2489

Ancient Monuments Laboratory
Report 6/95

REPORT ON MAGNETIC SUSCEPTIBILITY SURVEY, 1995, FARTHING DOWN, COULSDON, SURREY

N Linford

Ancient Monuments Laboratory Report 6/95

# REPORT ON MAGNETIC SUSCEPTIBILITY SURVEY, 1995, FARTHING DOWN, COULSDON, SURREY

N Linford

Summary

A number of subsurface soil samples were recovered from two extant earthwork features along the central ridge of Farthing Down, Coulsdon, Surrey for subsequent magnetic measurements. The values obtained for the volume magnetic susceptibility of the samples were then used to estimate the character of magnetic anomaly that these features would create, to aid both the interpretation of the disappointing 1991 magnetometer survey and improve the provision of advice regarding the use of geophysics in evaluation of this site.

Author's address :-

N Linford

Ancients Monuments Laboratory
English Heritage
23 Savile Row
London
W1X 1AB

**FARTHING DOWN, Coulsdon, Surrey.**

**Report on Magnetic Susceptibility survey, January 1995**

## Introduction

Farthing Down is a scheduled monument (Greater London 88) forming an area of open downland currently used for public recreation. The site contains an extensive flat grave Saxon cemetery and a number of extant earthworks related to a ?Saxon barrow group and an extensive Romano-British field system (Hope-Taylor 1948, 1949). Previous magnetometer survey (Fookes 1991), prior to the erection of a perimeter fence to enable the grazing of cattle over the site, proved disappointing given the generally favourable results obtained from surveys conducted over similar chalk geology. In the light of these results, the continuing need for a rapid and cost effective survey technique to assist with the ongoing management of the site and the archaeological assessment of any damage caused by the cattle grazing/scrub clearance, a more detailed investigation of the magnetic properties of sediments recovered from extant archaeological features was proposed (Linford 1994).

This study reports the results of magnetic measurements conducted on a number of soil samples recovered from transects across two extant archaeological features on the site. These results were examined in an attempt to identify both a characteristic magnetic response from sediments derived from these features and to predict the nature of the geophysical response that similar features would produce.

The site (NGR TQ 303572) lies over Upper Chalk.

## Method

A total of 58 soil samples were recovered from two archaeological features, a barrow and an Iron Age field boundary lynchet, identified as extant earthworks on the ridge of the site. Both features were covered by the 1991 magnetometer survey (see Figure 1), although no discernable geophysical response was noted (Fookes 1991).

After obtaining suitable scheduled monument consent from the Secretary of State, samples were recovered at 0.5m horizontal intervals along traverses crossing the entire width of both the tumulus and the lynchet. A gouge auger was used at each station point to recover samples of soil directly into 10cc plastic containers at 0.1m vertical intervals from the modern ground surface until the underlying chalk substrate was encountered.

A series of magnetic measurements detailed below, were subsequently applied to each of the recovered soil samples within 24 hours of the sampling exercise (Faßbinder and Stanjek 1994). The samples were neither sieved nor dried prior to measurement.

*Volume Magnetic Susceptibility*

The volume magnetic susceptibility ($\kappa$) of a sample is defined as the ratio between the induced magnetisation and the applied magnetising force when the material is subjected to an external magnetic field; in this study a Bartington MS2 meter and MS2-B laboratory coil were used to measure the volume susceptibility ($\kappa$) and (after correction for individual sample weight) the mass specific magnetic susceptibility ($\chi$). The frequency dependence of susceptibility ($\chi_{FD}$) was also measured by determining the difference in observed susceptibility when measured at two different frequencies of applied field (1Khz and 10Khz respectively).

*Artificial Magnetisation*

Isothermal Remanent Magnetism (**IRM**) is defined as the magnetisation acquired by a sample after deliberate exposure to a steady laboratory field at a constant temperature (Thompson and Oldfield 1986 p24). In large magnetic fields the **IRM** is seen to saturate and will not increase beyond a specific value defined as the Saturation Isothermal Remanence Magnetism (**SIRM**).

In this study a Molspin pulse induction magnetizer was used to create steady magnetic fields at room temperature to a maximum of 900mT; the magnetisation obtained in this maximum field was defined as the effective **SIRM** value for each of the samples. Immediately after the measurement of the **SIRM** value of each sample the same equipment was used to impart a backfield, in opposition to the original artificial magnetisation, of 30mT defined here as $\mathbf{IRM}_{\mathbf{-30mT}}$.

The magnetisation of the samples after each exposure was measured with a Molspin spinner magnetometer controlled by an Acorn Archimedes micro-computer.

*Magnetic Modelling*

A numeric magnetic model of the expected response from the archaeological features in this study was constructed following the method proposed by Linnington (1972). In this case each sample was assigned to a rectilinear prism with dimensions of $0.5\times2.0\times0.1$m with a magnetisation proportional to the measured volume susceptibility, $\kappa$ and the average flux density of the Earth's magnetic field in the UK (68000nT). The difference between the vertical component of the resulting magnetic field measured at two points separated by 0.5m was then calculated by summing the causative anomaly from each magnetic prism at an interval of 0.25m; providing a suitable approximation to the field measurements made with the GEOSCAN FM36 magnetometer used during the 1991 survey. The inclination of the Earth's magnetic field was assumed to be $68^{o}$ and the declination was assumed to be $0^{o}$.

## Results

*Soil Magnetic Measurements*

The results of the magnetic measurements are given in Table 1 and Table 2 for the tumulus and the lynchet respectively and a graphical representation of this data is given in Figure 2A and 2B; in both cases the chalk substrate was assumed to represent a horizontal datum.

Tumulus Feature (Table 1, Figure 2A)

The values of magnetic susceptibility obtained from the tumulus are all generally high, although there is little consistent variation between the topsoil layer and the deeper samples. Variation between the volume susceptibility ($\kappa$) and mass specific susceptibility ($\chi$) is most pronounced in the samples directly above the chalk substrate and can be attributed to a local increase in the quantity of chalk present within these samples. The only discernable trend in the magnetic measurements occurs 8m from the Northern end of the traverse and consists of a subtle local increase of both $\chi$ and **SIRM**; suggesting an increase in the concentration of ferrimagnetic minerals in this section of the tumulus.

Sample 2 (11.5m from N) is clearly anomalous and is characterised by high values of both $\chi$, **SIRM** and $\mathbf{IRM_{-30mT}/SIRM}$; which strongly suggests that it contains ferromagnetic iron (Thompson and Oldfield 1986 p17). Whilst this inclusion may well have been *in-situ* it seems more probable that this represents a flake of iron contamination derived from the auger itself.

Lynchet Feature (Table 2, Figure 2A)

Again values of magnetic susceptibility are consistently high, although no clear trends are evident in either $\chi$, $\kappa$, **SIRM** or $\mathbf{SIRM/IRM_{-30mT}}$. Values of $\chi_{FD}$ show no discernable pattern but, as with the results from the tumulus feature, fall within the range of values reported from natural samples recorded by Thompson and Oldfield (1986 p56).

*Magnetic Modelling*

Tumulus Feature (Figure 4)

Figure 4A shows the results from a numeric magnetic model constructed from a series of prisms with magnetisation proportional to the volume susceptibility of the soil sample at each sample point; the extremely high $\kappa$ recorded in sample 2 was replaced with an average value from the surrounding pair of sample points as the results of the magnetic measurements reported above strongly suggested it represented ferrous contamination. The underlying substrate was assumed to be chalk and was ascribed a negligible magnetisation and only the induced magnetisation due to the Earth's magnetic field was considered. Variations in the topography over the feature are detailed in Figure 4D and these values were used to evaluate the depth of each prism in the model rather than the assumption of a horizontal chalk datum used in the graphical display of the magnetic measurement results (Figure 2).

The resulting model produces a somewhat amorphous magnetic anomaly although the magnitude of the predicted response exceeds +2.0nT. Figure 4B demonstrates the not inconsiderable contribution from the topsoil layer, although subtracting this signature from the total modelled anomaly (Figure 4C) produces only a marginal change in the character and magnitude of the response.

Lynchet Feature (Figure 5)

Results from the magnetic model of the lynchet feature demonstrate a slightly reduced magnitude of response in comparison to the tumulus feature. Again, the topsoil layer (Figure 5B) produces a considerable contribution to the overall modelled anomaly.

**Discussion**

The results of the magnetic measurements from both sets of soil samples fail to demonstrate a discernable difference between the magnetic character of the topsoil and the subsoil samples derived from archaeological features. Whilst the volume magnetic susceptibility of the samples from both features are respectably high, there is no apparent correlation between the magnitude of magnetic susceptibility and association with anthropogenic activity on the site. This conclusion is corroborated by the more detailed magnetic measurements that also fail to differentiate the magnetic characteristics of the topsoil from those more closely associated with the archaeological features. Furthermore, there is no discernable deviation between the magnetic character of the samples derived from the tumulus and those from the field boundary lynchet.

Visual analysis of figure 3A shows no obvious correlation between the earthworks recorded on the OS map and the amorphous anomalies recorded by the magnetometer survey. Further comparison between the numerically predicted anomalies produced by the magnetic models and the enlarged portion of the 1991 magnetometer survey (Figure 3B) also fail to produce a thoroughly convincing correlation. However, a number of positive magnetic anomalies in the range of +2.0nT are visible throughout the dataset (see data plotted as white in Figure 3C) and it is impossible, without more detailed investigation, to discount their archaeological significance.

One possible source of error affecting this study may arise from the considerable area of topsoil stripped to the chalk substrate during the 1948-9 excavations (Hope-Taylor 1948, 1949) and the previous investigations of some of the barrows by Wickham Flower (1872). It is not entirely clear from the interim excavation reports whether either, or indeed both, of the features examined during this survey were disturbed by this activity. However, the results of the 1991 magnetometer survey (Fookes 1991) certainly covered areas containing extant earthwork features well beyond the scope of these previous investigations and again these failed to produce any discernable magnetic anomalies.

## Conclusion

The results of this study suggest that the interpretation of either magnetometer or topsoil magnetic susceptibility data from this site will be severely hampered by the absence of clearly discernable magnetic anomalies. This would appear to be related to the thin topsoil cover over the site and the failure of occupation related features, such as the tumuli groups, to be associated with cut ditches into the chalk substrate. Indeed, the results of the auger survey suggest that the topography of both the tumulus and lynchet features examined during this study are formed by a central accumulation of chalk and/or flint, opposed to a lens of magnetically enhanced soil. In this respect, the results of the magnetic models have usefully demonstrated the influence of both topography and the contribution of topsoil "noise" (Scollar 1990 pp443-5) to the resultant predicted anomaly.

Unfortunately, re-examination of the 1991 magnetometer survey data in the light of this study fails to enhance either the interpretation or conclusions reported by Fookes (1991). However, the significance of the positive magnetic anomalies in the 1991 survey data, with magnitudes in the range predicted by the numeric magnetic models presented in this study, cannot be discounted without further evaluation through trial excavation.

| | | | |
|---|---|---|---|
| Surveyed by: | H Compton (*Oxford-Brookes University*)<br>N Linford | Date of survey: | 18-19/1/95<br>29/1/95 |
| Reported by: | N Linford | Date of report: | 8/2/95 |

Archaeometry Branch,
Ancient Monuments Laboratory,
English Heritage.

## REFERENCES

Faßbinder, J.W.E. and Stanjek, H. (1993). Occurrence of Bacterial Magnetite in Soils from Archaeological Sites. *Archaeologia Polona* vol 31.

Fookes, G. (1991). Farthing Down, Coulsdon, Surrey, Report on Geophysical survey 1991. *Ancient Monuments Laboratory Report Series* **93/91**.

Hope-Taylor, B. (1948). Report of the Archaeological Excavations on Farthing Down, Coulsdon in 1948. *Surrey Archaeological Society* (Unpublished).

Hope-Taylor, B. (1949). Report of the Archaeological Excavations on Farthing Down, Coulsdon in 1949 (second and final season). *Surrey Archaeological Society* (Unpublished).

Linford, N.T. (1994). Mineral Magnetic Profiling of Archaeological Sediments. *Archaeological Prospection* **vol 1**.

Linnington, R.E. (1972). A Summary of Simple Theory Applicable to Magnetic Prospecting in Archaeology. *Prospezioni Archeologiche* **vol 7**.

Scollar, I, *et al* (1990). *Archaeological Prospecting and Remote Sensing*, Cambridge.

Thompson, R. and Oldfield, F. (1986). *Environmental Magnetism.* Allen and Unwin, London.

Wickham Flower, J. (1872). Notices of an Anglo-Saxon Cemetery at Farthing Down, Coulsdon, Surrey. *Surrey Archaeological Collections* **vol VI**.

**List of enclosed figures:**

**Table 1:** *Magnetic measurements of samples collected from the tumulus feature.*

| Sample Location | Depth (m) | K ($10^{-5}$) | $\chi$ ($10^{-8}$ $m^3Kg^{-1}$) | $\chi_{FD}$ | SIRM ($kAm^{-1}$) | $IRM_{-30mT}$ /SIRM |
|---|---|---|---|---|---|---|
| 0.0 | 0.1 | 62 | 50.4 | 15 | 4.484 | -0.421 |
| 0.5 | 0.1 | 298 | 248.3 | 3 | 37.81 | 1.0 |
| 1.0 | 0.1 | 55 | 49.5 | 14.5 | 3.313 | -0.427 |
| 1.5 | 0.1 | 60 | 51.7 | 7 | 3.234 | -0.520 |
| 2.0 | 0.1 | 69 | 55.2 | 13 | 3.710 | -0.494 |
| 2.5 | 0.1 | 84 | 63.2 | 11.9 | 4.764 | -0.524 |
| 3.0 | 0.15 | 76 | 57.6 | 9.2 | 4.118 | -0.512 |
| | 0.1 | 75 | 55.1 | 14.5 | 5.117 | -0.449 |
| 3.5 | 0.15 | 83 | 58.0 | 13.8 | 4.7 | -0.493 |
| | 0.1 | 72 | 59.5 | 13.5 | 4.784 | -0.480 |
| 4.0 | 0.2 | 89 | 50.6 | 15.6 | 4.202 | -0.576 |
| | 0.15 | 90 | 60.0 | 7.9 | 4.722 | -0.488 |
| | 0.1 | 76 | 63.9 | 10.2 | 4.241 | -0.510 |
| 4.5 | 0.15 | 88 | 59.5 | 12.3 | 4.161 | -0.510 |
| | 0.1 | 81 | 59.1 | 14 | 4.490 | -0.474 |
| 5.0 | 0.1 | 86 | 56.2 | 11.5 | 4.547 | -0.511 |
| 5.5 | 0.1 | 61 | 48.4 | 10.8 | 3.507 | -0.499 |
| 6.0 | 0.2 | 74 | 52.1 | 10.6 | 3.468 | -0.540 |
| | 0.15 | 66 | 53.2 | 9.2 | 3.415 | -0.524 |
| | 0.1 | 65 | 52.0 | 12 | 3.663 | -0.511 |
| 6.5 | 0.2 | 75 | 51.7 | 11.1 | 4.212 | -0.460 |
| | 0.15 | 63 | 54.3 | 11.3 | 3.252 | -0.488 |
| | 0.1 | 62 | 52.5 | 10.6 | 3.634 | -0.473 |
| 7.0 | 0.15 | 66 | 53.2 | 11.9 | 3.801 | -0.473 |
| | 0.1 | 67 | 53.2 | 13.3 | 4.167 | -0.493 |
| 11.0 | 0.1 | 75 | 60.5 | 10.8 | 6.286 | -0.460 |
| 11.5 | 0.1 | 102 | 69.9 | 12 | 3.673 | -0.564 |
| 10.5 | 0.15 | 75 | 56.4 | 11.5 | 5.353 | -0.489 |
| | 0.1 | 87 | 57.6 | 14.1 | 3.602 | -0.439 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9.5 | 0.15 | 71 | 56.3 | 12.3 | 4.458 | -0.482 |
| | 0.1 | 81 | 58.7 | 12.5 | 3.628 | -0.498 |
| 9.0 | 0.2 | 80 | 50.3 | 11.8 | 4.136 | -0.518 |
| | 0.15 | 76 | 53.1 | 10.3 | 4.332 | -0.497 |
| | 0.1 | 78 | 52.3 | 11.9 | 3.405 | -0.478 |
| 8.5 | 0.2 | 67 | 53.2 | 10 | 3.887 | -0.504 |
| | 0.15 | 70 | 51.5 | 11 | 5.072 | -0.431 |
| | 0.1 | 73 | 54.3 | 13.6 | 3.9 | -0.465 |
| 8.0 | 0.15 | 81 | 53.3 | 11.9 | 3.736 | -0.518 |
| | 0.1 | 67 | 53.6 | 13.3 | 3.479 | -0.507 |
| 7.5 | 0.2 | 75 | 52.3 | 11.1 | 3.637 | -0.520 |
| | 0.15 | 63 | 54.3 | 12.9 | 4.199 | -0.475 |
| | 0.1 | 70 | 50.0 | 13.2 | 3.754 | -0.483 |
| 10.0 | 0.15 | 76 | 44.6 | 12.3 | 4.295 | -0.504 |
| | 0.1 | 73 | 54.7 | 11.6 | 4.121 | -0.474 |

***Table 1 continued.***

**Table 2:** *Magnetic measurements of samples collected from the lynchet feature.*

| Sample Location | Depth (m) | $\kappa$ ($10^{-5}$) | $\chi$ ($10^{-8}$ $m^3Kg^{-1}$) | $\chi_{FD}$ | SIRM ($KAm^{-1}$) | $IRM_{-30mT}$ /SIRM |
|---|---|---|---|---|---|---|
| 3.5 | 0.15 | 86 | 62.3 | 11.6 | 4.121 | -0.516 |
| | 0.1 | 68 | 55.7 | 10.3 | 4.447 | -0.436 |
| 4.0 | 0.1 | 89 | 56.7 | 11.2 | 5.331 | -0.493 |
| 4.5 | 0.1 | 83 | 57.6 | 13.3 | 5.284 | -0.429 |
| 5.0 | 0.1 | 95 | 56.5 | 12.6 | 5.653 | -0.466 |
| 3.0 | 0.1 | 82 | 57.7 | 12.2 | 4.875 | -0.487 |
| 2.5 | 0.1 | 88 | 54 | 12.5 | 5.157 | -0.485 |
| 2.0 | 0.1 | 61 | 46.2 | 11.5 | 4.042 | -0.419 |
| 1.5 | 0.1 | 53 | 46.9 | 13.2 | 3.672 | -0.467 |
| 1.0 | 0.1 | 78 | 56.1 | 11.5 | 4.645 | -0.477 |
| 0.5 | 0.15 | 87 | 56.5 | 13.2 | 4.788 | -0.486 |
| | 0.1 | 85 | 55.9 | 14.1 | 5.489 | -0.493 |
| 0.0 | 0.15 | 71 | 60.2 | 9.9 | 3.718 | -0.536 |
| | 0.1 | 83 | 57.2 | 9.6 | 6.001 | -0.469 |

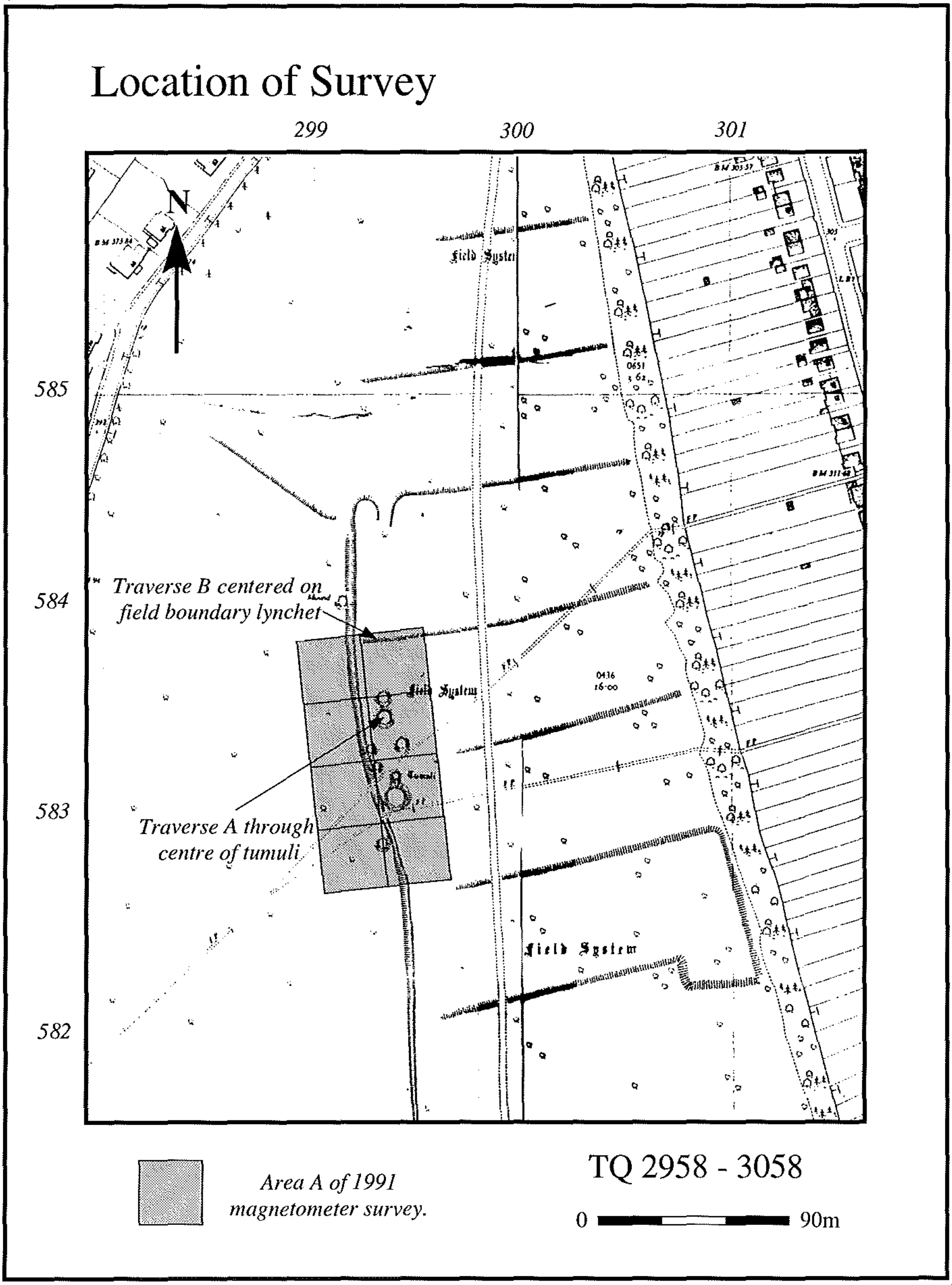



*Figure 1; FARTHING DOWN, Location of 1991 magnetometer survey and soil sample traverses.*

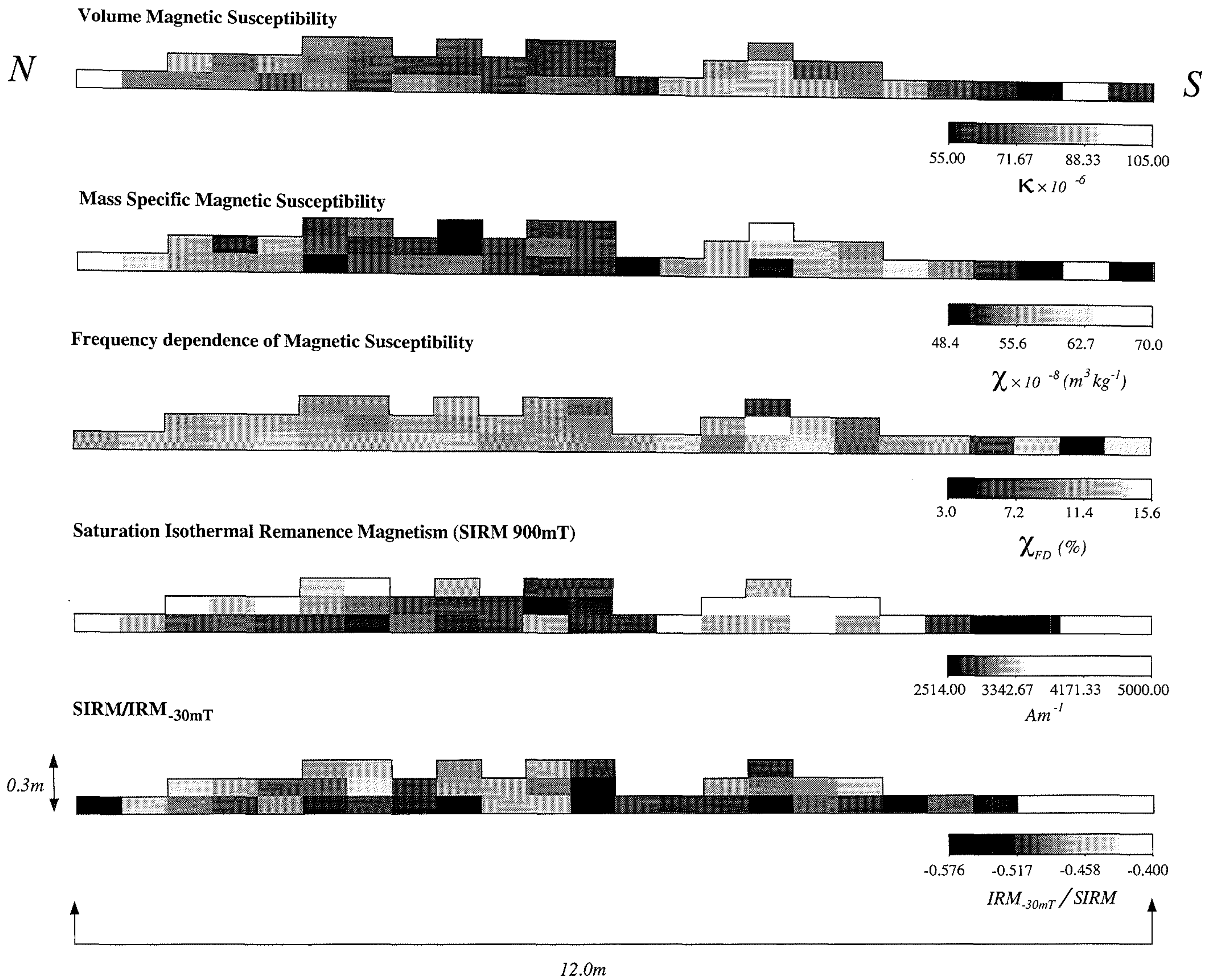



*Figure 2A; FARTHING DOWN, magnetic measurements of samples collected from tumulus feature.*

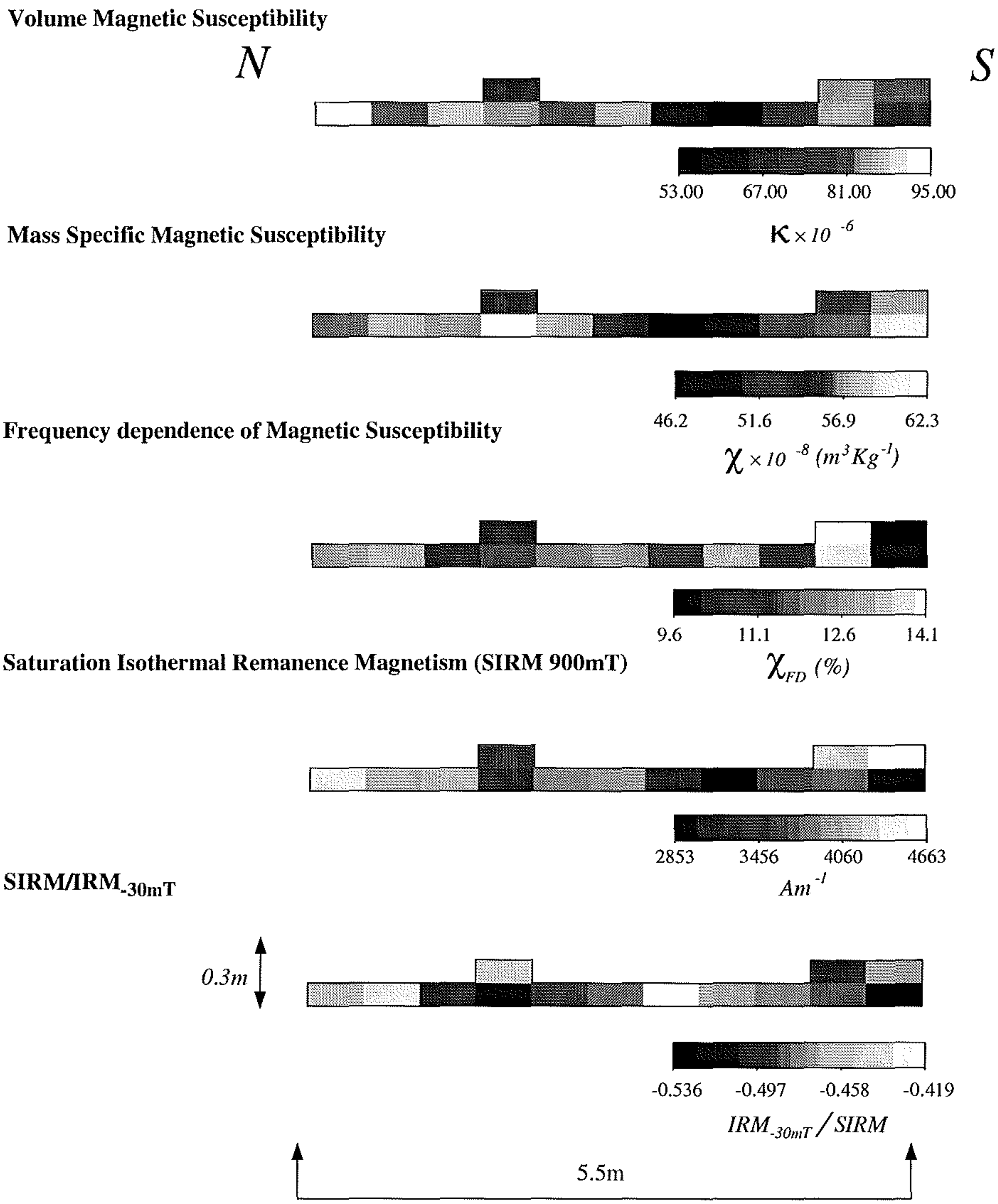


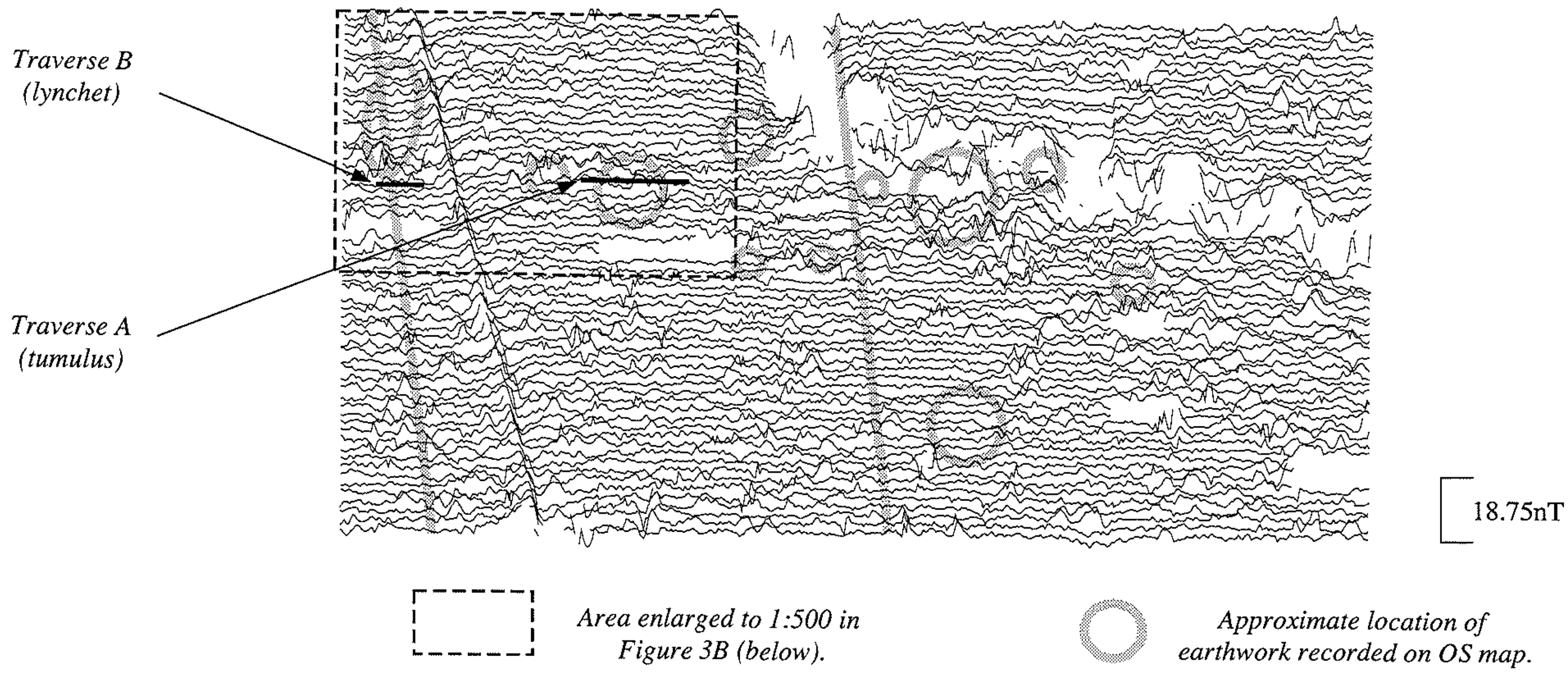

*Figure 2B; FARTHING DOWN, magnetic measurements of samples collected from lynchet feature.*

# FARTHING DOWN, COULSDEN, SURREY
Magnetometer survey May 1991

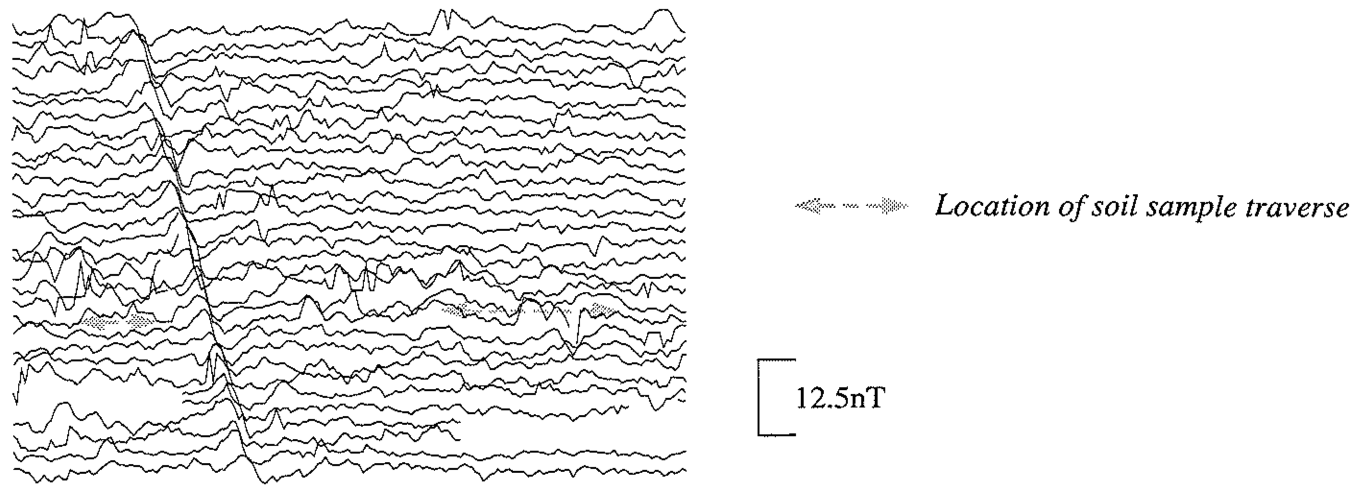
## AREA A

N

*3A. Traceplot of raw magnetometer data.*




*3B Enlarged Traceplot of raw magnetometer data.*




*3C. Linear greytone of raw magnetometer data.*

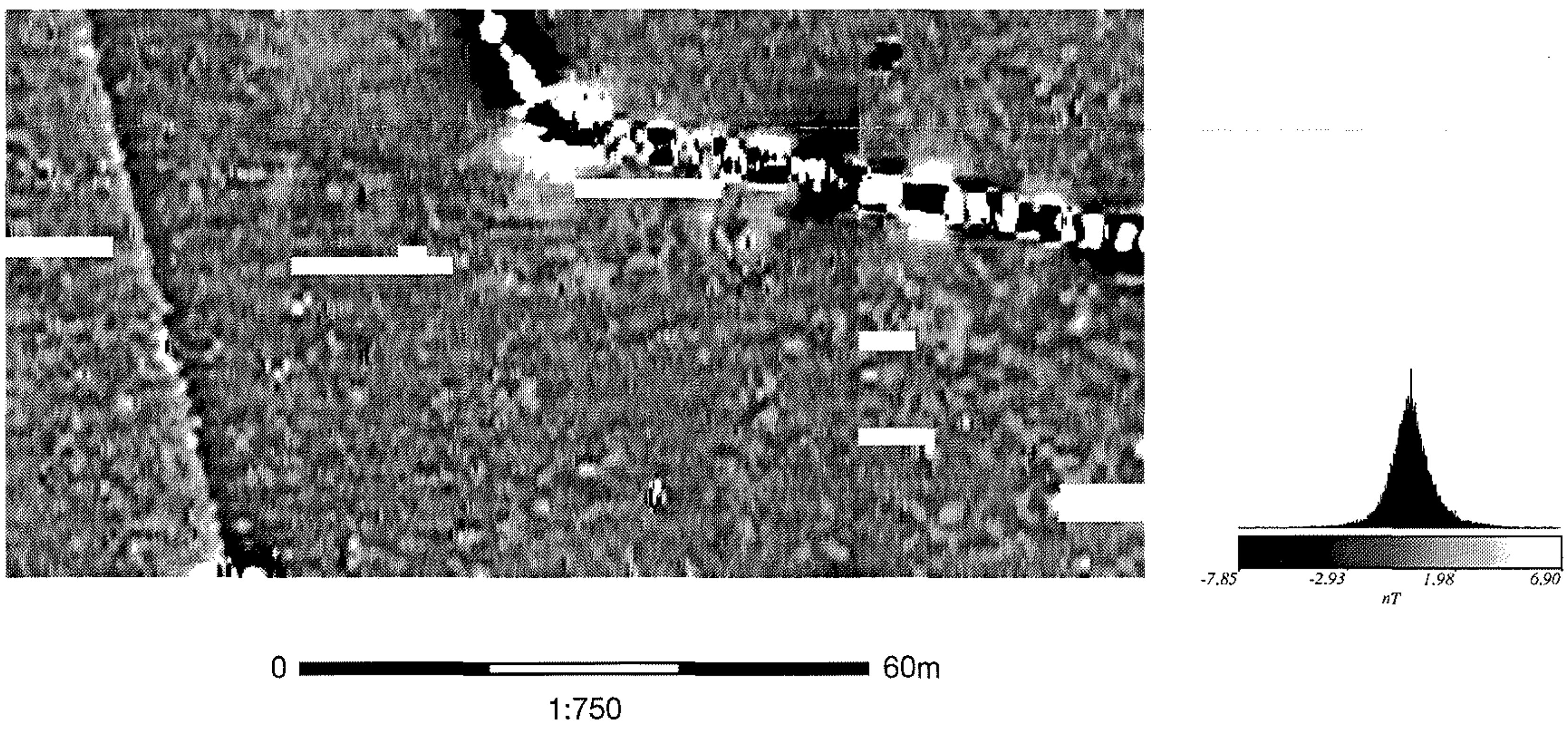



*Figure 3; FARTHING DOWN, data from Area A of the 1991 magnetometer survey over the northern tumuli group.*

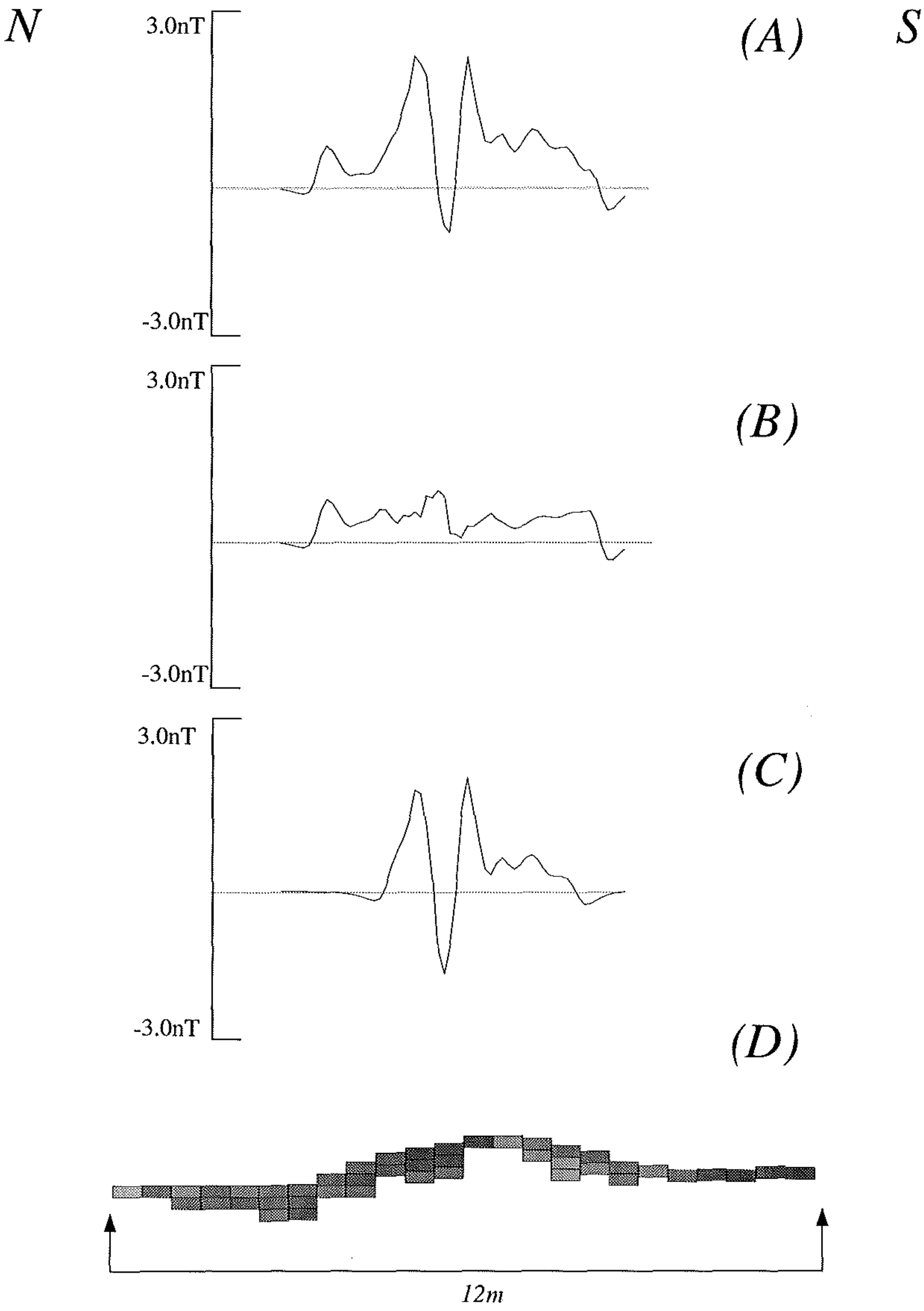



*Figure 4; FARTHING DOWN, results of (A) magnetic model over tumulus feature, (B) contribution of topsoil layer only, (C) result of tumulus feature less contribution from topsoil layer and (D) topographic section of numerical model 1:500.*

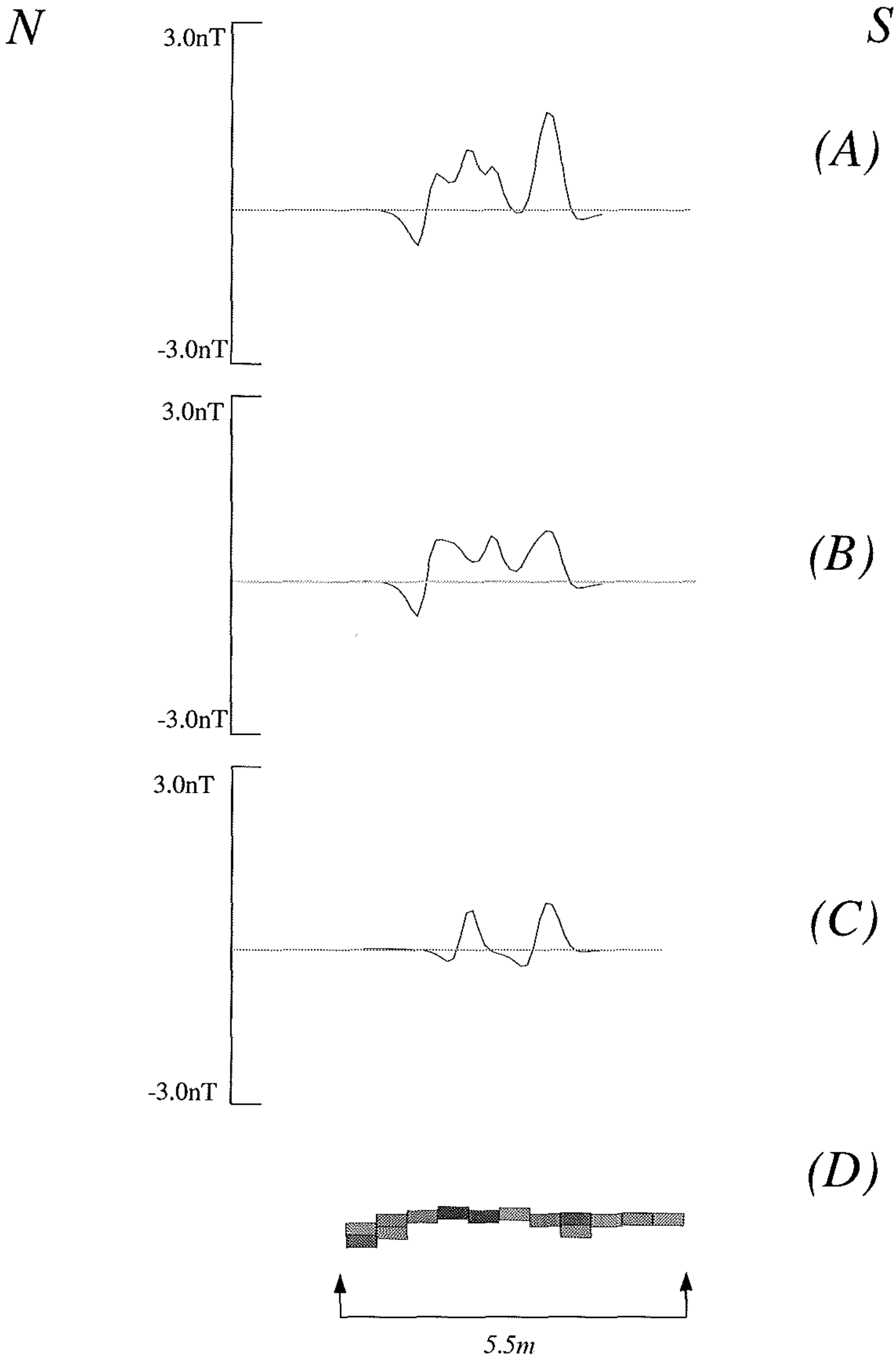



*Figure 5; FARTHING DOWN, results of (A) magnetic model over lynchet feature, (B) contribution of topsoil layer only, (C) result of lynchet feature less contribution from topsoil layer and (D) topographic section of numerical model 1:500.*