Glastonbury Abbey

Notes on the Medieval Floor Tile Collection

Jane Harcourt

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1. The tile collection

These notes are intended to accompany the report on the medieval floor tile collection in the monograph on Glastonbury Abbey published by the Society of Antiquaries. This contains details of the groupings revealed by size, design type and chemical and fabric analysis. Descriptions of the tile designs can be found in the Glastonbury Abbey Medieval Floor Tile Design Catalogue and details of the individual tiles analysed can be found in the database.

The medieval floor tile collection is a very small proportion of the original quantity which is unknown but must have been extensive. Glastonbury from the 13th century on was a very prosperous house and tiles were available literally on the doorstep for group 1 and at no great distance for groups 2 to 7. The percentage of plain tiles, less than 4%, must be a distortion of the true quantity, particularly as some areas, such as the abbot's hall, are thought to have been paved with plain tiles. Perhaps surprising is the survival of group 1 tiles, 6.25% of the total, of mid 13th century date and probably set in a high traffic, important setting and therefore more likely to have been replaced later. Possibly they were reused elsewhere? It is not surprising that group 7 features as the second largest in the collection given the potentially long production period but although this group may feature several sub-groups there is insufficient evidence to make any such division. Group 4 is more than twice as large as group 7; groups 3 and 4 are thought to be contemporaneous and their combined size is 61% of the collection. Assuming that these were in the east end of the church which would have been the first area to be dismantled some tentative conclusions can be drawn. There must have been a large number of them, not just a patch in front of the altar and production must have taken a concerted effort between 1274 and 1278 and they were almost certainly manufactured and laid before Edward I's visit in 1278. In addition, John of Taunton extended the east end of the church and it is possible that all this was tiled.

2. Tile numbering – general notes

The tiles are stored in green crates labelled T1 onwards which replaced wooden trays without re-arranging the distribution of the fragments. It was unclear whether this classification had any significance in archaeological context or not as some crates contain predominantly one design while others are completely mixed. Additional T numbers have been allocated to tiles on display and those in situ in the grounds. T520 has been given to a range of tiles which were not numbered and had no specific box, mainly being on display.

F. B. Bond had sorted out tiles by design and laid them out in the abbot's kitchen. These were later moved to the gatehouse and piled in a heap without retaining his sorting. Hence there is the rather disparaging term 'Bond's heap' used as a provenance. Wedlake's unpublished tile report (ref. Gatehouse Archive box 21, A650) indicates that the current classification was by design, largely the result of Charles Clayton's examination of "Bond's heap" in the gatehouse cellar. The wooden trays these were stored in were relocated during the war, returned later, "*but alas not in their previous good order*" which implies that stray fragments found their way into the nearest tray available.

Crate T92 could not be found anywhere in the gatehouse.

Some of the fragments appear to have been marked with the same number. Where this has occurred they are shown on the database with an ‘a’ or ‘b’ suffix. There are also two gaps in the database of 13 and 10 numbers respectively where the tile marking seems to have inadvertently skipped between numbers GLSGA:1988/762.80 to GLSGA:1988/762.94 and between GLSGS:1988/772.50 to GLSGA:1988/772.59.

Former handling collection T555-T572
These were obviously part of the collection but were not included in the main numbering sequences, probably because the cases they were housed in were not found until later. They are now in a green crate stored with the others. Most of these tiles are distinct because of their size and clarity and could be used for future displays but should not be used as a handling collection. T555 is the only example of this design and is a rare example.

3. Numbering of tiles on display

There are several tiles on display, some the only example of a design. Some of these are composites, the fragments not necessarily from the same tile and in some cases cut to fit. The near completeness of the design as well as its clarity, are probably the main reasons for choice.

Left hand panel - 7 tiles:

Display No.	Design	Group	Heraldry
1	33	4a	England
2	39	4a	Mortimer?
3	35	4a	de Clare
4a	36	4a	de Warenne
4b	37	4a	de Warenne
5	82	7a	de Spencer
6	79	7a	Cornwall reversed

Right hand panel - 5 tiles:

Display No.	Design	Group
7a	50	4b
7b	93	7a
8	87	7a
9	48	4b
10	42	4b

The central part is not numbered on the display board but is numbered for convenience on the following plan, starting from the back:

Left Panel			Central display Rear			Right Panel
1. T467 D33			11. T583 D0			7a. T524 D50
2. T526 D39		12. T584 D69		13. T466 D51		7b. T581 D93
3. T580 D35	14. T88 D126	16. T586 D101	17. T587 D47	18. T588 D135	19. T589 D129	8. T582 D87
4a. T527 D36	15. T585 D6					9. T465 D48
4b. T528 D37	20. T590 D46	22. T592 D63 (x4)	23. T593 D56	24. T530 D9	25. T594 D54	10. T523 D42
5. T525 D82	21. T591 D5					
6. T529 D79			26. T531 D72		27. T532 D20	

Numbering of tiles on display. Only the tiles on the side panels display numbers.

These are representatives of 7 of the 11 groups but variations in fabric are not that noticeable visually, especially in a display case. The examples of design 63 are interesting because they show how a corner motif, when adjoining other examples, creates part of the overall design.

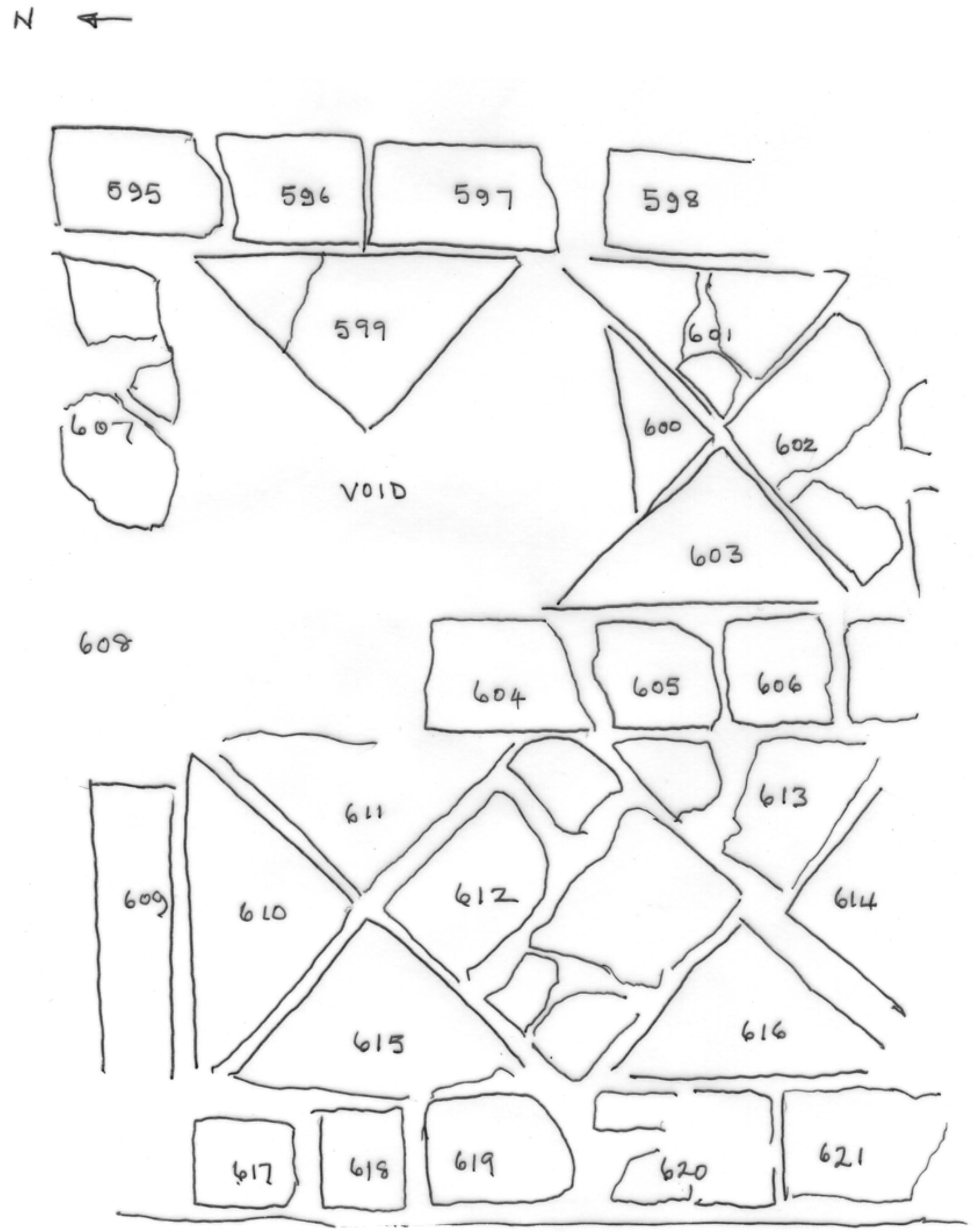
4. Numbering of tiles in situ in the north transept

Historical evidence

According to Bond '*An Architectural Handbook of Glastonbury Abbey*' (p 68) "the transept floors were almost certainly tiled over their whole area, and the excavations everywhere yield plentiful fragments. In the early days of the 19th century an area 8ft by 6ft of perfect floor tiling was uncovered in the transept chapel .... but all traces are gone. During the spring of 1909 in the course of levelling the grass bank a perfect fragment was found 'in situ' and this gives us the true level of the transept floor". Another patch of tiles was uncovered in 1921. There is no evidence that these are the two small areas which exist today but this is the most likely assumption.

The northern area of tiles

The northern of the two tiled areas measures approximately 54 by 64 cm. The layout appears to consist of a single whole tile set diagonally and surrounded by six triangular half tiles, all design 56, set within a black border. This is then repeated. It is unlikely to be a genuine layout as fragments of inlaid tiles are set in the border area and also because it seems to be a very small pattern to be used in such a comparatively large area.



North Transept northern area of tiles

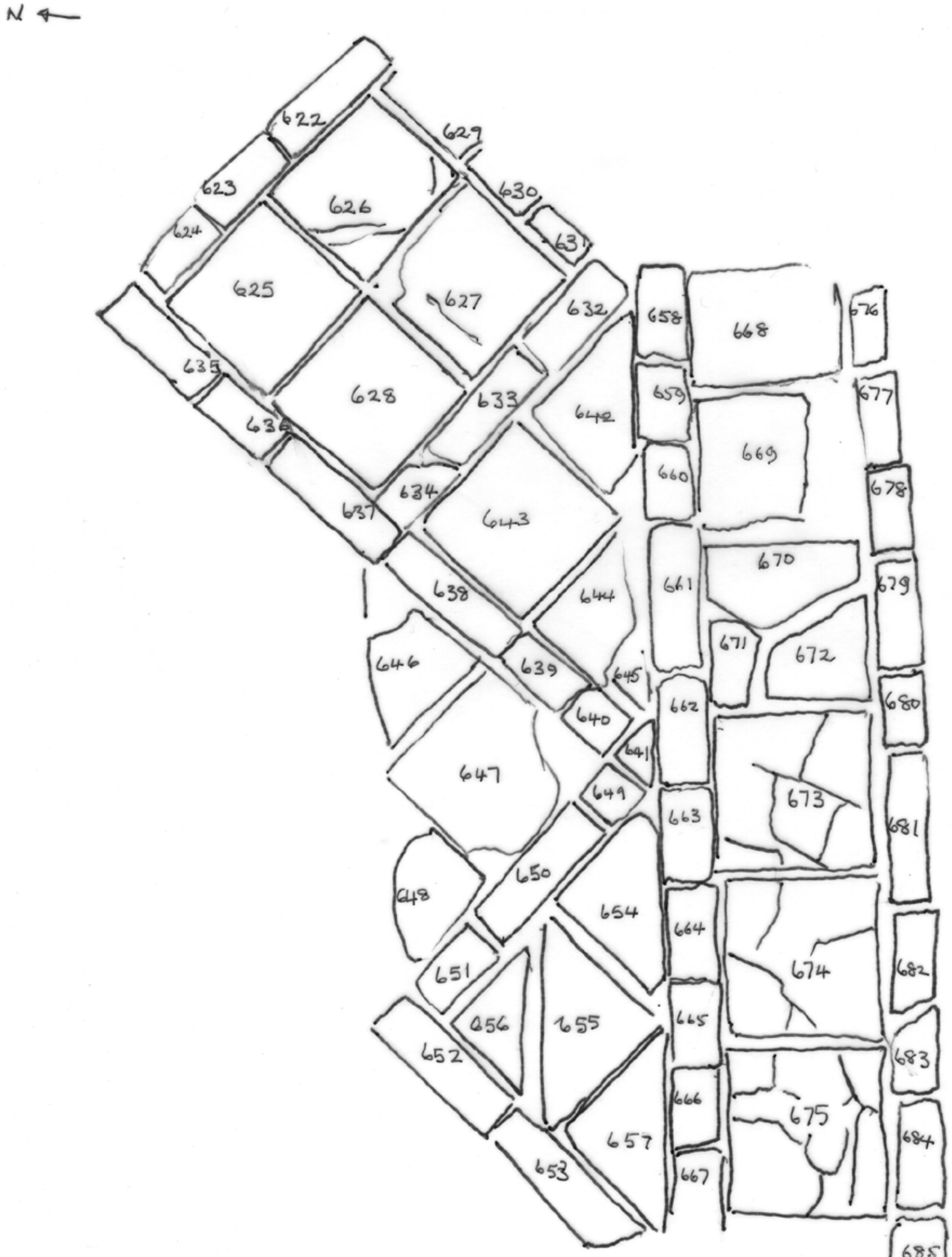
North Transept; northern area of tiles

The southern area of tiles

The southern area is more complex with a band of one tile width in a frame of black border tiles. Beside this is a lattice of black border tiles enclosing four whole tiles or, at the edges, a single whole tile and two triangular half-tiles. Most of the tiles in the band are design 37, heraldic arms of de Warenne. There is also a fragment of design 26, a large heraldic tile. The orientation of the heraldic tiles is towards the west, not towards the altar at the east which suggests that they are not in situ. Border tiles are normally laid to match the length of the inlaid tiles they are set against, with small square tiles, with slip, set at the intersections. In this layout the intersection tiles have been omitted, with the exception of one small triangular tile at the edge, and the border tiles have been butted against each other, necessitating odd lengths to be used here and there to make up the gaps caused by the omission of the intersection tiles. It is likely that all the tiles came from these areas but perhaps they were moved around until such time as they were set in concrete, when layouts were suggested.

The transept was built in the abbacy of Michael of Amesbury (1235-53) who was buried here. Tiles were produced during his abbacy but none appear here, these examples are all from the late 1279s. This may suggest that the early tiles were confined to small areas like the chancel, or that they were replaced by a large production surge prior to the visit by Edward I.

North Transept; southern area of tiles



North Transept southern area of tiles

5. Other sites with tiles from Glastonbury

i) Brighton Museum is mentioned in 'Notes and Queries for Somerset and Dorset, June 1911, vol. XII part XCIV, p.251 no.171. The entry reads: *"Tiles at Brighton Museum said to be 3 tiles and 2 fragments from Glastonbury Abbey"*. The description of 2 birds in a circle is similar to design 52.

ii) Edgarley House, now part of Millfield School. There were tiles from the abbey in the summerhouse, which was also constructed with stone and carvings from the abbey. Roger Parsons, Historian at Millfield School sent the following story about the Hermitage, on Edgarley Hall grounds:

"I also attach a photo of what the Porch family called The Hermitage, a kind of summer house modelled on the famous Abbot's Kitchen in the grounds of Glastonbury Abbey, built at Edgarley House in the 1830s when the family owned both Edgarley House and the Abbey. One of the first school magazines (1948) has an article on the Hermitage, one section of which reads 'Our soldier visitors during the war – British Royal Engineers and American GIs – must have loved it, if one may judge by the souvenirs they took away with them. They appear to have favoured particularly the tiles on the floor'!"

See also www.thisisdorset.co.uk/history-Edgarley-Hall. It is curious where these tiles came from. If there were not heaps of them around, and it is difficult to imagine this with the history of uninterested owners of the abbey, perhaps these were taken from the "*8' by 6' of perfect floor tiling uncovered in the transept chapel*", or from the Edgar chapel. Bond states " *much was uncovered about the year 1812-13 ..... what was uncovered was promptly eradicated*".

iii) Taunton Museum has a collection of Glastonbury material, including one tile which is not represented in the abbey collection, see B. Lowe's publication, design 500.

iv) The British Museum has 3 tiles from Glastonbury:

a) Ref. 1947,0505,683. This is design 33 at Glastonbury.

b) Ref. 1947,0505,1711. This is an alphabet tile letter T. If this did come from the abbey it implies a range of designs completely missing from the collection.

c) Ref. 1947,0505,1716. This design of a quatrefoil with a superimposed circle is similar to but not the same as B. Lowe's design 195 from Witham Friary. This is also not present in the collection.

v) Stradling Priory housed many objects from Glastonbury Abbey including many of the tiles. William Stradling published a description of house and collection in 1839, with the comments:

"At the east end is a small Oratory descended by three steps, as were the Chapels of the Monks of the order of La Trappe. It is divided from the other room by the ancient communion rails of St. Michaels Church in the parish of North Petherton. The date in inlaid figures of lead is 1635. The floor is composed of ancient monastic tiles from the Abbeys of Glastonbury and Tintern. On one from the latter,

are the Arms of the founder, Richard de Clare^ Earl of Pembroke, surnamed Strongbow Or, three chevronels gules. There are also several tiles from the ancient Chapel of St. John's Hospital, Bridgwater. "

The priory no longer exists and the collections were dispersed with no record of the present whereabouts of the tiles.

vi) Sites connected to Glastonbury Abbey also had tiled floors. Beckery Chapel possibly shows the importance of these pilgrim chapels. Although belonging to the abbey from the 12th century it had been leased out. Abbot Robert Petherton failed to reassert the abbey's ownership from the tenant Philip, vicar of Sowy, but his successor, John of Taunton, did and lavishly repaired it. John of Glastonbury recorded that John of Taunton appropriated other chapels and churches. It is therefore quite likely that these too were furnished with tiled floors as part of his refurbishment scheme.

These chapels would have fallen into disuse at the Dissolution and few traces survive of them.

6. Missing tile designs

This is a difficult aspect to assess as the collection is only a small fraction of the original total. There are however records of tiles known to have been at Glastonbury which now cannot be found.

The most significant ones are from the early church discovered by Theodore Fyfe in the 1927 excavations. He recorded a red plaster floor, possibly 7th century, a blue lias paved floor on a level with thick red tiles which could be ascribed to Thurstin (1077-1096). Three were seen by Wedlake so were probably still at the abbey in the 1970s but cannot now be found.

References

Fyfe, Theodore *Glastonbury Abbey Excavations 1927*, PSANHS vol.LXXII, ii, 1927, p.20-22
Wedlake, W. unpublished tile notes box 21, A650

Barbara Lowe recorded a number of designs in her Somerset census which was the result of over three decades work. Some of these designs cannot be found now at Glastonbury, some were possibly in the lost T92 box.

These include her design numbers:
D140 - probably D53
D141
D200
D212
D423
D462
D464
D500 Triangular divisions in four squares. Held at Taunton Museum.

Some designs were not seen physically by Barbara but she recorded them from tracings by A. Emden:

D137 This is Glastonbury design 190
D226
D284
D291
D292
D414
D480

There is a letter from C. A. Ralegh Radford to W. Wedlake in the archive dated 20th March 1980 (ref. Box 21, A649). In it Radford notes that the tiles he came across were mainly in robbed foundation trenches so were of no value for dating. A few fragments of tiles excavated from 1951-64 were added to Clayton's boxes if they added anything to the design. The "*rest were buried*". These may well be the fragments recently excavated by C. and N. Hollinrake. There are no surviving records of what tiles were deposited or where they were buried. This is not an unusual attitude for early excavators as tiles would take up valuable storage. Plain tiles particularly were considered as 'unimportant' but the policy of only retaining 'good examples' can lead to loss as well as distortion of quantity.

7. Provenance

Provenance, where recorded, is taken from Wedlake's notes. This is not a reliable source in that these tile fragments were not in situ when excavated and possibly the only conclusion that can be drawn is that where there is a wide scatter it implies that there were a great quantity of that design and a single provenance equals a small quantity. This is probably a safe conclusion but it could be affected by the consideration that some designs may not have appealed to souvenir hunters, leaving comparatively more of them around, or that some areas, like the nave, were destroyed soon after the Dissolution so we can assume that most of the tiles there went too.

8. Post Dissolution destruction of the abbey fabric

The violent end of the last abbot and the acquisition of the second wealthiest monastery in the country by Seymour, who was not overly sensitive to such properties, would suggest that disposal and dispersal might have been extremely rapid. However, it was an intention in Queen Mary's mind to restore Glastonbury. This led to the departure of the foreign weaving community introduced by Seymour but Mary's death in 1558 halted any revival. In Bond's '*An Architectural Handbook of Glastonbury Abbey*' (pp 28-33) he describes that at the time of Seymour's attainment there were 6 houses built and 22 others were lacking doors or windows. 16 more were required. By the end of the 16th century the nave was completely in ruins.

An account of 1741-2 refers to a "*Thomas Prew, a rank Presbyterian, who pull'd down and sold vast quantities of ye stones and roofed up ye vaults by blowing them up with gunpowder*".

The same source, a diary written by John Cannon, states that "*stones were laid up by lot in the Abbot's kitchen – the rest went to paving yards or stalls for cattle, or to the highway*". It is not improbable that this rubble would have included tiles.

In 1818 "*Mr Gwyn the puritanical possessor of Glastonbury Abbey is very busy in destroying the goodlisome ruins*".

A further period of destruction was orchestrated by John Down who owned the abbey for 60 years in the late 18th to early 19th century.

9. Chemical Analysis Of Floor Tiles From Glastonbury Abbey By Plasma Spectrometry (ICPS)

M.J.HUGHES

INTRODUCTION

The Glastonbury floor tiles have been divided by design, tile dimensions and fabric into eleven distinct groups, which may reflect different origins and/or periods of production. The aim of this scientific project was to investigate whether the groups showed any chemical characteristics which would enable the integrity of the groups to be checked, and to look for chemical relationships between the various groups. Additionally, comparison with previous analyses of tiles, and some pottery, would, it was hoped shed further light on the place of production of the groups, by finding close similarities in clay chemistry to previously-analysed ceramics from this region. It was of particular interest to see whether there was any connection with tiles and pottery found at Cleeve Abbey, the only other monastic site in the region for which we have analyses (Allan 1999; Harcourt 2000). The samples selected for analysis from Glastonbury included multiple examples from all but one of the eleven groups, totalling 51 samples and one waster tile similar to those found in the tile dump at Silver St, Glastonbury.

The groups and the questions which analysis might answer were as follows:
Group 1a (3 tiles analysed): exceptional depth tiles; fabric has numerous inclusions.
Group 1c (5): thick tiles, suggesting early date; possibly same fabric as group 1a; many white inclusions.
Group 2 (4): mosaic; fabric similar to groups 3 and 4; parallels at Beckery Chapel, Glastonbury.
Group 3 (5): large heraldic; limited numbers; very similar to group 4 tiles at Cleeve Abbey which at the time were thought to be made by a Gloucestershire tilery, given the distribution of such tiles (Harcourt 2000: 63). However, the group 3 tiles are now seen to be similar to group 2 which appears confined to Glastonbury and Muchelney, suggesting a more local source.
Group 4 (5): largest group of designs; with small white inclusions; fabric similar to groups 2 and 3 but not so well prepared, and containing some dark red inclusions; designs like Cleeve Abbey group 5; paralleled by designs 1 and 5 at Beckery Chapel, Glastonbury, and possibly contemporary with the mosaic tiles (group 2).
Group 7a (5): second largest surviving group; probably post group 4 – not as well made.
Group 7b (9): designs with some naturalistic freehand appearance, suggesting a local individual style; many white inclusions; like group 7a but less well prepared fabric; occurrence elsewhere confined to Muchelney – suggesting a limited and local production.
Group 9 (4): border tiles; fabric fine with inclusions; parallel to group 11 at Cleeve Abbey
Group 10 (4): thin tiles with interwoven wheat ears; fabric fine with inclusions, sandy feel.
Group 11 (4): possibly Donyatt products.

Chemical analysis using inductively-coupled plasma atomic emission spectrometry (ICP-AES, or ICPS for short) of the fabric of pottery gives a chemical fingerprint and thus information on its source, reflecting the clay from which it was made. It is widely-available, rapid, produce accurate results on many elements and at relatively low cost per sample (the sample dissolution and instrumentation are described in Thompson and Walsh 1989 and Potts 1987). The atomic emission version (ICP-AES, often abbreviated to ICPS) analyses all the major elements in ceramics (except silicon which can be estimated by difference if needed), plus a good cross-section of the trace elements including the transition metals and some rare earth elements. It differs from petrological methods in producing an overall composition of the whole fabric, mainly that of the clay. This tends to complement petrology which describes mainly the mineral inclusions within the clay.

Some recent examples of ICPS projects on ceramics include pottery from Lundy Island (Hughes 2005); delftware from production centres in London (Hughes 2008); ceramic building material from Hill Hall, Essex (Hughes 2009); and tin glazed tiles from London (Hughes 2010). Earlier ceramic studies using neutron activation analysis (NAA) included a project on tin glazed wares from London, Norwich and the Low Countries (Hughes and Gaimster 1999).

For the present project, if some of the groups of floor tiles had been made using the same clay, their chemistry would be very similar. Likewise groups with non-matching chemistry would indicate different production. Stopford (1990) defined *production groups* as a means of recording and studying medieval floor tiles. Tiles within a single production group were defined as having been made by the same person or people, or within the same industry, but also have been manufactured using similar processes (op cit, 2). Decorated tiles could belong to the same production group as plain tiles provided they fulfilled this definition. In the present case, the tile groups defined at Glastonbury appear to conform to this pattern. Analysis of medieval floor tiles from Bordesley Abbey (Stopford et al 1991) by neutron activation demonstrated that such production groups had similar chemical characteristics, and that multiple production groups could by chemical analysis be shown to have been made at the same location (see further, below).The production and distribution of decorated floor tiles from the north Midlands have also been studied by the same analysis method (Leese et al 1986).

ICPS Analysis (Inductively-Coupled Plasma Atomic Emission Spectrometry (ICP-AES))

Powdered samples were obtained from the tiles by drilling with 2 or 3mm diameter tungsten carbide drills fitted into a hand-held low voltage electric drill. In addition, the samples sent for ICPS analysis included two portions of a Certified Reference Material (NBS679 Brick Clay – produced by the US National Institute for Standards and Technology, Washington DC) spaced out in the analysis batch but without identification to the laboratory as such; these acted as analysis quality control samples. The analysis results on these control samples gave entirely satisfactory results. The weighed samples were placed in small individual Teflon (PTFE) beakers, treated with a mixture of hydrofluoric and perchloric acids and heated overnight on a hotplate to dissolve the ceramic. The acids were evaporated off and the residue dissolved in nitric acid and made to volume with ultra high quality water (Thompson and Walsh 1989, Potts 1987). All the ICPS results are given in full in Table 1, and the results are summarised in Table 2 as the average and standard deviation for each of the nine groups, which also includes the analysis of the waster tile.

Interpretation of the ICP analyses using Principal Components Analysis and Discriminant Analysis

Detailed interpretation of the analyses was then carried out with multivariate statistics, which simultaneously considers the concentrations of many elements in each sample. For this investigation, Principal Components Analysis (PCA) and Discriminant Analysis (DA) was used (Tabachnick and Fidell 2007); descriptions of their application to archaeology are given elsewhere (see for example, Baxter 1994 and 2003; Shennan 1997). The SPSS version 15 statistical package was used for this work (Pellant 2007). For interpreting the statistical plots produced in this project (Figures 1 -4), each individual item analysed has been shown by a symbol for either the fabric group to which it belongs, or other identity. Such plots are effectively chemical 'maps' for the items analysed, and if the ceramics within a group are made of the same clay, they will plot in the same part of the figure.

Principal Components Analysis looks for the largest variations in concentration of an element across the whole set of samples, so elements showing chemical differences between, in this case, different fabric groups, are particularly highlighted. Conversely, items which are similar in ICP analysis will plot close together or overlap; items or groups which have significant differences in clay chemistry will plot in different parts of the figures. An idealised principal components plot would show each group of pots in the same fabric as a cluster of points close together, but occupying different parts of the figure to other groups. The program does not use the group identity to define the statistics (though discriminant analysis does); the symbols merely identify the samples in the plots. The PCA was carried out in stages, in which items with significantly different chemistry were removed from the analysis to allow interpretation of those groups of pottery which showed subtler differences in chemistry.

Principal components analysis (PCA) was particularly useful for an initial examination of the ICP results; 22 of the ICPS elements shown in Table 1 were included in the tests, chosen for the reliability of measurement and not subject to post-depositional effects. Some elements are near their detection limit, while phosphorus and barium can be subject to post-deposition changes and cobalt was present in the drill. This left the following elements for the PCA statistics on all the ICP analyses carried out for this project: aluminium, magnesium, calcium, strontium, sodium, potassium, chromium, iron, manganese, nickel, zinc, lithium, scandium, yttrium, titanium, cerium, dysprosium, europium, lanthanum, neodymium, samarium, ytterbium, and zinc. Before carrying out all the statistical tests reported here, the results were first converted to logarithms to remove large element-to-element differences in numerical values.

Principal Component Analysis on all the samples analysed

A principal component analysis showed that tile 801.30 (group 2) was well separated on a plot of the first two principal components indicating that it had a radically different clay chemistry to all the rest of the samples. Most of the major element concentrations in this tile are at similar levels to the rest of the tiles, although iron is rather higher at 8.3%, but it has much higher concentrations of many trace elements, including the rare earth elements, and nickel and zinc; and significantly higher concentrations of vanadium and yttrium.

A second principal component analysis omitting tile 801.30 (Figure 1) showed that many of the fabric groups formed quite compact spreads – i.e. the points were close to each other within a fabric group, indicating close similarity in clay chemistry between the members of the fabric group. Samples on the left (groups 9 and 10) generally had lower concentrations of elements than those on the right, except significantly higher levels of potassium and manganese. Some of the groups showed close similarity to each other, but in addition groups 9 and 10 were separated on Figure 1 from the other seven groups. There are differences seen between the position on Figure 1 of groups 1-7, indicating that some at least of the groups do have significantly different chemical characteristics, while others seem to overlie each other, suggesting the use of similar clays.

Discriminant analysis on all Glastonbury tile groups

The next stage was to test the ten groups against each other using discriminant analysis, which looks for those combinations of chemical elements which will best distinguish between the different groups. In this case, the identity of the group to which each tile belongs is used by the discriminant analysis to define the statistical parameters (i.e. construct the resulting plots). From the resulting plot of the first two discriminant scores, it was immediately clear that groups 9 and 10 are very similar indeed chemically, with no visual separation between them in a plot of the first two discriminant scores (not shown) and that the other seven are also very similar to each other but clearly distinct from groups 9 and 10. This would suggest two quite different sources (origins) for on the one hand the tiles of groups 9 and 10, and on the other hand, groups 1 to 7. The average concentrations of elements in each group are given in Table 2, in which it is clear that groups 9 and 10 differ from the other seven in containing significantly lower concentrations of the major elements aluminium, iron, magnesium and calcium, but high levels of potassium; among the trace elements, many were significantly lower than the other groups: chromium, lithium, nickel, scandium, strontium, vanadium, and some of the rare earth elements. Existing ICP data on pottery groups in south-west England was searched (see below) to see whether the analysis pattern of groups 9 and 10 has been seen in pottery and tiles elsewhere in this region. However the first conclusion to be drawn from the ICPS analyses is that groups 9 and 10 represent the same production centre, but located on a distinctly different clay type geologically to groups 1 to 7.

Discriminant analysis on Glastonbury tile groups 1 to 7 alone

A second discriminant analysis was carried out, omitting the tiles of groups 9 and 10, and the resulting plot of the first two discriminant scores is shown in Figure 2. This time, differences emerged between groups 1- 7, while some pairing of groups was also clear: groups 3 and 4; 1a and 1c; and 7a and 7b. Only group 2 does not appear to pair with another group. The close pairing of the three sets of groups suggests a quite specific common origin for each pair, but differing between pairs. Just as the pairing of groups 9 and 10 suggests they belong to the same *production group* (as defined by Stopford), so also there seem to be four *production groups* among tile groups 1-7. Discriminant Analysis attempts to find chemical element combinations which will separate the groups. Failure to find significant differences (such as the pairs in Figures 2 and 3) implies there are no systematic chemical differences between those in each pair – i.e. they were made in the same workshop, although there may have been a time difference between their production. Considering the chemical elements (Table 2), groups 1a and 1c have the highest aluminium concentrations (usually indicating a higher proportion of clay to temper) but lowest strontium compared to the other groups.

Some of the questions posed to the scientific investigation can now be answered:

- Groups 3 (large heraldic) and 4 (largest number of designs) share a common production, though with a slight difference to group 2 (mosaic)
- Groups 7a (second largest group) and 7b (naturalistic design) share a common production. However the differences between the pairs 3/4 and 7a/7b are much smaller than Figure 2 might suggest. The left/right separation of groups accounts for 97% of the chemical differences, while the lower/higher separation only accounts for 2.5%. Thus the four groups 3, 4, 7a and 7b are chemically very similar, suggesting a common place of production. Given the distribution, design and fabric links between these groups, several of which implied local production, chemical analysis confirms that at least these four groups were locally produced.
- Groups 1a (exceptional depth) and 1c (thick tiles) share a common production. Further stages of discriminant analysis (see below) strongly indicated local production also for these groups and group 2, leaving only groups 9 and 10 made elsewhere.

Discriminant analysis highlights the elements which show significant differences between the groups. Examination of the loadings on the first and second discriminant scores indicates that the differences in groups in Figure 2 arise because groups on the left are generally higher in aluminium (-6.6), nickel (-3.2), and manganese (-2.6) but lower in titanium (5.3), neodymium (2.3), vanadium (2.3), lithium (2.1) and strontium (2.1) compared to those on the right (standardised loadings for the elements given in brackets). The pairs of groups 3/4 and 7a/7b separate on the second discriminant score, and groups 7a/7b have higher amounts of aluminium (-6.8) towards the bottom of the figure and to a lesser extent ytterbium (-1.8), but lower amounts of titanium (5.3), europium (2.3) and zinc (2.2). Magnesium and potassium are also significantly lower in 7a/7b compared to 3/4.

Discriminant Analysis comparing all the Glastonbury tiles, and previous ICPS analyses of tiles and pottery from Cleeve Abbey, and pottery from sites in west and south Somerset

Of direct relevance to the question of the place of production of the groups of tiles was a comparison with ICP analyses of a range of pottery from sites in west and south Somerset. A selection of the pottery and tiles from Cleeve Abbey have been previously analysed by ICP (Allan 1999; Harcourt 2000). Allan (1999) had access to the unpublished report on thin section and ICP analysis of Cleeve tiles by the late Alan Vince which was subsequently published by Harcourt (2000), and made a statistical comparison between the ICP analyses of pottery and tile from the site (Allan 1999: 67-8). It is now possible however to incorporate additional information not included in Vince's report, especially the Cleeve tile group for each sample analysed, to draw further conclusions about the relationship between the tile groups and their ICP analysis. Allan's statistical reprocessing of Vince's ICP data showed that a series of tiles found at Cleeve were in the 'Exmoor-Quantocks' thin section fabric type, and were produced from clays of the Mercia Mudstone geological formation (formerly Kueper Marl). Their ICP analyses were chemically similar to the products of the kilns at Nether Stowey and Crowcombe in the Quantocks. Vince had noted that these particular tiles (his thin section groups E and G) were in Harcourt's Cleeve tile groups 7-9, which formed the largest quantity of tiles at Cleeve, suggesting a local origin – which matches with the conclusions of Allan (1999: 67-8).

Allan (1999: 67-8) compared the ICP analyses of the pottery from the same site with the analyses of the tiles found at Cleeve Abbey (Harcourt 2000) by multivariate statistics. This showed that the tiles from Cleeve Abbey fell into two distinct chemical groups: it was proposed that one was associated with the production of ceramics in south Somerset, including Donyatt; the other was associated with the products of the kilns at Nether Stowey (and to a lesser degree Crowcombe) in the Quantocks. Thin-section study of the pottery from Cleeve also identified the latter as 'Exmoor-Quantocks' ware.

A Discriminant Analysis was carried out involving the following groups of ceramics:
All the Glastonbury tile groups
All the Cleeve Abbey tiles previously analysed
All the Cleeve Abbey pottery previously analysed
Coarse pottery from Glastonbury Abbey of South Somerset type
Samples from the newly discovered waster pits at Bovetown, about 100 m from the edge of the Abbey precinct

The Bovetown wasters (six sherds of pottery and one fragment of tile with visible limestone inclusions – see fuller report on their ICP analyses in N. and C. Hollinrake, forthcoming) were included to represent the chemistry of local Glastonbury ceramics. The average composition of these sherds is given in Table 2. The previous analyses of pottery and tile from Cleeve

Abbey had concluded that some were South Somerset products, so it was also of interest to include the Glastonbury coarse pottery samples which were expected to have the same chemical pattern. Because the ICP analyses had been carried out on different occasions, although by the same laboratory, for technical reasons there were a few missing values, so the discriminant analysis excluded four rare earth elements (neodymium, dysprosium, samarium and ytterbium) included in Figure 2. However two representative rare earth elements were included (europium and lanthanum). The resulting plot (Figure 3) was similar to the first discriminant analysis, showing a large separation between Glastonbury tile groups 9/10, and 1-7, but superimposed were a scatter of other items included in the analysis, treated as 'test' samples. These samples divided fairly clearly into those falling around tile groups 9/10, and around groups 1-7. The split between these two divisions was taken as about discriminant score 1 = 25. A significant number of 'test' samples plotted distant from both – suggesting production at other sites. The latter included the Glastonbury coarse pottery of South Somerset type, suggesting that none of the Glastonbury tiles were of this production.

To investigate further the relationship between these two distinct groups of ceramics (tile groups 9/10, and groups 1-7) and the tiles and pottery from other sites, the statistical processing was split further, treating each of these two sets of items separately.

Statistical study of the samples falling within the 'Exmoor-Quantocks' division of the previous Discriminant Analysis

Discriminant Analysis

A re-run of the discriminant analysis was carried out of Glastonbury groups 9 and 10 plus all the samples from the previous discriminant analysis which were chemically associated with them. This confirmed that the Glastonbury tiles groups 9 and 10, which had very distinctive chemistry compared to the other tile groups 1-7, were chemically similar to the 'Exmoor-Quantocks' groups of pottery, including Nether Stowey and Crowcombe. They were also associated with those tiles found at Cleeve Abbey which had previously been identified chemically and petrologically as belonging to this area of west Somerset (Allan 1999: 68; tiles L2031-36 in Cleeve design groups 1-3 and Vince fabrics A and B; L2048-2062 in design groups 7-9, and 11-12 in fabric groups E, F and G). These two series of Cleeve tiles form two related but slightly different chemical groups. Tiles L2031-6 have slightly higher concentrations of most elements compared to L2048-62, but significantly higher lime, strontium and zinc. Both are similar to the chemistry of Crowcombe and Nether Stowey pottery previously analysed (Allan 1999: 63), though not identical (see Table 4 and further tests below). The similarity between the ICP analyses of the tiles found at Cleeve Abbey and groups 9 and 10 at Glastonbury suggests a common origin for such tiles from both sites. A possible explanation, not previously considered in either of the publications on the Cleeve ceramics, is that since Cleeve itself lies on the edge of deposits of Mercia Mudstones and is within the 'Exmoor-Quantocks' region, Cleeve may itself be the site of production of 'locally produced' tiles found at Cleeve Abbey. A small amount of kiln debris and wasters have been found at Cleeve (Kent and Dawson 1998, 46). The border tiles (group 9 at Glastonbury) have parallels with Cleeve tile group 11. Statistically, their chemistry places them rather closer to group 10 than 9, but both 9 and 10 are chemically similar, so this parallel does seem confirmed in their clay chemistry. The tiles in Glastonbury groups 9 and 10 are slightly different chemically to the two Cleeve tile groups: they have mostly lower concentrations of many elements than the Cleeve tiles. However magnesium is significantly lower, only about half that of the Cleeve tiles. They are also lower in most elements compared to the Nether Stowey and Crowcombe pottery, except potassium which is slightly higher than those or the Cleeve tiles. These differences suggest different production groups to the Cleeve tiles but without more analyses of ceramics of known place of production within this region, present evidence indicates the Nether Stowey area.

The distinctive feature of the chemistry of groups 9 and 10 compared to 1-7 is the high level of the alkali potassium. Taylor (in Allan 1999: 59) found that Nether Stowey-type wares were characterised by the presence of white mica, the mineral muscovite whose chemical structure contains around 10% potassium oxide, so explaining the high levels of potassium in tiles falling within the 'Exmoor-Quantocks' division. The closely-similar clay chemistry of Glastonbury tile groups 9 and 10 may be explained by the tilers exploiting slightly different clay beds when making the two groups, perhaps at different chronological periods (e.g. Stopford's production groups).

Principal Components Analysis of tiles and pottery falling within the 'Exmoor-Quantocks' division of samples

To explore in more detail the relationship between tiles groups 9 and 10 and ceramics of 'Exmoor-Quantocks' chemical analysis, a Principal Components was carried out on these two groups from Glastonbury together with tiles and pottery from Cleeve Abbey falling on the right of Figure 3 (i.e. the 'Exmoor-Quantocks' samples) and pottery from Nether Stowey and Crowcombe. The resulting second and third principal components are plotted in Figure 4; the first component principally represents the proportion of diluting temper (43% of the variation in the analyses). The second component (19% variation) shows samples towards the top of the figure are richer in magnesium (0.78), manganese (0.71), zinc (0.70), potassium (0.63) and lithium (0.61); samples plotting more to the right (e.g. some of the Cleeve tiles) have generally higher lime (Ca: 0.88) and strontium (0.78) but lower zinc (-0.48) and lithium (-0.30). The Figure shows a clear patterning for the various groups. The two Glastonbury tile groups each probably represents a single firing/batch, since they form two compact clusters of points, very like the pattern shown by analyses of multiple examples of the same design of medieval floor tiles seen in previous analytical studies (Leese et al 1986; Stopford et al 1991). Both Glastonbury groups plot close to the pottery from Nether Stowey, on the east side of the Quantocks, suggesting production in this region.

However, groups 9 and 10 do not overlap with the tiles from Cleeve Abbey, which are different to other ceramic groups though close to Crowcombe pottery from the west side of the Quantocks. Production of these Cleeve tiles at Cleeve itself would be consistent with this Figure. As in the discriminant analysis of these tiles discussed above, there is some evidence of difference among the Cleeve tile groups, with tiles L2031-2036 (Cleeve design groups 1-3) to the right of the centre line of the third component and L2048-62 (design groups 7-9) to the left. Their average analyses are given in Table 4 to compare against Glastonbury tile groups 9/10 and Nether Stowey and Crowcombe pottery. The Cleeve tiles have significantly more magnesium (like Crowcombe) compared to the Glastonbury tiles. The pottery from Cleeve Abbey is different again to the Cleeve tiles (Figure 4), falling analytically between the samples from the two Quantocks kiln sites.

Statistical study of the samples associated with Glastonbury tile groups 1-7 in the previous Discriminant Analysis

Discriminant Analysis

A further re-run of the discriminant analysis was carried out of Glastonbury groups 1-7 plus all the samples from the previous discriminant analysis which were chemically associated with them. As in the initial statistical tests on the Glastonbury tiles alone (Figure 2), the same pattern of separation of the seven groups was found, but this time the relationship to the other samples could be observed. All the Bovetown ceramics were spread among or close to tile groups 1-7, but without a uniform pattern. Compared to south Somerset wares, Bovetown ceramics have systematically higher levels of aluminium, iron, potassium and sodium, such as found in Glastonbury groups 1-7 (see Bovetown report, this vol.). Some tiles from Cleeve fell among or close to some Glastonbury tile groups, but others were closer to Donyatt pottery.

The pottery from the production site at Donyatt plotted well away from any of the Glastonbury tiles, and were matched by many of the South Somerset coarse pottery from Glastonbury. This suggests that none of the Glastonbury tiles were associated with production at Donyatt, and the evidence of the Bovetown ceramics suggests that many if not all the Glastonbury tiles in groups 1-7 were locally made at or close to the Abbey. The Cleeve Abbey pottery analysed by ICP was split between production in the Quantocks area and South Somerset, as previously found (Allan 1999: 62-7).

Principal Components Analysis
Discriminant Analysis needed to be supplemented with principal components analysis to try to understand the detailed relationships between the analysed samples. The same elements used for the discriminant analysis were then applied to a principal components analysis of the Glastonbury tile groups 1-7 and associated samples. From this the following chemical groupings were found:
- A tile with the design of a lion with a curl on a circle and spade like corner motifs(D123 766.25) has an analysis unlike groups 9, 10, 1a, 1c or 2. It seems closest chemically to groups 3 and 7a, but in any case these are also closely similar chemically to groups 4 and 7b.
- Six of the Cleeve Abbey tiles fell within the spread of Glastonbury tile groups (L2037 and 2041 were assigned to group 1a; L2038-40 were assigned to group 7b; L2042 to group 2).
- The other five tiles from Cleeve fell within or close to the Donyatt samples (Coleman Smith and Pearson 1988) and coarse pottery from Glastonbury of South Somerset type (L2043-7 – four in Cleeve tile group 6 and one in 5; all those assigned by Vince to his fabric group C)
- none of the pottery from Cleeve Abbey falls within the spread of the Glastonbury tiles, but is associated with the Donyatt pottery (and confirms the earlier project's conclusion)

This refines the results of the study by Allan (1999), now that analyses of Bovetown ceramics have indicated the chemical pattern for Glastonbury ceramics. Cleeve tiles L2037-42 were previously thought to be Donyatt, since they were significantly different chemically to the 'Exmoor-Quantocks' tiles from Cleeve (which the present study has confirmed as belonging to the latter fabric). These Cleeve tiles which are now seen to fall within the same chemical spread as the Glastonbury tile groups 1-7, and which the chemical analysis suggests are produced locally at Glastonbury, include tiles in only Cleeve tile groups 4 (large heraldic tiles from the frater pavement) and 5 (the remainder of the tiles from the frater pavement, distinguished as different only in size) and are all those assigned by Vince to his fabric group D. Harcourt (2000: 49) noted that the fabric of these tiles (4/5) clearly shows they were not made locally at Cleeve. Discriminant analysis assigned individual tiles to be most similar to Glastonbury groups 2 (mosaic tiles), 1a (large depth tiles) and 7b (naturalistic designs).

The chemical groups found here within the Cleeve Abbey tiles conform exactly to the fabric groups C and D defined by Vince. He noted that glauconite was present in only these two fabrics out of all the Cleeve tiles studied petrologically, and fabric C was characterised by abundant quartz and muscovite silt. Chemically the tiles in fabric C (assigned here to Donyatt) share the relatively low proportions of clay relative to non-plastics (quartz) seen in the chemical analysis (i.e. systematically lower concentrations of aluminium and many other elements compared to the Bovetown kiln samples).

Turning to the general question of the origin of the seven groups 1-7 at Glastonbury, it is most significant that all the ceramics from the Bovetown kiln were associated with this series of tile groups, suggesting strongly that many of the Glastonbury tiles in groups 1-7 were locally made. From a negative point of view, given that we now have ICP analyses on many ceramics (mostly pottery) made all over Somerset, and no others are similar in chemistry to the tile groups 1-7, there is no evidence that any of these tiles were made elsewhere than Glastonbury. One has to address the issue of the different chemical analyses of the groups (Table 2) and the differences between groups seen by discriminant analysis in Figure 2.

Examples do exist of a range of chemical compositions being found for ceramics produced at one geographical centre. Donyatt pottery, made quite close geographically to Glastonbury, and also using local Lias clays, shows a variety of different clay chemistries between Donyatt kiln sites 3, 4 and 13 (Allan 1999: figure 6). At Bordesley Abbey, fourteen tile production groups were identified (Stopford et al 1991), eight of which by chemical analysis fell into four clay chemistry groups that were concluded to be local products (op cit p.356 and figure 2). Earlier study using neutron activation analysis on north Midlands tile production (Leese et al 1986) similarly showed multiple clay chemistries from tiles definitely made at the same site. Tiles in each design showed much closer chemistry to each other than to other designs, suggesting a 'batch' process for tiles of one design.

Earlier it was noted that groups 1a and 1c share a common production but are slightly different chemically to the other five tile groups from Glastonbury 2, 3, 4, 7a and 7b: groups 1a/1c contain minor amounts of lime, higher than in other groups, suggesting a slightly different clay source. A geological division cuts through Glastonbury itself, with the Abbey precinct and Silver Street (site of a dump of tile wasters of groups 1a/1c) lying on lime-containing Lower Lias 'Clay with some limestone' (Geological Survey sheet 296; cf Rahtz 1993, 13: figure 2) whereas the Bovetown kiln lies on Middle Lias 'Silt and clay'. A thin ribbon of the Middle Lias clay also runs E/W just south of the Abbey, with its northern boundary about 50 m north of, and parallel to, Bere Lane, though a much larger area of such deposits lie N and S of Bovetown, the W boundary being approximately Rowley Rd/ Leg of Mutton Rd. A single waster tile found at the Abbey (T464 GLR8893) was of the same design type as groups 1a/1c, examples of which were found as wasters in the Silver Street tile dump, and its analysis was very close indeed to the average composition of group 1c, confirming local production for groups 1a/1c. The tile is chemically slightly different to the pottery sherds from the Bovetown kiln, whose average is given in Table 2, and which are low in lime. However the single Bovetown tile analysed differs from the pottery in containing a few percent of lime, and is chemically more like the waster from Silver Street (same Table), though it shows slight differences in other elements. The low level of lime in the Bovetown pottery sherds seems to correspond with the Lower Lias silt and clay deposits on which it sits (i.e. the clay used was probably dug close to the kiln site itself). The other tile groups from Glastonbury which are low in lime (2, 3, 4, 7a and 7b) are chemically similar to clay used at the Bovetown kiln, though perhaps made at another location on the Lower Lias deposits. There may have been a preference for later phases of tile production at Glastonbury to be located slightly away from the Abbey precinct.

Four other tile fragments in group 11 with multiple stab keying and no stamps, only incised or slip decoration, were analysed to see their chemical relationship to the groups. In this run of principal components, three of the tiles (799.4, .11 and .42) were chemically similar to each other. They showed similarity in chemistry to a medieval sherd (no.13 in Allan 1999, 62: table 6) and three post medieval sherds (op cit, nos. 17, 28 and 29) from Cleeve Abbey previously analysed and four south Somerset coarse wares from Glastonbury (see Allan, this volume: 'The Pottery'). This group is chemically not far from the analyses of some Donyatt pottery from kilns 3 and 4 (discussed in Allan, op cit), and the three Glastonbury tiles are probably therefore Donyatt products. The fourth tile (785.60) was different in chemistry to the other three, but in this principal components was associated with six south Somerset coarse wares from Glastonbury, another sherd of medieval pottery from Cleeve Abbey (no.15 in Allan 1999, table 6 – see also the principal components plot, op cit, 66: figure 6), and the two sherds analysed from site 13 at Donyatt. This single tile (785.60) also appears to be a Donyatt product, but made at a different kiln to the other three tiles from Glastonbury. It seems significant that two of the three sherds of medieval period analysed from Cleeve Abbey of similar chronological period to the four Glastonbury tiles were associated chemically with these four tiles. The range of clay compositions for Donyatt kilns has been previously discussed by Allan (1999, 66), who suggested it probably reflected the mode of occurrence of clays at Donyatt in small individual clay lenses rather than continuous deep deposits.

Summary and Conclusions

Chemical analysis using inductively-coupled plasma atomic emission spectrometry (ICP-AES, or ICPS for short) of the fabric of ceramics gives a chemical fingerprint and thus information on its source, reflecting the clay from which it was made. Examples of all but one of the eleven tile groups found at Glastonbury have been analysed, and the results compared against each other and against analyses of tiles and pottery made at other known sites in the region. Detailed interpretation of the analyses was carried out with multivariate statistics, including Principal Components Analysis and Discriminant Analysis, which simultaneously consider the concentrations of many elements in each sample.

Groups 9 and 10 are clearly different chemically from the rest of the groups, and comparison with ICP analyses from other sites including tiles from Cleeve Abbey suggests they were made in west Somerset in the 'Exmoor Quantocks' clay fabric, possibly associated with, or close to, Nether Stowey, to the east of the Quantocks. Cleeve Abbey is located in the geological area of the 'Exmoor-Quantocks' fabric group and some of the tiles from there previously analysed now appear to be local products, being closer chemically to pottery from Crowcombe, lying to the west of Quantocks. These two Glastonbury tile groups are each very compact chemically, suggesting each was part of a single batch prepared at the same time.

The remaining groups 1-7 seem to share very generally a similar clay chemistry, indicating they were all made of Lias clays, in contrast to the west Somerset clays. They have now been concluded by analysis to all be Glastonbury products, representing probably four *production groups*. Glastonbury tile groups 1-7 have the characteristic chemical features matching analyses of pottery and tile wasters found at Bovetown, about 100m east of the Abbey precinct, and of a tile waster similar to those found in the Silver Street area where a dump of tile wasters were found. The chemical evidence strongly points to local production for all the tile groups 1-7, though with the use of slightly different clays, probably a chronological feature of tile manufacture.

Groups 1a (exceptional depth tiles)/1c (thick tiles) were made of very similar clay to each other and are thought to have been made at Glastonbury of Lower Lias 'clay with limestone' in the Silver Street area: the wasters have a slight lime content in contrast to pottery made in the Bovetown kiln. Of the remaining Glastonbury groups, 3(large heraldic) /4(largest number of designs) and 7a(second largest group) /7b(naturalistic design) pair up, though all four are very similar chemically; while group 2 (mosaic) is slightly different. However, all five tile groups seem to share the same chemical pattern of the low-lime Bovetown pottery (Middle Lias clay without limestone).

Some of the previously analysed tiles from Cleeve Abbey which were thought to be Donyatt products are now seen to be divided into some which have the characteristic chemical features of south Somerset ceramics, probably Donyatt products, and other Cleeve tiles which are chemically similar to some Glastonbury tile groups. Six tiles from Cleeve Abbey are now seen to have been made at Glastonbury (L2037-2042), based on their chemical analysis, including only tiles in Cleeve tile groups 4 (large heraldic tiles from the frater pavement) and 5 (the remainder of the tiles from the frater pavement, distinguished as different only in size). Two tiles (L2037 and L2041) were most similar to group 1a (exceptional depth) tiles at Glastonbury and to the Silver Street waster tile analysed. Three (L2038-40) were most similar to Glastonbury tile group 7b (naturalistic designs) and one (L2041) was most similar to Glastonbury tile group 2 (mosaic). From this we can now conclude that some specific tiles found at Cleeve Abbey were produced at Glastonbury.

The pottery from the production site at Donyatt was chemically unlike any of the Glastonbury tiles in groups 1-10, suggesting that none of these were made in south Somerset, where Donyatt was a major pottery production centre. However four tiles from Glastonbury group 11 with multiple stab keying and no stamps appeared to be products of two different Donyatt kilns. Five tiles analysed from Cleeve Abbey (L2043-7) were also similar in clay chemistry to pottery from Donyatt.

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Table and Figure captions

Table 1 List of samples and full set of ICPS analyses on tiles in groups 1-9 from Glastonbury Abbey.

Table 2 Average and standard deviation of the analyses of the tiles groups 1-10, and comparison averages of locally made pottery and tiles from Glastonbury.

Table 3 The average composition of Glastonbury and Cleeve Abbey tiles assigned to 'Exmoor Quantocks' fabric by chemical analysis compared with pottery from Nether Stowey and Crowcombe in the Quantocks, and some Cleeve tile groups.

Figure 1 A plot of the first two principal components arising from samples of ten of the tile groups at Glastonbury. The first principal component (containing 59% of the variation in all samples) had pottery richer in all elements except potassium and manganese towards the right of the Figure (elements listed in descending degree of contribution to the principal component). Principal component two (16% of the variation) had pottery which was richer in the elements manganese, nickel, zinc, dysprosium and magnesium towards the top of the Figure. Samples have been labelled with their tile catalogue number.

Figure 2. Discriminant analysis of the ICP data on all the tiles except groups 9 and 10 and tile 801.30 (group 2). The horizontal axis plots the first discriminant score (containing 97% of the difference between groups), and the vertical the second (a further 2.5%). The dark numbered squares mark the centre of the distribution of each tile group. Many of the groups are separated chemically from each other, though there is some pairing of groups apart from group 2 (i.e. the groups which fall into pairs are made of chemically similar clays, suggesting a similar origin, or use of the same clay resource).

Figure 3 Discriminant analysis of all but one of the tile groups from Glastonbury (labelled 1-11); tiles and pottery from Cleeve Abbey; samples from the kiln at Bovetown; and south Somerset pottery from Glastonbury and Oakhampton Park (based on slightly fewer chemical elements than Figure 2).

Figure 4 Principal Components analysis of Glastonbury tile groups 9 and 10 (numbered label); tiles and pottery from Cleeve Abbey falling on the right of Figure 3 (i.e. the 'Exmoor-Quantocks' samples; the Cleeve tile catalogue numbers have been given); and pottery from Nether Stowey and Crowcombe.

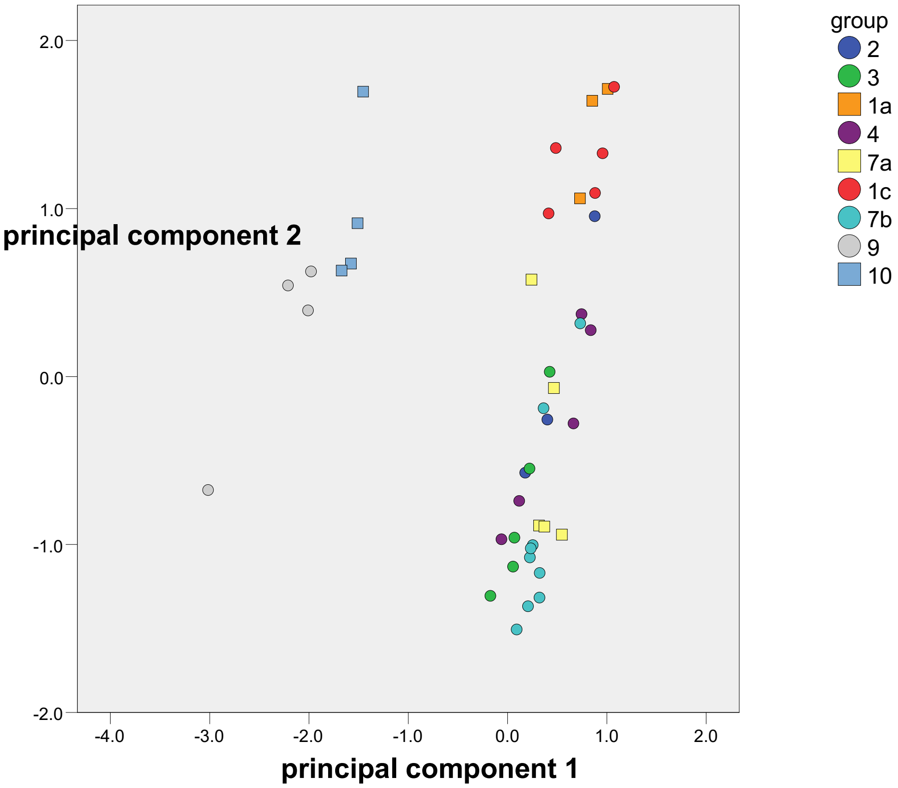

Figure 1

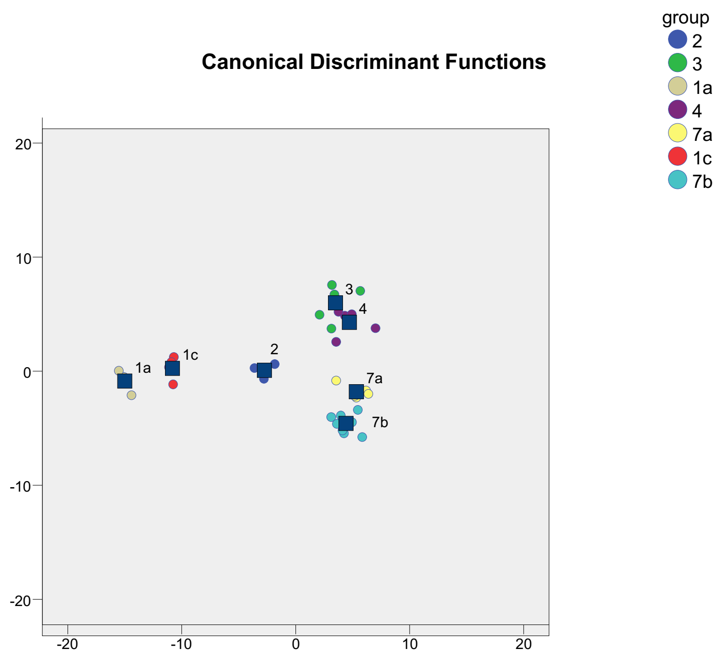

Figure 2

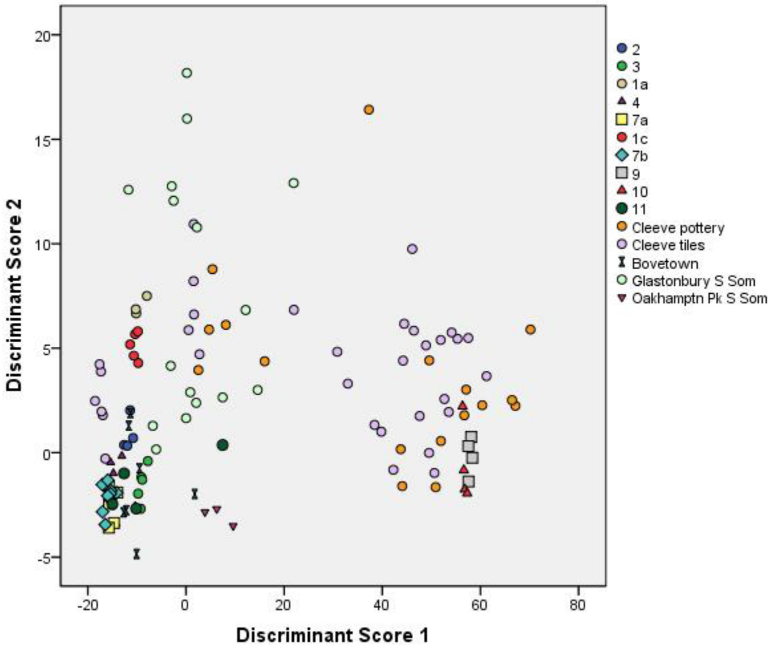

Figure 3

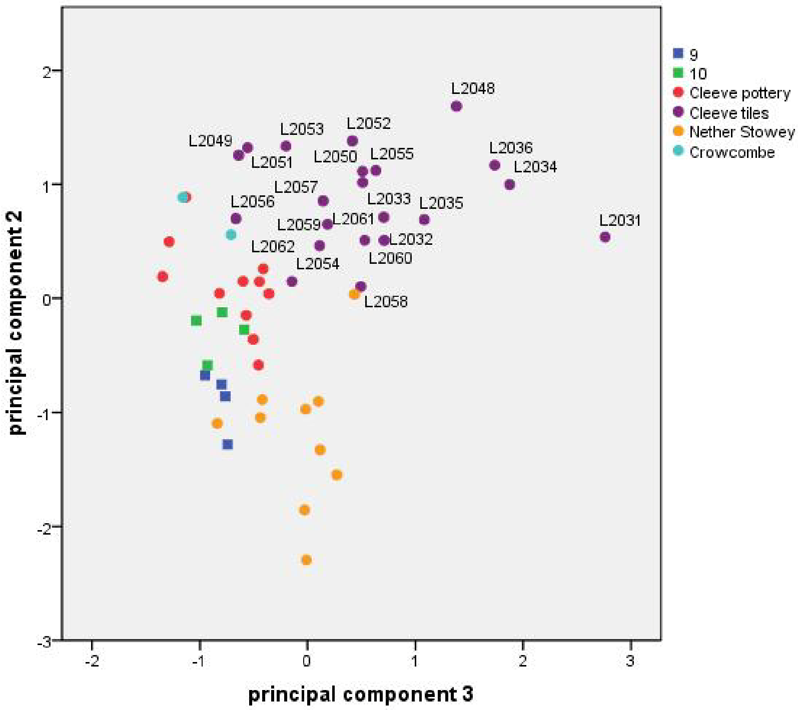

Figure 4

10. Fabric Analysis

MEDIEVAL FLOOR TILES FROM GLASTONBURY

ROGER TAYLOR

Samples examined with a Bausch and Lomb stereoscopic microscope at magnifications of x20 to x40. Coarser components are listed in order of abundance.

OUTLINE OF SITE GEOLOGY

A range of Jurassic Lower and Middle Lias rocks are possible sources of materials for the manufacture of tiles in the immediate area of Glastonbury.

The Bridport Sand Formation forming Glastonbury Tor is likely to be the principle source of tempering sand. The underlying Downcliff Clay Member, consisting of inter-bedded siltstone and mudstone as sources of clay, crops out more widely to the north of the Tor and is a potential source for the silty clays used.
The undifferentiated Lower Lias consisting predominantly of mudstones covers and even wider area around Glastonbury. The mudstones are commonly calcareous.

GROUP 2 (shaped tiles)

GLSGA: 1988/801.30 Narrow curved form. Oxidised, 29.2 mm thick, plain black glaze, hard fired.

Temper. Less than 1%

Quartz – Very rare rounded orange stained grains, 0.2 mm.

Matrix – Smooth slightly silty clay, very weakly calcareous.
Base sanding –Thin, very fine-grained quartz sand.

GLSGA: 1988/802.15 Narrow curved form. Oxidised with small reduced core, 25.6mm thick,
black glaze, hard fired.

Temper. Less than 1%

Quartz– Rare rounded opaque grains, 0.25 mm

Matrix – Calcareous silty clay, with silt grade quartz and sparse muscovite mica flakes.
Base sanding – Not apparent.

GLSGA: 1988/723.27 Wedge form (truncated), Oxidised 27 mm thick, wide scooped key, hard
fired.

Temper. None seen

Matrix – Very weakly calcareous with coarse quartz silt as abundant angular grains and sparse

muscovite flakes less than 0.05 mm
Inlay – White clay slip 0.86 mm thick with colourless quartz less than 0.05 mm common.
Base sanding – Very fine-grained angular quartz sand and mica.

GLSGA: 1988/737.21 Wide curved form, Oxidised reduced core, 26.75 mm maximum thickness, lower surface unevenly flaked away to reduce thickness, no key, hard fired

Temper. Less than 5%

Quartz – Sparse colourless transparent translucent and opaque rounded grains up to 0.2 mm.

Clay matrix – Weakly calcareous clay with abundant quartz silt and sparse muscovite flakes up to 0.1 mm. Inlay – Off-white to pale buff slip 1.1 mm thick
Base sanding – Absent.

Comment on Group 2

A group of tiles employing variably calcareous and silty clay with no deliberate tempering mineral additions.

GROUP 3

GLSGA: 1988/754.28 Mainly oxidised with a reduced area on the upper surface. 35.1 mm thick, pale brownish yellow glaze. Wide scooped key. Hard fired.

Temper. None seen

Clay matrix – Weakly calcareous clay with quartz silt and muscovite flakes up to 0.05 mm.
Inlay – Wide form, white slip with fine colourless quartz c 70%, 0.5-1.5mm thick.
Base – Fine quartz sand up to 0.1 mm and sparse mica flakes.

GLSGA: 1988/723.38 Oxidised with reduced area forming the upper surface, 29.3 mm thick, colourless glaze but brownish yellow in a thicker area, wide scooped key, hard fired.

Temper. None seen

Clay matrix – Non-Calcareous clay except for small white grains.
Quartz silt and fine sand with a scatter of muscovite flakes up to 0.2 mm
Inlay – Wide form, white slip 0.9-1 mm thick with colourless fine quartz sand c 50% and a scatter of larger sub-rounded grains, 0.1-0.5 mm.
Base sanding – Absent.

GLSGA: 1988/754.34 Mainly oxidised with reduced area on the upper surface, 33.6 mm thick, pale brownish yellow glaze. Scooped key, hard fired.

Temper. Less than 1%

Inlay – Wide form white slip up to 2 mm thick with transparent to white colourless quartz c 60%
Matrix – Calcareous, quartz silt with fine muscovite flakes less than 0.05 mm.
Base sanding – Fine angular quartz and sparse muscovite up to 0.1 mm.

GROUP 3 (TYPE 2)

GLSGA: 1988/723.17, Oxidised, 33.1 mm thick, asymmetrical wide scooped key pale yellow glaze, hard fired.

Temper. None seen.

Clay matrix – Calcareous with quartz silt with fine muscovite flakes less than 0.05 mm.
Inlay – Narrow form, white slip up to 1 mm thick with fine colourless quartz sand c 50%
Base sanding – Not seen.

GLSGA: 1988/723.22, Oxidised, 33.2 mm thick, pale yellow glaze, asymmetrical scooped key, Hard fired.

Temper. None seen.

Clay matrix – Calcareous with abundant quartz silt with fine muscovite flakes less than 0.05 mm.
Inlay – Narrow form, White slip c 0.5 mm thick with fine colourless quartz sand c 50%.
Base sanding – Quartz sand translucent angular to occasionally rounded with muscovite flakes up to 0.1 mm.

Comment on group 3.

The fabric of all the tiles from this group is essentially the same consisting of naturally silty clays with no evidence of added temper. The rare coarser mineral grains in 754.34 are probably incidental.

GROUP 1A

GLSGA: 1988/354.46 Oxidised with reduced central area on the upper surface, 38.4 mm thick, pale yellow glaze, deep scooped key, hard fired.

Temper. c 5%

Quartz – A scatter sub-angular to rounded grains, 0.1-0.3 mm rarely 1.2 mm.
Calcium carbonate – Calcite sparse white sub-angular calcite 0.2-2 mm.
Ferruginous pellets – Rare soft dark red to brown rounded and irregular grains, 0.6-1 mm, probably the result of oxidisation of limonitic grains in the clay.

Clay matrix – Calcareous, smooth clay.
Inlay – Narrow form, white slip 0.5-1.5 mm thick.
Base sanding – Not visible (mortar coating and chipping of base).

Note - White calcite fragments occur in the mortar on the base of this sample that are similar in size and appearance to those incorporated in the clay matrix.

GLSGA: 1988/723.31 Oxidised with a thin reduced area on the upper surface, 36.2 mm thick incomplete deep scooped key

Temper. c 5%

Calcium carbonate – Calcite/limestone, white partially calcined angular to rounded grains, 0.3-1.5mm.
Quartz – A scatter of transparent colourless occasionally light brown or opaque white sub-angular to sub-
rounded grains 0.2-1 mm.
Rock – Sandstone, an irregular fragment, 3 mm.
Ferruginous pellets – Rare soft dark red to brown rounded and irregular grains 0.8-2 mm, rarely 3.5 mm.
Probably the result of oxidisation of limonitic grains in the clay.

Clay matrix – Calcareous, smooth clay.
Inlay – White slip, 0.6-2 mm thick.
Base sanding – Probably absent.

GLSGA: 1988/723.86, Oxidised, thinly on the upper surface, with a reduced core, 36.5 mm thick. pale yellow glaze, incomplete deep scooped key. Hard fired

Temper. c 5%

Quartz – Transparent to translucent colourless and opaque grains, sub-angular to rounded grains,
0.1-1.0 mm.
Calcium carbonate – Calcite/limestone, sparse white partially calcined angular to rounded grains,
1-1.2 mm rarely 3mm.
Ferruginous pellets – Rare soft dark red to brown rounded and irregular grains 0.3-1.2 mm probably the
result of oxidisation of limonitic grains in the clay.
Clay matrix – Calcareous smooth clay
Inlay – Narrow form, white slip 1.5-2.5 mm thick.
Base sanding – Probably absent (base mainly covered with mortar)

Note - White calcite fragments occur in the mortar on the base of this sample that are similar in size and appearance to those incorporated in the clay matrix.

Comment on Group 1A

A group of tiles with a similar and distinctive fabric. The quartz and the partly calcined calcite/limestone appear to be deliberate tempering additions. why they are present in such small quantities is problematical. Possibly partially calcined lime such as is present in some of the mortars used, was added to the clay. The ferruginous pellets are likely to be an original weathering component of the clay. The slip inlay is unusual as it does not contain quartz.

GROUP 4

GSGA: 1988/336.12 Oxidised 26mm thick, surface eroding with remnants of devitrified pale yellowish glaze, hard fired, complex scooped key.

Temper. None seen.

Clay matrix – Smooth clay with some muscovite cleavage flakes up to 0.1 mm.
Inlay – Off-white clay slip 0.4-1.4 mm thick with colourless quartz grains, c 10%.
Base sanding – Absent

GSGA: 1988/736.29 Oxidised with reduced area on the upper surface, thickness 25.8 mm. Light brownish glaze, hard fired. Broad shallow scooped key.

Temper. None seen

Limestone – A single light grey partially calcined sub-rounded fragment >9.5 mm An incidental inclusion.

Clay matrix – Smooth clay with sparse muscovite flakes up to 0.05mm
Inlay – White clay slip with sparse colourless quartz sand, 0.2-1.5 mm thick.
Base sanding – Absent.

GLSGA: 1988/738.11 Mainly oxidised with reduced area on the upper surface thickness 24.8 mm. Pale brownish yellowish glaze, hard fired, broad shallow scooped key.

Temper. None seen.

Clay matrix – Very weakly calcareous, smooth clay with muscovite flakes up to, 0.1 mm
Inlay – Wing and star, white slip 0.5-1.5 mm thick with colourless quartz grains c 10%
Base sanding – Absent

GLSGA: 1988/738.14. Oxidised, thickness 21.1 mm, very pale yellow glaze, hard fired, shallow scooped key (part).

Temper. None seen.

Clay matrix– Smooth clay with sparse muscovite flakes up to 0.5 mm.
Inlay – Wing ornament, white slip 0.5-2.5 mm thick with colourless quartz grains c10%.
Base sanding – Absent.

GLSGA: 1988/797.17 Oxidised, thickness 25.3 mm, pale brownish yellow glaze, hard fired, broad shallow scooped key.

Temper. None seen.

Clay matrix – Smooth clay with fine muscovite flakes rarely up to 0.1 mm.
Inlay – White slip (animal hindquarters and tail) 0.5-1.2 mm thick with fine colourless quartz grains c 10%
Base sanding – Absent.

GROUP 7A

GLSGA: 1988/723.52 oxidised base and sides thickness 28.6 mm, brownish yellow glaze, shallow scooped key (part), hard fired.

Temper. None seen.

Clay matrix –Smooth clay with scatter of muscovite flakes up to 0.05 mm.
Inlay – White clay slip with colourless quartz sand, c 20%
Base sanding – Absent

GLSGA: 1988/731.60 Oxidised base and sides, reduced core and upper surface, thickness 25.9 mm, pale yellow glaze, shallow scooped key(part), hard fired, Temper. None seen

Clay matrix – Smooth clay with scatter of muscovite flakes up to 0.05 mm.
Inlay – White clay slip with colourless quartz sand c 20%, 0.75-1.5 mm thick.
Base sanding – Not seen, mortar coating base. probably absent.

GLSGA: 1988/742.7 Oxidised base and sides, thickness 24.5 mm, pale brownish yellow glaze, shallow side scooped key, hard fired.

Temper. None seen
Clay matrix – Smooth clay with sparse muscovite flakes up to 0.05 mm.
Inlay – White clay slip 0.5-1.5 mm thick with colourless quartz sand c 20%
Base sanding – Absent.

GLSGA: 1988/774/67 Oxidised with reduced core, thickness 24.3 mm, very pale yellow to colourless glaze, Irregular scooped key

Temper. None seen

Clay matrix – Smooth clay with a scatter of muscovite flakes up to 0.1 mm.
Inlay – White slip 0.5-1mm thick with transparent colourless and white quartz sand up to 0.5 mm c 20%.
Base sanding – Absent.

GROUP 1C

GLSGA: 1988/723.14 Cut and snapped triangular tile, oxidised with reduced patch in core, thickness 31.7 mm, Brownish yellow glaze, no key in small fragment, hard fired.

Temper. Less than 5%

Calcium carbonate – White partially calcined irregularly distributed grains, 0.2-2.2 mm.
Quartz – Rare transparent colourless to white opaque sub-angular to rounded grains, 0.6-0.8 mm.

Clay matrix – Moderately calcareous smooth clay with a scatter of muscovite flakes less than 0.05 mm.
Inlay – Off-white clay slip, 2-2.2 mm thick.
Base sanding – Absent, but tile base appears to have a greater concentration of white carbonate fragments and quartz grains.

GLSGA: 1988/724.3 Cut and snapped triangular tile, Edge and base oxidised, 30.1 mm thick, no key on fragment, brownish yellow glaze, hard fired.

Temper. c 5%

Calcium carbonate – A scatter of white, partially calcined, irregularly distributed grains, 0.1-1.5 mm, rarely 5 mm.

Quartz – Sparse transparent colourless transparent to opaque white and light brown, angular to rounded grains, 0.1-1.1 mm.
Ferruginous pellets – Sparse brown to deep red sub-rounded to rounded grains, 0.5-1.1mm.

Clay matrix – Moderately calcareous smooth clay with sparse muscovite flakes.
Inlay – White clay slip 11-1.5 mm thick.
Base sanding – Absent, but tile base appears to have a greater concentration of white carbonate fragments and quartz grains.

GLSGA: 1988/767.87 Patchily oxidised, 31.6 mm thick, no key on fragment, brownish yellow glaze, hard fired.

Temper. c 1%

Calcium carbonate – Sparse white partly calcined sub-rounded fragments, 0.2-1mm rarely 5 mm.
Quartz – Rare translucent colourless sub-rounded to rounded grains, 0.2-0.6 mm.
Ferruginous pellets – A scatter of brown to deep red sub-rounded to rounded grains, 0.5-1 mm

Clay matrix – Calcareous smooth clay with a scatter of muscovite flakes less than 0.05 mm.
Inlay – Off-white clay slip 2 mm thick.
Base sanding – Base coated with mortar residue.

GLSGA: 1988/797.11 Oxidised base and side, thickness 28.7 mm, small fragment no key.

Temper. c 5%

Calcium carbonate – A scatter of white partially calcined rounded fragments, 0.1-1 mm.
Quartz – A scatter of transparent to translucent colourless and opaque grey, angular to sub-rounded grains 0.1-1.2 mm.

Clay matrix – Calcareous smooth clay
Inlay – White clay slip 1-2 mm thick.
Base sanding – Absent, but tile base appears to have a greater concentration of white carbonate fragments and quartz grains.

GLSGA: 1988/802.7 small fragment no key thickness 31.9 mm.

Temper. c 15%

Calcium carbonate – A scatter of white partially calcined rounded fragments, 0.1-1.2 mm
Quartz – A sparse transparent to translucent colourless, angular to sub-rounded grains, 0.2-0.7 mm.

Clay matrix – Calcareous smooth clay.
Inlay – Off white clay slip 2 mm thick.
Base sanding – Absent, mortar coating obscures detail.

Comment on group 1C

A generally homogeneous group with a fabric essentially similar to that of Group 3 and with an inlay slip without quartz.

GROUP 7B

GLSGA: 1988/723.31 Oxidised base and sides reduced core and upper surface, thickness 26.2 mm, bubbled pale yellow to honey brown glaze, 4 side scooped keys, hard fired. Fracture rough and irregular.

Temper. Less than 1%

Calcareous – Sparse white rounded fragments,1 & 2 mm

Clay matrix – Smooth clay with some irregular streaky light and darker grey lamination and mottling, finely micaceous.

Inlay – White slip 0.2 mm thick with colourless sub-angular quartz sand c 20%.

Base sanding –Some white calcium carbonate grains embedded in lower surface.

GLSGA: 1988/724.17 Oxidised base and side reduced core and upper surface, thickness 26.7 mm. pale yellow to light honey glaze with bubbled surface, shallow side scooped key, hard fired.

Temper. None seen

Clay matrix – Uniform weakly calcareous silty to finely sandy clay.

Inlay – Geometric. Off-white clay slip 0.2-0.4 mm thick with fine-grained colourless quartz.

Base sanding – Not distinguishable.

GLSGA: 1988/727.59 Oxidised base and sides reduced core and upper surface thickness 23.2 mm, remnants of pale yellow to honey brown glaze. side scooped key, hard fired.

Temper. None seen

Clay matrix – Uniform silty clay with quartz rarely up to 0.15 mm and fine muscovite flakes less than 0.05 mm.

Inlay – White clay slip 0.2-0.6 mm thick, with colourless translucent angular to sub-rounded quartz c 20%.

Base sanding – Absent.

GLSGA: 1988/729.8 Oxidised base and sides light grey reduced core and upper surface, thickness 27.4mm, pale yellow to honey brown glaze, side scooped key, hard fired.

Temper. less than 1%

Calcareous inclusions – rare white rounded calcium carbonate grains, 0.8 &1 mm.

Quartz – Rare sub-angular grains, 0.3 mm.

Clay matrix – Uniform moderately calcareous silty clay with quartz and fine muscovite flakes less than 0.05 mm.

Inlay – Geometric, thin off white slip 0.1-0.4 mm with some very fine-grained colourless quartz.

Base sanding – A concentration of quartz sand and larger muscovite flakes up to 0.2 mm

GLSGA: 1988/729.49 Oxidised base and side with reduced core and upper surface, thickness 24.4 mm hard fired, very pale yellow to light honey glaze, 3 small side scooped keys on fragment, hard fired, irregular fracture.

Temper. less than 1%

Calcareous – Sparse pink rounded carbonate grains, 2.1 & 1.15 mm.

Inclusion – Hard dark glassy angular vesicular fragments, 4 & 5 mm and a localised scatter of

similar but smaller fragments up to 1.2 mm, probably incidental inclusions of vitrified kiln debris.

Clay matrix – Smooth clay with contorted light and dark grey lamination.

Inlay – Geometric, off-white clay slip 0.1-0.5 mm thick with colourless transparent to translucent quartz grains c 20%.

Base sanding – White calcium carbonate grains embedded in lower surface.

GLSGA: 1988/754.1 Oxidised base and sides reduced core and upper surface, thickness 28 mm, colourless and pale yellow to honey brown glaze, side scooped key, hard fired.

Temper. None seen

Clay matrix – Uniform silty clay with fine muscovite flakes.

Inlay – White clay slip mm thick with colourless translucent quartz

Base sanding – Quartz sand with muscovite flakes up to 0.2 mm.

GLSGA: 1988/754.9 Mainly oxidised with reduced core, thickness 26.7 mm, key obscured, shows cut for splitting to triangular tiles, colourless to pale honey glaze, hard fired.

Temper. None seen

Clay matrix – Uniform silty clay with fine muscovite flakes.

Inlay – White slip 0.2-0.5 mm thick with transparent to translucent angular to rounded quartz c 50%

Base sanding – Absent.

GLSGA: 1988/756. Oxidised with patchy reduction, thickness 17 26.8 mm, colourless, faintly greenish in places, to dark honey brown, bubbled in places, closely spaced small Side-scooped keys

Temper. None distinguishable.

Ferruginous pellets – Sparse reddish brown to dark brown rounded 0.3-2 mm.

Clay matrix – Variably calcareous smooth clay with traces of contorted light and dark grey lamination c.f. 729.49. Little detail is visible as the broken area is coated with mortar residue

Inlay – Branch and leaf. Clay slip , 0.2-0.5 mm thick, probably with fine quartz.

Base sanding – Fine quartz sand embedded in surface.

GLSGA: 1988/767.76 Medium grey reduced thinly oxidised base and side, thickness 25.1 mm. colourless to very pale yellow, bubbled glaze, side scooped key, very hard fired becoming vitrified (stoneware).

Temper. None seen.

Clay matrix – Uniform silty clay but with little detail visible because of high temperature firing. Small calcareous inclusions.

Inlay – Leaves and branch. White clay slip 0.2-1 mm thick with colourless translucent quartz sand c 50%.

Base sanding – Fine quartz sand.

GLSGA: 1988/767.82 Reduced slight oxidisation on side dark grey reduced core, thickness 27 mm, traces of very pale yellow to honey brown bubbled glaze, very hard fired becoming vitrified in part cf. 767.76. Small sided scooped keys.

Temper. None seen

Clay matrix – Silty clay not uniformly mixed and sandy in part. Sparse calcareous pellets 1-2 mm

Inlay – White clay slip 0.2-0.3 mm thick with fine colourless quartz sand c 20%.

Base sanding – Some quartz sand visible up to 3 mm

GLSGA: 1988/788.36 Oxidised base and side with reduced core and upper surface, thickness 25.6 mm, very pale yellow to honey yellow glaze hard fired, wide shallow side scooped key.

Temper. None seen

Clay matrix – Uniform silty to very finely sandy clay with fine muscovite flakes.

Inlay – White finely micaceous clay slip 0.1-0.2 mm thick with very sparse fine quartz sand.

Base sanding –Not distinguishable from matrix.

Comment on group 7B

The matrix clay of 723.31, 729.49, and 756.17 is distinctive in showing light and dark grey laminations. This does not occur in any of the other groups. The laminations are rather contorted within the tile and appear to contribute to irregular fracture surfaces of these examples. It is uncertain whether this clay variation simply represents a different clay source for a batch of tiles or whether they are from a different tilery. Certainly the more complete tile756.17 is more roughly finished compared with the rest of the tiles in the group.
The inlay ornaments of these examples are all different

GROUP 9 (Narrow-form tiles with distinctly bevelled sides)

GLSGA: 1988/726.2 Oxidised base and sides with reduced core and upper surface, thickness 23 mm, pale yellow glaze hard fired, distinctive 'horse hoof imprint' key (part), see group 9.

Temper. c 80%

Quartz – Transparent to translucent, mainly colourless, angular to rounded grains up to 0.5 mm but mainly less than 0.2 mm

Clay matrix – Calcareous with sparse muscovite flakes less than 0.05 mm.
Inlay – 0.5-1 mm thick with colourless quartz sand c 50%.
Base sanding – Not distinguishable from main quartz content.

GLSGA: 1988/727.1 Oxidised surfaces with reduced core, thickness 23.9, hard fired, distinctive key (part)

Temper. c 80%

Quartz – Transparent to translucent, mainly colourless, occasionally white opaque, angular to rounded grains up to 0.4 mm but mainly less than 0.2 mm.

Sand inclusion – Clean white sand/soft sandstone 2.5 mm, translucent to white opaque angular to sub-rounded grains up to 0.2 mm.

Clay matrix – Calcareous with sparse muscovite flakes less than 0.05 mm.
Inlay – White clay slip 0.2-0.5 mm thick with colourless transparent to translucent quartz sand c 50%.
Base sanding – Similar to main quartz content but slightly coarser, mainly about 0.3 mm.

GLSGA: 1988/736.24 Oxidised with reduced core, thickness 23.9mm, traces of pale yellowish brown glaze, hard fired, no key on fragment.

Temper. c 70%

Quartz – Transparent to translucent colourless and some brownish coloured grains, angular to rounded less than 0.2 mm.

Clay matrix – Calcareous with, sparse muscovite flakes less than 0.05 mm
Inlay – White clay slip up to 0.2 mm thick with fine grained colourless quartz sand, c 50%
Base sanding – Similar to main quartz content up to 0.3 with rare muscovite flakes 0.1 & 0.2 mm.

GLSGA: 1988/7?76.32 Oxidised base and one edge, 23.5 mm thick, pale greenish glaze, hard fired, no key on fragment.

Temper. c 70%

Quartz – Colourless angular to rounded grains up to 1.3 mm mainly less than 0.2 mm.

Clay matrix– Calcareous with rare muscovite flakes less than 0.05 mm.
Inlay – White clay slip 0.25-0.8 mm thick with fine-grained colourless angular to rounded quartz c 40%.
Base sanding – Probably absent.

Comment on Group 9

See comment for Group 10. Keying on 726.2 and 727.1 resembles that of Group 10.

GROUP 10

GLSGA: 1988/746.9 Grey reduced with thinly oxidised lower surface and edge, 18.7 mm thick, colourless transparent glaze. Distinctive oblique key (resembling print of a horses hoof), hard fired.

Temper c 70%

Quartz –Transparent, translucent to white opaque angular to rounded grains, up to 0.5mm mainly less than 0.2 mm.

Sand inclusions – Irregular patches of clean sand/soft sandstone, translucent to white opaque angular to sub-rounded grains up to 0.15 mm.

Matrix – Moderately calcareous with sparse muscovite cleavage flakes less than 0.05 mm.
Inlay – White clay slip c 0.4 mm thick with c 50% fine-grained colourless quartz sand up to 0.1mm.
Base sanding – Quartz, transparent, translucent to white opaque angular to rounded grains, 0.05-0.6 mm, mainly less than 0.1 mm. with Muscovite as sparse cleavage flakes up to 0.15 mm.

GLSGA: 1988/746.24 Thick oxidised surfaces with reduced core, 18.2mm thick, pale yellow glaze, distinctive key as 746.9, hard fired.

Temper. c 70 %

Quartz – Mainly translucent colourless angular to rounded grains up to 0.2 mm.

Matrix – Weakly calcareous with sparse muscovite cleavage flakes up to 0.05mm.
Inlay – White clay slip c 0.2 mm thick with c 50% colourless opaque quartz sand up to 0.1 mm.
Base sanding – Quartz, translucent to white opaque angular to rounded grains up to 0.4 mm.
Mainly less than 0.1 mm. with muscovite as rare cleavage flakes up to 0.05 mm.

GLSGA: 1988/746.116 Oxidised surfaces of variable thickness with reduced core, 19.3 mm thick, pale yellow glaze. Key form not visible, Irregular cavity which may represent a former soft sand inclusion similar to 746.9, hard fired.

Temper. c 60 %

Quartz – Transparent to translucent and white opaque angular to sub-rounded grains up to 0.4 mm.

Matrix – Moderately calcareous with sparse muscovite cleavage flakes less than 0.05 mm.
Inlay – White slip c 0.3 mm thick with c 50 % colourless quartz sand.
Base sanding – Essentially similar to 746.9.

GLSGA: 1988/746.147 Oxidised surfaces variable in thickness grading to a reduced core, 18.8mm thick, colourless glaze. Key similar to 746.9, hard fired.

Temper. c 70%

Quartz – Colourless translucent and opaque angular to sub-angular grains up to 0.4 mm, mainly less than 0.1 mm.

Matrix – Moderately calcareous with sparse muscovite cleavage flakes less than 0.05 mm.
Inlay – White slip less than 0.5 mm thick with quartz sand.
Base sanding – Essentially similar to 746.9.

Comment on group 10.

This group has physical similarities of thickness, fine design detail and sand grains size both of temper and base sanding with quartz and sparse muscovite flakes and calcareous matrix. The cleanly and distinctly bevelled sides are also characteristic. There are similarities of fabric and key shape with group 9 although group 10 are consistently thinner, perhaps because of the use of a different set of moulds. This fabric with a high sand content is similar to most of the inlaid medieval tiles from Exeter city and its vicinity which utilise the local Permian sands, except that they are not calcareous.

General Comments

Calcareous and ferruginous pellets. The sparse small white pellets occurring in some tile, some of which are hollow, are probably ‘race’. This is a geological term referring to such pellets occurring in the weathering profiles of calcareous clays. They indicate the clay was dug at a relatively shallow depth, probably less than 5 metres. The ferruginous limonitic pellets present in some tile also indicate clay dug from within the weathering profile.

Inlay.
The appearance of the inlay of the Glastonbury tiles and particularly those with quartz in the formulation is very similar to that found in medieval inlaid tiles from Exeter. As white firing clays are not local to either location it seems likely that the inlay was imported to both sites, probably pre-prepared. Possible sources are the white pipe clays of the Poole - Wareham area.

Temper.
The percentages given are visual estimates only, but give an idea of the mineral content and appearance under the microscope.

Hardness.

All the tiles are unabraded but can be scored with a hard steel needle. The general uniformity of firing indicates good kiln control. Two tiles in Group 7B cannot be scored and are comparable to stoneware indicating some degree of overfiring and localised variation of kiln temperature.