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WREST PARK, BEDFORDSHIRE

Analytical earthwork survey in the southwest quarter and evaluation trenches in the Mithraic Glade, Duke's Square, and Lady Duchess Square, November 2019

Thomas Cromwell and Magnus Alexander, with contributions by Polydora Baker, Olaf Bayer, Duncan H Brown, Rachel S. Cubitt, Gill Campbell, Francesca Gherardi, Nicola Hembrey, and Sarah Newsome

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SUMMARY
Three areas in the lower gardens received analytical earthwork surveys to examine the developments around the western Yew Quarter, the bridge across the serpentine canal in the extreme southwest corner, and the Mithraic Glade. The Yew Quarter is a palimpsest, and restoration to a given period may be difficult due to some restoration/replanting in the immediate vicinity that could lead to further misalignments with the original layout. The Mithraic Glade is dominated by a ridge running down its axis, and the mound at the southern end where the Root House was presumed to be. Around it to the north, west, and south are a number of phases of features relating to the rides and designs seen in early sketches and plans, but these are overlain and not entirely clear.

Nine trenches were excavated in three clearings in the gardens at Wrest Park to clarify the results of geophysical survey. These identified a structure on the site of the lost Root House from the 1740s, as well as foundations for garden statuary and lost sand footpaths. Land drains were also identified, representing multiple phases of water management on a notoriously wet site with clay soils. The information will help guide decisions about restoring features within the landscape.

CONTRIBUTORS
Magnus Alexander, Polydora Baker, Olaf Bayer, Duncan H Brown, Thomas Cromwell, Rachel S. Cubitt, Gill Campbell, Francesca Gherardi, Nicola Hembrey, Sarah Newsome

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Fort Cumberland, Portsmouth

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CONTACT DETAILS
Thomas Cromwell, Archaeological Excavation Team, Historic England, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD.
Tel.: 02392856752. Email: Thomas.cromwell@historicengland.org.uk

Magnus Alexander, Archaeological Investigations Team, Historic England, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD.
Tel.: 02392856740. Email: Magnus.Alexander@historicengland.org.uk

CONTENTS

FIGURES

TABLES

BACKGROUND

In autumn 2019 Historic England was asked to undertake two investigative projects in the gardens at Wrest Park, Bedfordshire. The Archaeological Projects Team at Historic England was asked to provide limited excavations in the gardens at Wrest Park to explore a number of features identified from historical records and to "ground truth" the recent geophysical survey carried out by the Geophysics Team, also at Historic England (Linford & Payne 2019). At the same time the Archaeological Survey and Investigation Team carried out analytical earthwork survey of selected areas of the southern half of the park, targeting areas of archaeological interest.

It was determined that analytical earthwork survey would be beneficial in three main areas: the western Yew Quarter, the Mithraic Glade and the approaches to the old bridge in the south-west of the gardens. The proximity of the latter two meant that it was possible to treat them as a single survey area.

For excavation three target areas were identified – the Lady Duchess Square and Duke's Square on the west and east sides of the axial reflecting pool that runs north-south down the middle of the gardens, and the Mithraic Glade in the southwest corner of the gardens. The work was required before the Christmas holidays, so a two-week excavation was planned running from 25 November to 6 December 2019. The weather was wet, and the poor-draining clay subsoil ensured the trenches remained saturated. All trenches were excavated by hand.

The Mithraic Glade is an oblong clearing named for the Altar of Mithras, a stone structure built in the centre in the 1740s, carrying Greek and Cuneiform inscriptions. It once boasted a "root house", a single-roomed structure built of twisted roots and branches that served as the shelter for a "hermit" arranged by the owners to act as high priest of the altar. The root house appears in a sketch from the 1830s but has long since been replaced by grass lawn. (Alexander et al, 2013)

The Lady Duchess Square takes its name from Lady Jemima Grey, Duchess of Kent (1675-1728), not to be confused with her granddaughter Lady Jemima, 2nd Marchioness Grey (1723-1797) who inherited Wrest Park in 1740 and spent decades altering and improving the gardens. The oval clearing once contained a column on a plinth in the centre erected in 1728/9 in memory of the Duchess, and a lead statue of Lady Jemima reading a book on a plinth to the south – these appear in sketches from the 1830s. The column was removed to the grounds of Trent Park, Middlesex in 1934, and the lead statue went to Coles Park, Hertfordshire. When the house at Coles Park was demolished in 1954 the lead statue was returned to Wrest Park. (Alexander et al, 2013)

The Duke's Square on the east side of the Long Canal consists of a circular clearing connected to a rectangular one, with sketches showing a column (erected 1728/9) in the centre of the circular space and two urns on plinths in the rectangular space. The column went to Trent Park in 1934. (Alexander et al, 2013)

This report combines the results of the analytical earthwork survey with the Site Archive Completion and Assessment reports for the excavation and represents the final dissemination of the 2019 work.

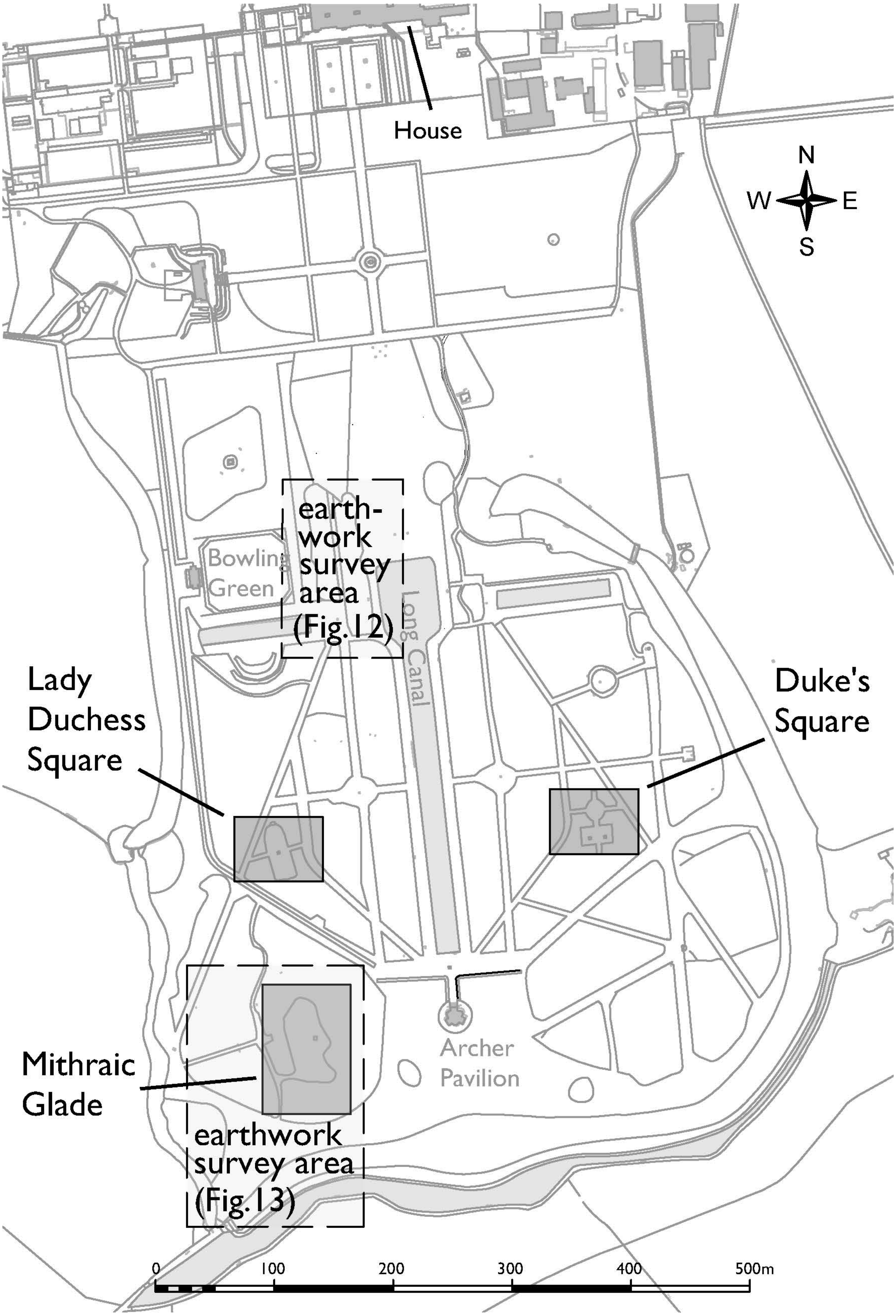

Fig 1: Plan of gardens showing areas of earthwork survey and areas targeted for excavation trenches. (Base map © Crown Copyright and database rights 2019. OS 100024900.)

ANALYTICAL EARTHWORK SURVEY – MAGNUS ALEXANDER

Methodology

Due to dense tree cover over most of the study areas, the survey was undertaken entirely by Total Station Theodolite (TST).

Control was established in open areas using a Trimble R8 survey grade GNSS (Global Navigation Satellite System) receiver to establish known control points for TST survey. The position of the control points was adjusted to the National Grid Transformation OSTN15 via the Trimble VRS Now Network RTK delivery service. This uses the Ordnance Survey's GNSS correction network (OSNet) and gives a stated horizontal accuracy of 0.010-0.015m per point, vertical accuracy being about half as precise.

The two areas (see Fig 1) were then surveyed using a Trimble 5603 TST by taking radiating readings from a series of stations in sequence to form two main closed loops or traverses. As the traverses were based upon GNSS control, survey was directly to Ordnance Survey National Grid, later adjusted for errors using proprietary Trimble software. Overall accuracy is comparable to GNSS though, unlike GNSS, decreases with length of traverse and distance between surveyor and station.

The survey data was downloaded into proprietary software to process the traverses and field codes and the data transferred into AutoCAD software for editing and plotting for checking in the field. Corrections and some small areas of additional survey were undertaken at this time by measuring in from known features using tapes. These were edited or added in AutoCAD.

Environment Agency lidar was also examined in order to contextualise surveyed features, particularly in areas of dense woodland which were inaccessible to survey, principally around the Mithraic Glade. This revealed little additional information.

Extent of survey

The survey covered the Yew Quarter itself and adjacent areas to the west as far as the edge of the Bowling Green, and south as far as the hedges defining the northern extent of the larger woodland panel (see Fig.12). Areas to the north and east of this had previously been surveyed in 2009-11 (Alexander et al 2013) though there have been substantial changes to the gardens since then including the creation of the evergreen garden, removal of hedging around the Bowling Green and the re-creation of a surfaced path alongside the Long Canal and on the line of the Horseshoe Path.

The limit of survey around the Mithraic Glade was defined by a drainage ditch to the east and a footpath and track to the north and west. To the south it merged into the survey to the south-west of the glade, which was less well defined. The focus of survey here was the approach to the causeway in the far south-west corner of the grounds, at the west end of Broad Water, but as many of the earthworks appeared to be linear and extended some way to the north and north-east the survey extended sufficiently in these directions to define their form and extent. The limit to the north was largely defined by an isolated oval block of relatively young trees, but to the north-east it was somewhat arbitrary and partially determined by available time and visibility (see hachures in Fig.13).

Historical development

Wrest Park is well served with map and other visual sources from the early 18th century onwards (see Alexander et al 2013, particularly Appendix 3 and 4, 242-298). These allow a detailed history of the site to be compiled and the key developments for each survey area are summarised below.

Western Yew Quarter

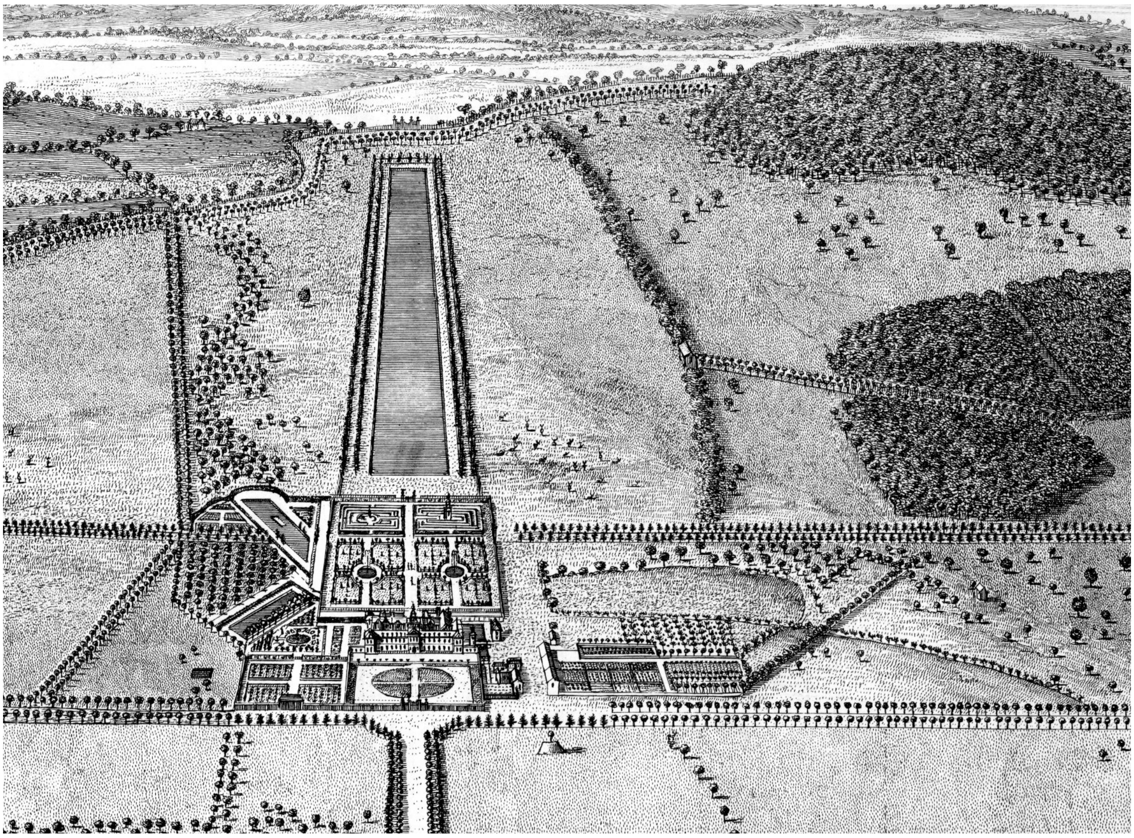

Fig 2: Detail from Kip & Knyff view of 1703/4 from the north. The old house is in the left foreground, and study areas are at top right. (Patricia Payne © Historic England DP029355)

The Kip and Knyff views of 1703-4 show the old house with a rectangular walled garden to its south. The south-west corner of this garden appears to have extended into the north-east of the Western Yew Quarter survey area. South of this was the central canal which had double hedges or lines of close planted trees to either side, though these probably lay to the immediate east of the survey area. The remainder of the surveyed area appears to have been featureless open parkland though there was a formal east/west avenue or ride to its immediate north.

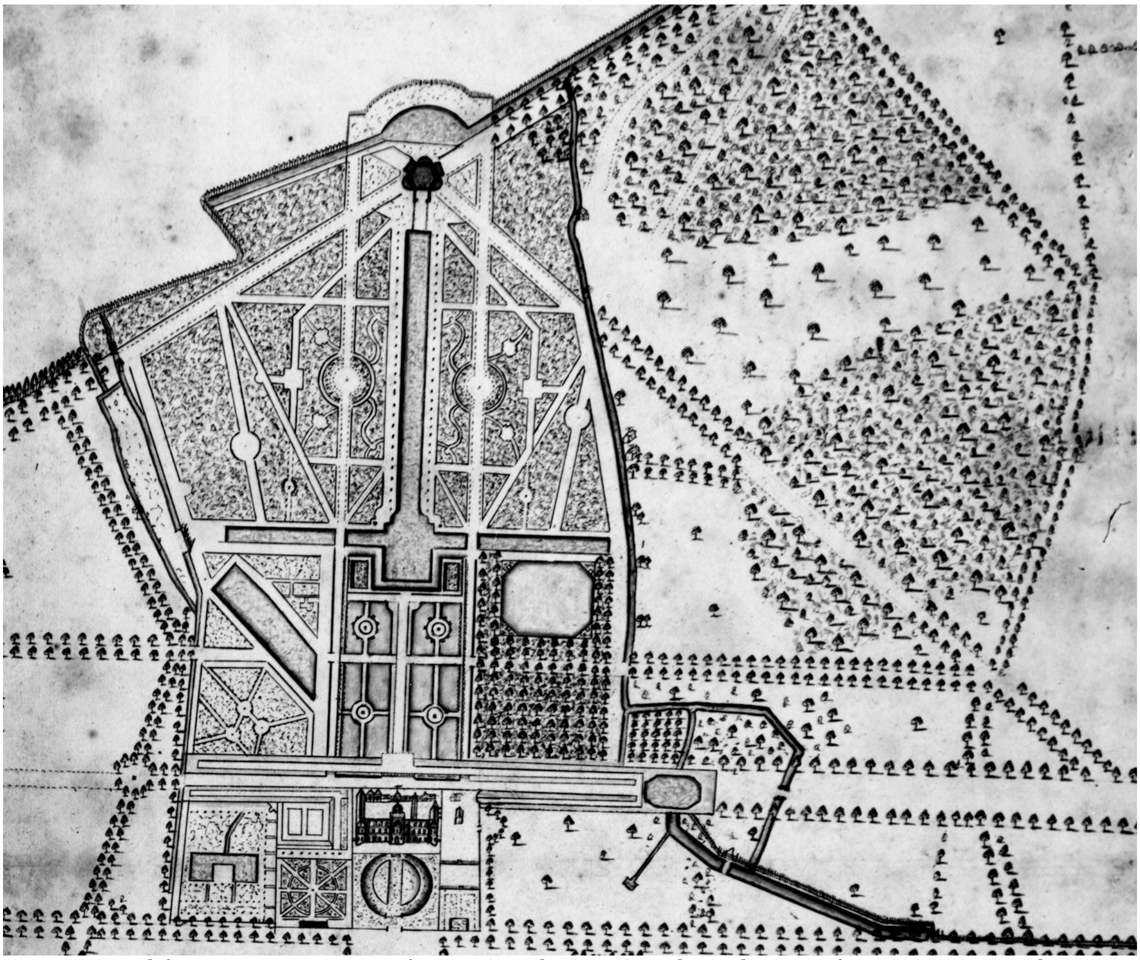

Fig 3: Detail from Laurence map of 1719 (south at top) with study areas from centre spreading upwards (Bedfordshire Archives L33/286 f3, Patricia Payne © Historic England DP110990).

By the 1719 Laurence map the north end of the canal had been enlarged to create a rectangular pool. The walled gardens were extended to the south by the addition of two rectangular blocks either side of the north end of this pool; the western occupied a large part of the east centre of the survey area and seems to have been a persistent feature defining surrounding path alignments. Cross canals had been added to the east and west of the pool and the western arm ran through the south of the survey area on the line of the existing water, with a path along its northern side. A north/south path along the inside of the west garden wall had been extended southwards to form a ride through the newly created west woodland panel, crossing the canal via a narrow causeway or bridge. The area to the west had been planted as a formal 'wilderness' or orchard with a regular grid of trees and the Bowling Green had been created occupying much the current footprint.

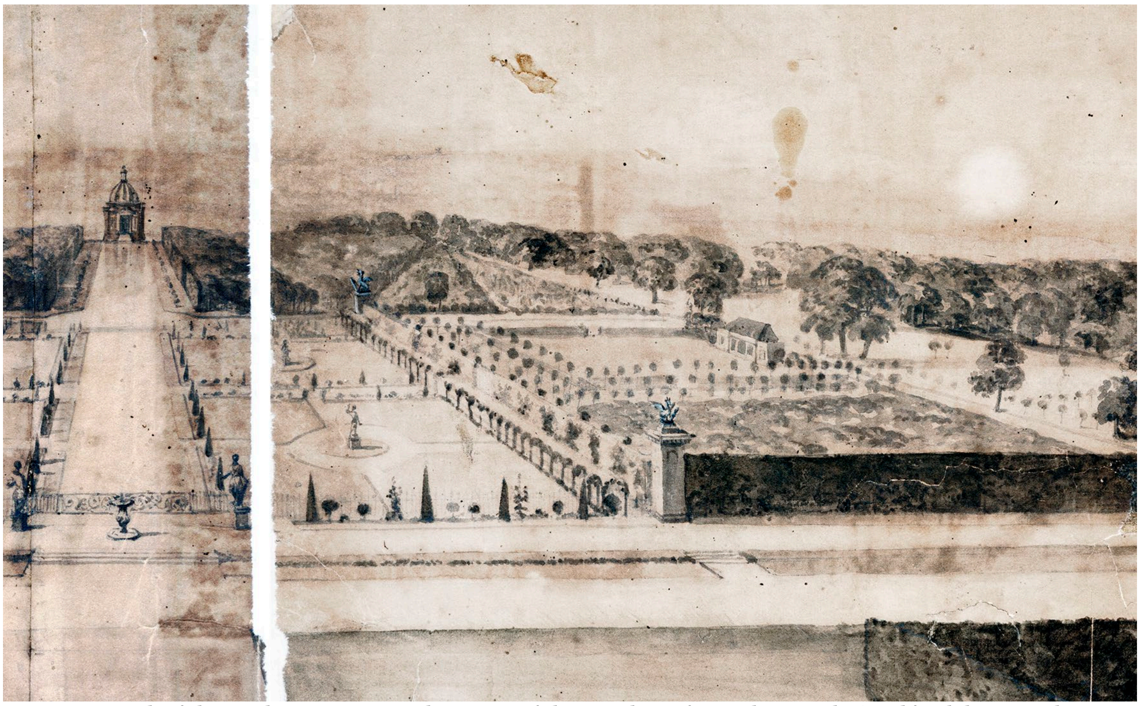

Fig 4: Detail of the early 1720s Angelis view of the gardens from the north (Bedfordshire Archive L33/128A © Historic England Archive e850345/7/8)

The Angelis' view of the gardens from the north, from the early 1720s (Figure 4), shows the survey area much as on the Laurence map but in little detail. The west garden wall was substantial with large piers at either end surmounted by statues of griffins but the south side of the garden appears to be open; it may have been so in 1719 though this is unclear. In the south-west corner the rectangular block of planting noted above can be seen, with a north/south path somewhat to the east of centre; based upon alignments with known features, this path probably lay to the immediate east of the survey area. The Bowling Green is also shown (with Bowling Green House for the first time) with four rows of small, relatively well spaced trees to its east.

Rocque produced two maps of Wrest in 1735 and 1737 (Figures 5 and 6), the latter more detailed as it focussed on the gardens and some of the differences between the two may be down to this difference in scale, though some appear to be due to genuine change in the gardens (Alexander et al 2013, 249-251). At the time of the first map the cross canal appears much as previously, though the north/south ride may have crossed it on a broader causeway and appears to have terminated a short distance north of this, at a small angular feature, possibly a niche. A path ran away east from this point on the approximate line of the south side of the rectangular block first depicted on the Laurence map and a little to the south a path ran west along the north side of the canal, again as in 1719. It is not clear if the west wall survived as this area is shown divided into strips; broader strips to either side of the probable wall line suggest rough ground or recent planting but the meaning of two well defined pale strips with dark hatching between is uncertain. A new boundary, perhaps a hedge, to the immediate east, may have been a replacement for the wall.

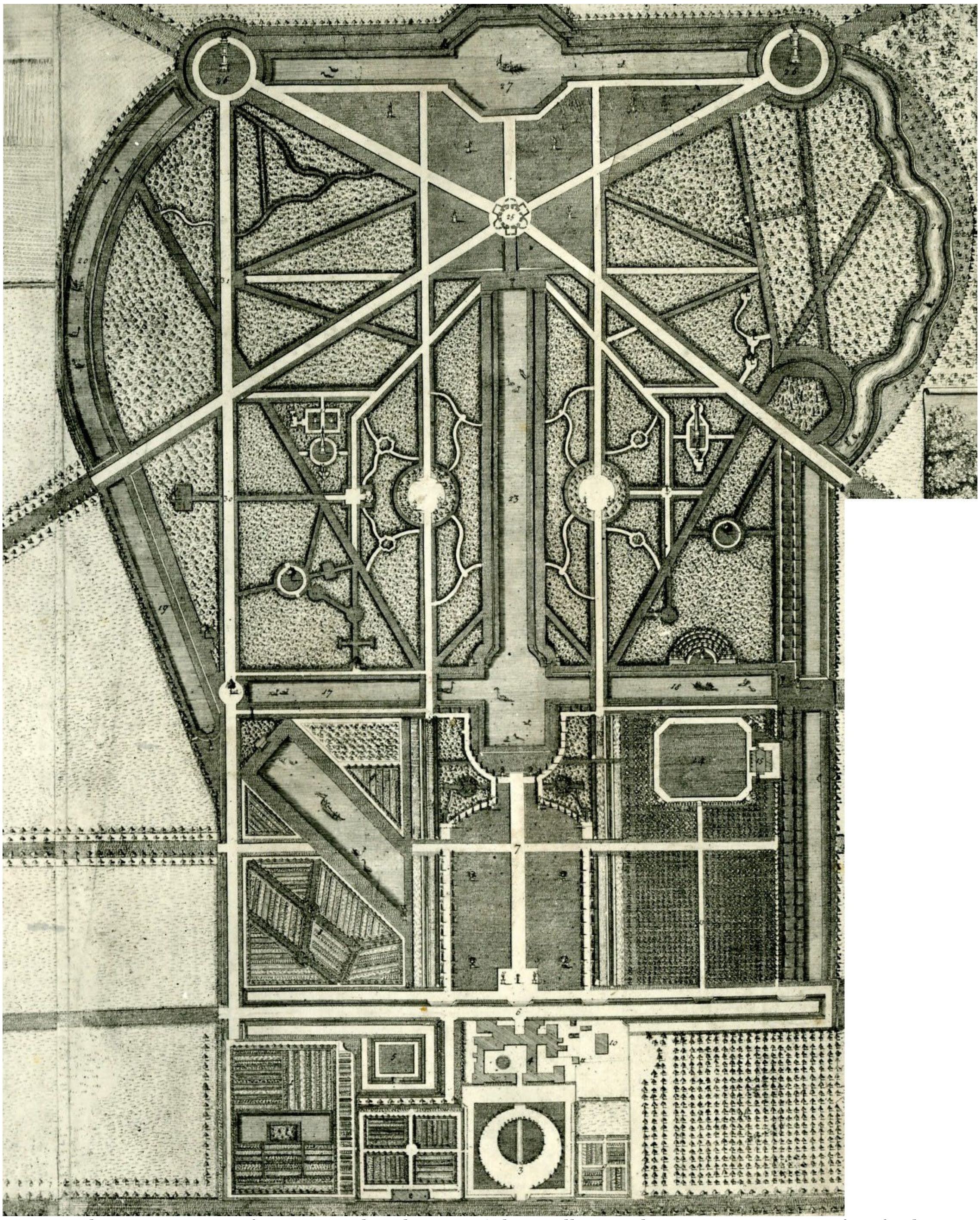

Fig 5: The Roque map of 1735, north at bottom (The Bodleian Libraries, University of Oxford, Gough Maps 1, folio 16b)

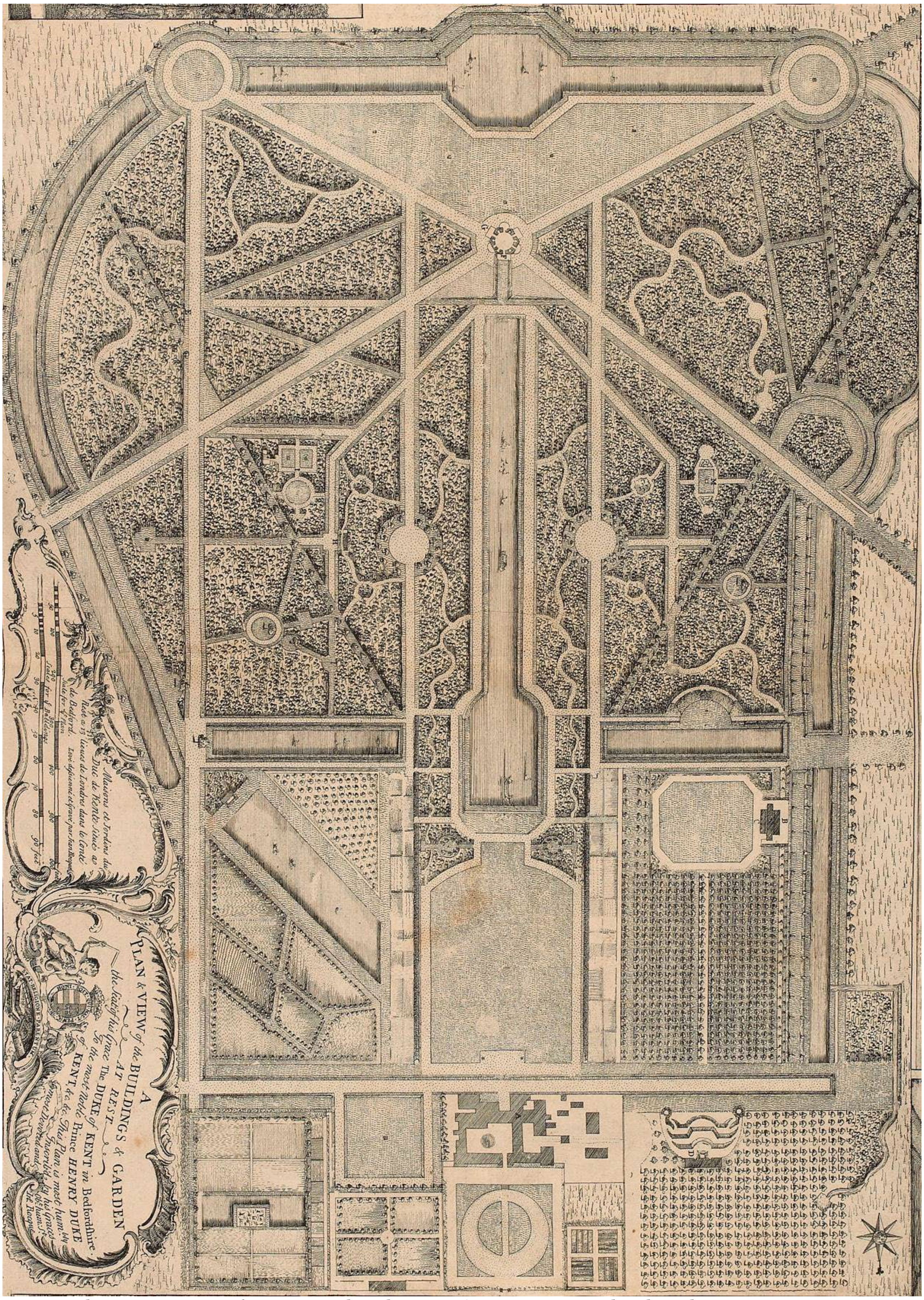

Fig 6: The Roque map of 1737, north at bottom (© Historic England Archive, Map Room AL0990,7)

To the west, the layout around the Bowling Green appears much as previously. An east/west path, aligned on the Bowling Green House, ran through the survey area, though the eastern part of this appears to align with the northern part of the rectangular block noted above. To the north of this was a circular feature and some small paths, most of which lay just to the east of the survey area. The 1737 Rocque map clearly shows that the west garden wall had been removed. In its place was a strip of smaller rectangular plots, reminiscent of a productive garden, occupying the same area as the strips noted on the earlier map. A new north/south path had been laid to the immediate west of this, but again the Bowling Green appeared as before. The east end of the cross canal, from the causeway to the pool, had been filled in and this and the area to the north of it, the eastern part of the survey area, divided into three similar sized blocks divided by paths, apparently with uniform planting, the central block occupying much the same footprint as the block added by 1719. The circular feature to the north survived and a new, sinuous path ran broadly north/south through the west of this area.

There is then a considerable gap in the record until the early 19th century when several maps, generally associated with enclosure, were drawn up (Alexander et al 2013, 252-4). These are all quite similar, large scale and depict the ground with little detail, but much as today. The most significant change that can be seen is the infilling of the end of the canal west of the former causeway, which was also extended south into the amphitheatre. The remaining part of the north/south ride also appears to have been removed, replaced by more sinuous paths in the woodland. Some of the cross paths seem to have survived however.

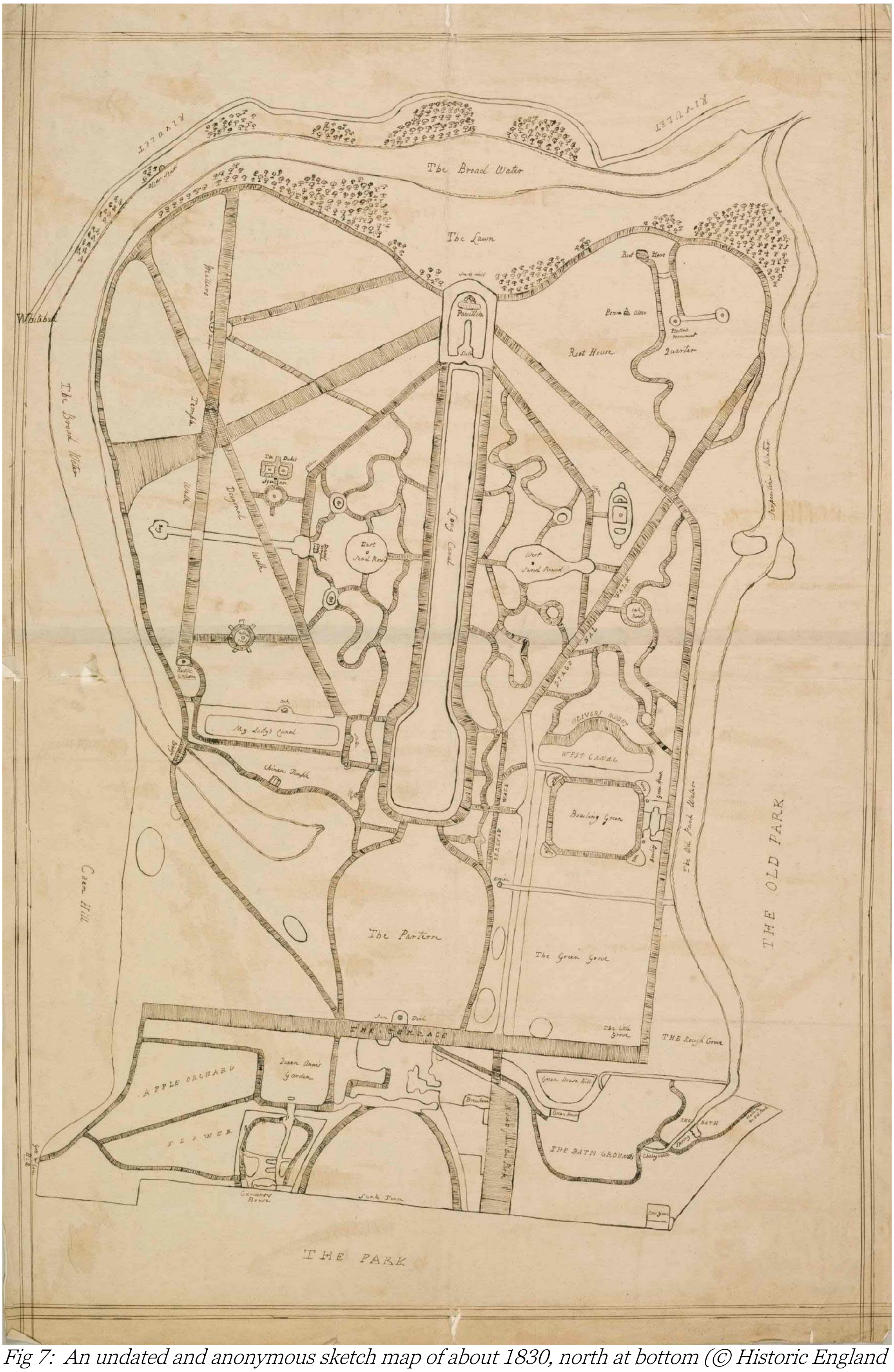

Fig 7: An undated and anonymous sketch map of about 1830, north at bottom (© Historic England DP110948)

A sketch map of about 1830 (Figure 7) gives an outline view of the gardens (Alexander et al 2013, 255-6). This appears to show that the central north/south path, labelled 'Berceau Walk', had been reinstated though it is not known when this took place and it may have been on a line slightly to the east. The north/south paths to the west, and the sinuous path to the east are also depicted, and the cross walk aligned on Bowling Green House is also shown as are others to the south.

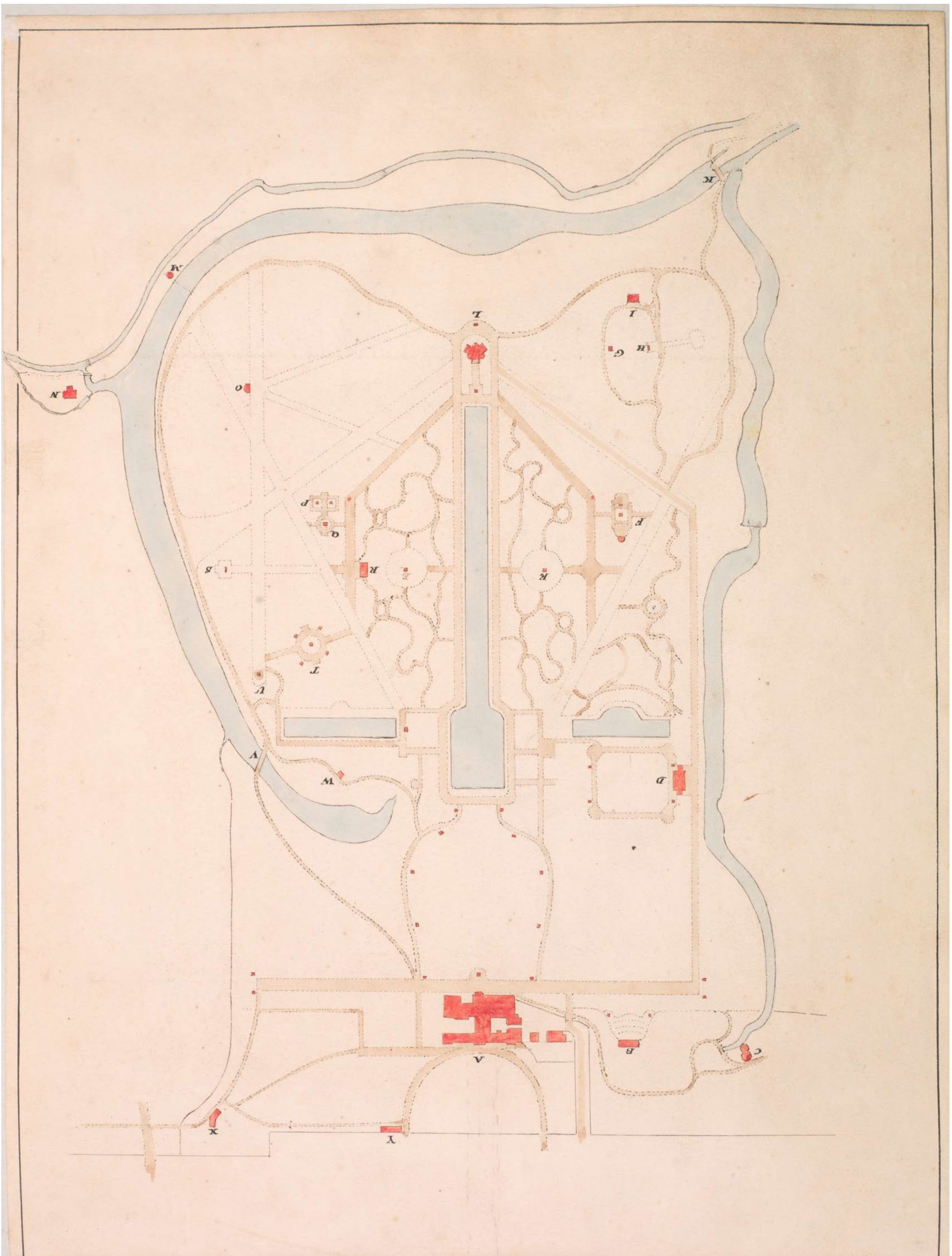

Fig 8: The location map from the 1831 'Views of Wrest Park album, north at bottom (© Historic England DP110018)

The 1831 album, 'Views of Wrest Park' (Figure 8), comprised a keyed map and a series of views of the house and grounds thought to have been made by Thomas, Earl de Grey (Alexander et al 2013, 266-298). There are no sketches of the surveyed area but the map shows the central north/south path (more certainly on a line to the east of the 18th-century path) and the cross path aligned on Bowling Green House with two other paths to the east and south of these. There is also a rectangular gravel area in the central south of the survey area from which a path ran west along the north side of the water before turning north to meet the path around the Bowling Green, where there were two statues along the east side.

Late 19th- and early 20th-century OS maps show this area largely unchanged.

Mithraic Glade and south-west

The Kip and Knyff views of 1703-4 (Figure 2) are from the north and do not show this area in detail. There is also a discrepancy between the two views. The closer view, which concentrates on the house and garden, suggests the survey area was entirely wooded. The wider view, which shows the whole park at the time, shows a narrow strip of trees to the west of the central canal that appears to be on the same line as the watercourse noted on the Laurence map above and may mark its course at this earlier date. To the south was what appears to be a slightly sinuous avenue of well-spaced, small to middle sized trees, though it is possible that this was straighter and formed the basis for an avenue shown on the Laurence map which ran through the south of the survey area. Beyond was a fence, with a narrow belt of trees immediately behind, that probably lay south of the survey area. Otherwise the survey area appears to have been open and featureless.

On the 1719 Laurence map (Figure 3) a narrow, slightly sinuous watercourse ran broadly north/south through the survey area, along the west side of the Mithraic Glade, but it is not possible to say if this was on the line of the surviving ditch or a little to its east. To the south this flowed into a narrow canal that ran from the south-west on a line similar to the western end of the existing water, though continuing straight north-east closer to the Archer Pavilion rather than curving away to the east. A broad avenue ran south-west from the pavilion into the south-east of the survey area but this stopped at the north/south watercourse. Apart from the trees of the avenue and a few to the immediate north, the rest of the survey area east of the watercourse appears to have had low planting. The area to the west seems to have been open parkland with areas of trees and rides, but little other detail.

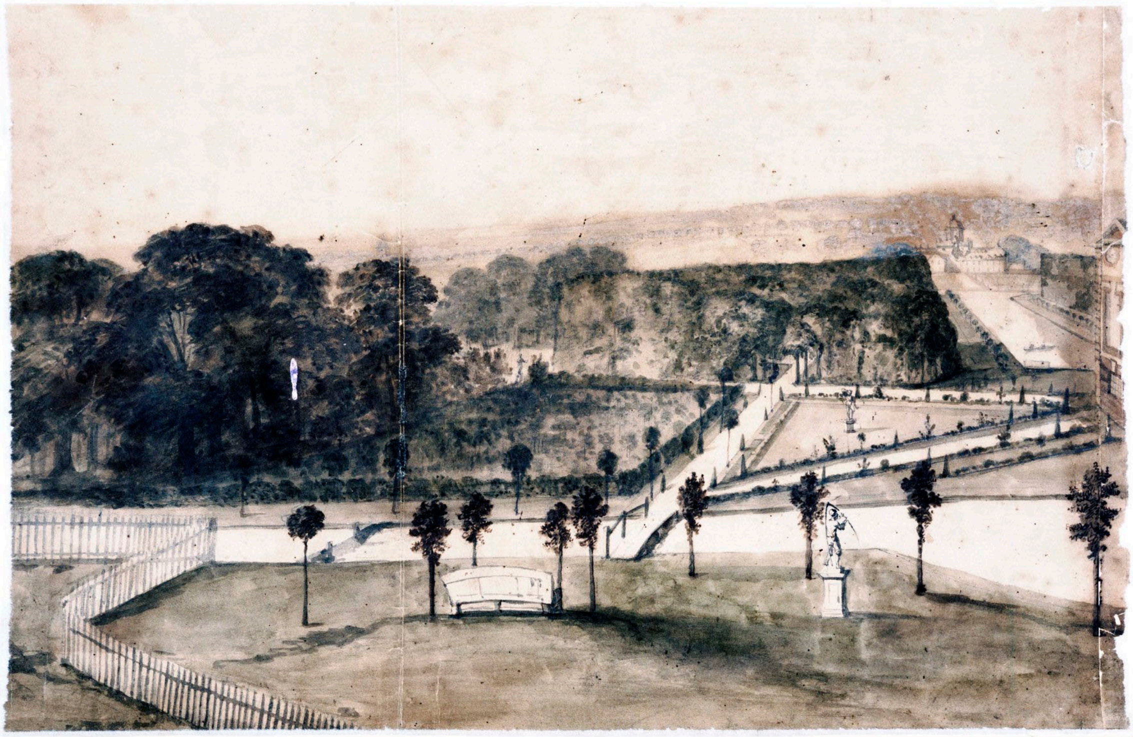

Fig 9: Angelis' sketch looking north, with Archer Pavilion at extreme right, and area of future Mithraic Glade centre-left. (Bedfordshire Archives L33/127, © Historic England Archive e850341/6)

The early 1720s Angelis' view of the gardens from the south (Figure 9) only shows the east of the survey area and has little detail. It appears that the eastern part of the area that would become the glade had low, probably recent planting, whereas the west contained numerous large, mature trees.

In contrast, several sketches of the area were produced by Tillemans in the late 1720s, which show the south of the gardens in some detail. One from the very south-west (Figure 10), shows that the south-west of the garden was dominated by a roundel formed by a circular path with a central obelisk. A path ran from this to the Archer Pavilion on approximately the same line as the avenue depicted by Laurence, but probably slightly to the north. There was no sign of the small north/south watercourse or the narrow north-east/south-west channel both of which must have been filled in apparently replaced by formal canals which ran away to the north and east with paths alongside. Much of the associated planting appears recent, though the area of the Mithraic Glade was occupied by a block of well-established woodland enclosed by a mature hedge.

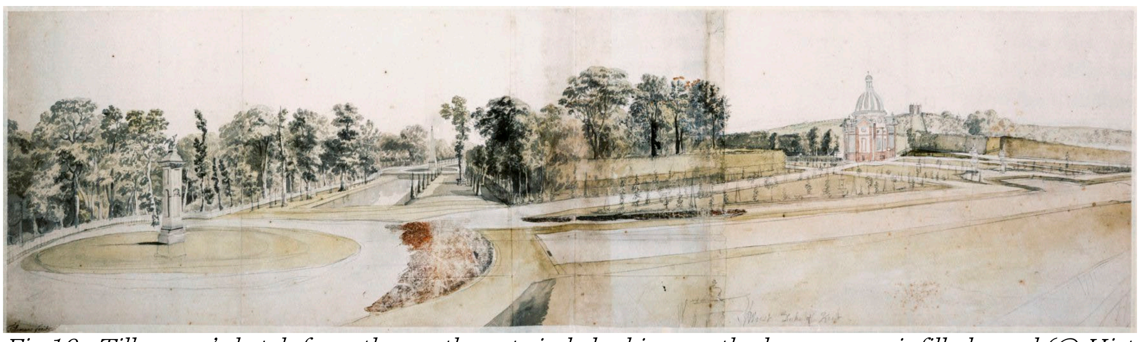

Fig 10: Tillemans' sketch from the southwest circle looking north along a now-infilled canal (© Historic England Archive, e850328)

The 1735 Rocque map (Figure 5) depicts the roundel, avenue to the pavilion and eastern canal shown on the Tillemans sketch. It makes it clear that the roundel was in the south-west of the surveyed area and that the canal ran on the same line as the straighter, approximately east/west section of the water to the south-east of the survey area and this continued straight a little further westwards than the point at which the current water curves to the south-west. To the north however, the northern canal and associated paths, had been removed, and the gardens had expanded westwards into the parkland as far as a broad sinuous waterway, the north end of which was on much the same line as the present Serpentine Water, though to the south it ran further to the west. The woodland to the east appears fairly uniform with some straight paths on various intersecting lines, some of which appear to be gravel, notably that around the roundel and to the pavilion, but most were probably grassed. There was no sign of the Mithraic Glade, but a small feature would appear to be in approximately the same location as Hutton's Monument. The monument bears an inscription stating that it was erected by Henry, Duke of Kent, to his friend Thomas Hutton, and as Henry died in 1740 it is likely this is the same feature. The 1737 Rocque map (Figure 6) shows the same basic plan but in the area of the Mithraic Glade the straight paths have been replaced by sinuous paths, apparently gravelled. The feature thought to be Hutton's Monument is not shown and one of the new paths starts in the same location so perhaps this wasn't the monument or perhaps some elements of the map were planned but never executed. The Root House, altar and glade are all thought to have been the creation of Jemima, Marchioness Grey, in 1748 (Alexander et al 2013, 71) and consequently are not shown on the Rocque maps.

As noted above there is then a gap in the record until the early 19th century when several similar maps were drawn up, but these are large scale with little detail (See Alexander et al 2013, Figures 102-5, 253-4. The watercourses to west and south were by then very much of the current form, predominantly the work of Lawrence 'Capability' Brown in the late 1750s. All the formal paths had been removed though the extent of the block of woodland encircling the Mithraic Glade still reflected these paths, which to the east and north can be dated back to at least 1719. A path curved around the south-west side of the main woodland block leaving an area of woodland to the south-west isolated from the rest. None depict the glade, nor any paths through the woodland, though some show what is probably Hutton's Monument. It is surprising that the glade, Root House and altar are omitted from these maps; perhaps as they were focussed on the enclosure of the surrounding landscape they only paid superficial attention to the gardens and should be treated with caution in this regard?.

The sketch map of about 1830 (Figure 7) does not show the glade either as it generally omits woodland. It does depict the Root House with a path running north-west for a short distance from its entrance before running more to the north, along what is now the west side of the glade. It also shows the 'Persian Altar' to the north and Hutton's Monument with a path running south, parallel to the path from the Root House and on the approximate line of the existing path but straighter, and a second path running west, again on the line of the existing path but stopping at a circular feature with a central point, though what this was is unclear.

The sketch map in the 1831 'Views of Wrest Park' album (Figure 8) seems to be rather inaccurate but shows a path layout around the Mithraic Glade much as today with the addition of a path passing in front of the Root House and curving north to run to the east of the altar before picking up the line of the existing paths again. A path also ran west from the Archer Pavilion, curving around the south side of the woodland to run north along its west side much as seen in some of the enclosure maps of about 1800-10. A slightly sinuous path ran south from this to the south-west corner of the grounds. The map also shows four structures within, or close to, the survey area: ‘The Altar’, ‘Hutton’s Monument’, and ‘The Root House’ in the vicinity of the glade; and ‘The Old Bridge’ to the south-west of the survey area. All are illustrated by sketches in the album (Alexander et al 2013, 285, 284, 278, and 289 respectively). The sketch of the Mithraic Altar is from the north east and shows a surfaced path in the foreground (presumably that shown on the map) and the Root House in the background. The Root House itself is shown to be of rustic construction with a thatched roof, and a surfaced forecourt and path in front of it. Hutton’s monument appears much as today with a surfaced path several metres in front of it, but much lower surrounding growth. The Old Bridge was quite an elegant, light structure but it is not possible to tell if it was of wood or cast iron.

Late 19th- and early 20th-century OS maps show the layout much as on the 1831 album map, though more accurately. By the time of the first edition 6 inch and 25 inch to the mile maps (surveyed 1881, published 1887) the Root House had been demolished. It is clear that the path to the west of the glade is on the line of the existing path as is the path running west from this. The path around the south and east sides of the glade is also shown but to the north it does not run on the same line as the modern path, initially running to its west, following its course for a short distance but continuing directly west to meet the other path rather than curving to the north. To the south and south-west, the survey area is generally shown as featureless apart from the path curving around the edge of the woodland first shown on the early 19th century enclosure maps, though a path from this to the far south-west corner of the grounds, as seen in 1831, is shown curving east around the small isolated block of woodland on the first edition maps.

Fig 11: Excerpts from 1831 plan (left) showing Root House (I) and Altar (G), (© Historic England DP110018), and 1881/1887 OS map (right) (National Library of Scotland, CC-BY-NC-SA)

Description and analysis

[Numbers in square brackets refer to features in Fig 12 and Fig 13]

Western Yew Quarter

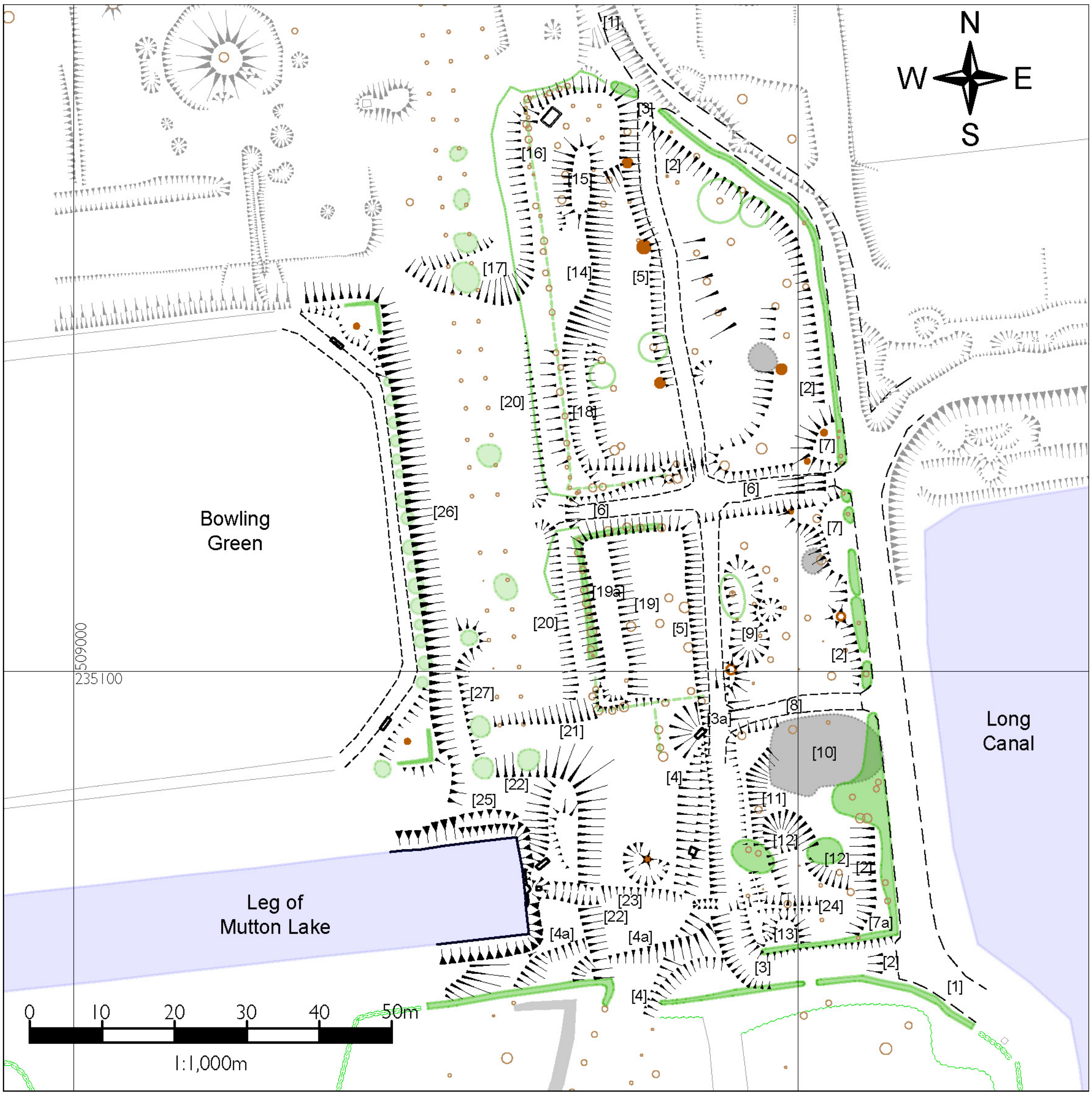

Fig 12: Earthwork Survey of the western Yew Quarter, 1:1000 at A4

The survey area is generally level and most of the scarps surveyed are slight.

The eastern extent of the survey is defined by the broad gravel path [1] running along the west side of the Long Canal, curving north-westwards around the quarter and then back away to the north. This was re-laid recently (date unknown) on a slightly different line to that indicated by the earthworks, both those surveyed in 2009 and here. Short, sharp, east facing scarps that fall towards this path from the quarter are most likely associated with this work (not shown on Figure 8). Within the quarter, set back 1.5m to 3.0m from the path edge, broad, low, west and south-west facing scarps [2] fall away from the path indicating its former, more westerly line, and that the existing yew hedges are secondary. Although only visible in several discrete sections these scarps are generally quite similar in size and scale which suggests a single origin. A single, uniform path on this line first appears on the 1st edn OS 25 inch to one mile map of 1882 so the visible scarps probably date from this period and suggest that the path was re-laid sometime in the later 19th century. However various sections of the path have a longer history than this: the south central part, running alongside the end of the canal basin is depicted on the 1735 Rocque map (Figure 5) but may also be shown on the 1719 Laurence map (Figure 3); the northern part, running north-west/south-east, is first shown on the 1735 map, and the southernmost section first appears on the 1737 Rocque map.

The southern half of the current north/south path through the centre of the quarter [3] is straight but the northern part is slightly sinuous, the result of tree growth forcing the path to deviate a little from its original line. It is on the line of the 'Berceau Walk' ('Berceau' is probably used here to mean shaded), probably laid out sometime in the first quarter of the 19th century; it is first shown on the sketch map of about 1830 (Figure 7), where it is named, and more clearly on the map in the 1831 album (Figure 8), where it had a sharp right-angled turn to the east at its southern end. There is a marked rise where it meets path [1], reflecting scarps [2] to the north. There are inward facing scarps resulting from erosion (by both foot and vehicular traffic) on both sides of the path along this east/west section, around the corner, where the outer western scarp is rather spread, and north for about 35m as far as [3a]. Traces of a slight ridge to the east may be remnants of an earlier path margin before larger vehicles led to a wider turn at the corner. Further erosion scarps [4] run to the west, leading SSW from this point towards the entrance to one of the main rides through the woodland to the south, and other similar scarps running east/west [4a] probably relate to traffic along the south side of the canal. Although depicted with various stratigraphic relationships all are very slight and merge with one another. These erosion scarps probably developed during the 19th and 20th centuries, but probably mainly since the 1950s when the gardeners began to use heavier vehicles in the grounds.

To the north of [3a] east facing scarps [5] fall towards the path along much of its western side, though these are slightly different in character to those to the south, generally being a bit higher but more spread. The erosion scarps [4] appeared to overlie a slight rise however, so it is possible that [5] originally continued further south. Whilst these scarps may also be the result of erosion associated with the 19th-century path it is possible that they are older as various features on this alignment appear on the early 18th-century Laurence (Figure 3) and Rocque (Figures 5 and 6) maps, though inaccuracies and uncertainty about depiction makes it impossible to be sure. To the north, at the far north of the survey area, scarp [5] curves to the west (see [16] below).

At about the halfway point of path [3] it is crossed at right angles by another straight path aligned on Bowling Green House [6]. This also has inward facing scarps, at least partially the result of erosion, though to the north these have counter-scarps and form low ridges. Traces of these features cross path [3] suggesting that path [6] is the earlier, which is confirmed by the mapping; there was a path here by 1735 (see Figure 5), and the eastern half may be shown in 1719 (see Figure 3), though this is less certain. Its alignment suggests the path may have been created at the time Bowling Green House was built in the early 1720s. It is not known why there are ridges to the north of this path, but not to the south. This path lies in approximately the position of the southern limit of the walled garden and whilst this garden did not extend to the west the two sections are of a different character (the eastern is lower and broader), so may have had different origins. The eastern ridge could be the remnants of the south garden wall or some other associated feature; the western ridge has a grown-out yew hedge on it and the earthwork may be the result of root growth and accumulation of material, its line determined by the path, hence the common alignment with that to the west. To the north and south of the east end of path [6] are two, irregular, flat-topped mounds [7], the southern one larger and more irregular than that to the north. These appeared to overlie scarps [2] to both north and south, so are probably relatively modern (19th/20th-century) dumps, but as their tops are at very similar levels, they may originally have been a single semi-circular feature cut by the path and so pre-dating it. There is a similar mound to the south [7a], apparently truncated by the eastern return of path [3].

The north-east quadrant of the quarter is almost featureless apart from: a broad, slight fall to the west; a slight and disturbed linear scarp running into the ridge to the north of [6], which may be on the line of a feature shown on the Rocque maps; and a semi-circular scarp, probably a relatively recent tree throw.

The area to the south of path [6] is quite different in character with several large irregular features. It is divided into two approximately equal parts by an east/west path [8], which appears to be of relatively recent origin, but once again features on this approximate line appear on all known historic maps of a scale that might be expected to show them. The area to the north of the path [8] is dominated by an approximately oval hollow [9], the shape of which is distorted by a tree throw to the east and a mound to the south-west. The mound appears to overlie the hollow and is in turn truncated by path [3] so the hollow may be relatively early but cannot be associated with any known features shown on historic maps. The centre of this area appears featureless but is in fact rather uneven. The relatively dense tree and shrub growth prevented both the identification of any coherent features and their survey.

To the immediate south of path [8] is a large area of animal burrows [10] and associated scrub growth which obscures any relationships between the areas to the north and south of it. A scarp to the north-west appears to be associated with paths [8] and [3] to the north and west and is probably the result of relatively recent erosion. A more pronounced scarp [11] curves south-west then south from the west of the disturbance to run parallel to path [3] though a few metres to its east. Until 1735-7 the area to the south and east of the burrowing was part of a cross canal leading west from the Long Canal basin so any features here must post date this, but the top of the north/south section of scarp [11] appears to align with a broad causeway carrying a ride south across the cross canal, perhaps the low and irregular character of this area is the result of settling of backfill deposits which has left the early 18th-century causeway sitting proud. The remainder of this area is rather irregular with two open hollows [12] and an irregular mound [13] of uncertain origin and date.

The area to the west of path [3] is generally slightly higher than that to the east, the transition marked by erosion scarps [4] to the south and scarps [5] to the north of [3a].

The north-west quadrant is dominated by a slightly irregular, broad, relatively prominent scarp [14] running slightly obliquely across the northern half of the area. At its north end this is overlain by a low, elongated mound [15]. It is unclear if a short scarp to the immediate east of this is a continuation of [14], related to a large adjacent tree, or a distinct feature. To the south of [15] there is the hint of a west facing counterscarp to [14]. The origin of these features is not certain as they are generally oriented north/south, whereas historic mapped features in this area ran slightly more to the NNW/SSE, though the central section of [14] does run on this line for a short distance.

As noted above, scarp [5] curves to the west to run to the north of this area and then turns south to run along the west side of the quarter [16], where it appears to be related to the grown-out yew hedge along this side of the quarter. The area to the north and west of mound [15] is slightly higher than that immediately outside the quarter, possibly related to the insertion of a service of some sort in the north-west corner of the quadrant.

To the west, a shallow scarp [17] curves away from scarp [16] along the west side of the quarter, forming a very shallow depression. Although scarps [16] and [17] run into one another, the relationship between the two cannot be determined due to rough ground and their slight character. The origin of this feature is unknown but could simply be natural variation compounded by foot and vehicular traffic.

To the south, scarp [14] turns slightly to run parallel to the west side of the quarter and divides into two separate scarps [18]. The lower eastern scarp may run beneath the ridge to the north of path [6] suggesting it pre-dates it, and also aligns with a slightly stronger, wider scarp to the south [19], possibly its continuation. The upper scarp overlies the ridge and appears to be related to the grown-out yew hedge apparently confirmed by a west facing counterscarp, similar to [16] to the north, though rather slighter.

South of path [6] a west facing scarp [19a] may be a counterscarp to [19]; although it merges with the scarp to the south of path [6] and is aligned with the grown-out yew hedge, its top is set back from it rather than in front of it (as with [16] etc to the north). Slight west facing scarps [20] to the west of the quarter follow the edge of rough ground beneath spreading yew branches and are probably the result of recent traffic, possibly mowing. The area between scarps [18]/[19] and [5] is largely level and featureless, apart from hints of a very slight west facing counterscarp to [5], though leaf litter made this uncertain and it was not surveyed. The 1719 map shows that in the early 18th century a north/south ride ran through here inside the west garden wall and into the woodland to the south. No certain evidence for this was seen and by the 1737 map the whole area appears to have been levelled with small rectangular plots, reminiscent of allotments, arranged in two parallel strips. The division between the two strips appears to have been on the line of scarps [18]/[19] and it seems possible that these date back to this period.

The area to the immediate south of this, is shown to have been open and partially surfaced in the 19th century and it seems several minor features and a north facing scarp to the west [21] may be related to this period, though this is uncertain. The canal to the south-west originally extended further east that today and must have been shortened between 1737 (Rocque map) and about 1800 (inclosure maps), but there is no evidence for the infilled section. A low, broad scarp [22] wraps around the canal, a fairly uniform 8.5m or so from it, and seems to define a low dam reinforcing the end. Low scarps between this and the canal are probably constructional and of limited significance. This dam need not be the same date as the infilling of the canal and could have been added later to improve management of water levels. A modern sluice, several access panels and intermittent gullies and scarps [23], presumably a modern drain running towards Long Canal, suggest that this continues to be needed. This feature continues into the low area to the east as a slight ridge [24], suggestive of a shallowly buried pipe. Steep scarps towards the canal appear to have been recut, no doubt on numerous occasions, though a slight curve out and shallow break in the slope to the north [25] are of unknown origin.

A relatively prominent scarp [26] was surveyed falling away from the east side of the Bowling Green. Presumably this is either the result of levelling when the green was originally laid out (sometime 1702-1719), or has built up during various minor works over the years since; its generally uniform character suggests the former. A series of shallow hollows along the top of [26] are the remnants of a yew hedge removed during the recent development of the garden (around 2012). To the north the scarp returns to the west forming a sharp right angled corner, but is less well defined. To the south, the last 15m of the main scarp reduces slightly in height and width, and a low irregular scarp [27] runs on a slightly different line just to its east. The relationship between these two scarps could not be determined due to a shallow tree hollow with a surrounding spread of material, but there are signs of erosion on both scarps, perhaps by visitors cutting through a gap in the hedge mentioned above; there are no planting hollows immediately above these scarps. To the south, the main scarp splits into two; the upper scarp is slight and returns to the west forming a low but distinct corner mirroring that to the north, and a slightly stronger lower scarp continues to the south. The latter cannot be related to any known map? evidence. Small but well-defined scarps run obliquely across each of the surveyed corners of the Bowling Green, parallel with a recently re-laid gravel path around its edge (the original path dates back to at least 1735). Two relatively young trees (perhaps about 40 years old) have been planted within each of the triangular areas defined by these scarps and some small shrubs planted outside these further defining the corners; some minor irregularities and scarps are probably associated with this work. Nevertheless, these corner features are depicted on the 1719 Laurence map and are likely to be original.

The area between the Bowling Green and the Yew Quarter is occupied by a modern avenue of trees (around 30 years old) and is largely featureless apart from several vegetation hollows (one of which has been mentioned above). These form two parallel north/south alignments, that to the west being longer and comprising seven hollows, that to the east three; only the southernmost of each forms a pair. These alignments suggest an avenue but do not match the existing one, which is narrower and offset to the east, though their orientations are almost identical. All maps that show this area with any clarity show tree planting in this area so it is difficult to suggest a date for these hollows though they may be early; the 1719 Laurence map seems to show an avenue here, and both the 1735 and 1737 Rocque maps show a walk on this line through a regularly planted ‘wilderness’.

Mithraic Glade

Fig 13: Earthwork survey of the Mithraic Glade and area to the south-west, 1:1000 at A4

The Mithraic Glade is dominated by a broad, flat topped ridge [28], running along its western side, up to 13.5m wide and a little over 60m long. It decreases in height from south to north narrowing slightly as it loses height. Though a tree and a tree throw break up its form somewhat, it is otherwise quite uniform. It has a slightly lobed southern terminus, from which it runs straight to the NNW for a little over 35m, turns to the north for almost 20m and then runs more to the NNE for a further 6m. Its western scarp is relatively short, steep and uniform, which contrasts with the eastern, which is much broader and more broken. The terminus appears to be similar to the western scarp, but several adjacent features make it difficult to be sure and a broad gully to the south and east [29] suggests the ridge could have been truncated somewhat. At its north end the western scarp curves to the NNE before curving back more to the NNW but the eastern scarp peters out to the south of this, with the west scarp running across its line. It is unclear if the ridge has been truncated by a separate feature that merges with it or if it simply loses form as the ground level rises slightly towards the path. The latter is perhaps more likely.

The 1719 Laurence map (Figure 3) shows that a watercourse of some sort ran from the north, along what would become the western edge of the glade, southwards to a second waterway. Though the inaccuracy of this map makes it difficult to be certain exactly where, it must have run to the west of this ridge. The general line of this watercourse suggests it could have run on the line of the existing drainage ditch, but was perhaps a wider gully, much disturbed occupying a broader footprint. The ground rises more steeply to the west so it is likely that the gully's east bank lay within the western edge of the glade, closer to the western scarp of ridge [28]. If so, then this might explain the difference in the appearance of the two sides of the ridge; material eroding from the western side of the ridge, by rainfall for example, would be carried away by the watercourse, leaving the scarp uniform and steep, which would not have happened to the east. This suggests that the ridge may have been built up in several phases, now only visible to the east. It also suggests that it is related to this watercourse in some way, probably deliberately constructed for some reason, or perhaps upcast from clearance.

As mentioned above a broad, shallow gully [29], around 8.5m across, runs east from south of the ridge terminus, and then curves to the north-east, but was not surveyed beyond the drainage ditch defining the limit of survey here. Geophysical survey recorded an anomaly running down the centre of this gully (Linford and Payne 2019, Fig 21 – gpr38) but this was much narrower than the gully and did not turn to the north-east, so it seems that any relationship between the two is circumstantial, perhaps both were different attempts to drain the same wet area. Ridge [28] appears to overlie this ditch suggesting the ridge is later than the gully but it is possible the gully truncated the ridge which subsequently slumped into it. The relationship was obscured by some low mounds [30] and a low ridge [31] running south from the terminus of ridge [28] for almost 13m. This appears to overlie the ridge terminus and gully [29] and so must be later than both, and to the east some material may have slumped into gully [29]. A low spread ridge about 10m across [32] in the base of gully [29] appears to approximately match a path shown on late 19th and early 20th century maps. To the north a slight, east facing scarp [33] and north/south ridge [34] appear to be picking up the line of this path once more, though there is no sign of it to the north where it is shown on the map returning to the west. There is also no sign of two paths identified by geophysical survey (Linford and Payne 2019, Fig 21 – gpr34/gpr35), other than in the south where one of the geophysical anomalies aligned with [32] and the path depicted on the OS maps. The only other earthworks in the glade itself are associated with the altar [35] and must either be associated with its erection, thought to have been in 1748, or post-date it.

To the south of the glade a low east/west mound [36], about 17.5m by 8.2m, was surveyed. The southern scarp of this mound is fairly uniform but the northern becomes increasingly spread from west to east. In part this might be the result of a slight fall in the underlying topography but the base of the scarp aligns approximately with the path depicted on early OS maps mentioned above, which may have truncated the mound slightly to its north-west. A tree is growing at its west end and there is a stump at its east end which may make it appear somewhat longer than it was originally. The mound may therefore have originally been squarer than today. It appears to be on the site of the Root House, as depicted on the 1830 sketch map and the 1831 album map (Figures 7 and 8 respectively), though both have limitations, and could be a spread of debris from its demolition or a laid surface more resistant to erosion.

Much of the glade is surrounded by drainage ditches of a similar form. In places these have low banks alongside [37] probably a result of dumping cleared debris alongside them. There are also several places where adjacent scarps suggest erosion into the ditches, some of which are quite large. At a few points gullies [38] show where drains connect beneath tracks. In other places scarps or gullies [39] suggest where a ditch continues as a subsurface drain.

To the west of the glade there is a general fall from the track, which is quite level, towards the drainage ditch along the west side of the glade. Several scarps run along this fall but few could be meaningfully interpreted [not numbered]. Whilst it is possible the lower east facing scarps relate to the earlier wider channel (above), the ground rises slightly from the existing ditch to their bases, their tops are higher than ridge [28] to the east, they do not align well with one another, and their overall line is an awkward match for that shown in 1719, particularly to the north.

The most significant feature in this area is Hutton's Monument which sits on a slightly elevated, sub-square mound [40] with stronger scarps to the east where the fall is greater, than to the west. On all sides, apart from the low western side, there were breaks in these scarps and map evidence suggests that the monument was enclosed and/or surrounded by a gravelled surface during the 19th century and these breaks likely relate to these features. The monument is thought to have been erected before 1740 and a small feature is shown in this area on the 1735 Rocque map, but not on the more detailed 1737 map (Figures 5 and 6). This is probably due to inaccuracy and omission (see below), though it is possible that the monument was taken down and re-erected.

To its north, mound [40] overlies a low, straight, uniform scarp [41], which does not quite align with the existing path. This scarp aligns with scarps to the south, that falling towards the glade at its entrance [42] and another to the south of this [43]. Although separated by some distance, the exact alignment and the straight nature of the scarps suggests a linear feature, running for at least 95m, underlying the existing path and pre-dating the mound. The obvious candidate for this is a long straight ride shown on the 1730s Rocque maps (Figures 5 and 6) but not the 1719 Laurence map or the 1720s Tillemans view (Figures 3 and 10), though the apparent correspondence is not precise. However if the geo-referencing of these maps is modified (by shifting this area about 15m to the south-east) then several other elements fall into place, notably the location of Hutton's monument (above) and the ride running WSW from it. It also aids the interpretation of several features to the south-west (below). Such an adjustment is also confirmed by earlier earthwork survey to the north-west (Alexander et al 2013, 182-7). If all this is correct then a gully [44] and some associated earthworks to the south of the monument, which cut this line, must post date the 1730s, but their origin and function is otherwise unknown.

South of this is a sub-circular hollow [45], set within a second broader, shallower, flat bottomed hollow [46]. The former appears to be secondary to the latter and may have been a tree throw, its larger than average size perhaps due to soft ground. The original shape of hollow [46] is unclear due in part to tree growth to the north-east but its west side is steeper and aligns with scarps [41]-[44], so may originally have been associated with the straight ride of the 1730s. Geophysical survey noted a high resistance anomaly to the immediate south and south-east (Linford and Payne 2019, Fig 21, gpr38) so perhaps the south side of the hollow is in fact part of a ramp created to allow easier access into the glade from the ride, perhaps around 1748 when many of the features here were created. An area of recent earthworks to the south [47], comprising several irregular mounds and hollows, prevents the identification of the south side of this possible ramp. The east side of the hollow was difficult to see due to vegetation but could just be a continuation of scarp [39] thought to mark a sub-surface continuation of the drainage ditch to the north, though with the eye of faith it is possible to suggest that perhaps gully [29] originally continued WNW and curved northwards through this area. Overall however, it seems most likely that the apparent hollow is the conflation of several features.

To the SSE of [47], is another recent mound [48] of material thrown up from an encircling trench, though for what purpose is unknown. East of this is a short north/south gully [49] that appears to curve around to the east leaving a low platform to the north. It was unclear however if this should actually be seen as a separate north facing scarp running east/west across the terminus of gully [49] as leaf litter made it difficult to read the relationship between the two, the alignment of this possible scarp with the north side of a ridge to the west suggests it is possible. To the east, another area of irregular earthworks [50], were probably from a recent tree throw.

South-west

Earthworks across the south-west survey area were all very slight with little variation and apart from a few tree hollows comprised numerous intersecting linear features, including ridges, gullies and isolated scarps.

In the north-east of this area, a slightly irregular, but generally straight scarp [51] was surveyed within dense vegetation defining the glade. This appears to continue to the north-east but could not be surveyed within increasingly dense growth. To the south-west it merges with the outer scarp of the ditch associated with platform [49] which curves away to the west. A low flat-topped bank [52] appears to continue the alignment of the straight section of [51] but is on a slightly different line. This overlies another scarp to the south-west [53] that may more closely match the alignment of [51], but this is uncertain; in both cases the discrepancy is minor. A further scarp [54] appears to continue this alignment and a smaller scarp [54a] beyond this is also on approximately the same line. It appears likely that scarps [51], [53], and [54] represent a single linear feature ([54a] less certainly so), at least 90m long, and that bank [52] is later, though very similarly aligned. From an examination of the mapping it seems likely that the earlier scarps mark the edge of a path/ride shown on the 1730s Rocque maps (Figures 5 and 6), as well as the 1720s Tillemans view (Figure 10). The date of [52] is uncertain but is likely to be a later walk dating from the mid-18th century when there are no known visual sources, perhaps when Jemima Marchioness Grey, and Lancelot Brown under her guidance, are known to have modified the grounds but retained many formal elements.

A low, flat-topped bank [55] to the south of [52] could be of a similar origin and date but as it appears to be more informal, following the curve of the water, it could equally be from any period after its modification by Brown. A low, south facing scarp [56] runs east from scarp [52] but the relationship between the two is obscured by a tree throw. As this runs parallel to the woodland fringe on a route regularly used by gardeners' vehicles it is possible this is a relatively modern feature as the ridge ([65] below) to its immediate west is rather degraded at this point.

To the south-west a low ridge [57] runs SSE from a modern maintenance hatch to an outlet on the north bank of the water to the south. This is clearly a modern service, probably a drain, and its construction appears to have obscured any connection between scarps [53] and [54]. South-west again, a low ESE facing scarp [58] runs over scarp [54a]. To the west of this are two further scarps that appear to form a broad, shallow gully [59] that narrows slightly to the south. It is likely [58] is a counterscarp forming a bank associated with the gully, all the scarps petered out at approximately the same point suggesting similar histories. To the south-west a south-west facing scarp [60] cuts across the west scarp of [59]. Map evidence suggests that the roundel shown in the 1720s Tillemans view and the 1730s Rocque maps should have been in the vicinity of [58]/[59]/[60] (and [54a] suggesting it is not related to [54]). It is likely that whatever activity the surveyed features represent it must have removed all surface evidence for this large feature. Perhaps the feature was less substantial and shorter lived than the historic maps suggest, but sub-surface evidence may survive. This also suggests that features [58]/[59]/[60] post-date the removal of the roundel, which probably took place when Brown remodelled the adjacent waterways in the 1750s. No known visual sources survive from the latter part of the 18th century and these features are difficult to interpret.

To the south-west of [60] several east facing scarps [61] run on curving lines approximately parallel to the south end of Serpentine. The level of Serpentine is almost 1.0m higher than Broadwater to the east, the height difference being managed by a weir, and it is clear that these scarps formed an earthwork dam retaining the south end of Serpentine at this higher level. The earthwork probably dates back to the work here by Brown in the 1750s, but it is clear that it has been eroded by traffic approaching the causeway, formerly Old Bridge, leading to the south side of Broadwater. Another scarp to the north [62] is also probably related to this traffic. To the east of the dam, a moderate fall towards Broadwater [63], above a much steeper recent recut, probably relates to traffic approaching the causeway/bridge from this direction. A small hollow within this scarp is probably a tree throw, but a broader, shallow, squarish hollow to the immediate north of this [64] could not be explained.

To the north a low ridge [65] runs WSW/ENE for almost 75m across most of the open survey area and is clearly one of the latest features here as it appears to overlie all other features surveyed. A flattened section suggests it was cut by a continuation northwards of the service indicated by [57] and its north end is also low and spread, perhaps by modern traffic associated with scarp [56] as noted above. Ridge [65] also appears to overlie scarps [66] and [67] to its north, but these are isolated features and it is difficult to say more about them. Given its appearance and the stratigraphic relationships, a 19th-century date for ridge [65] seems likely, perhaps a drainage conduit.

To the north of ridge [65], is a broad open gully [68] almost 10m across, running 65m north-east to south-west, which was seen to continue to the south-west in the park beyond the Serpentine. This is perhaps the earliest feature surveyed in this area. The south-east side of this gully is formed by a coherent scarp with a very slight change in orientation half way along the surveyed length, but the north-west is more broken up and could not be surveyed within the woodland, though it appeared to continue intermittently here, confirmed by lidar. It is overlain by several other features; in the south-west scarp [62] probably related to modern traffic (above), and a similar scarp to the north-east [69] likely related to modern traffic through the gap between the woodland blocks.

Examination of the lidar for this area revealed little additional information but did suggest that gully [68] may continue to the north of east/west ridge [70] (below), within dense woodland. A north-west facing scarp can be seen running from approximately NGR TL 09026 34660 to TL 09039 34675, a distance of about 20m, before running into mound [47] and the earthworks to its immediate north-east. As with the gully to the south, the north-west side is not clear in the lidar data and a south-east facing scarp to the south-east is perhaps more coherent, suggesting that the primary feature may be a ridge to the south-east of the gully. If so, it is possible that slight scarp [66] surveyed to the south-west is a remnant of this ridge, but the evidence is limited.

Gully [68] is overlaid to the north by a broad flat topped ridge [70], a little over 9m across, which is also related to a route between the blocks of woodland but this is probably older than the current gap between the woodland blocks; it appears to follow a track that skirted the south side of the woodland, shown on maps since about 1800. From about 1830 this appears to have been surfaced and it was depicted on OS maps well into the 20th century. To the west, ridge [70] overlies a low spur [71], apparently truncated on its west side by a second scarp also overlain by [70], though it is possible that this spur consists of material that has accumulated against [70]. The ridge [70] continues west beyond the limit of survey but to the east it peters out, with the northern scarp changing angle as it approaches the start of the track from the Mithraic Glade and the southern scarp weakening, becoming slightly irregular. It is likely that this is the result of neglect leading to a loss of definition of the formerly surfaced path, combined with heavier modern traffic following less well-defined routes. A scarp to the east [72], at the start of the track to the glade, is probably the result of erosion since this route was realigned (see [41] – [43] above), but it is uncertain exactly when this took place or if the route remained fixed. It is possible that the westward return to [72] marks the line of the north side of [70] (which possible continued to the east, see [49] above) and that the scarp to the immediate west has been pushed south by erosion during a period when the route lay more to the west. A mound to the south-east of [72] must be quite recent.

Conclusions

Western Yew Quarter

This is a complex area with evidence surviving from a number of phases of the development of the designed landscape. Its legibility has suffered from this complexity and the effects of previous restoration attempts. As a result of this, it has not been possible to draw out as much of the evidence for earlier layouts from the earthworks as had been anticipated, however this may be improved by taking into account the lidar evidence and any approximate dating of surviving planting provided by the tree survey.

A few general points can be made however. The recently re-laid track to the east of the survey area generally appears to be slightly to the east of its former line, but to the north it lies to its west. It is also following a line only established in the later 19th century. East/west path [6] appears to have been in constant use since at least 1735 and its eastern half, which once lay within the walled garden, may have considerably earlier origins. The current central north/south path [3] is on the line of the Berceau Walk as originally laid out, probably in the earlier 19th century. An earlier north/south ride ran on a line to the immediate west of this, as demonstrated by surviving drainage ditches within the woodland to the south of the survey area. No certain earthwork evidence was seen for this, though scarp [5] may have been related to its eastern edge. In the early 18th century this ran along the west side of the walled garden from the cross walk to the north of the lawns and continued south through the woodlands, beyond the Archer Pavilion. By 1735 the section north of [3a] had been modified and entirely removed by 1737 which may explain the lack of earthwork evidence.

The Yew Quarter is a palimpsest, and restoration to a given period may be difficult due to some restoration/replanting in the immediate vicinity that could lead to further misalignments with the original layout.

Mithraic Glade and south-west

Despite its size ridge [28] did not show up as an anomaly during geophysical survey in 2018 (see for example Linford and Payne 2019, Fig 21). Interpretation of this feature is difficult, but it seems most likely that it was associated in some way with a watercourse shown on the 1719 Laurence map, though this is uncertain.

In the south of the glade, mound [36] is thought to be the site of the Root House and a level area to the north could have been a forecourt. Several other features in the glade probably relate to paths in place by the earlier 19th century. The rest of the glade is largely featureless.

The areas to the north, west and south of the glade were also surveyed and these were more complex. Scarps [41] to [43] and perhaps the west side of [46] are thought to relate to a ride of the 1730s. The mound associated with Hutton's Monument clearly overlies this as well as several other unexplained scarps. The area to the south of the Root House contains several modern features and disturbed areas which has left those features likely to be earlier difficult to interpret.

The open area to the south-west contains numerous slight, generally linear features. Possibly the earliest is gully [68] which can be seen to continue into parkland to the south-west of Serpentine Water and also appears from lidar data to continue into woodland to the north-east. Another early feature, the north side of a path associated with the garden design shown on the 1720s Tillemans view and the 1730s Rocque maps, could be marked out by scarps [51], [53] and [54]. The dam retaining Serpentine [61] is also fairly early, probably associated with works by Brown in the 1750s, though it has been disturbed by later traffic. Most other features are harder to date: [52] may also be contemporary with Brown's works; [54a], [58], [59], and [60] may be from the later 18th century; [70] perhaps earlier 19th century; [65] possibly mid-late 19th century; and [57] is very probably post-war.

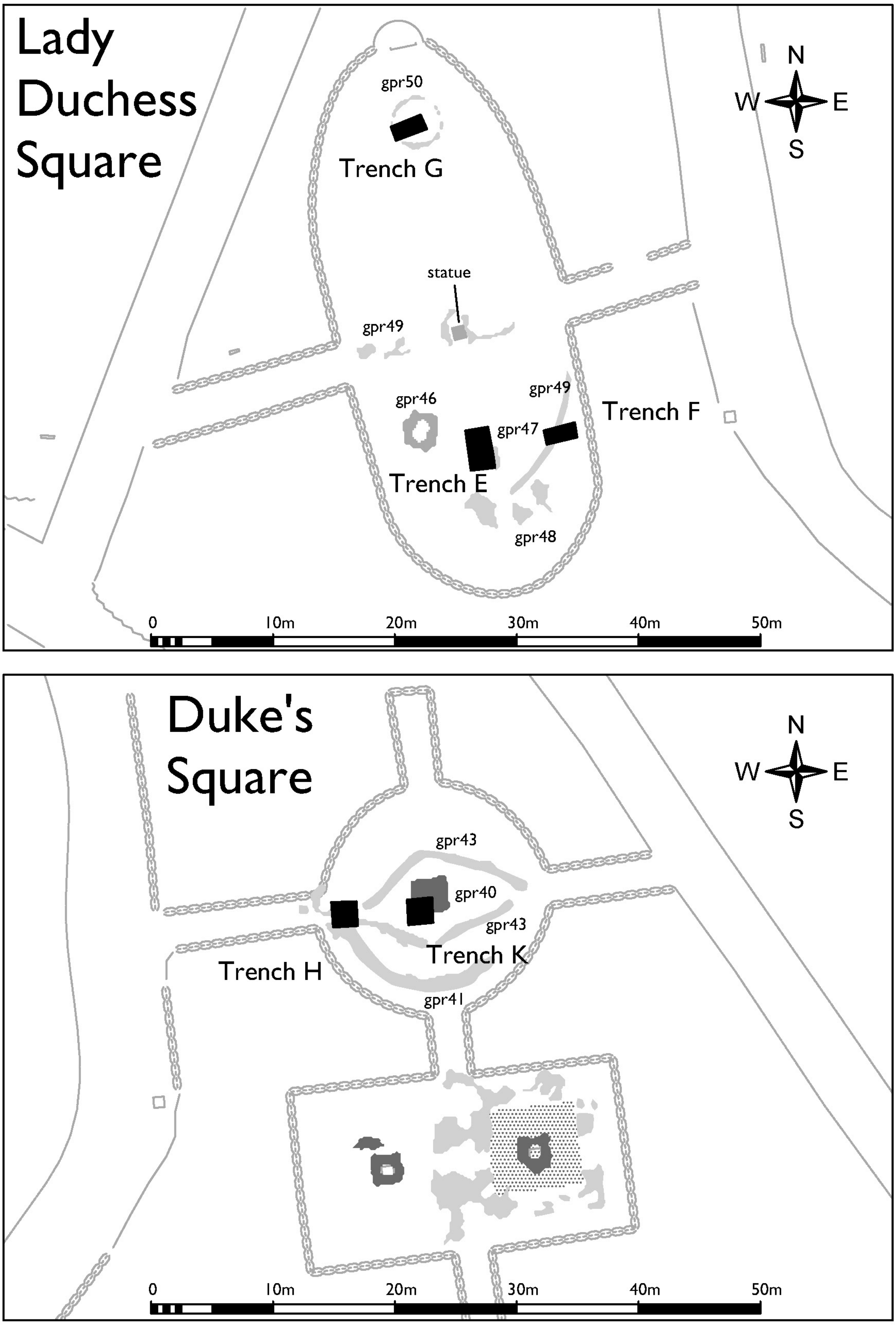

Fig 14: Lady Duchess Square (top) and Duke's Square (bottom) at 1:500 scale, with geophysical anomalies and trench locations. (Base map © Crown Copyright and database rights 2019. OS 100024900.)

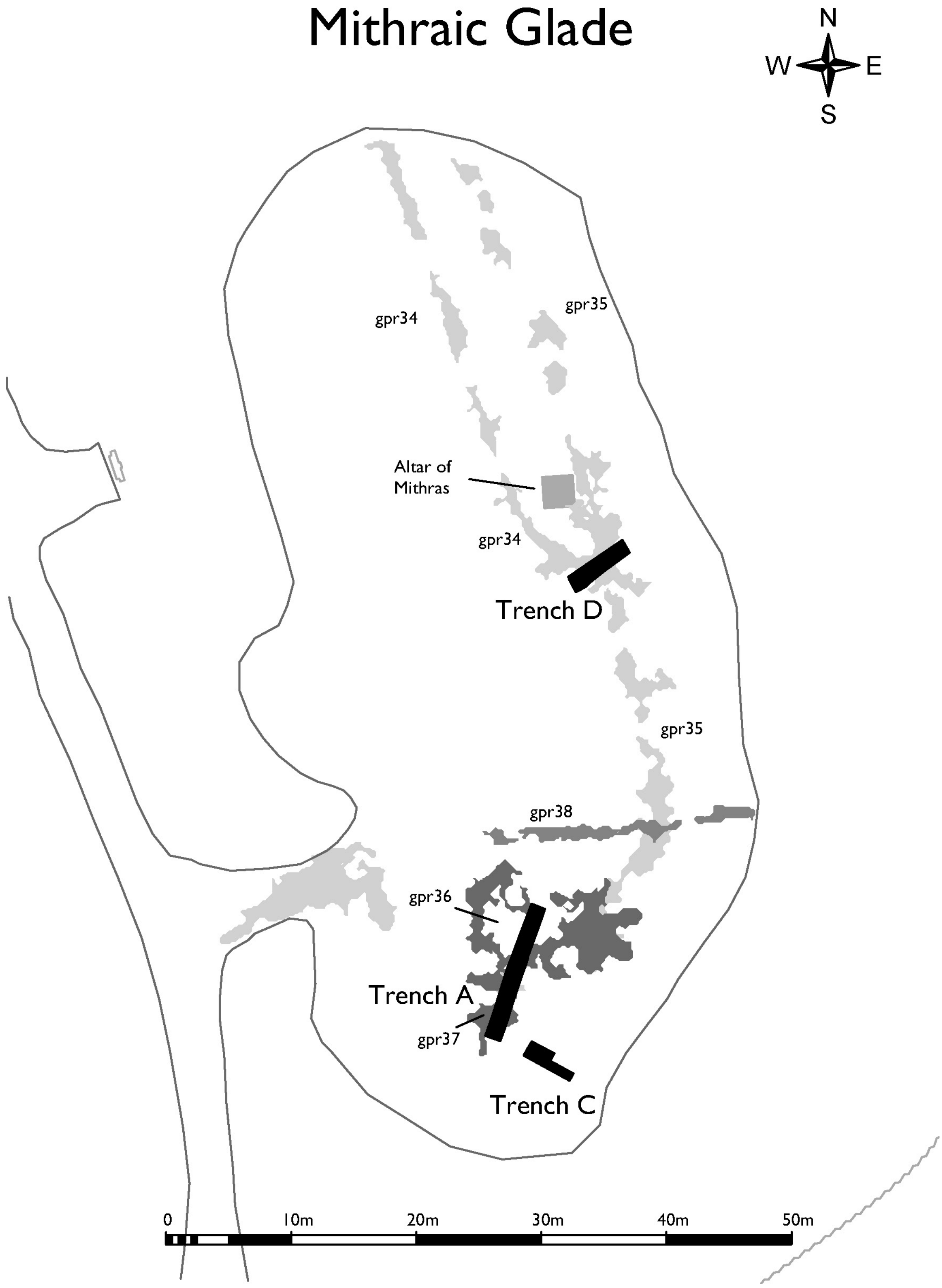

Fig 15: Plan of Mithraic Glade at 1:500 scale, with geophysical anomalies and trench locations. (Base map © Crown Copyright and database rights 2019. OS 100024900.)

Trench narratives – Thomas Cromwell

Trench A

This north-south trench within the Mithraic Glade was placed to cross through two rectangular geophysical anomalies (Linford & Payne 2019, gpr36 & gpr37, hereafter referenced as "gpr##") that were thought to be possible reflections of the root house constructed in the 1740s and sketched in the 1830s (Hann). As the two anomalies were laid out one directly north of the other, the trench passed through the middle of both. Two east-west trenches [trenches B & C] were proposed to cross trench A at right-angles passing through the northern and southern anomalies respectively. In this manner any surviving walls or floors would be sampled allowing for the exact plotting of buildings.

There was approximately 0.15m of dark organic topsoil to remove. Topsoil [context number 90102] contained three fragments of mortar, and 12 fragments of ceramic building material – one part-glazed tile fragment with attached mortar, six tile and mortar fragments, and five brick fragments. Also present here were two fragments of glass, a fragment of clay pipe stem, and a small spherical pebble, as well as animal bone including two sheep/goat metatarsals and other fragments, some possibly from metapodials also (SF3004, 30102-30117, all Finds hereafter referenced "SF##"). Some of these and other bones from Trench A and C have been radiocarbon dated (see below) and are contemporary with the known life-span of the structure (see Appendix 4) – the two sheep/goat metatarsals (SF 30104 and SF 30115) from [90102] have radiocarbon dates, 200 +/-22 BP (1800-1844calAD) and 208 +/-19 BP (1795-1833calAD) respectively.

Below that at the north end of the trench natural clay was found, ruling out any structure causing the northern anomaly [gpr36]. Cutting across the trench was a thin gravel spread [90104] pressed into the surface of the clay, approximately 1m wide, containing a sheep metatarsal (two fragments, SF3005 and SF30118, with SF3005 having a radiocarbon date, 228 +/-21 BP, or 1773-1815calAD) and a further large mammal longbone fragment (also recovered as SF3005). This gravel also overlaid a deposit of clean orange sand [90113] running south across the central section of the trench, varying in thickness up to 0.10m at its southern extent. This was interpreted as the path seen in early mapping and the 1830s sketches.

At the south end of the trench there was a 0.25m thick rubble deposit [90103] of brick fragments and mortar that was bounded on the north by brick footings [90105] of an east-west wall that stood in a construction cut [90106] that was filled on the north side by a mortar and brick deposit [90115] that extended out north over natural clay. On top of this was a rubble deposit [90114] sealing the space from the wall northwards to a line of brick edging [90116]. The sand layer [90113] ended at the brick, and was overlain by the rubble [90114].

Deposit [90103] had the appearance of either demolition waste from a brick wall, or hardcore deliberately laid down as a floor foundation. Below it was natural clay, with the clay surface at the same OD height as the clay at the north end of the trench. The deposit contained a single fallow deer metacarpal (SF30101) with adhering mortar and a radiocarbon date of 107 +/-22 BP (1893-1937calAD), and a medium mammal size rib fragment (SF3007), a water-worn pebble, a fragment of brick with attached mortar, and a fragment of industrial debris. Also collected were two iron door brackets, SFs 3001 and 3002.

It appears that trench A had brick foundations for a structure that then had a sand path running in front, with some gravel added as a separate episode at the edges of the sand path. The rubble at the south between the sand and the structure may tie in with maps that show the building set back from the path with an apron leading to the door.

Confirmation of a building defined by the walls in trenches A & C was a surprise given that a mature yew tree now stands in what must be the centre of the structure, and a more promising GPR shadow was seen at the north end where trenches A & B crossed. Several young yews appear in the 1830s sketches of the root house, with one still standing west of the building as a veteran tree and a second one represented by the stump of a tree throw to the east. Whether the tree in the house was a deliberate planting post-demolition or a self-seeded child of these older trees is a matter of debate, but it must have taken root not long after the building was demolished.

Fig 16: Wall foundation 90105 in Trench A.

Trench B

Not excavated. The natural clay in Trench A indicated that there was no need to explore the northern anomaly further.

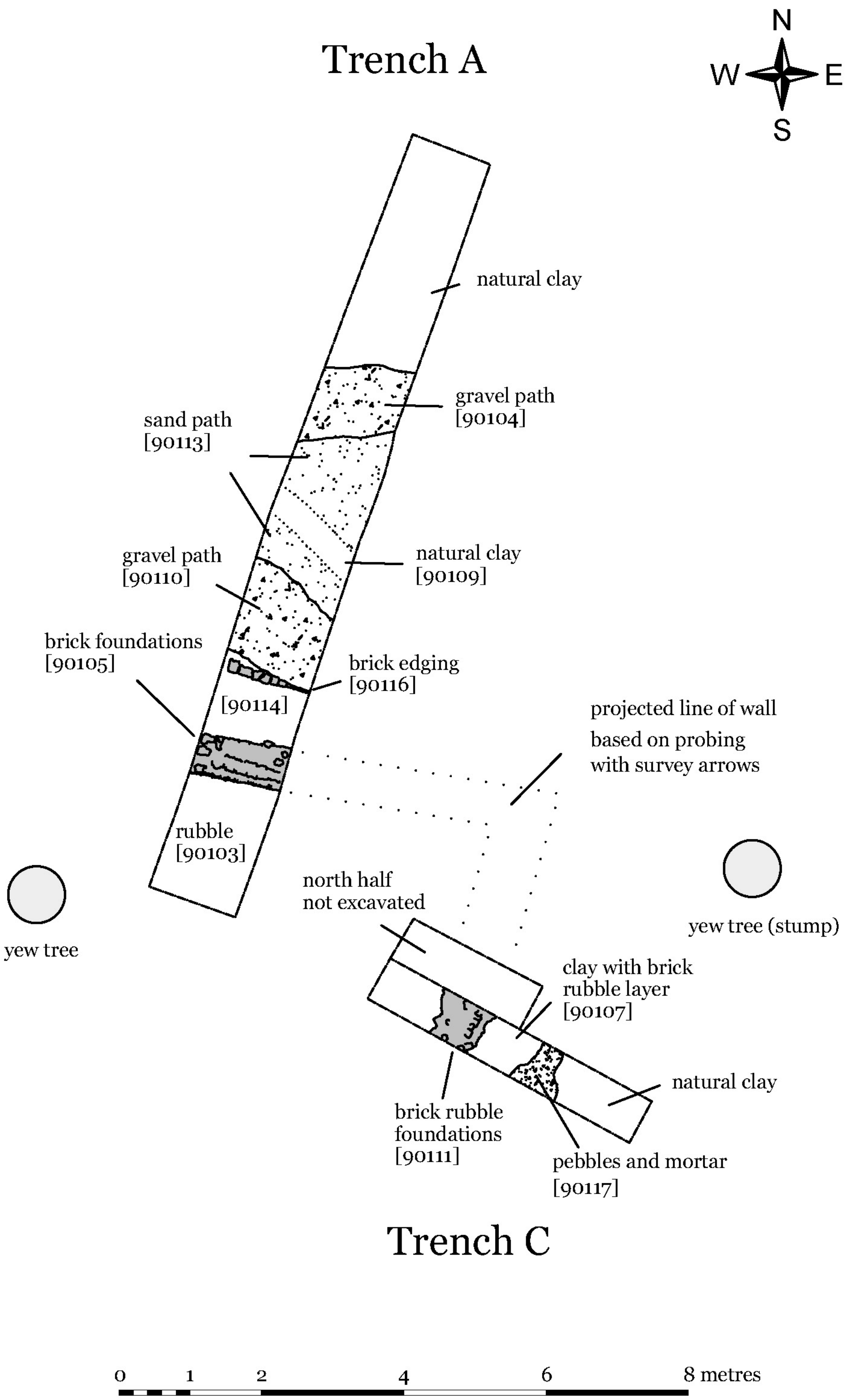

Fig 17: Plan of Trenches A & C at 1:100 scale.

Trench C

This trench cut east-west across the southern potential root house anomaly, and was opened once trench A had demonstrated the existence of structural features in this location. Only the eastern arm was opened, centred on where the geophysics suggested a wall might be located, and then it was extended accordingly. The western arm was occupied by the roots of a mature yew tree and thus was not available for excavation.

Below the topsoil [90101], from which a large iron nail (SF3003), a fragment of glass, a fragment of industrial debris, a pebble (SF30121), a fragment of tile with mortar, and two animal bones including a fallow deer metatarsal (SF30120, radiocarbon date 127 +/-21 BP or 1874-1916calAD) and medium mammal longbone fragment (SF3006) were collected, a thick layer of rubble [90107] was uncovered, containing 11 fragments of glass and a fragment of cream stoneware pottery. It faded out to the west, where it was overlain by a brown silty soil with mortar fragments [90108], from which were collected two fragments of glass. Excavation of the rubble revealed it sealed a brick-rubble linear structure [90111] running north-south, interpreted as a foundation for a wall. The west side of the structure was distinct, but the east face was a jumble of brick and mortar fragments, suggesting at least partial robbing during demolition. West of the wall was a clay layer [90112] that underlay the rubble and filled the lower part of the trench at its west end – from here was collected a cream stoneware base sherd, and 11 fragments of glass – some of which may be as early as 17th century. This came down to natural clay approximately 0.5m below the turf. East of the wall a surface of decayed mortar with pebbles [90117] was found sitting on the natural clay, extending approximately 1.25m from the wall, although the exact distance from the wall is impossible to judge due to the damaged east face. A thick deposit of silty clay [90118] covered the surface [90117] and extended east to the end of the trench, getting thicker as it went. This was possible evidence for landscaping after the building had been demolished. It contained ten fragments of glass, a fragment of brown stoneware pottery (a fragment of probable flowerpot was also found in this context), a single animal bone fragment (SF3008 identified as probably red/fallow deer through ZooMS analysis, Presslee (2023) , radiocarbon date 237 +/- 22 BP or 1763-1807calAD), and six pebbles; one pebble with mortar SF30119 from [90117] was also collected – these may all be from a possible floor surface.

Fig 18: Wall foundation 90111 in Trench C.

Trench D

Placed south of the Mithraic Altar to examine the intersection of two linear features, this trench started with 0.15m of topsoil [90401] that came down onto a layer of clean orange sand [90403] across the east half and natural clay [90404] across the west half. This coincided with the north-south linear anomaly [gpr35] that turned out to be a sandy path with no made edging of any kind. Cutting across the clay and sand running NW-SE was the cut of a pipe trench [90405, gpr34] filled with a mix of clay, gravel, and brick fragments [90402] to aid drainage and a fluted extruded ceramic land-drain pipe [90406] taking water across into the "goose foot" lawn south of the Archer Pavilion. No finds were collected from within Trench D.

Fig 19: Ceramic land drain and sand path in Trench D.

Trench E

Southern-most of three targets in the Lady Duchess Square, this trench examined a square anomaly [gpr47] that was likely the site of a statue seen in early sketches. This was the original Lady Jemima statue, now represented by a replica in the centre of the space. Deturfing soon revealed the anomaly to be a large square block of concrete [90501] of probable 20th century origin, with a pattern of lime mortar deposits [90509] on top that showed the original location of the plinth slabs currently under the replica – it had been located on this concrete block at some time before it was moved to the centre of the Lady Duchess Square. This ties in with the history of statues at Wrest Park being moved to another estate before some were returned after WW2. It is not clear whether the concrete entombs an earlier foundation structure. Two intersecting land-drain cuts were found [90503 & 90504] cut into the natural clay, with the earlier one [90503] running up to the concrete block that clearly truncated it. Drain [90504] was excavated to reveal a smooth ceramic drain pipe [90512] of likely late 19th/early 20th century origin. 876g of industrial debris was collected from backfill [90506], probably used as packing around the drain pipe.

Fig 20: Land drains and concrete base in Trench E.

Fig 21: Sand path in Trench F.

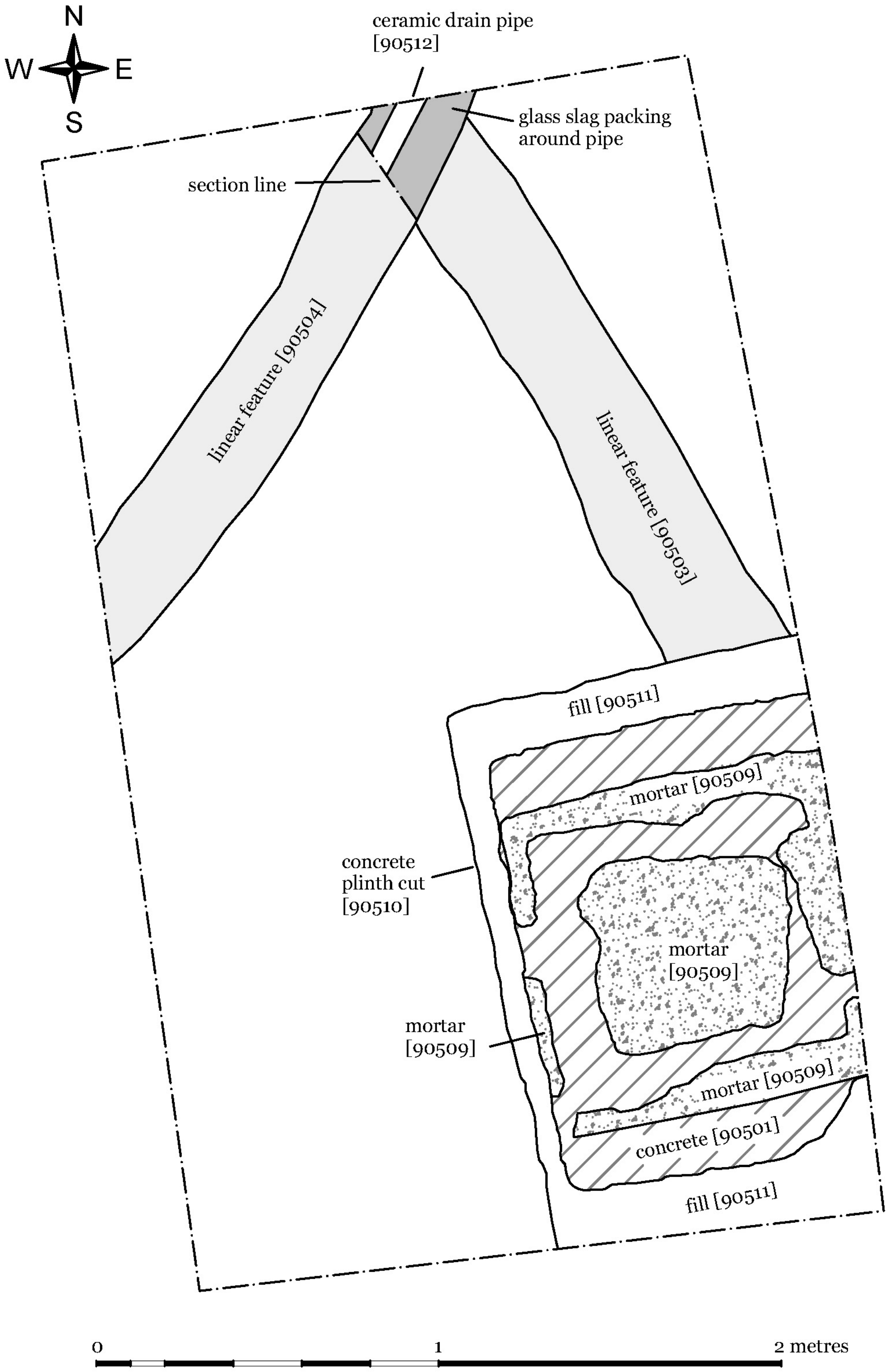

Fig 22: Plan Trench D at 1:20 scale.

Trench F

This was intended to test the path-like anomaly [gpr49] running down the east side of the Square. Early plans and sketches showed a path around the inside of the perimeter hedging. Below the turf a layer of orange sand [90603] similar to the sand in trenches A, D, G, and H was found, again with no made edging between it and the natural clay. This was clearly a perimeter path. No finds were collected from within Trench F.

Trench G

Anomaly [gpr50] showed as a ring in front of the enclosed curved seat at the north end of the Lady Duchess Square, and this trench was placed to examine it. On arrival it was clear the ring feature was the edge of a circular depression in the lawn, possibly from an old tree throw. Following the line of the anomaly there was a gravel deposit [90706] running across the west end of the trench. The centre of the trench was mottled by irregular linear dark features [90705] interpreted as rotted and decayed tree roots, set in a sandy deposit [90703] that overlay the natural yellow clay. It appears a tree was planted in front of the bench, surrounded by a gravel surface, and then removed presumably after falling over. There were patches of what appeared to be burnt wood within the root features, suggesting the tree stump may have been burned out to facilitate removal. A charcoal sample from within the roots was identified as mature holly (Ilex aquifolium L.) No finds were collected from within Trench G.

Fig 23: Tree root stains and sand deposit (top) in Trench G.

Trench H

This was sited at the west entrance into the Duke's Square to examine a curved anomaly [gpr41] that looked like a fragment of the perimeter path shown in 1830s sketches, and east-west linear anomalies [gpr43] that cut across the Square while bracketing the central plinth base [gpr40] in a lozenge shape. Below 0.15m of topsoil [90801], within which was found a single flint, was a layer of orange sand [90802] covering most of the trench, with natural clay exposed at the east side where the sand ran out. There was no edging material to contain the sand despite having a clear edge, implying it was deposited onto the clay in an area already stripped of turf, with the edge of the turf removal forming a boundary. This was interpreted as the circular perimeter path seen in 1830s sketches of the Square. Cutting through the clay, and running under the sand, was a linear clay-filled [90803] cut feature [90806] containing a land drain [90805] made of segments of ceramic pipe. 1265g of industrial debris was collected from [90803], probably used as packing around the drain pipe. Below the sand, and cut by the drain, was a thin layer of gravel [90804] pressed into the natural clay – this was interpreted as an earlier path material.

Fig 24: Ceramic land drain in Trench H.

Trench K

Placed in the centre of the circular northern part of the Duke's Square, this trench exposed the foundations of the plinth that stood here in early sketches, before the plinth and the obelisk on top were removed. The brick base [90904] was visible through the turf, so the trench was intended to examine its form. Below the usual 0.15m of turf [90901] a layer of brick and mortar rubble fragments [90903] sealed the foundations as well as the natural clay into which the foundations were cut. This appears to be demolition from something nearby, but it was not possible to tell if it came from the monument that once stood on the spot. Rubble dump deposit [90902] contained four fragments of white china pottery, two fragments of glass, and a single flint. The foundation cut [90905] was filled by the brick structure and then by clay [90906]. The brick structure appears to have been two separate episodes of construction, with a large square base four courses high that was only exposed in part – the part in the trench was 1.5m x 1.5m, but extended out and may be 2.5-3m square overall. This was well-built, with alternating courses of headers and stretchers. Set back 0.5m from the edges was a second stage consisting of a single layer of bricks, and it was square on to the edges of the base. This was no doubt the foot of an original plinth rising off the foundations. In turn it was capped by two courses of brick forming a rectangular pad that was off-centre to the underlying structure, suggesting it was a later addition during a re-modelling of whatever stood on top.

Fig 25: Brick footings in Trench K.

Lady Duchess Square addendum

The statue of Lady Jemima reading a book was taken to Coles Park in 1932 when Mr Murray (then owner of Wrest Park) built his new house (Alexander et al 2013, p79). It was recorded by the Ministry of Works in 1954 when Coles Park was being demolished, and then was moved back to Wrest (Alexander et al 2013, p80). Once it was determined that the existing statue of Lady Jemima had been erected in trench E on its return to the garden before being relocated to its current position in the centre of the Square, metal survey arrows were used as probes to examine the foundations without excavating at the base of the plinth. Solid masonry was encountered less than 0.2m below surface, extending out approximately 0.5m from the upstanding plinth in all directions. This was almost certainly the base for an earlier plinth, seen in the 1830s sketch with an obelisk on top. No doubt the Lady Jemima statue was first erected on its original location – albeit on a newly-poured concrete base – before being moved to the centre to create symmetry. Perhaps at first it was hoped that the obelisk that had been removed to Trent Park in 1934 (Alexander et al 2013, p79) was to be returned as well?

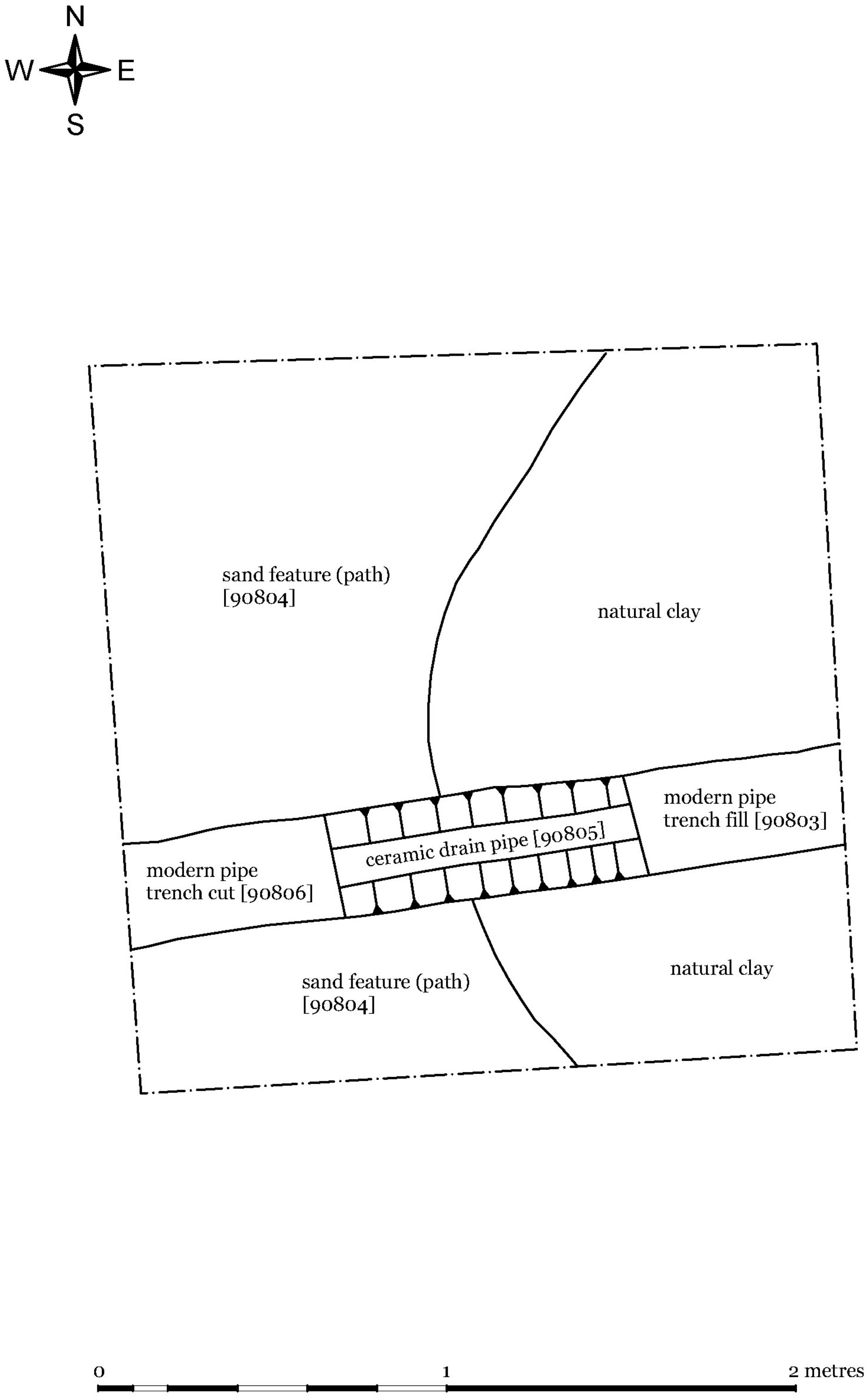

Fig 26: Plan of Trench H at 1:20 scale.

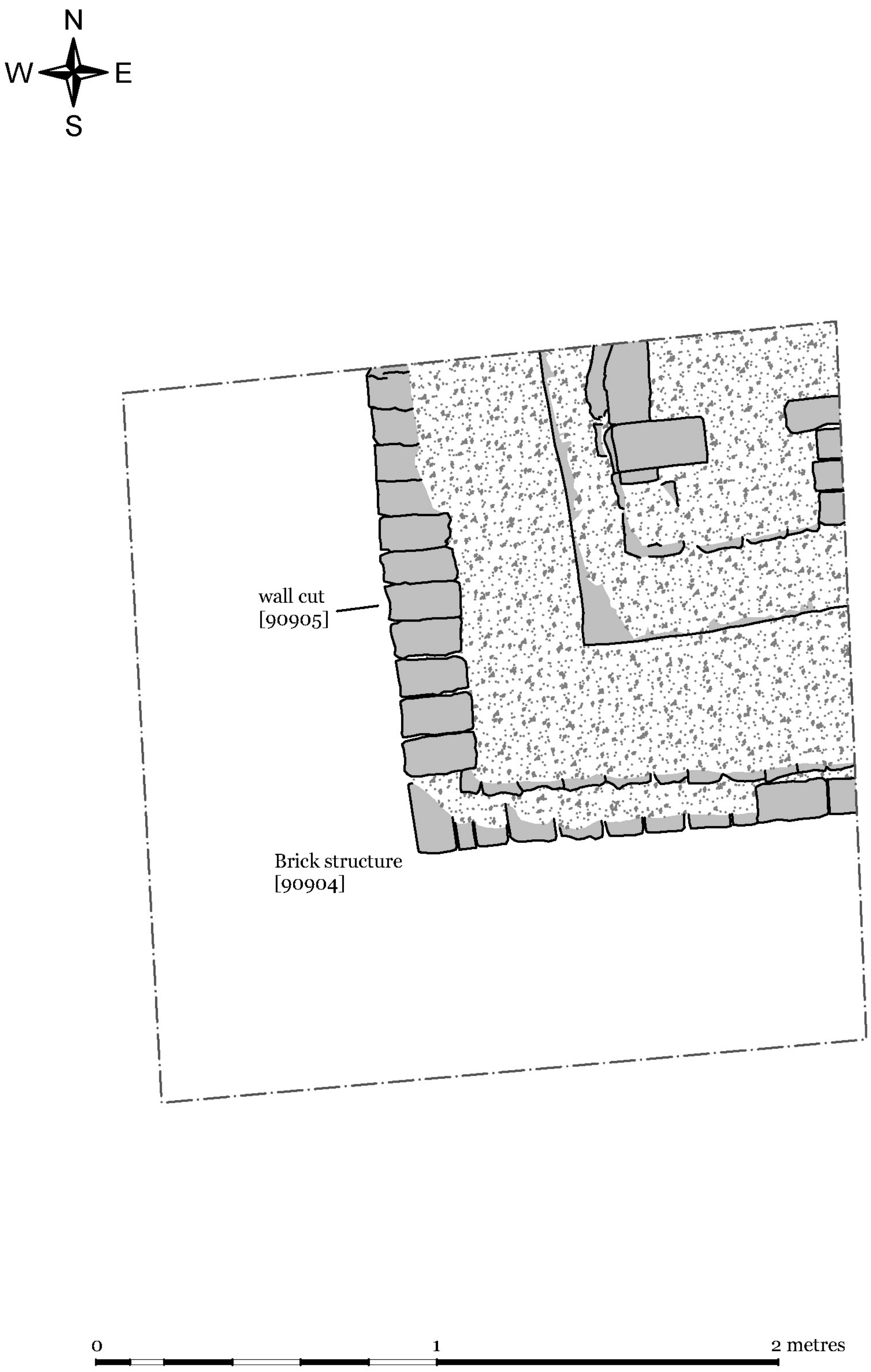

Fig 27: Plan of Trench K at 1:20 scale.

Phasing

Despite the small number of contexts it was possible to create a number of Structural Groups and Phases, as indicated in the matrices in Appendix 1. These were designated by trench rather than as a whole-site phasing because of the scattered nature of the trenches and lack of independent dating evidence that might support cross-trench linking.

Trench A

There were five phases of activity, stating with the natural clay (phase A0) followed by construction of a brick foundation wall and sand path deposit (A1). The wall and its associated contexts formed a Structural Group (SGA1). This was followed by the gravel against the wall (A2) and then demolition-related deposits (A3) followed by recent topsoil (A4).

Trench C

Four phases were recorded starting with a wall and mortar surface (phase C1) that was capped by a silt deposit (C2) and then demolition-related rubble (C3) and finally topsoil (C4.) The presence of potentially early glass (see below) in C1 and C2 deposits suggests a pre-Root House structure nearby, or importation during construction.

Trench D

Four phases in this trench started with the natural clay (phase D0) and sand path deposit (D1), cut by the Structural Group (SGD1) for a land drain (D2), and capped by topsoil (D3).

Trench E

The natural clay (phase E0) was first cut by a land drain (SGE2, phase E1) followed by a second drain (SGE4, phase E2) and concrete plinth base (SGE3, phase E2) and capped by topsoil (E3). The base of the existing Lady Jemima statue (SGE1) was recorded as part of Trench E, but is not phased because it does not link directly to the trench and was only explored by probing rather than excavation.

Trench F

As this trench had only one archaeological feature – a sand path – it was recorded as three phases, the natural clay (F0), the sand (F1), and the topsoil (F2).

Trench G

Starting with natural clay (phase G0), there was a phase of tree activity (G1) followed by sand and gravel landscaping (G2) and topsoil (G3).

Trench H

Natural clay (phase H0) was overlain by gravel forming a path (H1) which in turn was cut by a land drain (SGH1, phase H2). This was sealed by a sand path deposit (H3) and then topsoil (H4).

Trench K
Natural clay (phase K0) was cut by the construction of a brick plinth base (SGK1, phase K1), which was sealed by demolition rubble (K2) and then topsoil (K3).

Overview of the Artefacts - Nicola Hembrey

The assemblage of material from Wrest Park was modest in nature, as might be expected from a limited garden excavation. Most finds came from rubble dumps and as stray finds in topsoil.

Structural evidence consists of mostly ceramic building material, and some mortar; the brick and tile is post-Medieval in date. Window glass was also present in small quantity.

Industrial debris was found during the excavation, used as packing around land drains in order to percolate water in the absence of local gravel. There would likely have been a blacksmith somewhere on the estate.

A small assemblage of animal bone was present on site in the area of the possible root house. Many of these bone fragments are straight and splintered, possibly deriving from distal limb bones including metapodials, which may have been used as elements of a bone floor (see Baker, below; see Gherardi below for analysis of mortar adhering to one of the metapodials). In addition, several pebbles were found, one of which had mortar adhering; these pebbles may also have been elements of a floor, and would likely have had to have been brought on to the site from elsewhere. There is a known bone floor comprised of pebbles and animal bones in the bath house at Wrest Park (Kewley 2018).

The metalwork assemblage was very small, consisting only of three iron items. These comprised a single large structural nail (SF 3003) and two pieces of iron strip, SFs 3001 and 3002, the latter perforated by a small in situ nail. Both of the strip fragments are bent at a right angle and may represent binding or strengthening strips from a door or from an item of wooden furniture such as a chest.

A small quantity of vessel glass was present, including some datable post-medieval wine bottle fragments as well as shards of more modern glass. The typology of the glass is discussed by Cubitt (below) and the chemistry by Gherardi (also below).

A tiny assemblage of pottery was present on site, of post-Medieval date (see Brown, below). The only personal object retrieved was a fragment of post-Medieval clay pipe stem, and possibly the small spherical pebble.

Two flints were recovered, both from the area of the Duke's Square and have been reported on by Bayer (see below). Only one is a worked lithic, but constitutes an undiagnostic and undatable fragment.

Pottery – Duncan Brown
Four contexts produced an assemblage of eight small sherds, representing six vessels and totalling 42 grams in weight. All the pottery was characterised by ware type and vessel

type and quantified by weight in grams, sherd count and vessel count. Recording took place in July 2020, with data entered directly into a spreadsheet in Microsoft Excel that has been submitted for inclusion in the project archive.

Table 1 shows the range of types present in each context. The English white stoneware in Context 90107 is probably 19th century in date. It has a yellow-grey tinge to the salt glaze and is relatively thick-walled. Context 90112 produced a sherd of fine white English stoneware that could be 18th century. It is a fragment of a recessed base from what was probably a small jug. From Context 90118 came a body sherd from a flower pot and a fragment from a mug with a brown lead glaze and combed horizontal lines. The hard yellow fabric of the latter is typical of 18th century Staffordshire products. Context 90902 produced four fragments of white refined earthenware. Two rim sherds, from a dish or plate, fit together and another small body sherd is likely to be from the same vessel. An additional small, unrelated fragment is a slightly finer product. All these are likely to be 19th century but an earlier date is possible.

Although these finds provide a *terminus post quem* for the contexts that produced them they are so small and few in number that they are all highly likely to be residual. Given that the contexts in question are all layers or dumps this is even more probable and these finds can provide little to aid either chronological or socio-economic interpretations.

Table 1: The composition of the pottery assemblage by context and ware type.

Context	Ware type	Vessel type	Weight (g)	Sherd count
90107	English white stoneware	Unidentified	9	1
90112	English white stoneware	Unidentified	9	1
90118	Flower pot	Flower pot	6	1
90118	Staffordshire brown-glazed earthenware	Mug	4	1
90902	White refined earthenware	Dish/plate	13	3
90902	White refined earthenware	Unidentified	1	1
Totals			42	8

Vessel glass – Rachel S. Cubitt

Thirty-two fragments of glass were recovered from seven separate contexts. The majority of this assemblage comprises sherds from post-medieval vessels (n=25), and for the most part these are body sherds from wine bottles dating to the 17th to 19th centuries, and corresponding to the HLLA glass identified by Gherardi (see below).

Contexts (90102) and (90107) both include single small fragments from the bases of post-medieval wine bottles, for which a more refined date can be tentatively offered. The base fragment from (90102) is most likely part of a dome-shaped, pushed-up base with rounded heel, belonging to a Cylindrical wine bottle dating to the period 1735-1830 (Dumbrell 1983; Jones 1986, 95 fig 66). The fragment from (90107) is more difficult to categorise but may be from a Shaft and Globe or an Onion bottle, giving an overall date range of 1660-1730 (Dumbrell 1983).

In addition, context (90118) produced a rim/neck fragment from a free blown bottle with a beaded rim in a blue/aqua colour, probably dating to the 19th century. Bottles with this type of rim finish were used to contain a wide array of substances. Analysis by Gherardi indicates that this vessel was also made in HLLA glass (see below).

Seven fragment of vessel glass within the overall assemblage are modern in date. These include green wine bottle fragments from (90107). Context 90902 produced only modern vessel glass fragments - a colourless body sherd from a milk bottle and a fragment of brown glass, which may be from a beer bottle or foodstuff container. Both of these are likely to be of 20th century date.

Flint – Olaf Bayer

Two pieces of flint were submitted for assessment, one a non-artefact and the other a single individual undiagnostic fragment.

A single unworked chunk/piece of angular shatter was recovered from context (90902). Weight 13.3g, dimensions 36 x 27 x 16mm, struck from a mottled mid-dark grey flint with a weathered (not water-worn) nodular cortex. This piece is unlikely to be a prehistoric artefact and shows no definite traces of deliberate working. It could possibly have been imported on to the site as part of aggregate for landscaping.

A single possibly utilised/notched flake was recovered from context (90801). Weight 8.8g, dimensions 36 x 26 x 8mm, struck from a course grained light brown flint with mid to light grey inclusions and retaining no dorsal cortex. There are two areas of possible modification at its distal end isolating a point. Viewed on its dorsal side, there is a single diagonal snap at its right hand distal end. The left hand distal end has what looks like a single concave removal with possible traces of wear/utilisation on its inner edge. Several very small removals on both lateral edges are likely to be the result of post-depositional damage rather than utilisation or deliberate retouch. This artefact is the product of a flake-based technology, however, it is not possible to suggest a date.

Environmental evidence - Gill Campbell

A single piece of charcoal (sample 50701, context 9070) was recovered from a line of tree roots possibly representing former planting in Trench G. The fact that charcoal, as opposed to uncharred rootwood was present in this feature suggests that when this planting was cleared the resulting wood was burnt in ordered to dispose of it.

The single piece of charcoal was identified using standard procedures as mature holly (Ilex sp.) from a large branch or trunk; the growth rings being almost parallel. The fragment was examined in three planes (transverse section (TS), radial section (RS) and transverse longitudinal section (TLS) using a high power light reflecting microscope at magnifications of x100 to x500. Identification was carried out using a combination of publications (Schweingruber 1990; Gale and Cutler 2000; Hather 2000) and Historic England's modern comparative charcoal reference collection held at Fort Cumberland, Portsmouth.

It is not possible to establish from this single fragment whether the charcoal observed within this feature is from a single tree or whether a number of different types of tree/ shrub and individuals are represented within the fill of this feature.

Holly is planted in gardens to provide shelter, as a hedge and for its berries (Mitchell 1978, 315). Although generally described as a shrub or small tree growing up to 23 metres, individuals of 250 to 300 years in age are not unusual (Peterken and Lloyd 1967: Stace 1997, 456).

Animal bones - Polydora Baker

A small assemblage of 40 animal bones was recovered during excavations in the Mithraic Glade at Wrest Park in 2019. The investigations were undertaken by Historic England (HE) in collaboration with English Heritage Trust and directed by Tom Cromwell (HE). One of the aims of the analysis was to determine if the animal bones derive from a bone floor, documented historically for the Root House (1748) which was built in this area of the gardens but long destroyed. There is other evidence for the use of animals and animal bones at Wrest Park in the extant bone and pebble floor in the Bath House (1769-70) located *c.* 600m northwest of the Mithraic Glade (Kewley 2018; Armitage 1989a; Baker 2019), as well as from a small assemblage of animal bones from levelling deposits pre-dating the 1830s, under the parterre of the new Wrest Park House (Alexander et al 2013; Baker 2013). The 2019 assemblage is stored in a skull-size box (HE0103 Box 6; 250x180x165mm) at Historic England, Fort Cumberland, Portsmouth, UK, PO4 9LD.

Background: bone floors and bone waste at Wrest Park

Details gleaned from various historic documents including contemporary letters of the architect Thomas Edward, the owner Marchioness Jemima de Grey and her daughter Amabel suggest that considerable interest was taken in the original construction of a decorative floor in the Root House, and its later state of repair in the early 19th century (1801, 1820s; Hann 2021; A Hann pers comm 2021). The design was to include pebbles, horse's teeth and sheep's trotters. Here, 'trotters' is a term used for metapodials, which are part of the foot but form the lower leg in hooved animals. These along with other bones and teeth of cattle, sheep and horses were used to create, sometimes eye-catching, patterns in walls and floors of post medieval buildings including in urban centres and rural estates (Armitage 1989a, 1989b; Divers 2002; Yeomans 2017; Ward et al 2019). At Wrest Park, Edward advised that the teeth and bones could be obtained from 'anyone who keeps hounds and fellmongers' (Hann 2021, 21). The mortar used to set the whole is described as consisting of 'one part of terras, two parts of stone lime, and one sixth of brick dust with serum of blood.'" (Hann 2021, 22). Finally, once completed "'the pavement was to be black varnished using sealing wax dissolved in rectified spirits of wine, then painted over with plain oil to set the colour'" (Hann 2021, 19).

Recent study of the Bath House indicates that fallow and red deer metapodials exclusively were used to decorate the pebble and bone floor, but it is not known if the current floor includes original materials (Armitage 1989a; Baker 2019). A fallow deer metatarsal and humerus were present in the parterre assemblage, along with bones of cattle, sheep, pig, rabbit and medium Galliformes (chicken/pheasant/guinea fowl) (Baker 2013). The array of species and skeletal elements which include meat-bearing body parts, along with evidence of butchery on many specimens including the fallow deer humerus, suggest the assemblage derives mainly from food preparation and consumption waste, though the fallow deer metatarsal could also have derived from or been intended for structural use.

Aims

This analysis aims to

- Characterise the remains from each context and trench
- Identify skeletal elements and modifications that might help to further characterise the assemblage or individual remains
- Consider if the remains derive from domestic butchery, table waste or specialised use

Methods

All of the bones were hand-collected, assigned small find numbers and geo-referenced during excavation. The single environmental sample did not yield any animal bones. The entire assemblage is fully recorded in a zooarchaeology database. All bone and tooth fragments were identified to taxon where possible or where specific identification was not possible, to taxonomic class and size (*eg.* large mammal/cow size; medium mammal/sheep size). The bones were identified using the Historic England Zooarchaeology Reference Collection, and diagnostic including biometric criteria for fallow deer (Lister 1996) and sheep and goat (Salvagno 2020). One fragment selected for radiocarbon dating was also identified to taxon by ZooMS (Preslee 2023, Appendix 5). Bone zones were recorded where more than 50% of the diagnostic zone was preserved (after Serjeantson 1996). Bone fusion ages are after Popkin et al. (2012) for sheep, and Carden and Hayden (2006) for fallow deer. Measurements were recorded following Davis (1992), Driesch (1976) and Popkin et al. (2012).

Condition of the bones was carefully examined and recorded according to their general preservation, sharpness of fragment edges (angularity) and fragment completeness. The bones were also examined for erosion, root etching, weathering, animal gnawing, butchery, use wear and recent breakage. In some bone floors, trampling has resulted in smoothing of the exposed bone surfaces, with partial or complete wear of metapodial distal condyles (for example, see Divers et al 2002; Baker 2019). Exposure of the floors can lead to further deterioration of bones and teeth from weathering and destruction from rodent gnawing (Baker 2019).

Six bones, two fallow deer, one probable red/fallow deer, one sheep, and two sheep/goat, were selected for radiocarbon dating in order to investigate if they could be contemporaneous with the post-medieval bone floors and animal management at Wrest Park or if they might derive from modern materials. All of the specimens are isolated finds, ie with no associated or articulating parts/elements and thus cannot provide definitive dates for the archaeological contexts themselves. All, however, give results compatible with the known construction date of the Root House and Bath House in the mid and late 18th centuries, and lifespan of the former through to the 1830s, and possibly the late 19th c when the area was left to grass. Mortar present on one of the bones (and a pebble) was analysed for morphology and chemical composition (Gherardi this volume). The radiocarbon dating report is provided in Appendix 4 with select details discussed below.

Results

The assemblage includes a total of 40 bones recovered from Trenches A and C, which were situated to investigate geophysical anomalies in the area of the Root House. Eight specimens are identified to species (Number of Identified Specimens/NISP) and 32 to large (n=1) or medium mammal (n=31). The summary taxonomic data are presented in Table 2, preservation data in Table 3 and biometry in Table 4. The assemblage is listed by specimen in Table 5 and illustrated in Figures 28-34.

Preservation

Preservation of the bones is generally good, and consistent across the assemblage with no obviously degraded (possibly residual) or intrusive, modern bones (Tables 3,5). A few fragments are eroded through root-etching, weathering, and possibly post-excavation cleaning (washing), and eight bones show modern breakage. There is no evidence of animal gnawing, burning, bone working or use wear. The assemblage is however highly fragmented, possibly due to butchery and/or post-depositional breakage (see below). The bones identified to species are about one half to one third of their original length and measure 40-120mm, with most other fragments categorised as 1-20% complete and under 40mm (Figs 28-30).

Species and skeletal elements by trench and context

Trench A yielded 37 bones, 32 of which are from topsoil [90102] (SF3004, SF30102-17, Table 2, Figs 28-29). [90102] includes two sheep/goat (*Ovis aries/Capra hircus*) right proximal metatarsals (SF 30104, SF 30115 Fig 31) and one *cf.* sheep/goat (*Ovis aries/Capra hircus*) metapodial fragment (SF3004) representing a minimum number of two individuals. [90102] also yielded 29 non-countable medium mammal bones including possible proximal or distal metapodial shaft fragments (SF3004, SF 30105, SF 30112). Most other fragments are consistent with the size of sheep/goat but in some cases, they may derive from large deer size bones. Many of the splinters are very straight or have surface features suggestive of metapodials. Some could also derive from other straight shafted elements such as tibias (Table 5).

Also in Trench A, [90103] yielded a fallow deer (*Dama dama*) fused distal metacarpal (SF 30101) with traces of mortar on the bone cross-section and cortical surface (see Modifications below), and a medium mammal rib fragment (SF 3007) (Figures 30, 32). The mortar on the metacarpal may indicate it was used as building material;

alternatively, it may have become attached or stuck to the bone during burial. Context [90103] is interpreted as hardcore deposited to support the floor when the brick building was created, so it's possible that bones were mixed accidentally or deliberately into this material when laid down.

Context [90104] yielded two conjoining fragments of a sheep fused distal metatarsal (SF 30118, and one of two fragments recorded as SF 3005) and a medium (or possibly large mammal) longbone fragment (also SF 3005) (Figure 30). [90104] is a thin gravel spread pressed into soft clay post-construction of the brick wall, but it's impossible to say if the layer was contemporary with the Root House, its demolition, or indeed if it includes intrusive material from later activity (Cromwell pers comm 2021).

A further few fragments derive from two contexts in Trench C, including from topsoil [90101] and from a deposit of silty clay [90118] possibly laid down during landscaping following destruction of the building (Fig 30). [90101] yielded a fallow deer left proximal metatarsal with pathology (SF 30120 Fig 33) and a medium mammal longbone fragment (SF 3006). Both specimens are eroded through root etching or weathering. [90118] yielded a single large mammal longbone fragment (SF 3008), identified through ZooMS as a large bovid/cervid (probably red (*Cervus elaphus*)/fallow deer) (ZooMS_00265_01, Preslee 2023, Appendix 5). The fragment was initially identified as a possible fragment of a fallow deer size metacarpal (proximal shaft) and, given the presence of other secure fallow deer identifications on site this may be the more probable species. The peptide markers present are also common to a number of native and non-native bovid and/or cervid species though 'most can be excluded on the basis of geographical restrictions (Preslee 2023, Appendix 5)', date of extinction or importation in Britain, and/or size. For example, the Chital (or Axis) and Père David's deer, cervid species of a similar size to fallow and red deer respectively were imported to zoos and parks in the 19 c. (Harris and Yalden 2008; Whitehead 1964). The radiocarbon measurement of SF 3008 (ETH-120131) indicates that the individual almost certainly died before AD 1800, and hence predates these introductions (see Marshall et al 2022, Appendix 4). There is evidence of a fresh break but no obvious join to SF 30101 [90103], a fallow deer right distal metacarpal, also from Trench C, or to other fragments. The radiocarbon ages of SF 3008 and SF 30101 (ETH-120129) are not statistically consistent at the 5% or for that matter the 1% threshold thus these two bones most probably derive from different individuals. SF 30101 and SF 30120 (GrM-28790), the pathological metatarsal, however, are statistically consistent at the 5% threshold and could be of the same age, and individual (P. Marshall pers. comm. 2023, see also Marshall et al 2022, Appendix 4). A minimum number of two fallow deer is thus represented.

Age at death, sex, biometry and pathology

The sheep fused distal metatarsal ([90104] SF 30118, SF 3005) is from an animal over 28-40 months (Popkin et al 2012). This bone and one of the two sheep/goat proximal metatarsals (SF 30115) compare in size to a modern Cotswold ewe (HE 1352), and to larger post-medieval measurements (*eg*. Albarella et al 1997; O'Connell et al 1997; Fraser 2019). The second sheep/goat proximal metatarsal (SF 30104) is smaller and more similar in size to modern unimproved Shetland sheep (Popkin et al 2012) though within post-medieval ranges. No pathologies were observed.

The measurements of the fallow deer distal metacarpal ([90103], SF 30101) clearly distinguish it from red deer, plotting with data from modern reference male fallow deer and the largest fallow deer values for the medieval and post medieval periods at Dudley Castle (Sykes et al 2011; Thomas 2005) (Table 4; Figure 34). It is from an animal aged over 41 months (after male fusion data in Carden and Hayden 2006). The fallow deer proximal metatarsal ([90101], SF 30120) is pathological and exhibits a swelling on the medial side of the vascular groove, at approximately one third of the (original) shaft length below the proximal articulation (Fig 33). The original extent of the swelling is unknown as the bone is broken through the affected area. The preserved part protrudes c 2-3mm from the original bone surface and the swelling is smooth and dense in cross-section suggesting it was a 'long-standing' condition (Thomas 2005, 61). This modification has been observed in sheep, cattle, horse and deer but it's aetiology is uncertain – possible causes include normal age or sex related change, bruising and traumatic injury (ossified haematoma, in deer perhaps resulting from leaping the pale or during translocation), infection and periostitis, or genetic predisposition (*eg.* Thomas 2001; Thomas and Grimm 2011; Bartosiewicz and Gál 2013; Rassodnikov 2021). It is evidenced in 8% of fallow deer metatarsals at Dudley Castle, where it was present in all periods (Phases 6-8, early 14th c-mid 18th c) (Thomas 2005, 61-2, fig 136).

Modifications

Two fragments have cut marks (Table 3): sheep/goat metatarsal SF 30115 [90102] shows transversal fine cut marks on the medial, posterior and lateral sides of the proximal articulation, and short cuts on the posterior edge of the proximal articulation, all possibly associated with disarticulation of the lower hind leg or skinning; it also has a spiral fracture just above the mid-shaft and a small hole of indeterminate origin (Fig 31). A medium mammal shaft splinter ([90102] SF 30117) exhibits two transversal cut marks. Two specimens were noted as being possibly split axially but it is not clear if this is due to butchery or non-anthropogenic breakage. Spiral (green-stick) fractures are evident on 19 fragments including the sheep (SF 30118) and sheep/goat (SF 30104, 30115 noted above) metatarsals, a medium mammal longbone fragment (SF 30117) and fallow deer metacarpal (SF 30101). This suggests they were broken when relatively fresh, possibly during butchery or preparation for use rather than during later destruction of the building and floor.

As noted above, the fallow deer metacarpal ([90103] SF 30101) has flecks of mortar visible on the uncleaned bone and adhering directly on the cleaned, broken cross-section and cortical surface of the distal shaft and articulation which may indicate the bone was originally embedded in a structure (Fig. 32) (see Gherardi 2021 this volume). Analysis of the mortar was undertaken to investigate if it bears similarities to residues on other objects, as a potential means of identifying contemporaneous building materials. Gherardi (2021, this volume) found greater similarity between the mortar on the bone and a separate find, a pebble [90117] SF 30119, than with samples from other objects (iron bars) but it is not possible to say if the bone and pebble were used for a similar, contemporaneous purpose/structure. Radiocarbon dating of the metacarpal, and by proxy the associated mortar, indicates a date compatible with the known lifespan of the building and activity up to the later 19th c. The mortar from the pebble and iron bars also included lumps of unburned lime and brick dust, both mentioned in the historic mortar recipe. Chemical analysis of the mortar on the pebble identified the presence of lipids and proteins but further analysis would be required to investigate if derived from blood serum, also mentioned in the mortar description, or if resulting from contamination (Gherardi 2021, this report).

Discussion

The assemblage of animal bones recovered during the 2019 excavations at Wrest Park in the area of the Root House (Mithraic Glade) includes 40 fragments derived from topsoil and layers of building activity and destruction, and later landscaping. Analysis was undertaken to determine the possible uses and sources of the bones, for example whether deriving from table waste, building material or a combination of these. Radiocarbon dating of six bones indicates a date compatible with the construction and lifespan of the Root House up to the 1830s and later 19th c landscaping events. One of these a large mammal fragment was also submitted for ZooMS analysis. In addition, samples of mortar adhering to bone, iron and pebble finds were analysed in order to identify if these might have been used in a common structure (Gherardi 2021, this report).

The animal bone assemblage includes eight identified bones including sheep and sheep/goat metapodials from a minimum of two animals, fallow deer metapodials and a red/fallow deer fragment from at least two animals, and a further 32 unidentified longbone splinters, many of which are probably also from metapodials (and a single rib). The assemblage is highly fragmented but well preserved with limited weathering and root-etching and no evidence of animal gnawing. Many specimens appear to have been split or broken when fresh, but only two fragments have evidence of cutmarks, and none show any sign of use wear (eg from trampling). A fallow deer metacarpal has mortar adhering to its broken mid-shaft cross-section and cortical surface. A sheep metatarsal and fallow deer metacarpal are from adult or subadult animals in which the distal articulations were fully fused. The measurements indicate the presence of different size sheep, as evidenced in other post-medieval sites. The fallow deer bones are the size of modern male specimens; one of these, a metatarsal, has a bony protuberance on the proximal anterior surface, a pathology or abnormality of unknown aetiology observed in other zooarchaeological fallow deer and in some livestock.

The 2019 assemblage is consistent with previous findings of fallow deer and sheep in the parterre deposits at Wrest Park (Baker 2013), but the limited range of species and almost exclusive identification of metapodials in the 2019 assemblage differs from the parterre assemblage and to butchery and consumption waste encountered in other post medieval assemblages. These tend to include a wider variety of species (in particular on high-status sites) and body parts, even in small assemblages (Albarella 2019; Albarella and Pirnie 2008). Metapodials may accumulate on high-status sites through gifting or local butchery and consumption of venison, but are usually part of a varied assemblage (eg Albarella and Davis 1996, 2006; Thomas 2005). For example, the small parterre assemblage (NISP 44) contains a wide array of species including a fallow deer humerus and metatarsal (Baker 2013). Taphonomic factors, such as differential density (Lyman 1994) or selective recovery are unlikely to explain the species and anatomical bias in the 2019 assemblage, as other skeletal elements in deer, sheep and other species are equally dense, bone preservation at Wrest was good overall, and the excavation strategy emphasised careful recovery of ecofacts (Baker and Worley 2019).

The nature of the assemblage excavated in 2019 may instead reflect the supply and use of metapodials in floors of the Root House or other structures, with incorporation of smaller fragments deriving from these materials into the construction and demolition layers, and dispersal through landscaping activity. Fragmentation of the metapodials, roughly to one third/half of their original length is a documented method of bone preparation for use in floors (*eg.* Divers et al 2002; Armitage 1989b; Bourdillon 1990) but may also occur as part of carcass processing (Foster 2016). Knife marks around the proximal articulation of a sheep metatarsal are consistent with skinning and disarticulation of carcasses for meat, leather and/or for the bones themselves (*eg.* Albarella et al 1997; Albarella 2003). One of the more conclusive indications for use in a structure is the presence of mortar on a fallow deer metacarpal. The composition of the mortar is similar to that of one of the pebbles from Trench C (Gherardi 2021, this report). Pebbles were included in the Root House floor design and both pebbles and metapodials were used in the later Bath House floor (Kewley 2018; Baker 2019). Radiocarbon dates from six of the bones are consistent with the lifespan, demolition and rebuilding of the Root House, and later landscaping but predate the 20th c. (Marshall et al 2022, Appendix 4)

There is no wear on the articular surfaces of the sheep, sheep/goat and deer specimens, thus if originally intended for a decorative floor the bones may derive from an area protected from trampling, unused building supplies, or a different structure or structural use. Though not documented at Wrest itself, sheep metapodia were also used for other building purposes for example in fences around flowerbeds (Armitage 1989b, 157), and sheep tibias as roofing 'pins' to fix slates or tiles (Armitage 1989a, 214, 217, 1989b, 155).

The presence of sheep and sheep/goat metapodials is consistent with the historic description of the Root House floor design, and with their use in contemporaneous bone floors elsewhere. These were often sourced through the leather and bone industries (Albarella, 2003; Salvagno et al 2017; Yeomans 2015), as indeed advised by the Root House architect (Hann 2021), though some could have come from local flocks. The absence of equid teeth is puzzling, as these were to have formed part of the original Root House floor design; furthermore, tooth enamel is the hardest substance in the vertebrate skeleton, ensuring teeth survive even when bone does not (Lyman 1994). It's possible that equid teeth were not used, dispersed elsewhere, or that some remain buried. Fallow deer bones are not mentioned in historic records relating to the Root House, although they could have been used for later repairs (see Ward et al 2019 for an example of repair work at The Hermitage, Belton House). Metapodials of fallow and red deer were used in the later Bath House and possibly replaced during the 1960s renovations (Armitage 1989a), though the radiocarbon dates reported here for the Root House assemblage preclude a 20th c source (Marshall et al 2022, Appendix 4). Wrest Park had its own deer park, and venison was gifted and consumed locally (Hann 2021; Baker 2013) so it's possible some bone was obtained from Wrest's own herds.

To conclude, the small assemblage derived from excavations in the area of the Root House includes almost exclusively sheep, sheep/goat and deer metapodials and bone splinters. The absence/scarcity of other species and skeletal elements reflects in part the very small assemblage size but probably relates also to their use in bone floors, possibly in the Root House itself or the later Bath House. Over time, through various landscaping events, old materials and new supplies may have been destroyed, dispersed between areas and mixed into building features including in the Mithraic Glade. Future investigation of mortars and materials (*eg.* pebbles), and further biochemical (dietary isotopes) investigation of the fallow deer bones may help to clarify the nature of building activities and source of building materials at Wrest Park.

Table 2: Taxonomic and skeletal element distribution by trench, context and small find number

Table

Trench	Trench A																						Trench C				
Context	90102																		90103		90104		90101		90118		
Small Find (SF)	3004	30102	30103	30104	30105	30106	30107	30108	30109	30110	30111	30112	30113	30114	30115	30116	30117	*Subtotal*	3007	30101	3005	30118	3006	30120	3008	Total Elements	Total taxon
Sheep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	2
Metatarsal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	-
Sheep/Goat	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	*2*	-	-	-	-	-	-	-	-	2
Metatarsal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	*2*	-	-	-	-	-	-	-	2	-
Sheep/Goat?	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-	-	-	-	-	-	1
Metapodial	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-	-	-	-	-	1	-
Fallow deer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	2
Metatarsal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-
Metacarpal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-
cf. Fallow /red deer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Longbone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Large mammal (nc)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Longbone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-
Medium mammal (nc)	5	1	1	-	1	1	1	1	2	1	1	2	1	1	-	1	9	*29*	1	-	-	-	1	-	-	-	31
Metatarsal	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	*2*	-	-	-	-	-	-	-	2	-
Metapodial	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-	-	-	-	-	1	-
Long bone	4	1	1	-	-	1	1	1	2	1	1	-	1	1	-	1	9	*25*	-	-	-	-	1	-	-	26	-
Rib	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
Indeterminate	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	*1*	-	-	-	-	-	-	-	1	-
Total	6	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	9	*32*	1	1	2	1	1	1	1	40	40

Table 3: Preservation and modifications

Trench		Trench A			Trench C		Total
Context		90102	90103	90104	90101	90118	
Preservation							
	Good	30	2	3	1	1	37
	Moderate	2	-	-	1	-	3
Angularity							
	Battered	1	-	1	1	-	3
	Spiky	31	2	2	1	1	37
New break		4	1	1	1	1	8
Erosion/root/weathering		2	2	1	2	-	7
Completeness							
	1-20 %	30	1	2	1	1	35
	21-40 %	-	-	1	-	-	1

41-50 %	2	1	-	1	-	4
Butchery						
Cut	2	-	-	-	-	2
Split axially?	-	-	1	-	1	2
Spiral fracture	18	-	1	-	-	19
Max Length (mm)						
20	1	-	-	-	-	1
40	21	1	1	1	-	23
60	7		1	-	1	9
80	1	-	1	-	-	2
100	3	-	-	-	-	3
120	-	1	-	1	-	2
Total fragments	32	2	3	2	1	40

Table 4: Sheep, sheep/goat and fallow deer measurements (mm) and measurement ratios.

Tax-taxon; El-Skeletal element; Cxt-Context, SF-Small Find number; Sd Side; S-Sheep, G-Goat; Fa-Fallow deer; Mc-Metacarpal; Mt-Metatarsal; L: Left; R: Right. Measurements after Davis 1992, Driesch 1976, Popkin et al 2012 (NB as only one condyle is present and body side is indeterminate WC is WCM or WCL; De is Dem or Del; Dv is Dvm or Dvl; Di is Dim or Dil). Ratios De/Dv and De/Wc are multiplied by 100, after Salvagno 2020 figures 3.310 -3.311.

Tax	El	Cxt	SF	Sd	Measurements										
					Bp	BFp	Dp	-	-	-	-	-	-	-	
S/G	Mt	90102	30115	R	25.1	23.4	24.9	-	-	-	-	-	-	-	
S/G	Mt	90102	30104	R	19.7	19.2	19.8	-	-	-	-	-	-	-	
Fa	Mt	90101	30120	L	28.6	25.5	30.4	-	-	-	-	-	-	-	
					WC	De	Dv	Di	De/Dv	De/WC	-	-	-	-	
S	Mt	90104	30118	R/L	11.9	11.9	17.5	14.8	67.8	99.2	-	-	-	-	
					BFd	Bdfus	WCM	WCL	Dem	Dvm	Dim	Del	Dvl	Dil	
Fa	Mc	90103	30101	R	31.0	30.5	14.3	14.2	14.8	19.2	17.3	14.3	19.3	17.6	

Table 5: Wrest Park 2019: List of zooarchaeological remains by context.

Abbreviations as in Table 4. Addditional abbreviations: ID-Database identification number; Re/Fal?-cf. Red/Fallow deer; Mp-Metapodial; Lb-Longbone; Ind-Indeterminate; (nc)-Non-countable; ; N: Number of fragments; Sp/Ax/Ct: Spiral fracture/Axially split/Cutmarks; Pr: Preservation; G: Good; M: Moderate; Rt: Root etching; A: Angularity; S: Spiky; B: Batterred; E/W: Eroded/Weathered; Nw: New break; Co: Completeness (% of complete bone); L: Length (in 20mm intervals)

ID	Cxt	SF	Tax	Elem	Sd	N	Description	Butchery	Pr	Rt	A	E/W	Nw	Co	Max L (mm)
270	90102	30104	S/G	Mt	R	1	Proximal shaft, zones 1-3. Radiocarbon # ETH-120130	Sp	G	-	S	-	-	41-50	<80
269	90102	30115	S/G	Mt	R	1	Proximal shaft, zones 1-4. Two conjoining fragments. Possible modern abrasion. Transversal cuts on medial, lateral and posterior surface. Radiocarbon # GrM-28792	Sp, Ct	G	-	S	?	+	41-50	<100
274	90102	3004	S/G?	Mp	-	1	Probably metapodial distal shaft zone 5 or 6	-	G	-	B	-	+	1-20	<60
268	90101	30120	Fa	Mt	L	1	Proximal shaft, zones 1-4 with pathology: buttress on anterior medial surface. Radiocarbon # GrM-28790	-	G	+	S	+	+	41-50	<120
283	90101	3006	Mm	LB (nc)	-	1		-	M	+	B	+	-	1-20	<40
275	90102	3004	Mm	Mt	-	1	Possibly sheep/goat size metapodial	-	G	+	S	-	+	1-20	<40
276	90102	3004	Mm	LB (nc)	-	1	Straight splinter. Two conjoining fragments. Partly rounded edges possibly due to cleaning	-	M	-	S	-	-	1-20	<40
277	90102	3004	Mm	LB (nc)	-	1	Possibly fragment of posterior surface of a metapodial	-	G	-	S	-	-	1-20	<40
278	90102	3004	Mm	LB (nc)	-	1	-	-	G	-	S	-	-	1-20	<40
279	90102	3004	Mm	LB (nc)	-	1	Cortical thickness similar to fallow deer size	-	G	-	S	-	+	1-20	<20
298	90102	30102	Mm	LB (nc)	-	1	-	Sp	G	-	S	-	-	1-20	<40
304	90102	30103	Mm	LB (nc)	-	1	Straight splinter	-	G	-	S	-	-	1-20	<40
285	90102	30105	Mm	Mt	-	1	Shaft fragment, possibly distal metapodial,	-	M	+	S	+	-	1-20	<60
300	90102	30106	Mm	LB (nc)	-	1	Possible metatarsal, slight evidence for anterior midline ridge between metatarsals 3 and 4	Sp	G	-	S	-	-	1-20	<40
292	90102	30107	Mm	LB (nc)	-	1	Long straight splinter, possibly posterior shaft of metapodial	Sp?	G	-	S	-	-	1-20	<60
293	90102	30108	Mm	LB (nc)	-	1	Long straight splinter, possibly medial-posterior shaft of metatarsal, or tibia fragment	Sp?	G	-	S	-	-	1-20	<100
294	90102	30109	Mm	LB (nc)	-	1	Straight broad splinter, sheep/goat/deer size	Sp	G	-	S	-	-	1-20	<40
295	90102	30109	Mm	LB (nc)	-	1	Straight broad splinter, sheep/goat, /deer size	Sp?	G	-	S	-	-	1-20	<60
303	90102	30110	Mm	LB (nc)	-	1	Straight short splinter	Sp	G	-	S	-	-	1-20	<40
302	90102	30111	Mm	LB (nc)	-	1	Straight short splinter. Possible sheep/goat/deer metacarpal anterior surface	-	G	-	S	-	-	1-20	<40
296	90102	30112	Mm	Mt	-	1	Probably metatarsal proximal shaft based on	Sp	G	-	S	-	-	1-20	<60
297	90102	30112	Mm	Indet	-	1	Small straight splinter	-	G	-	S	-	-	1-20	<40
284	90102	30113	Mm	LB (nc)	-	1	Long splinter, probably metapodial, size sheep/goat or deer	-	G	-	S	-	-	1-20	<100
299	90102	30114	Mm	LB (nc)	-	1	Possible metatarsal, slight evidence for anterior midline ridge between metatrsals 3 and 4	Sp	G	-	S	-	-	1-20	<40
301	90102	30116	Mm	LB (nc)	-	1	Straight splinter	-	G	-	S	-	-	1-20	<40
286	90102	30117	Mm	LB (nc)	-	1	Possibly metatarsal or tibia shaft. Size large sheep/deer	Sp?	G	-	S	-	-	1-20	<60
287	90102	30117	Mm	LB (nc)	-	1	Straight splinter, cortical thickness similar to large sheep or deer	-	G	-	S	-	-	1-20	<60
288	90102	30117	Mm	LB (nc)	-	1	Narrow straight splinter	-	G	-	S	-	-	1-20	<40
289	90102	30117	Mm	LB (nc)	-	1	Straight splinter, relatively thin cortical thickness	-	G	-	S	-	-	1-20	<40
290	90102	30117	Mm	LB (nc)	-	1	Straight splinter. Two transversal cuts at one end	Ct	G	-	S	-	-	1-20	<40
291	90102	30117	Mm	LB (nc)	-	4	Short broad fragments, all possibly with spiral fractures. Cortical thickness similar to large sheep or deer. One fragment with transversal cuts on medial, lateral and posterior surface	Sp	G	-	S	-	-	1-20	<40
271	90103	30101	Fa	Mc	R	1	Distal shaft, zones 5-8. Fused. Mortar on cross-section and cortical surface. Radiocarbon # ETH-120129	Sp	G	+	S	-	-	41-50	<120
280	90103	3007	Mm	Rib (nc)	-	1	-	-	G	+	S	+	+	1-20	<40
282	90104	3005	Lm	LB (nc)	-	1	Possible metacarpal fragment. Cortical thickness similar to identified fallow deer bones	Sp	G	+	S	-	-	1-20	<40
281	90104	3005	S	Mt	-	1	Posterior distal shaft, conjoining with SF30018. Abrasion of internal surface probably due to washing. Radiocarbon # GrM-28791	-	G	-	S	-	+	1-20	<60
272	90104	30118	S	Mt	-	1	Distal shaft zones 5&7 or 6&8, conjoining with SF3005. Fused	Ax	G	-	B	+	-	21-40	<80
273	90118	3008	Re/Fa?	LB (nc)	-	1	Probable metacarpal, lateral proximal side. Possible fallow deer as surface in red deer is more curved. Radiocarbon # ETH-120131. ZooMS_00265_01	Ax?	G	-	S	-	+	1-20	<60

Fig 28: Animal bone assemblage Context [90102] SF 3004-30109. Photo P Baker ©Historic England

Fig 29: Animal bone assemblage Context [90102] SF 3010-30116. The fragments from SF 30115 are conjoining. Photo P Baker ©Historic England

Fig 30: Animal bone assemblage. Left: Contexts [90101] SF 3006, 30120; [90103] SF 3007, 30101; [90104] SF 3005, 30118; [90118] SF 3008. Right: Conjoining fragments from context [90104] SF 30118 and 3005. Photos P Baker ©Historic England

Fig 31: Sheep/goat right metatarsal with cut marks, and hole of indeterminate origin Context [90102] SF 30115. Left: lateral view. Right: posterior view. Arrows indicate location of cut marks. Photos P Baker ©Historic England

Fig 32: Fallow deer metacarpal Context [90103] SF 30101. Left and middle: as excavated, with mortar adhering to the broken shaft cross-section. Right: after cleaning and sampling for radiocarbon, showing mortar on distal posterior shaft and distal articulation. Photos: left and middle S Hawke, right P Baker ©Historic England

Fig 33: Fallow deer metatarsal with remodelled bone on medial side of the vascular groove Context [90101] SF 30120. Left: dorsal view; Right: medial view. Photos P Baker ©Historic England

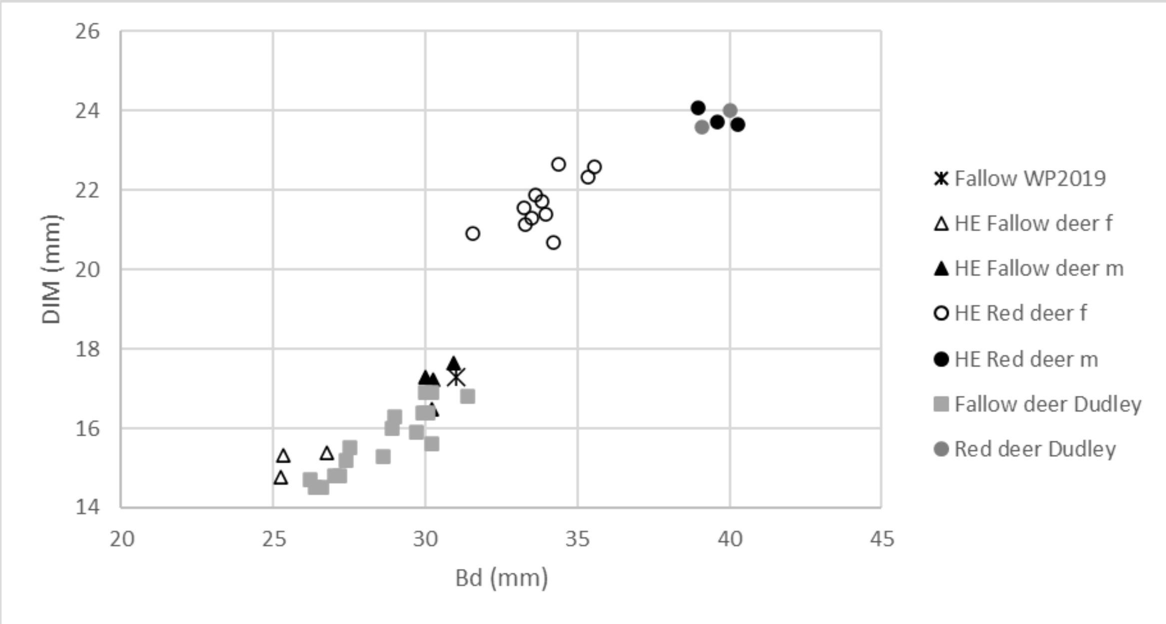

Fig 34: Fallow deer metacarpal measurements compared to modern reference specimens of red deer and fallow deer in the Historic England (HE) Zooarchaeology reference Collection and to measurements from Dudley Castle (Thomas 2005). DIM: Internal medial condyle depth (measurement 3 after Davis 1992); Bd after (Driesch 1976)

Analysis of industrial debris - Francesca Gherardi

Introduction

During the excavation in the garden at Wrest Park, lumps of slag that are potentially industrial debris were found, probably used as packing around drain pipes. The details are described in Table 6.

Table 6: Contexts of industrial debris.

Context	Trench	Description
90101	C	Topsoil
90103	A	Fill
90506	E	Drain fill
90803	H	Drain fill

Trenches A and C are located in the proximity of the Mithraic Glade, where a root house was constructed in 1740s but no longer in existence.

The lumps of slag contain mineral inclusions, consistent with a high temperature process using a mineral fuel. Coal was commonly used for industrial processes, particularly in more recent periods (Bayley, Dungworth, and Paynter 2015), but was also used for non-industrial applications, such as fuelling boilers. This report describes the visual observations and X-ray fluorescence (XRF) analysis that was carried out to study the industrial debris, and determine what process produced it.

Background

Preliminary observations indicated that the majority samples might be waste material from secondary iron-working (smithing). In the blacksmithing process, the reaction between the iron objects, the fuel (coal or charcoal), possibly a flux and the clay hearth lining at high temperatures produces slag. This waste product accumulates when the droplets of liquid fall down and solidify at the bottom in the smith's hearth and they form lumps of slag, which are then removed by the blacksmith.

Smithing slags show great variability, even in the same context. The texture of the slag (vitreous or crystallised) depends on the chemical composition and the cooling conditions, while the shape is correlated to the type of the hearth (Serneels and Perret 2003). The volume of the slag depends on the size of the objects under production, the duration of the smithing activity, the temperature in the hearth, and the chemical composition of the metallic iron at the start of the process (Dunster and Dungworth 2012).

The most common smithing slags have a plano-convex shape, as they are usually characterised by slightly concave and smooth upper surfaces and convex rough bottoms, often with small inclusions of sand or burnt clay (Bayley, Dungworth, and Paynter 2015).

Also, the mineralogical and chemical composition of smithing slags is very heterogeneous. Iron-based minerals (fayalite, magnetite, hematite, wüstite, etc.), silicates, and particles of iron alloys are common compounds. In addition, unfused pieces of rock or ceramic can be observed (Serneels and Perret 2003).

Three categories of smithing slags can be identified (Serneels and Perret 2003):

1. Dense grey slag (SGD, *scorie grise dense*)
2. Sandy-clayey slag (SAS, *scorie argilo-sableuse*), which is rich in silica and other elements found in granites, sandstones and clay, and with a low iron content.
3. Iron-rich rusty slag (SFR, *scorie ferreuse rouillée*), which is rich in iron as metal, oxide or oxy-hydroxide particles.

In addition, different types of fuel (charcoal, coal, and coke) have been used by blacksmiths. Charcoal is the most used fuel in more ancient blacksmithing activities. It is rich in carbon and its ashes contain higher amounts of calcium and potassium compared to coal (Dunster and Dungworth 2012). Coal and coke are more common in post-medieval and historic industry (Bayley, Dungworth, and Paynter 2015), and those ashes contain more aluminium, silicon and iron compared to charcoal ash.

Methods

The samples were analysed by XRF, using a Bruker M4 Tornado μ-XRF spectrometer. The data were collected at 50kV and 200 μA with a vacuum. The tabulated results are averages of at least 3 analyses and normalised. The surface of two samples from contexts 90506 (labelled 90506 a and b) and 90803 (labelled 90803 a and b) were cleaned with a brush in order to remove soiling and analysed.

Results and discussion

The majority of the slag fragments are characterised by a glassy, smooth, dark brown-rusty surface and rough bottom surfaces with fragments of stone, ceramic and burnt clay incorporated (so resemble the SFR type of smithing slag described in the Background section) (Figure 35).

The slags collected from context 90506 and 90803 were analysed and have a similar elemental composition; they are rich in FeO (30-60 wt%), with variable amounts of SiO_2 (10-38 wt%), Al_2O_3 (11-20 wt%) and CaO (6-16 wt%) (Table 7). Silica, alumina and calcium oxide derive from clay, sand or stones, introduced in the slag predominantly with the fuel ashes or from the hearth lining, and possibly as a flux used to remove the oxidised surface of the metal. The smithing slag recovered from context 90103 contains less FeO (23 wt%), but it is richer in SiO_2 (55 wt%) and K_2O (3 wt%) (Table 7).

The reasonably high iron content confirms that the slag is more likely to be a waste product of smithing, than from a non-industrial process. According to the literature, slags produced with charcoal fuel are less rich in Al_2O_3 compared to coal/coke. The high Al_2O_3 content in the smithing waste recovered at Wrest Park probably indicate that coal was used as a fuel.

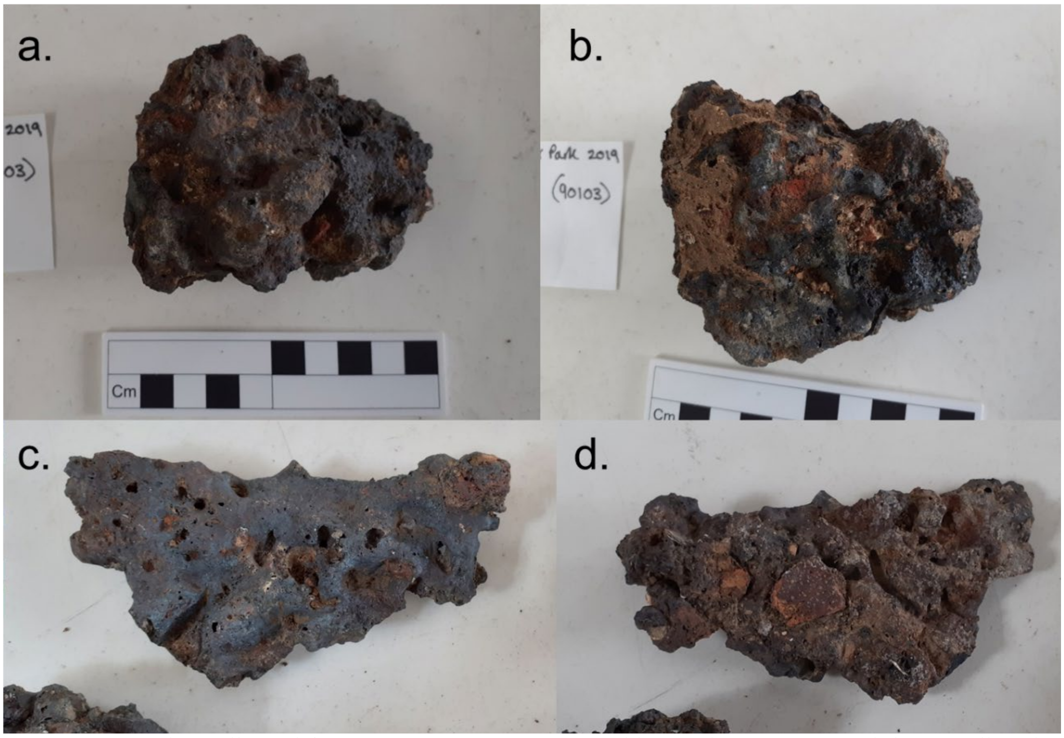

Fig 35: Samples collected from context 901013 (a. and b.) and 90506 (c. and d.). Small inclusions of ceramic, stone and clay can be observed at the bottom of the slags (b. and d.).

Table 7: Chemical composition (microXRF, wt% oxides, normalised) of the industrial debris (bd = below detection).

		MgO	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**K_2O**	**CaO**	**TiO_2**	**MnO**	**FeO**
90101	Average	0.91	20.36	53.49	bd	0.03	2.86	15.84	0.48	0.07	5.58
	St.dev.	0.06	0.70	0.83		0.02	0.37	2.10	0.03	0.01	0.67
90103	Average	0.13	10.84	54.51	0.05	0.32	3.20	5.34	0.61	0.10	23.30
	St.dev.	0.19	0.34	2.62	0.07	0.07	1.00	2.31	0.05	0.06	1.95
90506 a	Average	7.12	11.15	14.07	0.31	bd	0.58	11.08	0.35	0.22	54.56
	St.dev.	2.35	1.79	1.83	0.13		0.24	1.56	0.10	0.05	7.27
90506 b	Average	3.02	19.19	37.80	0.06	bd	1.13	7.95	0.23	0.14	30.23
	St.dev.	0.94	1.16	1.85	0.01		0.05	0.24	0.10	0.02	4.38
90803 a	Average	3.07	11.66	18.43	0.16	0.05	0.40	15.77	0.44	0.25	49.46
	St.dev.	1.69	2.36	3.23	0.14	0.09	0.11	0.67	0.03	0.04	5.08
90803 b	Average	0.42	13.98	10.25	1.07	0.02	1.59	6.18	0.97	0.28	64.75
	St.dev.	0.15	2.35	5.49	0.20	0.02	0.38	1.30	0.02	0.02	9.69

The exception is the sample collected from context 90101 (topsoil), which shows bubbly-spongy features, plus it has a lighter colour, and it is less dense compared to the other slags (Figure 36). This sample is rich in SiO_2, Al_2O_3 and CaO, with an FeO content lower than 6 (wt%) (Table 7). It is not diagnostic of a metalworking process, and it is probably a fuel ash slag, produced by reaction of ash from a fuel with clay.

Fig 36: Sample collected from context 90101.

Conclusions

Industrial debris was recovered during the excavations in the garden at Wrest Park.

Visual observations allowed the identification of probable smithing slags, with a smooth and glassy upper surface and convex rough bottoms, with small inclusions of sand, ceramic or burnt clay. The slags show variation in FeO content, and the high Al_2O_3 content indicates that coal was used as a fuel during the smithing process. The slag had been re-used in the contexts in which it was found, so the location of the smithy is unknown.

Trenches A and C are located in an area where a root house was constructed in 1740s but is no longer in existence. This could be a possible reference to approximately date the industrial debris.

Finally, it is important to consider that the sample collected from context 90101 (topsoil) with bubbly-spongy features was collected from the topsoil, while the rest of the assemblage, which shows great similarities even though it is distributed in different places, was recovered from stratified contexts.

Chemical analysis of the glass assemblage - Francesca Gherardi

Introduction

During the excavation in the garden at Wrest Park, glass fragments were recovered. Most of them are fragments from green glass bottles and colourless or nearly colourless windows, and a few from glass vessels. The details of the collected materials are described in Tables 8 and 9. The glass samples were found in two areas of the garden: the Mithraic Glade (trenches A and C) and the Duke's square (trench K). Most of the samples were recovered from the Mithraic Glade, where a root house was constructed in the 1740s but is no longer in existence.

Table 8: Contexts of glass fragments

Context	Trench	Description
90101	C4	Topsoil
90102	A4	Topsoil
90107	C3	Rubble
90108	C3	Soil west of rubble
90112	C1	Clay
90118	C2	Silty clay
90902	K2	Rubble patch

Background
The study of glass composition can reveal information about the raw materials used to make it. The compositional changes reflect the technologies and the resources available at a specific time, and this allows us to assign a chronology to specific glass types. In particular, studies of the chemical composition of glass vessels and windows from Britain dated from the 14th century to the present are available and can be used as a guide to date finds (Dungworth 2012a, b). The glass types of particular significance to this report are known as: high-lime low-alkali (HLLA) glass, mixed alkali glass, and soda-lime-silica (SLS) glass.

- HLLA glass was used to manufacture tableware, bottles, and windows from the late 16th century (Dungworth et al. 2006). HLLA glass was produced until the end of 19th century, and from the early 18th century it was mainly used for the manufacture of bottles (Cable and Smedley 1987). This type of glass is characterised by low aluminium, and high phosphorous and calcium, and it was made by simply using sand and plant ashes.

- Mixed alkali glass has soda:potash ratios close to one. It is found in post-medieval assemblages, but for vessels it was abandoned in favour of lead crystal/flint glass at the end of the 17th century. It dominates window glass through the 18th and into the beginning of the 19th centuries. This type of glass was prepared using a variety of plant or seaweed (kelp) ashes (Dungworth et al. 2006, Henderson, Adams, and Mann 2005).

- SLS glass was manufactured using synthetic soda. Synthetic soda, made following the Leblanc process, was introduced as a flux in British glass production from the fourth decade of the 19th century. SLS glass contains little or no phosphorus, potassium or strontium. Colourless SLS glass exhibits a much lower iron content compared to HLLA glass, probably as a result of the use of better quality raw materials, such as low-iron sands (Dungworth 2012a, b).

Materials and methods
According to the colour, shape and weathering conditions, the samples were divided into six main groups (Table 9 and Figure 37):

1. Dark green glass fragments (dark green round symbols in the graphs);
2. Very decayed dark green glass fragments (sage green round symbols in the graphs);
3. Green glass fragments with a golden weathering patina (light green round symbols in the graphs);
4. Brown glass fragment (brown round symbol in the graphs);
5. Light blue/colourless fragments from bottles or vessels (light blue round symbols in the graphs);
6. Light blue/colourless window glass (light blue triangle symbols in the graphs).

The samples were washed with cold water and a soft brush, in order to remove residues of soil. The samples were then analysed by XRF, using a Bruker M4 Tornado μ-XRF spectrometer. The data were collected at 50kV and 200 μA with a vacuum. The tabulated results are averages of at least 3 analyses and normalised. Since XRF is a surface technique and many samples are characterised by altered surfaces, it is important to consider that weathering affects the collected results.

In order to identify compositional groups in the assemblage, principal component analysis (PCA) was carried out on thirteen of the major and minor base glass elements (Na_2O, MgO, Al_2O_3, SiO_2, SO_3, K_2O, CaO, TiO_2, MnO, Fe_2O_3, SrO, PbO, P_2O_5) using R software. The scores of principal components (C) 1 and 2 were plotted alongside the eighteen variables represented by vectors. The variance of the first two principal components based upon the concentrations of the thirteen glass elements corresponds to about 60% of the total variance of the original dataset.

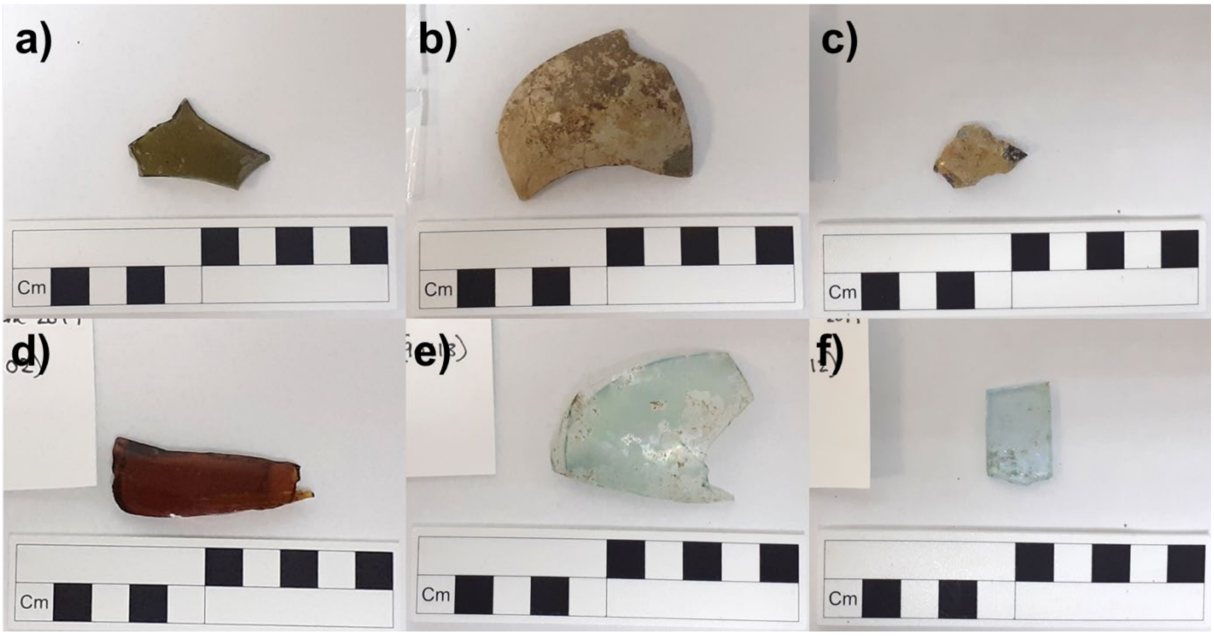

Fig 37: The glass samples can be divided in to six main groups according to the colour, shape and weathering conditions: a) dark green glass fragments; b) very decayed dark green glass fragments; c) green glass fragments with a golden weathering patina; d) brown glass fragment; e) light blue/colourless fragments from bottles or vessels; f) light blue/colourless window glass.

Results

A summary of the results is given in Table 9 and the full analytical results are given in Table 10. The probable glass type is also given in the final column of Table 9.

Some of the glass fragments are characterised by severe weathering, and element depletion occurred. In addition, some weathered samples exhibited higher contents of some elements (such as Al_2O_3 and Fe_2O_3), therefore their chemical compositions slightly differ from what would be expected for a specific glass type.

Table 9: Description of the analysed objects.

Context	Trench	Description of the fragment	Type of glass
90101	C4	Light blue/colourless window glass	HLLA
90102 a	A4	Dark green glass fragments	HLLA

90102 b	A4	Green glass fragments with a golden weathering patina	HLLA
90102 c	A4	Very decayed dark green glass fragments	HLLA
90107 a	C3	Dark green glass fragments	HLLA
90107 b	C3	Dark green glass fragments	HLLA
90107 c	C3	Very decayed dark green glass fragments	HLLA
90107 d	C3	Very decayed dark green glass fragments	HLLA
90107 e	C3	Very decayed dark green glass fragments	HLLA
90107 f	C3	Very decayed dark green glass fragments	HLLA
90107 g	C3	Very decayed dark green glass fragments	HLLA
90107 h	C3	Light blue/colourless window glass	Mixed alkali glass
90108	C3	Very decayed dark green glass fragments	HLLA
90112 a	C1	Very decayed dark green glass fragments	HLLA
90112 b	C1	Very decayed dark green glass fragments	HLLA
90112 c	C1	Light blue/colourless window glass	Mixed alkali glass
90112 d	C1	Light blue/colourless window glass	HLLA
90112 e	C1	Dark green glass fragments	HLLA
90112 f	C1	Very decayed dark green glass fragments	HLLA
90112 g	C1	Green glass fragments with a golden weathering patina	HLLA
90112 h	C1	Green glass fragments with a golden weathering patina	HLLA
90112 i	C1	Green glass fragments with a golden weathering patina	HLLA
90112 j	C1	Light blue/colourless window glass	HLLA
90118 a	C2	Light blue/colourless fragments from bottles or vessels	HLLA
90118 b	C2	Light blue/colourless fragments from bottles or vessels	HLLA
90118 c	C2	Very decayed dark green glass fragments	HLLA
90118 d	C2	Light blue/colourless window glass	HLLA
90118 e	C2	Light blue/colourless fragments from bottles or vessels	HLLA

90902 a	K2	Brown glass fragment	SLS
90902 b	K2	Colourless window glass	SLS

Principal component analysis (PCA) was carried out in order to illustrate the different groups identified in the glass assemblage (Figure 38). The length and direction of the vectors (Figure 38b) show the contribution of each element (variable) to the two principal components. Three groups can be identified:

1. Group 1 (blue circle): SLS glass.
2. Group 2 (red circle): Mixed alkali glass.
3. Group 3 (green circle): HLLA glass. In this group, three samples (orange circle) show a slightly different chemical composition compared to the other samples, probably due to element depletion caused by weathering or adhering soil.

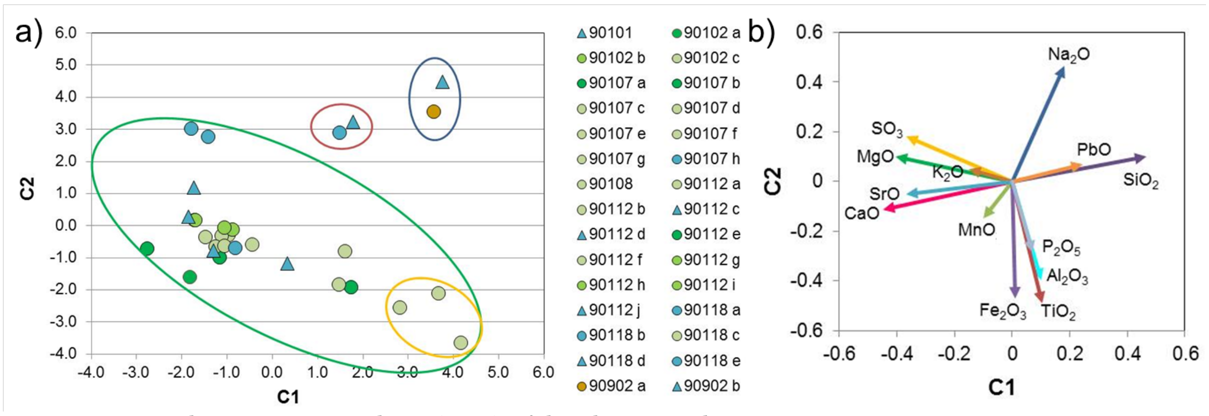

Fig 38: Principal component analysis (PCA) of the glass samples.

In Figure 39, by observing the graph of the Na_2O and K_2O content of the glass fragments, the glass forms three main groups. The first one (red circle) includes SLS glass with a high Na_2O content, due to the use of synthetic soda as a flux. The second group (blue circle) comprises colourless mixed alkali glass, in which the soda:potash ratios is close to one. The rest of the glass assemblage is HLLA glass, and it includes colourless and green glass.

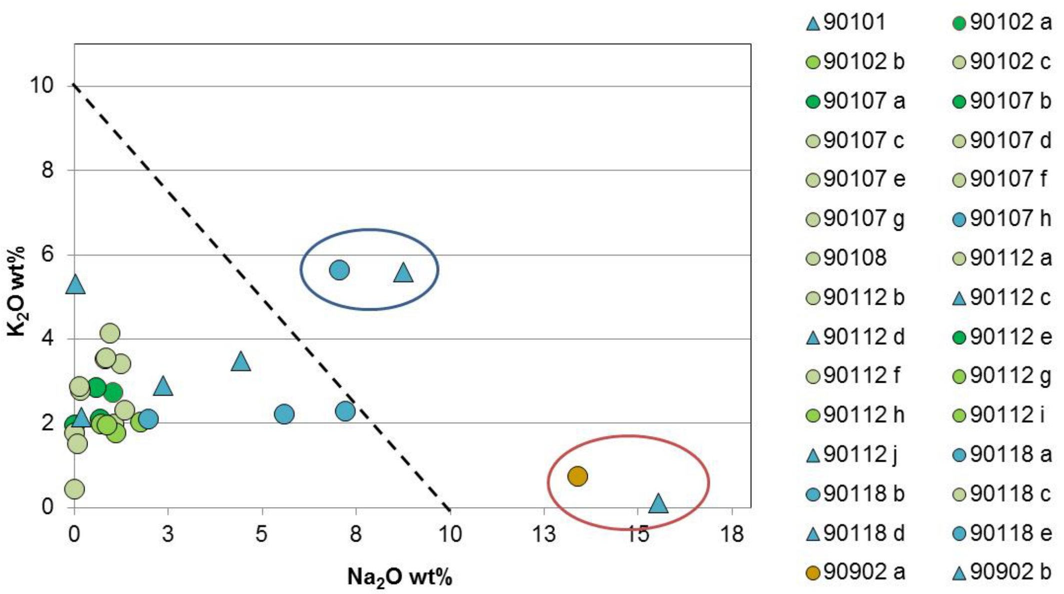

Fig 39: Correlation of Na_2O and K_2O wt% in the glass fragments.

In Figure 40, by plotting the Na_2O and the sum of MgO, CaO, K_2O, and P_2O_5 contents in the glass, the data provide information about the alkali source used in the mix. One group includes the modern SLS glass (red circle), characterised by high sodium due to the use of synthetic soda as an alkali source, but lower concentrations of MgO, CaO, K_2O, and P_2O_5 compared to the rest of the assemblage. The rest of the assemblage includes woodash-lime glass, in which plant ash was used as alkali source, and comprises mixed alkali (blue circle) and HLLA glass.

In the HLLA glass samples, some fragments exhibit a slightly different chemical composition (orange circle in Figure 41), with low CaO and Na_2O contents, probably due to depletion of calcium and sodium from the surface due to surface weathering (Figs 40 and 41). Three samples (90101 and 90118a and b) have slightly raised Na_2O contents and all have a pale or light blue colour, so these glasses may have intermediate HLLA / mixed alkali properties (they are the 3 points closer to the dividing line in Figure 39).

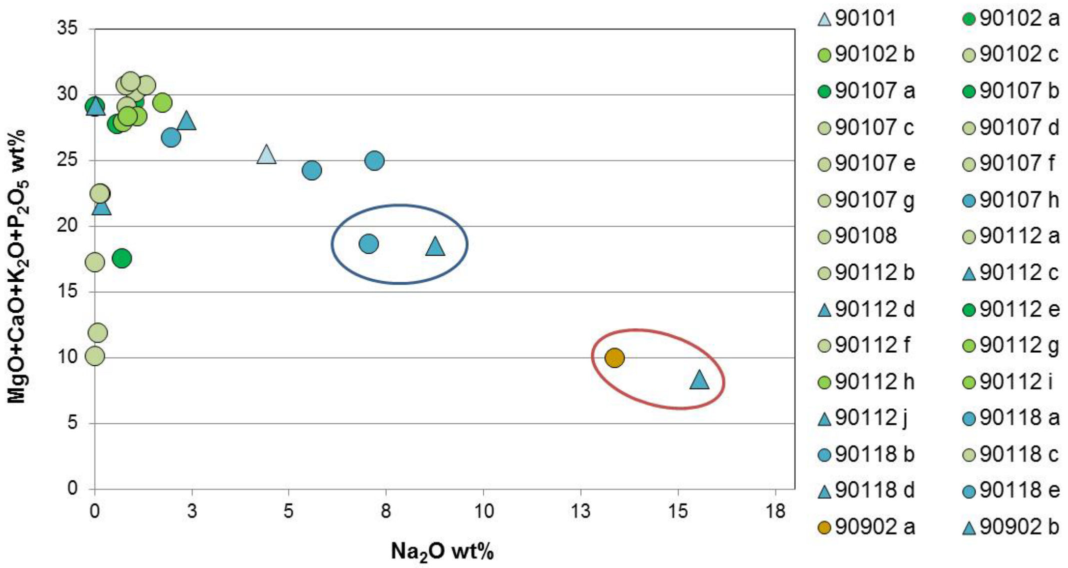

Fig 40: Correlation of Na_2O and the sum of MgO, CaO, K_2O, and P_2O_5 wt% in the glass fragments.

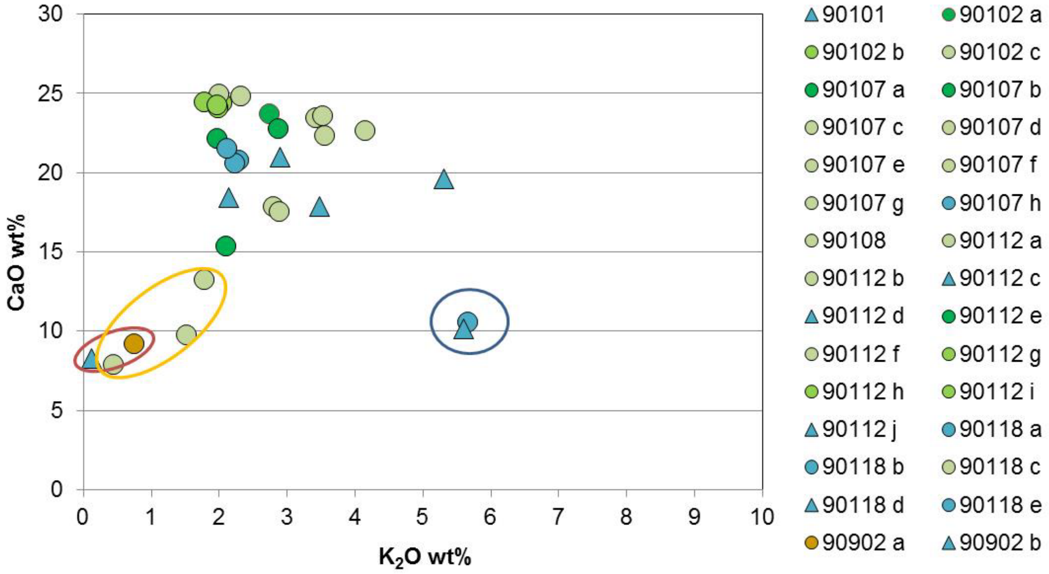

Fig 41: Correlation of K_2O and CaO wt% in the glass fragments.

Discussion

The study of the chemical compositions of the glass samples from Wrest Park provides some indications about the assemblage, by comparing the data with results gathered from glass bottles, vessels and windows from Britain from the 14th century to the present.

HLLA glass has a long history of use, particularly for bottles, and many of the dark green fragments recovered from Wrest Park may derive from this type of container. The composition of HLLA bottle glass changes slightly over time however, and the chemical composition of much of the Wrest Park green glass shows similarities with HLLA glass from 1700-1850, as it shows lower concentrations of phosphorous compared to the HLLA glass from the 16th and 17th centuries, due probably to the use of leached ashes instead of fresh plant ashes (Table 10) (Dungworth 2012b).

There are also a few fragments of probable HLLA window glass in the Wrest Park assemblage (from phases C1 and C2), but these predate 1700 (Dungworth 2012a). Light blue/colourless HLLA glass samples have a similar composition to the green ones, but with a lower iron content, and they have been probably produced at a similar time. A few of these samples (window glass from phase C4 and vessel glass from C2) also contain higher sodium levels than typical for HLLA glass, but not so much as found in 18th-century windows, so these are still likely to be from the 17th century (Dungworth et al. 2006).

Colourless mixed alkali glass, of the type described by Dungworth (Dungworth 2012a) as dominating from 1700-1835, was found in phases C1 and C3.

Many of the glass fragments were chemically similar to at least one other from the same phase in the same trench so could well derive from the same object, for example 90112a and b, 90118a and b, 90112 g, h and i.

The two fragments of more recent glass, made with synthetic soda so from the 19th or 20th century, are both from the rubble in Trench K, and include a piece of colourless window glass and a brown vessel/bottle fragment.

Conclusions

The assemblage recovered in the gardens at Wrest Park comprises glass from bottles or vessels and windows and it is representative of three compositional groups: dark green HLLA glass dominates but there is a small amount of lighter coloured mixed alkali glass, used for windows and vessels, and modern SLS glass.

Most of the glass was found in Trench C in the Mithraic Glade, where a root house was believed to be constructed in the 1740s but is no longer in existence. This date is consistent with the type of glass used (HLLA bottle glass and mixed alkali window glass) although there are also a small number of older (17th-century) fragments (from two or three windows and one or two vessels) also from Trench C.

A small amount of modern (19th- or 20th-century) SLS glass was found in Trench K in the Duke's Square.

Table 10: Chemical composition (microXRF, wt% oxides, normalised) of the surface of glass fragments (bd = below detection).

Sample		Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	SrO	P_2O_5	BaO
90101	Avg	4.4	3.2	2.6	65.9	0.3	3.5	17.9	0.1	0.2	0.9	0.2	0.9	bd
	std	0.5	0.1	0.1	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	
90102 a	Avg	1.0	3.0	6.9	58.9	0.4	2.7	23.7	0.3	0.2	2.6	0.1	bd	bd
	std	0.1	0.2	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0		
90102 b	Avg	1.7	1.8	3.0	63.6	0.4	2.0	24.4	0.1	0.1	1.4	0.2	1.1	bd
	std	0.9	0.8	0.8	2.1	0.1	0.1	0.9	0.0	0.0	0.0	0.0	0.1	
90102 c	Avg	1.2	2.4	3.0	62.6	0.3	3.4	23.5	0.2	0.2	1.6	0.1	1.3	0.1
	std	0.1	0.1	0.0	0.4	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
90107 a	Avg	0.6	1.9	7.3	61.8	0.3	2.9	22.8	0.2	0.4	1.5	0.1	0.2	bd
	std	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	
90107 b	Avg	bd	5.0	5.0	62.7	0.2	2.0	22.1	0.2	0.2	1.8	0.2	bd	0.6
	std		0.2	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0		0.0
90107 c	Avg	bd	bd	6.4	73.6	bd	1.8	13.2	0.3	0.2	2.0	0.1	2.2	0.1
	std			0.0	0.3		0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0
90107 d	Avg	1.1	1.9	3.2	63.0	0.3	2.0	24.9	0.1	0.1	1.7	0.1	1.4	bd
	std	0.1	0.2	0.1	1.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.1	
90107 e	Avg	1.3	2.1	2.5	62.9	0.3	2.3	24.9	0.2	0.1	1.8	0.1	1.2	bd
	std	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	
90107 f	Avg	0.8	2.4	4.1	61.7	0.3	3.5	23.6	0.2	0.2	1.7	0.1	1.2	0.1
	std	0.2	0.1	0.3	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
90107 g	Avg	0.1	0.3	4.1	71.1	0.1	2.8	17.8	0.2	0.2	1.5	0.1	1.6	0.1
	std	0.0	0.1	0.1	0.5	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.1	0.0
90107 h	Avg	7.0	2.2	2.0	71.5	0.1	5.7	10.6	0.1	0.1	0.3	0.1	0.2	bd
	std	1.0	0.2	0.6	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	
90108	Avg	bd	bd	7.1	79.0	bd	0.4	7.9	0.4	0.1	3.0	0.1	1.8	0.1
	std			0.2	1.5		0.2	1.6	0.0	0.0	0.1	0.0	0.2	0.0
90112 a	Avg	0.9	2.5	3.0	62.1	0.3	4.1	22.7	0.2	0.3	1.7	0.1	1.7	0.1
	std	0.1	0.1	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0

90112 b	Avg	0.8	1.9	3.7	63.7	0.3	3.6	22.3	0.2	0.2	1.6	0.1	1.3	0.1
	std	0.1	0.7	0.4	1.9	0.0	0.2	1.2	0.0	0.0	0.0	0.0	0.1	0.0
90112 c	Avg	8.8	2.6	1.3	70.6	0.1	5.6	10.1	0.1	0.1	0.3	0.1	0.2	bd
	std	0.8	0.1	0.2	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	
90112 d	Avg	0.2	0.7	8.9	67.3	0.1	2.1	18.4	0.2	0.1	1.3	0.1	0.3	0.1
	std	0.2	0.3	0.5	0.8	0.0	0.2	0.8	0.0	0.0	0.1	0.0	0.1	0.0
90112 e	Avg	0.7	bd	11.0	68.5	bd	2.1	15.3	0.3	0.3	1.5	0.1	0.1	bd
	std	0.2		0.2	0.9		0.1	0.9	0.0	0.0	0.0	0.0	0.1	
90112 f	Avg	0.1	bd	6.6	78.3	bd	1.5	9.8	0.3	0.1	2.5	0.1	0.6	0.1
	std	0.1		0.5	3.3		0.5	4.3	0.1	0.1	0.9	0.0	0.1	0.0
90112 g	Avg	1.1	2.1	4.9	63.1	0.6	1.8	24.5	0.2	0.1	1.6	0.1	bd	bd
	std	0.6	0.6	1.1	0.8	0.1	0.1	0.6	0.0	0.0	0.0	0.0		
90112 h	Avg	0.7	1.7	4.7	64.2	0.4	2.0	24.1	0.2	0.1	1.7	0.1	0.2	0.1
	std	0.1	0.3	0.4	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
90112 i	Avg	0.9	1.9	4.2	64.0	0.4	2.0	24.3	0.2	0.1	1.7	0.1	0.2	0.1
	std	0.2	0.2	0.1	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
90112 j	Avg	2.4	3.2	4.4	63.0	0.4	2.9	21.0	0.2	0.1	1.2	0.2	1.0	bd
	std	0.2	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	
90118 a	Avg	7.2	1.8	1.2	65.1	0.8	2.3	20.8	0.1	bd	0.5	0.1	0.1	bd
	std	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0		0.0	0.0	0.0	
90118 b	Avg	5.6	1.4	1.5	67.1	0.8	2.2	20.6	0.1	bd	0.5	0.1	bd	bd
	std	0.4	0.0	0.2	0.4	0.0	0.0	0.2	0.0		0.0	0.0		
90118 c	Avg	0.1	0.5	5.2	69.3	0.1	2.9	17.5	0.3	0.2	2.0	0.1	1.5	0.1
	std	0.2	0.7	1.2	3.8	0.1	0.8	3.2	0.0	0.0	0.1	0.0	0.1	0.0
90118 d	Avg	0.0	2.9	1.8	66.1	0.2	5.3	19.6	0.2	1.3	0.7	0.1	1.4	0.2
	std	0.0	0.4	0.2	1.6	0.0	0.3	0.9	0.0	0.1	0.0	0.0	0.1	0.0
90118 e	Avg	2.0	2.1	3.5	65.3	0.2	2.1	21.6	0.2	0.1	1.8	0.2	1.0	bd
	std	0.6	0.5	0.4	1.3	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.1	
90902 a	Avg	13.4	bd	1.8	74.4	bd	0.7	9.2	0.1	0.1	0.3	bd	bd	bd
	std	0.1		0.1	0.0		0.0	0.0	0.0	0.0	0.0			
90902 b	Avg	15.5	bd	0.5	75.1	0.2	0.1	8.3	0.0	0.0	0.1	bd	bd	bd
	std	0.3		0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0			

Chemical analysis of mortars residues on objects - Francesca Gherardi

Introduction

During the excavation of the Mithraic Glade, an animal bone and two iron bars with attached mortars were recovered from deposit 90103 (trench A). This deposit is believed to either collect waste from a brick wall or to be built as a floor foundation. One pebble with mortar was also found in another deposit with decayed mortar and pebbles (90117, trench C). Trenches A and C are placed in the Mithraic Glade, where a root house was believed to be built in the 1740s but is no longer in existence.

The presence of objects with residues of attached mortars can be linked to the existence of pebble and bone floors, which was well documented in the letters of the architect Thomas Edward, the owner Marchioness Jemima de Grey and others, during the construction of the root house (Hann 2021). According to the historical documents, the mortar used to set pebbles and bones consists of '*one part of terras, two parts of stone lime, and one sixth of brick dust with serum of blood.*'. Finally, once completed '*the pavement was to be black varnished using sealing wax dissolved in rectified spirits of wine, then painted over with plain oil to set the colour'* (Hann 2021).

Mortars collected from the recovered objects (Table 11) have been analysed to evaluate the morphology and chemical composition and assess if the materials are part of the same structure.

Table 11: Contexts and description of mortar residues on some objects from the assemblage.

Context	Trench	Description of the objects
90103	A	Mortar residues on animal bone (30101)
90103	A	Mortar residues on flat iron bar (3001)
90103	A	Mortar sample from flat iron bar (3001)
90103	A	Mortar residues on curved iron door bracket (3002)
90117	C	Mortar residues on pebble (30119)

Materials and Methods

The objects were observed by stereomicroscopy (Leica M420 stereomicroscope).
A sample of mortar from the iron bar (3002) was analysed by scanning electron microscopy (SEM), using a FEI-Inspect F combined with an energy dispersive

spectrometer (EDS) INCA X-Act. The samples were coated with 15nm of carbon, and the images were collected using a back-scattered electron (BSE) detector. The EDS data were collected at 25KeV and quantified using Oxford Instruments INCA software.

The mortar residues on the objects were analysed by micro-X-ray fluorescence (μXRF) to study their elemental composition, using a Bruker M4 Tornado μ-XRF spectrometer. The data were collected at 50kV and 200 μA with a vacuum. The tabulated results are averages of at least 3 analyses and normalised.

Samples from the mortar residues were investigated by FTIR spectroscopy, using a Spectrum 100 spectrometer (Perkin Elmer) equipped with a DTGS detector, fitted with Attenuated Total Reflection (ATR) diamond-ZnSe crystal accessory. Spectra were recorded over the range 650-4000 cm^{-1}, with a resolution of 4.00 cm^{-1}, and were averaged over 32 accumulations.

Historical documents report that blood was added in the mortar formulation. Investigations were carried out to determine the presence of any organic additives. About 30 mg of fine powders collected from the mortar attached to the pebble (30119) were put in a glass tube and a solvent extraction was carried out using the following solvents: acetone, ethanol, isopropyl alcohol, toluene, and distilled water. The liquid extracts were deposited on silicon polished windows (Crystran Ltd, United Kingdom), and analysed by FTIR spectroscopy in transmission mode after gentle evaporation of the solvents. Background spectra were recorded with silicon windows and subtracted from the sample spectra. This procedure was not performed on every sample, but only on the one attached to the pebble, as it requires several mg of material. This test was mainly carried out to assess the reliability of the methodology and as a background for future investigations.

Results and discussion

Residues of mortars have been identified by visual observations on some objects recoverd from the excavation (Table 11). Stereomicroscopy observations allowed the observation of the morphology of the mortar, the binder, and the aggregates (Figure 42). No aggregates were observed in the mortar flakes on the animal bone, suggesting that either fine-grained aggregates or only the binder is still attached to the bone (Figure 42a and b). Aggregates with different sizes (mostly fine-grained aggregates, with sizes < 1mm) were found in the mortars from the iron bars and the pebble (Figure 42 c-f). Particles of unburned lime (white lumps) and brick powder were also identified.

Residues of wax or paint were not observed on the analysed objects, despite historical documents suggest their use as coatings for the floor.

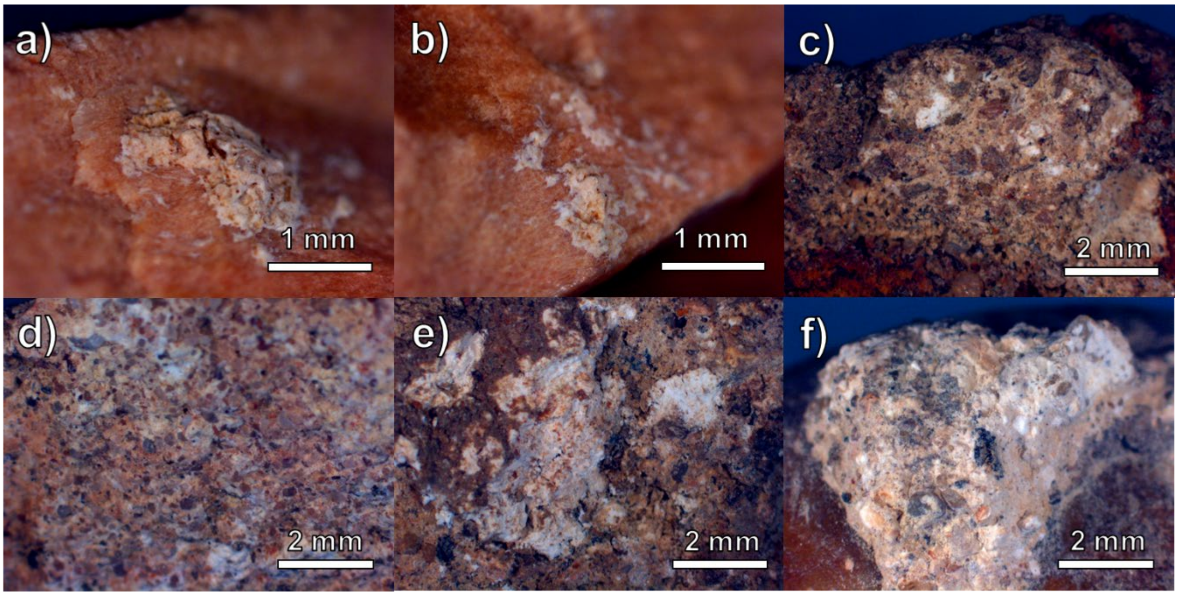

Fig 42: Stereomicroscopy images of mortar residues on animal bone (a. and b.), flat iron bar (c. and d.), curved iron bar (e.), and pebble (f.).

A small sample of mortar was collected from the iron bar (3002) and analysed by SEM-EDS. The images confirmed the presence of aggregates with different sizes (Figure 43). The elemental analysis of the mortar characterises the lime-based binder as mainly consisting of calcium carbonate. The aggregates are silicates and iron oxides (hematite), indicating that sand was used to enhance the mechanical resistance of the mortar. The coloured maps of the main elements (calcium, silicon and iron) highlighted the distribution of the binder and the aggregates in the mortar, showing a high binder/aggregate ratio.

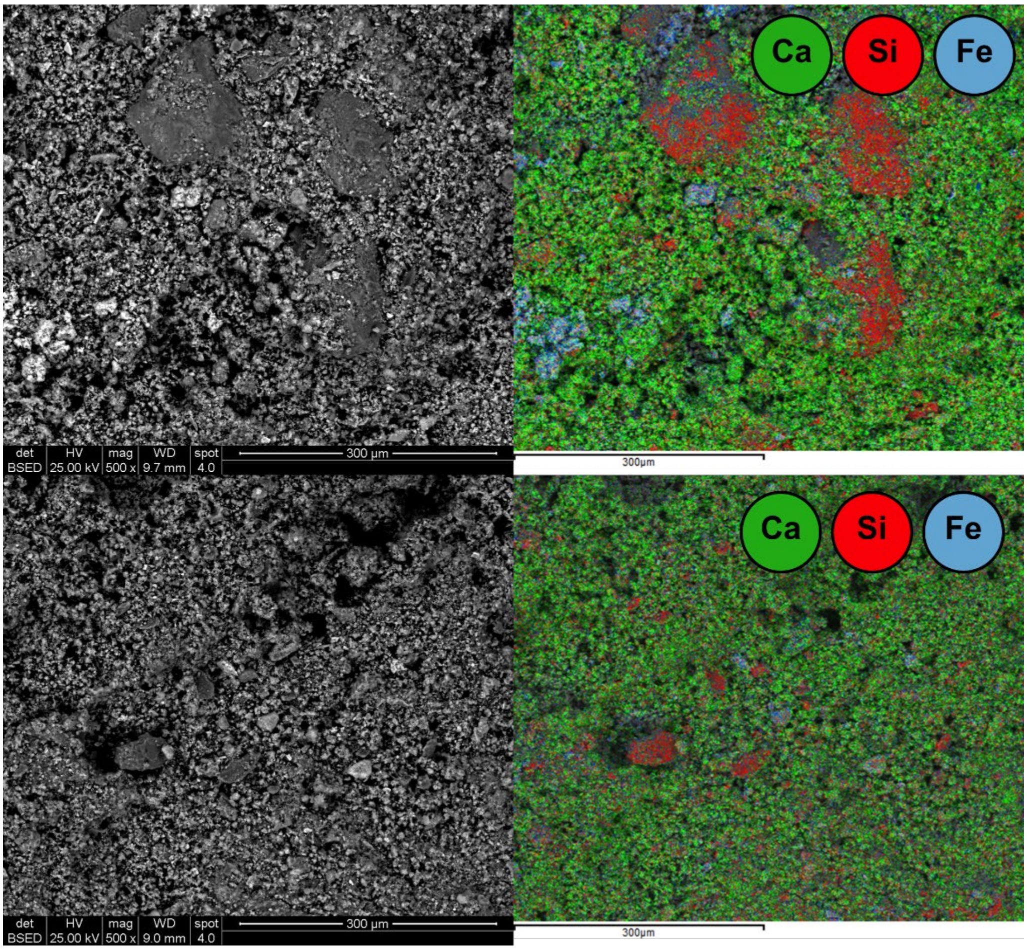

Fig 43: SEM images (BSE detector) and coloured maps of the main elements (calcium-Ca, silicon-Si and iron-Fe) of mortar collected from an iron bar (3002).

Homogenous areas of the binder of the mortars have been investigated by micro-XRF (Table 12). The elemental compositions of the mortars from the iron bars are comparable, especially regarding Al_2O_3, SiO_2, SO_3 and K_2O contents. The higher content of iron (FeO) in the mortars attached to the iron bars can be due to contamination from the iron bars. By comparing the chemical composition of the mortar found on the animal bone and on the pebble, some similarities can be noticed, especially regarding Al_2O_3, SiO_2, SO_3 and K_2O contents. A higher amount of P_2O_5 was found in the mortar attached to the bone compared to the pebble, and this is probably due to X-rays coming from the bone underneath (Table 12).

Ultimately, the results indicate that there are not significant differences in the mortar compositions. However, the mortars attached to the iron bars showed greater similarities between each other, and the mortars on the animal bone and on the pebble had more comparable composition.

Table 12: Chemical composition (microXRF, wt% oxides, normalised) of mortar residues from objects of the assemblage (bd = below detection).

Spectrum		**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**K_2O**	**CaO**	**TiO_2**	**MnO**	**FeO**	**MgO**
Mortar on animal bone (artefact number 30101)	Avg	2.73	6.46	2.03	0.27	0.22	85.75	0.11	0.03	1.96	0.18
	std	1.07	2.86	1.10	0.06	0.15	4.91	0.07	0.01	0.93	0.12
Animal bone (artefact number 30101)	Avg	0.51	0.62	48.05	0.18	bd	50.29	0.01	bd	0.04	0.20
	std	0.01	0.01	0.01	0.01		0.01	0.01		0.01	0.01
Mortar on flat iron bar (artefact number 3001)	Avg	4.38	13.95	0.30	1.09	0.38	71.81	0.18	0.11	7.43	0.27
	std	2.50	7.89	0.06	0.25	0.39	14.76	0.16	0.04	4.34	0.08
Mortar sample from flat iron bar (3001)	Avg	3.14	10.92	0.41	0.84	0.58	81.90	0.15	0.07	1.50	0.22
	std	2.24	5.00	0.22	0.62	0.31	9.47	0.10	0.01	1.10	0.25
Mortar on curved iron bar (artefact number 3002)	Avg	5.64	13.83	0.86	0.78	0.60	73.76	0.30	0.06	3.67	0.34
	std	2.43	4.73	0.61	0.12	0.54	9.12	0.25	0.02	1.57	0.38
Mortar on pebble (artefact number 30119)	Avg	3.14	8.60	0.49	0.52	0.16	83.05	0.16	0.26	3.39	0.07
	std	0.37	1.35	0.18	0.12	0.08	1.24	0.02	0.27	1.52	0.06

FTIR spectra collected form the mortars attached to the objects exhibit signals related to calcium carbonate and sand (silicates) used as aggregates (Figures 44-49). The presence of calcium carbonate is suggested by the bands at about 1410 (asymmetric C-O stretching), 875 (out-of-plane bending vibration) and 713 cm^{-1} (in-plane bending vibration) (Rampazzi et al 2016). Silicates exhibit bands in the 1200-900 cm^{-1} region. In particular, the broad band with the main peak centred around 1010-1030 cm^{-1} is due to Si-O stretching vibrations, while the broad band at about 3400 cm^{-1} is related to OH stretching (Madejová 2003). In addition, clay minerals were also found in the mortar attached to the iron bar (3002) (Figure 48).

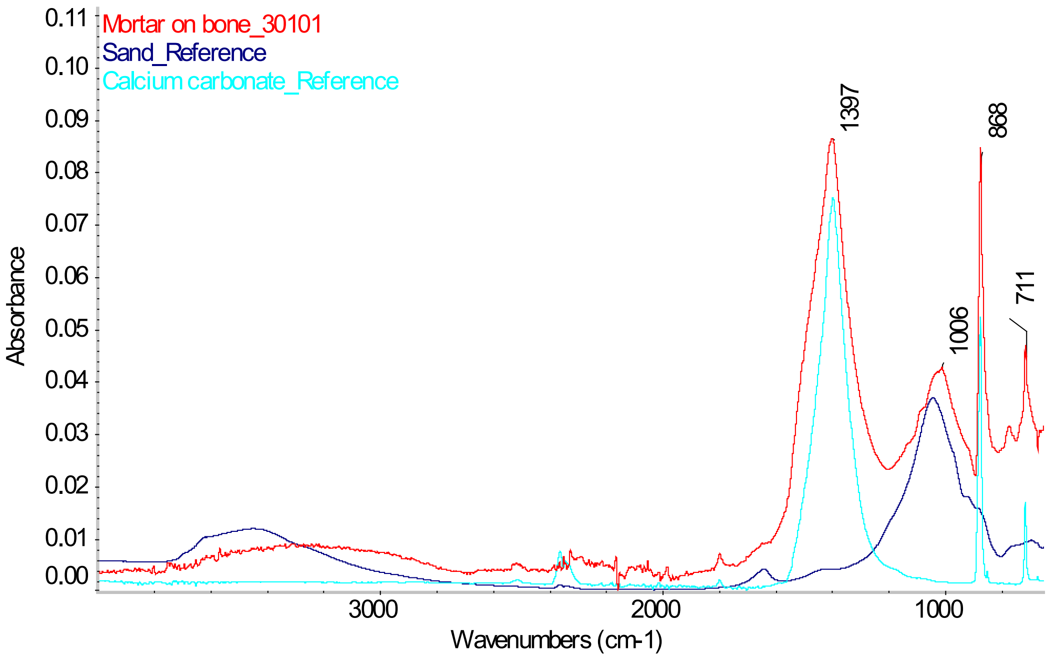

Fig 44: ATR-FTIR spectrum collected from the mortar attached to the animal bone (30101), and the FTIR spectra of reference samples of calcium carbonate and sand.

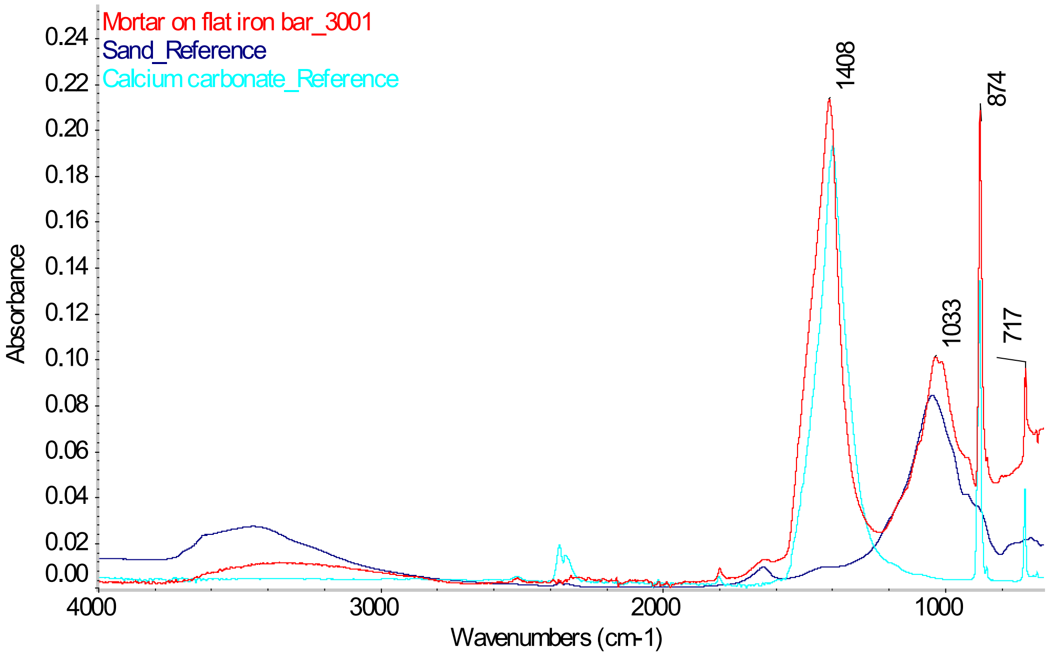

Fig 45: ATR-FTIR spectrum collected from the mortar attached to the flat iron bar (3001), and the FTIR spectra of reference samples of calcium carbonate and sand.

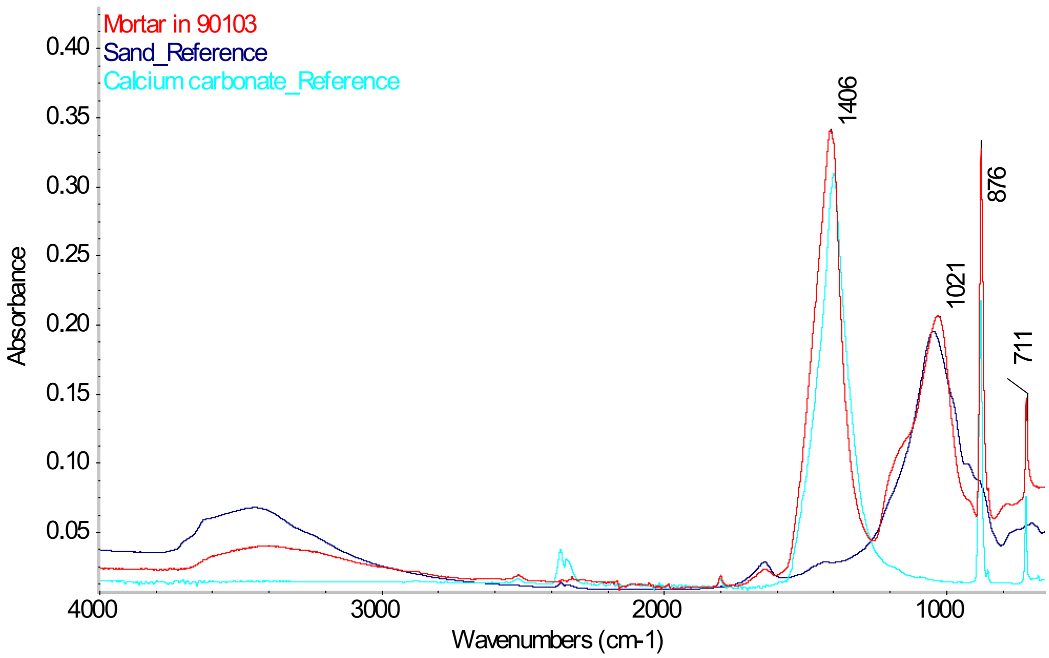

Fig 46: ATR-FTIR spectrum collected from the mortar residues from flat iron bar (3001), and the FTIR spectra of reference samples of calcium carbonate and sand.

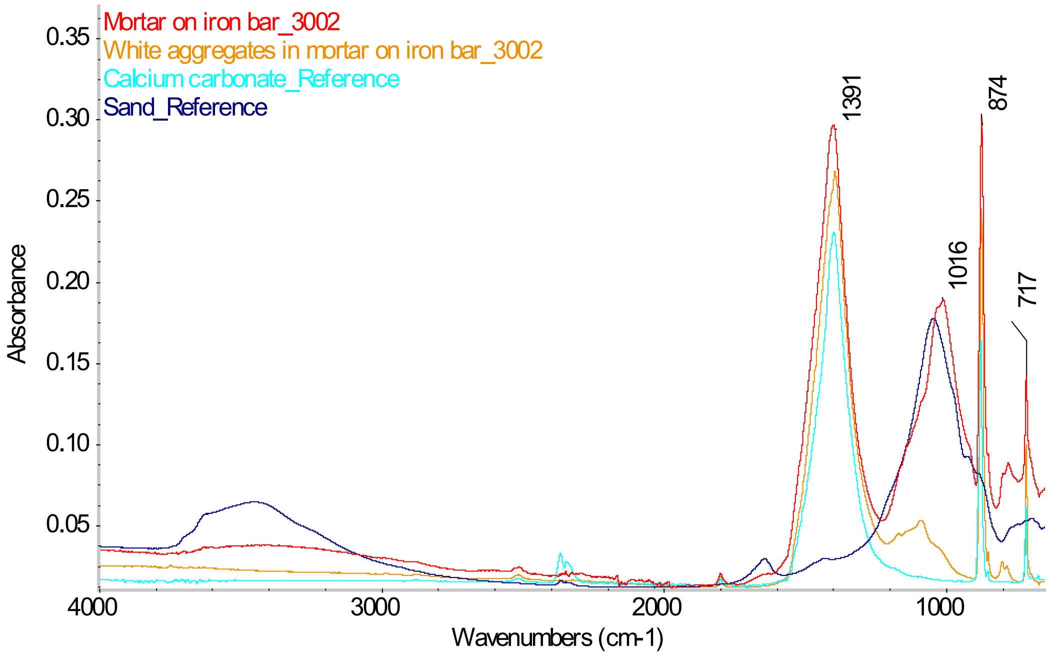

Fig 47: ATR-FTIR spectra collected from the mortar residues attached to the curved iron bar (3002) and white lumps in the mortar. For comparison, FTIR spectra of reference samples of calcium carbonate and sand are reported.

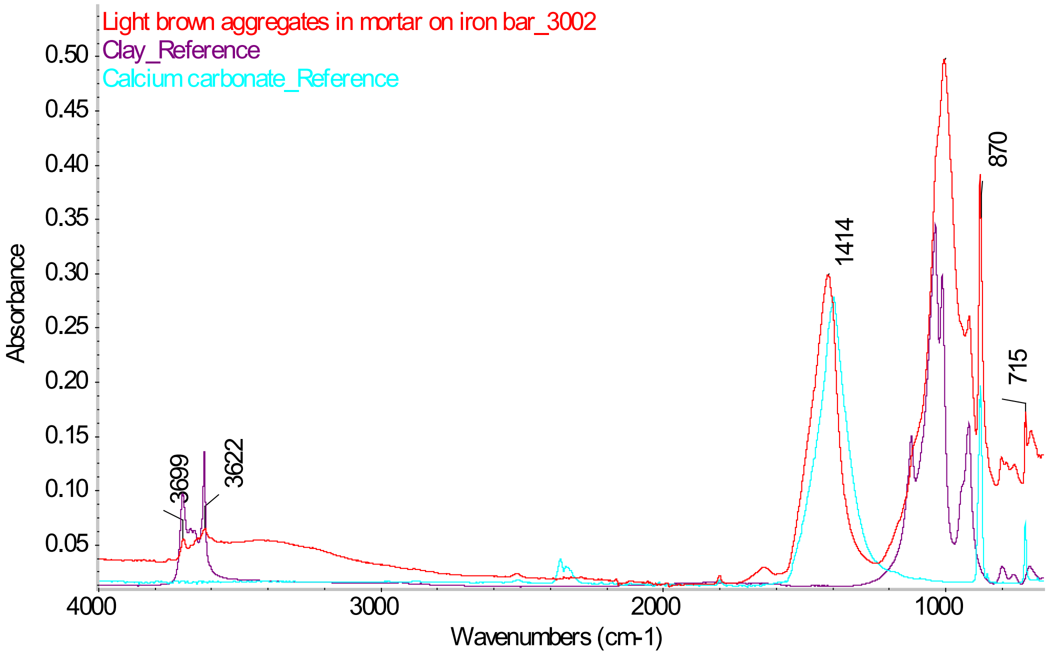

Fig 48: ATR-FTIR spectra collected from light brown aggregates in the mortar residues attached to the curved iron bar (3002), and the FTIR spectra of reference samples of calcium carbonate and clay.

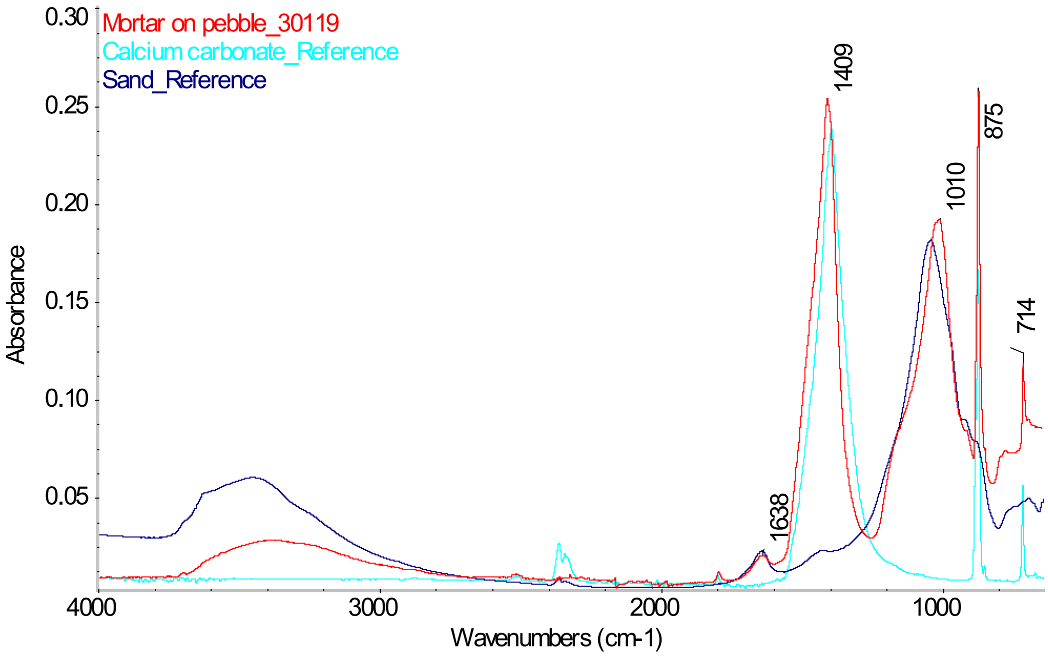

Fig 49: ATR-FTIR spectrum collected from the mortar attached to the pebble and the FTIR spectra of reference samples of calcium carbonate and sand.

To assess the presence of organic compounds in the mortar, chemical extraction in different solvents was performed on the mortar attached to the pebble. The FTIR spectra of water (Figure 50) and ethanol (Figure 51) extracts from the mortar attached to the pebble exhibit absorption peaks that can be attributed to the presence of lipids and proteins. The signals at about 2930 and 2840 cm^{-1} (CH_2 asymmetric and symmetric stretching, respectively) are related to methyl and methylene groups present in fatty acids long chains and proteins (Oleszko et al 2017, Lin et al 2017). The peaks at about 1745 cm^{-1} (C=O stretching) and 1167 cm^{-1} (CO-O stretching) are associated to esters (in cholesterol or fatty acids). Signals from proteins can be observed in the spectra, due to the bands at about 1640 cm^{-1} (C=O stretching of amide I), 1545 cm^{-1} (N-H bending of amide II), and 1150 cm^{-1} (C-O stretching). Bands related to phospholipids can be detected at about 1100 cm^{-1} (PO_2 symmetric stretching) and at 1240 cm^{-1} (PO_2 asymmetric stretching) (Oleszko et al 2017, Lin et al 2017). Some peaks (at about 1420 and 870 cm^{-1}) are due to residues of the inorganic fraction, in particular calcium carbonate.

The presence of lipids and proteins in the extracts from the mortar can be due to site use and contamination, but the possibility that it is connected to the use of blood serum in the formulation cannot be ruled out. Unfortunately, only one sample was investigated, therefore no comparisons can be made among the samples from the assemblage. The specific presence of blood serum can be further investigated by gas chromatography-mass spectrometry (GC-MS) analysis on every mortar sample recovered from the site.

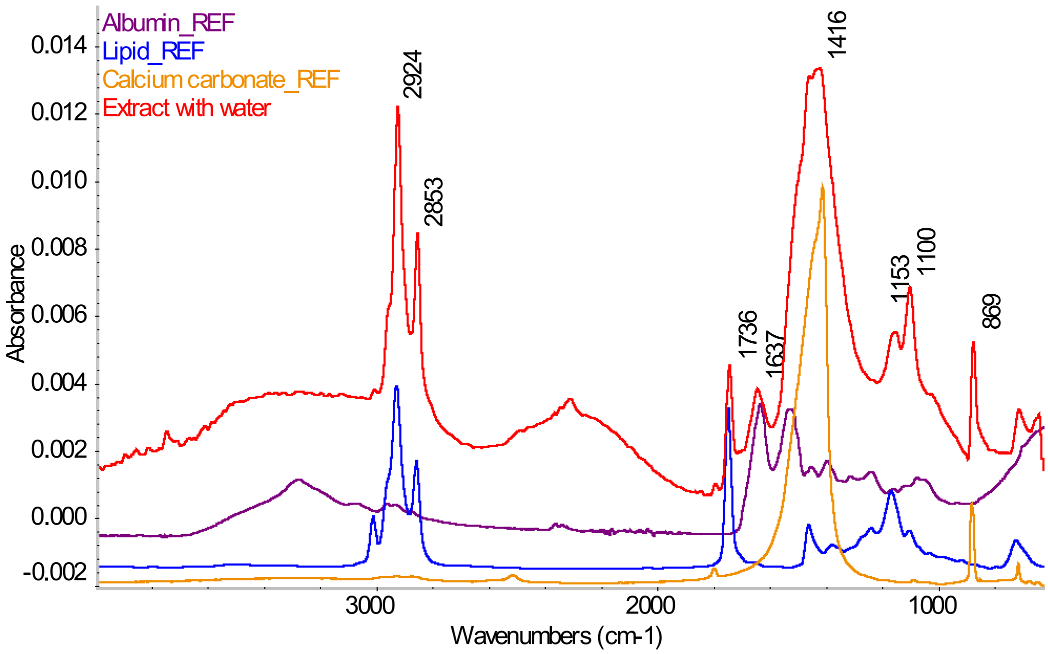

Fig 50: FTIR spectrum of the extract with water from the mortar attached to the pebble and the FTIR spectra of reference samples of a calcium carbonate, a lipid, and the albumin protein.

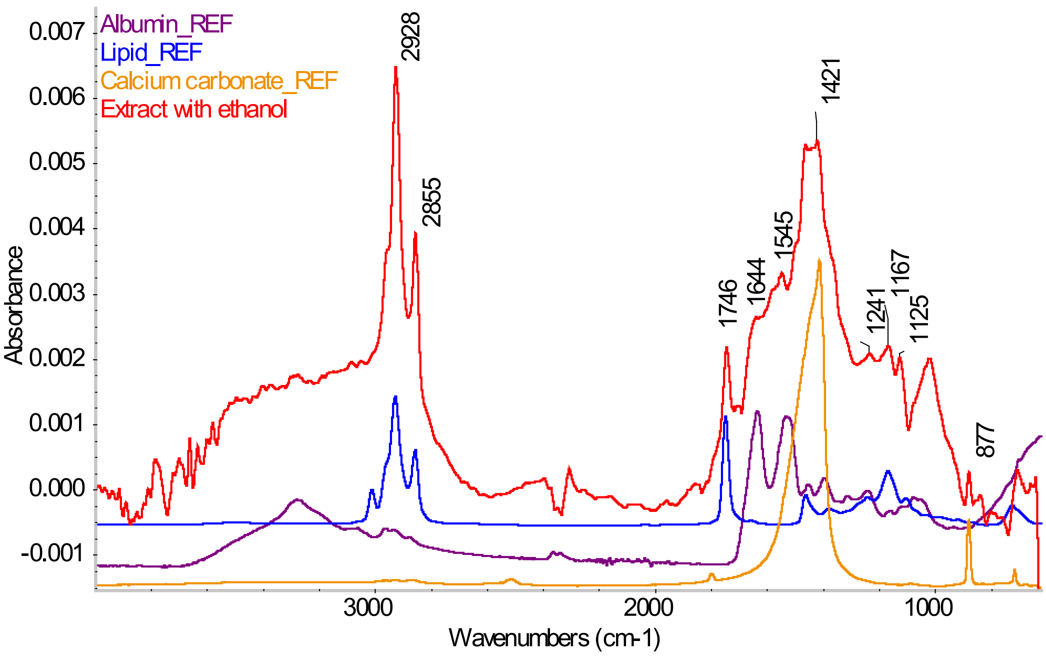

Fig 51: FTIR spectrum of the extract with ethanol from the mortar attached to the pebble and the FTIR spectra of reference samples of a calcium carbonate, a lipid, and the albumin protein.

Conclusions

Mortars attached to some objects recovered during the excavation of the Mithraic Glade were investigated to evaluate their composition, and if the materials can be connected to the existence of a pebble and bone floor, as suggested in historical documents.

Morphological observations and chemical analysis proved that the mortars are lime-based, while sand and brick powder were added as aggregates. In addition, XRF analysis indicates that there are no significant differences in the chemical compositions of the mortar samples. A more thorough study of the mortar and aggregates will be required to assess whether the materials are part of the same structure or not. To do this, larger samples will be required than those that are currently available.

Signals to be ascribed to lipids and proteins were observed in FTIR spectra of liquid extracts from the mortar attached to the pebble. Even though site contamination may have occurred, the addition of blood serum in the mortar formulation cannot be excluded. Further investigations using GC-MS on every sample from the assemblage are recommended to fully investigate this hypothesis.

Overall Excavation Discussion

In the Duke's Square we confirmed the existence of the perimeter path and identified the mysterious east-west features as land drains and discovered phasing of the statue bases that had previously been assumed to be single-event construction.

The Lady Duchess Square also included a statue base, but it had been cast in concrete to hold a returning statue that was subsequently moved to a different location where it re-used an old foundation. Sand-made paths were confirmed, and a mysterious feature resolved as a tree-throw from an ornamental tree complete with landscaping in the form of a circular path around it.

The Mithraic Glade revealed the footings of a building in the location of the root house, although it was robbed of any in-situ trace of the bone-and-pebble floor mentioned in letters during its construction (Hann 2021). Despite a lengthy description of how to construct deep foundations for root houses in letters from Thomas Edwards who directed the construction at Wrest (Hann 2021) the brick structure uncovered during excavations appears to be sat directly on the natural clay. There was a sand path in front of it that tied in with maps and period sketches, and this continued up the east side of the glade. It is possible that an original and more ephemeral structure was built in 1749 and later replaced by the remains found in Trenches A & C to the extent that the original footings were no longer visible, or that an original construction occurred elsewhere in the vicinity that did not reveal itself in the trenches.

While the trenches in each of the three areas revealed different features, there were some constants across the whole site. Most notable was the use of a layer of clean orange sand for paths, with no visible edging or repairs. This may have represented a single episode of path construction across the entire garden since the same material and detailing is seen in the Duke's Square, Lady Duchess Square, and Mithraic Glade, or perhaps a single regime of path maintenance using the same materials over a period of time. Also ubiquitous are the ceramic land drains, although the different forms of the pipe segments point to multiple episodes of construction. The presence of large pieces of industrial furnace waste in the packing of these drains is interesting. The wetness of the site no doubt called for new drainage schemes on a regular basis.

Overall Excavation Conclusions

Having set out to test the interpretation of features from the geophysical survey, armed with historic maps and other information, this small intervention managed to locate a structure where the root house should be, and identified paths and plinths as well as land-drains. These should enable plans for the conservation and even restoration of the three areas investigated, but also will allow refinement of interpretations of the geophysics results – discussion of excavation results with Neil Linford and Andy Payne have been very useful. Questions about the root house still remain, but would require substantial further excavation to resolve.

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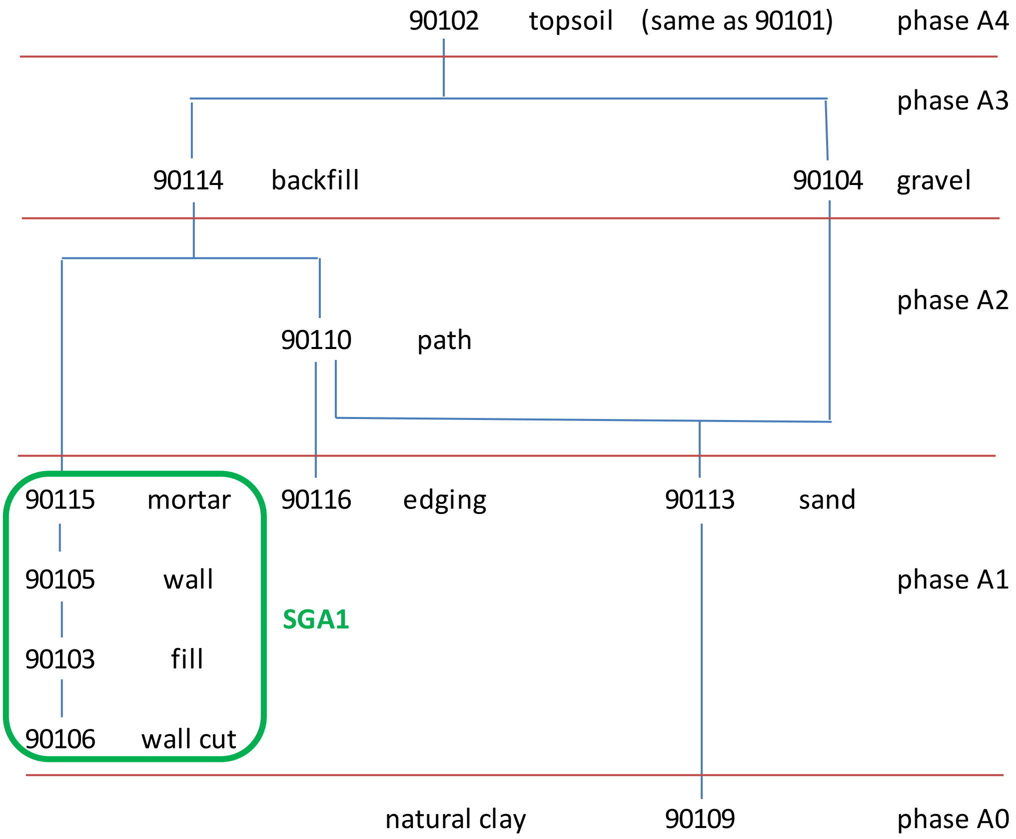
TABULATED ARCHIVE DATA

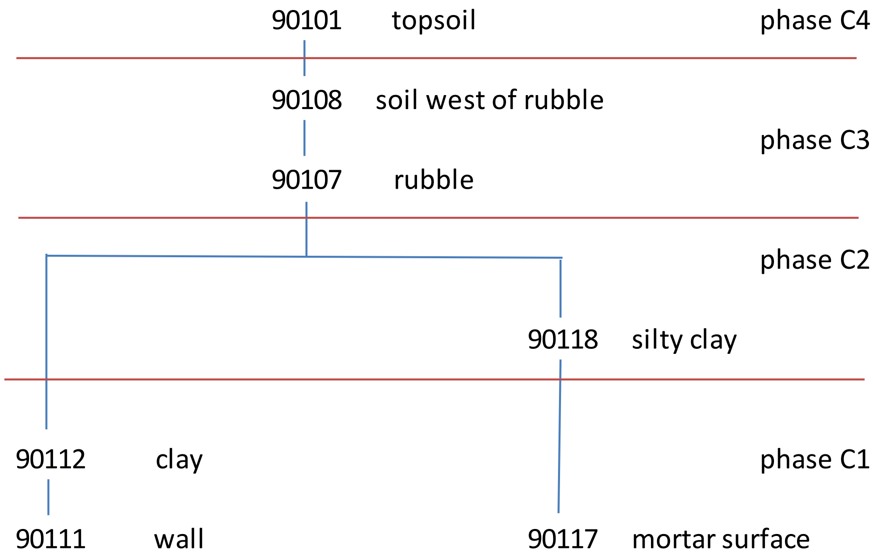
Context records	58
Assemblage records	61
Sample records	1
Drawing sheets	15
Boxes (Assemblages)	9
Images (digital photographs)	200
Scanned sketch digital images	9

APPENDIX 1: MATRICES

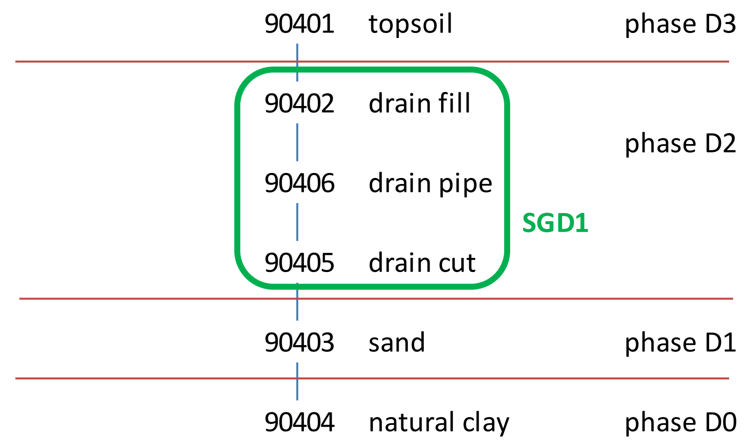
HE 0103 Wrest Park **Trench A matrix**



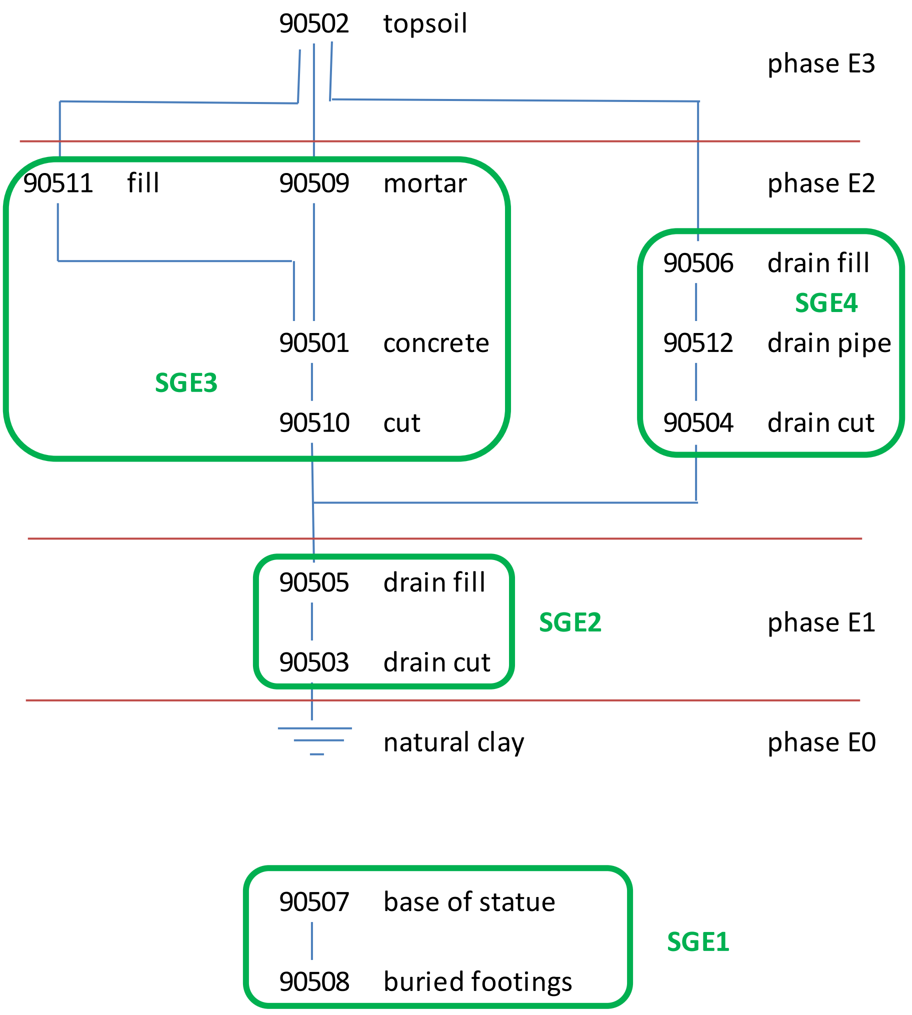
HE 0103 Wrest Park **Trench C matrix**



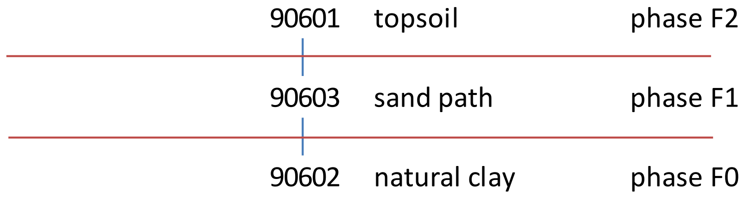
HE 0103 Wrest Park **Trench D matrix**



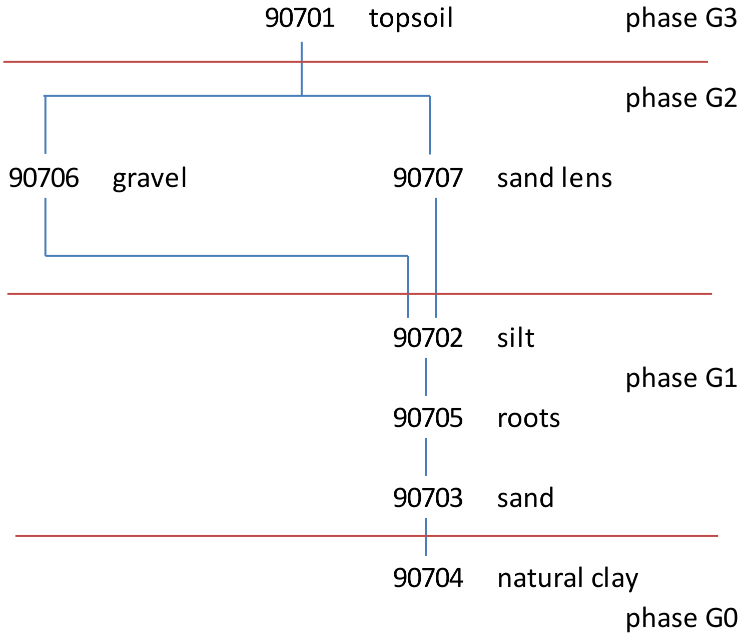
HE 0103 Wrest Park **Trench E matrix**



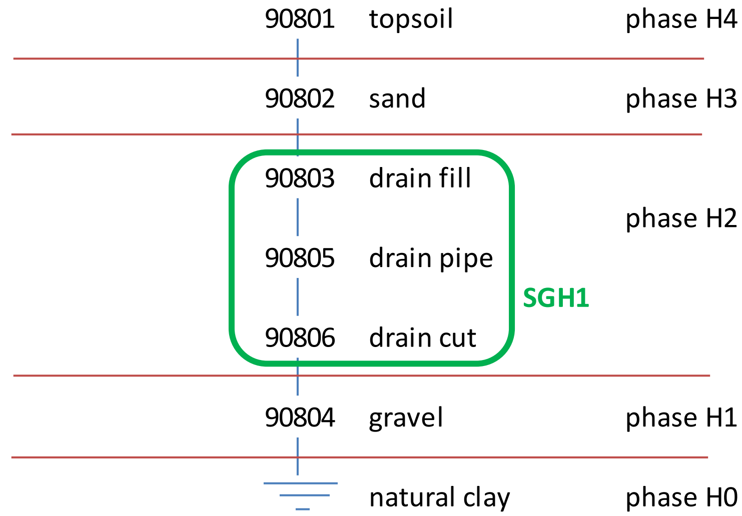
HE 0103 Wrest Park **Trench F matrix**



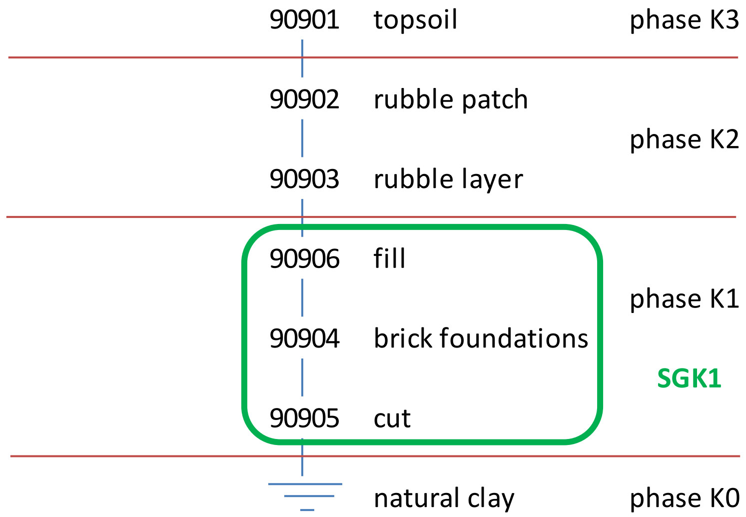
HE 0103 Wrest Park **Trench G matrix**



HE 0103 Wrest Park **Trench H matrix**



HE 0103 Wrest Park **Trench K matrix**



APPENDIX 2: INTERPRETIVE CONTEXT INDEX

Context number	Subclass	Interpretative Summary	SSD Name	Phase	Structural Group	Images Shown On	Sections Intersected By	Plans Shown On	Sample ID	Assemblages
90101	Deposit	Topsoil eastern arm trench C	Trench C, Mithraic Glade	C4		7039, 7040, 7041	20103, 20102, 20104			3003, 3006, 30120, 30121, 1000205, 1000207, 1000237, 1000240
90102	Deposit	topsoil trench A	Trench A, Mithraic Glade	A4			20101			3004, 30102, 30103, 30104, 30105, 30106, 30107, 30108, 30109, 30110, 30111, 30112, 30113, 30114, 30115, 30116, 30117, 1000059, 1000077, 1000079, 1000081, 1000136, 1000155, 1000218, 1000221, 1000223
90103	Deposit	rubble dump under wall 90105	Trench A, Mithraic Glade	A1	SGA1	7525, 7526, 7527, 7528		2102		3001, 3002, 3007, 30101, 1000233, 1000235, 1000242

90104	Deposit	Gravel path	Trench A, Mithraic Glade	A3		7524, 7531		2100		3005, 30118, 1000199
90105	Masonry	masonry wall Trench A	Trench A, Mithraic Glade	A1	SGA1	7525, 7526, 7527, 7528, 7544, 7545, 7546	20101	2102		
90106	Cut	construction cut for wall (90105)	Trench A, Mithraic Glade	A1	SGA1	7544, 7545, 7546	20101	2102		
90107	Deposit	Rubble spread	Trench C, Mithraic Glade	C3		7529, 7530, 7533, 7534, 7547, 7548, 7549, 7561, 7039, 7040, 7041, 7042, 7043	20103, 20102, 20104	2101, 2103		1000213, 1000215
90108	Deposit	Soil west of rubble 90107	Trench C, Mithraic Glade	C3		7529, 7530, 7533, 7534, 7547, 7548, 7549	20103, 20102	2101, 2103		1000202
90109	Deposit	Natural clay ridge	Trench A, Mithraic Glade	A0		7532, 7550, 7551		2100		
90110	Deposit	gravel path	Trench A, Mithraic Glade	A2		7535, 7536, 7541, 7542, 7543	20101	2102		
90111	Masonry	Wall foundation in east arm trench C under 90107	Trench C, Mithraic Glade	C1		7537, 7538, 7539, 7547, 7548, 7549, 7561, 7042, 7043	20102	2103		
90112	Deposit	Clay up against 90111	Trench C, Mithraic Glade	C1		7537, 7538, 7539, 7547, 7548, 7549	20102			1000227, 1000229

90113	Deposit	Sand path	Trench A, Mithraic Glade	A1				2100		
90114	Deposit	construction backfill in cut 90106	Trench A, Mithraic Glade	A3		7544, 7545, 7546	20101	2102		
90115	Deposit	mortar spread	Trench A, Mithraic Glade	A1	SGA1	7544, 7545, 7546	20101			
90116	Masonry	Gravel path - brick edging	Trench A, Mithraic Glade	A1			20101	2102		
90117	Deposit	Mortar and pebble surface	Trench C, Mithraic Glade	C1		7559, 7561, 7030, 7031, 7032, 7039, 7040, 7041, 7042	20103, 20104	2103, 2104		30119
90118	Deposit	Grey silty clay east of "floor" 90117	Trench C, Mithraic Glade	C2		7030, 7031, 7039, 7040, 7041	20104	2103		3008, 1000209, 1000231, 1000251, 1000259
90401	Deposit	Topsoil	Trench D, Mithraic Glade	D3						
90402	Deposit	fill of land drain	Trench D, Mithraic Glade	D2	SGD1	7023, 7024, 7034, 7035, 7036, 7037, 7038	20401	2400		
90403	Deposit	Path organge brown sand	Trench D, Mithraic Glade	D1		7023		2400		
90404	Deposit	Natural clay	Trench D, Mithraic Glade	D0		7023		2400		

90405	Cut	Slot through land drain	Trench D, Mithraic Glade	D2	SGD1	7034, 7035	20401	2401		
90406	Deposit	Ceramic pipe land drain	Trench D, Mithraic Glade	D2	SGD1	7034, 7035, 7037	20401	2401		
90501	Masonry	concrete foundation base in SE corner trench E	Trench E, Lady Duchess Square	E2	SGE3	7565, 7566, 7567, 7568		2501		
90502	Deposit	topsoil trench E	Trench E, Lady Duchess Square	E3						
90503	Cut	field drain cut trench E	Trench E, Lady Duchess Square	E1	SGE2	7565, 7566		2501, 2502		
90504	Cut	cut for field drain trench E	Trench E, Lady Duchess Square	E2	SGE4	7565, 7566, 7574, 7575, 7576, 7577		2501, 2502		
90505	Deposit	backfill of field drain cut 90503	Trench E, Lady Duchess Square	E1	SGE2			2501, 2502		
90506	Deposit	backfill of field drain cut 90504	Trench E, Lady Duchess Square	E2	SGE4	7574, 7575, 7576, 7577		2501, 2502		1000249

90507	Masonry	Base of Jemima statue in Duchess Square	Duchess Square (no SSD)		SGE1					
90508	Masonry	Original plinth footings for obelisk in Duchess Square	Duchess Square (no SSD)		SGE1					
90509	Masonry	mortar scar on concrete plinth 90501	Trench E, Lady Duchess Square	E2	SGE3	7567, 7568		2501		
90510	Cut	construction cut for concrete plinth 90501	Trench E, Lady Duchess Square	E2	SGE3			2501, 2502		
90511	Deposit	construction backfill for trench 90510	Trench E, Lady Duchess Square	E2	SGE3			2501		
90512	Masonry	ceramic drain pipe in cut 90504	Trench E, Lady Duchess Square	E2	SGE4	7574, 7575, 7576, 7577		2502		
90601	Deposit	Topsoil Trench F	Trench F, Lady Duchess Square	F2						
90602	Deposit	Natural clay	Trench F, Lady Duchess Square	F0				2600		

90603	Deposit	Gravel path	Trench F, Lady Duchess Square	F1		7578, 7579, 7580		2600		
90701	Deposit	Topsoil Trench G	Trench G, Lady Duchess Square	G3						
90702	Deposit	Silty layer below topsoil	Trench G, Lady Duchess Square	G1		7013, 7014, 7015, 7016, 7017, 7018, 7021, 7022, 7569, 7570		2700		
90703	Deposit	Yellow sand levelling deposit	Trench G, Lady Duchess Square	G1		7016, 7017, 7018, 7021, 7022, 7569, 7570		2700		
90704	Deposit	Natural clay	Trench G, Lady Duchess Square	G0		7569, 7570, 7573		2700		
90705	Deposit	Tree root lines	Trench G, Lady Duchess Square	G1		7569, 7570, 7573		2700	50701	
90706	Deposit	possible remnant of gravel path	Trench G, Lady Duchess Square	G2		7569, 7570, 7571, 7572		2700		
90707	Deposit	Sandy lens deposit	Trench G, Lady	G2		7569, 7570		2700		

			Duchess Square							
90801	Deposit	Topsoil	Trench H, Duke's Square	H4						1000034
90802	Deposit	Clean sand deposit - probably later path	Trench H, Duke's Square	H3		7504, 7505, 1000045, 1000049, 1000050		2800		
90803	Deposit	Fill of ceramic land-drain cut 90806	Trench H, Duke's Square	H2	SGH1	1000045, 1000050	20800	2800		1000244
90804	Deposit	Original gravel path around edge of Duke's Square	Trench H, Duke's Square	H1		7514, 7515, 1000049, 1000050				
90805	Deposit	Ceramic land drain	Trench H, Duke's Square	H2	SGH1	7514, 7515, 1000050	20800	2800		
90806	Cut	Cut for ceramic land drain	Trench H, Duke's Square	H2	SGH1	7514, 7515, 1000049, 1000050	20800	2800		
90901	Deposit	Topsoil trench K	Trench K, Duke's Square	K3			20901			
90902	Deposit	Brick fragments dump deposit	Trench K, Duke's Square	K2		1000067		2900		1000038, 1000039, 1000043
90903	Deposit	rubble dump to level the ground	Trench K, Duke's Square	K2		1000068	20901			

90904	Masonry	Large footings and square brick plinth remnants from former garden feature	Trench K, Duke's Square	K1	SGK1	7506, 7507, 7508, 7509, 7510, 7511, 7512, 7516, 7517, 7518, 7519, 7520, 7521, 7522, 7523, 1000067, 1000069, 1000070, 1000071, 1000072	20901, 20902	2900, 2901		
90905	Cut	Construction cut for plinth footings	Trench K, Duke's Square	K1	SGK1	7506, 7507, 7508, 7509, 7510, 7511, 7512, 7516, 7517, 7518, 7519, 7520, 7521, 7522, 7523, 1000070, 1000071, 1000072	20901, 20902	2900, 2901		
90906	Deposit	Fill of plinth construction cut	Trench K, Duke's Square	K1	SGK1	1000071, 1000072		2900		

APPENDIX 3: LIST OF ANIMAL BONES BY CONTEXT AND SMALL FIND NUMBER.

Abbreviations: ID Bone identification number; Cxt-Context; SF-Small Find number; Tax-taxon:S-Sheep, G-Goat; Fal-fallow deer; El-Skeletal element: Mc-Metacarpal; Mt-metatarsal: Lb Longbone, Rb Rib, I Indeterminate; Sd Side: L Left, R Right, I indeterminate; N Number of fragments; Zones Diagnostic bone zones after Serjeantson (1996); Pres Preservation: G Good, M Moderate; Ang Angularity: B Battered, S Spiky; Root Root etching; W Weathering/Erosion; NB New break; p present; Completeness Element completeness category; Rc Radiocarbon

ID	Cxt	SF	Tax	El	Sd	N	Zones	Pr	An	Rt	W	NB	Co%	Notes	Rc #	Rc age (BP)
283	90101	3006	Mn	Lb	-	1	-	M	B	p			1-20%			
268	90101	30120	D	Mt	L	1	1-4	G	S	p	p	p	41-50%	Pathology: buttress	GrM-28790	127+/-21
274	90102	3004	OC?	Mp	I	1	5/6	G	B			p	1-20%	Probably metapodial		
275	90102	3004	Mn	Mp	I	1	-	G	S	p		p	1-20%	Possible metatarsal		
276	90102	3004	Mn	Lb	I	1	-	M	S				1-20%	Splinter; two refitting fragments; possibly abraded through washing		
277	90102	3004	Mn	Lb	I	1	-	G	S				1-20%	Possible metapodial		
278	90102	3004	Mn	Lb	-	1	-	G	S				1-20%			
279	90102	3004	Mn	Lb	-	1	-	G	S			p	1-20%	Cortical thickness could indicate fallow deer size		
298	90102	30102	Mn	Lb	-	1	-	G	S				1-20%			
304	90102	30103	Mn	Lb	-	1	-	G	S				1-20%	Splinter		

270	90102	30104	OC	Mt	R	1	1-3	G	S				41-50%		ETH-120130	200+/-22
285	90102	30105	Mn	Mt	I	1	-	M	S	p	p		1-20%	Size roe/sheep/goat		
300	90102	30106	Mn	Lb	-	1	-	G	S				1-20%	Possible metatarsal		
292	90102	30107	Mn	Lb	-	1	-	G	S				1-20%	Splinter, possible metapodial		
293	90102	30108	Mn	Lb	-	1	-	G	S				1-20%	Splinter, possible metatarsal/tibia		
295	90102	30109	Mn	Lb	-	1	-	G	S				1-20%	Splinter, deer/sheep/goat size		
294	90102	30109	Mn	Lb	-	1	-	G	S				1-20%	Splinter, deer/sheep/goat size		
303	90102	30110	Mn	Lb	-	1	-	G	S				1-20%	Splinter		
302	90102	30111	Mn	Lb	-	1	-	G	S				1-20%	Possible sheep/goat metacarpal		
297	90102	30112	Mn	I	-	1	-	G	S				1-20%	Splinter		
296	90102	30112	Mn	Mt	I	1	-	G	S				1-20%	Probable fallow deer/large sheep/ goat metatarsal		
284	90102	30113	Mn	Lb	-	1	-	G	S				1-20%	Splinter, probable deer/sheep/goat size metapodial		
299	90102	30114	Mn	Lb	-	1	-	G	S				1-20%	Possible metatarsal		
269	90102	30115	OC	Mt	R	1	1-4	G	S		p	p	41-50%	Two refitting fragments; size of Cotswold ewe HE1352	GrM-28790	208+/-19
301	90102	30116	Mn	Lb	-	1	-	G	S				1-20%	Splinter		
287	90102	30117	Mn	Lb	-	1	-	G	S				1-20%	Splinter		

288	90102	30117	Mn	Lb	-	1	-	G	S				1-20%	Splinter		
289	90102	30117	Mn	Lb	-	1	-	G	S				1-20%	Splinter		
291	90102	30117	Mn	Lb	-	4	-	G	S				1-20%	Spiral fractures		
290	90102	30117	Mn	Lb	-	1	-	G	S				1-20%	Splinter		
286	90102	30117	OC?	Mt	I	1	3/4	G	S				1-20%	Size Cotswold ewe HE1352		
280	90103	3007	Mn	Rb	I	1	-	G	S	p	p	p	1-20%			
271	90103	30101	D	Mc	R	1	5-8	G	S	p			41-50%	Distal fused; mortar present	ETH-120129	107+/-22
281	90104	3005	O	Mt	I	1	-	G	S			p	1-20%	Associated with 90104 SF 30118, bone ID 272	GrM-28790	228+/-21
282	90104	3005	Ln	Lb	-	1	-	G	S	p			1-20%			
272	90104	30118	O	Mt	I	1	5&7/6&8	G	B		p		21-40%	Distal fused; associated with 90104 SF 3005 Bone ID 281		
273	90118	3008	Ln	Lb	I	1	-	G	S			p	1-20%	Possible fallow deer metacarpal	ETH-120131	237+/-22

APPENDIX 4: RADIOCARBON DATING AND CHRONOLIGICAL MODELLING

Peter Marshall, Irka Hajdas and Sanne Palstra

Six radiocarbon measurements were obtained on animal bones from the Wrest Park 2019 excavations (Table A4.1). All are conventional radiocarbon ages (Stuiver and Polach 1977).

Radiocarbon dating was undertaken by the Laboratory of Ion Beam Physics, ETH Zürich, Switzerland and Centre for Isotope Research, University of Groningen, the Netherlands in 2021. The three animal bone samples dated at the Laboratory of Ion Beam Physics, ETH Zürich underwent ultrasonic cleaning in distilled water before gelatinisation and ultrafiltration as described by Hajdas et al. (2007; 2009). They were then combusted in an elemental analyser and graphitised using the fully automated system described by Wacker et al. (2010a). Graphite targets were then dated using a 200kV, MICADAS AMS (Synal et al. 2007, Wacker et al. 2010b).

Carbon and nitrogen stable isotopic ratios were obtained on sub-samples of the ultrafiltered gelatin at the Department of Geology, ETH Zürich, using a ThermoFischer Flash-EA 1112 elemental analyzer coupled through a Conflo IV interface to a ThermoFisher Delta V Isotope Ratio Mass Spectrometer.

The three samples dated at the Centre for Isotope Research, University of Groningen, were pretreated using an acid-base-acid protocol (4% HCl, 1% NaOH, <1% HCl), gelatinised, and filtered (50μm) (Dee et al. 2020). The samples were then combusted in an elemental analyser (IsotopeCube NCS), coupled to an Isotope Ratio Mass Spectrometer (Isoprime 100) for measurement of %C, %N, C/N, $\delta^{13}C$ and $\delta^{15}N$. The resultant CO_2 was graphitised by hydrogen reduction in the presence of an iron catalyst. The graphite was then pressed into aluminium cathodes and dated by AMS (Synal et al. 2007; Salehpour et al. 2016).

Data reduction was undertaken at both laboratories as described by Wacker et al. (2010c). Both facilities maintain continual programmes of quality assurance procedures, in addition to participation in international inter-comparison exercises (Scott et al. 2017). Details of quality assurance data and error calculation at Groningen are provided by Aerts-Bijma et al. (2021), and similar details for ETH are provided in Sookdeo et al. (2020).

Chronological modelling

The six measurements are statistically inconsistent at the 5% level (T'=31.8; T'(5%)=11.1, ν=5; Ward and Wilson 1978) and are thus are not all of the same actual age.

When we calibrate a radiocarbon measurement (Fig. A4.1 – outline distribution), we assume that the calendar date of the sample is equally likely to fall at any point on the calibration curve. For one sample, this is a reasonable assumption; but as soon as we wish to calibrate a second measurement from a site, this assumption is no longer valid. The radiocarbon measurements on animal bones from Wrest Park are therefore related.

What we need is a way to account for the 'relatedness' of sets of radiocarbon dates. Bayesian statistics allow us to do this. Given the animal bones were all found on the same site we can therefore postulate their collection starts, it continued at a relatively constantly rate for some period of time, and it then ends. By, using the archaeological information that the radiocarbon dates relate to activity that continued for a certain period (and that it started before it ended!), our model can assess how much of the scatter on the radiocarbon dates comes from statistics and how much is real, historical duration.

The model (Fig. A4.1), implemented in OxCal 4.4 (Bronk Ramsey 2009) using IntCal20 (Reimer et al. 2020), assumes a uniform rate of animal bone collection for use at Wrest Park (Zeidler et al. 1998). Given the stable isotope results (Table A4.1) indicate that the dated animals consumed a diet predominantly based upon terrestrial C_3 foods, the radiocarbon results are unlikely to be affected by any significant reservoir effects and so a fully terrestrial calibration curve can be employed. The model provides estimates for the beginning of animal bone acquisition in *cal AD 1525–1795* (*95% probability*; StartWrestPark; Fig. A4.1) probably in *cal AD 1605–1665* (*39% probability*) or *cal AD 1730–1790* (*29% probability*), and its end in *cal AD 1690–1760* (*12% probability*; *EndWrestPark*; Fig. A4.1) or *cal AD 1770–1995* (*66% probability*), probably in *cal AD 1700–1715* (*3% probability*) or *cal AD 1785–1915* (*65% probability*). Figure 2 shows the estimated length of the phase of animal bone collection to be between *15–250 years* (*95% probability*; *WrestPark*; Fig. A4.2), probably between *20–145 years* (*68% probability*).

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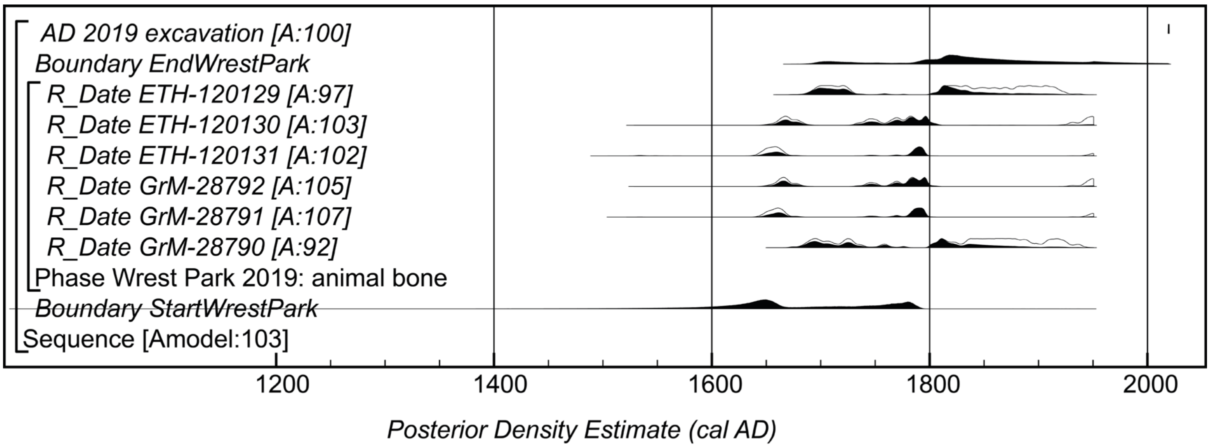

Figure A4.1: Probability distributions of dates from Wrest Park. Each distribution represents the relative probability that an event occurs at a particular time. For each of the dates two distributions have been plotted: one in outline, which is the result of simple radiocarbon calibration, and a solid one, based on the chronological model used. Other distributions correspond to aspects of the model. For example, the distribution 'StartWrestPark is the estimated date when the first animal died. The large square brackets down the left-hand side of the diagram, along with the OxCal keywords, define the overall model exactly (http://c14.arch.ox.ac.uk/)

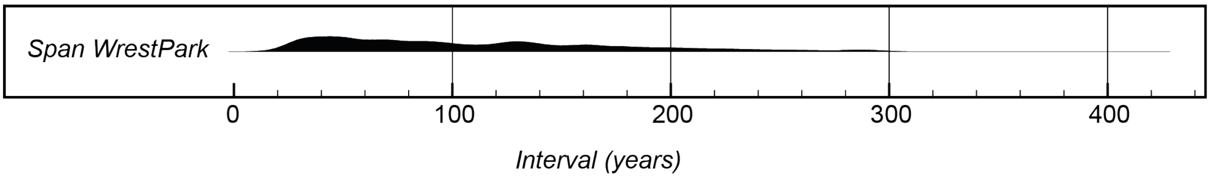

Figure A4.2: Probability distribution for the number of years during which animals utilised at Wrest Park were collected, derived from the model defined in Figure A4.1

Table A4.1: Wrest Park 2019: radiocarbon and stable isotope measurements

Laboratory number	Sample reference, material and context	$\delta^{13}C_{IRMS}$ (‰)	$\delta^{15}N_{IRMS}$ (‰)	C/N ratio	Radiocarbon age (BP)	*Highest Posterior Density interval (95% probability) cal AD*
GrM-28790	SF 30120, animal bone, fallow deer metatarsal (P Baker)	−22.6±0.15	5.5±0.3	3.2	127±21	*1673–1743 (40%) or 1751–1766 (4%) or 1772–1779 (1%) or 1798–1895 (49%) or 1908–1920 (1%)*
GrM-28791	SF 3005, animal bone, sheep metatarsal (P Baker)	−21.9±0.15	4.3±0.3	3.2	228±21	*1643–1678 (33%) or 1742–1752 (2%) or 1764–1800 (60%)*
GrM-28792	SF 30115, animal bone, sheep/goat metatarsal (P Baker)	−22.4±0.15	5.8±0.3	3.2	208±19	*1651–1684 (26%) or 1737–1756 (9%) or 1760–1804 (59%) or 1946–1951 (1%)*
ETH-120129	SF 30101, animal bone, fallow deer metacarpal (P Baker)	−22.4±0.1	4.6±0.1	3.2	107±22	*1683–1732 (40% or 1756–1761 (1%) 1800–1912 (54%)*
ETH-120130	SF 30104, animal bone, sheep/goat metatarsal (P Baker)	−22.1±0.1	7.1±0.1	3.2	200±22	*1653–1687 (24%) or 1731–1809 (70%) or 1947–1951(1%)*
ETH-120131	SF 3008, animal bone, large mammal long bone (P Baker)	−22.0±0.1	6.7±0.1	3.2	237±22	*1640–1673 (36%) or 1743–1751 (1%) or 1765–1800 (58%)*

APPENDIX 5: ZOOARCHAEOLOGY BY MASS SPECTROMETRY (ZOOMS) REPORT

Zooarchaeology by Mass Spectrometry (ZooMS) Report

HISTORIC ENGLAND: HE0109 Wrest Park Evaluation 2019

Author(s): S. Presslee

Date: 20/03/2023

BioArCh

Department of Archaeology

Environment Building, Floor 2

Wentworth Way

Heslington

York

YO10

5DD

THE UNIVERSITY of York

BIOARCH

Summary

1. 1 bone fragment was supplied for ZooMS analysis.

2. The bone fragment was subsampled and collagen extracted using acid demineralisation.
3. The resulting peptides were analysed using MALDI-ToF mass spectrometry and the spectrum provided an identification of likely red or fallow deer.

Introduction

Collagen

Collagen is the main protein of connective tissue in animals and the most abundant protein in mammals, making up about 25% of the whole-body protein content. Its fundamental structural unit is a long (300-nm), thin (1.5-nm-diameter) protein that consists of three coiled subunits: two α1 chains and one α2 chain. Each chain contains precisely 1050 amino acids, wound around one another in a characteristic right-handed triple helix to form tropocollagen subunits that are in turn bound in super-helices with each other to form the collagen molecule.

There are, so far, 28 collagen types, with types 1-4 being the most predominant as follows;

Type 1: the most common collagen (bone and teeth is almost exclusively Type I). It is also found in tendons, skin, artery walls and fibrocartilage with other collagen types.

Type 2: cartilage, vitreous humour of the eye.

Type 3: reticular fibres, artery walls, skin, intestines and the uterus.

Type 4: Basal lamina, eye lens, kidney.

Like many proteins the amino acid sequence of collagen is unique to every species, although the uniqueness may only be represented by a single amino acid substitution in the whole protein molecule.

Zooarchaeology by Mass Spectrometry (ZooMS)

ZooMS is a cheap, fast method of analysis that allows us to identify species from skeletal remains through Matrix Assisted Laser Desorption Ionisation Time of Flight Mass Spectrometry (MALDI-TOF-MS) and the subsequent analysis of collagen peptides. This analysis can also act as a cheap and quick method for screening samples for further proteomic analysis.

Materials & Method

Materials

- Hydrochloric acid
- Ammonium bicarbonate (AmBic)
- Sodium hydroxide
- Acetonitrile (ACN)
- Sequencing grade trypsin
- Trifluoroacetic acid (TFA)
- α-cyano-4-hydroxycinnamic acid (matrix)
- C18 ZipTip® pipette tips
- Calibrant
- Conditioning solution (0.1% TFA in 50:50 ACN:Water)
- Washing solution (0.1% TFA)

ZooMS ID	Sample Reference	Weight (mg)
00265-01	SF 3008; Cxt 90118	40.1

Table Z1. The weight of the sub-sample used for the analysis.

Methods

Destructive acid demineralisation

1. 250 µl of 0.6M HCl was added to the sample before being placed in the fridge at 4°C to demineralise for 48 hours.
2. After 48 hours the sample was removed from the fridge and spun down in a centrifuge. The acid was removed and 200 µl of 0.1M sodium hydroxide was added to remove any humic contamination. The Eppendorf was vortexed briefly before being centrifuged and the supernatant removed.
3. 200 µl 50mM AmBic was added in order to 'rinse' the sample. The Eppendorf was vortexed briefly before being centrifuged again for one minute and the supernatant removed. This rinsing process was repeated twice more.
4. 200 µl of AmBic was then added to the sample, followed by incubation for one hour at 65 °C to release any available collagen into solution.
5. After this, 100 µl of supernatant was transferred to a new Eppendorf ready for digestion, and the remaining 100 µl was stored at -20 °C for further analysis if needed.
6. 1 µl of the enzyme trypsin was added to the new Eppendorf and the sample was digested overnight at 37°C. The enzyme breaks down the protein into fragments

called peptides, which can then be analysed via mass spectrometry.

7. Following digestion, the sample was centrifuged and 1 µl of 5% TFA solution was added to terminate trypsin activity.
8. Peptides were then extracted from the sample solution using C18 ZipTip® pipette tips and eluted with 50 µl of conditioning solution. This helps remove any contaminants from the sample that may hinder the analysis.
9. 1 µl of the sample was spotted onto a Bruker ground steel target plate and mixed with 1 µl of matrix. The matrix helps ionise the peptides and allows them to be detected. The sample was spotted in triplicate and the plate was run on the Bruker UltrafleXtreme MALDI-ToF MS. A calibrant of 6 known peptides was spotted next to the sample to allow for external calibration prior to sample analysis.

Results

The averaged spectrum of the sample is shown in Figure Z1 below. The spectrum showed peptide markers that are common among many bovids and cervids in the ZooMS reference database. A full list of the possible species and the markers are shown in Table Z2.

Due to some of the mass information being missing for peptide marker a2 889, the list of possible species cannot be narrowed down further using peptide mass fingerprinting.

However, most of the possible species can be discounted due to geographical restrictions. The majority of species listed are not native to the UK and therefore the most likely identification is that of either red or fallow deer.

		Peptide markers												
Common name	**Species**	α1 508	α2 978	α2 978 (+16)	α2 484	α2 502	α2 292	α2 889	α2 793	α2 454	α1 586	α1 586 (+16)	α2 757	α2 757 (+16)
Impala	Aepyceros melampus	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Hartebeest	Alcelaphus buselaphus	1105	1180	1196	1427	1550	1648	1590	2131	2792	2883	2899	3017	3033
Springbok	Antidorcas marsupialis	1105	1180	1196	1427	1550	1648	1532	2131	2792	2883	2899	3017	3033
Blue wildebeest	Connochaet es taurinus	1105	1180	1196	1427	1550	1648	1590	2131	2792	2883	2899	3017	3033
Hirola	Damaliscus hunteri	1105	1180	1196	1427	1550	1648	1590	2131	2792	2883	2899	3017	3033
Tsessebe	Damaliscus lunatus	1105	1180	1196	1427	1550	1648	1590	2131	2792	2883	2899	3017	3033
Thomson's Gazelle	Eudorcas thomsonii	1105	1180	1196	1427	1550	1648	1532	2131	2792	2883	2899	3017	3033
Gazelle	Gazella sp.	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033

Grant's Gazelle	Nanger granti	1105	1180	1196	1427	1550	1648	1532	2131	2792	2883	2899	3017	3033
Oribi	Ourebia ourebi	1105	1180	1196	1427	1550	1648	1532	2131	2792	2883	2899	3017	3033
Steenbok	Raphicerus campestris	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Saiga	Saiga tatarica	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Elk	Alces alces	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Chital Deer	Axis axis	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Red deer	Cervus elaphus	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Fallow deer	Dama dama	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Pere David's deer	Elaphurus davidianus	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033
Irish Elk	Megalocero s giganteus	1105	1180	1196	1427	1550	1648	-	2131	2792	2883	2899	3017	3033

Table Z2. The full list of species showing all the same possible peptide markers. The dashed line for peptide marker a2 889 indicates that the mass of the peptide marker for that species is unknown. The full list of references in which these markers are defined is available in the bibliography.

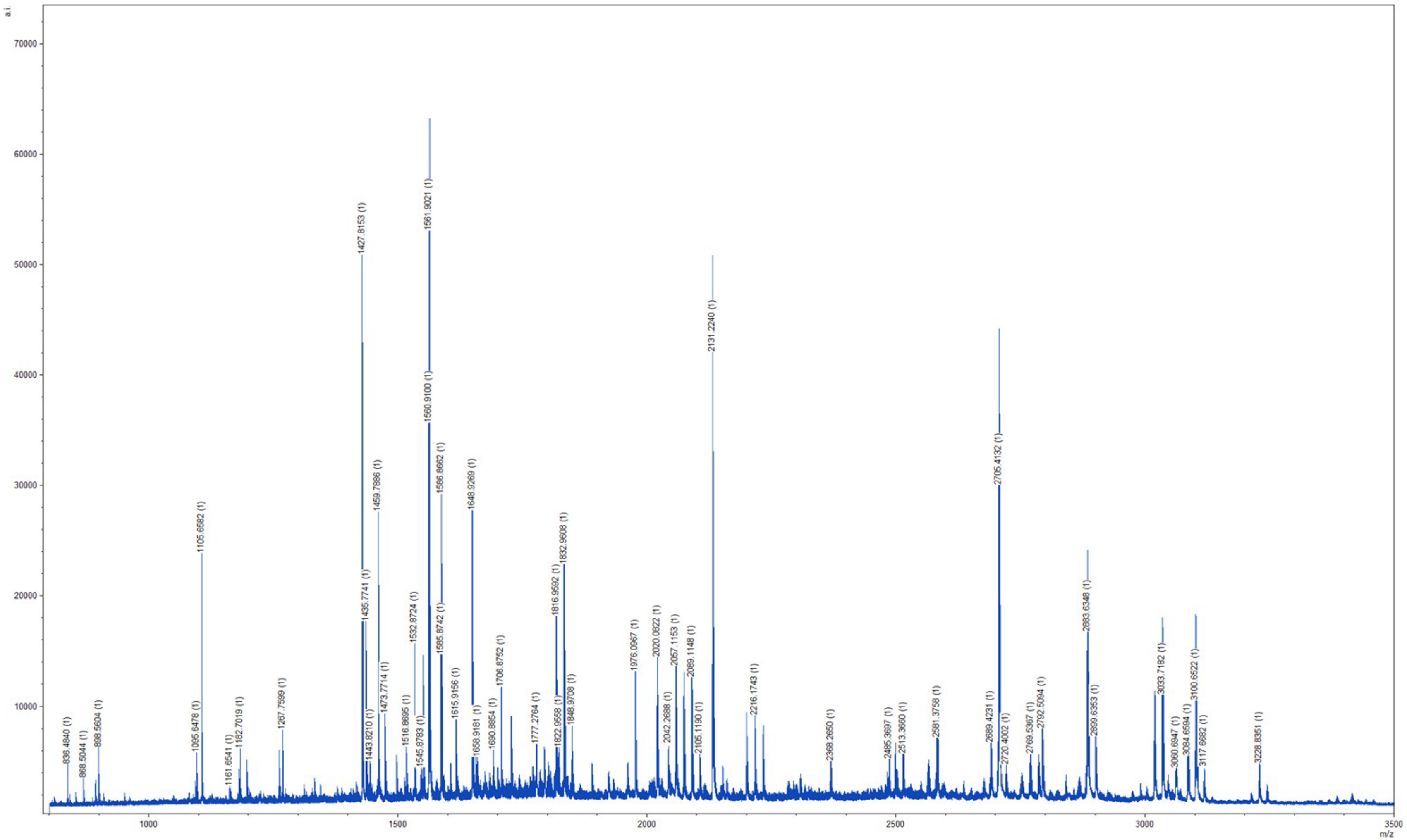

Figure Z1. The averaged spectrum for sample 00265-01.

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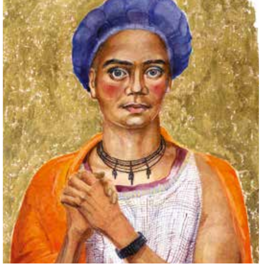

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