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A Geophysical Survey at Dún Ailinne, County Kildare, Ireland

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Dún Ailinne, in County Kildare, was an important center of ceremonial and ritual activity in the Irish Iron Age (600 B.C.–A.D. 400). The site is located on a hill and is surrounded by an earthen bank and ditch. Excavation of the summit 35 years ago revealed a series of timber structures that were arguably the focus of the site's Iron Age use. This early research examined only ca. 10% of the site's interior; so from 2006 to 2008 a new program of research employed a targeted topographic survey and a magnetometer survey to determine if there was evidence of additional features inside the bank and ditch, or whether the rest of the site beyond the summit was empty. The results show that the area outside of the excavated summit was characterized by many and varied features of archaeological interest, including additional enclosures and likely structures of the Iron Age and both earlier and later periods. These data allow us to better understand the use of Dún Ailinne during its Iron Age florescence and provide us with directions for future archaeological research.

Introduction

The site of Dún Ailinne, County Kildare, Ireland, is enclosed by an earthen bank and ditch and located on the top of Knockaulin Hill (FIG. 1). It is one of the major sites of the Irish Iron Age (ca. 600 B.C.–A.D. 400). In documentary sources of the Early Christian period (A.D. 400–800), Dún Ailinne is consistently grouped with three other sites (Tara, County Meath; Navan Fort, County Armagh; and Rathcroghan, County Roscommon) (FIG. 1) as significant pre-Christian social and political centers (Grabowski 1990; Hicks 2007). Together, these four sites have become known conventionally as the “royal sites” of the Irish Iron Age, since early historical documents peopled them with semi-legendary kings. The use of the term royal site is retained here despite the fact that “royal” conjures an inaccurate image of the social reality during that period.

Recent geophysical research and excavation (Newman 1997; Lynn 1997; Johnston and Wailes 2007; Barton and Fenwick 2005) demonstrated that the historical sources, while misinterpreting the social context of the royal sites,

were correct in recognizing them as a coherent group. The sites differ in significant ways, however. They share a set of features, including a hilltop location in a landscape of ritual sites from all prehistoric periods, an outer bank with an internal ditch surrounding the site, and the presence of timber structures including both circular and figure-of-eight shapes within the bank and ditch enclosure. Among their differences, Navan and Tara both have central mounds, which Dún Ailinne lacks, Tara incorporates an earlier burial in its enclosure, Navan has the extraordinary 40 m-long structure, and all differ in size and internal organization. Nevertheless, the shared characteristics would have allowed an ancient observer to know that they were in a royal site; the differences presumably reflected regional and local preferences for the structuring of space and associated behaviors (Johnston 2006). As research continues (Waddell, Fenwick, and Barton 2009), interpretations of the royal sites become more sophisticated, contributing to our understanding of ceremonial life in the Irish Iron Age.

Along with the excavations at Navan and Tara (Lynn 1997; O'Sullivan 2005; Grogan 2009), Bernard Wailes'



Figure 1. Map showing the location of Dún Ailinne. The Irish Ordnance Survey Grid Reference for Dún Ailinne is N818078 and the Irish National Grid is E282030, N207880. The other three royal sites are also indicated for reference.

excavations at Dún Ailinne from 1968 to 1975 (Johnston and Wailes 2007) provided important information for our understanding of royal sites. Although activity on the hill began in the Neolithic, during the third millennium B.C., and continued into the Bronze Age, Dún Ailinne's major florescence is represented by large ceremonial structures that probably date to the early centuries A.D. Iron Age use of the site culminated in a period characterized by large-scale ceremonial feasting (Crabtree 2007). While some of these sites, most notably Tara, retained significance (particularly in the political realm), others, like Dún Ailinne, were largely eclipsed as ceremonial and ritual centers after the arrival of Christianity in Ireland in the 5th century A.D.

While the earlier excavations at Dún Ailinne provide evidence for site use, they were concentrated primarily on the summit of the hill. A large area was excavated; but the site covers some 13 ha, and only about 10% of the site inside the bank and ditch was tested. This raises a series of questions about how the rest of the site was used: are there

other structures, and if so, what kinds were they and where were they located; or was it left open, perhaps to facilitate large gatherings or for other ritual reasons; and how is it similar to and different from the other royal sites? In order to address these questions, we undertook a geophysical and topographic survey of the interior of the site. This project included both remote sensing (resistivity and magnetometry) and a targeted topographic survey of several areas within the bank and ditch.

Geology, Geomorphology, and Topography

The site of Dún Ailinne lies on a prominent hill just south of Kilcullen, County Kildare (FIG. 2). The hill is steep, rising to a height of 180 masl, and the bank and ditch surrounding the site are arranged somewhat off-center, extending more towards the north than the south (FIG. 3). The hill commands panoramic views of the surrounding landscape, including the central lowlands to the south and west and the flat pasturelands of the Curragh to the NW. The River Liffey Basin/Dublin Bay area is clearly visible to the north, while the eastern horizon is dominated by the granite uplands of the Wicklow Mountains. With the exception of several low, rounded hills, such as those at Old Kilcullen (179 masl, 1.5 km to the south) and Carrighill Upper (166 masl, 2.5 km to the sw), the surrounding countryside is characterized by a relatively flat to undulating topography.

Geologically, the hill is composed of slate and graywacke bedrock that lies oblique to the surface, running ENE–WSW, and that frequently outcrops in roughly parallel ridges. Its hardness varies; in some places it is very hard, while in others it is quite soft and friable. This stone was quarried in the past, as shown by numerous quarry holes and ditches of various sizes on the inside edge of the enclosure ditch. A sheet of glacial till lies over the bedrock, and is 1 m or more deep between the ridges of bedrock, but thin or nonexistent where the bedrock ridges occur. As is commonly the case, the glacial till contains fragments of diverse geological origin (including Antrim flint) and varies considerably in texture; in most places it is more like gravel but in others it is fine and sandy (Johnston and Wailes 2007: 6). While specific effects of this geology have not been established, it is possible that some of the magnetic anomalies detected in the geophysical survey are the result of the varied constituent elements of the underlying rock, as well as its proximity to the surface.

After the site was abandoned as a ceremonial center, the hill was used for agricultural purposes during different time periods. Both the topographic and magnetometer surveys described below provide evidence that the site was plowed on multiple occasions, and the field boundaries vis-



Figure 2. Dún Ailinne, looking nw. The bank and ditch surrounding the site are marked by the first dark line of vegetation coming down from the summit of the hill. Photograph by S. A. Johnston.

ible in earlier aerial photos of the site attest to previous agricultural fields. Since the 1950s the site has been under improved grassland and most of it is cleared. The exception is an area to the sw, where dense gorse reappeared after some earlier clearance. The hill is now used as pasture for both cattle and sheep.

The landscape around Dún Ailinne contains numerous ritual sites, some visible from the hill itself. In a recent survey of the Curragh, the flat open plain that lies to the nw, Clancy (2006) identified 179 of these ritual sites, the vast majority of them burial mounds probably representing various prehistoric and historic periods. The lack of dating for many of these sites makes it difficult to determine the sequence of land use in this area. It is likely that some of these ritual monuments influenced the locations of others.

Summary of the 1968–1975 Excavations

There are few surface indications of the prehistoric use of Dún Ailinne (FIG. 4). The site is enclosed by a large bank

with a ditch adjacent to its interior side. Such an arrangement is referred to as “hengiform,” since it resembles the henge monuments (large ceremonial enclosures with varying internal arrangements of structures) of the Neolithic and early Bronze Age (Hicks 1975; Stout 1991) rather than the typical arrangement of later hillforts (Raftery 1994). The original entrance through the bank and ditch is on the east. Within this enclosure, there are two surface features. The first is an arc-shaped embankment on the summit whose age and function could not be determined, but is certainly post-Iron Age based on excavation. The other is a rocky depression in the northern part of the hill that was apparently enlarged sometime in the past. It is known as St. John’s Well, presumably because it retains water when it rains or because there is (or was) an underground spring there (although this has not been determined).

Excavations on the summit of the hill were initiated in 1968 (see Johnston and Wailes 2007 for a detailed analysis of the excavations). They revealed that, while intensive



Figure 3. Aerial photograph of Dún Ailinne, looking sw, taken in 2007. Photograph courtesy of Frank Coyne, Aegis Archaeology Ltd.

use of Dún Ailinne occurred during the Iron Age, there was activity on the hill beginning in the Neolithic. Remains dating to the first half of the third millennium B.C. consisted of a single disturbed burial (Feature 293) and scattered lithic and ceramic artifacts, as well as a circular ditch that probably dates to this period. Evidence from the Bronze Age, perhaps a thousand years later, was ephemeral: a single ceramic vessel, the sole survivor of a disturbed burial (Feature 2790), was the only definite Bronze Age artifact, though some of the other artifacts, including lithics, beads, and metal jewelry could also belong to the Bronze Age.

In contrast, the evidence from the Iron Age was substantial. A sequence of at least three circular timber complexes was built on the summit of the hill, each representing a separate phase (FIG. 5). Using the labeling conventions of the original excavator, these were designated by colors (see Johnston and Wailes 2007: 6 for an explanation of this system). The first major structure, the smallest and simplest of the three, was the White phase. It comprised a single circular palisade trench 23 m in diameter with a fea-

ture at the center composed of two opposed arcs of post-holes. This was succeeded by the Rose phase, a more complex undertaking. The Rose phase structure had a figure-of-eight shape, with a smaller enclosure (21 m maximum diameter) adjacent to the southern perimeter of a larger enclosure (38 m maximum diameter), both marked by multiple concentric timber palisades. The entrance to the latter was elaborated by the construction of a funnel-shaped timber palisade that narrowed as it approached the larger circle. The final and most elaborate of the three complexes was the Mauve phase. This comprised a series of concentric circular structures. The outermost was a double palisade (43 m maximum diameter), with an entrance to the NE. Within this was an open timber circle (20 m diameter) made of 30 large posts surrounding a smaller circular feature (6 m diameter). This last small circular feature had no apparent entrance, the timber palisade that marked it being continuous. The final phase of Iron Age use, as noted above, mostly consisted of faunal remains that showed evidence of butchering and roasting. These were interpreted as evidence of large-scale feasting (Crabtree 2007).

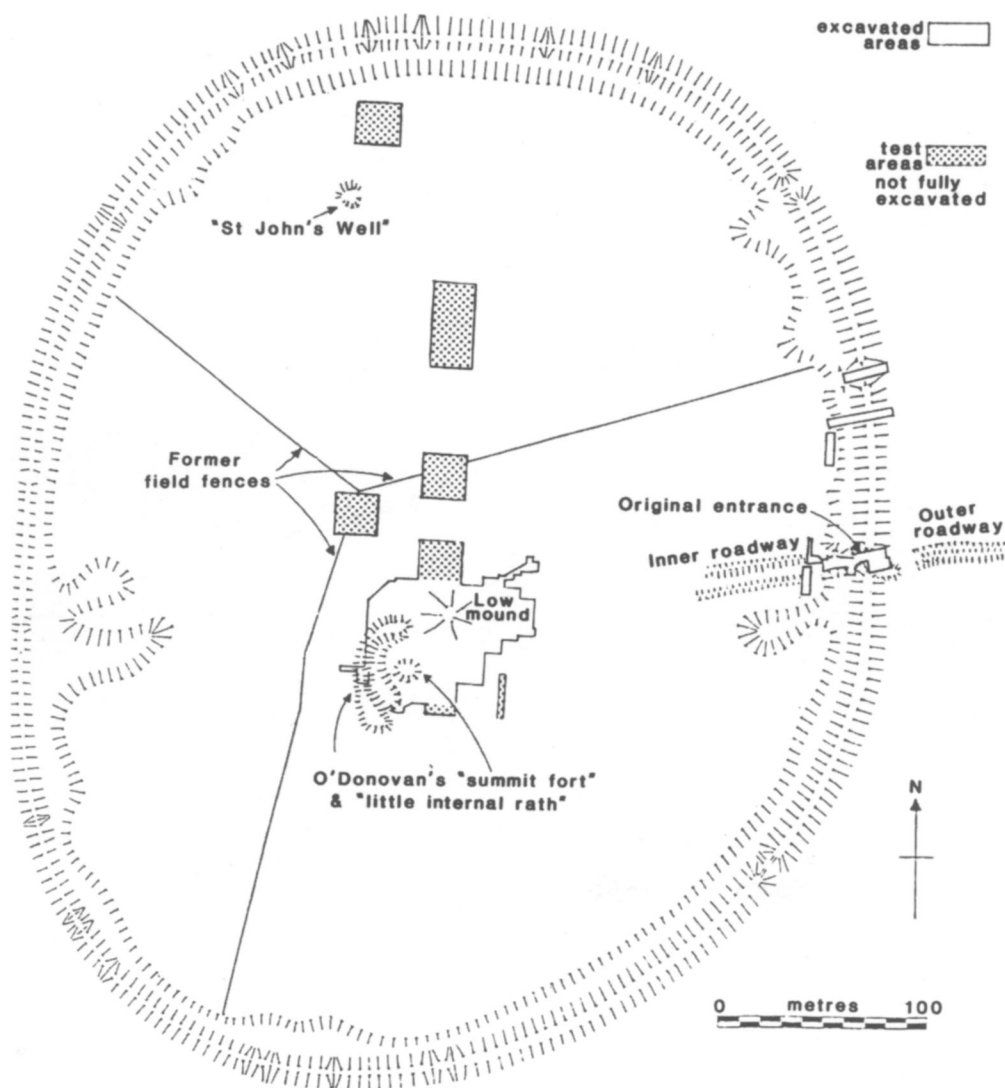


Figure 4. Site plan of Dún Ailinne from the 1968–1975 excavations showing the areas excavated. The outlined area in the center is the summit of the hill, and a detail of this is shown in Figure 5. Adapted from Johnston and Wailes 2007, fig. 1-1.

The timber structures were probably used for ritual or ceremonial purposes rather than residential ones. They are generally too large to have been roofed without internal support, for which there is no evidence, nor is there evidence of hearths or other features typical of domestic use. While there is animal bone, it is almost exclusively confined to the final phase of Iron Age use and not associated with any of the previous timber structures that appear to have been dismantled before the animal bone was deposited. Thus, the lack of domestic debris or features associated with these structures, suggests that they are ritual or ceremonial in nature.

Structural evidence from the Iron Age was extensive,

but the quantity of artifacts from the period was surprisingly small. Most artifacts typical of the Irish Iron Age were represented (e.g., glass beads and bracelets, bronze rings and brooches, and iron weapons), but there were few examples of each. Of note are two largely intact bronze fibulae, a bone ornament (possibly a pin head), an iron spearhead, and a sword. Overall, the recovered artifacts suggest the objects were brought to and/or worn at the ceremonial gatherings that arguably characterized Iron Age Dún Ailinne. In addition, a number of artifacts (e.g., slag, worked bone fragments, and possibly waste glass) indicate low-level manufacturing, possibly associated with the larger ceremonies.

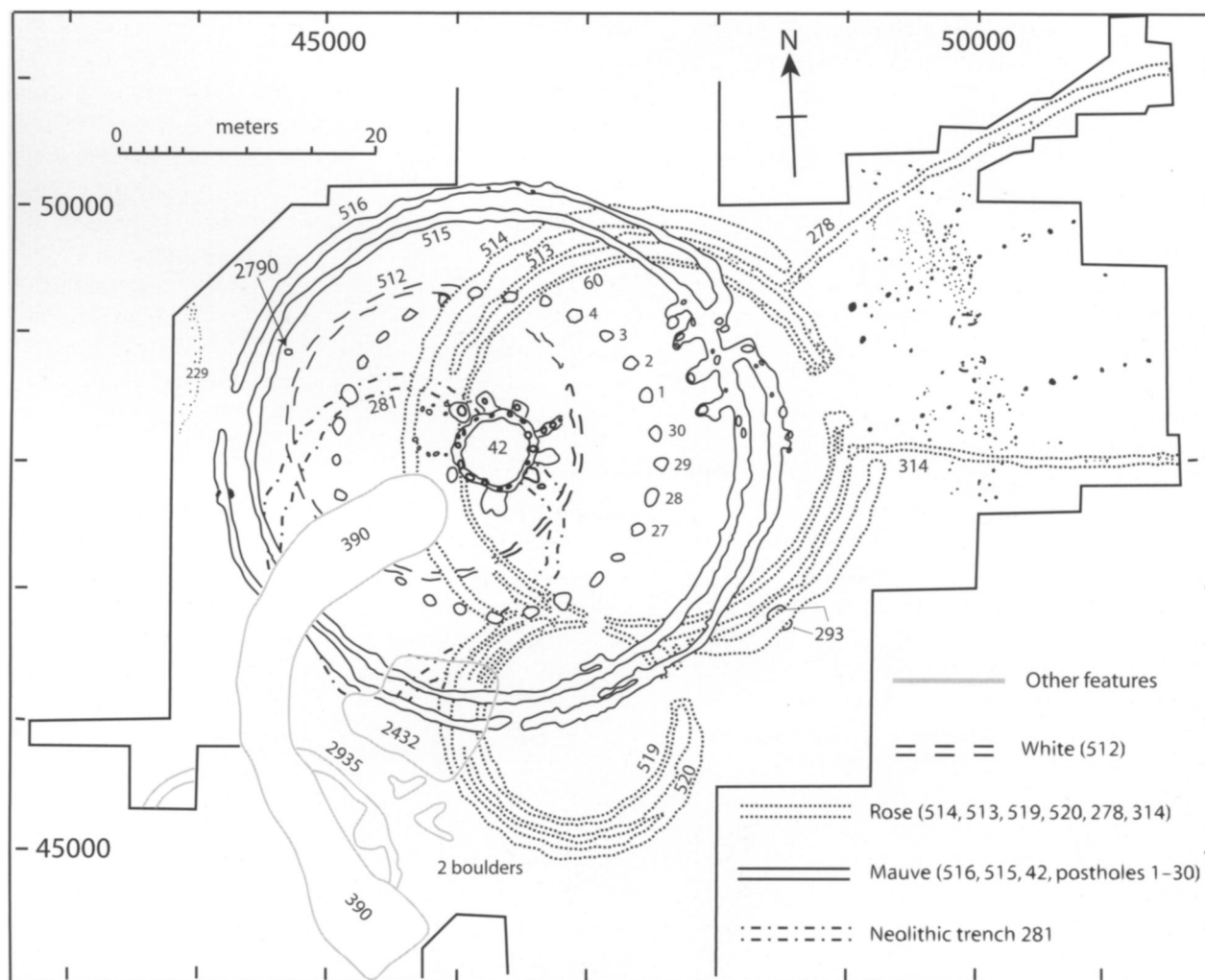


Figure 5. The main excavated area on the summit of the hill showing the major features by phase. This is the outlined area indicated in Figure 4. Adapted from Johnston and Wailes 2007, fig. 2-1.

The Survey

The excavations permitted the interpretation of the Iron Age use of Dún Ailinne, although they were confined to a limited area within the bank and ditch on the summit of the hill. This meant that some features could not be fully defined (e.g., the extent of the funnel entrance to the Rose phase structure), and limited information was available about the remainder of the site. A magnetometer survey over the interior was carried out in 1968 (Ralph 1968), but no anomalies of particular interest apart from generalized areas of burning were identified (Johnston and Wailes 2007: 4). It is not entirely clear why this was so, given the wealth of features identified some 40 years later, but it may have to do with aspects of geophysical research of that time period.

In order to expand our understanding of activity at Dún Ailinne beyond the earlier excavated area, we initiated a geophysical and topographic survey of the site's interior over three seasons, from 2006 to 2008. The survey grid was set out with a total station using a previously established control network consisting of four temporary survey stations, and is based on 20 m multiples of the Irish National Grid. The primary focus was a magnetometer survey of the 13 ha within the bank and ditch. With the exception of two areas in the sw of the site (about 1.5 ha in total) that were covered in thick gorse, the entire area inside the bank and ditch was surveyed, as well as an area just outside the site's original entrance. In the first season, we also conducted a resistivity survey over a small area on the summit, but the results, while interesting, did not warrant further use of this technique given its time consuming and expen-

sive nature. Finally, we conducted a targeted topographic survey in three interior places and across the bank and ditch in four locations.

The topographic survey was conducted using a Topcon GTS-235W total station in conjunction with a TDS-Recon data collector with TDS Survey Pro software. All data were transferred to Excel spreadsheets and analyzed using Surfer 8 software to produce a variety of graphic representations. The accuracy of the measurements depends on both the instrument and the precision of its operators. The instrument documentation registers 2 mm accuracy but under actual conditions it is more likely to be within 1–2 cm horizontally and vertically. This approach produced data that could be presented in several different formats depending on the specific conditions for each area, and that could also be combined with the data from the magnetometer survey.

The magnetometer survey was conducted using two Geoscan FM36 fluxgate gradiometers. Measurements were recorded at 0.5 m intervals moving south to north along parallel traverses spaced 0.5 m apart within a grid composed of 20 × 10 m survey panels. The survey of the interior had maximum dimensions of 440 m N–S × 356 m E–W, and encompassed a total area of approximately 11.5 ha. In addition, a small, subrectangular area (maximum dimensions 100 m N–S × 63 m E–W) just outside the original enclosure entrance was investigated. Data collected during the survey were downloaded and processed using Geoplot software. The survey panels have been corrected for drift and edge-matched, and excessively high readings were eliminated from the combined data to reduce the effect of spuriously high magnetic anomalies (“spikes”) due to ferrous litter, etc., in an attempt to highlight weaker anomalies of potential archaeological significance.

Topographic Survey Results

The topographic survey provided significant data on the profile of the bank and ditch and on the general surface characteristics in those areas where it was employed. For example, on the summit it revealed evidence of later historical agricultural use of the site in the form of “ridge and furrow” marks, a series of undulating, parallel ridges that represent the last phase of plowing at the site (FIG. 6). These could date anywhere from the medieval period to the 19th century, though the close spacing suggests they are post-medieval. Two other results are also notable. During the excavations, a depression was observed as a surface feature that ran from the site entrance straight up the hill towards the summit for about 70 m (Johnston and Wailes 2007: 28–29). This was dubbed the “inner roadway” to distinguish it from a second, more sinuous, shorter, and shallower depression that extended from outside the en-

trance down the hill for about 40 m (the “outer roadway”). The surface indications of the inner roadway petered out well before it reached the summit area that had been excavated earlier and it was uncertain how the roadway related to the series of timber structures subsequently identified. The topographic survey was initiated to trace the surface indications of this roadway nearer to the summit. Second, we wanted to get a precise topographic image of St. John’s Well. It was not investigated in the earlier excavations, but since wet places were often given ritual significance during the Iron Age in Ireland (Raftery 1994; Cooney and Grogan 1999), we attempted to obtain data on the feature as a precursor to future investigations.

Inner Roadway

The area over the inner roadway was surveyed as a series of parallel transects perpendicular to the length of the road. Readings along each transect were taken at 50 cm intervals, with a spacing of 1 m between transects at the east end of the road, increased to 5 m near the central portion, and reduced to 2 m intervals at the western end. Cross sections of the roadway generated by the survey indicate that, while shallow and indistinct, there is a measurable depression as the roadway nears the summit, a subtle feature almost invisible to the naked eye. Figure 7 (top) shows a topographic image of the roadway superimposed on the data from the magnetometer survey. The roadway runs straight up from the site entrance through the apparent entrance to the summit enclosure (FIG. 7, bottom). This was not obvious because the depression in the ground is not visible along its entire length and there is no surface indication of the summit enclosure or its apparent entrance. Thus, the survey has confirmed the projected path of the roadway.

St. John’s Well

St. John’s Well has potential significance in the context of known Iron Age ritual activity in Ireland and elsewhere in Britain and Europe. A major focus of ritual life was the deposition of objects (most commonly metal, e.g., weapons, jewelry, and harness fittings, though other, more perishable objects may also have been included) in watery places such as lakes, rivers, and bogs (Raftery 1994; Cooney and Grogan 1999). There is no evidence to indicate when St. John’s Well was enlarged, yet an Iron Age date is a viable hypothesis since this was the period when the hill received the most attention in prehistory. The well was surveyed over an approximately 12 × 12 m grid, with readings taken at 50 cm intervals, and at closer intervals in areas with highly variable topographic relief. Topographic and surface maps were produced by interpolating data to 10 cm intervals using the Surfer kriging algorithm.

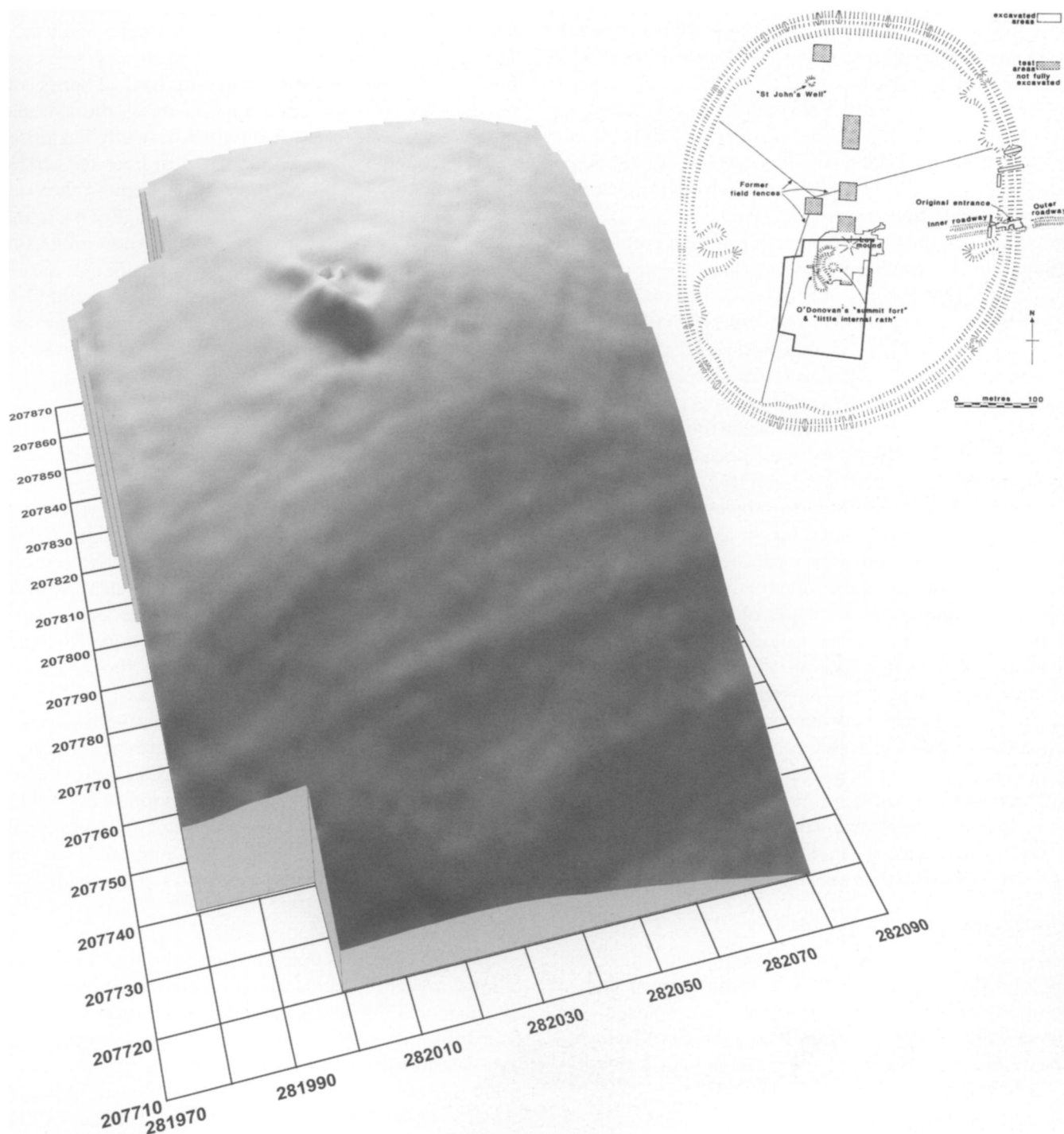


Figure 6. Surface topographic image of the summit of the hill. The inset shows the location of the surveyed area relative to the site plan. The semicircular mound corresponds with O'Donovan's summit fort in the site plan in Figure 4. The remains of ridge-and-furrow plowing are clearly visible as undulating ridges south of the mound, running approximately NNE–SSW across the area. Grid references are provided to indicate the area's location relative to the Irish National Grid.

The surface image (FIG. 8, left) shows the asymmetric shape of the well's interior surface. It is roughly square, and

three sides of it are fairly steep or near vertical. The fourth side, to the NW, slopes more, apparently the result of waste

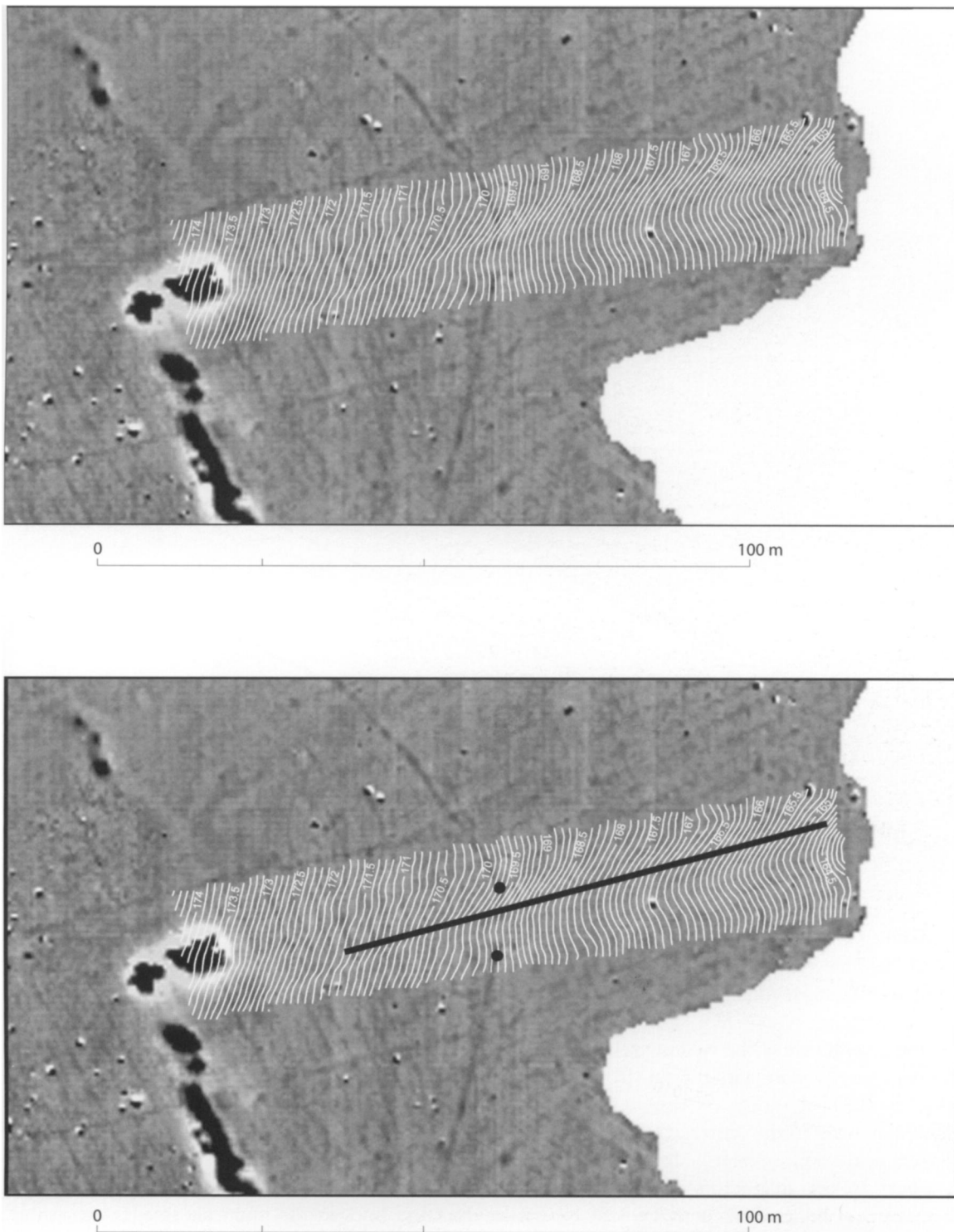
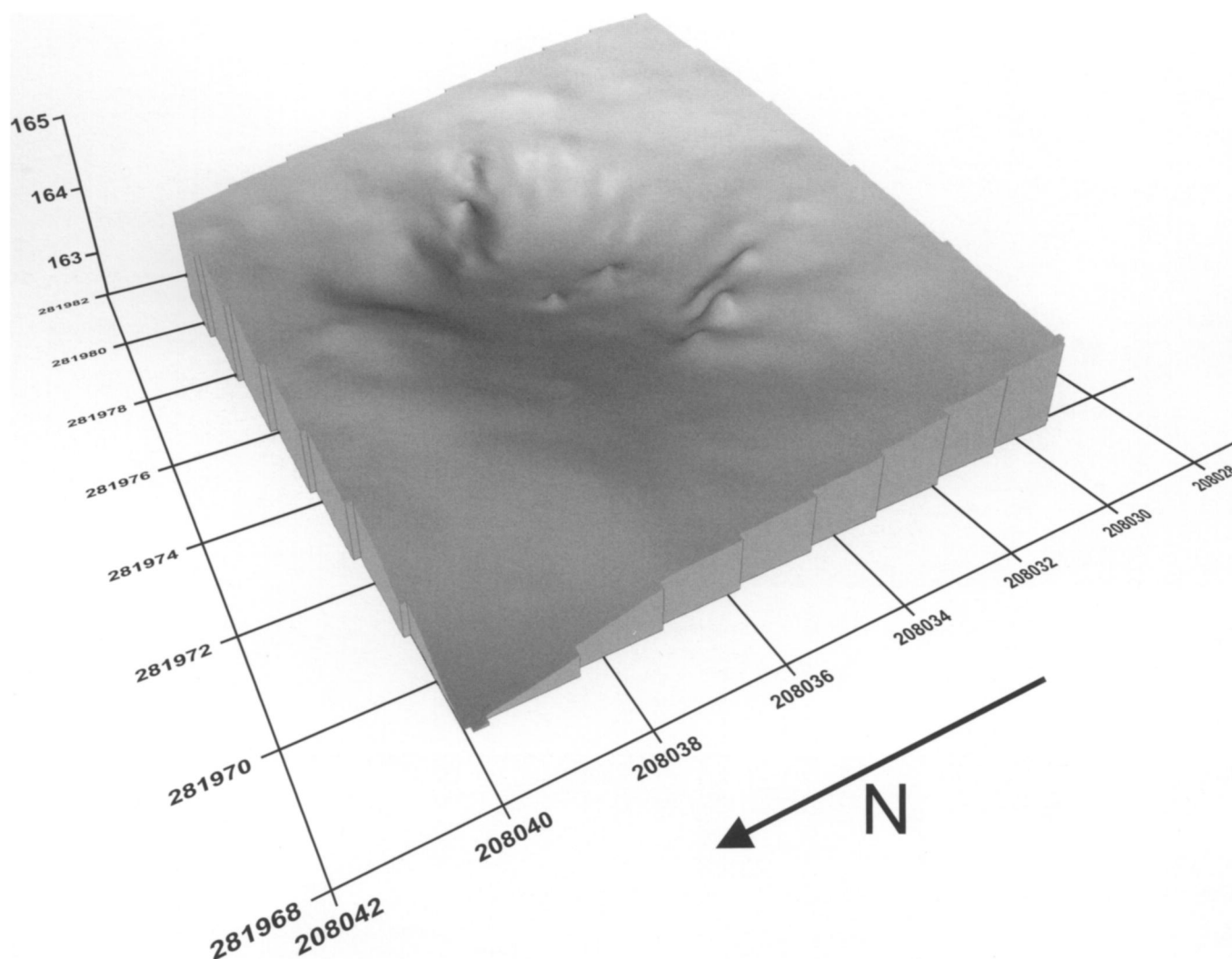


Figure 7. Topographic image of the inner roadway superimposed on the magnetometer image. Unlabeled image (top); and image with the entrance to the summit enclosure marked with black dots and the center line of the roadway indicated by a black line (bottom).

material deposited during the widening of the original geological feature. Large projections visible on the surface are

rock outcrops, emerging from the grassy surface on the sides and at the top of the well. The orientation of the well



corresponds with a possible gap in the summit enclosure as shown in Figures 9 and 10. The well is marked with a circle in Figure 10, and its southeastern edge is approximately parallel with the enclosure gap.

Owing to the possible importance of the well in prehistory, the well surface image was overlain with the data from the magnetometer survey (FIG. 8, right). As this image shows, there is one anomaly lying in the center of the well and a second one adjacent to the southwestern edge. These anomalies do not appear in the magnetometer image shown in Figure 8 (this page) because of the large scale necessary to encompass the whole site. With the topographic survey, however, we were able to focus on the well and examine it in more detail for the placement of magnetic anomalies. The anomaly positioned inside the interior surface of the well is of particular interest. Its significance is uncertain; it may be a pit, either natural or artificial, possibly containing artifacts or other deposits, or it

may reflect some other human activity associated with the well. If so, some connection with the Iron Age is possible. It may also be that the bedrock beneath the surface at the bottom of the well is registering as a magnetic anomaly as a result of the constituent elements of the rock. Without further research it is impossible to know.

Magnetometer Survey Results

Figure 9 shows the magnetometer data for the interior of the site. A large number of features (indicated by the darker dots and lines in the grayscale image) are visible, demonstrating that the interior of the site was indeed used heavily. Interpreting a magnetometer image is like a combination of data analysis and a Rorschach test, and many of the features are uncertain. Figure 10 outlines those discussed in the text. One that clearly stands out is the dark, discontinuous band of very strong magnetic anomalies (Feature 19; FIG. 10) running ESE–NNW (at one end it ap-

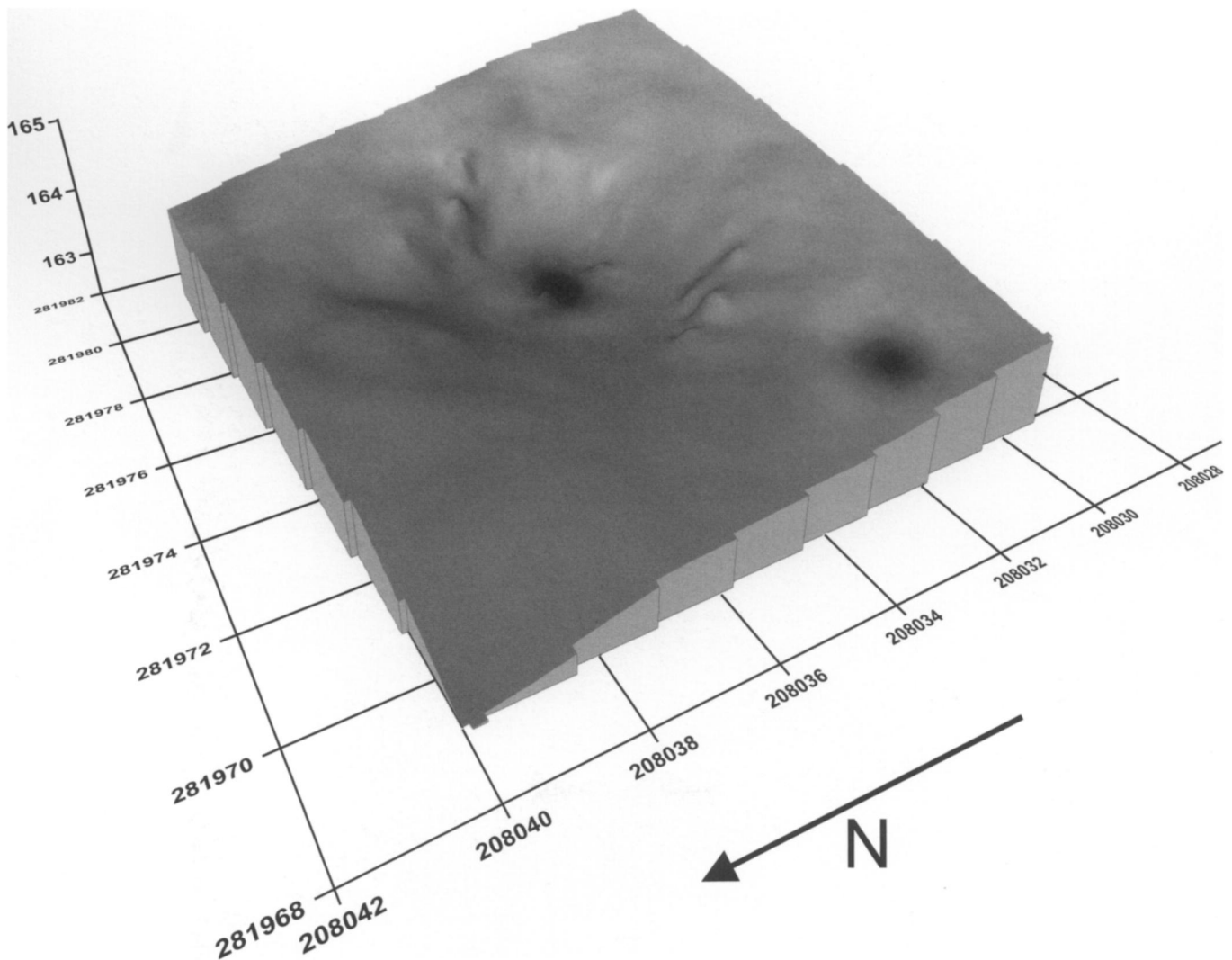


Figure 8. Surface plots of St. John's Well (left) and St. John's Well overlain with the magnetometer data (right). The dark areas (center and adjacent to sw edge) indicate magnetic anomalies. Grid references are provided to indicate the feature's location relative to the Irish National Grid.

appears as a large, inverted L shape). It is possible that this band, and in particular the L-shaped anomaly, are of archaeological interest, but their general orientation and extent suggest that they are geological and may relate to an igneous intrusion or seam in the underlying bedrock. A number of other features are also well delineated and of clear archaeological significance. Below, we discuss the most important features.

More Recent Historical Features

Linear striations over the surface of the site are one of the more striking aspects of this image (FIG. 9). These are the remains of plowing, probably dating to the post-medieval period. The overall ridge and furrow pattern indi-

cated by magnetometry is aligned in various directions in different parts of the site, forming a crisscross pattern in some areas. The overlapping pattern suggests multiple phases of plowing, perhaps a result of changing field alignments in different periods. The topographic survey mirrors the magnetometry data for the most recent ridge and furrow, but the earlier, underlying pattern situated at different angles may suggest that a long period of time passed between the different phases of plowing. Further indication of agricultural use lies in the field boundaries (Features 1–4), three of which converge just nw of the center of the site. These three appear on the Irish Ordnance Survey maps of the 19th and early 20th centuries, and so date at least to this period and possibly earlier.

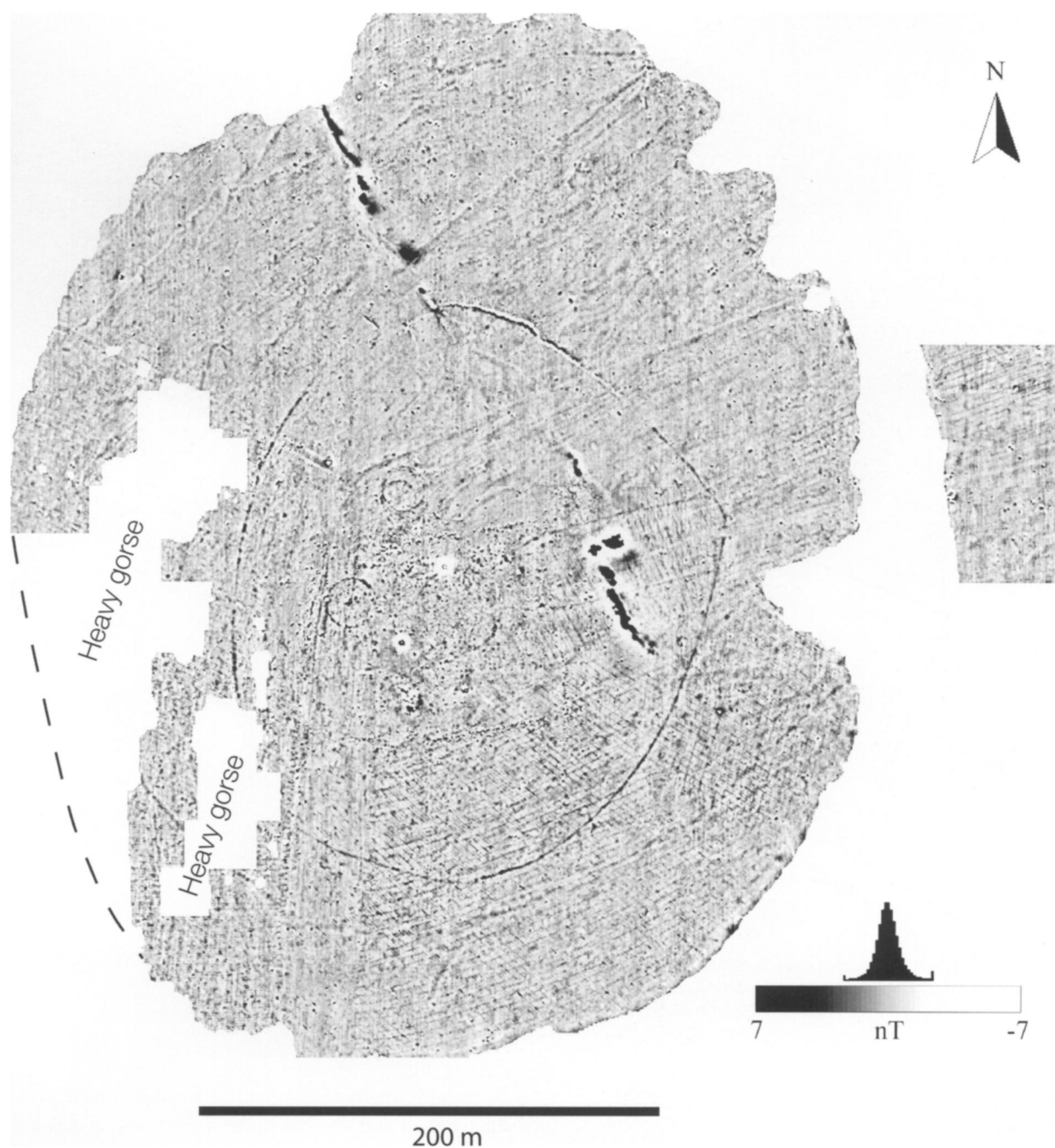


Figure 9. Grayscale image of the 2006–2008 gradiometry survey of the interior of Dún Ailinne. Magnetic anomalies are indicated by darker (positive) or lighter (negative) color.

Iron Age Features

While the dates of many of the features are unknown, several can be assigned to the Iron Age. One of these is the series of arcs in the center of the site (collectively designated Feature 5), representing the palisade trenches of the Rose and Mauve phase timber structures discovered in the

earlier excavations, and dating to the Iron Age (Johnston and Wailes 2007). Another is the subcircular enclosure that rings the summit of the hill (Feature 6). It appears as a narrow band of positive magnetic readings 0.5–1 m in width and is quite large, with maximum overall dimensions of approximately 240 m N–S × 200 m E–W. Given its width and the fact that the excavated Iron Age trenches held timber

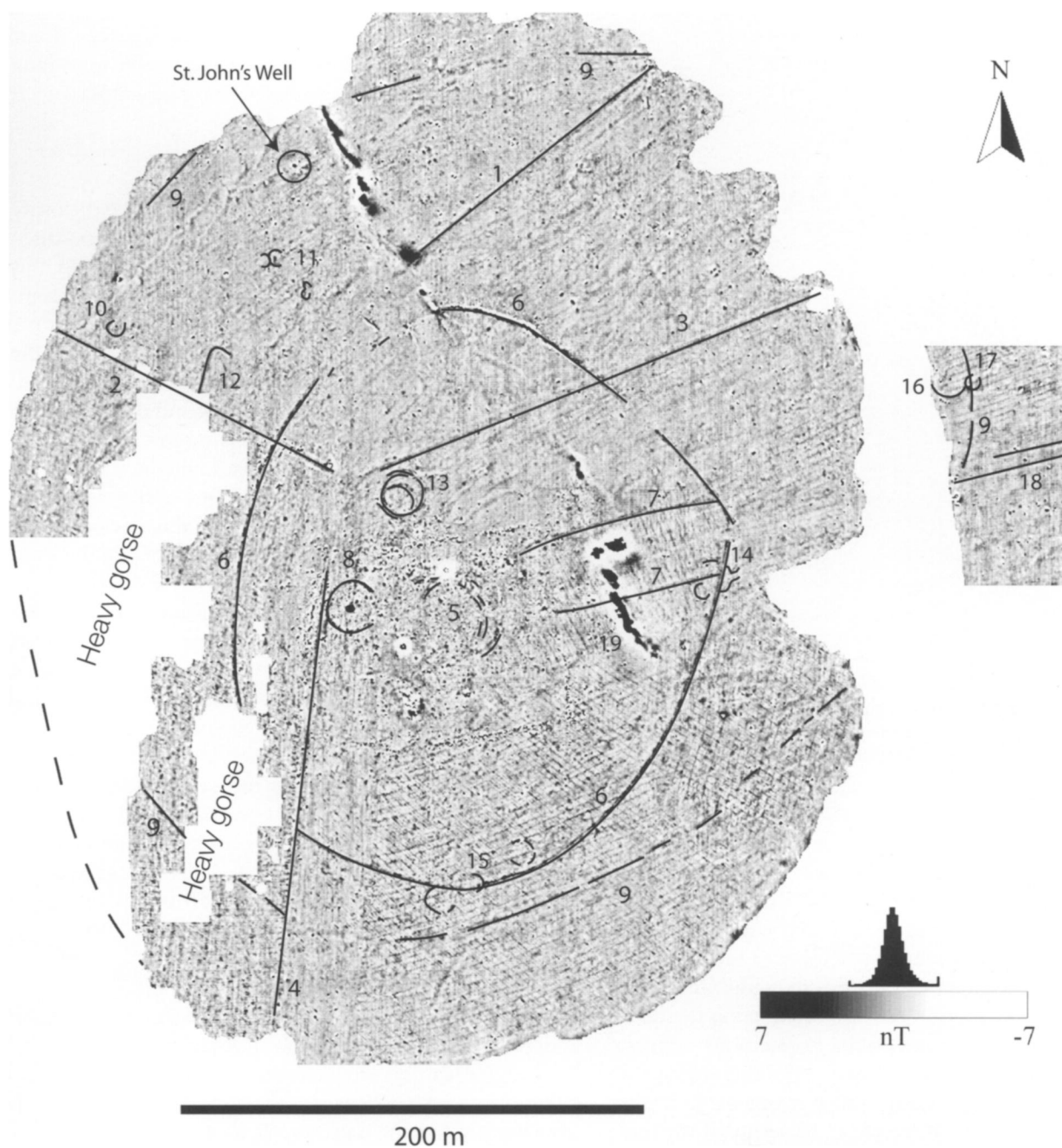


Figure 10. Grayscale image as in Figure 9, with major features outlined in black. Numbers are referred to in the text.

palisades, it, too, probably held a palisade. There are possible indications of a number of gaps along its circumference, but the formal entrance appears as a gap to the east where the enclosure is almost pointed. This entrance also aligns with that through the bank and ditch and is integrated with the funnel entrance to the Rose phase complex (Feature 7). For reference, Figure 11 shows the plans of the

Rose and Mauve phase timber structures superimposed on the magnetometer image from Figure 9. This shows that the funnel begins at the entrance into the larger of the Rose phase palisades and ends at the entrance of the summit enclosure. The spatial relationship, therefore, indicates that the summit enclosure is contemporary with the Rose phase complex, which in turn has been dated to the Iron Age



Figure 11. Enlargement of the grayscale image of the area inside the summit enclosure with the timber structures from the Mauve and Rose phases superimposed. The funnel entrance of the Rose phase structure in the grayscale image is integrated with the summit enclosure entrance.

(Johnston and Wailes 2007: 177–182). As noted above, the inner roadway also extends through this entrance.

The continuation of the Rose phase entrance funnel (Feature 7) indicated on the magnetometry image is also Iron Age. The full extent of this feature could not be determined during excavation because of limits on the excavated area. Figure 11 focuses on the magnetometer image within the summit enclosure (Feature 6), and shows the superimposed Rose and Mauve phase structures from the excavation plan (FIG. 5). Here, it can be seen that the funnel, indicated by a pair of narrow bands of positive magnetic readings spaced roughly 30 m apart and running ENE–SSW, becomes parallel 35–40 m after it begins and then continues for some 60 m before ending at the entrance to the summit palisade. Similarly, the rest of the arc-shaped feature (Feature 8), which is on the western edge of the excavated area in Figure 5 (labeled as Feature 229), was also identified. It shows up very distinctly as a positive magnetic anomaly measuring approximately 20 m in diameter. Its narrow width suggests that it may represent a slot-trench for a timber structure akin to some of the other excavated features. A small, roughly circular anomaly,

measuring about 4 m in diameter, lies at its center. Some of the other discrete magnetic anomalies visible in its interior may represent pits or other features of archaeological significance.

Earlier Enclosure

A particularly important feature is the massive enclosure (Feature 9) which appears to predate the bank and ditch surrounding the site. It appears as a slender, discontinuous band of positive magnetic readings that, like the summit enclosure, is also subcircular in plan; however, this feature, which is far larger, is oriented on a different axis than the summit enclosure. More importantly, it not only encompasses most of the area inside the bank and ditch, but also extends a short distance beyond the eastern entrance, apparently running underneath the bank and ditch. Although quite clearly defined from the SW around to the east, where it averages 1 m in width, the rest of this enclosure can only be traced in places on the north and NW; on the west, where survey was limited by gorse cover, it exhibits virtually no geomagnetic expression. Sufficient portions have been geophysically mapped to illustrate its enormous scale, extending to some 390 m in maximum diameter (NNE–SSW). Its relatively narrow width and the occurrence of numerous, irregularly spaced gaps along its circumference suggest that the enclosure may have held a discontinuous timber palisade. There is no way to determine the date of this feature from geophysical data, but the fact that it seems to run under the Iron Age bank and ditch suggests that it predates them. Since there is evidence for the use of the hill from the Neolithic through the Iron Age (Johnston and Wailes 2007), it could date to any of these periods.

Features of Uncertain Date

Most of the features visible in the magnetometer image cannot be dated with precision. Depending on how many of the faint features are included, the total number of features ranges from dozens into the hundreds. Many of them are circular, and the narrow width of some suggests that they might also be slot trenches for palisades. The more clearly delineated are described here. Figure 12 shows enlargements of some of these.

In the northwestern part of the site, there are several arc-shaped and circular features expressed as faint, positive magnetic anomalies, with diameters ranging from about 3 to 6 m. Included in this group is a small, circular feature (Feature 10; FIG. 12), 5 m in diameter, with a discrete magnetic anomaly at its center and two apparent pairs of conjoined or overlapping arcs to the NE (collectively designated Feature 11; FIG. 12). To the south of these is an inverted L shape (Feature 12; FIG. 10) indicated by positive mag-



Figure 12. The magnetometry image with selected areas enlarged. Feature numbers are the same as in Figure 10.

netic readings. It runs in a NNE direction for a distance of approximately 20 m before curving to the wsw and continuing for a further 10 m. Within the summit enclosure, just to the north of the summit (Feature 13; FIG. 10), is a feature defined by two closely spaced, concentric rings of positive magnetic readings approximately 20 m in overall diameter. This partially overlaps with a discontinuous, semicircular arc of positive magnetic gradient roughly 15 m in diameter that is either part of the first feature or a sep-

arate feature. Near the apparent entrance to the summit enclosure is a faint, positive magnetic, circular anomaly (Feature 14; FIG. 12). It is 14 m in diameter and appears to be conjoined to the sw, figure-of-eight style, with a smaller circular anomaly 5 m in diameter; of particular interest are the suggestions of a funnel-like entrance feature—defined by two linear anomalies—at the eastern side of the larger of the two circular features and the discrete, positive anomaly at its center that could represent a pit.

Finally, there is a line of semicircular features just within the southern edge of the summit enclosure (Feature 15; FIG. 12), each measuring 5–10 m in diameter. The relationship between these and the summit enclosure is unclear, but some of them may run underneath it. These features are of interest because they might be ring ditches and may contain burials. Burials are present at all four royal sites; some are in close proximity to the sites, as with the passage tomb on the hill of Tara (O'Sullivan 2005), and all known royal sites are situated in landscapes containing burials from various prehistoric periods (Johnston 2006).

Outside the Entrance

Multiple features were detected to the east of the main enclosure entrance (FIGS. 9–12). These include as many as six circular anomalies of positive magnetic readings, the largest of which (Feature 16) is about 15 m in diameter and appears to overlap with the line of the earlier enclosure (Feature 9) to the west. Adjoining, or possibly overlapping this feature on the east is a second, smaller circular anomaly of positive magnetic readings (Feature 17), approximately 6 m in diameter, with a discrete magnetic anomaly at its center. It also appears to overlap with the line of the earlier enclosure, as does another, even smaller circular anomaly located a short distance to the south. Finally, the sunken outer roadway, which begins just outside the entrance through the bank and ditch, registers as a pair of parallel linear features of negative magnetic gradient (Feature 18), oriented ENE–WSW and spaced approximately 6 m apart; these continue down the slope beyond the edge of the survey area.

Interpretations

Geophysical investigation has become a standard tool in archaeological research and has provided important data on Irish royal sites. The work undertaken at Tara (Newman 1997) and by various researchers at Navan (e.g., Kvamme 1996) reinforces the value of this approach for identifying characteristic features. Geophysical investigation has also contributed significant data at Tara (Fenwick and Newman 2002) and Rathcroghan (Barton and Fenwick 2005). To some extent, these results prompted our research at Dún Ailinne, and the number of new features identified here has enhanced our ability to understand its internal structure more fully and integrate our findings with other royal sites.

At least some of the features at Dún Ailinne are Iron Age or earlier in date. The summit palisade and the continuation of the Rose phase entrance funnel are obviously connected with the other known features on the summit and belong to the Rose phase ceremonial use of the hill in the Iron Age. The massive enclosure that appears to run be-

neath the bank and ditch can be similarly dated to a time before the latter were constructed. Radiocarbon dating suggests that the bank and ditch belong to the later part of the first millennium B.C. (Johnston and Wailes 2007: 29), indicating an earlier date for the enclosure, perhaps earlier in the Iron Age or in the Bronze Age or Neolithic. Similar enclosures were identified at Rathcroghan, encircling the mound itself and its associated features (Barton and Fenwick 2005; Waddell, Fenwick, and Barton 2009), and at Tara, encompassing the Ráith na Senad and a Neolithic passage tomb (Fenwick and Newman 2002). Each of the three enclosures has a different configuration, location within the site, and relationship to associated features, and they may well date to different prehistoric periods. In a more general sense, the enclosures represent another feature shared by royal sites.

The rest of the features at Dún Ailinne are undated. The fact that many of them are circular suggests contemporaneity with the known Iron Age features on the summit, but circular features in Ireland are hardly confined to the Iron Age. Several may run underneath the summit enclosure, indicating that they are earlier than this feature. What is apparent, however, is that the space inside the bank and ditch at Dún Ailinne held many structures at any given time and rarely, if ever, was left free of buildings. This is a shared characteristic of the royal sites. Geophysical research at three of the other royal sites revealed that their internal space was far from empty, and likely included structures from different periods, each phase possibly building on previous arrangements and incorporating them in symbolically important ways. Analyses of the ways these structures might have been experienced have been proposed for both Tara (Newman 2007) and Navan (Lynn 2003). At Dún Ailinne, this may have been expanded to include the space outside the bank and ditch. The survey outside the original entrance showed a number of features that may have been linked with those inside in ways we are only beginning to understand.

The structure of internal space at Dún Ailinne has implications for the activities associated with the site. Excavation indicates that Dún Ailinne was used for ceremonial purposes (religious, economic, political, or some combination of these) that may have changed over time. Rising above the surrounding landscape, the timber structures visible on the summit would have been an imposing sight, making a symbolic statement associated with these ceremonial activities. As the visual focal point of the hill, it is possible that the summit alone was the focus of activity, with the rest of the area inside the bank and ditch remaining open, perhaps forming a buffer between those on the summit and those outside the bank and ditch. Our geo-

physical survey, however, indicates that this is not correct, and that the space inside the bank and ditch was at times filled with structures.

Given the chronological uncertainties, we cannot be certain what was visible on the surface during any given period; we can only speculate about the rituals that might have occurred. For example, the anomaly at the center of St. John's Well may be a geological feature, yet there is ample evidence for similar ritual deposits in Irish prehistory, including those associated with Navan. The feature known as the King's Stables, generally considered to be part of the larger Navan complex, is an artificially constructed pond dating to the later Bronze Age. It is located NE of Navan Fort and contained an incomplete human skull (Lynn 1977). Just east of this is Loughnashade, a small natural lake from which four large bronze horns were recovered in the 19th century (Raftery 1987). In this larger context, such deposits at Dún Ailinne may also be associated with ritual activities.

Burial ritual was also practiced at Dún Ailinne. Excavations revealed two burials, one from the Neolithic and one from the early Bronze Age (Johnston and Wailes 2007: 76, 82–83), and there are additional burials in the surrounding landscape (Clancy 2006). Burials are associated with the other royal sites as well. The passage tomb at Tara (O'Sullivan 2005) containing burials from the Neolithic and the Bronze Age has already been noted and there are many probable burials in the surrounding landscape there and at Rathcroghan (Newman 1997; Waddell 1983, 1988; Waddell, Fenwick, and Barton 2009). Prehistoric burials are also recorded from the surrounding area at Navan and possibly within the enclosure as well (Warner 1986, 1994; Lynn 1997). If the circular features at the southern end of the summit enclosure at Dún Ailinne are ring ditches and do contain burials, the role of burial ritual here would be greatly expanded.

Other rituals may have involved movement through the site, choreographed to incorporate whatever structures, past and present, were visible at the time. As noted, other researchers have explored similar possibilities for Navan and Tara. At Dún Ailinne, these rituals could have integrated the outer and inner roadways, the Rose phase funnel-shaped entrance, and the concentric arrangement of enclosures beginning with the bank and ditch. Depending on the phase, ritual movement would have included the summit enclosure and the figure-of-eight structure of the Rose phase or the three concentric timber features of the Mauve phase. The incorporation of still-visible earlier structures would have enhanced such ceremonial movement, allowing for the addition of further layers of meaning. Given the number of features identified in this survey, the possibili-

ties for ritual expression at Dún Ailinne were only limited by the imagination of those who constructed and experienced the ceremonies on the hill.

Conclusion

The geophysical survey at Dún Ailinne has contributed significantly to the interpretation of this important Irish archaeological site. It has provided important evidence through the mapping and identification of features and the combination of these two sources of data. It has also indicated fruitful areas for future research, e.g., determining which of the myriad anomalies indicated by the magnetometry are natural and which are of archaeological significance, and whether dating evidence for the latter can be obtained. Specific questions include the following: what was the anomaly at the center of St. John's Well? Which of the apparent gaps in the summit enclosure are intentional and which are the result of the fill(s) in certain areas being insufficiently magnetic to be detected by the gradiometer? What is the exact relationship between the bank and ditch and the earlier enclosure on the hill? These are questions that can now be addressed given the data provided by the geophysical survey, and their answers will add significantly to our understanding of the royal site at Dún Ailinne and the ceremonial life of Ireland's prehistoric inhabitants.

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