Resistivity Survey, February 2005



English Heritage 2005

SILBURY HILL, WILTSHIRE Geophysical Survey, February 2005

Fluxgate gradiometer data

a) Traceplot of range truncated and drift corrected data
b) Greyscale plot of range truncated and drift corrected data

Earth resistance data

c) Traceplot of raw data
d) Greyscale plot of raw data
e) Greyscale plot of enhanced data

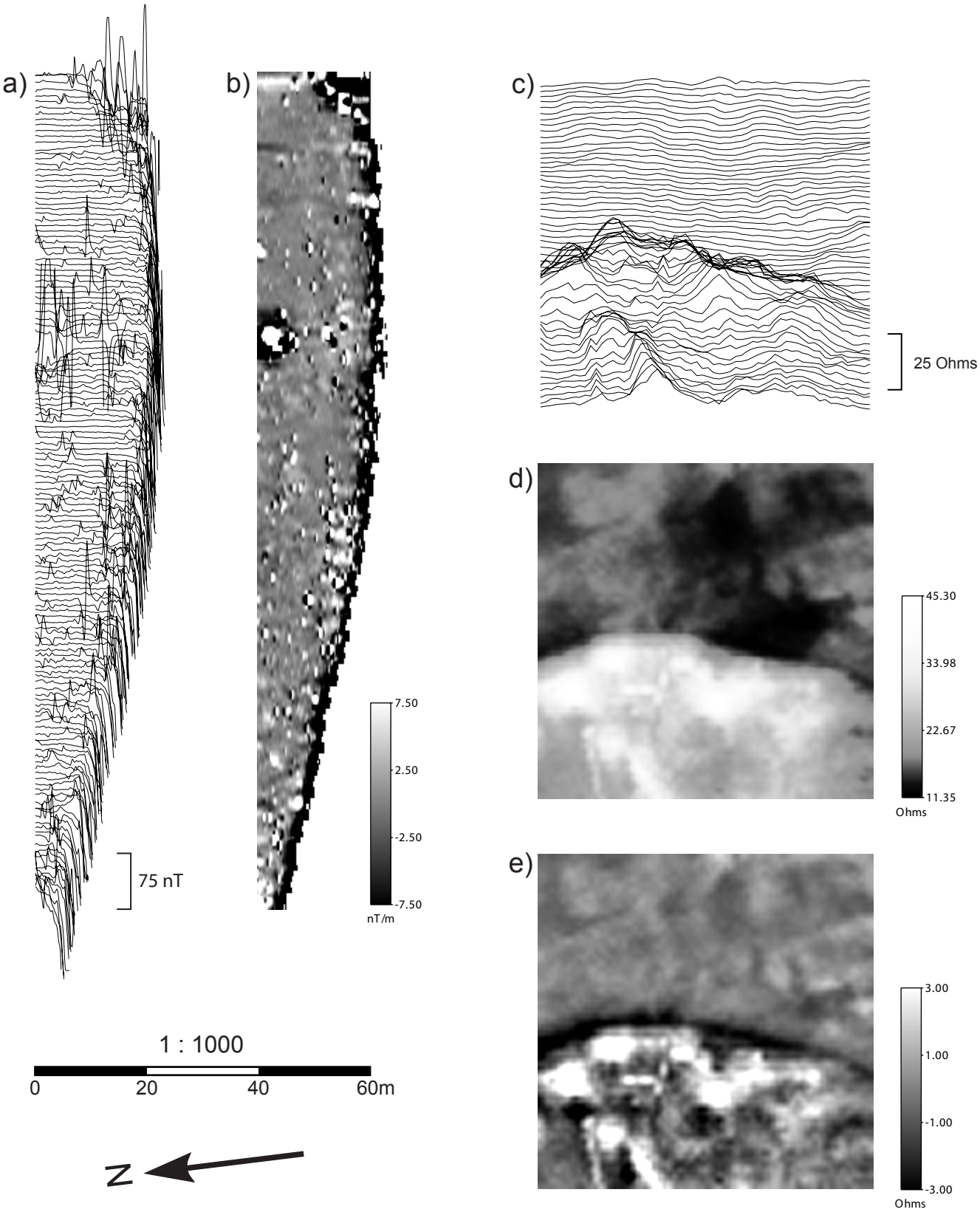
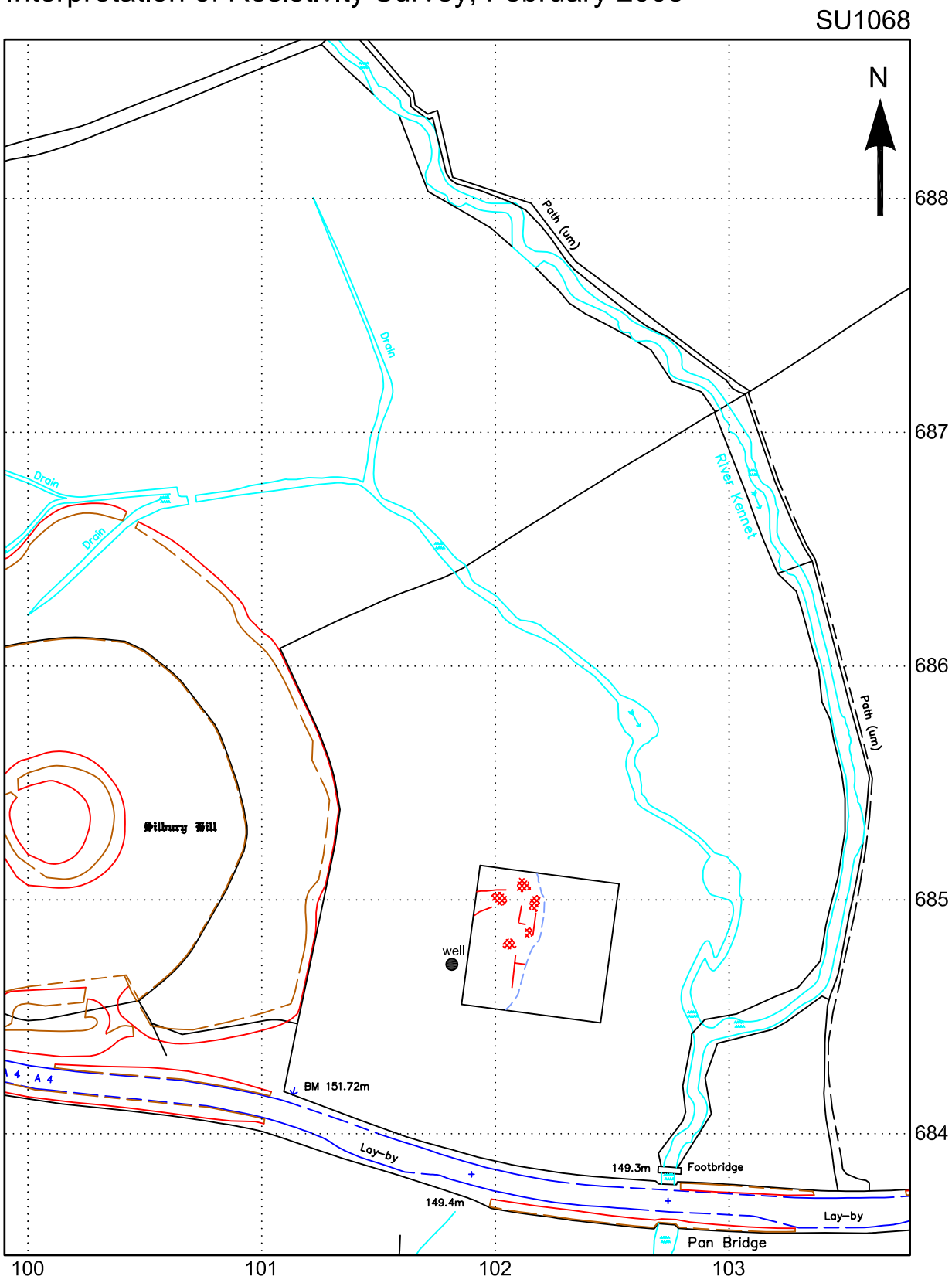


FIGURE 10

SILBURY HILL, WILTSHIRE

Interpretation of Resistivity Survey, February 2005



1:2500

0 30 60 90m

high resistance areas (**r1**)

linear high resistance anomalies (**r2**)

boundary between high and low resistance (gravel/alluvium)

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