Squaring the Circle?

Geophysical Survey across part of the Southern Inner Circle of the Avebury henge

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Introduction

This report describes the results of fieldwork carried out as one component of the AHRC-funded *Living with Monuments Project* that seeks to investigate the earliest structural activity at Avebury through a combination of detailed archival work (both antiquarian; earlier survey; unpublished 1930s excavation records) and targeted geophysical prospection. It has long been suspected that the innermost settings of the henge – the inner circles - along with their attendant features (i.e. the Cove to the north and Obelisk to the south) mark some of the earliest megalithic settings in the structure (Gillings and Pollard 2004; Gillings et al 2008: 165-6). For a number of reasons, our understanding of these crucial areas is partial and fragmentary. Surviving antiquarian records are contradictory (Ucko et al. 1991) and with the exception of limited slots at the base of the surviving uprights (Gillings et al 2008: 153-169), there have been no modern excavations in the northern inner circle. In the southern inner circle Keiller’s large-scale excavations of 1939 only explored the westernmost half and area directly around the Obelisk (Smith 1965).

Geophysical coverage has likewise been patchy. Whilst the entire henge has recently been surveyed using gradiometry as part of Darvill and Lüth’s on-going surveys of the Avebury landscape, no resistivity surveys have been carried out since 1989, despite improvements in both instrumentation and processing capabilities. This is despite the proven utility of soil resistance survey in detecting the presence of buried megaliths, stone destruction features (e.g. Gillings et al. 2008) and sarsen-lined postholes (2012-15 excavations on the line of the West Kennet Avenue). These are features that have proven stubbornly unresponsive to gradiometer survey limiting its effectiveness in the detection of stone-related features. Take for example the provisional results collected by Darvill and Lüth across the Southern Inner Circle which show little beyond metallic debris (Darvill and Lüth pers comm).

Given the known presence of substantial buried sarsen stones at Avebury alongside highly compacted stoneholes (the upright sarsens weighing anywhere between 15 and 100 tonnes) it is particularly surprising that no large-scale GPR surveys have been attempted at Avebury, despite the success of GPR in detecting buried megaliths in an evaluation carried out in 2000 as part of work on the line of the Beckhampton Avenue (Gillings et al. 2008: 64-66).

The extent of prior resistance surveys is indicated in Figure 1. The area was covered in 1989 by the Ancient Monuments Laboratory using an RM4 and DL10 twin probe configuration and a typical 1m sampling interval (see Clark 1990, Fig 35 for a photographic record of this survey). The results were published by Ucko et al. (1991: 219-220) and reflect the instrumentation and data processing options available at the time. The results of this survey were far from conclusive, the authors noting that “[a]lthough resistivity anomalies are present throughout the survey data, it is not possible to discriminate with any confidence between those reflecting possible prehistoric features and those which are natural or spurious” (Ucko et al. 1991: 220). They illustrated this by noting how Keiller’s excavated area is indistinguishable (in terms of anomalies) from the remainder, concluding that the “whole of this area of the site therefore continues to be an enigma” (ibid). A more recent survey (2003) was carried out by Martin Papworth of the National Trust, using RM15 instrumentation and a 0.5 x 1.0m sampling resolution. This demonstrated conclusively how effective soil resistance survey was in detecting buried sarsens, but focused solely upon the eastern half of the quadrant, not extending as far to the west as the Southern Inner Circle (Papworth 2012).
The decision to focus initially upon the Southern Inner Circle followed archival research carried out in 2016 working with the unpublished detail of the 1939 Keiller excavations and attendant finds assemblage, as well as the geophysical results and antiquarian records collated and published by Ucko et al (1991).

Although it is not the intention of this report to discuss the results of this archival work in detail (this will be covered in a full research paper), in short it has served to raise important questions over the following: the veracity of Keiller’s reconstruction of the so called ‘z-feature’ setting of small sarsens around the location of the Obelisk; the attribution of a number of undated cut features to a generalised ‘medieval’ phase of activity; the assumption of a single, coherent phase of planned stone erection in the interior of the Southern Inner Circle; the conclusion by Ucko et al. that the inconsistencies in the earliest antiquarian records (in particular those of Aubrey) were insurmountable.

The 1939 excavations in the south-eastern quadrant recovered pottery and worked flint, likely to be of earlier Neolithic date and concentrated in the area immediately around the Obelisk. To date, no structural features (with the possible exception of four small pits or post-holes: Smith 1965, 201) are known to be associated. However, there are grounds for believing that a series of chalk-dug linear features encountered during 1939, and interpreted by Keiller as an unconventional, open-sided medieval ‘lean-to’ constructed
against the bulk of the fallen Obelisk megalith (a 7m long sarsen) are in fact of early Neolithic date. This is based on: the absence of medieval pottery from these features; the presence here of a concentration of early Neolithic material; their morphology, where in plan the closest match is with a growing body of excavated early Neolithic houses and mortuary enclosures. Furthermore, the axis of the structure is shared by that of the ‘Z-feature’ stone-holes (stones i-xii) of the Southern Inner Circle (Smith 1965: Fig 69). It is hypothesized that the latter represent a later lithic elaboration of this ‘foundational’ structure.

The z-feature (stones i-xii) has always presented an interpretative conundrum – a rectilinear feature within a monument of circles (though perhaps analogous in some ways to the Northern Inner Circle Cove), and one constructed using very small sarsens. Smith did consider a link with early Neolithic funerary architecture in her closing discussion: “Pending further exploration of the area within the Southern Inner Circle at Avebury, any interpretation of the structure represented by Stones i-xxii must be tentative in the extreme. Yet it is worth pointing out that if the arrangement now revealed should prove to be duplicated in reverse on the eastern side of The Obelisk the whole plan would resemble that of a long barrow with forecourt marked out by a symbolic peristalith of small standing stones” (1965: 250-251). By shedding more light on the form of the small sarsen settings, it was hoped the survey would confirm or otherwise Smith’s suspicions about the architecture of this deepest space within the henge intentionally referencing earlier Neolithic mortuary monuments.

Figure 2 – The survey area (shaded grey). The Square Array resistivity survey was limited to the subset of full squares (shaded in blue). Image incorporates data ©Crown Copyright/database right 2012. An Ordnance Survey/EDINA supplied service.
The survey
An area of 0.567 hectares was surveyed to the immediate east (and over-lapping with) the area excavated by Keiller in 1939. The survey area also overlapped with the Papworth survey block further to the east. In practice 12 full and 5 partial 20m\(^2\) grid squares were surveyed, aligned as closely as possible to a reconstruction of Keiller’s own excavation grid (Figure 2). Soil resistance survey was carried out initially using a Geoscan RM85 with a multiplexed 3 probe parallel twin array, with a probe spacing of 0.5m and traverse and sampling intervals of 0.5 and 1.0m respectively. In an attempt to maximise the amount of information recovered this was followed by a second survey of 10 of the full grid squares using a 0.75m square array (Clark 1990: 46-47) with a traverse interval of 1.0m and sampling interval of 0.25m (Geoscan RM85 & MSP25 cart). To remove any twin-peaking effects two sets of readings were logged at right-angles to one another (‘alpha’ and ‘beta’ datasets). All data was processed using the Geoplot 4 (Beta) software suite and the survey grid was geo-referenced using a Leica DGPS post-processed to Ordnance Survey CORs data.

It should be noted that at the time of survey the ground was unexpectedly dry, with local National Trust staff noting anecdotally that the preceding winter had been the driest in memory. This was certainly noted during the twin-probe survey, where high contact resistance resulted in very noisy data across a number of the grids where the mobile probes had not been inserted to a sufficient depth. These grids had to be re-surveyed. In the case of the cart-based square array, where insertion depth could not be altered, it resulted in excessively noisy data that masked any archaeological features (as is evident in Figure 5). In light of this it would be prudent to repeat the square array survey at a later date when ground conditions are much wetter.

Ground Penetrating Radar (GPR) uses an electromagnetic radar wave propagated through the soil to search for changes in soil composition and structures (Conyers and Goodman 1997, 23ff), measuring the time in nanoseconds (ns) taken for the radar wave to be sent and the reflected wave to return. The variations in the Relative Dielectric Permittivity (RDP) in different deposits produces reflections in the profile data of the survey. Lower frequency survey antennae (50Mhz or 100Mhz) are generally used for geological survey, whereas higher frequency antennae (250Mhz, 500Mhz or 800Mhz) are utilised for archaeological surveys. The technique has been applied successfully on a range of archaeological sites, in particular over substantial urban archaeological remains (Nishimura and Goodman 2000; Neubauer et al. 2002).

The GPR survey was conducted using a Sensors and Software Noggin Plus system with 500Mhz antenna and Smartcart. Data were collected along traverses spaced 0.5m apart along the x direction of each survey grid across target areas of the sites in the northern, central and southern areas of the survey. Data were processed using GPR Slice software. The different survey profiles were presented in their relative positions, and all profiles were then processed to remove background noise. A bandpass filter was applied to each profile to remove all high and low frequency readings. The presence of hyperbola in the data were utilised to produce an estimation of signal velocity through the deposits at each site, facilitating a calculation of the depth of different features across each site. Profiles were then converted into grid data and were sliced horizontally to produce a series of time slices through each survey area.

The results – Twin Probe Resistivity Survey
The results of the survey are presented below along with interpretation and discussion (Figures 3 and 4). Figure 3 displays the basic data along with a composite interpretative plot derived from this image along with the high and low-pass filtered datasets displayed in Figure 4. The survey has been successful in detecting a number of features which indicate the locations of former megaliths. These take the form of discrete very high resistance anomalies (presumably marking buried stones), moderately high responses (possibly deeply buried stones or concentrations of stone debris) and lower resistance features (most likely destruction pits). Some of these had been previously identified by Keiller (as hollows) and as broad
anomalies by the 1989 geophysical survey. A number have not previously been recorded. There are also two large (5-10m), more amorphous high resistance anomalies, along with a number of SE-NW (and perpendicularly) aligned linear features corresponding to former boundaries (some of which are clearly visible in the field as earthworks) and possible drainage features (more intermittent and running NE_SW) (Figure 3).

Although not indicated on the interpretation plot, it is interesting to note that the interior of the Southern Inner Circle seems to be more generally characterised by a higher resistance (i.e. darker) signature. The broad band of low resistance crossing the top third of the plot (on a SW-NE alignment) most likely reflects disturbance resulting from the complex sequence of medieval and post-medieval boundary ditches partially excavated by Keiller (Gillings et al. 2008: Figure 8.8) and visible in part as surviving earthworks.

![Figure 3](image)

*Figure 3 – the twin-probe resistivity results (displaying +/- 3 standard deviations) and composite interpretation (incorporating features visible in the filtered data presented in Figure 4).*

**The results – Square Array resistivity survey**

The results from the square array survey are presented in Figure 5 – please note that only full grid squares without substantial linear earthworks (that made traversing the cart impossible) were surveyed as indicated on Figure 2. With the exception of the faint traces of the main NW/SE boundary feature, the noisiness of the data makes it difficult to discern any clear archaeological features. What is interesting is that the area of the Keiller trench does appear to be visible as a markedly quieter band on the SW edge of the survey area – presumably the looser fill retaining more moisture and thus ameliorating the contact-resistance issues encountered across the remainder of the surveyed area.
Figure 4 – the data after A. High-pass filtering (to emphasise smaller amplitude anomalies) and B. Low-pass filtering (to emphasise broader trends). Data is displayed at -3/3 standard deviations.

Figure 5 – Square array resistivity data – Alpha, Beta and combined datasets
Figure 6 – Selected GPR depth-slices (surface to 1.7m)
The results – GPR survey
The time sliced GPR results (from the surface to a depth of 3.1m) are presented in full in Figure 12, with key slices depicted in Figures 6 and 8. Setting aside anomalies that only appear in a single slice and those parallel with the direction of survey (left to right) and/or grid edges, a number of linear and discrete anomalies are evident, including a number of former stone positions displaying a variety of signatures. A full interpretation is presented in Figure 7 where the level of re-inscription (over-tracing) can be read as a direct proxy for the persistence of the feature with depth. Setting aside the linear boundaries present as earthworks today and characterised by Keiller through excavation (Ucko et al 1991: Plate 52) as well as general noise adjacent to the modern village boundaries, 16 stone-related (1-16) and three other features (A-C) have been identified (Figure 7). These are discussed (in conjunction with the results of the resistivity surveys) below.

Feature A
Adjacent to a modern boundary wall at the edge of the current village, this manifested as a high-resistance spread as well as an amorphous GPR anomaly. A hollow was also recorded by Keiller in this area at the time of his excavations. This is most likely a spread of sarsen relating to medieval and/or post-medieval structural activity, though the possibility that it masks prehistoric features (or the burial/destruction of such) cannot be ruled out.

Feature B
This is the edge of Keiller’s 1939 excavation trench.

Feature C
This curious sub-circular feature was evident in the GPR data only at a depth between 0.5 and 0.9m below the present surface, and on close scrutiny appears to comprise a series of discrete, small circular anomalies (Figure 8A). Most likely prehistoric, similar concentric circular features were identified by Ucko et al in the Northern Inner Circle in their 1989 surveys (Ucko et al. 1991: Plate 67) though these curious features have yet to be ground-truthed through excavation.

Figure 7 – GPR interpretation (NB: repeat inscriptions denote anomaly persistence with depth).
**Stones 1-3, 6**  
Small buried sarsens associated with the continuation of the z-feature setting (Figure 8A).

**Stones 4-5**  
Destruction pits/debris relating to the continuation of the z-feature setting.

**Stones 7-8, 11, 13, 15**  
Substantial, deeply buried sarsens of the Southern Inner Circle (visible at depths of between 0.5 and typically 1.6m, with stone 13 reaching 2.3m) (Figure 8A).

**Stones 10 and 12**  
Probable destruction pits (low resistance) and compressed stone sockets (GPR reflection) relating stones of the Southern Inner Circle (10 and 12) and an inner stone setting between the Southern Inner Circle and z-feature (9) (Figure 8B).

**Stones 9 and 16**  
Probable destruction pits (low resistance) and compressed stone sockets (GPR reflection) relating to a pair of stones aligned on Southern Inner Circle stone 10 and z-feature stone 6.

**Stone 14**  
A spread of large chunks of sarsen, most likely packing stones, resulting from the destruction of a substantial Southern Inner Circle sarsen and subsequent removal of usable building stone.

**Stone ?**  
A possible stone position visible in the GPR data (depths 0.3 – 0.6m) but masked in part by debris relating to the modern boundary. What is interesting is that the linear boundary features appear to align/sight-upon this location. The pattern of later boundaries in this area deliberately aligning on standing stones was a phenomenon attested through excavation by Keiller (see Gillings et al. 2008: Figure 8.8).

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Figure 8 – detail of GPR depth-slices
Discussion
When we integrate the results of this survey with Keiller’s excavation data, a more complete picture of prehistoric activity in the area of the Southern Inner Circle emerges (Figure 9).

The value of soil resistance survey in the investigation of the Avebury landscape has once again been confirmed (see also Ucko et al. 1991 and Gillings et al. 2008) as has the considerable potential of GPR. The latter, in particular, has proven invaluable in detecting and characterising the signatures left by former megaliths, which in turn is helping to better understand the complex inner settings of the monument (Figure 10).

As can be seen, the obelisk lies at the approximate centre of a square setting of standing stones, adding significant weight to Smith’s insightful conjecture. Rather than a proper circle, the Southern Inner Circle itself appears to be distorted (as are both the Northern Inner Circle and Outer Circle of stones) - in this case flattened on its eastern side. There is also the strong suggestion of a pair of radiating lines of standing stones aligned upon stone xii of the z-feature (excavated by Keiller) which in turn point to either phasing and/or unexpected levels of complexity in the arrangement of megalithic settings (Figure 11).

The survey results provide a strong indication that the inner settings of the Southern Inner Circle do in fact form a rectilinear setting with both the Obelisk and the putative early Neolithic house-like structure set along its axis. Smith’s conjecture that the setting might resemble a long barrow, though, obviously, without mound (1965, 251), starts to take on more credibility. With a better sense of the detail of chronology, we are now aware of a greater temporal gap between long barrows and the main (mid 3rd millennium BC) phase of megalithic settings at Avebury; at first sight implying that if the setting does reference long barrow architecture it is representational of something archaic. However, we do not know the date of the inner settings. On the one hand, the Peterborough sherds recovered from the stone holes of I, iv, viii and ix - presumably residual (Smith 1965, 226), but given its fragility not necessarily by a long interval - might suggest a latest 4th or early 3rd millennium BC date is possible. On the other, the primary Peterborough Ware associations and late 4th millennium BC dates for the nearby Millbarrow, which incorporates peristalith architecture (Whittle 1994), likewise narrows down the temporal gap - both late long barrows and the inner settings may be working from a concurrent architectural tradition. Only further dating, likely from material recovered through further, targeted, excavation can resolve this. In her symbolic ‘long barrow model’, Smith considered the Obelisk to be a substitute for a burial deposit (1965, 251). Perhaps, given its proximal position, it might be better to see the house-like structure occupying that role; reaffirming a conceptual linkage between houses and long barrows, built around the reproduction of rights, resource and lineage, long acknowledged (e.g. Thomas 2013).
Figure 9 – Excavated and surveyed features of the Southern Inner Circle. Image incorporates data ©Crown Copyright/database right 2012. An Ordnance Survey/EDINA supplied service.

Figure 10 – the configuration of megalithic settings within the Southern Inner Circle. Image incorporates data ©Crown Copyright/database right 2012. An Ordnance Survey/EDINA supplied service.
Conclusion

The two-days of survey carried out have been remarkably successful, not only confirming the broad resistance anomalies detected in 1989, but adding considerable interpretative detail to their characterisation. They have also revealed wholly unexpected stone settings and features in the interior which in turn allow us to tender the first full reconstruction of at least one phase of the enigmatic z-feature setting and part of the Southern Inner Circle.

From a management perspective, until now the precise location of the 1939 Keiller trenches has been impossible to verify, as the reference pegs used in the 1939 excavation no longer exist and boundary changes (albeit subtle) have been enough to introduce potential errors of the order of metres. In this respect, the ability of both surveys (but particularly the GPR in the 0.5-0.8m depth range) to precisely locate the edges of the Keiller excavation trenches, should not be under-estimated, and full GPR survey of the quadrant should be a priority in order to fully map his interventions.

Having identified a number of features of interest in the area the next stage will be to further ground-truth the results through excavation in order to: identify (and where possible date) the stone sockets associated with each megalith; date and characterise the episodes of sarsen burial and destruction attested; search for further features that fall below the detection limits of the surveys carried out (e.g. the stakeholes and very shallow gulleys associated with the settings of the kind encountered by Keiller). Further geophysical survey is also needed – not least GPR of the entire quadrant and more precise data collection and 3D modelling to better characterise the morphometry and volume of each of the buried stones. Given the uncertainties surrounding the Northern Inner Circle and Cove settings (Gillings and Pollard 2004) this should also be a priority area for Resistance and GPR survey of this kind.
Figure 12 – GPR depth slices from surface to 3.1m
Acknowledgements
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Bibliography


Appendix 1

Section 42 Technical Detail Questionnaire
Historic England Geophysical Survey Summary Questionnaire

Survey Details

Name of Site: Avebury

County: Wiltshire

NGR Grid Reference (Centre of survey to nearest 100m): SU 1072 6868

Start Date: 18/4/17  End Date: 20/4/17

Geology at site (Drift and Solid):

Solid (bedrock) HOLYWELL NODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)

No Drift recorded at this location

Known archaeological Sites/Monuments covered by the survey
(Scheduled Monument No. or National Archaeological Record No. if known)

Avebury Henge, Southern Inner Circle. Scheduled Monument 28130; MWI14282

Archaeological Sites/Monument types detected by survey
(Type and Period if known. "?" where any doubt).

Former megalithic settings (late Neolithic)
Possible pit/post circle (late Neolithic-early Bronze Age)
Buried former megaliths (medieval to post-medieval)
Destroyed former megaliths (post-medieval)
Field boundaries (medieval to post-medieval)

Surveyor (Organisation, if applicable, otherwise individual responsible for the survey):

Dr. Mark Gillings (University of Leicester)

Name of Client, if any:

None
Purpose of Survey:
To establish/clarify the structural detail of the unexcavated SE quadrant of the Southern Inner Circle of Avebury (complementing the excavated evidence revealed by Keiller in 1939).

Location of:

a) Primary archive, i.e. raw data, electronic archive etc:
Dr. Mark Gillings, School of Archaeology & Ancient History, University of Leicester

b) Full Report:
Copies of the full report have been deposited with: the HER; Historic England and the National Trust (Alexander Keiller Museum, Avebury).
Technical Details

(Please fill out a separate sheet for each survey technique used)

Type of Survey (Use term from attached list or specify other): Resistivity

Area Surveyed, if applicable (In hectares to one decimal place): 0.5ha

Traverse Separation, if regular: 0.5m Reading/Sample Interval: 1.0m

Type, Make and model of Instrumentation: Geoscan RM85

For Resistivity Survey:

    Probe configuration: (Multiplexed twin)

    Probe Spacing: 0.5m

Land use at the time of the survey (Use term/terms from the attached list or specify other):

    Grassland - Pasture
**Technical Details**

*(Please fill out a separate sheet for each survey technique used)*

**Type of Survey** (Use term from attached list or specify other): Resistivity

**Area Surveyed, if applicable** (In hectares to one decimal place): 0.5ha

**Traverse Separation, if regular**: 1.0m  **Reading/Sample Interval**: 0.25m

**Type, Make and model of Instrumentation**: Geoscan RM85 & MSP25

**For Resistivity Survey**:

  **Probe configuration**: Square

  **Probe Spacing**: 0.75m

**Land use at the time of the survey** (Use term/terms from the attached list or specify other):

Grassland - pasture
Technical Details

(Please fill out a separate sheet for each survey technique used)

Type of Survey (Use term from attached list or specify other): Ground Penetrating Radar

Area Surveyed, if applicable (In hectares to one decimal place): 0.5ha

Traverse Separation, if regular: 0.5m  Reading/Sample Interval: 0.05m

Type, Make and model of Instrumentation: Noggin Plus 500 Mhz Antenna and Smartcart

For Resistivity Survey:

Probe configuration:

Probe Spacing:

Land use at the time of the survey (Use term/terms from the attached list or specify other):

Grassland - pasture

Additional Remarks (Please mention any other technical aspects of the survey that have not been covered by the above questions such as sampling strategy, non standard technique, problems with equipment etc.):
List of terms for Survey Type

Magnetometer (includes gradiometer)
Resistivity
Resistivity Profile
Magnetic Susceptibility
Electro-Magnetic Survey
Ground Penetrating Radar
Other (please specify)
List of terms for Land Use:

Arable
Grassland - Pasture
Grassland - Undifferentiated
Heathland
Moorland
Coastland - Inter-Tidal
Coastland - Above High Water
Allotment
Archaeological Excavation
Garden
Lawn
Orchard
Park
Playing Field
Built-Over
Churchyard
Waste Ground
Woodland
Other (please specify)