# Characterisation Studies of Selected Anglo-Saxon Pottery from the London Transport Museum, Westminster (LTM03)


## *Alan Vince*


Samples of twenty-nine Anglo-Saxon pottery vessels found during excavations at the London Transport Museum in 2003 were selected and submitted for analysis by Lyn Blackmore (App 1). The samples were chosen to answer a series of questions about the identity and source of both the locally-produced and imported pottery.

The samples were analysed using thin sections, which were prepared by Steve Caldwell, University of Manchester, and stained using Dickson's method (Dickson 1965), and chemical analysis, carried out under the supervision of Dr J N Walsh, Royal Holloway College, London, using Inductively-Coupled Plasma Spectroscopy (ICP-AES). A range of major elements was measured and presented as percent oxides (App 2) and a range of minor and trace elements was measured and presented as parts per million (App 3).

The "local" wares consist of handmade vessels often with a dark brown or black core due to the presence of carbon in the body. A series of samples were taken from cremation urns, some of which were *in situ* and others redeposited in later, mid-Saxon deposits. To compare with these a series of samples of loom weights were taken. These two groups of samples were compared to test whether the cremation vessels were likely to have been made on or near the site. Samples of other decorated handmade vessels were taken for comparison. The remaining "local" ware samples were chosen in order to identify inclusion types noted at x20 magnification. These could be divided into several separate fabric groups in thin section.

In total, these "local" wares could be grouped into seven fabric groups based on thin section analysis whilst chemical analysis indicates that the loom weights are not made from the same clay as the pottery samples, and that the pottery probably comes from at least three different sources.

A single sample from a vessel tentatively identified as Ipswich ware was sampled. The thin section indicates a similar range of inclusions to those seen in Ipswich ware but the chemical composition is indistinguishable from that of the "local" wares and thus the source of this vessel is still unclear.

Samples of ten wheelthrown imported vessels were taken and these proved to be divisible into five distinct fabric groups based on thin section analysis. Chemical analysis suggests that these come from at least three separate clay sources.

## Local wares

### Thin section Analysis

#### Fabric 1 = Chaff-tempered ware

A single thin section of the chaff-tempered fabric was made (V4643). The following inclusion types were noted:

- Organics. Moderate carbonised inclusions up to 4.0mm long and 0.3mm wide. Usually surrounded by a darkened halo and partially filled with light brown phosphate.
- Altered Glauconite. Spare subangular fragments up to 0.2mm across.
- Rounded quartz. Sparse grains up to 1.5mm across but mostly up to 0.5mm across.
- Clay/iron. Sparse rounded pellets up to 0.8mm across. Darker in colour than the groundmass but with a similar texture.
- Chert. Sparse subangular fragments with subangular quartz inclusions up to 0.2mm across and chalcedonic infill of similar-sized voids.

The groundmass consists of optically anisotropic baked clay minerals, moderate angular quartz up to 0.1mm across, sparse rounded opaques c.0.15mm across.

#### Fabric 2 = MSFL

A single thin section of this fabric was made (V4632). The following inclusion types were noted:

- Rounded Quartz. Moderate fragments up to 1.0mm across. Some are probably of lower Cretaceous origin and others probably of Triassic origin.
- Flint. Sparse angular fragments up to 1.0mm across.
- Chert. Sparse rounded grains up to 1.5mm across, some brown-stained and some porous with ferroan calcite filling the pores.

The groundmass consists of optically anisotropic baked clay minerals, abundant angular quartz up to 0.1mm across.

#### Fabric 3 = ESSTOL

A single thin section of this fabric was made (V4639). The following inclusion types were noted:

Calcareous sandstone. Abundant angular fragments of sandstone up to 2.0mm across, consisting of well-sorted angular grains up to 0.2mm across in a ferroan calcite groundmass.

Sandstone. Sparse angular fragments of sandstone up to 2.0mm across consisting of well-sorted overgrown quartz grains up to 0.3mm across.

Oolitic limestone. Sparse angular fragments up to 1.5mm across, consisting of brown micrite ooliths c.0.5mm across in a groundmass of ferroan calcite. The ooliths mainly have a core consisting of ferroan micrite or a non-ferroan calcite shell fragment.

Quartz. Sparse angular fragments up to 3.0mm across consisting of strained elongate crystals.

Mudstone/relict clay. Moderate subangular fragments of similar colour and texture to the groundmass but showing signs of bedding.

Muscovite. Rare laths up to 1.0mm long.

The groundmass consists of light brown optically anisotropic baked clay minerals and sparse angular ferroan calcite up to 0.1mm across. The fabric is laminated and the laminae are mainly open but some are filled with brown phosphate, which also surrounds some of the inclusions.

## Fabric 4 = MSLQA

A single thin section of this fabric was made (V4636). The following inclusion types were noted:

Rounded quartz. Moderate fragments up to 1.0mm across. Most have a coating of dark brown to opaque material and in some instances similar material fills veins in the grains.

Fossiliferous limestone. Moderate angular fragments up to 1.5mm across. These contain non-ferroan fossil fragments including bivalve shell. In one instance a rounded quartz grain c.0.5mm across is present.

Relict clay. Sparse rounded grains up to 1.0mm across with a similar texture to the groundmass but slightly lighter in colour.

Organics. Sparse elongated carbonised inclusions, up to 3.0mm long and 0.3mm wide.

The groundmass consists of optically anisotropic baked clay minerals, moderate angular quartz grains up to 0.1mm across and sparse muscovite laths up to 0.1mm long.

## Fabric 5 = SLGS

Two samples were grouped together because they contain rounded quartz sand. However, they do differ in detail and are described separately here:

### *V4633*

The following inclusion types were noted in thin section:

- Quartz. Abundant subangular quartz up to 0.3mm across and sparse rounded grains up to 0.5mm. A minority of the rounded grains appear to be of Lower Cretaceous origin.
- Organics. Sparse carbonised inclusions, some straight some curved, up to 2.0mm long and 0.2mm wide.
- Opaques. Sparse rounded grains, up to 1.0mm across. The larger fragments contain quartz inclusions of similar size and shape to those in the remainder of the section.

The groundmass consists of light brown, highly birefringent baked clay minerals and few other inclusions, except for moderate fragments of opaque material.

Altered glauconite? Rare rounded fragments up to 0.3mm across.

*V4634*

The following inclusion types were noted in thin section:

- Quartz. Moderate rounded grains up to 1.0mm across, some with a dark brown coating and others with dark brown stained veins.
- Clay/iron concretions. Sparse rounded dark brown fragments up to 1.0mm across with an oolitic structure.
- Organics. Sparse irregular voids up to 0.2mm across surrounded by a darkened halo.

The groundmass consists of light brown optically anisotropic baked clay minerals, sparse angular quartz, sparse rounded opaques and sparse rounded dark brown clay/iron grains all up to 0.1mm across.

## Fabric 6 = [LYN! Neither of these samples had a MOLAS code at the time]

The two samples of this fabric both contain angular fragments of acid igneous rock, as part of a mixed inclusion suite. The following inclusion types were noted:

- Acid igneous rock. Moderate angular fragments of a medium-grained igneous rock up to 2.0mm across containing crystals of altered orthoclase feldspar, perthite and quartz.
- Quartz. Moderate rounded and subangular grains up to 0.5mm across. These include well-rounded grains with iron-stained veins.
- Sandstone. Sparse angular fragments of a medium-grained sandstone consisting of interlocking overgrowth grains of quartz up to 0.5mm across.

The groundmass consists of optically anisotropic baked clay minerals, moderate angular quartz up to 0.1mm across and moderate muscovite laths up to 0.1mm long.

### Fabric 7 = Fired clay loom weights

No samples of the fired clay were thin sectioned. However, examination of the six samples selected for ICPS analysis at x20 magnification indicates that they can be grouped into two fabric groups. The first contains sparse rounded, polished quartz grains up to 1.0mm across, subangular flint up to 1.0mm across, and organics up to 2.0mm long, often surrounded by a blackened halo. The groundmass contains abundant quartz and moderate muscovite silt up to 0.1mm across. All are low-fired with a light brown surfaces and margins and a dark grey core. The second group consists of a single sample, V4613, which has a coarser texture, with a groundmass containing abundant subangular quartz up to 0.2mm across. It contains moderate burnt out calcareous inclusions up to 2.0mm across. This sample is oxidised red throughout but was definitely from a loom weight.

## Chemical Analysis

Eighteen samples of probable local origin were analysed using ICPS.

The distinction between one of the fired clay samples, V4613, and the remainder (Fabric 7) is supported by the ICPS analysis which indicates that this sample has higher estimated SiO, $Fe_2O_3$, CaO, MnO, Ba, Li, Ni, Sc, V, Y, La, Ce, Nd, Sm, Eu, Dy, Yb and Co than the remainder. It also has a lower $Al_2O_3$, $TiO_2$, Cr and Zn content.

Factor analysis indicates that both MnO and Y have abnormally high values in one sample each and these elements have been excluded from further analysis. A second factor analysis, which excluded both those two elements and CaO, $P_2O_5$ and Sr, all of which are highly mobile, found that the Fabric 2 sample has high Rare Earth values which lead to it having a much higher Factor 1 score than any of the remainder. The rest of the samples have very similar F1 and F2 scores although the $K_2O$ and $Na_2O$ values for the Fabric 7 samples are higher on average than for the pottery samples, leading to higher F1 and F2 values for these samples. There is no apparent patterning in the F1 or F2 scores for the pottery fabrics. The third and fourth factors together distinguish the Fabric 1 samples from the remainder. This is due to high V, Cr and $Fe_2O_3$ scores for the Fabric 1 samples.

These results suggest that the chaff-tempered pottery, Fabric 1, and the fired clay, Fabric 7, were made from different sources of clay. There are insufficient numbers of samples of the other fabrics to be able to say more about the source of the clay used to make them, except they are different from both of those groups and that a combination of all four factors can distinguish the different fabric groups.

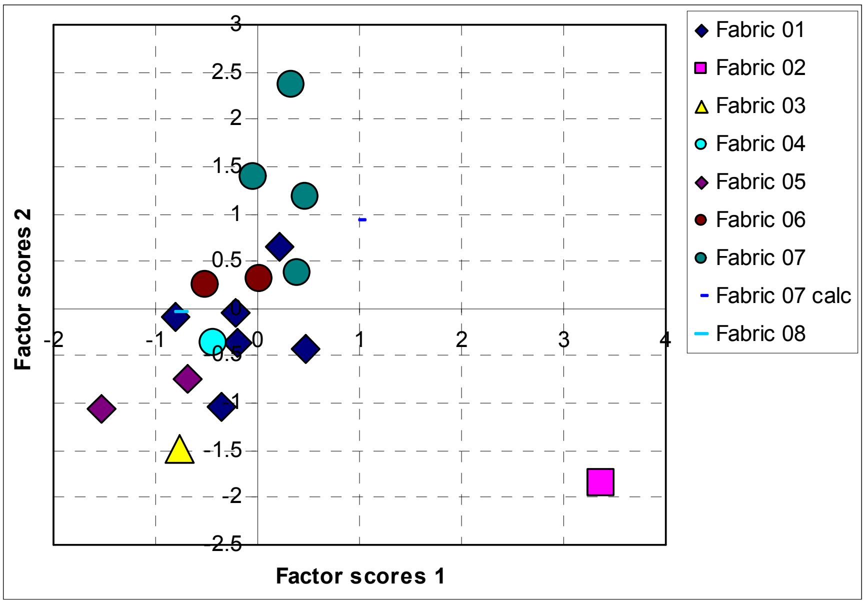


*Figure 1*

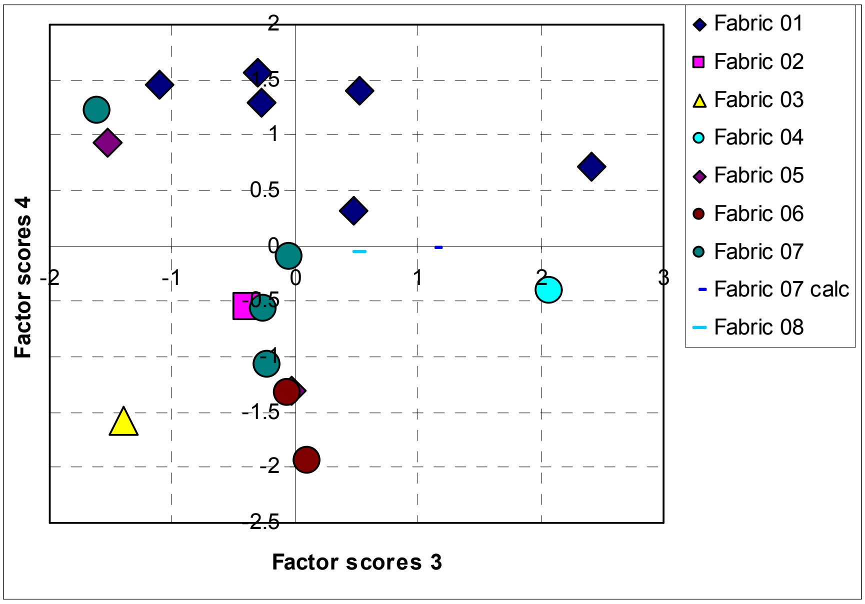


*Figure 2*

## Discussion

The chaff-tempered pottery, Fabric 1, and the loom weights, Fabric 7, have very similar characteristics at x20 magnification. However, the chemical composition of the two groups differs. It is very likely that the loom weights were produced locally and the visual characteristics of the fabric are consistent with the use of a brickearth. The single anomalous fired clay sample, V4613, is also likely to have been made from local brickearth and is chemically more similar to the other fired clay samples than to any of the other “local” samples.

The petrological composition of Fabric 2 is also consistent with the use of a brickearth although chemically the sample is distinctly separated from the remainder by its high rare earth element content whilst its F3 and F4 scores place it with Fabric 7.

The calcareous sandstone inclusions in Fabric 3 might be of Jurassic or Cretaceous origin. In either case, they are unlikely to have been present in a Thames valley sand and either indicate a source to the southeast, in one of the valleys draining the Weald, or, perhaps more likely, to the north or northeast, in which case the sandstone would almost certainly be of middle or upper Jurassic origin. This rock type is not, however, commonly found in early to mid Anglo-Saxon pottery in East Anglia or the Midlands.

The fossiliferous limestone found in Fabric 4, is certainly of Lower Cretaceous origin and no possible candidate has be found by the author to the north of the Thames. Therefore, this fabric is probably from the southeast of England.

The Fabric 5 samples are similar to wares found to the southwest of London, utilising iron-cemented sands of Tertiary age in a light-firing clay which is also of Tertiary age (the Barton Beds, which outcrops in patches to the south of the Thames around Kingston). Chemical analysis indicates that both samples have a composition similar to that of other “local” pottery.

The Fabric 6 samples are mostly likely to come from East Anglia, where the igneous rock could either have come from the midlands or from northern England or Scandinavia. The other inclusion types are consistent with this interpretation and probably favour the midlands origin of the sand, which would have been of fluvio-glacial origin. Similar fabrics occur on sites in northern Kent, such as Springhead, and might have been traded along the coast from East Anglia. They are possibly evidence for an East Anglian trading connection with the Thames and southeast in the period preceding the production of Ipswich ware.

## Ipswich ware?

One sample of possible Ipswich ware was thin-sectioned.

### Thin section Analysis

#### Fabric 8

The following inclusion types were noted:

- Quartz. Moderate well-rounded grains ranging from c.0.2mm to 1.0mm. Some of these have iron-stained veins and shapes which suggest a Lower Cretaceous origin.
- Flint. Sparse angular unstained grains up to 0.5mm across.
- Altered glauconite. Sparse rounded grains up to 0.3mm across.

- Opaques. Sparse well-rounded grains up to 0.3mm across. Also, one rounded fragment 1.5mm across with sparse angular quartz inclusions.
- Clay/iron concretions. Sparse rounded concretions with a variable iron content and oolitic structure.
- Chert. Sparse rounded fragments up to 1.0mm across.

The groundmass consists of optically anisotropic baked clay minerals, abundant angular quartz grains up to 0.1mm across and sparse muscovite laths up to 0.1mm long.

### Chemical Analysis

The ICPS data for this sample was included in the factor analysis of the local wares described above. The results indicate that this sample is similar to the local wares, but especially to Fabric 1 (Figs 1 and 2, Fabric 8). Comparison with samples of Ipswich ware from sites elsewhere (Barton upon Humber, York, Hinxton and Ipswich itself) indicates that there is only slight separation of the local London products from those from Ipswich and that the Fabric 8 sample consistently plots in areas of overlap between the two groups, so that it is impossible to say for certain whether it is an Ipswich product or a local ware.

## Imported wares

Ten samples of wheelthrown imported pottery were examined. One of these is a whiteware, similar to the products of the La Londe kilns in the lower Seine valley (Fabric 12). One is a fragment of grey burnished ware of the most common type found in Mid Saxon England (Fabric 11) and thought to originate in the southern Belgium/Northern France region (Mainman 1993). The remaining samples are of wares which are not common on mid-Saxon sites in the London area but which occur in some numbers at the London Transport Museum site (Fabrics 9, 10 and 13).

### Thin section Analysis

## Fabric 9

Four thin sections of Fabric 9 were made. The fabric is a reduced grey sandy ware and the following inclusion types were noted in thin section:

- Quartz. Moderate rounded and subangular grains up to 0.3mm across.
- Coarse Siltstone/Fine Sandstone. Sparse rounded fine-grained sandstone with a brown cement and grains up to 0.1mm across.
- Clay/iron. Sparse rounded dark brown grains up to 0.3mm across.
- Opaques. Rare subangular grains up to 1.0mm across.

- Muscovite. Sparse laths up to 0.3mm long.

The groundmass consists of optically isotropic (1 section, V4623) or anisotropic (3 sections, V4625, V4627 or V4630) baked clay minerals, sparse angular quartz up to 0.1mm across, Muscovite laths up to 0.1mm long. Subangular dark brown/opaque grains up to 0.1mm across.

### Fabric 10 = NFRWB

A single example of this fabric, a fine-textured oxidized ware, was thin-sectioned (V4621). Since the inclusions are almost identical to those in Fabric 9 but less frequent it might simply be a finer version of that fabric. The following inclusion types were noted:

- Quartz. Sparse subangular grains up to 0.3mm across.
- Coarse Siltstone/Fine Sandstone. Rare rounded grains up to 0.3mm across.
- Chert. Rare subangular grains up to 0.4mm across.

The groundmass consists of optically anisotropic baked clay minerals with rare angular quartz inclusions up to 0.1mm across and moderate dark brown grains less than 0.5mm across.

### Fabric 11

A single thin section was examined (V4622). The following inclusion types were noted:

- Opaques. Sparse rounded and subangular fragments up to 1.0mm across.
- Voids. Sparse irregular voids up to 1.0mm across which might have contained calcareous or organic inclusions, or be the result of trapped air in the potting clay. Some have a darkened halo surrounding them and clearly once contained organic inclusions.

The groundmass consists of optically isotropic baked clay minerals, abundant angular quartz up to 0.1mm across, sparse rounded dark brown grains up to 0.1mm across.

### Fabric 12

A single sample of this fabric was thin-sectioned (V4623). In the hand, the fabric is light-firing with dark blue-grey surfaces and margins. The following inclusion types were noted in thin section:

- Quartz. Abundant angular and subangular grains, ranging from c.0.2mm to 0.5mm. Several of the grains have an extremely low sphericity.
- Opaques. Sparse subangular grains ranging from c.0.2mm to 0.5mm across.

The groundmass consists of optically anisotropic, highly birefringent baked clay minerals with few inclusions. The outer margins are opaque as a result of carbon diffused into the body.

Fabric 13

Three samples of this fabric were thin-sectioned (V4624, V4628 and V4629). All have similar inclusions to Fabrics 9, 10 and 12 and the difference is mainly in the colour/iron content of the groundmass and the frequency of opaques. The following inclusion types were noted:

Quartz. Moderate angular grains with a low sphericity to well-rounded highly spherical grains, ranging from c.0.2mm to 1.0mm.

Opaques. Moderate grains c.0.1-0.2mm across. Many are well-rounded with high sphericity whilst others show signs of a euhedral outline. Both features suggest that these are concretions formed *in situ*.

Altered glauconite? One of the three samples, V4628, contains moderate rounded light brown isotropic grains. These may be altered glauconite or may be clay pellets and reflect a relatively high firing temperature.

The groundmass consists of pale brown, optically anisotropic clay minerals, sparse angular quartz grains and sparse dark brown to opaque grains up to 0.1mm across.

## Chemical Analysis

Factor analysis of the ten sherds of imported fineware found four factors. Of these, only one, F2, showed patterning correlated to the fabric groups (Fig 3). Fabric 12 has the lowest/negative F2 score, followed by the three Fabric 13 samples, whilst fabrics 9, 10 and 11 form a single group. High F2 scores are due mainly to MgO, K2O and Cu values.

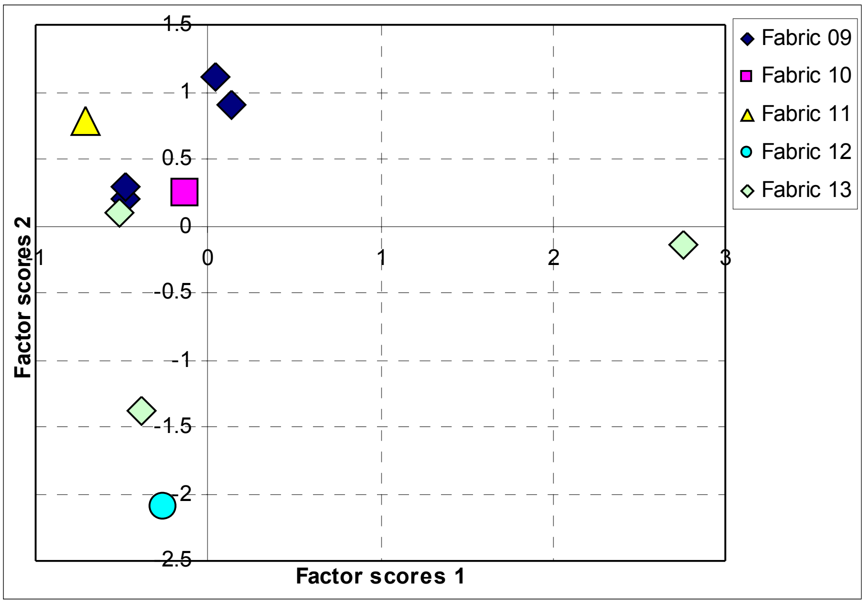


*Figure 3*

The ICPS data were then compared with that from a series of samples of Lower Seine origin, some of which come from the production site at La Londe and others from consumer sites in France and England, and with samples of Middle Rhenish origin and Carolingian date from consumer sites in England and Norway (Badorf ware; Hunneschans ware and Walberberg ware from Lundenwic, Kaupang, Flixborough and York). Samples of unknown, presumed northern French/southeastern Belgian origin were also included. These include mid Saxon grey and black burnished wares (three sample from Flixborough, Young and Vince forthcoming, coded BLBURN) and samples of Evison's group I imports of early Anglo-Saxon date (Evison 1979). The samples come from Bayfield in Norfolk, Penn and Whitmore 2007, and Hadleigh and Coddenham in Suffolk, together with one probable example from Lundenwic – MoLAS code NFGWB). This analysis clearly showed that none of the LTM samples are of Lower Seine origin but showed no clear patterning of the non-Lower Seine samples. The analysis was therefore repeated excluding those samples. Four factors were found and a plot of F1 against F2 indicates that the Middle Rhenish samples have negative F1 scores whereas the black and grey burnished wares from other English sites have positive F1 scores, as do the Evison Gp 1 samples. The Fabric 11 and 12 samples both group with the Middle Rhenish wares as does a sample of a light-bodied black surfaced import from Flixborough (BLBURNW), whilst the Fabrics 8, 9, 10 and 12 samples group with the other early and mid Saxon imports. However, one of the Fabric 12 samples is distinguished by a high F2 score. Neither the F3 nor F4 scores show any obvious patterning. This analysis places the one sample which is clearly of the same fabric as the other grey and black burnished wares with its companions whilst the BLBURNW sample is visually and petrologically similar to the Fabric 11 sample, and plots close to this sample in this analysis.

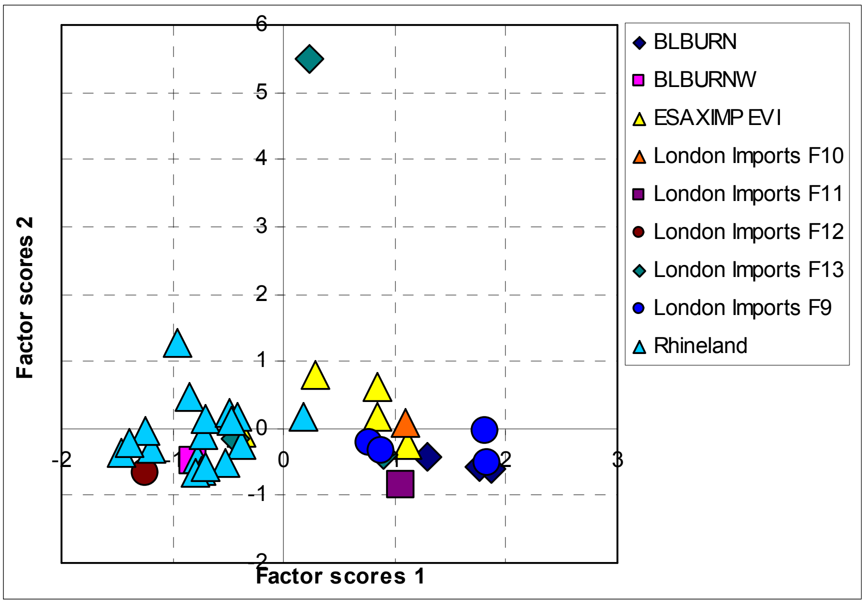


*Figure 4*

## Discussion

One of the ten imported wheelthrown ware samples has a very different clay matrix to the remainder, Fabric 11. This is paralleled in other samples of Grey Burnished ware from England and is consistent with the analysis of the chemical composition, which suggests that this sample has the same source as those from Flixborough. A survey of the continental evidence for these wares suggests a source in the northern France/southern Belgium area (Mainman 1993).

The remaining samples all have a fine-textured clay groundmass, in some cases with a moderate or high iron content and in others with a low iron content. It is likely that they are made using Tertiary clays, but unfortunately such clays outcrop widely in the potential source areas for these wares. The character of the quartzose sand found in Fabrics 9 and 10 suggests that these two fabrics have the same source and differ solely in the quantity of sand added as temper. Their chemical composition is consistent with having the same source and links them with Fabric 11, the Flixborough Grey Burnished ware samples and with an import from DRY90 (V1742). A similar northern French/southern Belgian source is therefore probable.

Fabrics 12 and 13 have similar quartz sands, both including some extremely angular quartz grains. However, Fabric 13 contains some well-rounded quartz grains absent from Fabric 12. The factor analysis of the chemical composition data, however, clearly separates the two fabrics and suggests that Fabric 12, and a white-bodied grey burnished ware from Flixborough, might have a Rhenish origin whilst the three Fabric 13 samples have rather different compositions, which may suggest that actually they may come from different sources or, that the clay used to produce them is variable in composition.

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*Appendix 1*

| TSNO | Context | cname | Fabric | Form | Action | Description | subfabric |
|---|---|---|---|---|---|---|---|
| V4611 | 8685 | FCLAY | 7 | LOOM WEIGHT | ICPS | | |
| V4612 | 8571 | FCLAY | 7 | LOOM WEIGHT | ICPS | | |
| V4613 | 8747 | FCLAY | 7 calc | LOOM WEIGHT | ICPS | | |
| V4614 | 8656 | FCLAY | 7 | LOOM WEIGHT | ICPS | | |
| V4621 | 8763 | MSAXIMP | 10 | SPP | TS;ICPS | BURNISHED EXT;FLANGED RIM | NFRWB;FINE OXID RED |
| V4622 | 8800 | MSAXIMP | 11 | JAR? | TS;ICPS | BURNISHED LINES EXT | |
| V4623 | 8655 | MSAXIMP | 12 | JAR? | TS;ICPS | CARINATED;BLACK SURFACES | SANDY;CF LA LONDE BUT COARSER? |
| V4624 | 8362 | MSAXIMP | 13 | JAR? | TS;ICPS | | LOW FE CLAY;GSQ;ANG FLINT |
| V4625 | 8310 | MSAXIMP | 9 | JAR? | TS;ICPS | LOOKS WT | FINE SILTY MICACEOUS BODY;SPARSE SAQ |
| V4626 | 8310 | MSAXIMP | 9 | JAR? | TS;ICPS | NOT DEFINITELY WT;BURNISHED EXT | FINE SILTY MICACEOUS BODY;SPARSE SAQ |
| V4627 | 8227 | MSAXIMP | 9 | JAR | TS;ICPS | WIRE-CUT BASE;WT | OXID BROWN CORE;BLACK SURFACES;SAQ <0.3MM |
| V4628 | 8265 | MSAXIMP | 13 | JAR | TS;ICPS | WT;BLACK SURFACES | OXID BROWN CORE;BLACK SURFACES;SAQ <0.3MM |
| V4629 | 8155 | MSAXIMP | 13 | JAR | TS;ICPS | WT;BLACK SURFACES;VERT BURNISHED EXT | OXID BROWN CORE;BLACK SURFACES;SAQ <0.3MM |
| V4630 | 8154 | GRBURN | 9 | JAR | TS;ICPS | CORRUG SHOULDER;ROUNDED RIM;BURNISHED EXT | FINE |
| V4631 | 8292 | FCLAY | 7 | LOOM WEIGHT | ICPS | | |
| V4632 | 8757 | EMSAXLOC | 2 | JAR | TS;ICPS | FROM CREMATION POT ;HM | MSFL |
| V4633 | 8169 | MSAXLOC | 5 | JAR | TS;ICPS | HM | SLGSD |
| V4634 | 8362 | MSAXLOC | 5 | JAR | TS;ICPS | STAMPED;HM | SLGSC;GSQ;SILTY MICACEOUS GROUNDMASS |
| V4636 | 8310 | MSAXLOC | 4 | JAR | TS;ICPS | HM | MSLQA;GSQ;CALC |
| V4637 | 8657 | MSAXX | 6 | JAR | TS;ICPS | HM | FELDSPAR? |
| V4638 | 8090 | MSAXLOC | 6 | JAR | TS;ICPS | HM | SARSEN? |
| V4639 | 8766 | MSAXLOC | 3 | JAR | TS;ICPS | | SUGARY SST |
| V4640 | 8851 | ECHAF | 1 | JAR | ICPS | STAMPED | CHAFF;SILTY GROUNDMASS |
| V4641 | 8855 | ECHAF | 1 | JAR | ICPS | CREMATION POT | CHAFF;SILTY GROUNDMASS |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| V4642 | 8570 | ECHAF | 1 | JAR | ICPS | CREMATION POT | CHAFF;SILTY GROUNDMASS |
| V4643 | 8543 | ECHAF | 1 | JAR | TS;ICPS | STAMPED | CHAFF;SILTY GROUNDMASS |
| V4644 | 8840 | ECHAF | 1 | JAR | ICPS | CREMATION POT | CHAFF;SILTY GROUNDMASS |
| V4645 | 8829 | ECHAF | 1 | JAR | ICPS | CREMATION POT | CHAFF;SILTY GROUNDMASS |
| V4646 | 8757 | IPS? | 8 | JAR | TS;ICPS | BURNISHED EXT | |

## *Appendix 2*

| TSNO | Al2O3 | Fe2O3 | MgO | CaO | Na2O | K2O | TiO2 | P2O5 | MnO |
|---|---|---|---|---|---|---|---|---|---|
| V4611 | 9.74 | 3.97 | 0.56 | 0.58 | 0.4 | 1.96 | 0.58 | 2.29 | 0.024 |
| V4612 | 10.34 | 4.43 | 0.95 | 0.98 | 0.74 | 2.53 | 0.59 | 0.62 | 0.056 |
| V4613 | 6.41 | 4.16 | 0.59 | 0.96 | 0.32 | 1.61 | 0.34 | 0.24 | 0.044 |
| V4614 | 9.96 | 3.86 | 0.92 | 0.69 | 0.34 | 1.99 | 0.56 | 0.48 | 0.033 |
| V4621 | 19.66 | 7.9 | 2.38 | 0.95 | 0.32 | 3.55 | 1.02 | 0.19 | 0.041 |
| V4622 | 18.76 | 6.28 | 2.08 | 0.72 | 0.35 | 3.27 | 1.07 | 0.13 | 0.017 |
| V4623 | 19.13 | 4.49 | 0.7 | 1.16 | 0.19 | 2.39 | 0.79 | 0.77 | 0.031 |
| V4624 | 18.37 | 5.14 | 1.22 | 1.16 | 0.22 | 2.42 | 0.94 | 0.45 | 0.066 |
| V4625 | 18.1 | 6.25 | 1.96 | 1.02 | 0.36 | 3.55 | 0.95 | 0.32 | 0.027 |
| V4626 | 18.35 | 6.02 | 2.01 | 1.09 | 0.34 | 3.58 | 0.95 | 0.44 | 0.035 |
| V4627 | 15.57 | 6.4 | 2.02 | 0.82 | 0.4 | 2.9 | 0.86 | 0.48 | 0.032 |
| V4628 | 17.64 | 7.38 | 1.51 | 1.84 | 0.19 | 2.8 | 0.63 | 1.38 | 0.511 |
| V4629 | 16.35 | 6.64 | 1.54 | 0.64 | 0.34 | 2.88 | 0.97 | 0.29 | 0.019 |
| V4630 | 14.81 | 7.56 | 1.82 | 1.48 | 0.43 | 2.73 | 0.87 | 0.92 | 0.075 |
| V4631 | 9.16 | 4.95 | 0.81 | 0.46 | 0.7 | 2.46 | 0.63 | 0.27 | 0.038 |
| V4632 | 12.66 | 5.37 | 0.78 | 1.57 | 0.35 | 1.36 | 0.5 | 0.88 | 0.084 |
| V4633 | 12 | 5.54 | 0.56 | 1.84 | 0.25 | 1.51 | 0.43 | 1.51 | 0.038 |
| V4634 | 12.14 | 4.04 | 1.21 | 1.12 | 0.17 | 1.82 | 0.56 | 0.47 | 0.067 |
| V4636 | 15.26 | 6.96 | 1.89 | 3.91 | 0.41 | 3.03 | 0.78 | 0.57 | 0.061 |
| V4637 | 14.84 | 5.46 | 1 | 1.33 | 0.58 | 2.93 | 0.78 | 0.77 | 0.033 |
| V4638 | 14.23 | 6.04 | 0.92 | 1.74 | 0.67 | 2.92 | 0.64 | 1.43 | 0.102 |
| V4639 | 15.92 | 3.89 | 0.87 | 5.48 | 0.23 | 2.06 | 0.58 | 1.69 | 0.106 |
| V4640 | 12.4 | 6.9 | 1.25 | 1.45 | 0.39 | 2.4 | 0.6 | 1.72 | 0.025 |
| V4641 | 9.54 | 5.68 | 0.7 | 1.29 | 0.42 | 1.75 | 0.51 | 2.73 | 0.071 |
| V4642 | 13.52 | 5.38 | 1.2 | 1.2 | 0.45 | 2.53 | 0.65 | 1.15 | 0.052 |
| V4643 | 15.42 | 11.5 | 1.92 | 1.12 | 0.25 | 2.65 | 0.72 | 2.62 | 0.03 |
| V4644 | 14.12 | 6.97 | 1.1 | 1.93 | 0.44 | 2.4 | 0.67 | 1.34 | 0.165 |
| V4645 | 10.89 | 4.74 | 0.66 | 0.47 | 0.27 | 1.98 | 0.54 | 3.11 | 0.022 |
| V4646 | 12.34 | 5.69 | 1.25 | 0.92 | 0.32 | 2.12 | 0.71 | 0.4 | 0.044 |

*Appendix 3*

| TSNO | Ba | Cr | Cu | Li | Ni | Sc | Sr | V | Y | Zr* | La | Ce | Nd | Sm | Eu | Dy | Yb | Pb | Zn | Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V4611 | 476 | 104 | 22 | 30 | 30 | 11 | 97 | 82 | 21 | 73 | 36 | 70 | 37 | 6 | 1 | 4 | 2 | 28 | 72 | 10 |
| V4612 | 499 | 94 | 20 | 36 | 34 | 10 | 132 | 72 | 25 | 67 | 35 | 70 | 37 | 7 | 1 | 4 | 2 | 14 | 75 | 11 |
| V4613 | 337 | 55 | 13 | 27 | 30 | 8 | 65 | 56 | 21 | 44 | 26 | 60 | 28 | 6 | 1 | 4 | 2 | 15 | 41 | 12 |
| V4614 | 343 | 104 | 26 | 34 | 42 | 11 | 82 | 86 | 23 | 87 | 34 | 67 | 36 | 6 | 2 | 4 | 2 | 17 | 125 | 13 |
| V4621 | 381 | 144 | 33 | 101 | 72 | 22 | 127 | 197 | 31 | 124 | 49 | 93 | 51 | 6 | 2 | 6 | 3 | 30 | 121 | 24 |
| V4622 | 413 | 167 | 47 | 57 | 51 | 22 | 128 | 199 | 37 | 135 | 65 | 105 | 67 | 9 | 2 | 6 | 3 | 22 | 91 | 18 |
| V4623 | 491 | 107 | 19 | 46 | 33 | 18 | 184 | 164 | 23 | 110 | 78 | 135 | 77 | 11 | 2 | 4 | 2 | 34 | 81 | 14 |
| V4624 | 407 | 115 | 24 | 101 | 50 | 18 | 121 | 146 | 27 | 98 | 51 | 107 | 53 | 10 | 2 | 5 | 3 | 25 | 93 | 17 |
| V4625 | 471 | 121 | 39 | 55 | 39 | 20 | 134 | 191 | 29 | 114 | 49 | 85 | 50 | 7 | 2 | 5 | 3 | 25 | 113 | 17 |
| V4626 | 495 | 108 | 40 | 60 | 37 | 21 | 147 | 188 | 28 | 112 | 49 | 85 | 50 | 7 | 2 | 5 | 3 | 23 | 119 | 18 |
| V4627 | 538 | 144 | 37 | 62 | 72 | 17 | 124 | 153 | 55 | 105 | 50 | 131 | 57 | 14 | 4 | 11 | 5 | 22 | 130 | 24 |
| V4628 | 551 | 152 | 31 | 58 | 137 | 21 | 262 | 189 | 283 | 111 | 90 | 147 | 111 | 16 | 7 | 29 | 16 | 34 | 206 | 25 |
| V4629 | 361 | 116 | 23 | 51 | 33 | 19 | 114 | 164 | 16 | 101 | 32 | 57 | 32 | 4 | 1 | 2 | 2 | 23 | 89 | 13 |
| V4630 | 449 | 118 | 29 | 45 | 65 | 17 | 188 | 146 | 31 | 93 | 48 | 77 | 50 | 6 | 2 | 5 | 3 | 23 | 120 | 20 |
| V4631 | 434 | 79 | 20 | 34 | 31 | 9 | 87 | 79 | 25 | 80 | 35 | 65 | 37 | 7 | 1 | 4 | 2 | 18 | 66 | 11 |
| V4632 | 385 | 120 | 24 | 60 | 59 | 15 | 140 | 118 | 67 | 109 | 67 | 145 | 73 | 18 | 5 | 11 | 5 | 21 | 123 | 17 |
| V4633 | 464 | 113 | 22 | 24 | 22 | 11 | 205 | 110 | 12 | 65 | 16 | 28 | 17 | 0 | 1 | 2 | 1 | 15 | 45 | 6 |
| V4634 | 339 | 88 | 23 | 34 | 34 | 12 | 133 | 87 | 17 | 77 | 28 | 66 | 29 | 5 | 1 | 3 | 2 | 17 | 104 | 12 |
| V4636 | 482 | 145 | 34 | 48 | 84 | 17 | 118 | 152 | 36 | 96 | 44 | 93 | 47 | 8 | 2 | 6 | 3 | 20 | 129 | 28 |
| V4637 | 526 | 89 | 26 | 59 | 60 | 14 | 146 | 119 | 22 | 119 | 35 | 77 | 37 | 6 | 1 | 4 | 2 | 20 | 118 | 15 |
| V4638 | 512 | 103 | 27 | 57 | 61 | 14 | 280 | 122 | 23 | 120 | 44 | 93 | 46 | 7 | 1 | 5 | 2 | 23 | 95 | 15 |
| V4639 | 635 | 102 | 31 | 23 | 38 | 15 | 233 | 103 | 41 | 115 | 31 | 45 | 31 | 1 | 1 | 2 | 3 | 15 | 81 | 11 |
| V4640 | 651 | 132 | 135 | 46 | 54 | 14 | 217 | 136 | 33 | 86 | 36 | 66 | 39 | 6 | 2 | 5 | 3 | 24 | 93 | 13 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V4641 | 603 | 104 | 30 | 36 | 34 | 10 | 192 | 110 | 25 | 76 | 32 | 67 | 34 | 6 | 1 | 4 | 2 | 22 | 107 | 12 |
| V4642 | 704 | 137 | 1,093 | 53 | 42 | 15 | 134 | 128 | 21 | 84 | 35 | 60 | 36 | 5 | 1 | 4 | 2 | 17 | 293 | 12 |
| V4643 | 1,001 | 146 | 82 | 60 | 97 | 17 | 157 | 180 | 42 | 103 | 45 | 82 | 49 | 7 | 2 | 7 | 4 | 21 | 167 | 18 |
| V4644 | 555 | 136 | 40 | 50 | 64 | 14 | 158 | 154 | 33 | 99 | 43 | 73 | 46 | 6 | 1 | 6 | 3 | 22 | 99 | 18 |
| V4645 | 509 | 125 | 170 | 24 | 38 | 13 | 120 | 107 | 26 | 88 | 34 | 63 | 36 | 8 | 2 | 5 | 3 | 15 | 73 | 11 |
| V4646 | 354 | 90 | 37 | 39 | 37 | 14 | 111 | 131 | 20 | 91 | 31 | 59 | 32 | 4 | 1 | 3 | 2 | 17 | 112 | 14 |