The search for Bathampton Down Stone Circles

Geophysical surveys

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Abstract

Geophysical surveying has been carried out on Bathampton Down, Bath at a location where stone circles had been indicated by the Reverend Scarth in 1857 and Tratman in 1958. Dowsing in 2009 had suggested two circles at this site.

Magnetometry was undertaken using a Bartington twin fluxgate gradiometer, in an area of 60m square. It showed the prehistoric field boundaries, a section of disturbance reminiscent of findings at Stanton Drew stone circles and possible post holes.

Twin probe resistance was carried out in an area of about one hectare, and resistivity profiling and ground penetrating radar were used in an area of 40 m square. The resistance confirmed the field boundaries, and revealed possible small enclosures or buildings and a group of stone signals. The results of resistivity profiling were suggestive of individual standing stones. The radar images were cluttered but supportive. The data are not conclusive but are suggestive of part of the stone monument. The findings from dowsing were not confirmed.

A limited magnetometry survey was also performed on a previously unidentified round barrow site. The findings were not conclusive but consistent with two barrows.

Acknowledgements

We would like to thank Bath Golf Club for their full support and co-operation in the survey, including the use of a buggy, the club house and car park.

We also thank English Heritage, in particular Hugh Beamish, Inspector of Ancient Monuments, for their forbearance as we had mistakenly neglected to ask their permission to carry out the survey inside a scheduled monument.

We were very helpfully assisted with the survey by the following members of Bath and Camerton Archaeological Society : Owen Dicker, Laurie Scott and Roger Wilkes. Tim Lunt kindly produced the viewshed.

We also thank The British Library for the figures from the Skinner MS , and Mr Paul Daw for information about his findings from dowsing.

The report was expertly produced by Jude Harris to whom we are extremely grateful.

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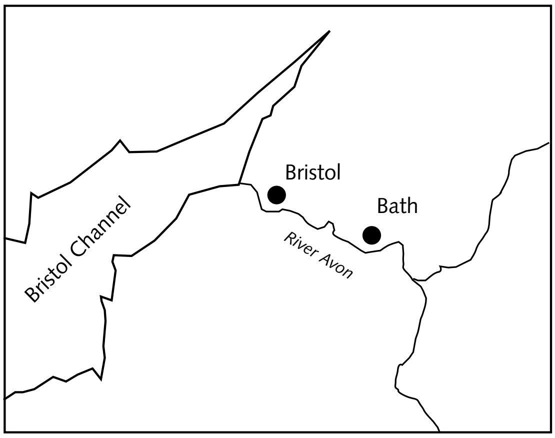

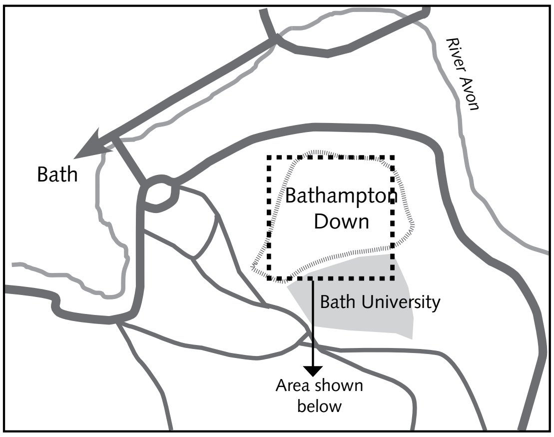

Figure 1.1 The position of Bathampton Down and the City of Bath.

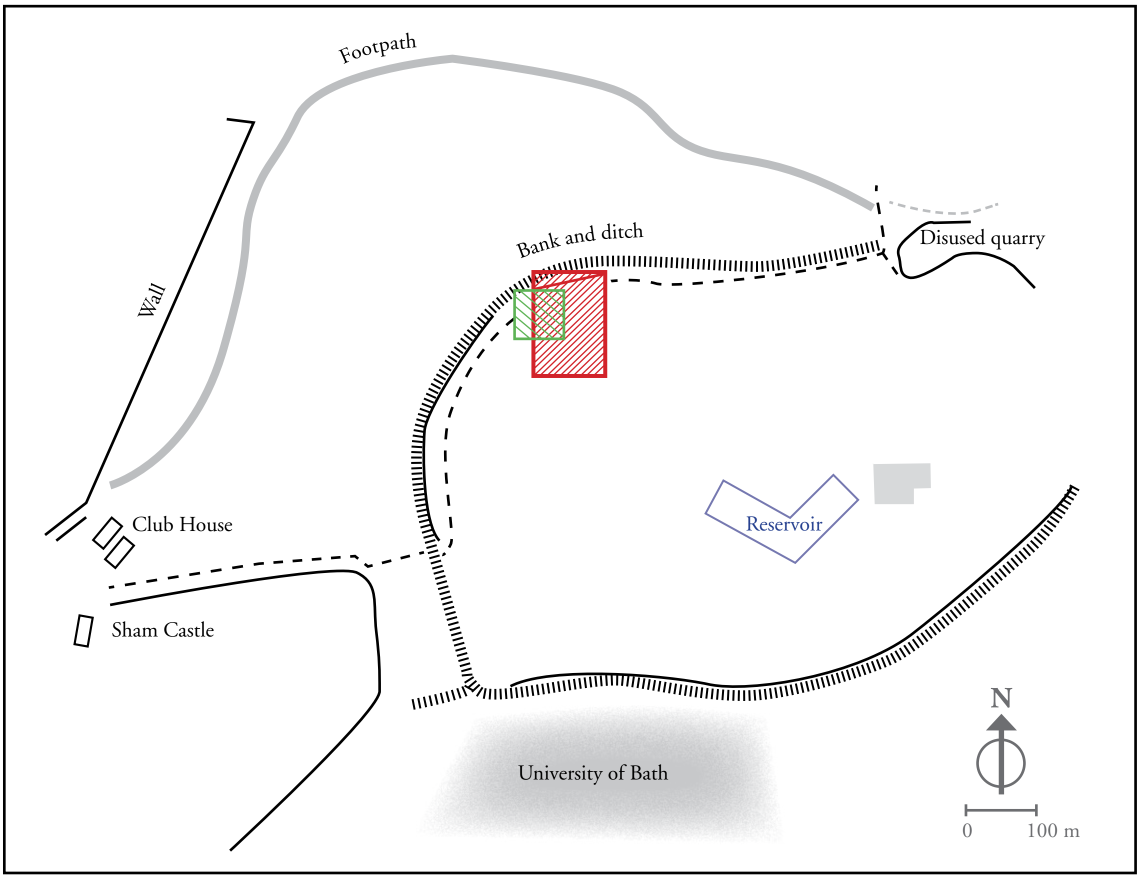

Figure 1.2 Plan of the areas of geophysical survey on Bathampton Down. The green square indicates the area subject to magnetometer survey and the red area shows the area surveyed by resistance. The area to the north of the diagonal line could not be surveyed. The grey block to the east of the reservoir shows the area of magnetometer survey of the 'round barrow' site. The hilltop enclosure is marked by hachures.

1 Introduction

1.1 Location

Bathampton Down is situated on the east of the city of Bath. The River Avon almost encompasses the Down, as it forms a ring around on its western, northern and eastern sides. To the south, the high ground continues as Claverton Down. The location is shown in figure 1.1.

Bathampton Down is dome-shaped with the summit masked from below by steep tree-covered slopes. The gradient eases over the last 30m in height making the top area flat. Much of the Down is covered by an extensive ancient field system while the summit is occupied by Bathampton Camp Enclosure, a scheduled monument *(Thomas, 2008)*. The area has been greatly indented over the ages by quarrying while much of the Down has been the location of Bath Golf Club for 130 years.

The area of interest in this search is approximately 1 Ha, centred on ST772652, which sits just above the 200 m line. It is within the golf course, next to a practice area and is reserved for nesting skylarks during the summer. This gives it some protection from encroachment by the golf course.

The area surveyed in the search is shown in figure 1.2.

1.2 Background

In his early 19C diaries, the Reverend John Skinner of Camerton sketched three large recumbent stones which he had seen on the Down. He thought that they might have been used in 'some Religious circle or British work' (fig 1.3). However these were on the west of the Down, several hundred metres away from the area of interest (fig 1.4) *(Skinner MS 33671)*.

A clear description of stone circles was first reported by the Reverend Scarth *(Scarth 1857)*. In his review of various earthworks in the locality he wrote that this 'most curious and important feature' of Hampton Down Camp had apparently not been noticed by Skinner or other antiquarians. Scarth described the remains of stone-circles 'similar in appearance to those of Stanton Drew'. They were positioned in two enclosures (of the prehistoric field system), 'on the sloping side of the hill towards the river, near the north-west entrance to the camp'. The enclosures were 'approached by avenues of stones leading out of the camp'. Scarth's observation that 30 larger stones had been taken away suggests a large monument though the proposed similarity to Stanton Drew is puzzling. It seems unlikely that the stones were of similar geology: although they could be dragged to Bath without much extra difficulty, the final kilometre up very steep slopes would seem impossible. Perhaps he was referring to a rough, untooled finish, but local stone.

The story was next taken up much later by Professor Tratman as part of his researches into lost stone circles in the region *(Tratman, 1958)*. He found no evidence remaining on the surface, but suggested that the most likely location of the stone circle would be in the region centred on ST772652, that is an area of 100 m square, 'near the north-west entrance' to the Bathampton Camp. This is on the northern edge of the plateau of the down, sloping gently down to the rampart of the Camp, before the ground slopes steeply down. The site commands a superb view across the valley to the southern edge of the Cotswolds, up into northwest Wiltshire and westwards down the Avon and Chew valleys. The view south is now masked, mainly by Bath University.

In 2009, surveyor Mr Paul Daw from Cambridge produced a plan of two small stone circles which he claimed to find by dowsing. The centre of the southeast circle was placed at ST7720065200, that is, the grid reference given by Tratman but precise to the nearest metre. His plans are shown in figure 1.5. The Bath and Camerton Archaeological Society (BACAS) had met Mr Daw and compared results at Stanton Drew *(Oswin et al, 2011)*. The Bathampton Down circle offered a further opportunity to test the capability of geophysics and also the history of descriptions of the circle.

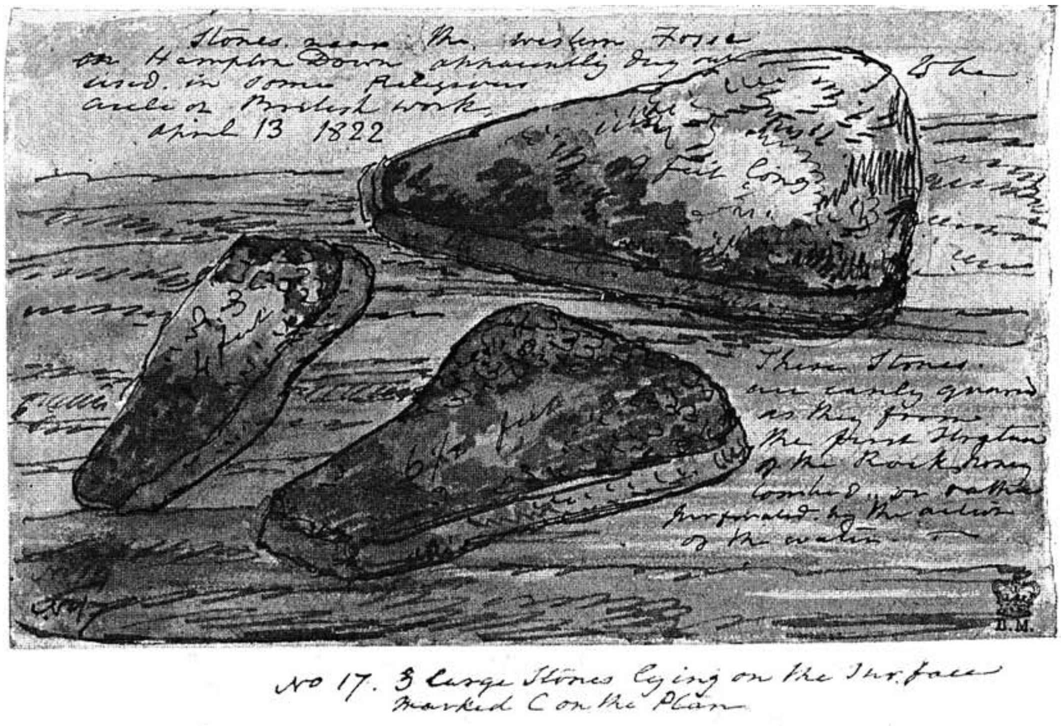

Figure 1.3 The Reverend John Skinner's sketch of three large stones, from April 13 1822. The text reads 'Stones near the western Fosse on Hampton Down apparently dug out and used in some religious circle or British work'. The top stone was nine feet long. *(© British Library Board, MS 33671)*.

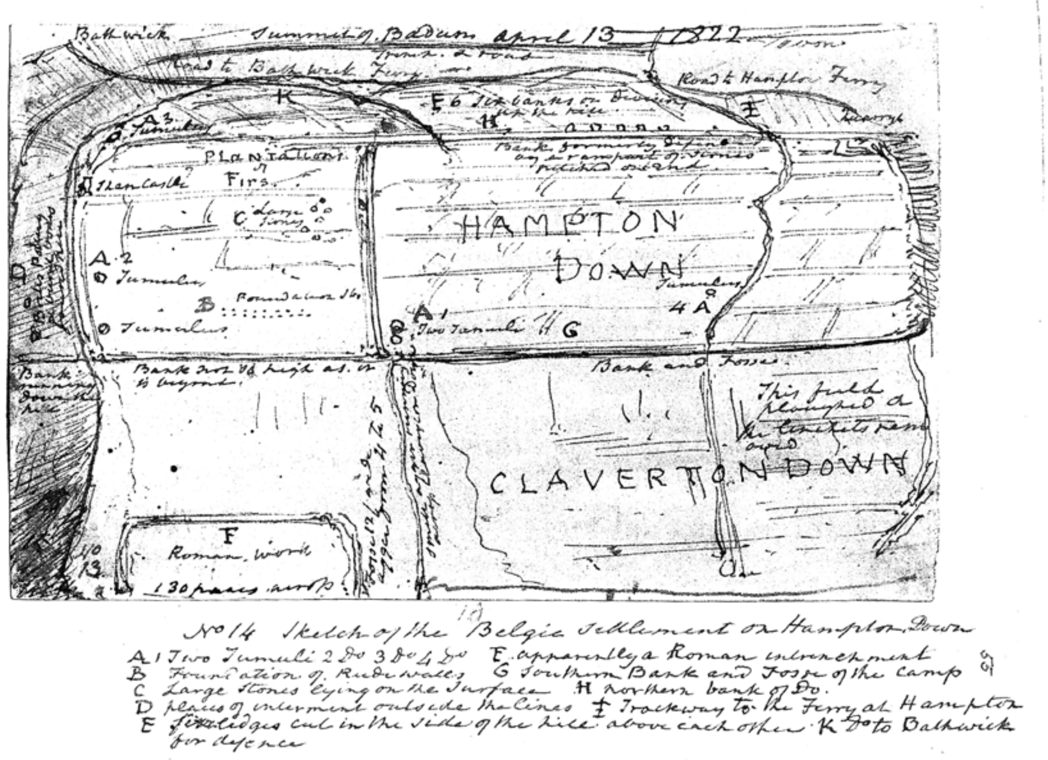

Figure 1.4 The Reverend Skinner's sketch map of Bathampton Down . Position C in the top left square is labelled 'Large stones lying on the surface' *(© British Library Board, MS 33671).*

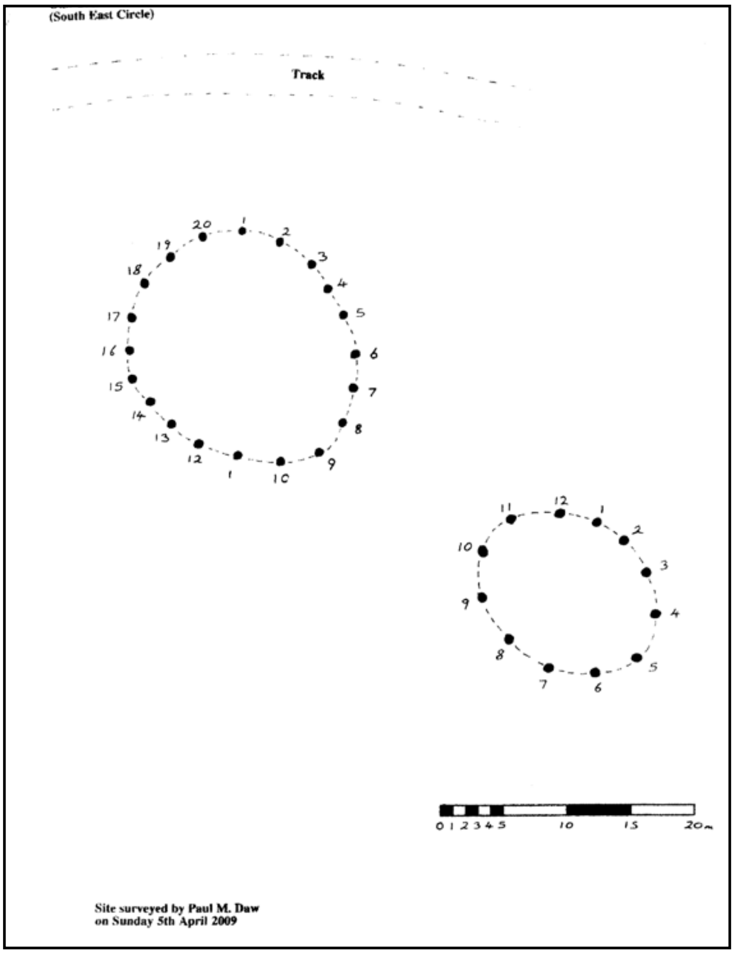

Figure 1.5 Paul Daw's dowsing plan of possible stone circles.

1.3 Dates

The survey started in November 2010 with a magnetometer survey. Following this, a resistance survey was started, but freezing weather throughout December meant that it was not completed until February 2011.

2 The instruments we used

2.1 Magnetometer

The magnetometer survey was carried out using a Bartington 601-2 twin fluxgate gradiometer. This is illustrated in figure 2.1. The device detects very small anomalies in the Earth's magnetic field, such as might be caused when soils have been subject to high temperatures through burning, or where material of different magnetic properties had entered disturbed ground. The magnetometer can detect anomalies down to about 0.05 nT, whereas the Earth's magnetic field is approximately 50,000 nT. Fluxgate devices only detect changes in the vertical component of the magnetic field.

As this is a very sensitive detector, the operator is required to be magnetically clean, wearing clothing with no metallic components and removing all metallic objects. The detection of archaeology still relies however on observing patterns in the computer output plan, so a subjective element is still present.

Figure 2.1 The Bartington magnetometer in use at the site on Bathampton Down.

After survey, the magnetometer data are downloaded to computer via an RS232 link, using software provided by Bartington. The files are then fed through de-stripe processing before being mapped in INSITE v3 proprietary software. The de-stripe software used was developed by BACAS and uses a zero median technique.

The device was set to record data at higher density than is normally used. It sampled eight readings per metre along lines 0.5 m apart, giving 6400 readings per 20 m square. This was in line with procedures used at Stanton Drew *(Oswin, Richards and Sermon 2011).* This required the operator to walk at a steady 1.0 m per second, the speed set into the machine, and imperfections in this constancy of speed can be seen as a slight rippling in targets. The mapping also assumes 20 m squares are laid out exactly and that baselines were straight.

2.2 Twin-probe resistance

Initially, surveying was undertaken using a Geoscan RM15D, but after this developed a fault, the survey was continued using a TR/CIA device. Both are similar in appearance. The RM15 is illustrated in figure 2.2. An electronics package and data recorder sits on a movable frame which has two probes (one potential, one current) placed half a metre apart. The instrument is also connected to a pair of remote probes (one potential, one current) stationary in the ground. This enables a resistance value to be determined, although that value depends on the separation of the remote probes (fixed for any square surveyed) and the moisture content of the ground below the moving probes (that is, whether it be soil or stone).

Figure 2.2 Twin probe resistance meter on the Down. The background view is to the west.

As with magnetometry, observing archaeology involves interpreting a plot on a computer screen *(Oswin, 2009)*. It also assumes the remote probes are remote, in reality more than 15 m from the nearest measurement point, as well as assuming that the survey squares are true and baselines straight.

Data were downloaded via a RS232 link using BACAS proprietary software and mapped using INSITE v3. For both instruments, readings were taken at 0.5 m intervals along lines 1 m apart, giving 800 readings per 20 m square. As well as generating plans in INSITE, we have a facility for mapping up to four squares in XL to provide higher resistance resolution.

Resistance survey does not impose restrictions on operator dress, but is slower and is physically harder work than magnetometry.

2.3 Resistivity profiling

The TR/CIA resistance meter has a facility for connecting probes in a long line four-at-a-time in order to obtain depth information. This is known as pseudosection or resistivity profiling. The four probes are connected in Wenner configuration, with current passing between the outer two while the potential is measured between the inner two. If the spacing between probes is one metre, the horizontal resolution is one metre and the vertical resolution is half metre. The spacing can be increased up to six metres to obtain vertical data down to three metres, but as the depth increases, the number of useable probes reduces, so the elevation plot is 'V' shaped.

If the half-mete depth data are subtracted from the one metre depth data, the information between half and one metre down can be obtained, and so on to full depth. In practice, the subtraction process is done using finite difference mathematical techniques.

Figure 2.3 shows the profiling kit in use. Figure 2.4 shows a typical output. Of the three images, the first is derived directly from measured data, the second is the digital version of the first and the lowest is the outcome of the finite difference calculation and represents a 'worm's eye view' of the archaeology.

The starting spacing can be reduced to half metre to increase depth and length resolution, but length and depth of section are sacrificed. Profile results in this report from now on show only the third image

Data from the TR/CIA are downloaded using TR software and converted to suitable file format, and RES2DINV freeware is then used to process the data to produce the profiles. The resistivity scale colour key can be adjusted in range and linear or log scales can be used.

Figure 2.3 Resistivity profiling on the site.

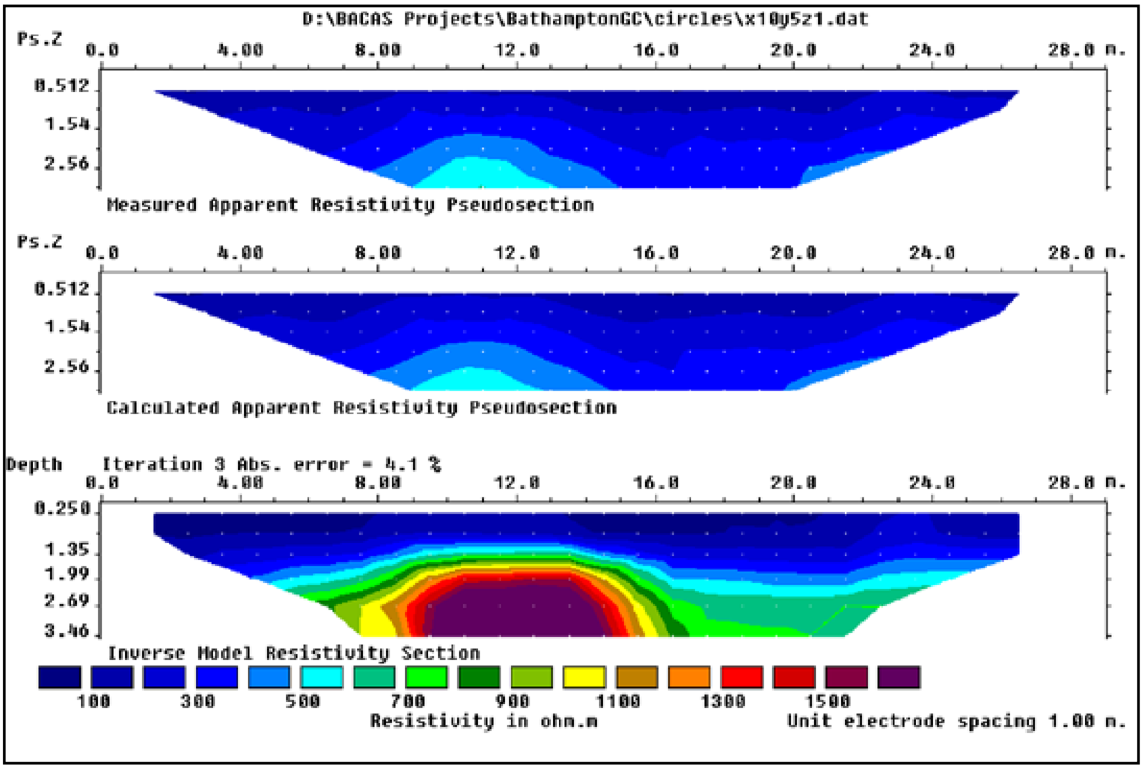

Figure 2.4 Typical output from profiling. Blue represents low values, red and purple indicate stone objects.

2.4 Ground penetrating radar

BACAS was generously donated a ground-penetrating radar (GPR). This is a MALA X3M, complete with 250 MHz and 500 MHz antennae and odometer wheel. For work here, the 250 MHz antenna was used. Figure 2.5 shows the radar, with the antenna being towed like a sled with the instrumentation mounted on top of it.

The device works by sending very short microwave pulses into the ground. Energy is reflected off a solid object back into the antenna. If the time difference between transmission and reception is measured, the depth of the object can be calculated if the wave speed is known. The wave speed will vary from soil to soil and is much less than the wave speed in air. Time differences are measured in nanoseconds (nano means a millionth divided by a thousand) and pulses can be transmitted at a high rate. The reflection data can be assembled into a three-dimensional picture. Data from the MALA radar are downloaded into REFLEXW software to produce the output.

Figure 2.5 Ground penetrating radar on the site.

2.5 GPS

Measurements of national grid reference were made using a hand-held GPS meter. This can provide the reference to five digits for each of easting and northing, that is location precise to one metre, but is only accurate to five metres. It is assumed Mr Daw used a similar device to locate his plans, so there could be a root mean square error of seven metres between recorded locations.

Note that grid squares for survey were laid out with tapes and were generally accurate within 20 cm.

3 The survey

3.1 Magnetometer survey

A 60 metre square was laid out so that it should encompass the circles predicted by Mr Daw, and divided into nine 20 m squares. The grid was aligned to magnetic north. The coordinates of the grid corners, obtained by GPS (to 5 m accuracy) were 77156 65236, 77217 65236, 77155 65176 and 77216 65176. The southern corners of the square were each measured in to two fixed points using tapes and measurements kept so that the grid could be reconstructed. The square could not be extended to the north without encroaching on the rough ground of the camp ramparts, and could not be extended to the west without encroaching onto a playing area of the course, albeit a practice area.

The grids were surveyed at high data density, 8 readings per metre, lines (north-south) half metre apart.

The results of the survey are shown in figure 3.1, and figure 3.2 show anomalies in relation to the predicted circles. The two diagonal lines appear to represent prehistoric field boundaries, which are still evident as banks on the ground. The northeast line appears to have a number of possible postholes following it in a line about 5 m to the southwest. The series of parallel lines running down the west side of the strip are taken to be signs of modern disturbance possibly associated with the golf course.

There were no signals which might represent buried stones or empty sockets in the positions or patterns predicted by Mr Daw, but there was an area of disturbance in the southeast corner which was reminiscent of results obtained in the south southwest circle at Stanton Drew *(Oswin et al, 2011)*. On the basis of these findings it was decided to carry out a resistance survey.

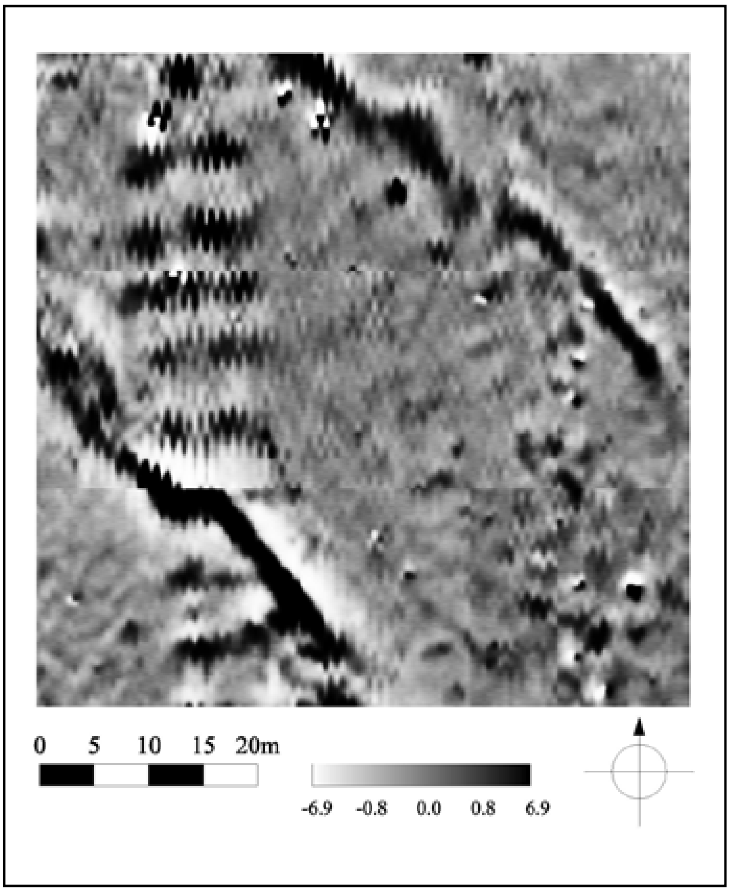

Figure 3.1 The magnetometer survey. The two diagonal lines show the prehistoric field boundaries. The north-east line appears to have a number of possible postholes following it in a line about 5m to the south-west. The series of parallel lines running down the west side of the strip are taken to be signs of modern disturbance. The area of disturbance in the south-east corner can be seen.

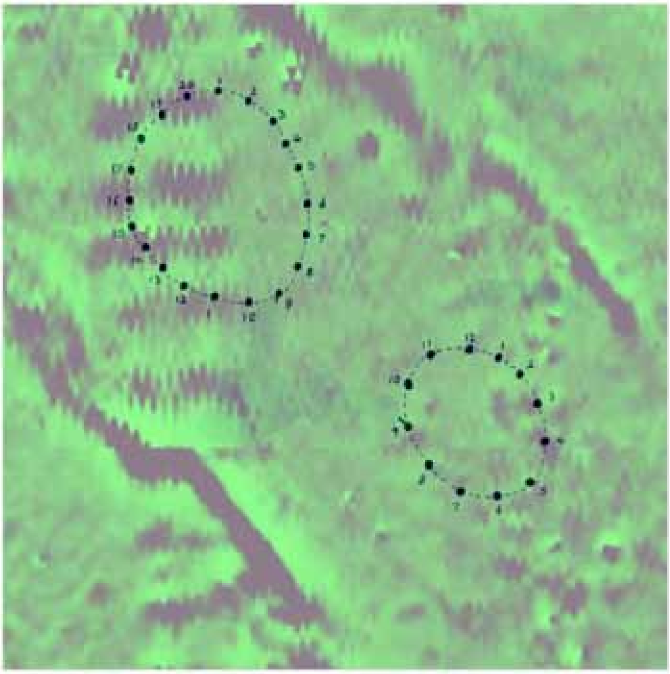

Figure 3.2 Magnetometer survey overlaid on dowsing plan.

3.2 Twin probe resistance survey

The four grids that make up the centre and south-eastern portion of the original block were laid out as a 40 m square. The western three grids were discarded henceforth as there seemed to have been significant disturbance here.

The grids were surveyed at 2 readings per metre along lines (north-south), lines one metre apart. This is the normal resistance arrangement in BACAS.

The output is shown in figure 3.3. On all resistance plots generated in INSITE by BACAS, dark represents higher resistance. An enhanced version of this, using XL to increase the definition of the resistance scale is shown in figure 3.4. The diagonal lines of the field boundaries are replicated, suggesting that there is stone in them. The overlay of resistance and magnetometry is shown in figure 3.5. This was in line with expectations from excavations elsewhere on the down *(Thomas, 2008, p 38)*. Lines heading perpendicularly from the southwest line seem to form rectangles, possibly small enclosures or buildings.

The principal interest was however in a group of individual stone signals in the south-eastern portion of the square, which formed arcs. The signals of interest are shown superimposed on the resistance plot in figure 3.6 (which also indicates the circle suggested by dowsing). These were considered the best evidence for a buried stone circle, or remaining part of a circle.

In order to test this idea, the area covered by resistance was extended to the south, southeast, east and north to see if there were similar patterns close by. The pattern was not extended to the west because of the disturbance observed in magnetometry and the proximity to golf practice area.

The extent of the area, approximately 1 ha, is shown in figure 1.2 and the output is shown in figure 3.7. There is some similar activity to the southeast, but generally, stone-like signals appear as large, amorphous areas, suggesting that these are places where the underlying rock strata come close to the surface.

The full resistance survey still suggested that the marked signals in figure 3.6 as the most likely remaining components of the stone circle.

Figure 3.3 Resistance survey of 40 m square. The diagonal lines of the field boundaries are replicated suggesting the presence of stone. The south-eastern part of the square shows a group of individual stone signals. Lines heading perpendicularly from the south-west line seem to form rectangles suggestive of small enclosures or buildings.

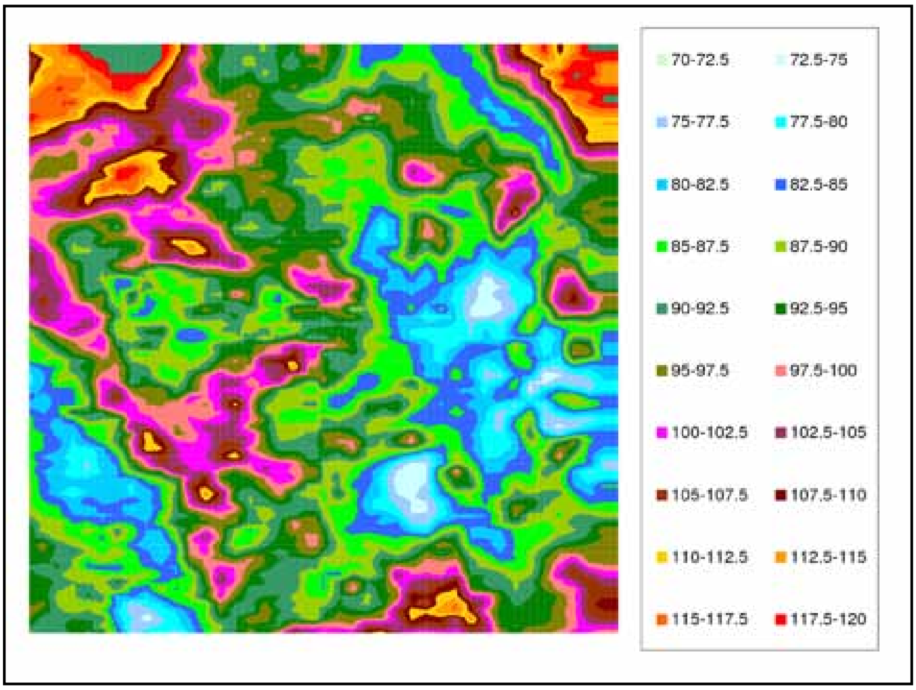

Figure 3.4 Resistance survey with high definition scale.

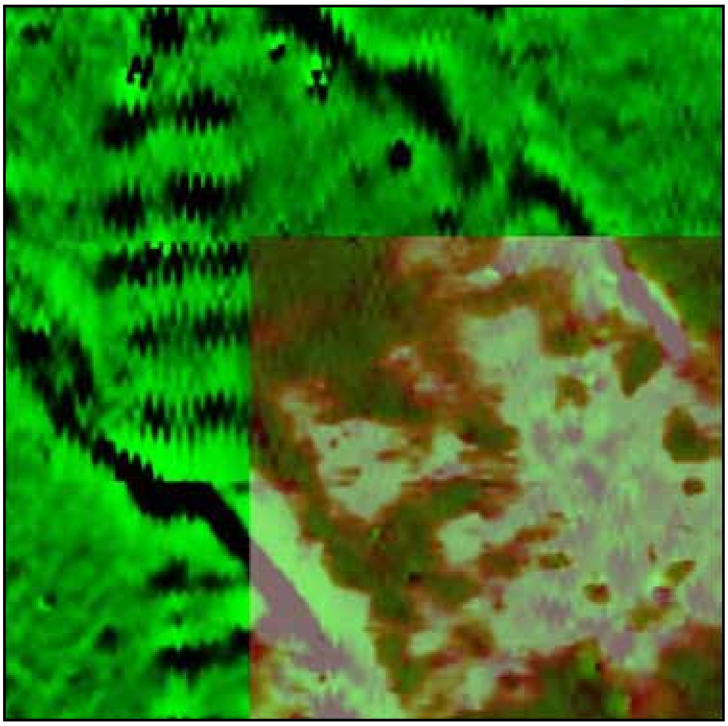

Figure 3.5 Overlay of resistance and magnetometer surveys.

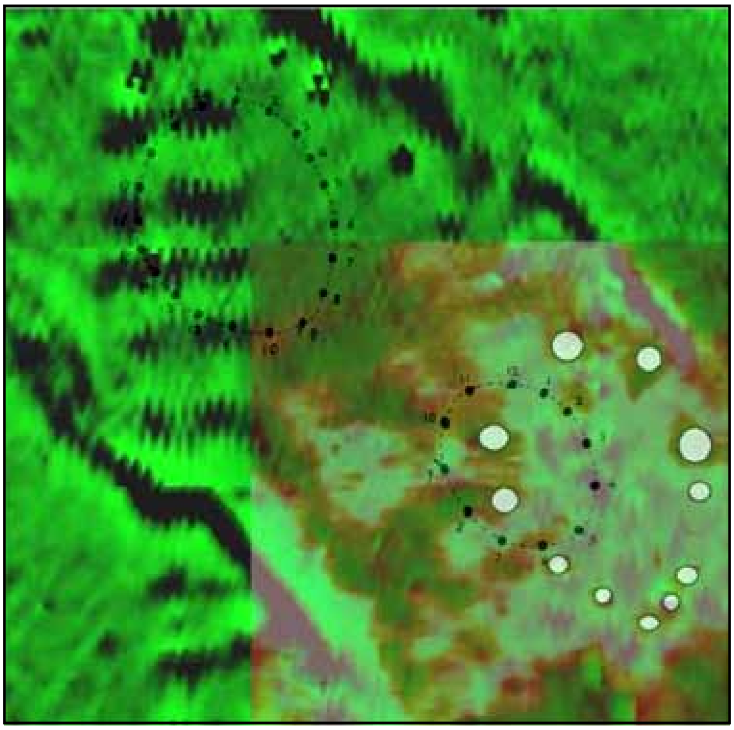

Figure 3.6 Resistance survey with possible stones indicated by white circles. The dowsing plan has been overlaid.

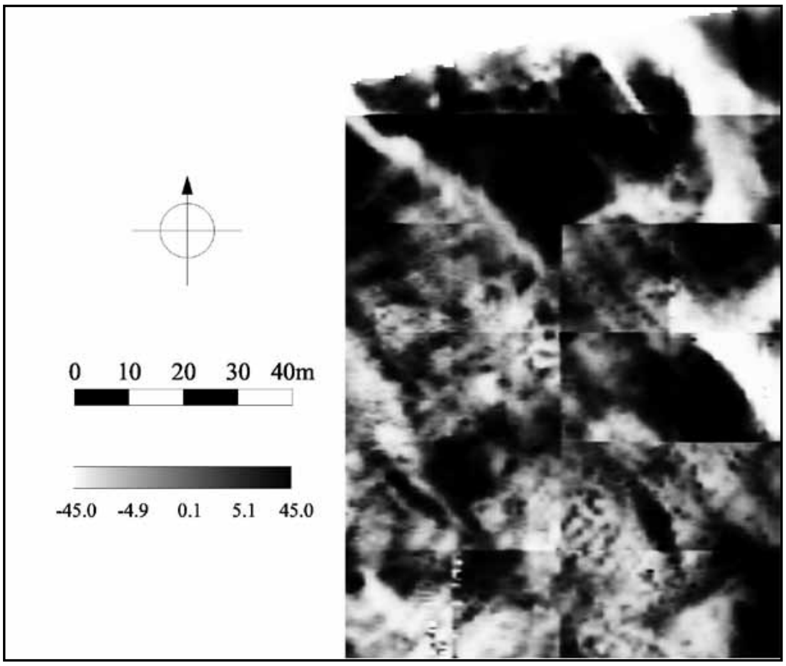

Figure 3.7 Complete area of resistance survey.

3.3 Ground-penetrating radar

The 40 m square originally set up for resistance survey, shown in figure 3.3 was also subject to ground-penetrating radar (GPR). This used the 250 MHz antenna taking readings every 0.1 m on traverses 1 m apart. The traverses were taken in a zig-zag pattern and care was taken to start each traverse with the centre of the antenna over the baseline so that there was no offset between neighbouring lines.

Wave velocity was not calibrated, and for this exercise, it was assumed to be 0.06 m/ns. Any nominal depths quoted make this assumption. The colour scheme used for data presentation was 'Rainbow1' with yellow as neutral and purple and red as opposite extremes.

The depth slice at 1.1 m (nominal) is shown in figure 3.8. The picture is too cluttered to be of great use, but two of the possible stones can be picked out (as arrowed) and the field boundary can also be seen. Individual depth profiles along specific lines were found to reinforce stone identities once identified and this will be discussed further in the following section.

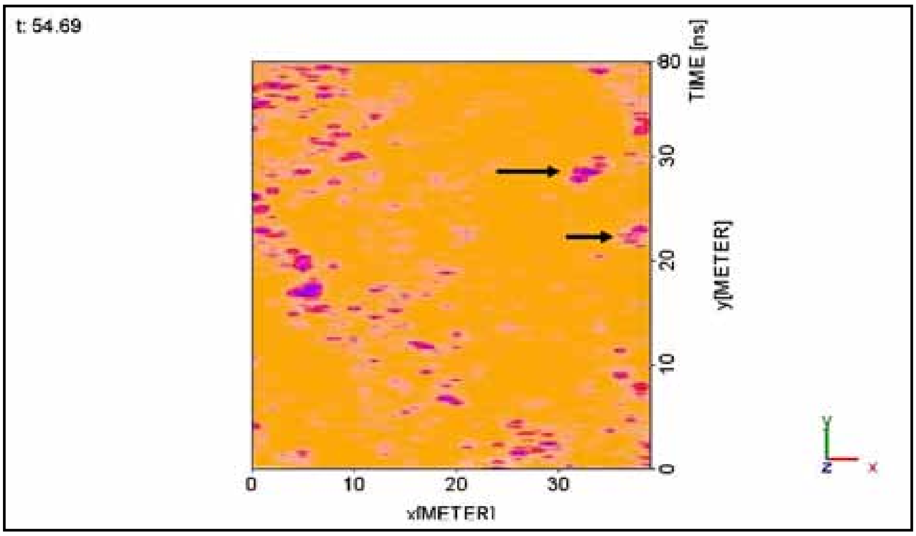

Figure 3.8 Radar depth slice at nominal depth 1.1m. Orange is neutral and purple and red are opposite extremes. Two possible stones are marked by arrows.

3.4 Resistivity profiles

Profiles provide depth information, as does radar, but at much lower resolution. In this particular case, that proved to be useful. They are also much slower to take. Only eight profiles using 30 probes could be done in the day available. There is very little intuition provided by the individual readings as the profile is assembled.

Six profiles were taken at various lines across the original 40 by 40 m square using the probes at 1 m spacing. These were at 10, 18, 27, 33, 35 and 37 m from the west end and all started 5 m north of the southern baseline. Two profiles were taken with 0.5 m spacing, on lines 33 and 37. These were over position thought most likely to show evidence of stones. The decreased spacing improves resolution but reduces the length of the line, making positioning more critical, and it also reduces the depth which can be seen. Physically, resolution is only probe spacing horizontally and half probe spacing vertically, although the mathematical process may increase the density of data to apparently finer resolution. The half metre and metre spacing plots on lines 33 and 37 do not match resistivity readings exactly, suggesting that there may be some limitations in the method.

Figure 3.9 shows a number of the profiles overlaid on the resistance plot of the original 40 m square. Note that the plot has been turned through 90 degrees so that left to right represents south to north. The profile at 35 m has been omitted for clarity, as has that with half metre spacing at 33 m. The half metre space profile at 37 m has been overlaid on the one metre space. All the profiles are shown individually in Appendix A, but these have been arranged for comparison with the twin-probe results and are placed on the lines where they were taken. Scales have been retained on the 10 m profile but not on the others. All resistance scales have been kept the same on the profiles. The vertical scales are not set to match the horizontal scale.

The 10 m profile shows a large stone object which corresponds to dark on the twin-probe plot and may represent wall footings. The profiles at 18 and 27 m show no individual strong features, suggesting that variations in resistance shown on the twin-probe plot are mainly due to effects close to the surface.

The plots at 33 and 37 show discrete stone signals at either end. These would have benefited from a longer profile at provide more information at greater depths but that was not feasible. These stone signatures are candidates for remaining stones of the circle, especially those towards the northern ends of these lines. Note, however, that they appear to be under considerable depth of soil.

Figure 3.10 compares the 37 m profile (half metre spacing) with the radar profile obtained on that line. Depth scales have not been set to match, but there seems to be a strong radar return at the point where profiling shows high resistivity. There is a similar correspondence on the 33 m line.

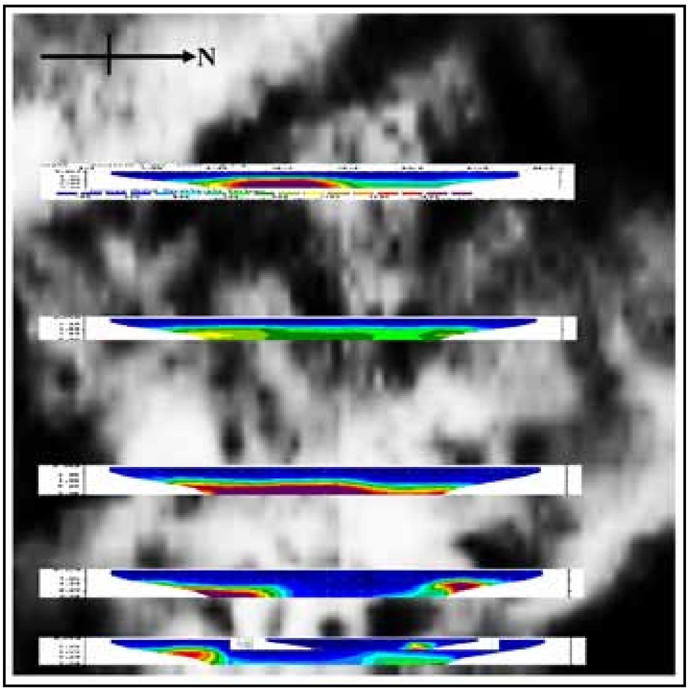

Figure 3.9 Resistivity profiles overlaid on the resistance plot of the original 40m square. The plot has been turned through 90 degrees so that left to right represents south to north. The profile at 37 m has been omitted for clarity, as has that with half metre spacing at 33 m.

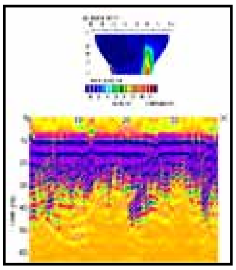

Figure 3.10 Comparison of 37m profile (half metre spacing) with equivalent radar profile. The depth scales have not been set to match but a strong radar return can be seen where profiling shows high resistivity.

3.5 Comment

Twin-probe resistance and resistivity profiling have shown the best evidence for the possible remains of the stone circle. Magnetometry has shown field boundaries which probably would have been later than the circles, and possible post holes. There is no correspondence between dowsing plots and geophysics techniques within the accuracies quoted for placements, although it was the dowsing results which led to the site of the geophysical survey.

4 Discussion

There is now nothing to see on the surface to suggest the former presence of stone circles or avenues in the area. We have only the word of an antiquarian of the mid nineteenth century (Scarth, 1857), writing in a paper about other archaeological features. It is curious that John Skinner, a more meticulous recorder of antiquities, did not include any sign of stones here on the down in his maps of 1822 but showed stones elsewhere nearby. This leads to some doubt as to the existence of the monument. Scarth was talking about a big monument as he mentions that some 30 stones were already removed.

The suggested similarity with the stones of Stanton Drew also makes for problems. Apart from a few stones which may have originated near Bath, most at Stanton Drew are in varying shades of red, a colour not met close by here. One would also question whether any large non-local stones could be brought up the long, steep slopes to this hilltop position. Stones might have been dragged downhill from Dundry to Stanton Drew but a reverse journey would be hard to contemplate. It is most likely that any megalithic monument here would be built from stone quarried on the hilltop. One or two large stones are still visible in the bases of walls and elsewhere around the golf course but there is no way of knowing if they were connected with the circles. Scarth states that many of the stones ended up in parks and gardens around Bath, but these are not obvious.

Tratman (1958) suggested that if what Scarth said was true, the monument would be most likely to lie in the area covered by this survey. This was a simple suggestion, not an assertion of the presence of stone circles.

Mr Daw appears to have taken Tratman's location literally and claims to have discovered a small stone circle centred on an exact definition of Tratman's approximate location, and another small circle (actually, he has drawn ellipses) a little to the north-west.

As our own researches were spurred by Mr Daw's assertion, we initially surveyed an area which encompassed his claimed monuments. Using instruments to produce two-dimensional plans, we found anomalies which may represent the remains of the megalithic monument close to, but not exactly at, Mr Daw's location. Resistance survey indicated possible individual standing stones and magnetometer survey indicated a possible complex internal structure analogous to that at Stanton Drew, particularly the south southwest circle.

Use of three-dimensional surveying techniques has shown that even some of these features were only surface effects, but there are a few which could possibly belong to stones of the monument, and these are quite deep below the present ground surface.

It is on the basis of these that we can state that we may have found part of the monument. Our data are far from conclusive and it would take excavation to confirm that we have located the circle. The data are not sufficient for a realistic estimate of the shape or diameter of the circle. There were no signs of a possible second circle to the northwest, but the ground here had been disturbed in modern times.

If this is the site of a demolished stone circle and avenues, its appearance may have been similar to those at Stanton Drew but its setting is very different. Whereas the Stanton Drew monument sits in a vale, close by water, Bathampton Down overlooks the River Avon but from a commanding position at a great height. The site is at 200 m OD at the top of a steep slope, although not quite at the summit.

Our findings would place the stone monument on a site where Bathampton Camp was constructed much later. This so-called Camp is thought to have been a huge (perhaps 32 hectares) early Iron Age hilltop enclosure *(Thomas 2008)*. Although hillforts were sometimes built on sites previously occupied by 'semi-religious monuments' *(Dyer 2003)*, there do not seem to be other records of this in the case of stone circles.

There are three standing stones in Bushy Norwood Field, still on high, flat ground, about 1 km to the south. However, these are known to be part of an eighteenth century horse race course. Other stones in the field were bulldozed in the nineteen forties *(Whitaker, 2000, 51)*. The presence of these stones has previously caused confusion with the stones of a circle *(Quinn, 1997)*.

A full plot of the horizon has not at this stage been done, although it may be important *(Ruggles, 1999)*. Figure 4.1 is a computer-generated viewshed from this location. The view across to the north side of the valley gives a surprisingly flat skyline, that of the southern Cotswolds. The one notch, just at the west end of Freezing Hill is just masked by Lansdown. To the east, the steep slope of Bathford Hill is just visible. Further round towards the south, the view is restricted by the summit of the Down, and also now by the university.

To the south-west, the ridge of Southdown and hills beyond rise towards the Mendips. There is only low ground to the west, along the Avon and Chew Valleys, although paradoxically, Stanton Drew is masked. There are no obvious astronomical alignments, but a detailed study might show that there are some.

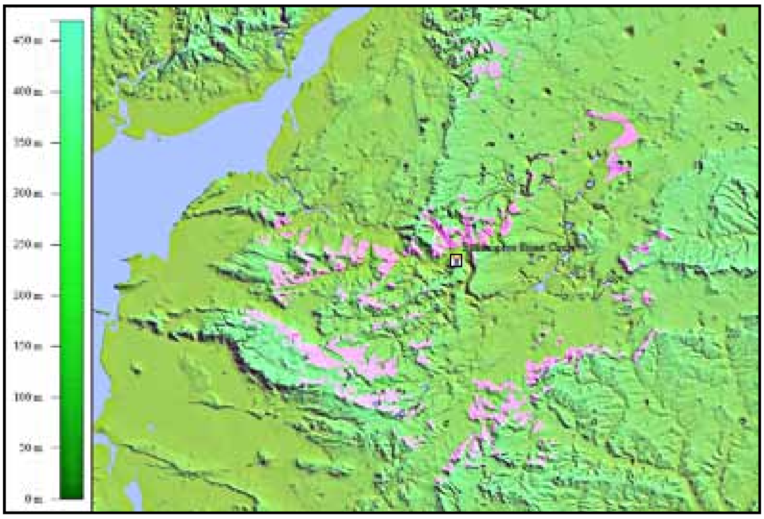

Figure 4.1 Computer- generated viewshed from 2m height at the stone circle site. View to 30km with the ground visible in pink. *(Image from Tim Lunt. Contains Ordnance Survey data © Crown copyright and database right 2010).*

The only link to Stanton Drew is really that both are in North Somerset. In other respects, particularly in siting, it has more in common with Kingston Russell (Dorset), shown in figure 4.2, Rollright (Oxfordshire), figure 4.3 or Arbor Low (Derbyshire), shown in figure 4.4.

Figure 4.2 Kingston Russell stone circle on its hilltop with Lyme Bay in the background.

Figure 4.3 Rollright Stones. The ground slopes away into the valley beyond the stones.

Figure 4.4 Arbor Low stone circle on its hilltop, with distant views.

It is unlikely that excavations to confirm the presence of the remains of the stone circle would be feasible in the near future, so the geophysical evidence reported here is the only support for Scarth's claims of the mid nineteenth century. There are limits to what we can say about the plan of the monument, but we are cautiously optimistic that there was a hilltop stone circle here.

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Appendix A Data

The raw download data from the instruments have been retained and can be made available. The purpose of this appendix is to provide sufficient information that the data can be assembled in the correct pattern.

The plans shown have been generated in INSITE v3. BACAS prefers this because of its versatility although the software is now generally regarded as obsolete. This does mean that some difficulties could be encountered if other processing software is used, or there may be a need to re-order the data files to bring them in to line with the requirements of other processing software.

A1 Magnetometry

A set of nine grid squares of 20 m side was set out. Grid north was set to magnetic north. Each grid was started in the south-west corner heading north on the first traverse. Readings were taken at 8 per m along traverses half metre apart, giving 6400 data points per square. Note that the responses from each side of the Bartington 601-2 were interleaved, and the data was sorted into a continuous file during download using Bartington proprietary software. For each line (40 per square), data are listed starting at the southern end, i.e. in parallel arrangement even if that is not how it was recorded in survey.

Note that BACAS practice is to start one line in from the western edge, one reading up from the southern baseline *(Oswin, 2009.115, fig 5.8c)* to ensure that grids mesh together without gap or overlap.

The grids were then passed through a BACAS proprietary destriper, which works by assigning a zero value to the median of each line, and subtracting the median values from all other readings in the line. The input files for INSITE processing are then stored in a folder. Those with prefix 'm' represent unprocessed data, those with prefix 'd' are the de-striped data.

Figure A1 shows the layout of the grid squares. The arrows show the start points and starting directions.

A2 Twin probe resistance

The initial area subject to resistance survey was the four grid squares that are the south-east portion of the magnetometer survey, that is grids 2, 3, 5 and 6 of those in figure A1. These are grids 1, 2, 3 and 4 respectively in figure A2, which shows the order of surveying using resistance. Note that blocks of four squares were surveyed at a time, the order of the block depending mainly on proximity to the first block.

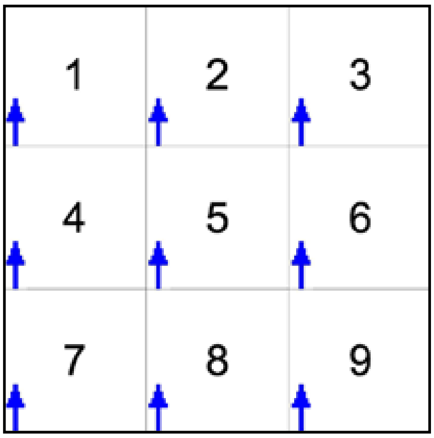

Figure A1 Layout of magnetometer grid squares.

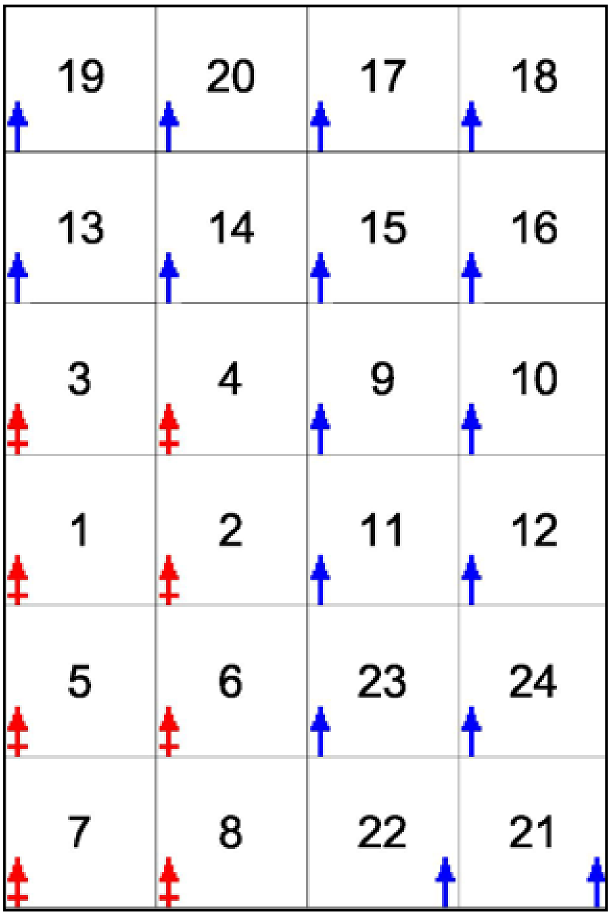

Figure A2 Layout or resistance grid squares. Red arrows indicate RM15 , blue arrows TR/CIA.

For resistance, readings were taken at 40 per line (i.e. half metre intervals) on lines 1 m apart, giving 800 data points per square. Note that, although the squares were generally started in the south-west corner, two grids at the east of the southern end of the plot were started in the south-east corner. This was because there was a little encroachment on to the golf course, and it was important to be clear of this and into the 'out-of-bounds' area as quickly as possible.

The survey started using a Geoscan RM15D device, but this became faulty during the course of the survey. Indeed, two grids, 7 and 8, have received some remedial treatment in INSITE to correct faulty low readings, although the low readings are still present in the raw data files. The resistance files have a prefix 'r' in the raw data set.

The initial four squares were also plotted using an XL spreadsheet, which re-laid out the string of data points into a square pattern and interpolated lines to provide a square of 80 by 80 points. This was graphed using XL contour graph routines.

After the fault was established, the survey was completed using a TR/CIA resistance meter. This was physically very similar, with half metre probe separation on the frame but had different download characteristics. All grids were walked south to north 'up' the grid, north to south 'down'. The data order on the RM15 followed this (i.e. 'zigzag' data) but the TR/CIA sorted this so that data points always rise heading north (i.e. 'parallel data). In figure A2, squares with red arrows with bars represent 'zigzag' (RM15) while those with blue simple arrows represent 'parallel' (TR/CIA).

A3 Resistivity profiles

The TR/CIA meter has a facility to operate a set of four probes in Wenner configuration (Oswin, 2009, 36), the four being selected from a line of 30 probes. In the first six measurements, the probes were set 1 m apart, giving a 29 metre line. In the last two cases, the probes were set 0.5 m apart, giving a 14.5 m line. Note that the readings for a set of four probes actually relate to the point between the second and third probe, this means that the data set is shorter than the probe line by 1.5 times probe spacing at each end.

The first 'line' of data represents the data from spacings with no unused probes, e.g. probes 1 m apart in a normal case. The second line represents spacings with one unused probe, i.e. 2 m apart. Note that because the TR/CIA device sorts 'up' and 'down' lines automatically into 'up' lines, the second line has data point numbers reversed. The third line represents 2 unused probes, probes 3 m apart, up to a final line of five unused spacings, probes 6 m apart. Lines always start from probe 0, the southernmost, and all readings progress along each line 1 probe at a time. Each line must be positively ended by an 'end X' command before the next line is started.

In order to cover the area of greatest interest, the 1 m spaced profiles were started with the 0 probe 5 metres out from the southern baseline. A profile might be named, for instance, x18y5z1. This means that it is 18 m east of the western baseline, starts 5 m north of the southern baseline and has 1 m probe spacing. For the two half metre spacings, these have a 'z05' label, and the y value indicates how many metres north of the southern baseline (not how many north of the y5 line) the 0 probe was placed.

The data files were downloaded from the meter and converted to RES2DINV-compatible format using TR proprietary software. Only the simple RES2DINV freeware was available. Once all eight measurements had been viewed, each was done again using the contour adjusted to 'user-defined linear' with a minimum of 100 ohm-m and intervals of 100 so all would be directly comparable.

The print-out has three components on screen. The top is a direct plot of the measurements taken, the second is the nearest quantised digital equivalent to that and the lowest is the result of the finite difference analysis. Only the analysis results are shown here.

Figure A3 shows four plots with 1 m spacing: x10y5z1; x18y5z1; x27y5z1 and x35y5z1. Figure A4 shows the two lines which were done at both 1 and 0.5 m spacings, and the two lines of each are placed on the page to show how they overlap. These are x33y5z1 and x33y21z05; and x37y5z1 and x37y15z05.

Note that the correspondence of the two versions of each line in figure A4 is not perfect: they cannot be overlaid with full agreement of resistivity data. This may be a measurement limitation on the method.

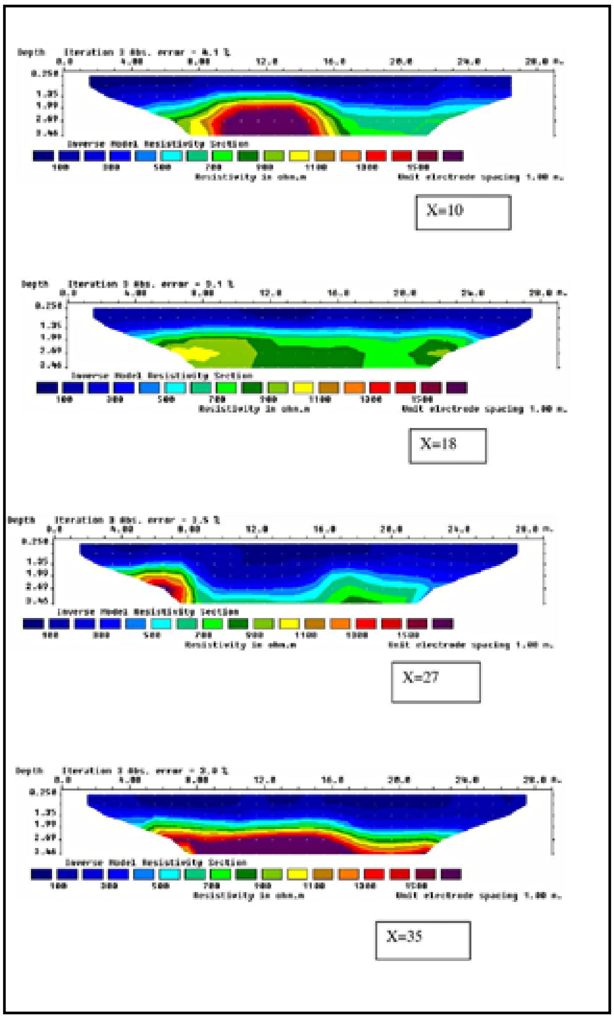

Figure A3 Four resistivity profiles with 1 m spacing (a) at 10 m, (b) at 18 m, (c) at 27 m, (d) at 35 m.

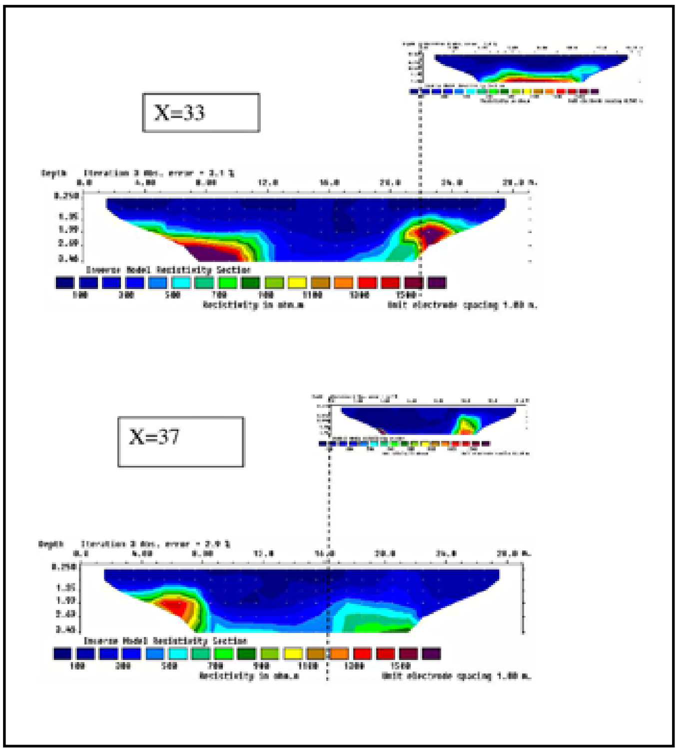

Figure A4 Resistivity profiles at 33 m and 37 m. (a) 33 m, 1m spacing (b) 33 m, 0.5 spacing (c) 37 m, 1m spacing, (d) 37 m, 0.5 m spacing.

A4 Radar

All radar was done with a MALA X3M device using a 250 MHZ antenna, taking data at 0.1 m intervals measured by the odometer wheel. Forty lines, each 40 m long were taken over the original four grid squares of the resistance survey. Lines were 1 m apart. A zig-zag north-south pattern was walked, so each second line needs to be reversed when assembling a three-dimensional cube of the results. Care was taken to start each line from an accurate position so that there was no 'jitter' in the results.

A5 Grid position

The 60 by 60 m grid used for magnetometry was measured in by hand-held GPS, but this is only accurate to 5 m. In order to ensure reproducibility, the extremes of the southern baseline were tied into semi-permanent features using 100 m tape measures. The square was then assembled using a Pythagorean triangle of sides 60, 60 and 84.84 and subdivided into 20 m squares.

Tying in the ends of the southern baseline is as follows:-
  51.5 m from the waymark (figure A5)
  83.9 m from the end of the wall (figure A6).
The eastern end is
  84.15.m from the west tree (figure A7)
  50.0 m from west edge of drain cover (figure A8).

Figure A5 Waymark used to set grid

Figure A6 Wall end used to set grid

Figure A7 Tree trunk used to set grid

Figure A8 Drain cover used to set grid

All other grids were derived from this baseline and squares made using Pythagorean triangles 40, 40 and 56.56 or 20, 20 and 28.28.

Appendix B The Barrow Site

Bathampton Down has 8 round barrows on the Sites and Monuments record *(Thomas, 2008)*. Aerial photographs are very suggestive of the outlines of an additional two undocumented barrows *(NMR 21860/14, 23 Oct 2002)*. These seem visible on the ground, and have also been noticed by Bath archaeologist, Marek Lewcun.

A high data density magnetometer survey was carried out on this site which is also within the golf course, near the reservoir (Figure 1.2). This was centred on ST775649, where there was rough grass on very uneven ground. A square 60 m by 60 m was laid out on a north-south alignment and sub-divided into nine 20 m squares for survey. The grid references (from hand-held GPS) were 77555, 65049; 77614, 65060; 77644, 65023; 77568, 64991. The grids were extended east to take in two more 20 m squares. The third grid, the most south-easterly, could not be surveyed as it was under trees, with low canopy.

The results are shown in Figure B1. They are somewhat inconclusive as there are so many other signals in this area, presumably from the many small surface quarries which have left this ground so uneven. However, there are possible features in the south and south-west of the area which may correspond to the barrows. They are in the expected locations.

The order of grids is shown in figure B2. All grids were started at the south-west corner, heading north. Data are 8 points per metre along lines, lines half metre apart, 6400 per grid square. The data were collected on an interleaved zig-zag pattern, but were sorted on download to parallel data.

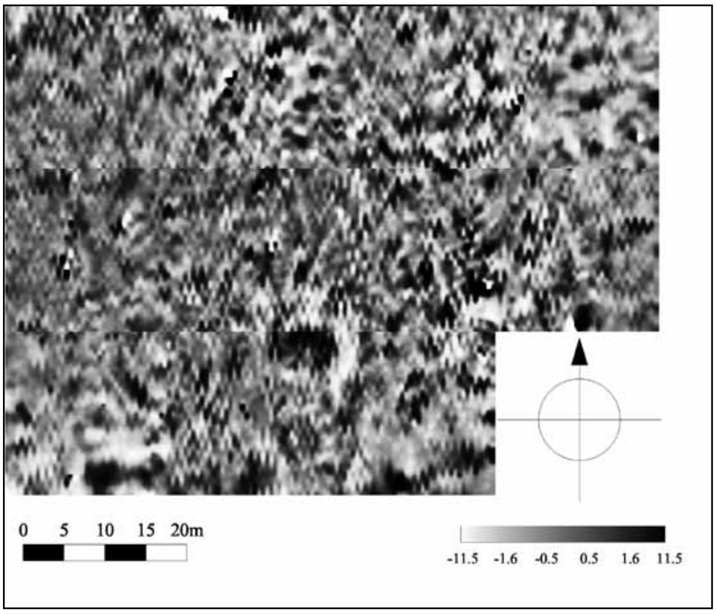

Figure B1 Results of magnetometer survey of the round barrow site. Two possible features can be seen in the south and south-west which may correspond to the barrows.

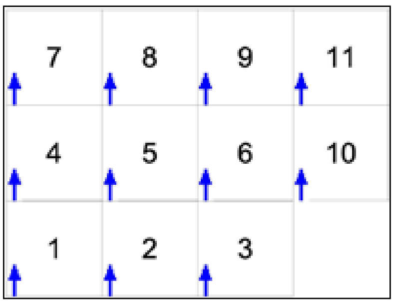

Figure B2 Layout of magnetometer grid squares.