The importance of Ermine Street (Great North Road) in the development of Great Wymondley

Great Wymondley is located along the route of the historic Roman road known as Ermine Street. Ermine Street, as mentioned earlier, was a major Roman road that connected London to York and passed through various towns and settlements, including close to Great Wymondley.

In the context of Great Wymondley, Ermine Street would have been an essential trade and transportation route during Roman times, connecting the emerging villa and settlement to larger important Roman settlements and towns. Over the centuries, the landscape and road network have evolved, so the exact alignment of Ermine Street may not exactly match the modern road network (the A1M north). Not surprisingly we have a Roman Villa at the end of Gravely Road not so far behind Milksey cottages. Graveley Road junction with Ermine Street. The excavation finds of the 1930's excavation have been discussed.

We have mentioned the field system concerning veteran legionary connections with Great Wymondley.

Probably, very important archaeology from the Roman period exists east of Great Wymondley to the famous Ermine Street. Ermine Street was the equivalent of a motorway back in 2^{nd} century AD Romano Britain.

Ladder Settlement A1M

Ladder settlements, in the context of Roman roads, refer to the network of towns and settlements that developed along these roads during the height of the Roman Empire.

Roman roads were a remarkable feat of engineering and played a crucial role in the expansion and administration of the Roman Empire. These roads facilitated the movement of armies, goods, and people across vast distances, connecting different parts of the empire. Alongside these roads, settlements naturally sprang up to cater to the needs of travellers and traders. These settlements are often referred to as "roadside settlements" or "roadside towns."

Here are some key points about these settlements along Roman roads:

1. **Location:** Roman roads were strategically planned and constructed to connect major cities, military outposts, and economic centres. As a result, settlements developed along these roads in locations that were convenient for travellers and traders to stop and rest.
2. **Amenities:** These settlements provided various amenities and services to people using the roads. They included inns (known as "mansions"), taverns, stables, workshops, and other facilities that catered to the needs of travellers, soldiers, and traders.
3. **Economic Activity:** The presence of a constant stream of travellers and traders led to economic opportunities for the inhabitants of these settlements. Some settlements specialized in certain goods or services, capitalizing on the regular flow of people along the roads.
4. **Communication and Information:** Roadside settlements also served as points of communication and information dissemination. News, messages, and orders from the central authorities could be conveyed quickly along the road network.
5. **Importance of Connectivity:** The growth and prosperity of these settlements were closely tied to the maintenance and use of the Roman road network. When the empire declined and road maintenance diminished, these settlements often suffered as well.
6. **Archaeological Significance:** Many modern cities and towns have their origins as settlements along ancient Roman roads. Archaeological excavations have revealed the remains of these settlements, shedding light on the daily lives of the people who lived and worked there.

In summary, the ladder settlement detected near the historic Ermine Road in the Great Wymondley Solar site is very important from a local heritage perspective because it was potentially the routeway for the villa or villas that existed in the area.It would have been handy for veterans in retirement living Great Wymondley to be summoned if necessary to put down unrest.

You will see an example of a ladder settlement on page 155 of the attached documentation .Healam Bridge, Yorkshire, Fluxgate gradiometer survey (1 x).5m) carried out in advance of road widening. Of the A1 trunk road.

You will note that the local community has had no access to the results of the Geophysics…in map form. We would like to see this.

Q…WHERE IS THIS?

D shaped feature found in the fields

A "D-shaped" Neolithic feature in archaeology refers to a type of archaeological site or structure that has a semi-circular or crescent-shaped layout, resembling the letter "D." These features are commonly found in Neolithic (New Stone Age) contexts and can encompass a variety of archaeological elements, including enclosures, settlements, pits, ditches, and other forms of architecture.

These D-shaped features are often associated with ceremonial or domestic activities, and their specific purposes can vary based on the archaeological context and the culture of the time. They might have served as ritual gathering spaces, communal areas for feasting or other social activities, storage areas, or even as the layout for structures such as huts or houses.

One well-known example of D-shaped Neolithic features is the Durrington Walls site, located near Stonehenge in England. Durrington Walls is a large circular earthwork enclosure with an entrance on one side, forming a D-shaped layout. This site is believed to have been used for various communal activities and gatherings related to the Stonehenge complex.

It's important to note that the interpretation of archaeological features can be complex and can change based on discoveries and research. The understanding of D-shaped Neolithic features, like many archaeological topics, continues to evolve as new evidence comes to light and researchers gain deeper insights into the lives and practices of ancient cultures.

I have noted the importance of the recent work of Professor Mike Parker Pearson and we should not underestimate that this 218-acre solar site may contain the historic origins of hunter-gatherers who ultimately settled to farm the land. You will see page 127 of the attached pages...The Iron Age settlement at Norse Road, Bedfordshire. I include this whole section on surveying prehistoric sites so you can see how different surveying prehistoric sites is from Roman.

The Motte and Bailey castle...listed monument.

This of course was the later cultural centre of medieval Great Wymondley. This site started the slight movement west to higher ground but also sits not so far from the Roman villa.

Conclusion

We need to have independent advice on the robustness of the damage mitigation strategy. Withholding key information on the findings leaves it opaque and it is not the unfiltered view of North Herts archaeologists that the solar farm proposal will not damage important heritage features. The fact that the council has voted to give the go-ahead to the solar farm is more born from expedience and a tick box rather than giving the local objectors the full picture. North Herts archaeologists in our view are conflicted by the decision.

The above-ground magnificent buildings of later medieval Great Wymondley only reflect the ongoing importance of the village (kings, Chancellors, Cup bearers, Sheriffs of Herts and Cambridge)The old Roman Road still gave important access to the twin power centres of York and London. London even in recent history took the produce from the farmlands of the Haileys of Delamere..emphasizing the importance of grain, vegetables and everything arable to feed the capital.

6

SURVEYING ON PREHISTORIC SITES

It is clear when delving into the distant past that many sites, or features, defy explanation even when excavated, and given the nature of remotely sensed information this is even more of a problem in the interpretation of geophysical data. However, it is possible to illustrate the use of geophysical techniques on prehistoric sites with reference to the following broad categories: strata definition, palaeochannels, field systems and enclosures, settlement enclosures and settlements, ritual sites and burials. By and large, the archaeology on prehistoric sites is relatively simple, that is compared to deeply stratified urban sites.

Archaeologists often class the features that they find on prehistoric sites as 'negative' archaeology and by this they mean that the features are cut into the subsoil or earlier deposits. As these features often silt up with material of higher magnetic susceptibility from topsoil or settlement refuse, the preferred technique on such sites is magnetic survey. However, the nature of the archaeology associated with the early man severely limits the use of geophysical techniques. Certainly during the Palaeolithic the dispersed and ephemeral nature of the surviving archaeology means that there is little remaining that the techniques can detect. During the Mesolithic, even though longer lived sites with good evidence for fires exist, finding them provides the sort of challenge that most geophysicists would rather pass by. With the exception of locating underground cave systems, see for example Noel and Biwen (1992), Chamberlain *et al.* (2000), Pringle *et al.* (2002), geophysics is unlikely to assist substantially in the search for early hominids or early hunter-gatherers.

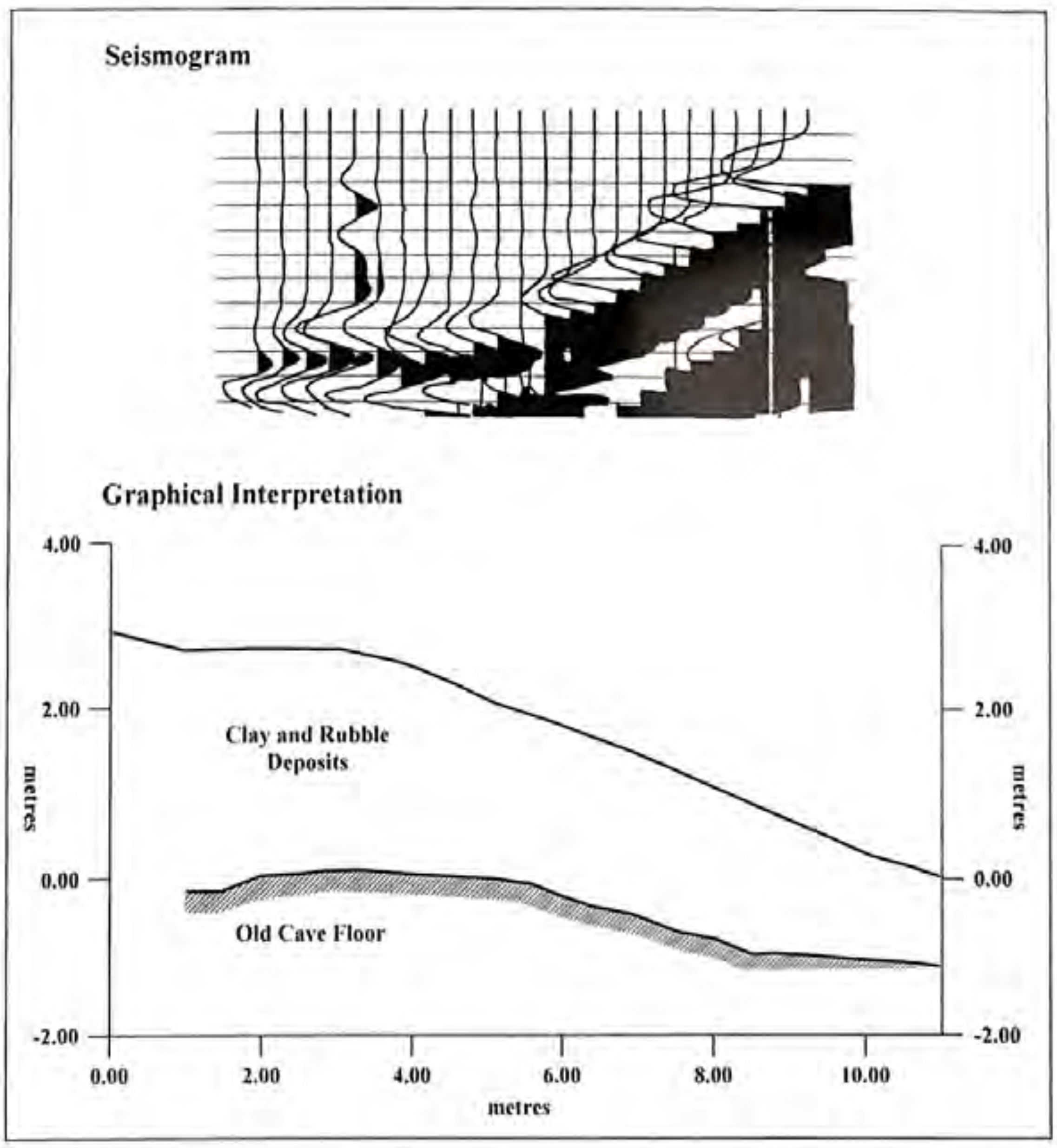
However, once such sites have been discovered, often by chance or field-walking, geophysical techniques can be used in a variety of situations to help archaeologists who are investigating Palaeolithic or Mesolithic sites. The most obvious is the use of magnetic techniques to locate areas of burning within a stripped excavation area where there are no visible indicators on the ground surface. In this instance very closely spaced sampling intervals are required and, due to the shallow nature of such deposits, the investigation is usually best undertaken with the Bartington magnetic susceptibility coil.

Strata definition

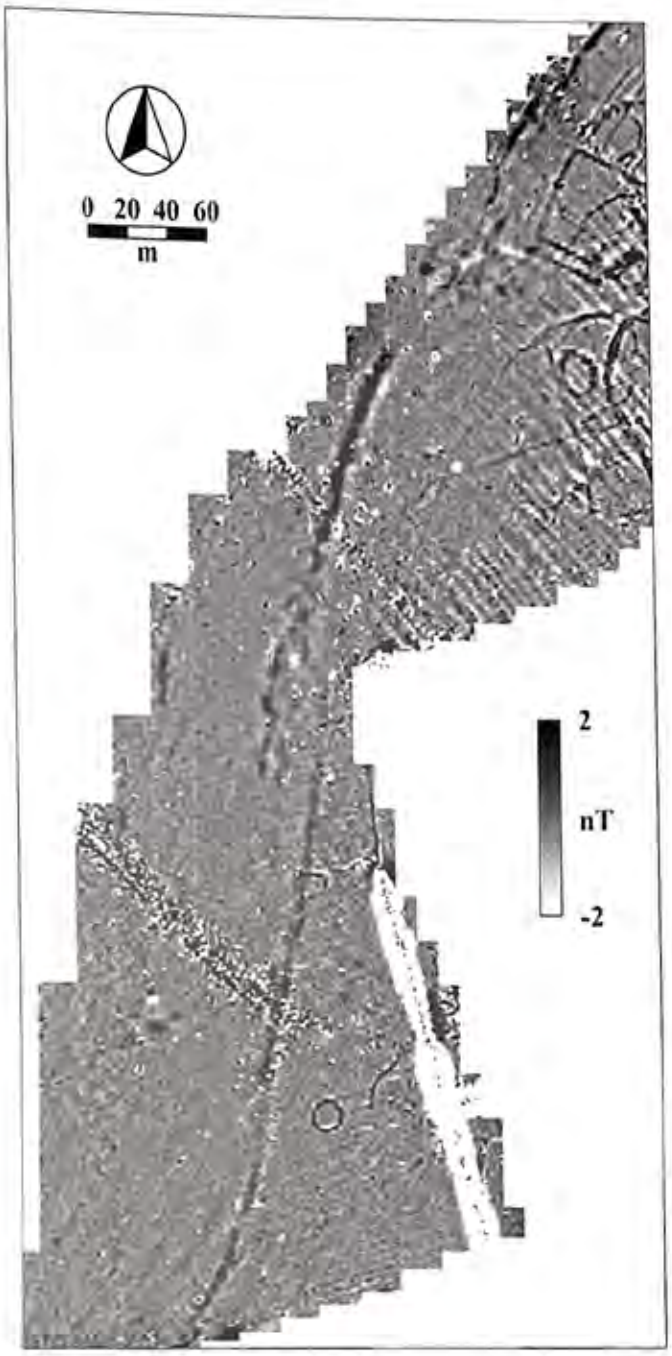
Other ways in which geophysics can help on early prehistoric sites is in estimating the depth of deposits which overlie bedrock, or in identifying major differing soil horizons. For example, at Cooper's Hole, Cheddar, as part of a *Time Team* investigation into the cave site, it was important to try to establish the thickness of deposits overlying the original cave floor. The information was needed to assess how much material would have to be physically removed before the archaeologically interesting layers were reached. While coring might have provided a simple solution to the problem, and GPR a more sophisticated approach, the low cave roof and clay deposits meant that neither was possible. It was decided instead to employ seismics (**53**). Twenty-four geophones were used at 0.5m separations and spot heights were established using an EDM system. A 12lb hammer and metal plate were used as the energy source. The results indicate that the clay and rubble deposits overlying the bedrock floor decrease in depth further into the cave. At the entrance they are in the order of 3m deep while 12m into the cave they are only 1m deep. A good refracting layer was clearly identified below the deposits; the velocities suggested that this surface equated with the solid stalagmite floor of the cave. Subsequent excavation confirmed these results.

Palaeochannels

Perhaps the main use of geophysics in early prehistoric investigations is in the identifying of palaeochannels or niche-type environments that are likely to have



53 *An example of a seismogram which was used to produce an estimate of the depth of deposits overlying the old cave floor at Cooper's Hole, Cheddar*



54 *This data set from Riverside Meadows, Bedfordshire, contains a multitude of anomalies from many origins. There is evidently an archaeological 'site' in the north-east corner of the survey, as well as pipes, paths and ploughing trends. What is notable here is the intermittent band of broad and weakly positive response that is the result of a former river channel. Fluxgate gradiometer survey. 1 x 0.5m.* GSB survey for Albion Archaeology

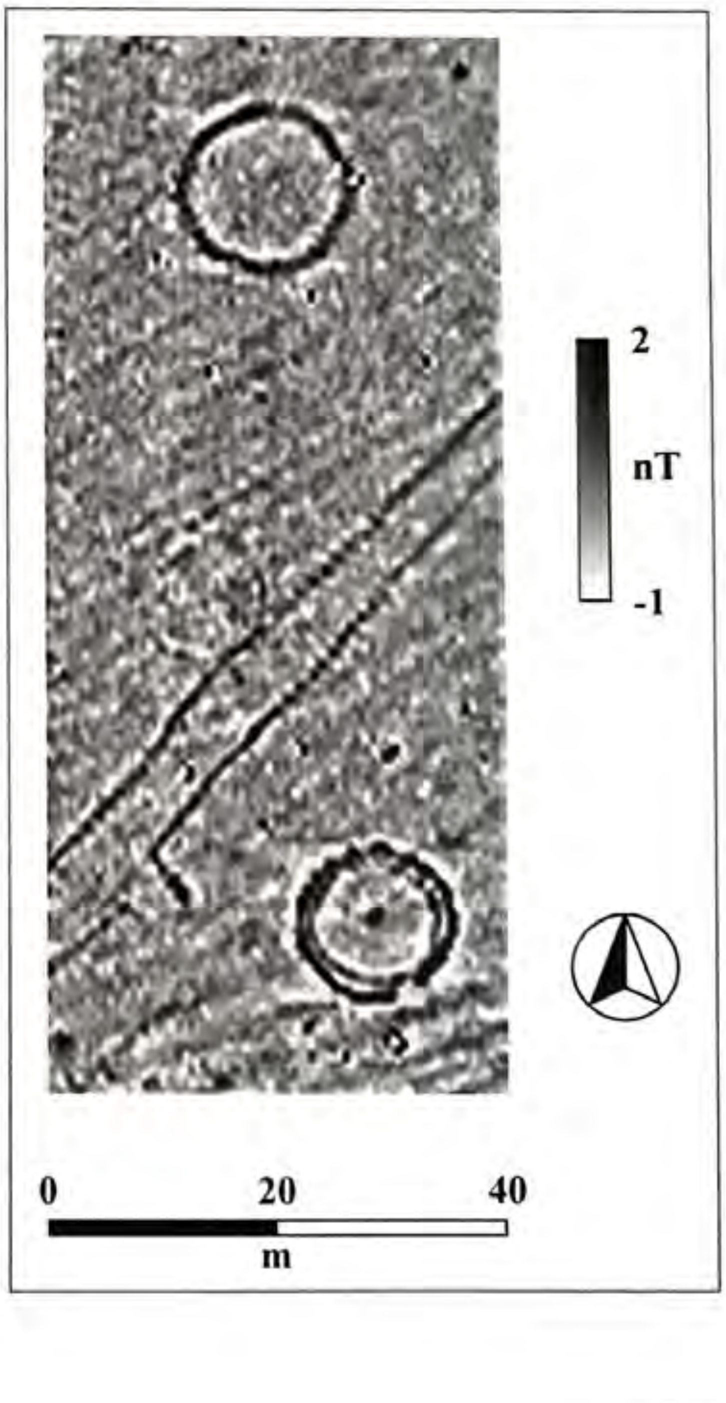
attracted early man as they were obvious sources of both water and wildlife. A paper by Weston (2001) has highlighted the use of prospecting techniques in identifying palaeochannels. While resistance methods, particularly electrical imaging, can play an important role in investigating such channels, magnetic techniques are ideally suited for mapping their courses. At Riverside Meadows we carried out a fluxgate gradiometer survey in advance of proposed development and identified a plethora of magnetic responses that can be equated with ditches and enclosures (**54**). However, in this instance the anomalies of interest are those associated with a palaeochannel that runs parallel to the existing river course. It is very easy to follow the course of this channel even though the magnetic anomalies vary along its length. The bands of magnetic gravels and alluvium that fill the former channel vary according to the speed of flow of the water, the deposition rates and the source material being deposited. As a consequence a small-scale survey may not be able to identify a channel due to a lack of magnetic contrast at a particular point. It may, therefore, be necessary to sample large areas in order to be able to resolve the course of most palaeochannels.

Field systems and enclosures

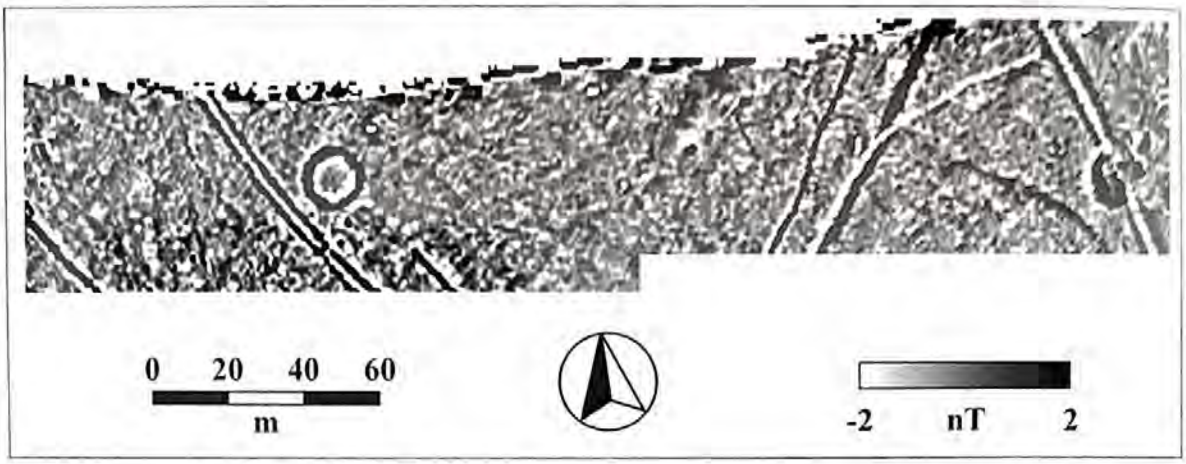
Field systems are the ubiquitous by-product of an organised, more sedentary life that describes much of later prehistory. These may range from the division of land for stock control or arable production, to larger boundary markers differentiating ownership of land. These can take the form of lynchets, pit alignments, ditches, banks, hedges, fences and walls; each will leave a different geophysical signal when they are removed from the landscape by being dismantled, ploughed out or otherwise destroyed (**55**).

Early fields tend to lack the regularity and complexity of later planned landscapes. Extensive field systems can survive as earthworks or they are often visible from the air as cropmarks. Consequently, since the patterns and alignments are often well documented, templates already exist to compare with the results from a geophysical survey and these help considerably with interpretation. Many of the clearest geophysical images of field systems inevitably come from the later part of prehistory, and the overlap with those from later periods is often apparent.

Perhaps some of the best examples of old field boundaries come from Cornwall, as seen in figure **56**. From a geophysical point of view these features produce very distinctive, yet highly variable responses. In some instances a double positive magnetic anomaly, flanking a negative response, is visible, while



55 *Typical magnetic responses from field systems comprised of ditches cut into the ground. It is impossible to ascertain whether the ring ditches are associated with the former boundaries. Fluxgate gradiometer data. 1m x 0.5m.* GSB survey for CPM



56 *Magnetic survey, from Probus in Cornwall, illustrates the variety of responses from differing field systems. Here we have not only single positive responses over buried ditches, but the typical Cornish double response. Fluxgate gradiometer data, 1 x 0.5m.* GSB survey for Cornwall Archaeological Unit

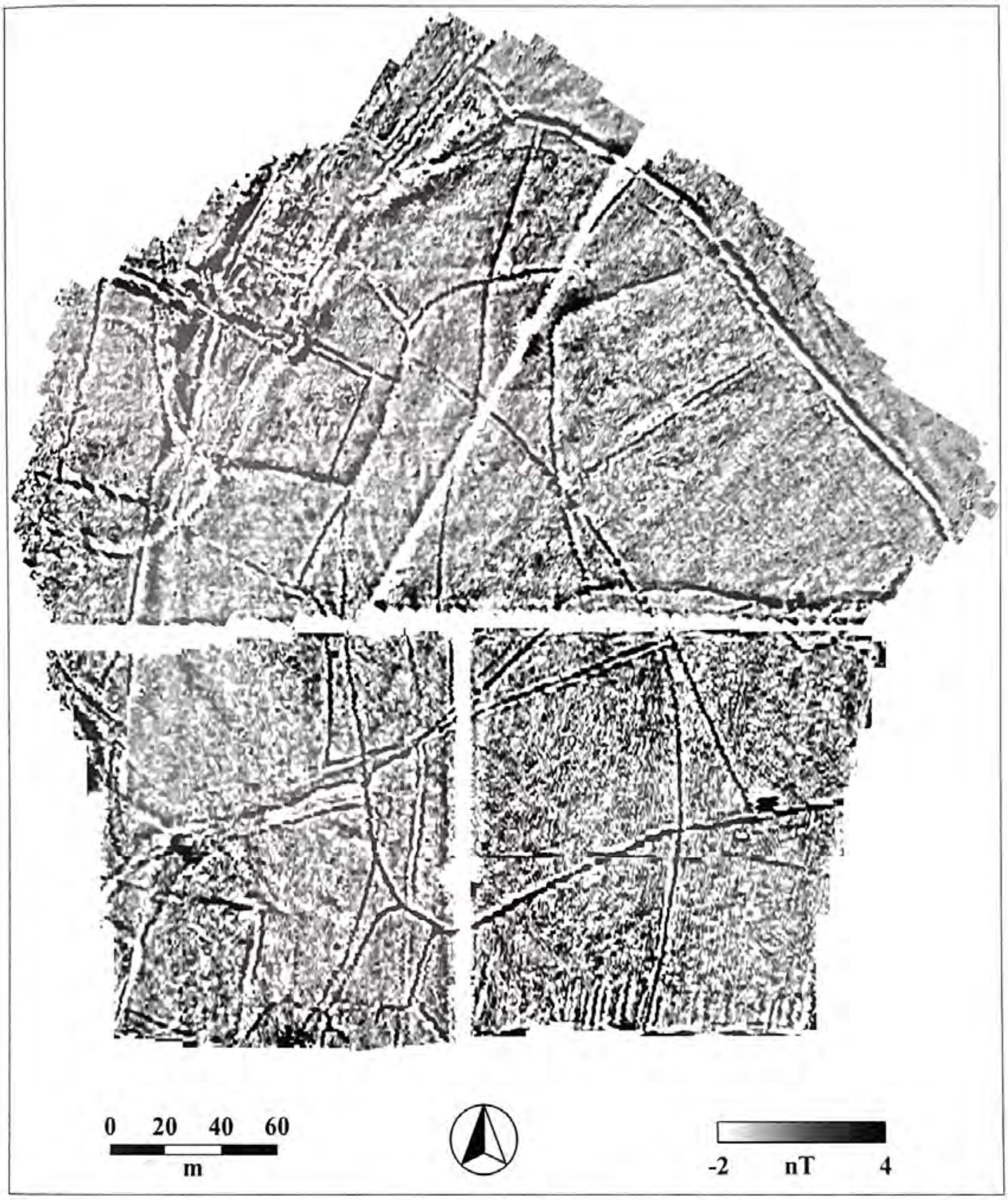
in others there is either a positive and negative anomaly, or simply a positive response. These responses can be associated with a) ditches flanking a bank; b) a bank with a single ditch; or c) a bank comprising igneous stone faces and an earthen core. It is certain that the dating of any boundary is fraught with problems as in many instances they follow the same line for hundreds, if not thousands of years (**57**).

While geophysics may have limitations in dating archaeological remains, it often comes into its own when investigating cropmark sites and checking the accuracy of any aerial photographic rectification. One prehistoric site studied in the early 1990s near Rugby, Warwickshire, clearly demonstrates the level of errors that can occur, in this instance probably as a result of field boundaries being moved. A maximum discrepancy between the geophysics and the rectified plot of some 20m in east-west and 10m north-south was noted (**58**). Also there was a considerable difference in the shape of some of the enclosures, while others correlated far better. This example does not suggest in any way that aerial photographic rectification 'does not work' or that geophysical data sets are necessarily 'better'; geophysical survey has been used here to refine the aerial photographic evidence and has produced a more accurate and, importantly as the enclosure is no longer skewed, a more meaningful archaeological interpretation.

Settlement enclosures and settlements

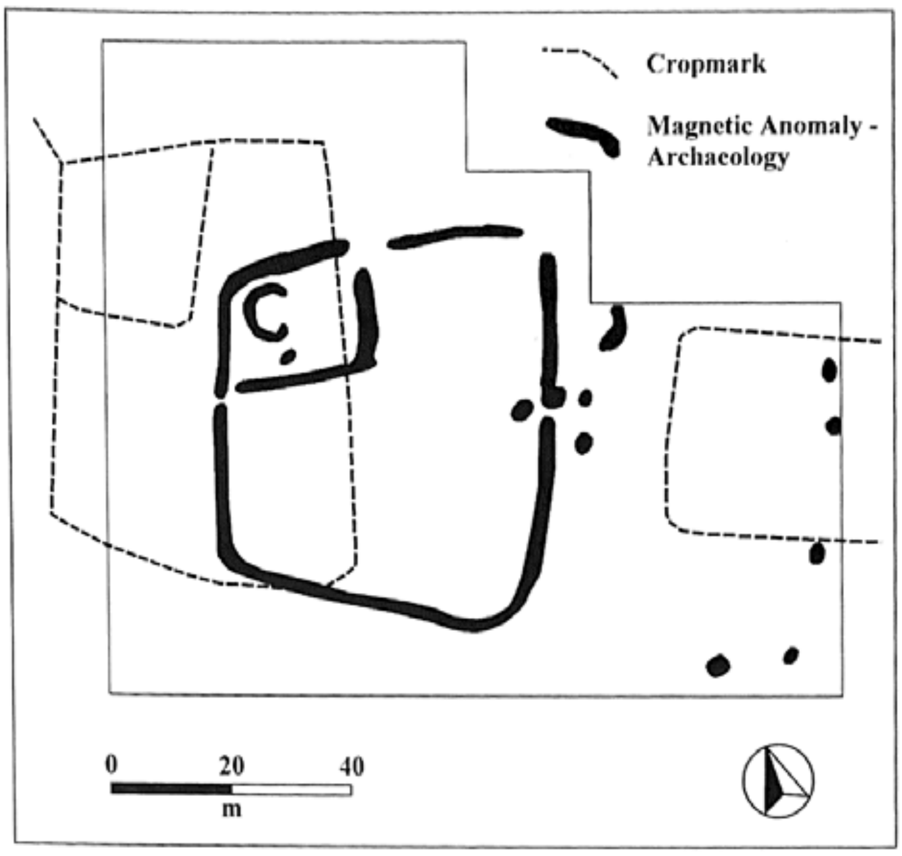
Settlement sites, because of their very nature – lots of burnt features and rubbish deposits – invariably produce good magnetic results, even in the prehistoric period. Clearly the range of sites is vast and only a few examples can be included here, but these will hopefully serve to demonstrate the diversity of sites and features that can be mapped geophysically.

In the late Bronze Age one particular type of site associated with habitation that is common in the landscape are burnt mounds. They are scattered throughout



57 *In some areas geophysical survey can reveal field systems that are the product of many thousands of years of landscape management. This survey from Cambourne, Cornwall, illustrates this point; at the north-eastern edge of the survey the present field boundary mirrors an earlier boundary while elsewhere, the modern boundaries, seen here as white 'blanks' cut across the former landscape divisions. Fluxgate gradiometer data. 1.0m x 0.5m.* GSB survey for Cornwall Archaeological Unit

southern England, and extend northwards, with major concentrations in the Isle of Man, Scotland and particularly in the Northern Isles; burnt mounds are also common in many other parts of the world. Although they vary greatly in size and date, they broadly comprise large heaps of fire cracked stones and midden deposits. These often form a horseshoe-shape which extends around a hearth and stone water trough. The stones are heated on the fire, submerged into the trough and

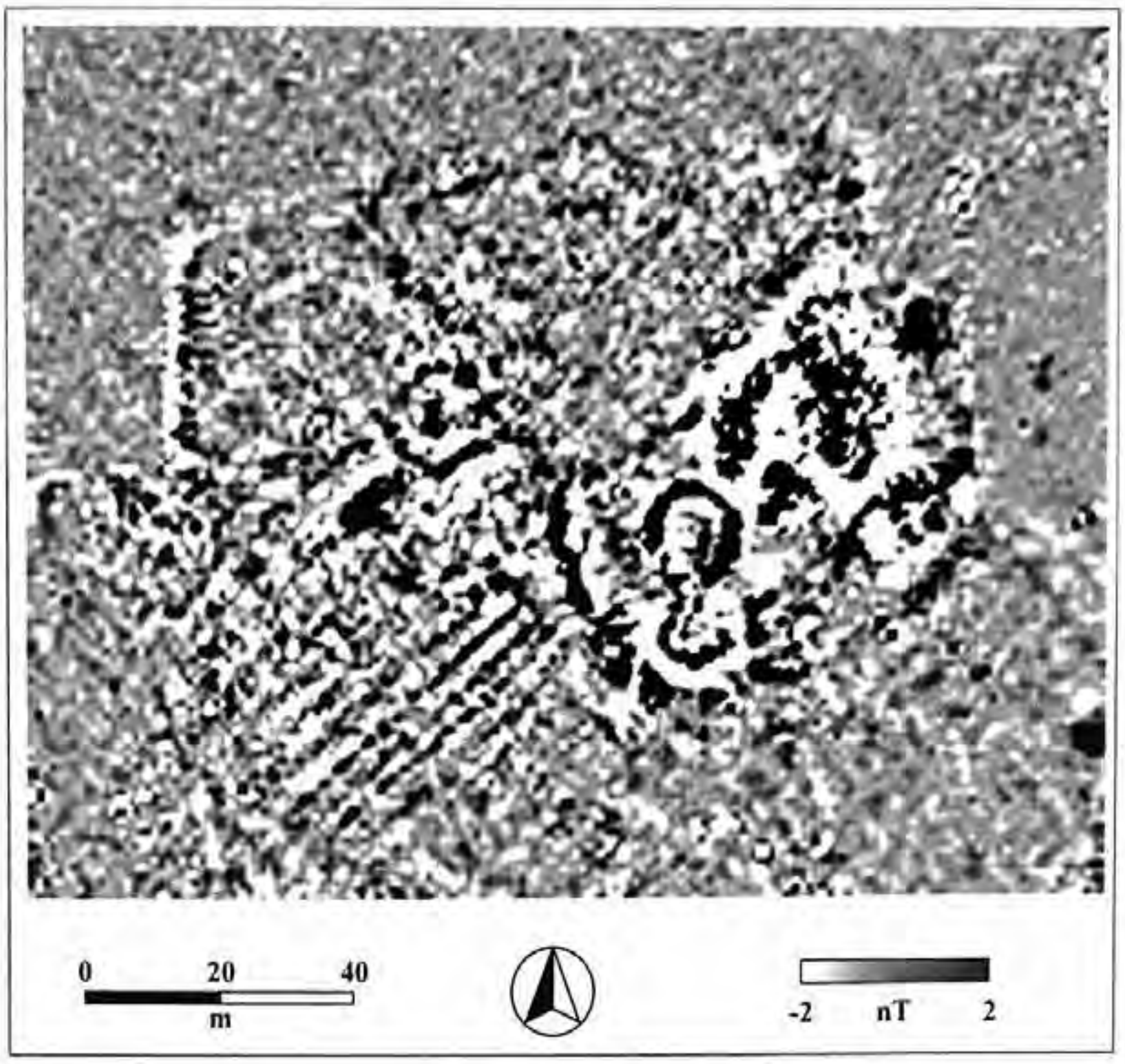


58 *This interpretation shows the spatial differences between a rectified cropmark and area geophysical survey. The interpretation of the latter produces a plan closer to the ground truth. Interpretation produced in a CAD package.* GSB survey for CPM

used to heat the water either for cooking or perhaps as some form of early sauna. The process results in a large numbers of fire-cracked stones that are simply discarded onto the 'burnt' mound. While a few of these sites have been surveyed using other techniques, the more common way to investigate the sites is using magnetic methods. The results from Shelly Knowe in Orkney are particularly dramatic (**59**), in part due to the presence of two adjacent round houses in the data (see Dockrill forthcoming). The responses are particularly strong as features have been dug into the midden material.

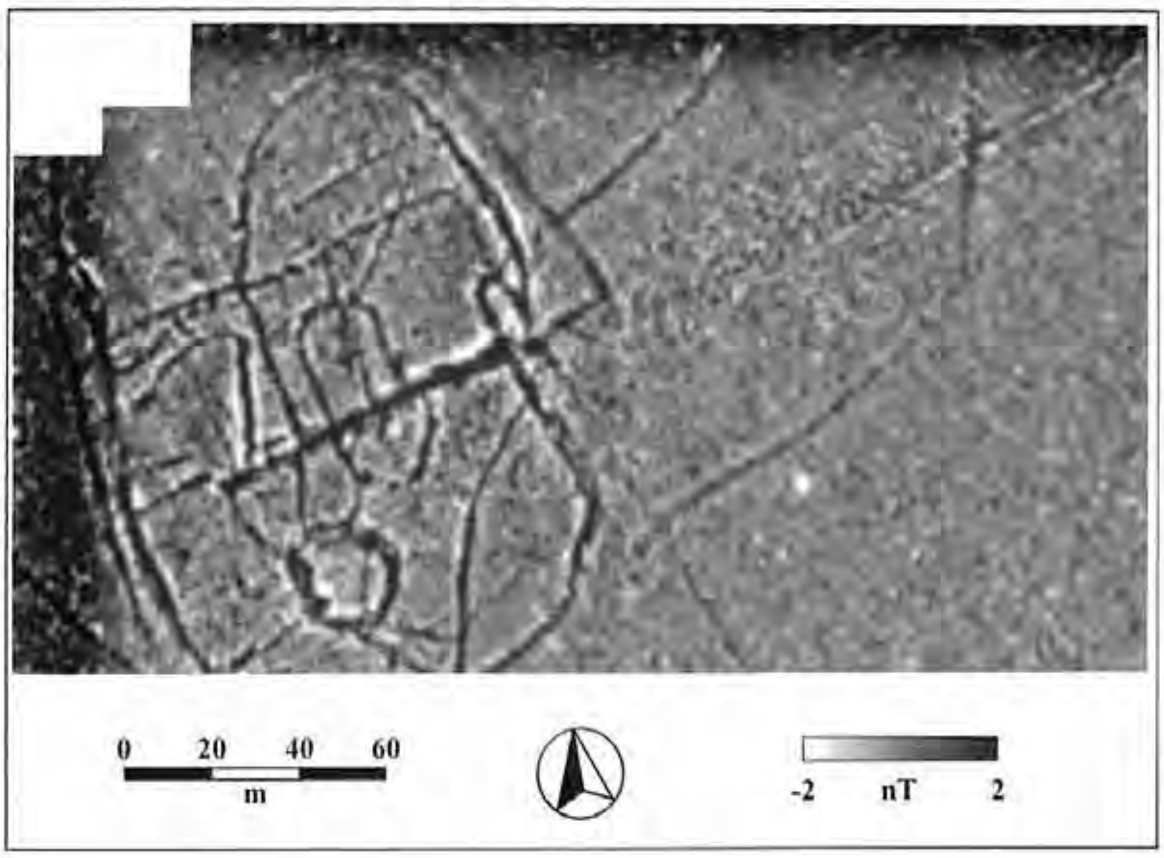
During the Iron Age there is a tremendous variety of settlement enclosures (see for example Haselgrove 1999) though one group, so-called 'D-shaped' enclosures, are very distinctive. A good example of such a site is at Norse Road (Dawson and Gaffney 1995) where the geophysics identified a complex of anomalies in and around the 'D' enclosure (**60**). While various alignments are visible suggesting a number of phases of activity, another aspect of these data is of particular interest. The strength of the responses in the centre of the complex is much greater than those further away. This effect has been observed on numerous sites and reflects the decrease in magnetic enhancement of the feature fills on the periphery of the main activity. Known as the 'habitation' effect (see Gaffney *et al.* 2002) this is particularly noticeable when there has been small-scale industrial-type activity or burning in one part of a site and the associated magnetically enhanced material becomes incorporated into nearby open features. Thus the same ditch some 30m away from a source of burning will not have the same level of magnetic response as that close to the activity. While this is essentially a behaviouralist view of rubbish disposal, on other sites the disposal of magnetically enhanced material is potentially more complex (see Stones of Stenness, below).

An unusual group of sites are the so-called 'banjo' enclosures, a descriptive term that derives from their shape. Various archaeological interpretations have been presented, from high-status settlement to stock enclosures, though they have

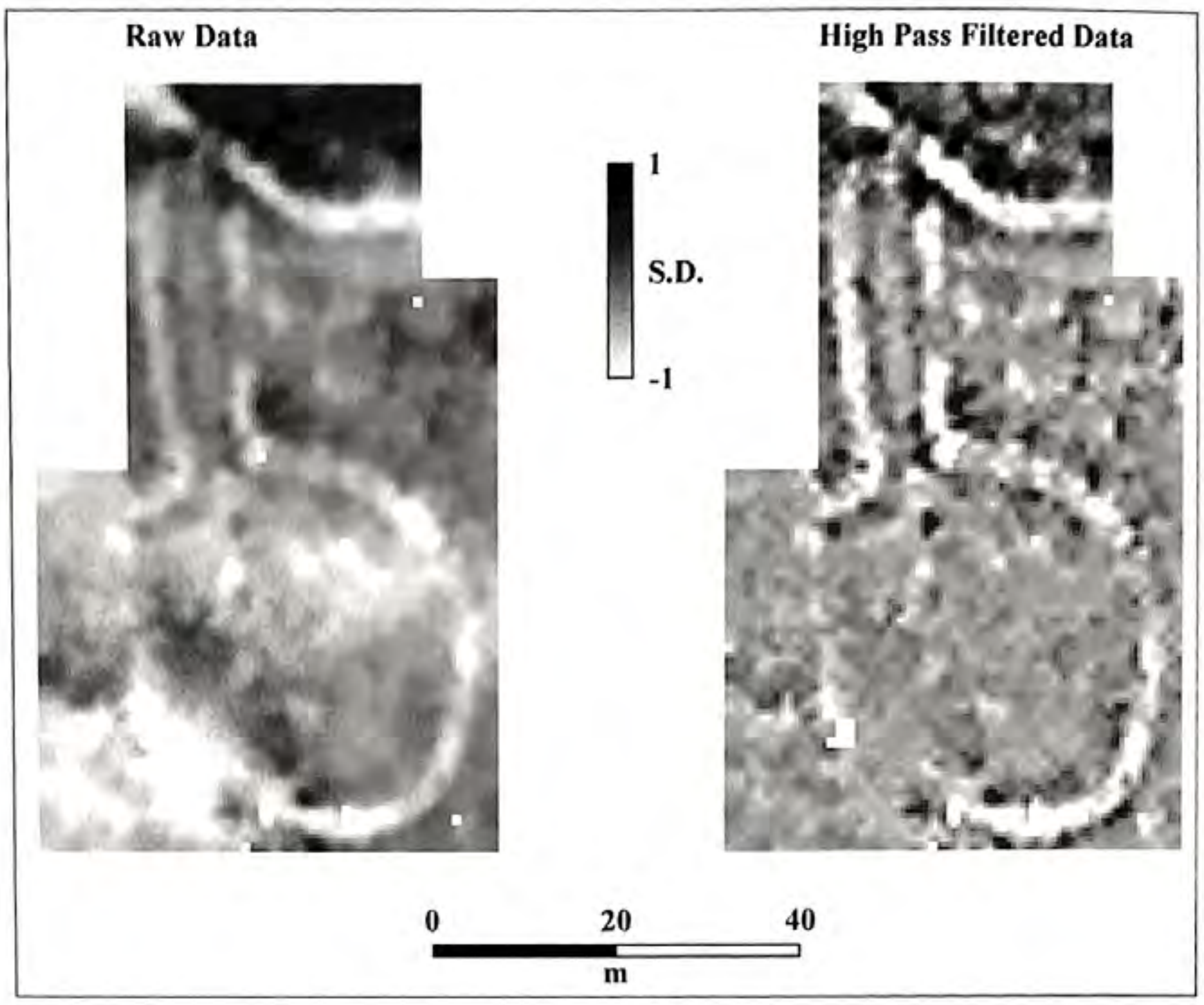


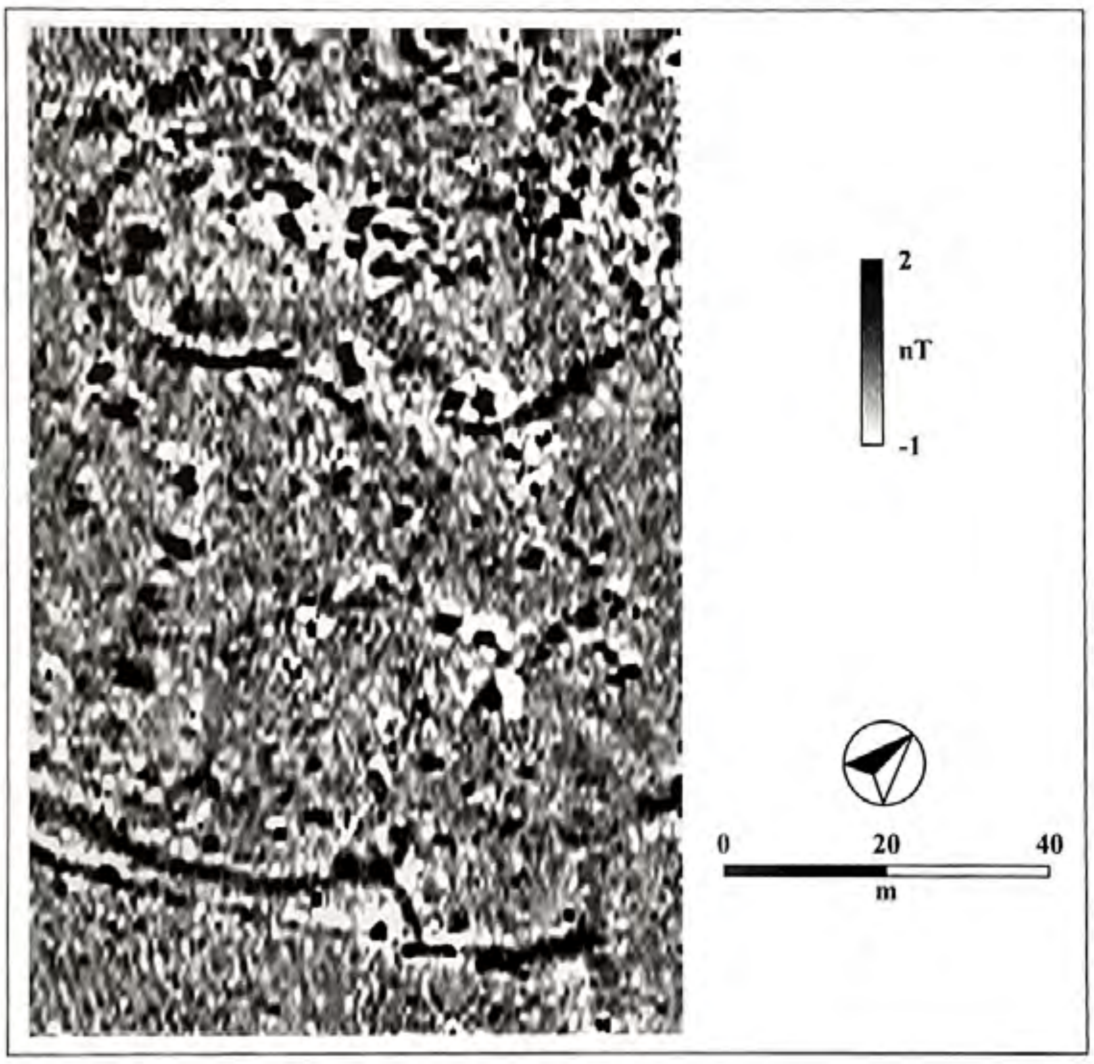
59 *A prehistoric landscape on the Isle of Sanday, Orkney, as revealed by a fluxgate gradiometer survey. The data were hand logged over a 1 x 1m survey grid.* GSB survey for Steve Dockrill/Historic Scotland

also been earmarked as 'ritual' in the past. Three examples are shown; one resistance and two magnetic surveys. The first, the resistance survey at Hamshill, is different to the other two in that it comprises a partially upstanding monument surviving in a densely wooded area. The neck and body of the banjo comprise narrow, stone revetted banks either side of an earthen core, hence the low resistance readings that reflect the latter (**61**). The other two sites are both located in arable fields and have been levelled. The Beach's Barn banjo has a number of large pits inside the body of the feature (**62**) and is surrounded by a complex of other archaeological features, some of a similar period while others are Romano-British



60 *The Iron Age site at Norse Road, Bedfordshire was first noted from the air as a D-shaped enclosure. The magnetic survey is of note due to the weakening of the response away from the core of the site. This decrease is usually referred to as the 'habitation' effect. Fluxgate gradiometer survey. 1 x 0.5m.* GSB survey for Albion Archaeology





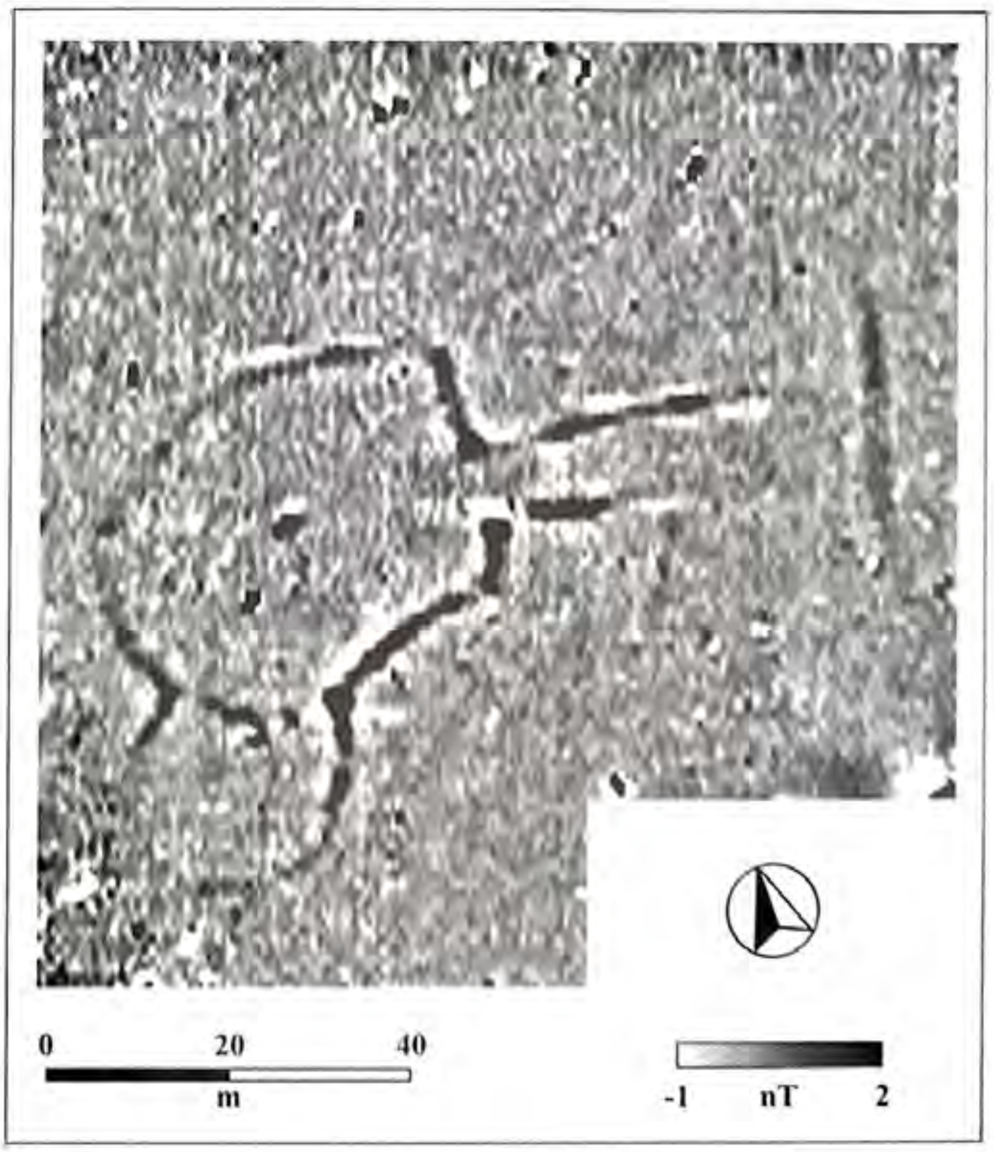
61 (Above) *Twin-Probe resistance survey on a 1 x 1m grid. The raw data have been interpolated to produced a smoother image.* GSB survey for RCHME. © Crown copyright NMR

62 (Left) *At Beach's Barn, Wiltshire, fluxgate gradiometer survey revealed a mass of anomalies suggesting much reuse of the land. Within the data set was evidence for a banjo enclosure. Over the centuries the thin soils over the chalk bedrock give little protection to sites of this type. Data collection 1 x 0.25m; interpolated in image*

in date. By contrast, a banjo near to Leamington Spa appears to be in isolation, a much wider survey failed to identify any other archaeological features, although it contains one large central pit (**63**). The site is also intriguing in that there is a small annex attached to the main body. The variation of internal detail suggests that these sites did have an everyday settlement function rather than some unknown 'ritual' use.

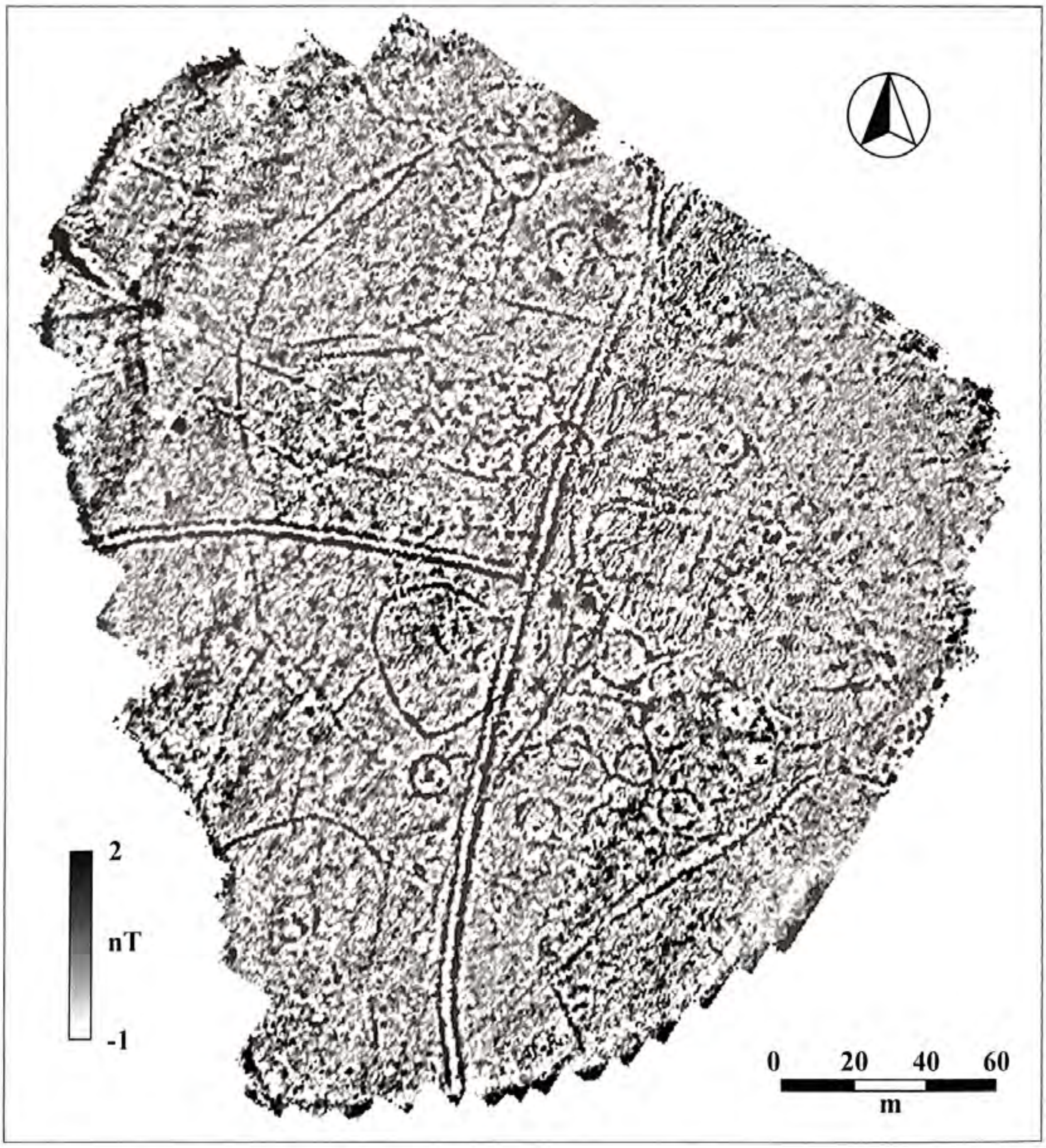
One of the earliest applications of magnetometers was in the study of hillfort interiors (see for example Fowler 1959; Aitken and Tite 1962) where work in the late 1950s, with a proton instrument, was followed by test excavation to verify the findings. Geophysicists are not normally afforded this luxury of being able to immediately excavate anomalies. At sites where a subsequent invasive archaeological investigation does take place, the excavation is usually undertaken some time after the survey and is often carried out by a totally separate organisation. With some of our work, notably the television programme *Time Team*, we have been very fortunate in that small trial excavations are regularly based on the results of geophysics and are often undertaken immediately after the data has been collected and analysed. Thus at Gear hillfort, in Cornwall, where approximately 7ha were surveyed in under three days, we were also able to see the results of excavations within a very short period of time. The complexity and density of the settlement as revealed by the geophysics within the hillfort is quite remarkable (**64**). There are zones of activity, trackways, ditched paddocks, enclosures and numerous round houses visible in the magnetic data. The geophysical evidence was supplemented by carefully targeted trenches which provided critical dating evidence and also an assessment of the state of preservation of the features.

A number of hillfort sites in southern England have been investigated geophysically by English Heritage (Payne 1996). Having well-defined limits, usually in the form of massive defensive ramparts, these sites provide a discrete area which can be studied in their totality. Payne has demonstrated that the results of the geophysical work not only provide valuable information on the nature of occupation at the sites

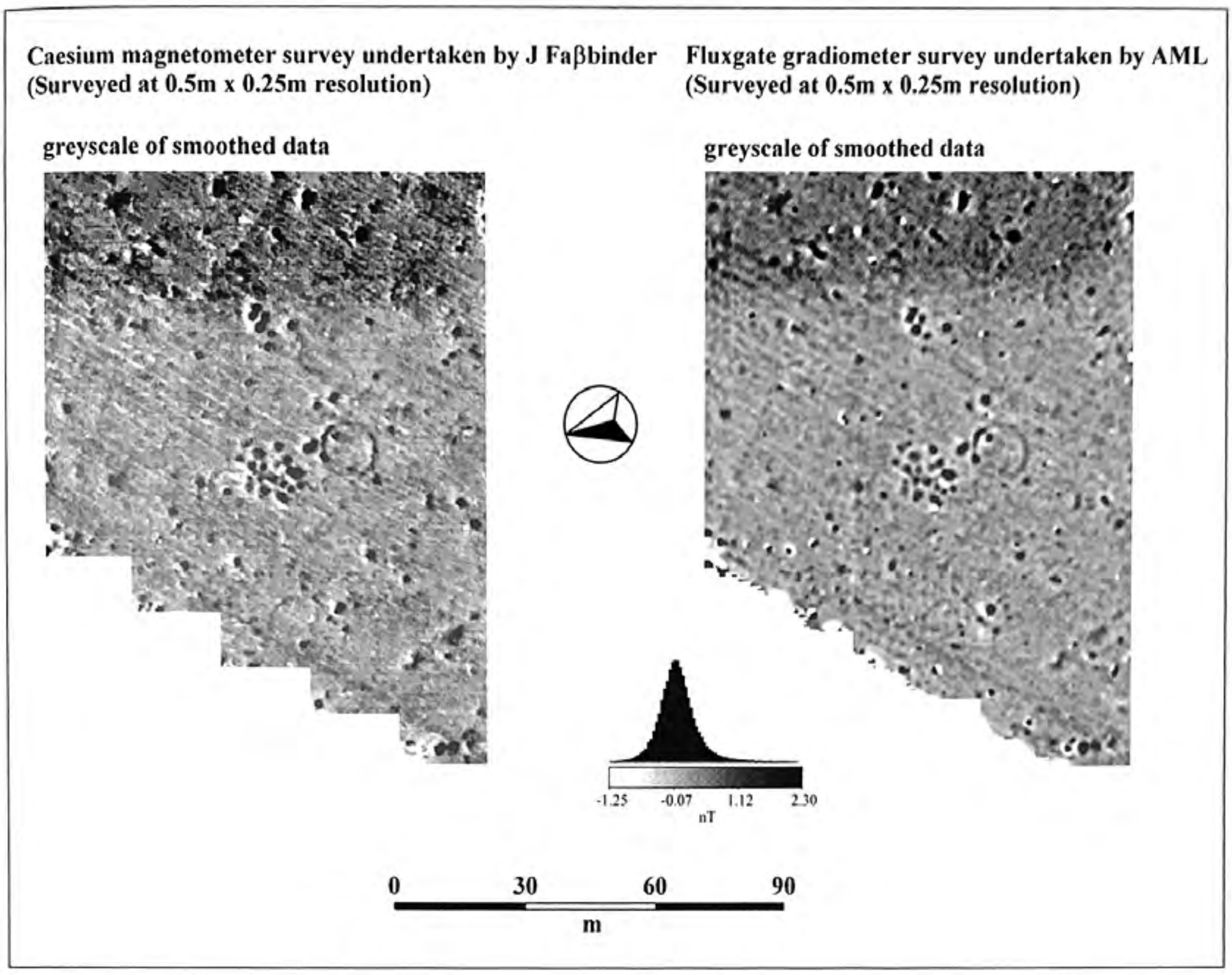


63 *The banjo enclosure shown here has an annex attached to one side. In contrast to the previous two examples this site lies within an area of relatively few archaeological sites. Fluxgate gradiometer survey. 1 x 0.5m.* GSB survey CPM

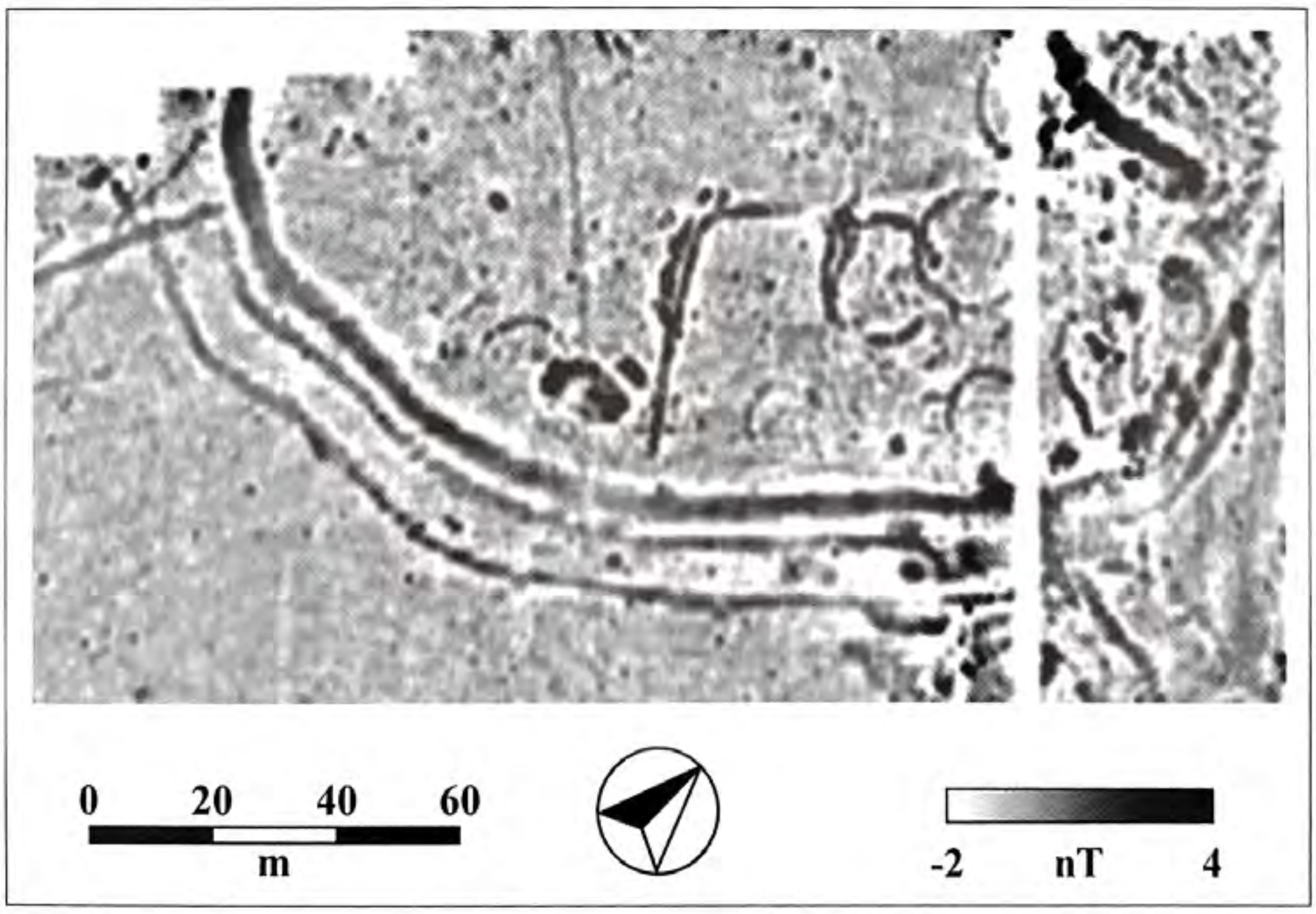
– the density of dwellings and storage pits, for example – but they can also aid the conservation and management issues at such sites (**65**). While this role of geophysics has become more recognised, the fact that geophysics can help locate and identify new hillforts is perhaps surprising. At Westwood, in Somerset, this is exactly what happened (Gater *et al.* 1993). While investigating the site of a 'lost' Bronze Age barrow on the edge of a prominent hill in Somerset, for the Royal Commission on Historic Monuments (RCHME), two large curving ditch-like anomalies were noted in the magnetic data. Scanning in the adjacent field identified a complex of anomalies and the gradiometer survey was extended. This detailed work revealed a triple ditched (and banked) enclosure encompassing an area of approximately 2ha (**66**). There is an internal subdividing ditch which contains a number of ring ditches



64 *This image is of* c.*7ha of fluxgate data. 1.0m x 0.5m. Prior to this survey no archaeological information, apart from limited fieldwalking evidence, was know from the interior of this hillfort*



65 *Detailed survey using both caesium vapour and fluxgate gradiometry from the interior of Segsbury hillfort. Given the high resolution of the data collection the images contain much fine detail. As seen elsewhere there is very little difference between the two hand-held devices.* The images were supplied by Andy Payne, English Heritage



66 *Detailed fluxgate survey (1 x 0.5m) over the 'lost barrow' at Westwood revealed the defences of a hillfort and several ring ditches.* GSB survey for RCHME. © Crown copyright NMR and an apparently open area presumably used for the penning of animals. Although there is a scatter of pits across the whole of the site, the density is not great, perhaps only 50 pits with diameters greater than 1m in size.

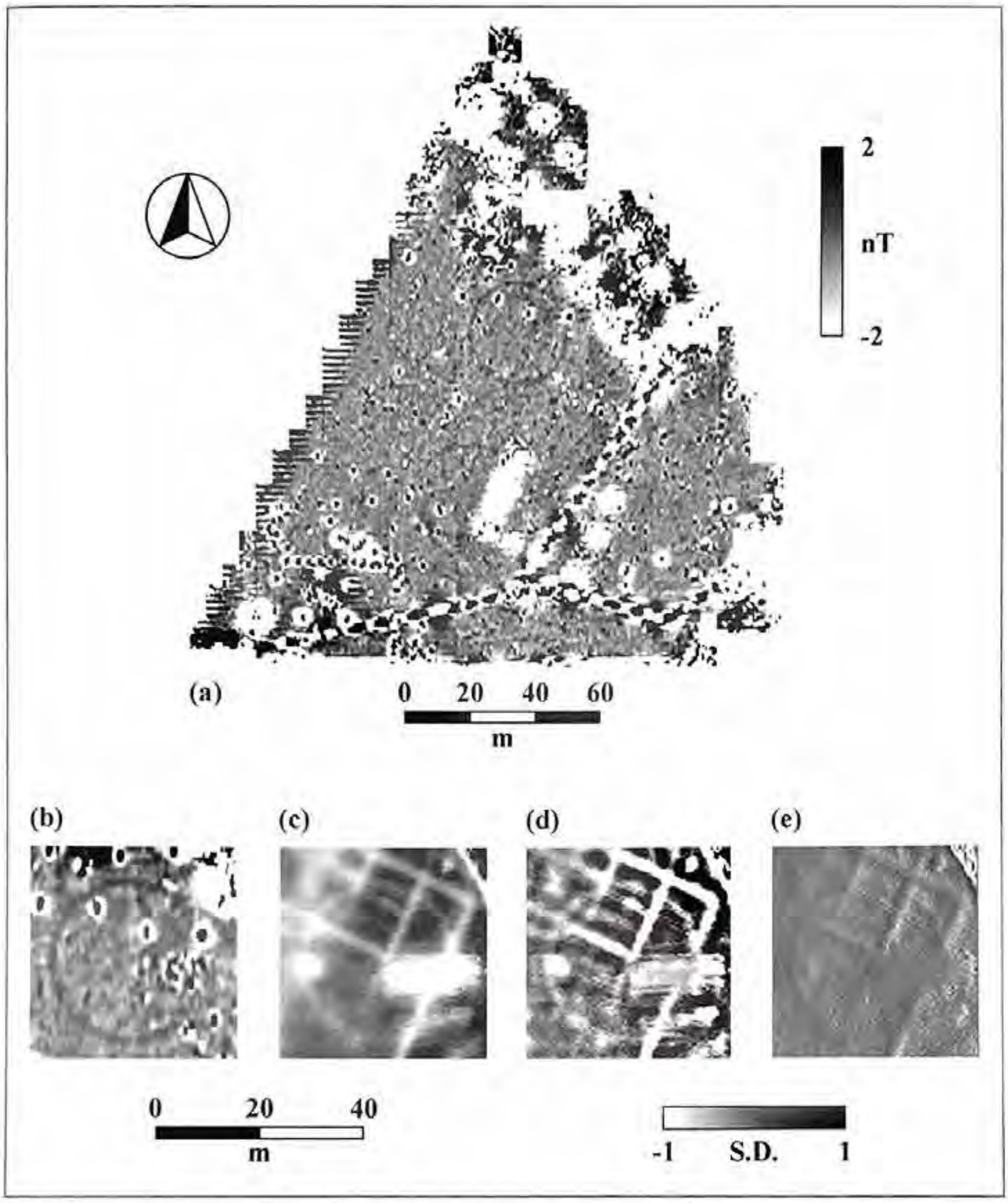
Ritual sites

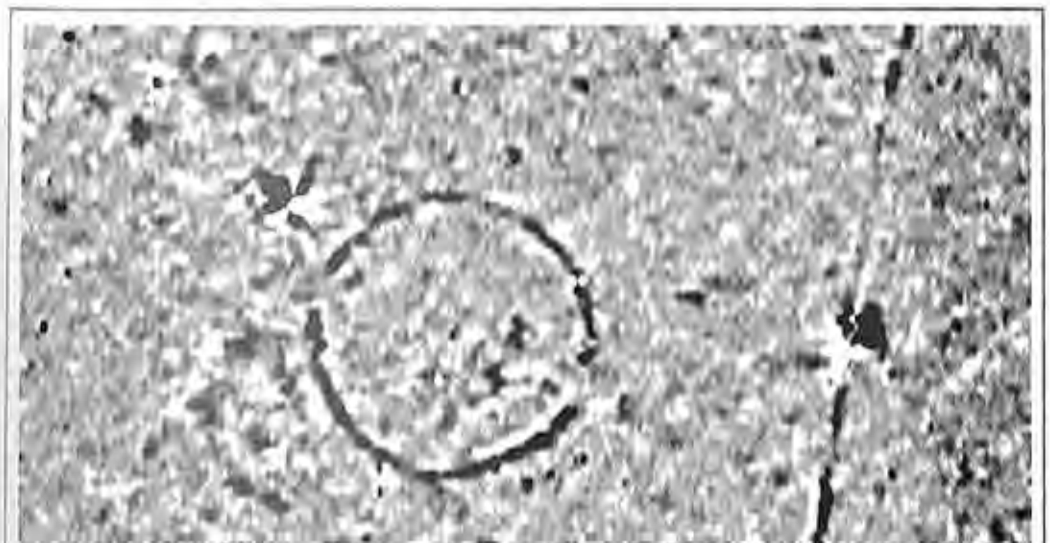
Depending upon which definition of the word 'ritual' is adopted, the variety of sites that fall into the category is endless. While some types, such as cursus monuments, are archaeologically important, many 'ritual' sites provide little characteristic in terms of geophysical response. Therefore, we will confine ourselves to a few of the more unusual sites where geophysics has revealed important archaeological patterning.

One of the best known, early magnetic surveys that provided a dramatic geophysical image was by Clark (1973) at the stone circle and henge monument known as the Stones of Stenness in Orkney. The magnetic anomalies associated with the ditch produced a striking plot of the site with igneous dykes (strongly magnetic volcanic formations) clipping the edge of the monument. The site was recently re-surveyed and then extended to cover a wider area of the surrounding landscape (GSB 2002). Parts of the resultant plot, reproduced here (**colour plate 14**), again show the ring ditch and the complex of dykes, which could easily be mistaken for field boundaries without proper analysis of the nature and strength of the magnetic anomalies. The variability of the strength of the magnetic response from the circular ditch may be archaeologically important. As there is no 'habitation' effect at work here, the variation in enhanced magnetic material may be significant and relate to ritual disposal of that material.

One of our most surprising results was the discovery of a hitherto unexpected ring ditch on a sports playing field in Worcestershire as part of a standard archaeological evaluation exercise. Playing fields are often difficult for geophysics because of a number of complicating factors: past landscaping to level the fields; underlying field drains and service trenches; sand pits and artificial surfaces for practice areas; and magnetic interference associated with metal goal posts. Examples of all these effects are visible in figure **67** but in amongst all the noise is a distinctive ring anomaly measuring approximately 30m in diameter. Unfortunately the north-eastern arc of the ring is magnetically disturbed by modern ferrous material, thus it was not possible to be certain whether or not there was a genuine break at this point. Excavation confirmed the existence of an 'entrance' and provided dating evidence to suggest that the site is a henge-type monument.

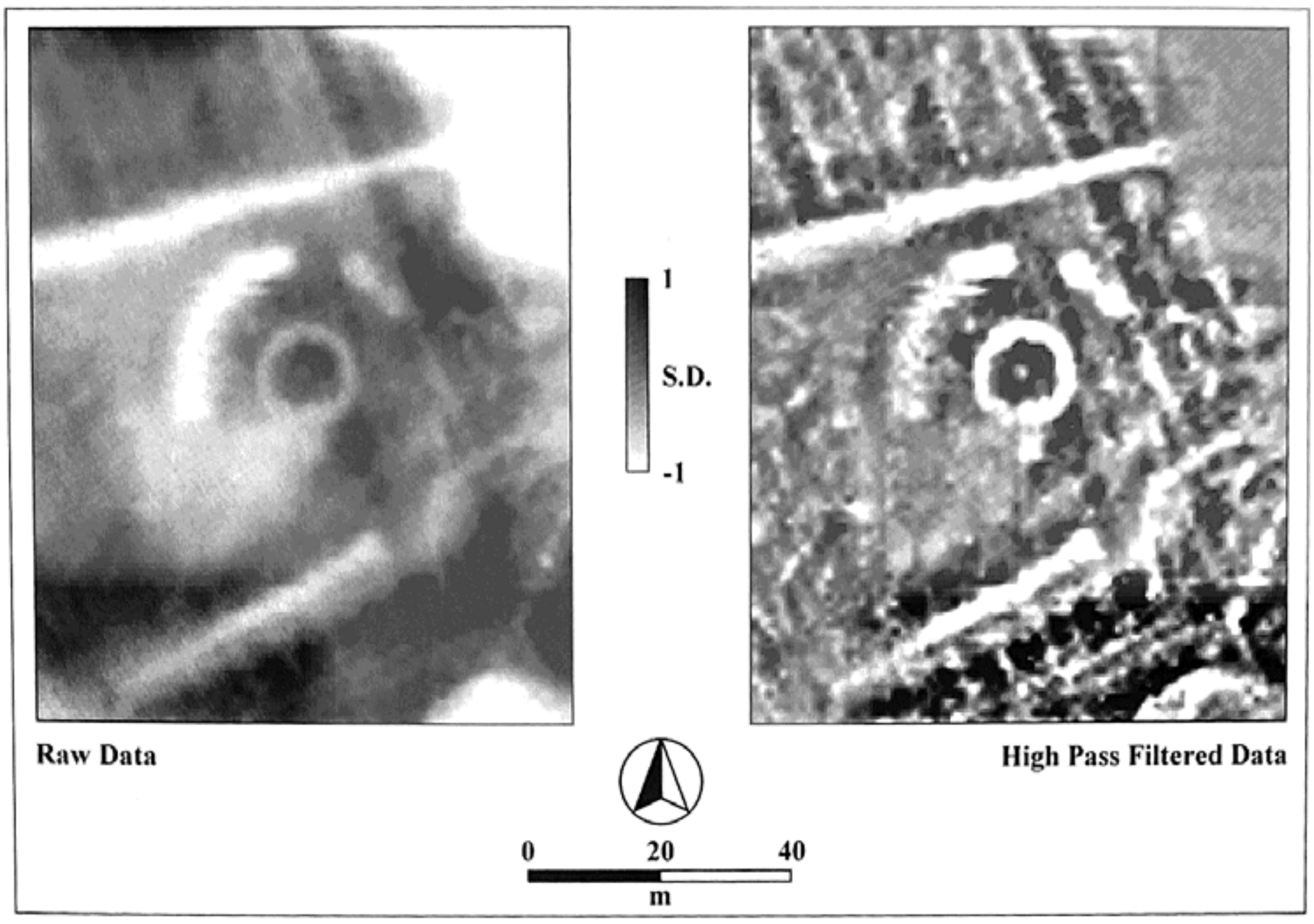
Another example of a henge, this time a Class II henge, that is a henge with two entrances, is from Catwick in Yorkshire (**68**). The entrances show clearly in the magnetic data and there are a number of internal responses of archaeological potential. However, when the area outside of the henge is also analysed there are similar magnetic anomalies, and this wider perspective makes the interpretation of the internal detail less certain. It is apparent that there are a number of amorphous anomalies across the survey area and they could all be either archaeological in origin or the result of a natural soil effect. By way of contrast, the results from Stanton Drew





67 (Above) *(a) Fluxgate gradiometer survey over a school playing field at Perdiswell produced many anomalies of modern origin. In amongst the ferrous debris can be seen a ring ditch. After a small trial excavation the ring was resurveyed (b) and also subjected to Twin-Probe resistance survey. The resistance data is shown in (c) raw (d) filtered and (e) relief plot. The large area of disturbance is due to the trial trench, while the grid is a result of white lining on the playing field.* GSB survey for WHEAS

68 (Left) *Fluxgate data set 1 x 0.5m. A Class II henge from Catwick in East Yorkshire. Whilst there are many anomalies of possible interest within the henge, similar anomalies can be found outside of it; it is possible that all of the pit-type anomalies are natural rather than the product of anthropogenic action.* GSB survey for ARCUS



69 *The Twin-Probe resistance data set. 1 x 1m. The data on this henge-type site were collected by Continuing Education students undertaking a short course in archaeological geophysics run by the University of Leeds in conjunction with GSB*

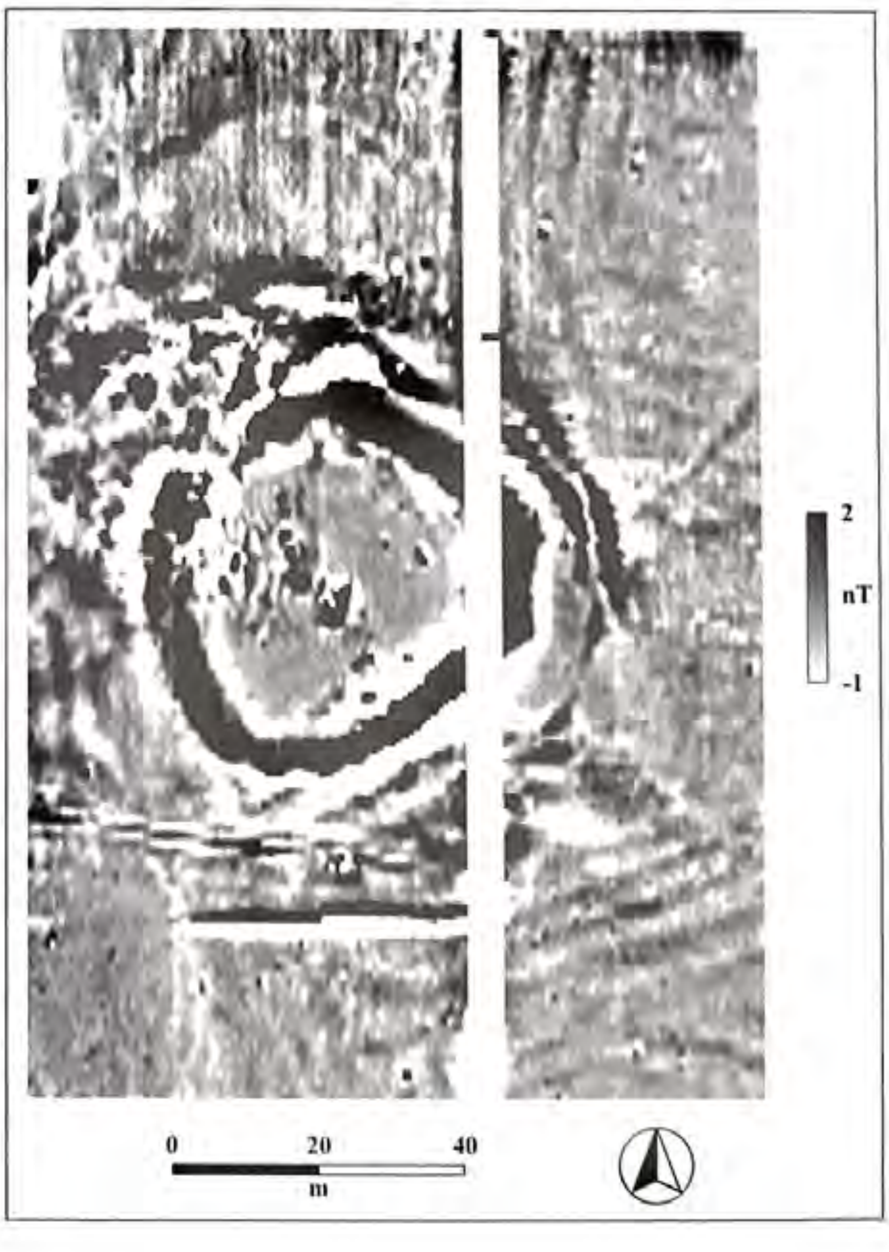
in chapter 3 show the amazing internal detail that can, under good conditions and high sample density, be extracted from henge monuments (see **31**).

Also probably falling into the category of henge is a site first noted from the air in North Yorkshire. Magnetic surveying at the site near Gargrave hinted at the complexity of the site; however, the responses were weak due to a lack of magnetic enhancement that is typical on an infrequently used site. Fortunately, the resistance results have provided an unambiguous plot indicating a central circular low resistance ditch anomaly measuring 15m in diameter (**69**). There may be a central pit and a possible area of high resistance in the inner north-east quadrant. Beyond the north-west and north-east extremities of the ring are two arcs of low resistance readings suggestive of ditches. There is no evidence for matching arcs in the south-west or south-east. Two straight linear ditches run to the north and south of the site, though whether an integral part of the monument or later field boundaries is uncertain. The diagonal trends crossing the survey area are associated with ploughing, some of which seem to stop at these 'boundaries', although others continue through. Even though the results are clear, without excavation the interpretation of this collection of responses will remain puzzling.

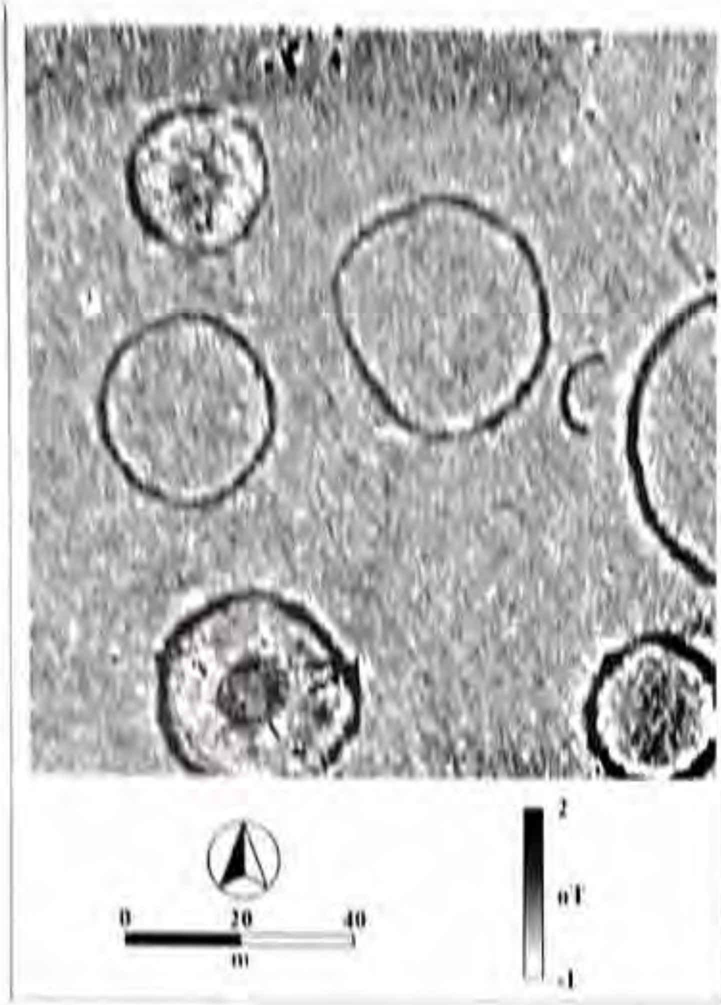
A totally enigmatic site which provided perhaps even more dramatic and unexpected results is Mine Howe in Orkney. Here, a series of steps was rediscovered by a local farmer extending some 7m down into the centre of a prominent earthwork mound. During a detailed geophysical investigation, which was carried out primarily to try to establish whether there were any chambers surviving in the mound, a substantial ditch up to 8m wide and 2m deep was discovered. Viewed best in the magnetic data (**70**) the ditch encircles the mound with an opening/entrance in the north-west. The complex of magnetic responses at this point is associated with a concentration of archaeological activity, including small-scale metalworking processes.

GPR survey was carried out at Mine Howe but failed to penetrate through the Boulder Clay and so the question of whether there are further chambers in the mound remains unresolved. However, the technique initially provided useful profiles and depth information for the ditch (**colour plate 15**) and aided the excavations. Subsequent time-slicing of the data resulted in a clearer picture of the ring ditch in plan view and at differing depths (**colour plate 16**).

Finally, mention must be made of Stonehenge, which is part of one of the most important archaeological landscapes in Western Europe. It is perhaps surprising that the first geophysical survey of the monument itself was only carried out in 1994. However, during the past decade the land surrounding the henge has been subjected to an unprecedented amount of archaeological geophysics. While some of the work has been research orientated, even more surveying has been undertaken due to the evaluation of land as a result of proposed improvements in the local road network and a suggested new visitor centre for the monument. A result of this is that data have been collected over many hundreds of hectares and it is clear that at this scale the geophysical information is contributing to the understanding of Stonehenge at the landscape level, rather than at the monument, or site, level (David and Payne 1997).



70 *Fluxgate gradiometer data from Mine Howe in Orkney. 1 x 0.25m. The results indicate a substantial ditch surrounding the mound and a plethora of other archaeological responses, particularly concentrated around the entrance in the north-west.* GSB survey for OAT/Historic Scotland



71 *A remarkable complex of barrow ditches, some exhibiting internal features, presumably graves. Fluxgate gradiometer data, 1 x 0.25m.* GSB survey, data courtesy of Dr Charly French, Cambridge University

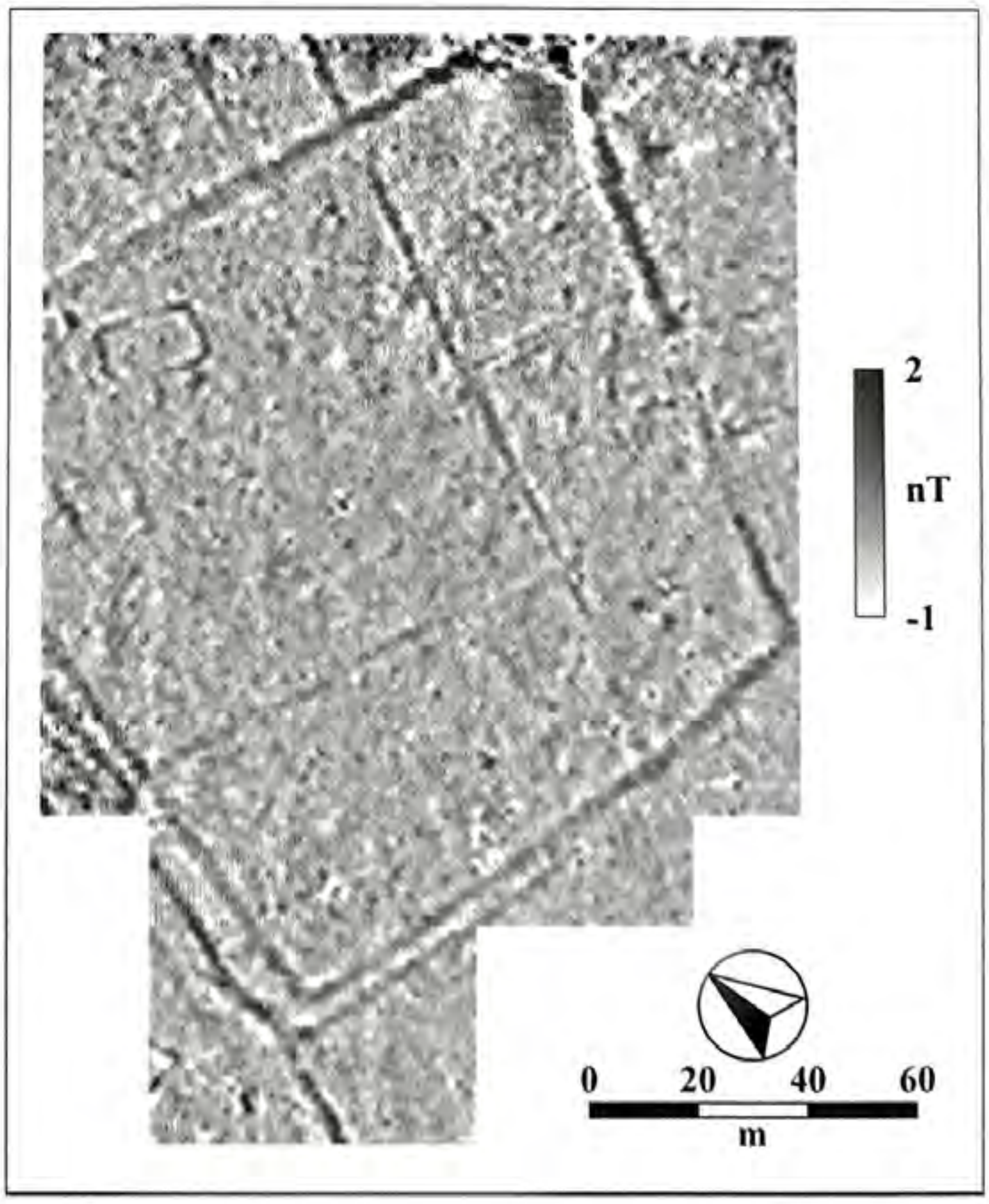
Burials

The range of funerary practices and burial types in the prehistoric period is immense. While geophysics can play an important role in identifying and mapping many of these sites, it is important to point out that the actual burial, i.e. the body or the grave cut, is a very difficult target to locate. There is no instrument that can detect bodies *per se* in the same way that a metal detector can find metal. Apart from the corpse and any grave goods, normally the same soil goes back into a grave as was dug out in the first place; consequently there tends to be little or no physical contrast that can be detected. However, the burials are usually located within a larger monument and it is these features, such as a surrounding ring ditch, that are more susceptible to detection.

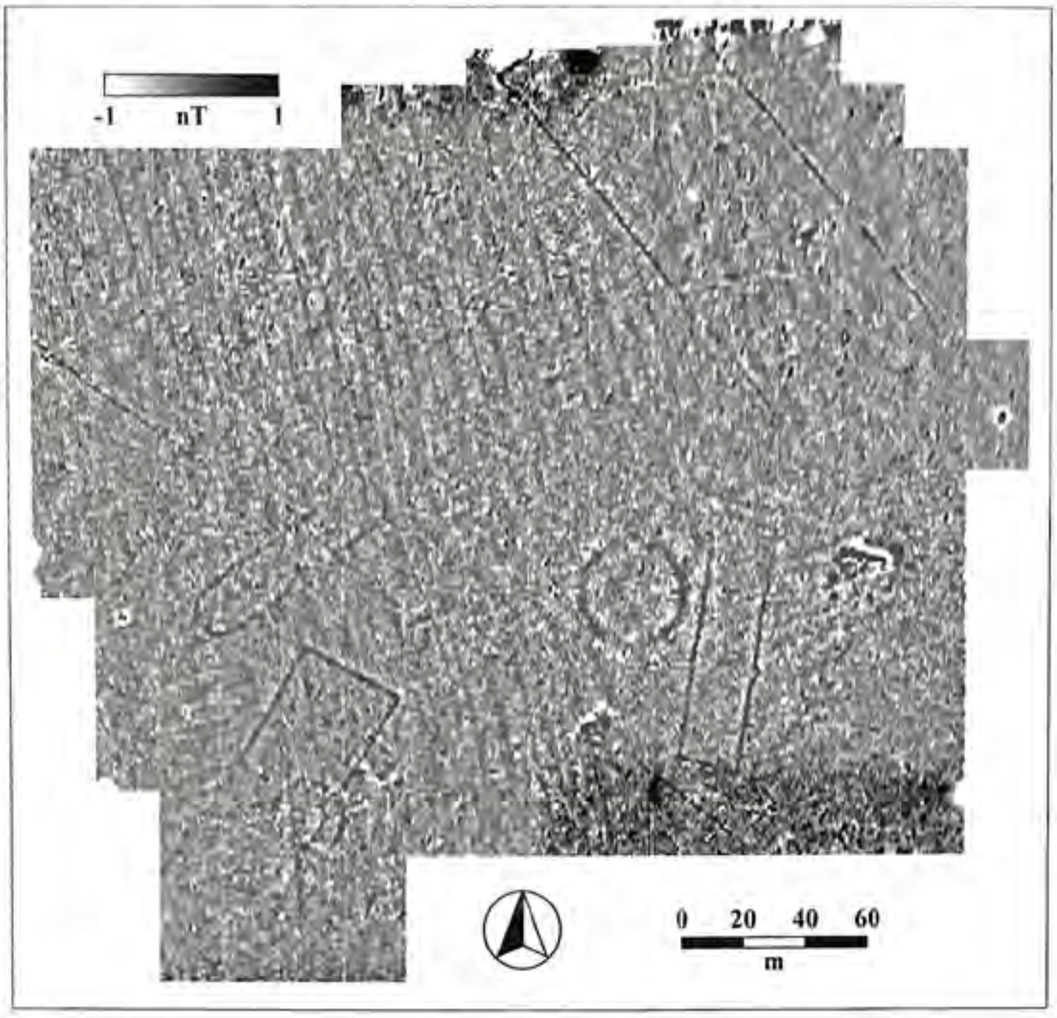
Perhaps the most common burial feature visible in the British landscape, either as upstanding monuments or as ploughed-out cropmarks, are barrows. These come in a variety of shapes and forms but geophysically they tend to comprise of the ditches that surrounded the long or round barrows. Occasionally if fire has been part of the burial practice, an internal burial can be located or if the grave is cut into chalk there may be a measurable magnetic contrast. At Wyke Down in Dorset, Dr C. French of Cambridge University has been carrying out a research project on the barrow group and the surrounding rich archaeological landscape (French *et al.* forthcoming). Part of the research design for the project has involved employing geophysics on a variety of ploughed-out sites and upstanding funerary monuments. While both have produced very clear results, there are interesting differences between the magnetic responses (**71**). Within the surviving mounds there is evidence for internal ditches and pits, presumably graves. Where the sites were ploughed flat, either the ring ditches were the only surviving feature or they contained areas of increased magnetic responses due to enhanced deposits being disturbed and dispersed by ploughing.

A rarer type of funerary site, a Neolithic mortuary enclosure, was identified during the survey of a Romano-British villa complex in Berkshire. It transpired that the villa was destroyed during the construction of a railway line, but during the search for the building the extended magnetic survey recorded a small rectilinear ditched enclosure (**72**). The shape and orientation of the features when compared to the other linears suggested that it dated to a different period from the Romano-British remains. On typological grounds alone it was thought to be perhaps Neolithic and excavation confirmed this hypothesis, though no actual burials were discovered. However, at another location the significance of this type of site could be easily mistaken, especially if the data set included many intercutting features.

The construction of the Bedford bypass in the early 1990s provided a rare opportunity to carry out an extensive geophysical survey over a landscape rich in a variety of archaeological features, largely Neolithic/Bronze Age in date. The work was carried out in conjunction with the Bedfordshire Archaeology Service (now Albion Archaeology). In particular part of the area that needed to be



72 *A small rectilinear enclosure within a complex of Romano-British field systems. Excavation suggested that the feature may be Neolithic in date and possibly a mortuary enclosure. Fluxgate gradiometer survey. 1 x 0.5m*



73 *A prehistoric landscape known as the Cardington Cursus Complex in Bedfordshire. Fluxgate gradiometer survey. 1 x 0.5m.* GSB survey for Albion Archaeology

surveyed is known as the Cardington Cursus Complex (**73**). The complex comprises a group of monuments associated with a small cursus; a variety of rectilinear enclosures exist, together with a 'paper clip' enclosure, and they follow a similar orientation to the cursus. There are also a number of circular features in the landscape. The complex is interpreted as a funerary landscape of some considerable longevity. Other complexes have been identified in the Midlands and East Anglia and although limited excavation has been carried out, the monuments are seen as coherent groups and not an accidental grouping. The alignment of the features is seen to be associated with sunrises and sunsets; as such it is believed that the complexes were involved with rites that accompanied the funerary functions of the monuments.

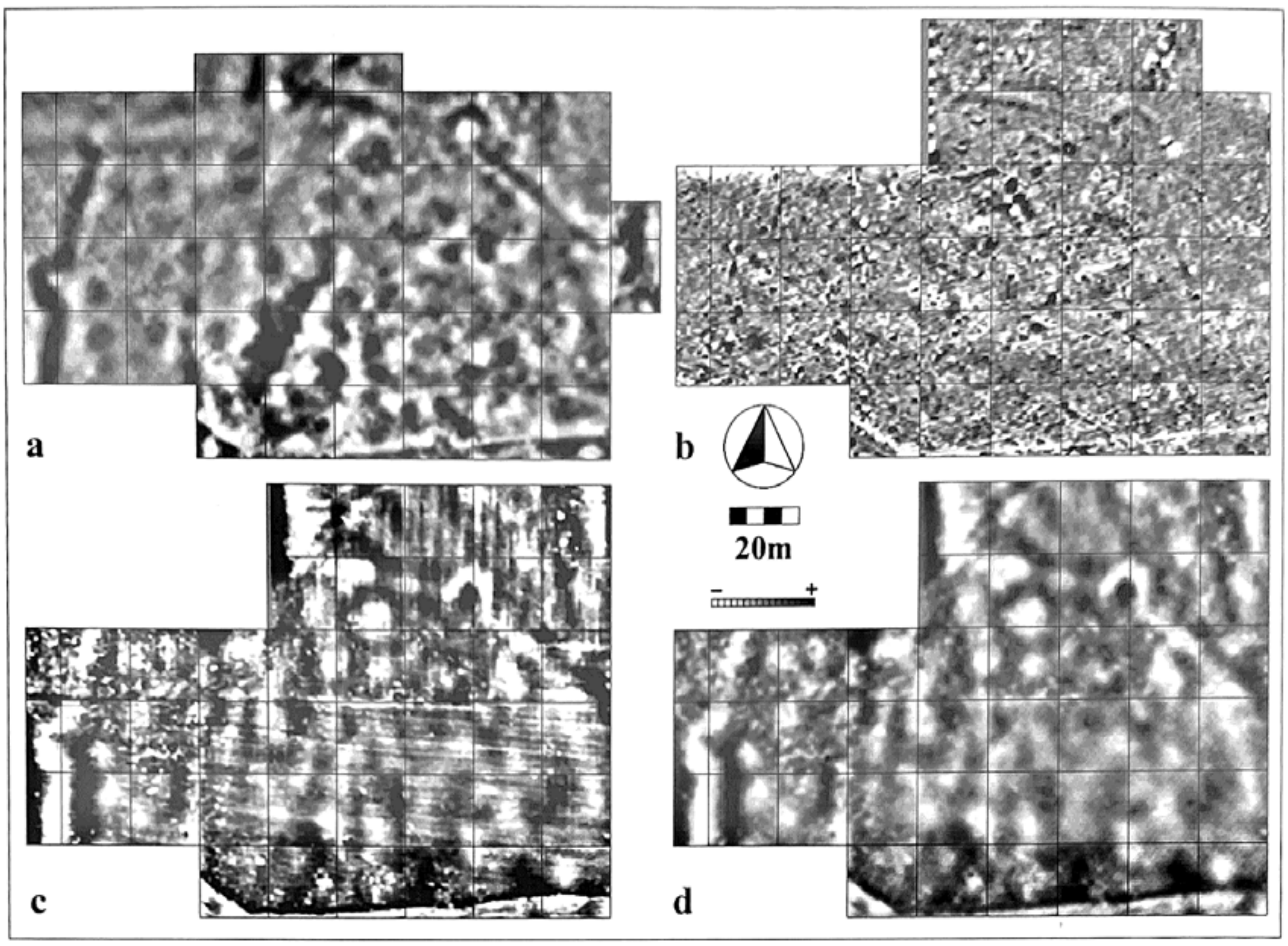
The complex was first identified from the air and fieldwalking recovered a number of artefacts, mainly flint tools and flakes. The aim of the geophysical survey was to accurately locate on the ground the cropmark features and to see if other features invisible to aerial photography could be detected. The site lies in a flat river valley on river sands and gravels, not the best of soils for magnetic enhancement. Furthermore, as we have seen, the nature of funerary and ritual complexes rarely leads to a significant enhancement of the magnetic properties of the soils. In this instance little magnetic contrast was observed between the archaeological features and the subsoil. The ploughed nature of the ground, including areas of potato furrows, added to the levels of noise to the extent that in places some of the anomalies associated with the archaeological features seem to disappear. Thus at one end an enclosure may be clearly visible as a low strength magnetic anomaly, while at the other it is poorly defined. Many of the linear anomalies also have the appearance of being fragmented. This is in part a function of the angle of strike of the collection traverse to the feature, an aliasing effect, but also due to the variable depth of topsoil.

When the results are compared with the aerial photographic transcription there are only minor differences in the plotted locations, though the 'paper clip' enclosure proved to have a discrepancy of a few metres. No major additional archaeological features were located in addition to those identified on the aerial photographs, though a few previously unrecorded linear features were interpreted. However, when the magnetic contrasts are so weak it is difficult to be confident about locating pit-type features, and although a few potential targets were highlighted it is quite possible that others were missed. This is a limitation of evaluation surveys. They tend not to allow for more intensively sampled surveys to be carried out, or for the work to be performed at a time when the ground conditions are most suitable. Thus, even though this is an excellent survey undertaken over a decade ago, the confidence levels remain low when one considers the problems associated with the mapping of subtle, but important, elements of this archaeological landscape, e.g. pits, slots and gulleys.

Wider perspective

Despite the fact that the first ever use of resistance survey in Britain was to try to locate pits of prehistoric date at Dorchester, it is now known that the technique is not very efficient at locating such features. But there are clearly specific cases on early sites where the technique has advantages over magnetometry. An example of one use of resistivity within a prehistoric study is connected with the estimation of the extent of flint mining in Poland. Herbich (1993) provides a thought-provoking set of electrical results using a variation on the 'Schlumberger' array at the sites of Polany and Krzemionki. Initially he performed a series of symmetrical Schlumberger soundings along a line and chose two separations for area survey that would illustrate both the near surface and the base of a known rubble horizon. It was clear that there was a substantial zone in both separations where the resistivities were common. Herbich argued that this was a result of the mixing of the geological layers by excavation and that the near surface variation was the result of undisturbed layers. Furthermore he predicted that the shafts themselves would be in the crossover area between the two zones and this was confirmed on excavation.

Most of the case studies presented in this chapter have shown that magnetometry, in the form of fluxgate or caesium vapour gradiometry, is the favoured approach on the majority of prehistoric sites in Britain. The magnetic technique has also proved extremely successful in the Americas, as can be seen in the spectacular magnetic map from Big Hidatsa Village (Weymouth 1986). However, it



74 *Data from Whistling Elk, South Dakota, USA. The resistivity data (a), collected using a 1m Twin-Probe separation, has illustrated the major elements of this native American village. The gradiometer data (b) is less informative but suggests that at least some of the houses were burned to the ground. The images in (c) and (d) are conductivity data collected using a Geonics EM38. The strong plough marks in the raw conductivity data (c) have been removed in (d) using Fourier methods.* The image is courtesy of Dr K. Kvamme. For an extensive description of the data from this site see Kvamme 2003

has been found that much closer sampling intensities are often required on these native American sites and the same is also true on many European sites in countries like Austria and Germany. In many cases eight samples per metre are often collected along traverses that are separated by 0.5m. The major reason for such high sample density is that the magnetic signal-to-noise is often very low and the target features themselves are small and/or insubstantial. As a result it is important to get a very good estimate of the background in order to work out what is signal rather than noise.

An excellent, recently published example of a multi-technique approach comes from the work of Kvamme (2003) on sites on the North American Great Plains of the Dakotas. Figure **74** shows some of his data collected at Whistling Elk Village which dates from *c.*AD 1300, but in this context a prehistoric site. Although on the majority of sites that Kvamme has surveyed, magnetic survey has proved most fruitful, the increased depth, *c.*1m of overburden, at Whistling Elk Village proved better for Twin-Probe resistance and EM38 conductivity surveying. His work shows that it would be wrong to discount other techniques that are available to archaeologists working on prehistoric sites.

Earlier in this chapter GPR was shown to be used on textually homogeneous soils to detect features that were otherwise invisible to geophysical techniques. Another EM application is over features of greater size. Frohlich and Lancaster (1986) describe the use of a Geonics EM31 instrument to identify shaft tombs in countries situated in the Middle East. This particular EM induction meter works at a frequency of 9.8kHz and has the coils separated by a fixed distance of 3.66m. Used in its vertical format this instrument can induce electrical currents in the ground down to a depth of 6m. At Bab edh-Dhra in Jordan the authors reported discriminating in-filled shafts and tombs and non-filled tombs. A significant interpretation was that while most shafts showed an increase of about five per cent in conductivity, those that had been recently robbed produced much higher increases, perhaps as much as 100 per cent. This of course allows efficient excavation but also significant mitigation strategies to be put in place as the burials can only be efficiently protected if their location is known.

Summary points

• Magnetometry is the preferred technique for identifying near surface cut, or negative, features that are commonly found on prehistoric sites.

• On sites that produce low-level responses it is imperative that a systematic approach is used to produce high quality data.

• 'Traditional' sampling intervals of 1 x 1m are not sufficient for collecting magnetic data on these sites. At least two samples per metre must be collected in one direction, and in some instances, mapping early sites in USA for example, the sample density may have to be increased several times.

• Many settlement sites can be located by rapid assessment using a fluxgate gradiometer and, if conditions permit, magnetic susceptibility can also be used. Ephemeral, or ritual, sites are often difficult to find with any rapid assessment or, indeed, with detailed survey.

• Other techniques should not be discounted. This is especially true of sites that are at a depth beyond the detection limits of a gradiometer.

7

SURVEYING ON EARLY HISTORIC SITES

It is probably true that more geophysical surveys in the UK have been carried out on sites from this time period compared to all the others. Of course there are a great number of Roman sites but the overriding fact is that geophysical techniques tend to work well on archaeological remains from this period. The nature of the archaeology is such that the sites are liable either to have good magnetic enhancement that is ideal for gradiometer survey or, due to the increased use of stone as a building material, they are favourable for resistance and GPR surveys. Although data collected over Roman sites often show considerable complexity, they frequently conform to highly regular patterning and this can lead to particularly good, if not 'true', archaeological images.

While there are many different types of sites within the early historic period, it is convenient to illustrate the potential of geophysical techniques in the following broad categories: roads, field systems, villas, settlements and towns, fortified sites and industrial sites.

Roads

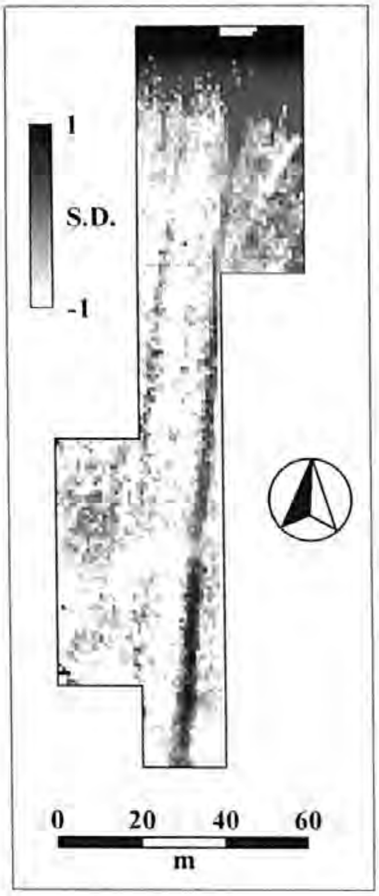
An integral part of any landscape is the network of roads and in the Roman period in Britain roads were constructed to serve both military and supply purposes. They are theoretically simple targets; the roads are often described as substantial stone features, constructed with several layers of hardcore and flanked by a ditch either side. In practice this 'standard' is rarely seen, and there are few geophysical examples; the 'standard' road may be a reality in, or close to, urban or fortified areas – they are clearly less substantial features in more rural locations and areas away from sources of suitable hardcore. Even when the road is classically made the geophysical evidence can be surprisingly slight. In the example shown overleaf, from Cheshunt in Hertfordshire, we were initially confused by the resistance data collected over what was believed to be a section of Ermine Street (**75**). The survey was started at the southern end of a field where the road was thought to emerge.

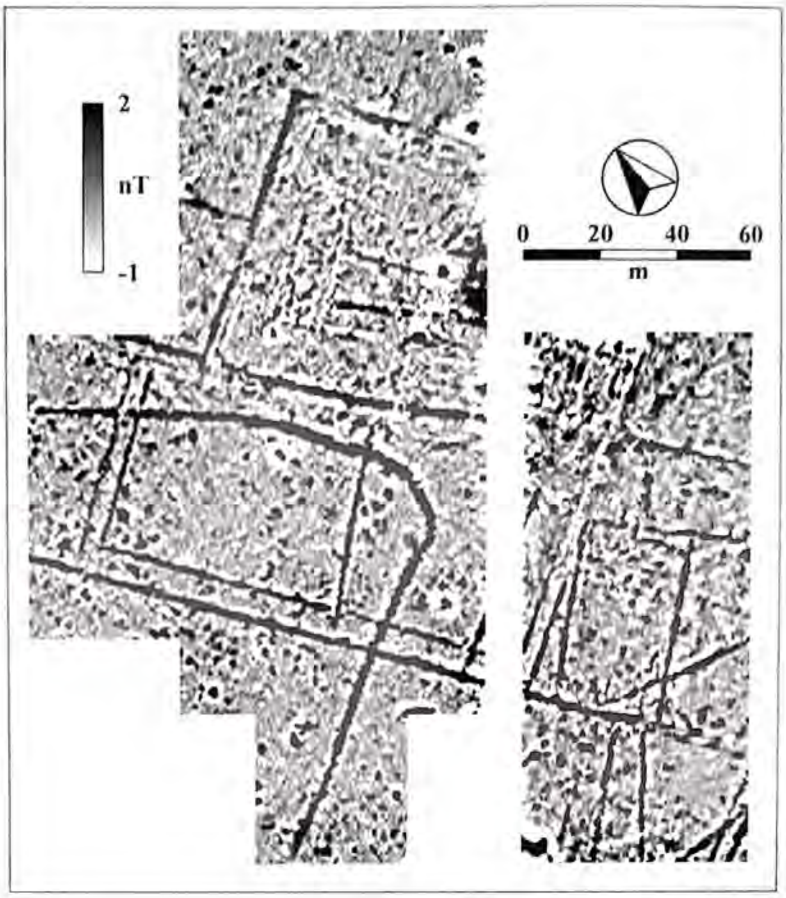
Within the data a clear high resistance anomaly was identified and we automatically assumed this to be the road surface. The survey was extended northwards and a second linear high resistance anomaly was discovered, aligned parallel to the first. As we expanded the survey, the two anomalies continued to follow each other and then we realised that these were the ditches flanking the road, being set some 17m apart. Our interpretation was that the ditch fills were better drained than the surrounding subsoil, hence the high resistance response, and that the original road surface must have been ploughed away. Excavation confirmed this interpretation; the side ditches had become filled with the gravel that had originally formed the road surface.

Given that Roman roads are justly famous for following straight lines, it is easy to devise strategies for locating them, as long as it is known in roughly which direction they are aligned. A standard procedure is to use search transects that are surveyed at right angles to the projected course of the road, either with magnetometry to locate any side ditches, or with resistance survey to locate the core of the road (see figure **47**). An alternative but similar strategy is to utilise an Electrical Imaging system to investigate a vertical section across the supposed line of the road. A survey of this type was undertaken at Lambeth Palace in the heart of London in an effort to find a Roman road that was apparently exposed in the 1930s. As the road was believed to be buried at about 2m depth, and adjacent to a buried garden wall and a medieval moat, it was decided that standard area survey may not be applicable. As a consequence, imaging data was collected perpendicular to the orientation of the road; the spacing between the probes was 1m and it was anticipated that the current would penetrate about 3m into the ground. The results (**colour plate 17**) show a zone of low resistivity data associated with the moat, a discontinuity linked with the garden wall and a lozenge of high resistivity material. The latter was in the correct location and at the approximate depth of the presumed road. Looking at this highly resistive body it is tempting to interpret the anomaly as the road, but it does not appear to have side ditches or a ground surface associated with it. It was with some reservation that excavation was undertaken at this spot and that caution was justified; a lens of natural gravel, probably fluvial, was unearthed at a depth of *c.*1.3m. This is a good example illustrating that not all anomalies have to be archaeological in origin even though on face value they appear to be.

Field systems

As noted in the previous chapter, field systems are notoriously difficult to date. Even the excavation of these features can often produce little or poor dating evidence and this is especially true when considering managed landscapes at some distance from settlement foci. It is impossible to date field systems in anything other than a broad brush manner using geophysical techniques, and our illustration here is linked to a site that has significant elements that are known to be





75 *Ermine Street, Hertfordshire. Twin-Probe resistance data. 1 x 1m. The two parallel linear high resistance responses indicate the gravel-filled ditches flanking the road, which itself has been ploughed away*

76 *Waltham Villa, Gloucestershire. The fluxgate gradiometer data, collected at 1 x 0.5m intervals, indicate a complex of Romano-British features associated with the villa building. The main building is situated between the nT scale and the north arrow. In addition, a large curving anomaly was recorded that excavation dated to the Iron Age*

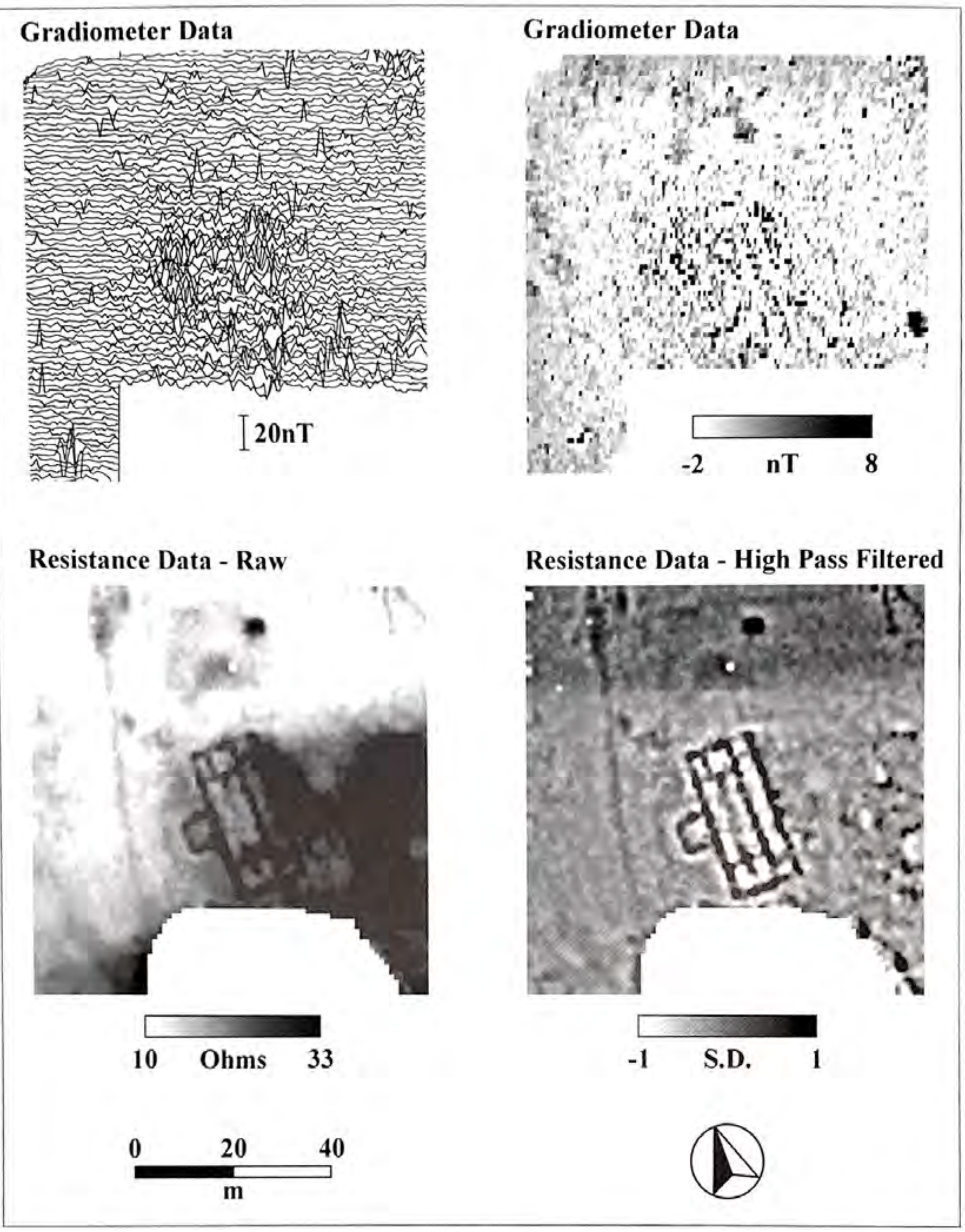
Roman in date. At Waltham Villa in Gloucestershire the planned rectilinear fields, paddocks and trackways associated with the villa complex are clearly visible in the magnetic data (**76**). A separate, large curving ditch anomaly was found on excavation to be an earlier, Iron Age, feature and this continuity of landscape use is a common scenario seen within geophysical data. Closer examination of the results also reveals several fields cutting, or being cut, by a trackway and some following a slightly different axis to the main complex. While multiple phases can clearly be inferred from the geophysical data, it can be difficult to attempt to sort out even what appear to be simple stratigraphical relationships on the basis of the anomalies. In part this is a problem with all remotely sensed data; the techniques, both the data capture and processing, are designed to simplify the data into understandable images. The fact that buried features that are physically so close to one another that their signals may combine to produce a single anomaly illustrates the over-simplification that is inherent within the techniques and methodologies.

Villas

Although in Latin the word 'villa' means farm, in terms of the physical archaeological remains 'villa' is not so easy to define. Esmonde Cleary (1999) has suggested that it is 'a rural site exhibiting Roman-style buildings and architecture'. As a result the term is used to describe hundreds of sites ranging in date from the first to the early fifth centuries AD. Furthermore, they are seen to vary in size from a small dwelling to something on a par with a modern day mansion. As such, villa sites provide a source for some of the most impressive geophysical results that have been carried out, with examples to be found across the whole of the Roman Empire.

Villas commonly survive in modern rural landscapes and, as a consequence, tend to be free from later clutter that often obscures the results in more urban locations. The remains often comprise low foundations below thin topsoil and the walls follow fairly regular plans. As a result they are often revealed as crop or parch marks on the ground surface, although they are easier to plan from the air. The variation in the local moisture regime that creates the marks on the ground surface also generates anomalies within resistance data captured in area survey. However, when the aerial evidence is at a peak the resistance contrasts are generally past the optimum; in fact, the best time for a resistance survey over a villa, or any other stone structure, is during periods when the soils are moist in comparison to the building material. Many of the grander villa buildings incorporated hypocaust and areas of burning associated with fire boxes that fed the heating system. These factors, coupled with large quantities of brick, tile and fired clay that are often present, also make the sites attractive for magnetic survey. Because of the high level of activity in and around the villas, the associated field systems often produce clear responses, while the building itself tends to result in a distinctive area of magnetic noise. On several sites this magnetic 'noise' has been used to pinpoint where resistance survey, a slower technique, should be targeted. Although wall lines occasionally show in the magnetic data from villa sites, the clarity is seldom on a par with the resistance results.

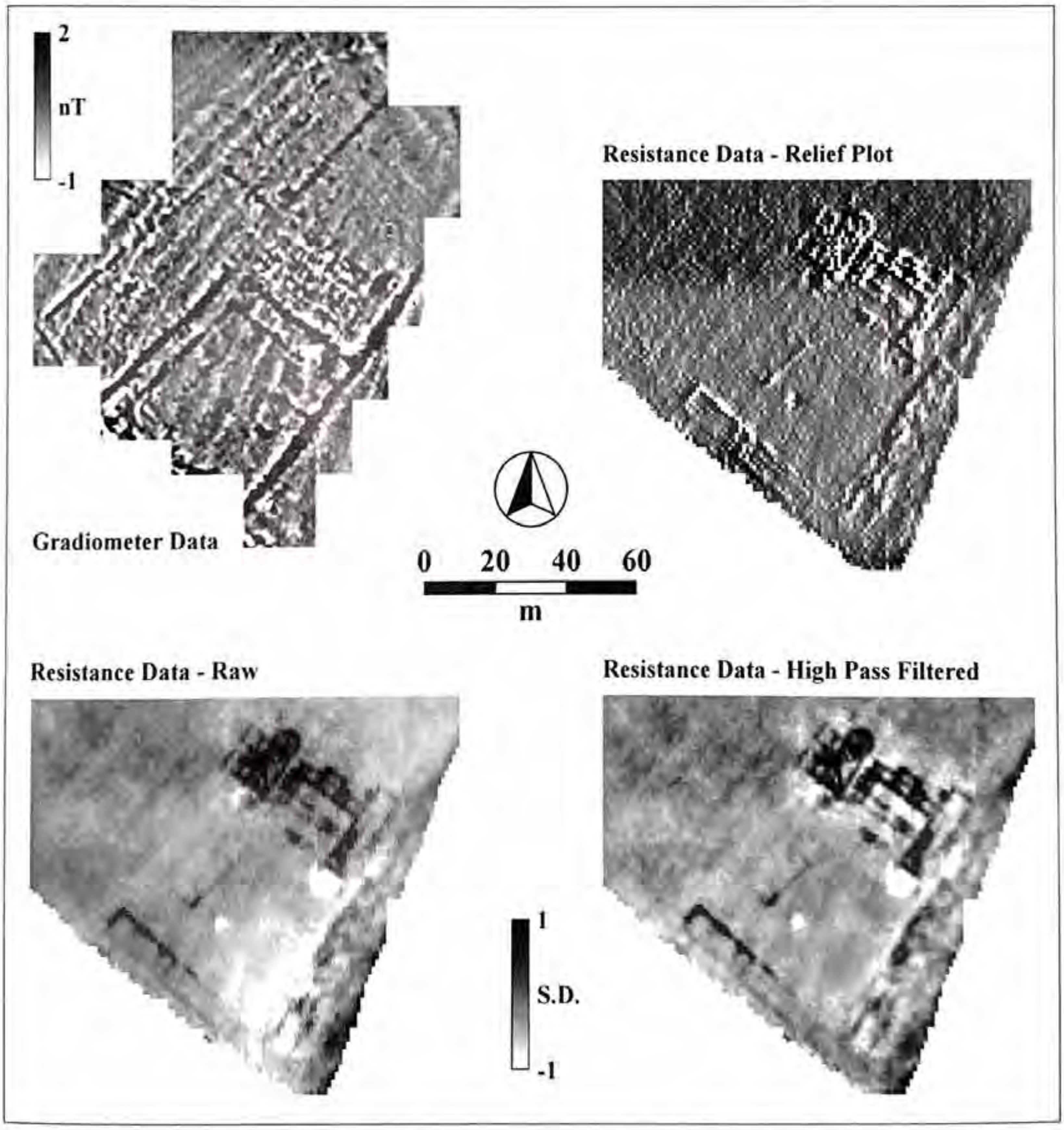
The first example is from a site in Hampshire that was originally earmarked as having archaeological potential in the 1950s and 1960s, when ploughing brought to the surface a heavy scatter of Roman tile fragments (tegulae, imbrices and flue tiles) and red brick tesserae. In addition, in the northern face of a quarry adjacent to the site, wall foundations and floor surfaces, possibly associated with a small building, are still visible. It was decided to scan the area of the artefact scatters with a fluxgate gradiometer and this quickly identified a zone of magnetic noise that coincided with a slight earthwork platform. A detailed fluxgate gradiometer survey was targeted on this spot and confirmed the findings of the scanning. The erratic nature of the anomalies is due to the fired bricks, tiles and rubble associated with the former building. It is even possible to see one or two of the walls as a negative anomaly. However, it is only when the follow-up resistance results are viewed that a striking clear plan of a multi-roomed building becomes visible (**77**).



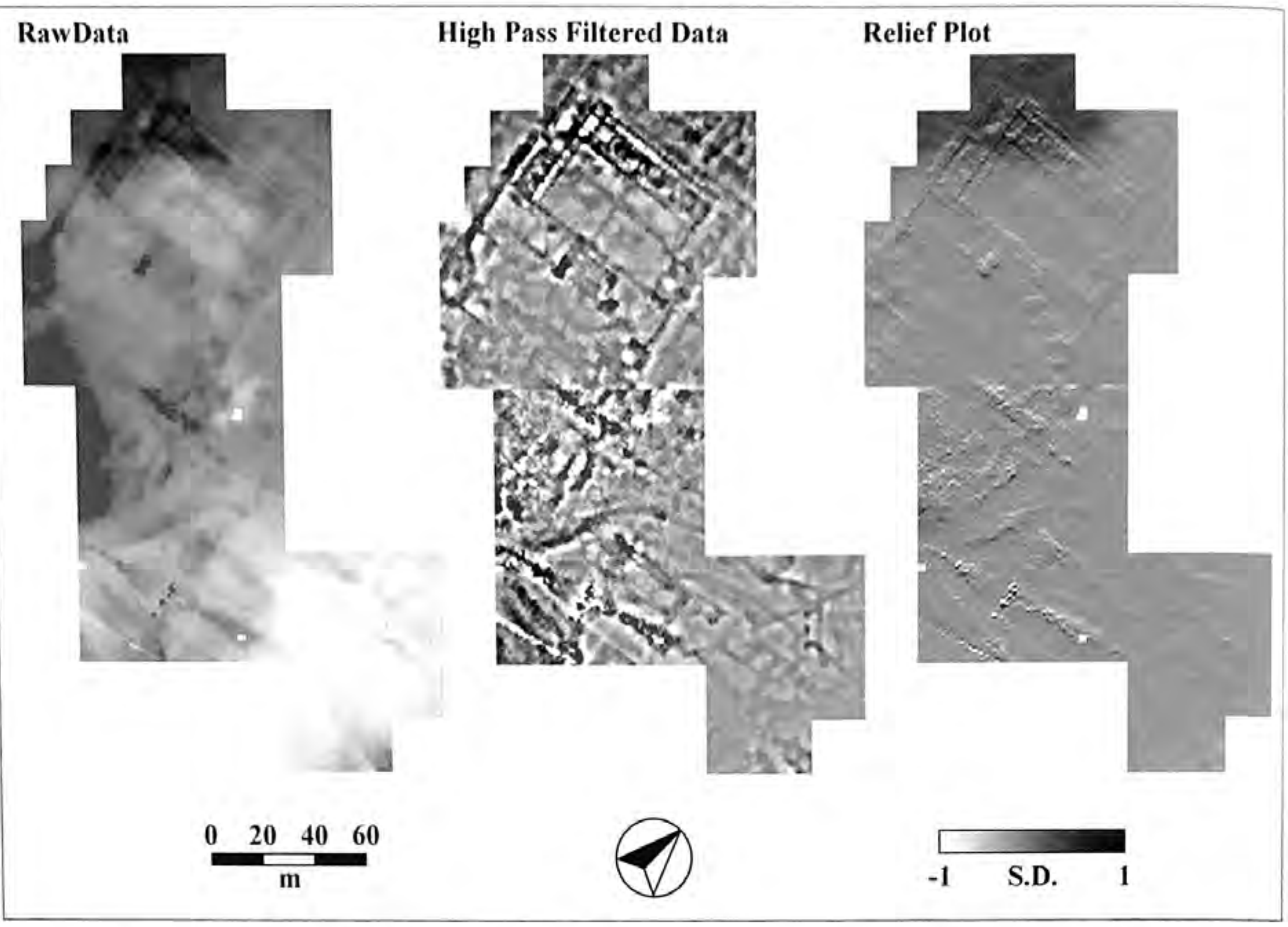
77 *Wanborough Roman Villa, Hampshire. Fluxgate gradiometer data (1 x 0.5m) and Twin-Probe resistance data (1 x 1m). The magnetic data indicate an area of noise that coincides with the villa building whilst the resistance data provide a clear plan of the building foundations.* © Crown copyright NMR

There appear to be nine or ten rooms or corridors and an apsidal room within an overall structure measuring approximately 38 x 18m. It is interesting to note that the building has no walls extending to the south, towards the edge of the quarry, indicating that the remains in the cliff section do not join with the main building. Other features in the data include what are presumed to be paths or boundary walls, plus some substantial pits, visible in both data sets.

A survey of the villa at Tockenham, Wiltshire revealed a wealth of both magnetic and resistance anomalies associated with the villa complex. The magnetic data indicate a series of small fields, enclosures, paddocks and/or garden features surrounding the main building. There are also several well-defined discrete anomalies which are indicative of large pits, perhaps used for storage or rubbish. Once again there is a distinct area of increased magnetic noise that corresponds with the foundations of the building. A resistance survey was targeted over the magnetic noise and the resultant plan includes detail of several rooms and corridors, plus one clear apsidal room which is believed to be a dining room or *triclinium* (**78**). There is a series of smaller rooms arranged around a small, rectangular intra-mural courtyard; on the northern edge is an unusual response that on partial excavation was believed to be an elaborate octagonal entrance. The range



78 *Tockenham Roman Villa, Wiltshire. Fluxgate gradiometer data (1 x 0.5m) and Twin-Probe resistance data (1 x 1m). The two complementary datasets indicate differing elements of the villa complex*

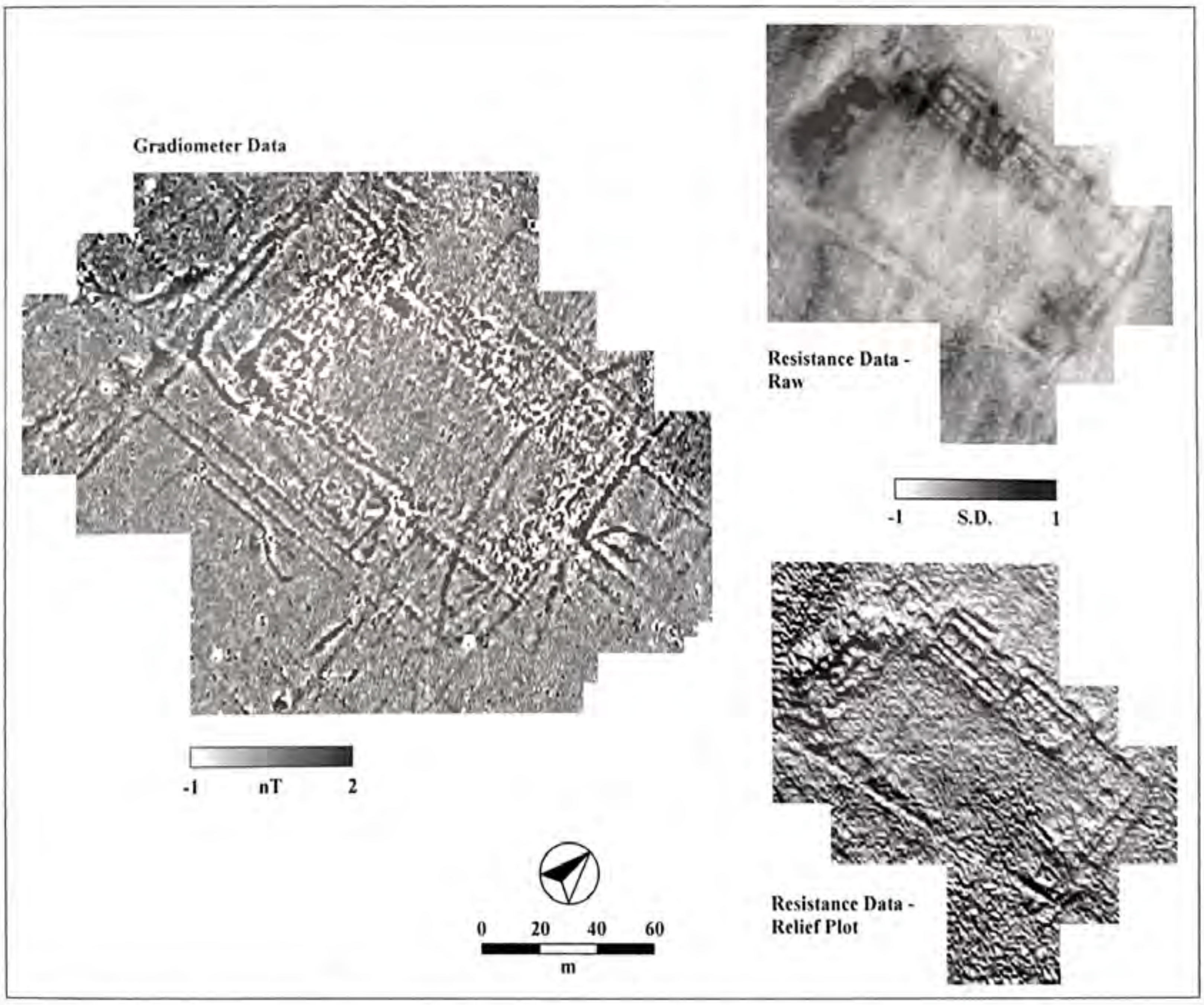


79 *Turkdean Roman Villa, Gloucestershire. Twin-Probe resistance data. 1 x 1m. A remarkably clear image of the villa complex was obtained during two visits to the site, both made in the spring but one year apart. It has proved impossible to seamlessly match the top half of the data from the first visit with the bottom half from the later survey*

of buildings attached to the eastern part of the courtyard is believed to be in the location of the bathhouse (Harding and Lewis 1997). The data also suggest more than one phase of activity, with wall lines on different alignments.

Moving up the scale in size, the villa at Turkdean, in the Cotswolds, afforded some of the best results we have ever obtained. The excitement of revealing for the first time ever a complete plan of the villa, was heightened by the fact the survey was undertaken for a 'live' broadcast for *Time Team* and watched by some 3 million viewers. Part of the resistance data are reproduced here, both 'raw' and following mathematical filtering to remove the effects of the geological background (**79**). The resistance survey covered about 2.4ha of land, with the core of the site covered in 1997 and extended in 1998. There are clear differences in the sharpness of the responses between the two periods of work. In the 1998 data the anomalies are considerably broader and this change relates to the weather conditions prior to each survey; although both data sets were collected in the spring, the '98 survey was later and consequently missed the peak signal resolution. As a result of this reduction of signal the data sets proved very difficult to merge. To produce the final versions of each display has involved an enormous amount of post-survey manipulation. Thankfully the hard work has paid off and it is possible to see very fine archaeological detail, from the existence of courtyards surrounding aisled corridors down to the level of individual doorways into some of the rooms. The plan provided a perfect template for deciding where to place the trial excavation trenches, and these confirmed the presence of wall foundations and floors, surviving immediately below the turf. The resistance data was complemented by over 6ha of magnetic survey (see Holbrook *et al.* forthcoming).

At Dinnington, the plan of a similarly large villa building (*c.*120 x 70m) was recovered, again using resistance as the primary technique, though in this instance it was possible to infer differing building phases within the data (**80**). The results suggest that an original building developed into the north corridor of a courtyard villa, by expanding to the west and east with the addition of two wings. The results also indicate the possible presence of a formal gateway structure. Excavation confirmed the existence of an earlier building and further identified a number of mosaics on the western wing of the building. These accounted for the broad areas of high resistance visible in the results. When the magnetic results are analysed, they indicate not only a distinctive area of noise that corresponds with the building but also clear trends in the data that reflect the modern-day ploughing. Excavation



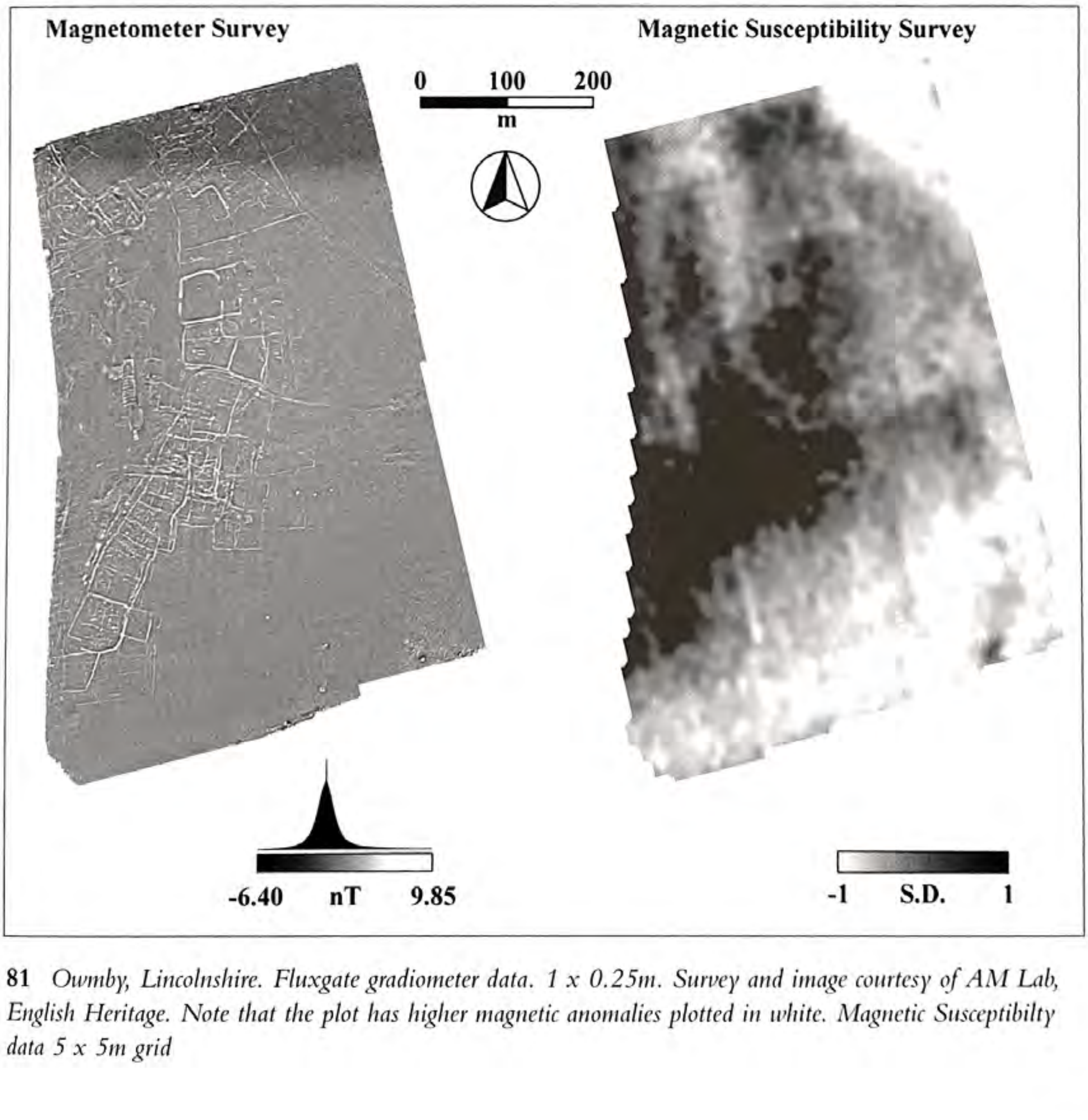
80 *Dinnington Roman Villa, Somerset. Fluxgate gradiometer data (1 x 0.25m) and Twin Probe resistance data (1 x 1m). The latter covers only part of the magnetic survey but is at the same scale* of the mosaics showed dramatically the effect of this ploughing on the buried archaeology, with severe score lines cutting through the mosaics which survive within 15cm of the ground surface (**colour plate 18**).

Settlements and towns

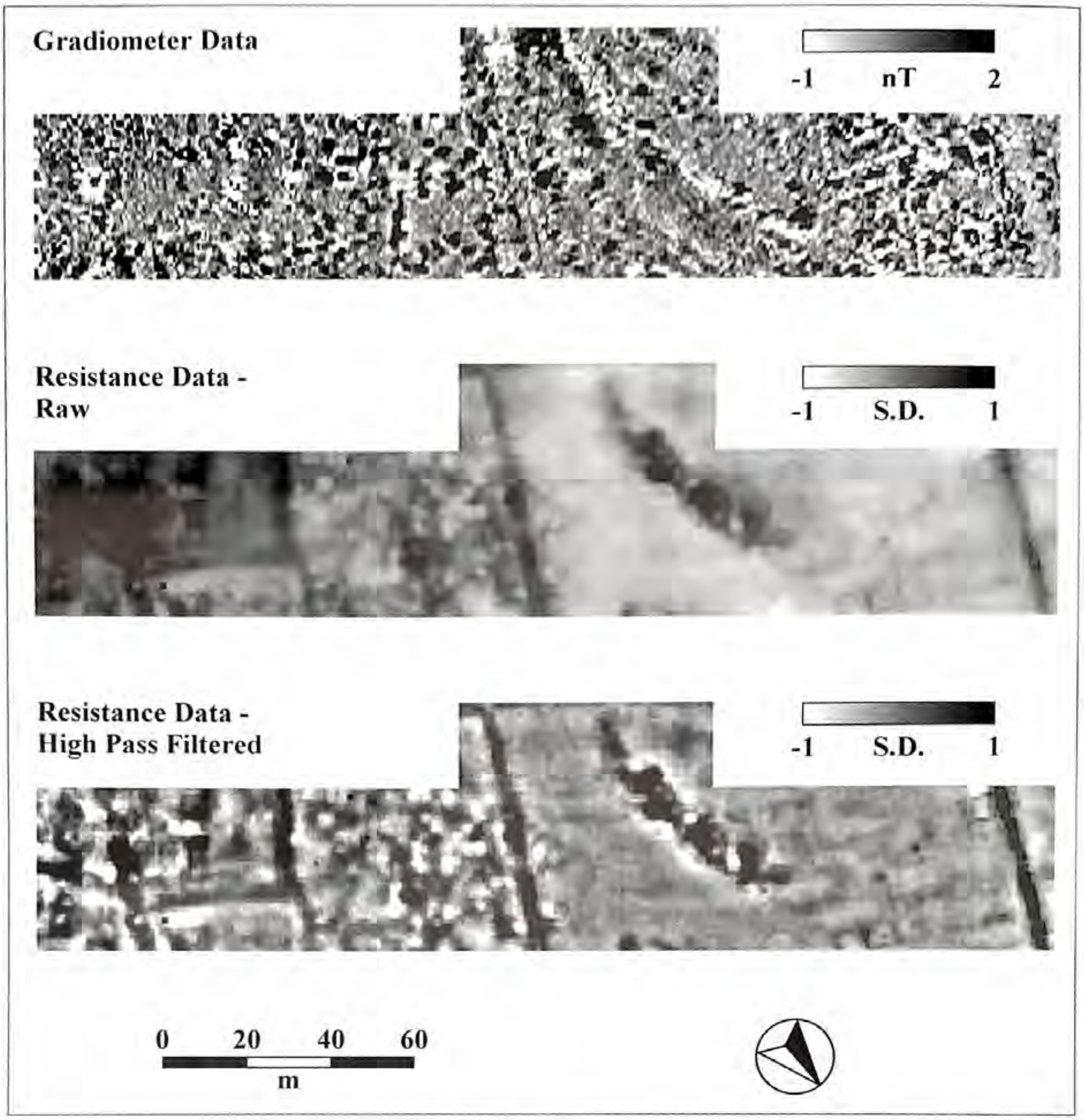
Roman roads and particularly the junctions between them often became the focus for settlements. These developed in a variety of ways and the buried remains have long been the focus of aerial photographers. At Sedgefield, County Durham, we were able to map an unusual example of one such settlement. Although prior to the geophysics tentative enclosures had been noted on aerial photographs and numerous metal detector finds had been recovered, it was not until the gradiometer survey was carried out that the complexity of the site was appreciated. Straddling a trackway or road is a regular pattern of small enclosures/paddocks that form a pattern known as a 'ladder' settlement. Whilst such settlements are relatively common in the Midlands and southern Britain, this was apparently the first time a complex had been surveyed so far north. Small-scale excavation found a distinct lack of actual occupation deposits amongst the finds. It would appear that the southern half of the site comprised workshops, stock enclosures and small-scale industrial type activity, in the form of kilns and metal working areas. One clear magnetic anomaly proved on excavation to be a small pottery kiln that had survived intact (**colour plate 19**). A scatter of larger anomalies, visible in the magnetic data, was interpreted on excavation to be clay pits that had become back-filled with a mixture of magnetically-enhanced deposits. While time did not permit the full mapping of the extent of the settlement at Sedgefield, the English Heritage survey at Owmby, Lincolnshire provides a largely complete picture of ribbon development along Ermine Street (**81**). The survey is a good example of the link between enhanced magnetic susceptibility in the topsoil and the core of the archaeological site.

Survey during the early 1990s at the Roman town of *Calleva Atrebatum* (Silchester) reveals the value of differing data processing. There are clearly important elements of the town within each data set, but the problem is the scale of the site. The surveys shown in figure **82** only cover a small percentage of the area within the town walls of Silchester, some 40ha in total. Without recourse to the extensive aerial photographic or excavation evidence, it is impossible to understand how representative the geophysical results are of the interior of the town, or to comprehend the significance of the detailed response. A larger, more recent survey of Silchester, by English Heritage, has shown that magnetic data correlates well with the known layout of the town (Martin 2000).

Moving to the top of the scale in size are the results from the Roman city of *Viroconium* (Wroxeter). Wroxeter covers about 78ha of land near to the Shropshire town of Shrewsbury and was the fourth largest town in Roman Britain. The town is largely under grass and has been researched by antiquarians and archaeologists for many centuries. While the site has been intensively studied from the air (Wilson 1984), modern excavation, primarily by Philip Barker, has looked at less than one per cent of the town (White and Barker 1998). As a result the interpretation of the site had to come from the aerial evidence, which suggested that perhaps 40 per cent of the town was blank. A research design was prepared that integrated a magnetic survey of the whole of the town, thereby avoiding expensive and damaging excavation (Buteux *et al.* 2000). Earlier work in the environs of Wroxeter had often produced poor responses due to the local soils which are seasonally waterlogged, high in clay content and occasionally fail to produce magnetic anomalies above the soil background. While that may not have been a good omen for undertaking a large-scale survey in this area, the fact that the survey was within a Roman city improved the odds of success. In fact the soils inside most towns or cities, whether ancient or modern, are completely altered from their parent formations due to the immense amount of work that has been undertaken on them; they are often black with organic and burnt material.

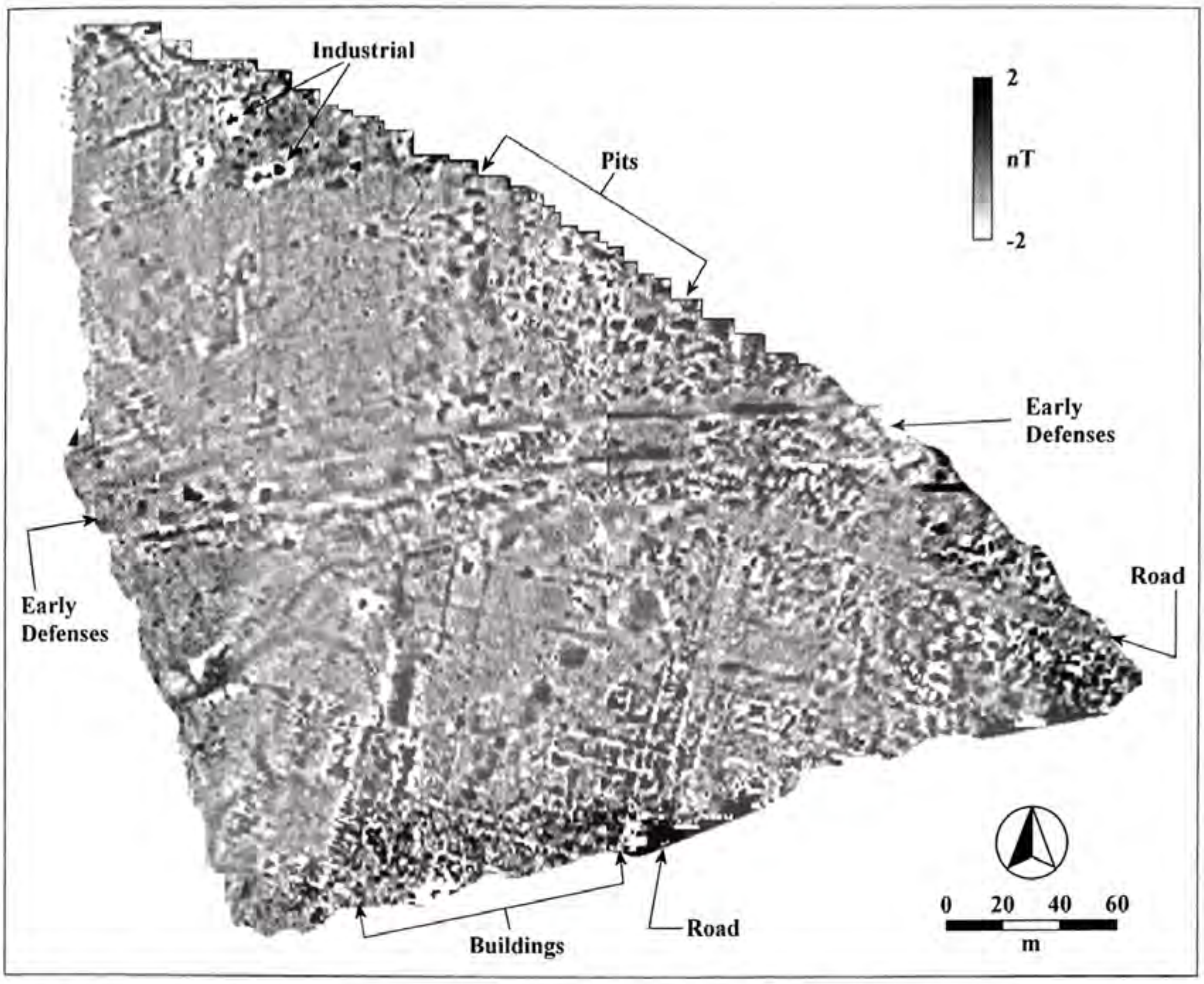


81 *Owmby, Lincolnshire. Fluxgate gradiometer data. 1 x 0.25m. Survey and image courtesy of AM Lab, English Heritage. Note that the plot has higher magnetic anomalies plotted in white. Magnetic Susceptibilty data 5 x 5m grid*



82 *Silchester Roman town. Fluxgate gradiometer data (1 x 0.5m) and resistance data (1 x 1m).* GSB survey for Professor Mike Fulford, Reading University

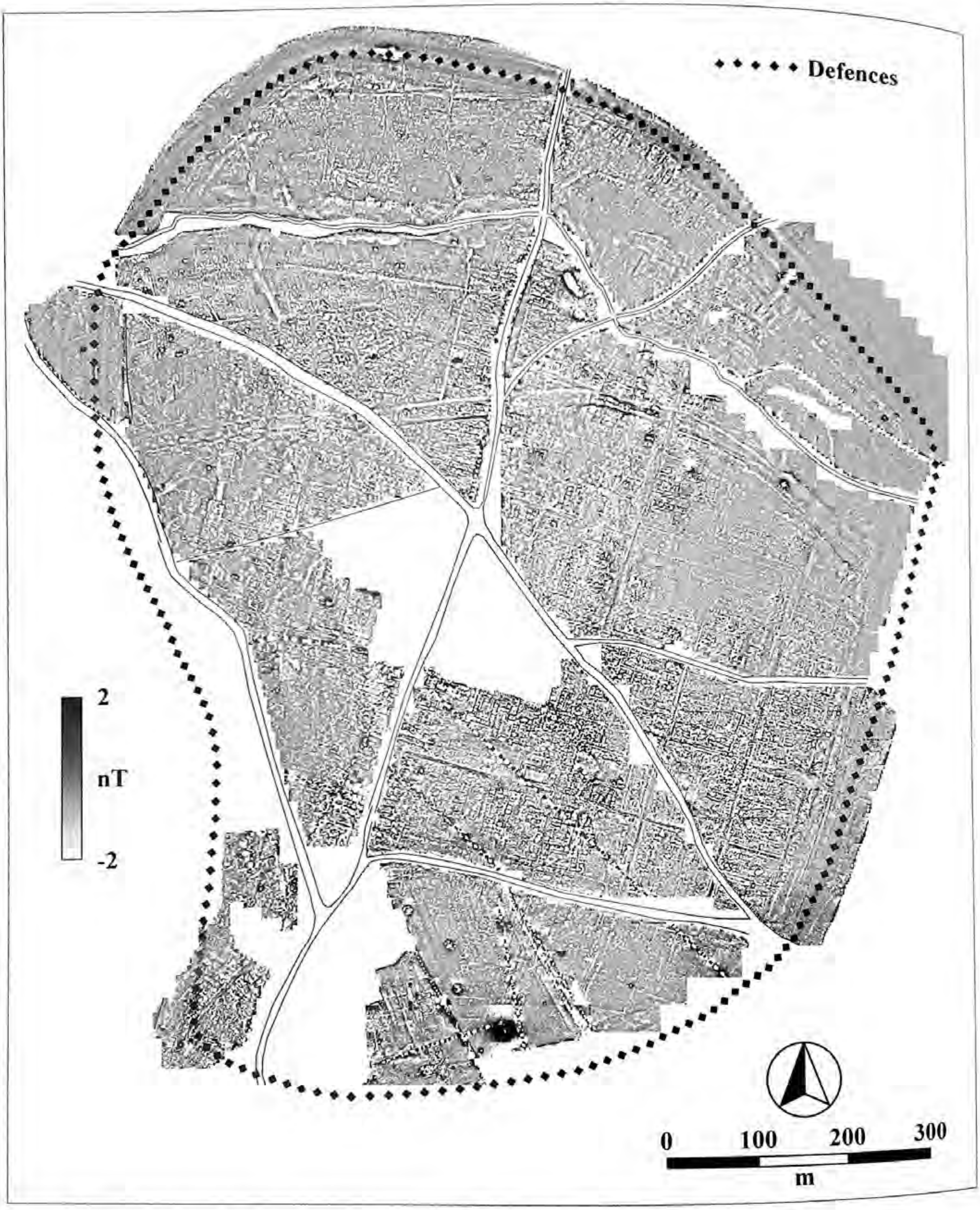
The detail from one of the 15 fields that were surveyed can be seen in figure **83**. The wealth of information in this image is typical of the density and complexity of archaeology detected within ancient towns using a fluxgate gradiometer. The data are split into two by responses from the later Roman defences and are clearly different either side of them. To the south can be seen part of a regular road grid as well as negative responses from stone-built buildings that are aligned with the road system. To the north of the defences the anomalies become more randomised, with a significant number of responses attributed to pits as well as a few suggesting industrial origins. There are also numerous ditch anomalies as well as areas of disturbance that indicate increased soil noise due to disturbed archaeological features or strata.



83 *Wroxeter Roman city. Fluxgate gradiometer survey (1 x 0.5m). Part of the complex indicating defences, roads, buildings, industrial activity and pits.* GSB survey for BUFAU and Wroxeter Hinterland Project

The interpretation of the results had to be undertaken in a highly systematic manner as the overall data set contained nearly 3 million readings, covered over 70ha of ground and was undertaken by two different groups (GSB Prospection and the AM Lab, English Heritage). A further complication is that from the first block of data collection to the final interpretation the project covered a four-year span. Prior to the main publication in *Archaeological Prospection* a classification of the anomalies was agreed (Gaffney *et al.* 2000). This is reproduced in **Table 2** and, while it is specific to the Wroxeter site, it is useful to understand how the collaborators broke down the components of a complex magnetic data set.

The overall magnetic data set from Wroxeter is reproduced in figure **84** and the city can be seen to be virtually filled with anomalies of archaeological interest. In fact the magnetic survey shows a remarkably well-developed city with some rare insights into economic, social and functional zonation. However, the geophysical data can only be pushed so far; there is little control over the temporal variation and it is assumed that the settlement and activity evident in the data shows a maximum extent within the town's defences. No matter how sharp the image is it should not be supposed that we know all there is to know about Wroxeter.

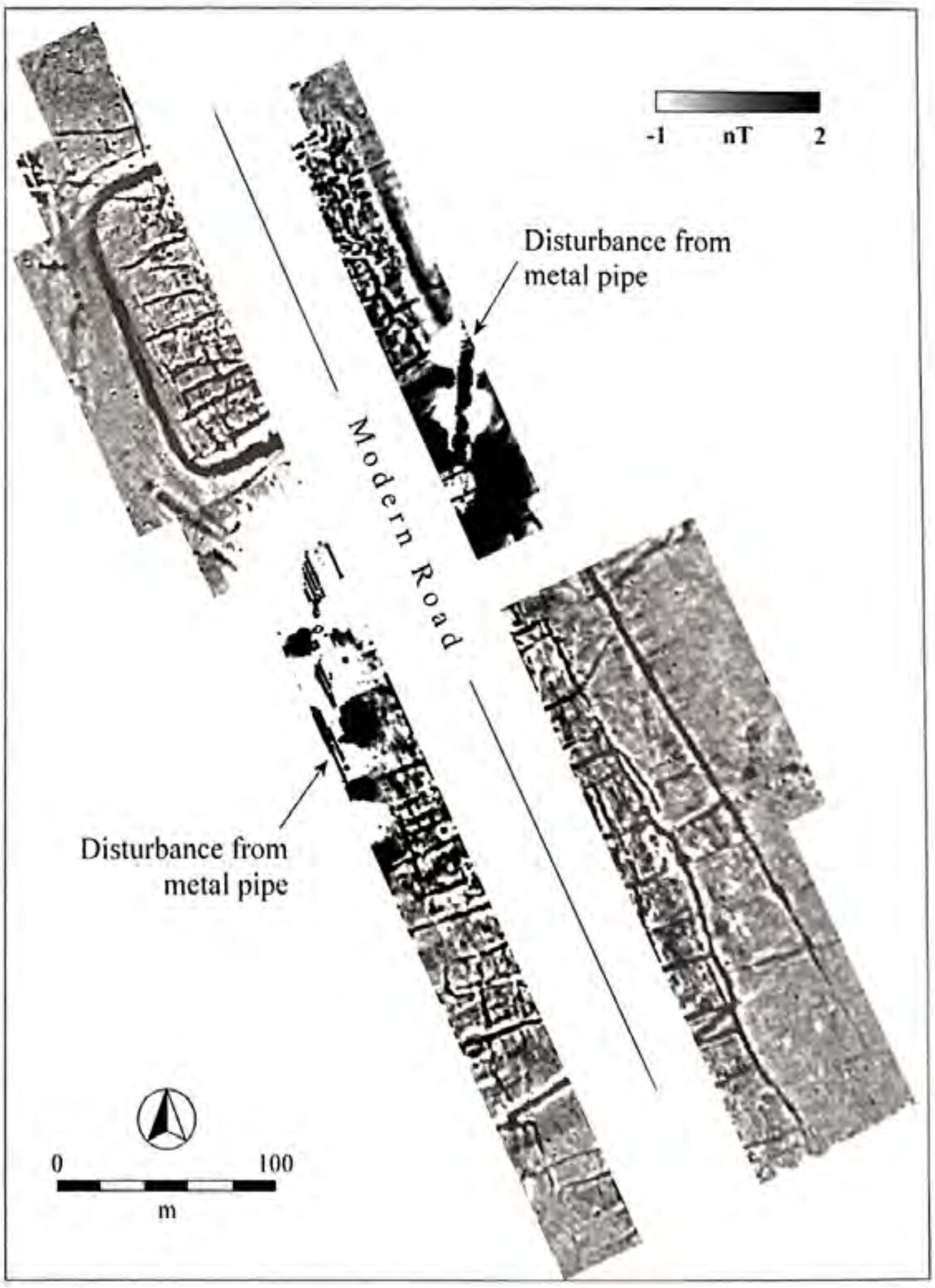


84 *Wroxeter Roman city. Fluxgate gradiometer survey (1 x 0.5m). Approximately 70ha of data, more than 3 million data readings, were collected by GSB and the AM Lab during separate visits over a 4-year time span.* Work carried out in conjunction with BUFAU as part of the Wroxeter Hinterland Project

Fortified sites

There were a wide range of military installations used by the Romans; these included 'temporary/marching' camps through to legionary fortresses, and they varied in size and complexity from less than one hectare to several tens of hectares. Close military control of certain areas was maintained through a series of forts and fortlets served by an intricate road network (Hanson 1999). In Britain, at the hubs of the network were the legionary fortresses of York, Carleon and Chester; one level down were the main forts and then fortlets; watch-towers/signal stations, or turrets as they are called on Hadrian's Wall, formed the smallest bases. Some of the installations were simply ditched and banked enclosures with temporary encampments, while others were occupied longer term and had stone buildings and defences. From a geophysicist's point of view, magnetic and resistance surveys are usually most productive, though the increasing use of GPR on the continent demonstrates the extra level of information that can be obtained if time permits.

As we have already shown, some of the earliest geophysical work in Britain was carried out in the 1950s, in advance of widening the A1 trunk road. It is



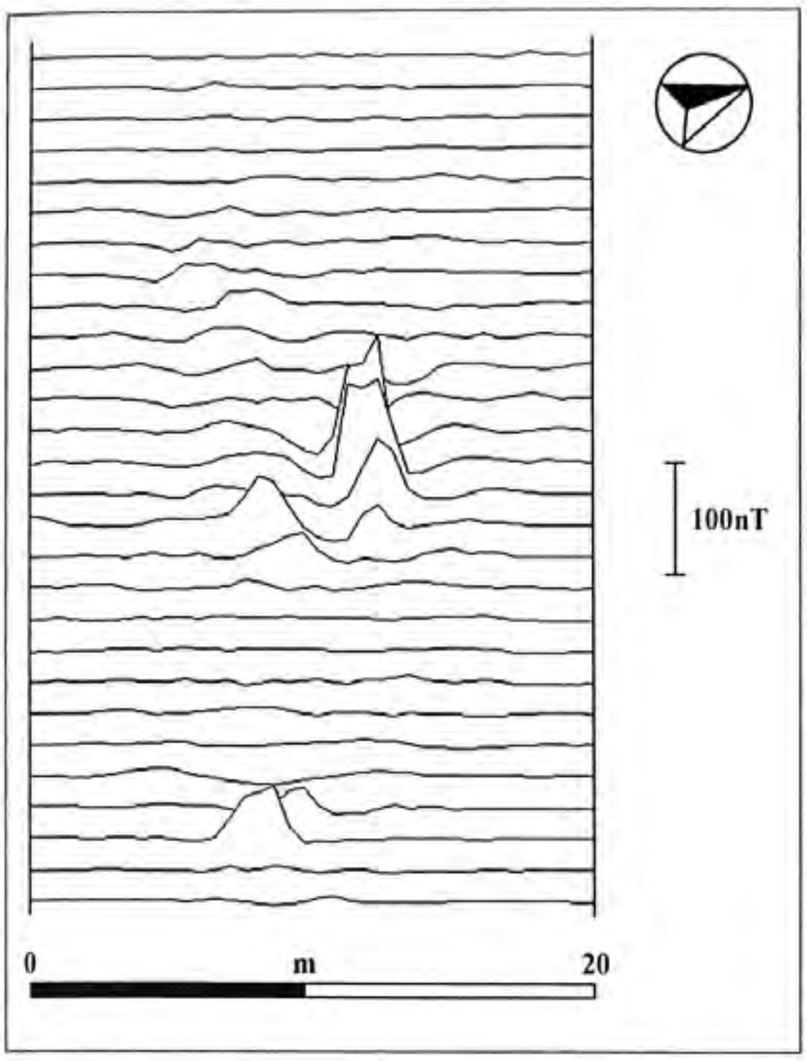
85 *Healam Bridge, Yorkshire. Fluxgate gradiometer survey (1 x 0.5m) carried out in advance of proposed widening of the A1 trunk road. The results indicate a Roman fort and ladder settlement which both straddle the line of the road.* GSB survey for Ed Dennison/AWP/BHWB on behalf of the Highways Agency somewhat ironic, therefore, that almost 50 years later we found ourselves carrying out similar work prior to the A1 being upgraded to motorway status. During this project geophysics was employed extensively to evaluate large stretches of land and several new sites of importance were located. Of particular interest was the mapping of a previously suspected fort and settlement at Healam Bridge (**85**). Here the existing A1 is seen to pass right through the centre of the site and a so-called ladder-type settlement that extends to the south. There is a dramatic difference between the levels of magnetic enhancement inside the fort compared to the immediate area outside. In places the fort ditches appear to overlie smaller ditches on a differing alignment, perhaps indicating that the fort was constructed over an existing strategic site. Given the dangers associated with stratigraphical relationships, it may be that we are reduced to saying that there is simply more than one phase of activity. Unfortunately the interface between the presumed military and civilian settlements has been obscured by a modern gas pipeline. The survey further shows a good example of continuity of road usage over a 2,000-year span, with the A1 following the exact line of Dere Street, one of the major Roman arterial roads.

Industrial sites

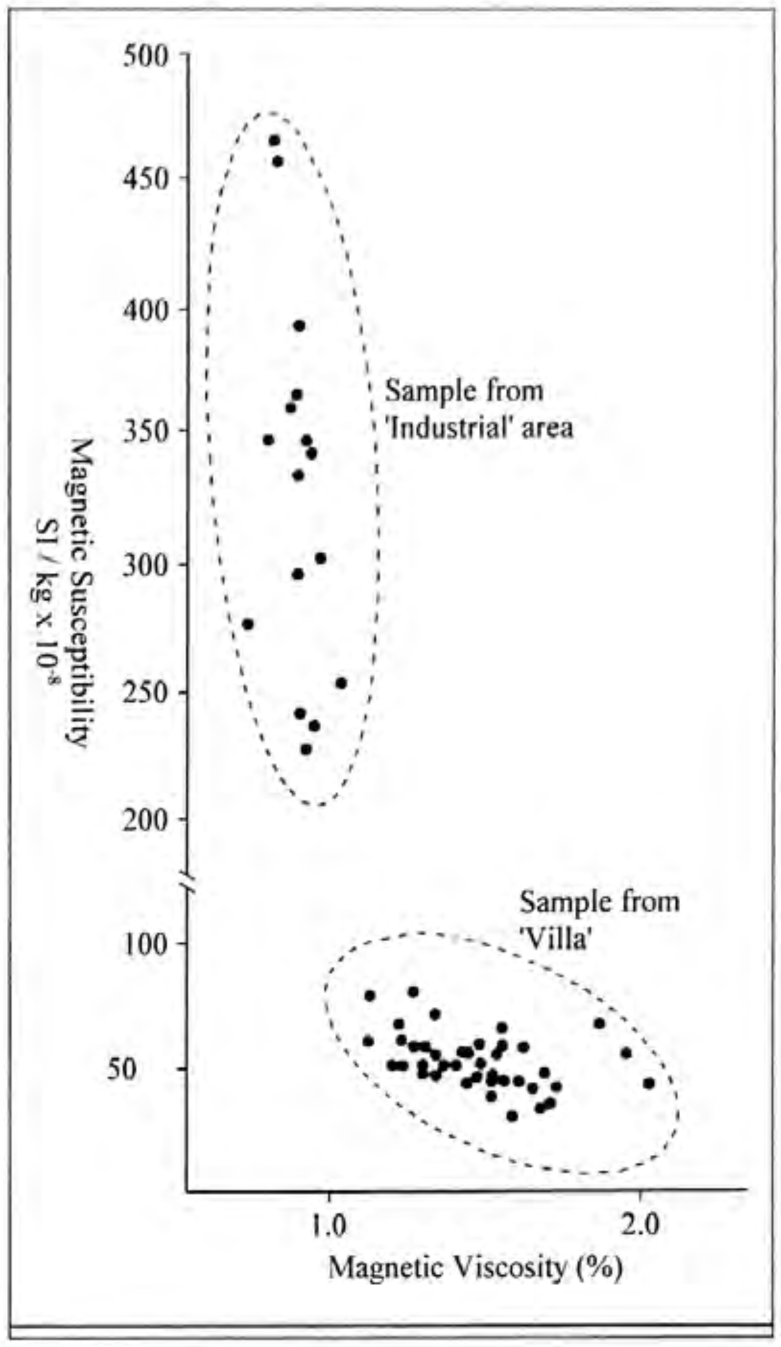
Pottery (and tile) kilns have long been considered 'classic' targets for magnetic survey. Having been fired to high temperatures, when they cool down the magnetic minerals in the clays realign with the Earth's magnetic field and retain a relatively strong field of their own. As we have seen in chapter 1, this thermoremanent magnetisation was first recognised in the 1950s as making kilns suitable targets for detection by proton magnetometers. Since that time, probably hundreds of kilns have been surveyed and numerous theoretical models produced, attempting to predict the magnetic field associated with the different types of structures.

In their simplest form a kiln will comprise a central chamber, where the pots or tiles are fired, set within the walls of the structure. Thus when a magnetometer passes over a kiln the instrument will see first one wall, then the interior and then the second wall. The resultant anomaly will comprise two peaks either side of an enhanced anomaly. The reason for this is that the highly fired clay walls have a stronger field than the interior which lacks the mass of structural clay. In the accompanying example (**86**) a survey over an expected Romano-British kiln complex in the New Forest produced a strong anomaly of over 100nT, which has a double peak in two of the traces. Clearly there is nothing in the geophysical data to suggest a Romano-British date; in this instance the supporting archaeological evidence in terms of pottery wasters provides an implied date.

Chesters Villa, situated on the northern shore of the Severn Estuary, has been subjected to a number of geophysical surveys. During a resistance survey over the main buildings in 1987, topsoil samples were collected from over the villa

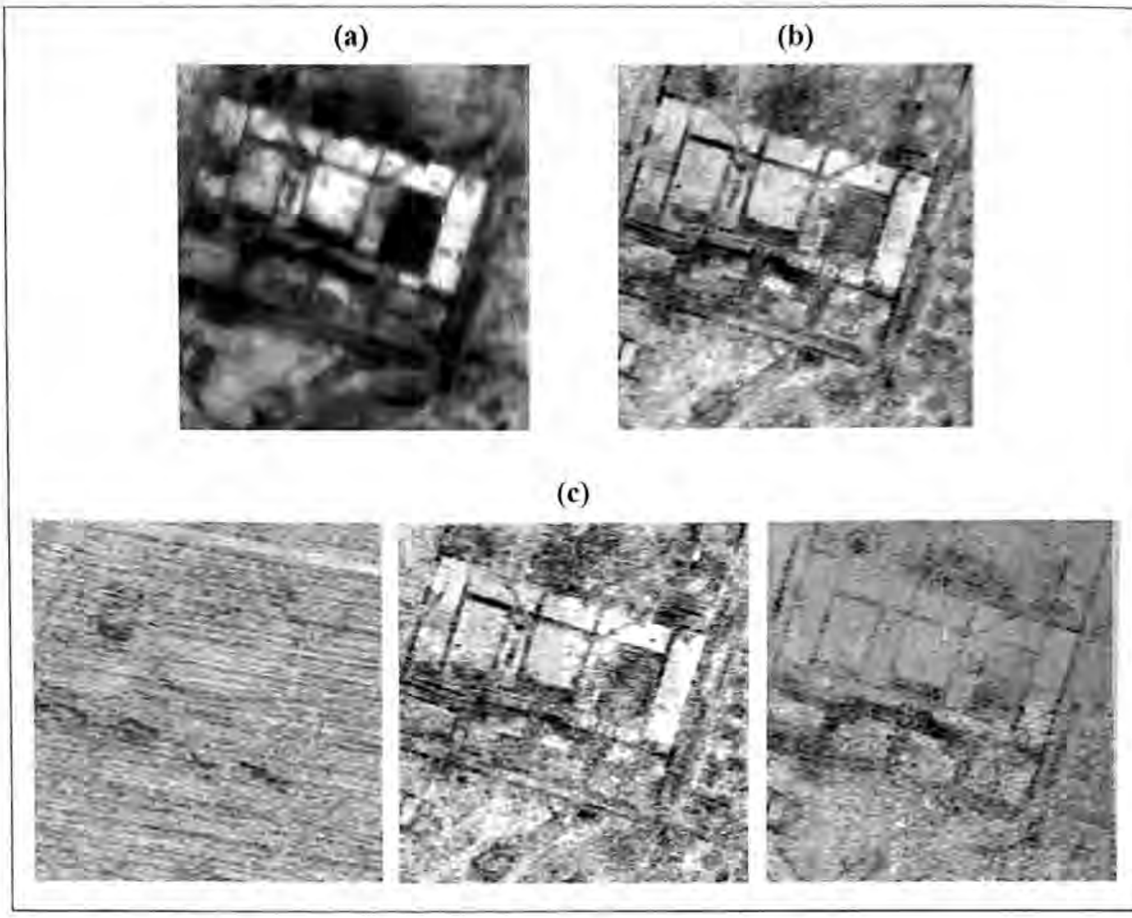


86 (Above) *Sloden enclosure, New Forest. Fluxgate gradiometer survey. 1 x 0.5m. Results demonstrate a 'classic' double peak over a suspected pottery kiln of Romano-British date.* GSB survey for RCHME. © Crown copyright NMR



87 (Right) *Chester Roman Villa, Gloucestershire. The diagram shows a plot of the magnetic susceptibility vs magnetic viscosity, and illustrates the different signatures between soils derived from settlement and industrial areas. The soil samples were collected over a 20m grid that was established for a resistance survey. Prior to excavation a gradiometer survey revealed very strong responses which were related to industrial processes and ditches infilled with debris from that activity*

and a nearby spread of dark earth. The field was known to have produced substantial amounts of tap slag and charcoal and after ploughing it was clear that much of it was to be found over the spread of the dark earth (Fulford and Allen 1992). The soil samples were tested for magnetic susceptibility as well as magnetic viscosity as it was hoped that the two areas would produce different signatures. In fact the results classically illustrate the difference between soils that are derived from settlement (moderate magnetic susceptibility and viscosity) and those derived from industrial activity (high susceptibility and low viscosity) (**87**). This small-scale soil analysis definitively supported the fieldwalking evidence. Excavation at the site revealed masses of tap slag and evidence for a number of furnaces. A fluxgate gradiometer survey revealed the extent of the industrial site and it was found that it was largely contained within an enclosure (Gaffney and Gater 1992).



88 *Data collected at the Roman town of Carnuntum: (a) is a resistivity plot, while (b) is a broad GPR time slice covering a depth of about 1.5m of ground. The two images are highly compatible. However, the GPR data has added information in that narrow slices can also be produced to reveal the variation with depth. In (c) three images are shown with the shallowest on the left and the deepest time slice on the right. For a more extensive discussion of this survey see Nebauer* et al. *2002. The images have been supplied by ZAMG Archeo Prospection (R), Vienna*

Wider perspective

Geophysical surveying of early historic sites has a long history. In fact a great number of the 'classic' geophysical surveys have been undertaken on large sites such as those at Sybaris and Xanten in Europe. These sites have a common theme in that they are high status sites and have produced equally impressive results. While it is true that the majority of sites from this period were graced with more humble abodes, many of the recently published examples are still from the tradition of grand sites. Surveys from all over the Roman world have consistently delivered significant results; in fact from the heart to the extremities of the Empire measurements have been collected using virtually every geophysical technique and productive results are nearly always obtained.

The abundance of good quality, complementary data from many of these sites has led to an explosion of publications that base their interpretations on multi-method analysis. This work has ranged from lowly Romano-British villas (e.g.

Corney *et al.* 1994) through villas owned by individual Emperors (Piro *et al.* 2003) and incorporates strategies for the investigation of whole towns (Gaffney *et al.* 2000, Neubauer *et al.* 2002). Data from some of the work at the Roman town of Carnuntum in Austria can be seen in figure **88** and this high resolution, multi-technique approach has allowed the researchers to produce a very specific interpretation using the following categories: mortar, foundation, hypocaust, drain, wall, staircase and tiles (Neubauer *et al.* 2002).

The concept of high resolution, multi-technique studies has become fairly routine across much of the Mediterranean zone and encompasses research not only in the Roman but also the earlier part of the historic period. Again the scale of work is highly variable but increasingly the surveys are embedded within sophisticated research designs. For example the geophysical work on the island of Alonnisos (ancient Ikos) has focused on the production of amphorae during the fourth century BC, but is part of a wider archaeological, ethno-archaeological and geomorphological study to inform on the diachronic land use of the island. The overall objective is to understand how the economy supported a minor classical polis, which in turn will feed into the debate on how the island interacted with the mainland of Greece (Sarris *et al.* 2002).

Summary points

• During the historic period, the increasing use of stone as a building material is important in the choice of technique. In mild temperate climates, such as those found in Britain, the technique that is most often used on sites that are suspected to have this type of buried remains is resistance survey. In countries where the soil is naturally dry and a good electrical contact is difficult to achieve then GPR systems come to the fore.

• Magnetic surveying remains important in prospecting for sites from this period because the settlement sites were often large, long-lived and had a significant element of intensive burnt features, associated for example with hearths or industrial processes. The settlements often produce an imprint of enhanced magnetic susceptibility on the surface of the soil that can be mapped using magnetic susceptibility.

• As the sites are often complex or multi-phase, it is clear that a battery of techniques can be usefully applied. This, along with appropriate analysis, may result in closer integration with other information sources and allow a more coherent archaeological answer.