Characterisation studies of Anglian and Anglo-Scandinavian pottery from York

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Introduction

York has produced far and away the largest collection of pottery dating to the mid Saxon and Anglo-Scandinavian period in Northern Britain. The Anglo-Scandinavian material has received the majority of attention culminating in Mainman's study of the Coppergate Anglo-Scandinavian pottery ({Mainman 1990 #20753}). The mid Saxon pottery, by contrast, was very poorly known in York until the late 1980s and the excavation of the Redfern's Glassworks site at Fishergate (aka the Fishergate site), on the east bank of the Ouse downriver of the walled city ({Mainman 1993 #20763}). Whereas the Coppergate sequence is paralleled at several other sites in the city, notably the Lloyd's Bank site, mid Saxon pottery is rare on other sites and almost always recovered from residual contexts. Furthermore, the evidence from Fishergate indicates that occupation did not start until the early 8th century, and may not have lasted for long.

Until recently, there was no pottery from domestic contexts of early Anglo-Saxon date from the York area although the range of pottery fabrics used is probably represented accurately by the vessels used in the two cremation cemeteries of Heworth and The Mount.

NASP

The Northumbrian Kingdom Anglo-Saxon Pottery survey (NASP) is a survey of pottery use in Northern Britain. The aims of the survey are both practical and theoretical.

A primary aim is to provide a classification for pottery fabrics which is objective but practical. This will allow current and future ceramic study to be carried out by different people and different organisations. A second aim is to examine the role of pottery in ethnic, political and economic life.

There are two main groups of immigrants into the York area during the 5th to 11th centuries. The first were Anglo-Saxons. The fate of the earlier, British, inhabitants of the area is unclear: in some cases they may have co-existed with the newcomers, as in the kingdom of Elmet, centred on Leeds, to the west of York. In other cases there may have been a total replacement of population or an intermixing of the two populations. Pottery studies cannot determine the racial background of the people making and using the pottery but they can indicate where there are cases of continuity or disruption from the Roman period and they can establish the cultural background of the makers and users of the pottery. The second immigrant group was Scandinavian. Broadly speaking, Norwegian settlers moved into the western parts of the country and Danish ones into the eastern parts. Pottery was scarce or absent in the Norwegian homeland whereas the Danish immigrants were used to using handmade black gritty pottery, similar in many respects to that used in the York area before their arrival. Despite this, the pottery used in York in the years immediately following the Scandinavian take-over was mainly thrown on a wheel and produced by potters trained in the Carolingian traditions of pottery making.

The ways in which politics might influence the pottery used in York might include the development of a recognisable York style of pottery and the degree to which pottery made or used in the city was distinct from that used in neighbouring polities, such as Mercia, to the south, or Bernicia, to the north. There is also evidence, documented and discussed by Symonds, for the collection of tariffs on goods crossing political boundaries (REF).

Finally, the economic connections between the inhabitants of York and others can be examined using pottery finds. These may indicate the existence and nature of a rural hinterland around the city, the relationship between York and surrounding regions and the existence and nature of overseas trade.

This paper presents an early stage in this survey, the results of a selective re-examination of some of the pottery previously published from York.

A small collection of handmade coarsewares found in York has been interpreted by Mongahan as being of Sub-Roman date, evidence for the continued use of pottery by the British inhabitants of York after the loss of the area by the Roman Empire ({Monaghan 1997 #113}). Furthermore, a re-examination of the Wellington Row sequence by Mark Whyman suggests to him that a longer chronology for the late Roman deposits is likely, and that there are differences in the character of the calcite-tempered pottery in these late layers which suggest that it is contemporary ({Whyman 2001 #44953}). These two studies would suggest a late start for the Anglo-Saxon pottery sequence in the immediate area of York, although it is possible that there was a British enclave surviving within the fortress, colonia or unwalled suburbs surrounded by Anglo-Saxon settlements in the Vale of York.

Early Anglo-Saxon pottery has so far only been examined visually, at x20 magnification using a binocular microscope to study the pottery from The Mount and Heworth. Most of this pottery is characterised by the presence of coarse-grained sandstone fragments and overgrown quartz grains derived from this sandstone (SSTMG). Examination of visually similar material from sites such as Catterick, Piercebridge and West Heslerton suggests that there are probably several distinctive subfabrics within this group whose study might help to show whether any of these sites shared the same pottery sources as those used in the York area. Recently, a domestic settlement producing Anglo-Saxon pottery was excavated at Heslington Hill by FAS (Mainman 2003).

The mid Saxon assemblages from Fishergate consist of handmade Anglian coarsewares, Ipswich wares, handmade shell-tempered wares and a range of wheelthrown imported wares. The handmade shell-tempered wares were examined and sampled as part of the analysis of the pottery from Flixborough (REF). This showed that the entire collection consisted of Northern Maxey-type ware and was produced in a restricted part of north Lincolnshire. All of the illustrated sherds of handmade Anglian coarsewares were examined at x20 magnification and 17 samples were taken for further study. This analysis suggested that there were 5 or 6 subfabrics within this category, each coming from a different source. The imported wares are of two main groups: buff fabrics and grey or black surfaced, burnished wares. The latter wares were examined at x20 magnification for comparison with the Flixborough finds and visually matched the two fabric groups recognised there. No further analysis was carried out. The ware had previously been the subject of a NAA study carried out as a student project at the Department of Archaeological Sciences, University of Bradford. The data from this project only exists as a faint dot-matrix printout and it was not possible to transcribe. The buff wares have not been re-examined and are assumed to be either from the middle Rhine or the Seine valley.

The Anglo-Scandinavian pottery of York is best represented by the material from the Coppergate excavations ({Mainman 1990 #20753}). Excluding Residual Roman sherds there are ** sherds stratified in phases dated by dendrochronology and coins between the late 9th and the mid 11th centuries. Roman pottery forms a huge proportion of the earliest, Period 3, assemblages but is present in smaller quantities throughout the sequence, indicating the likelihood of residual Anglo-Scandinavian sherds as well. As Mainman points out several times in the monograph, the degree of residuality in the later periods of the excavation could be considerable. In particular, the deposits from Period 5A are interpreted as being formed by upcast from the digging out of the floor spaces of the Period 5B structures in c.975 whilst there are phases of dumping in Period 5Cr which were deposited no earlier than the mid 11th century but which clearly contain a large amount of residual pottery.

The transition from Anglo-Scandinavian to Norman pottery in York is best seen in the Coppergate sequence. By Period 5C the surviving stratigraphy consisted of a block to the front of the site (Period 5Cf) and a block to the rear (Period 5Cr). Both are probably roughly contemporary. There is a sharp increase in the quantity of Stamford ware vessels, both glazed and unglazed, found in both sequences. In the rear area, there is a single dendrochronological date, for a post-built structure which cut through Period 5B strata and was itself sealed by dumping, in two phases, with an episode of pit digging between the two. At the street frontage the Period 5C levels contain no York Gritty ware and no splashed wares. At the rear of the site there is a small amount of Stamford ware in the first dumping, alongside a large amount of probably residual pottery. The features between the dumps produced over 600 sherds of pottery, with considerably less residual Roman pottery. This assemblage too is almost devoid of York Gritty or Splashed wares and dominated by Stamford and Torksey wares. Finally, there the second phase of dumping contains a small proportion of York Gritty and Splashed wares, alongside residual Roman and Anglo-Scandinavian wares. The dating of this rear sequence depends on two pieces of information. Firstly, the post-built structure which precedes the first dumping has a dendrochronological date (from one timber) of 1014-54. It is fairly certain, therefore, that it is a pre-Conquest structure. It is impossible to estimate the duration of its life. If it were maintained it might have survived for 20-30 years. However, one interpretation of the read dumped deposits is that they were a response to the creation of the Kings Pool, formed following the damming of the Fosse following the construction of the castle at the junction of the Fosse and the Ouse. If so, this would place the high Stamford/No York Gritty phase in the post-conquest period, although still within the 11th century. An indication of the speed of this transition is given by the pottery associated with the construction of York Minster, which was dedicated in 1080, which consisted of York Gritty and

Splashed wares with virtually no Stamford or Torksey wares ({Holdsworth 1995 #45003}, 475). Thus, potentially, there are three 11^{th}-century ceramic horizons in York:

a) Assemblages dominated by Torksey ware. Late 10^{th} to early to mid 11^{th} century.

b) Assemblages dominated by Stamford and possibly wares. Pre- or Post-Conquest?

c) Assemblages dominated by York Gritty and Splashed wares. By 1080AD

It is worth pointing out that a very similar sequence was found and independently dated at Lincoln where the sharp decline in Torksey ware and upsurge in Stamford ware also seems to take place around the time of the Norman conquest.

Samples were taken of handmade Anglo-Scandinavian wares from Coppergate, to see whether they were made with the same materials as the earlier Handmade Anglian coarsewares. Samples of York A and D wares and Torksey ware were taken for chemical analysis and finally a group of samples of York Gritty ware were analysed, to test Jean le Patourel's suggestion that York Gritty ware might be a continuation of the York A ware tradition.

Analysis

Handmade Anglian Coarsewares

Seventeen samples of handmade Anglian coarsewares from the Fishergate excavations were selected for examination. Under x20 magnification they could be grouped into six subfabrics (Table 00).

Table 1. Samples of Handmade Anglian Coarsewares from Fishergate, York (Site 1985-6.9)

TSNO	Context	REFNO	cname	Action	Subfabric	subfabric
V15395289		DR159	SST	TS;ICPS	F1	MGSST
V15405741		DR002	SST	TS;ICPS	F2	MGSST
V15414876		DR116	ECHAF	TS;ICPS	C/D	CHAFF
V15424820		DR054	SST	TS;ICPS	C/D	FINE MGSST SAND,CHAFF
V15434185		DR140	ESAXLOC	TS;ICPS	B	MGSST,RQ,GSQ
V15445587		DR030	SST	TS;ICPS	E	MGSST;BIOTITE/FELDSPAR
V15455663		DR223	ECHAF	TS;ICPS	C/D	CHAFF
V15465587		DR031	SST	TS;ICPS	E	MGSST;BIOTITE/FELDSPAR

V15472458	DR039	SST	TS;ICPS	F1	MGSST
V154810183	DR009	SST	TS;ICPS	F2	MGSST
V15493415	DR007	SST	TS;ICPS	F2	MGSST
V15506497	DR074	SST	TS;ICPS	C/D	FINE MGSST SAND,CHAFF
V15513360	DR050	SST	TS;ICPS	F1	MGSST
V15523360	DR051	SST	TS;ICPS	F1	MGSST
V15533360	DR049	SST	TS;ICPS	F1	MGSST
V15543360	DR047	ECHAF	TS;ICPS	C/D	CHAFF
V15551839	DR127	SST	TS;ICPS	A	MGSST;MICACEOUS MATRIX

Subfabric A

A single example was sampled (V1555). The visual characteristics are a sandstone sand containing overgrown quartz grains in the order of 0.5 to 2.0mm across and a silty groundmass containing muscovite.

In thin section the following inclusion types were noted:

abundant subangular sandstone fragments up to 2.0mm across. The sandstone is composed mainly of quartz grains, mostly overgrown. In some cases it is clear that iron cement had accumulated before the overgrowth and is now present within the quartz grains. There is slight evidence for a subsequent kaolinitic cement.

Moderate limestone, shell and microfossils up to 1.5mm across. Although it is possible that all three originated in the same rock there is no proof that this is the case. The limestone has a mixed clay/sparry ferroan calcite cement and contains unidentified bioclasts. The shell includes thin-walled species including one with a layered structure which has subsequently been partially re-crystallised. The microfossils include two or three possible echinoid spines. The shell and microfossils have a faint pink stain and are therefore composed of non-ferroan calcite and one spine has a central hole filled with ferroan calcite.

Sparse rounded fine-grained sandstone up to 1.0mm across. The rock is composed of well-sorted angular quartz and muscovite up to 0.1mm across with a ferroan calcite cement.

Sparse organic inclusions up to 1.0mm long.

Sparse rounded phosphate inclusions.

The groundmass consists of anisotropic baked clay minerals and moderate angular quartz and muscovite silt, together with moderate spherical iron-rich pellets.

The spherical pellets in the groundmass are probably faecal pellets and are typical of Jurassic clays and limestones. The ferroan calcite cement in the limestone also suggests a Jurassic or Lower Cretaceous date. The closest outcrops of similar rocks are in the Vale of Pickering and the Hambleton Hills. The sandstone, however, appears to be lower Carboniferous. Such sandstones are the main component of the fluvio-glacial gravels in the Vale of York but are only found in associated with a wider range of rock types in the Vale of Pickering. The most likely circumstances to explain these various features is that the pot was made from a boulder clay derived at least in part from Jurassic rocks and tempered with Vale of York sand. This suggests a source within the Vale of York to the south of Northallerton and probably close to the western side of the outcrop of Jurassic rocks. The lack of distinctive Cretaceous rocks and minerals might indicate a source further north than the Wolds, but this would require sampling of potential boulder clays to prove. It is quite possible that tills in the York area itself include suitable Jurassic-derived material.

Subfabric B

The distinguishing feature of subfabric B is that it contains rounded quartz grains, and that some of those grains are polished, water-worn grains of lower Cretaceous origin. One sample was thin sectioned, V1543. The following inclusion types were noted:

Abundant subangular quartz grains up to 1.0mm across. Some have euhedral outlines but others do not. The grains are almost certainly derived from lower Carboniferous sandstones but there are no composite grains, such as were noted in subfabric A, nor any evidence for iron-staining of the sandstone before overgrowth.

Sparse rounded quartz grains, mostly completely unstrained monocrystalline grains up to 1.0mm across. These are probably the polished, water-worn grains identified by eye and are derived from Lower Cretaceous strata.

Sparse well-rounded quartz grains up to 0.5mm across. These are ‘millet seed’ quartz grains derived from the lowest strata of the Permian (the Yellow Sands). Some of these grains are cracked. There are also a few examples of completely altered feldspar of similar roundness.

Sparse angular flint up to 0.5mm. This contains typical microfossils and is undoubtedly of Upper Cretaceous origin.

Sparse large laths of muscovite, up to 0.5mm long.

The groundmass consists of anisotropic baked clay minerals and abundant subangular quartz of coarse silt and fine sand grain (up to 0.2mm across).

The mixed suite of inclusions in this fabric are consistent with the use of a Vale of York sand taken from a source to the south of the chalk outcrop. As with subfabric A, this does not necessarily exclude the York area itself.

Subfabric C/D

By eye, the distinguishing characteristic of this subfabric is the presence of a fine-textured quartz sand derived in the main from lower Carboniferous sandstones and deliberate chaff tempering. Five samples were thin sectioned, V1541, V1542, V1545, V1550 and V1554. Although the samples differ in the amount of chaff and quartzose temper they contain they clearly belong to the same subfabric. The following inclusions were noted:

Moderate angular fragments of a medium-grained micaceous sandstone up to 2.0mm across. The grains consist mainly of quartz and some muscovite. The quartz grains are overgrown with some signs of the original grain boundary and there is a mixture of kaolinite and microcrystalline silica cement.

Abundant subangular quartz grains, of similar character to those in the sandstone.

Sparse euhedral quartz grains up to 1.0mm across. These are similar in size and appearance to those derived from lower Carboniferous sandstone in subfabrics A and B.

Sparse muscovite laths up to 0.5mm long and 0.1mm thick.

Moderate to abundant organic inclusions, probably chaff, up to 2.0mm long

The groundmass consists of anisotropic baked clay minerals and rare angular quartz silt, muscovite laths and rounded mottled red clay pellets.

The texture of the clay matrix in this fabric distinguishes it from subfabrics A and B whilst the sandstone is different in many respects to those in subfabrics A and B. Nevertheless, similar rocks outcrop in both the lower Cretaceous and the Coal Measures in west Yorkshire. The limited range of inclusions either suggests a source close to the outcrop of this sandstone or may be explained by ice transport. However, it is not consistent with river transport since (a) the larger fragments are too angular and (b) no contribution from other strata are present.

Subfabric E

By eye this subfabric is distinguished by angular fragments of a biotite granite and euhedral quartz grains of lower Carboniferous type. Two thin sections were made, V1544 and V1546. They differ in the quantity of micrite which they contain but are otherwise comparable. The following inclusions were noted:

Abundant angular fragments of acid igneous rock, up to 3.0mm across. The rock is composed of biotite, feldspar and quartz with accessory magnetite and tourmaline. The feldspar is partly altered, often in an inner zone.

Sparse sandstone of similar grain size and shape to that in Subfabric C but with no cement and no muscovite, up to 1.0mm across.

Sparse euhedral quartz grains of lower Carboniferous type up to 1.0mm across

Sparse to moderate rounded micrite fragments up to 1.5mm across. The fragments have only a fair pink stain and may therefore be partly composed of dolomite. They contain no microfossils and are probably not chalk, which tends to take a strong pink stain.

The groundmass consists of inclusionless anisotropic baked clay minerals.

Erratic granitic rocks occur in the Vale of York and are particularly common in vessels used at Catterick, Scorton and Piercebridge. The micrite fragments may be either of Jurassic or Permian age.

Subfabric F

Visually, this subfabric is characterised by a coarse sand composed of fragments of lower Carboniferous sandstone or its constituent grains. Eight thin sections were made (V1539, V1540, V1547, V1548, V1549, V1551, V1552, V1553) which allowed the subfabric to be divided into two on the basis of differences in the groundmass:

abundant angular quartz of coarse silt grade (renamed as Subfabric F1)

inclusionless groundmass (renamed as Subfabric F2)

Despite this difference, the range of inclusions seen in thin section is identical:

Abundant fragments of coarse-grained feldspathic sandstone up to 2.0mm across. The feldspars include unaltered orthoclase feldspar as well as heavily altered grains. The quartz grains are overgrown and c.1.0mm across and there is a kaolinitic cement. These characteristics identify the rock as a Millstone Grit of arkose character.

Sparse angular medium-grained sandstone up to 2.0mm across. This is represented by a single fragment which is more similar to that in subfabric E than those in subfabric C/D.

Sparse laths of muscovite up to 0.5mm long. No examples were seen in any of the sandstone fragments.

The groundmass of F1 contains abundant coarse quartz silt and sparse muscovite up to 0.1mm long and that of F2 contains no inclusions. Both contain sparse rounded mottled clay pellets, as seen in Subfabric C/D.

Chemical analysis

All 17 thin sectioned samples were also analysed using ICPS. Given that the maximum number of samples per subfabric was only 5 it is not possible to say for certain whether the chemical composition of the samples varies. However, it is clear that there is little difference between any of the samples, with the two granitic samples being the least similar to the remainder. This is probably due to their high feldspar and biotite content and, possible to the presence of enhanced quantities of trace elements in the accessory magnetite.

One sample had two outlying values (i.e. more than 4 sd from the mean for this group of 17 samples). This was the sample of Subfabric A and the aberrant values are for MnO and Zn.

To take account of the varying amount of inert silica present in each sample, both as temper and in the groundmass, the values for each measured element were divided by that of Al_2O_3. Since many of the thin sections showed that post-burial phosphatic and calcareous concretion had taken place the Pearson correlation of other measured elements with these two were calculated. For CaO, the strongest correlation was with Sr followed by P_2O_5. These were followed by MnO and Fe_2O_3. For P_2O_5, the strongest correlation was with CaO, Sr, MnO, Zn, Ba and Fe_2O_3. Thus it seems that some of the iron present in these samples is also due to post-burial contamination. Despite this, it is clear that even the values for these elements can reflect real differences in original composition. The two highest CaO values, for example are for the two samples in which limestone was visible in thin section.

A factor analysis was then carried out on the dataset, excluding all those elements strongly correlated with Fe_2O_3, CaO or P_2O_5 (i.e. with a Pearson correlation index of 0.7 or higher).

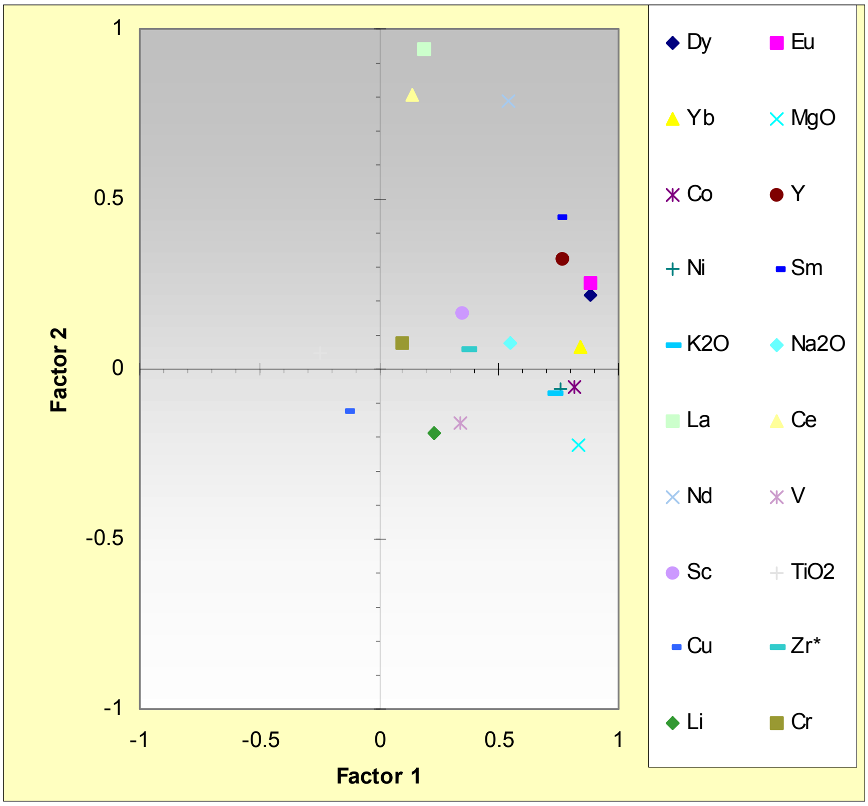

Figure 1

The two major factors and the contribution made to them by the included elements are shown in fig 1 and a plot of these two factors for the entire York ICPS dataset is shown in Fig 2. The two subfabric E samples are distinguished but the remainder have similar compositions, for these measured elements, to York A, York D and HM 1 (see below) and can be distinguished from the various whitewares and from Torksey ware. This suggests that, like those wares, these Anglian handmade coarsewares, with the possible exception of subfabric E, were made from "local" clays.

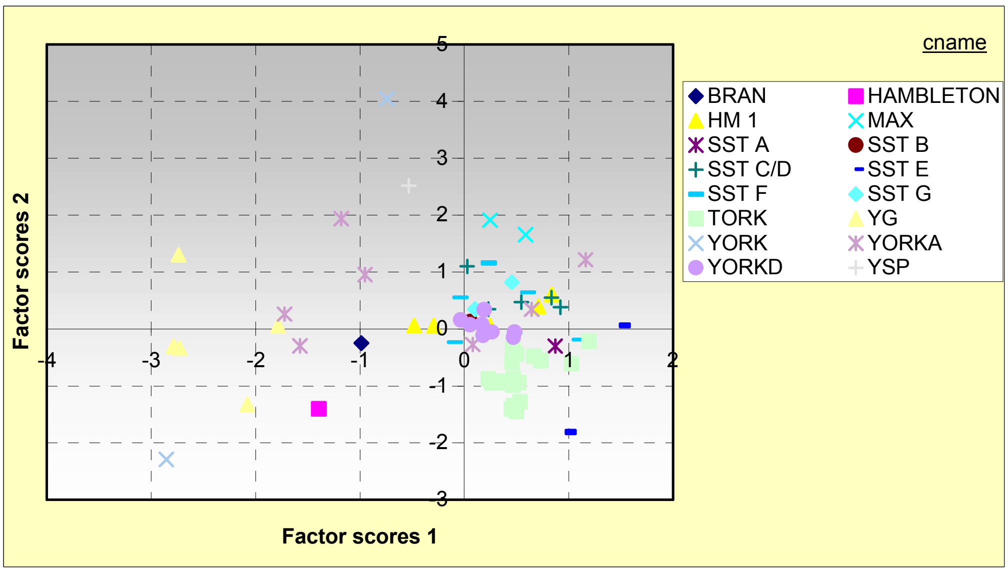

Figure 2

The relationship between these Anglian and Anglo-Scandinavian York wares is better shown by omitting the wares which are certainly not made in York (Fig 3).

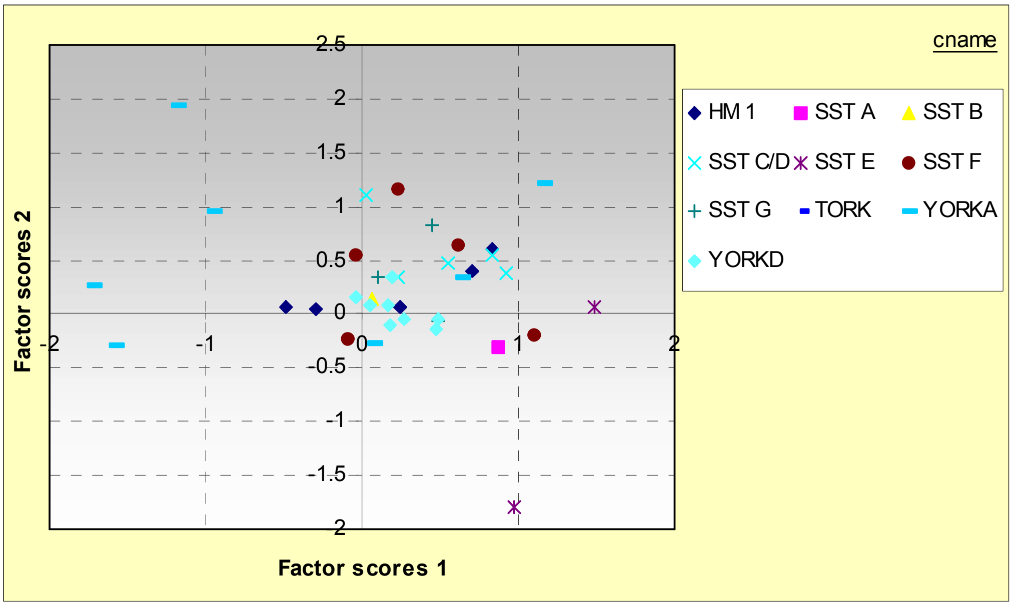

Figure 3

Combining the evidence from all three methods (binocular microscope study, thin section analysis and ICPS), it seems that there are about half a dozen distinct fabrics within the handmade Anglian wares from Fishergate (it is uncertain whether the difference between subfabrics F and G is meaningful). However, until samples of boulder clay outcrops, artefacts made from then, and fluvio-glacial sands in the lower Vale of York have been collected and studied we cannot say whether these groups represent different potting communities or the exploitation of a very variable geology in or close to York.

Northern Maxey-type ware

Two samples of Northern Maxey-type ware from Fishergate were examined as part of the analysis of the pottery from Flixborough, North Lincolnshire. Both thin section and ICPS studies confirmed that these samples were identical to samples from a range of sites in central and northern Lincolnshire and that the shell temper is actually disaggregated shelly limestone, probably from the Great Oolite series ({Whitwell 1991 #43973}). The archaeological interpretation of the Northern Maxey-type ware data is difficult and three models would fit the facts:

a) the ware was produced at a single centre and distributed from there. Minor differences in petrography and chemical composition would, in this model, be explained as a mixture of sampling error (e.g. sparse echinoid spines seem to be more common in samples from northern Lincolnshire) and post-burial alteration (which is certainly the case for the Flixborough material which is heavily leached).

b) The ware was produced in several discrete centres. In this model one might identify a Central Lincolnshire group, characterised by the absence of echinoid spines, and a Northern Lincolnshire group characterised by their presence. Arguments against this interpretation are: firstly that there is no evidence that echinoid spines are indeed more common in the Great Oolite exposures in the north of the outcrop than they are in the Lincoln area and secondly that the chemical data does not correlate with these minor fabric variations but instead there is a slight correlation with findspot.

c) The ware was produced at numerous centres throughout the potential source area (i.e. along the dip slope of the Lincoln Edge from the point where these rocks emerge from their Quaternary cover around Scunthorpe down to the point where the ware is replaced on sites by Southern Maxey-type ware, in the Sleaford area.

Model C is more in keeping with the situation suspected in the early Anglo-Saxon period whereas Model A is more similar to the situation in East Anglia, where Ipswich ware seems to have been the product of a nucleated, urban, industry. It is, in any case, clear that finds of Northern Maxey-type ware in York are Lincolnshire products and from that part of the county on the Great Oolite outcrop. Therefore, even if production was dispersed or polyfocal there is evidence for long-distance exchange with York.

Anglo-Scandinavian Handmade 1 (HM1)

Samples of handmade wares from late 9th/early 10th-century levels at Coppergate were sampled ({Mainman 1990 #20753}).

A series of thin sections of these wares had been made by Dr Mainman and with her permission these were re-examined.

A collection of 19 thin sections of 15 different HM 1 vessels made by Dr A Mainman was examined and on that basis four subfabrics were identified (Table 2). Five samples were then selected for ICPS analysis. Four of these samples came from sectioned vessels of subfabric a and given the similarity in chemical composition of the other sample it is likely that this too was from a Subfabric A vessel.

Subfabric A

This subfabric contains the following inclusion types:

moderate angular fragments of sandstone up to 2.0mm across. The sandstone contains a high proportion of feldspar. The quartz grains range up to 1.0mm across and have overgrowth. There is some kaolinite cement. The rock is therefore identified as a lower Carboniferous sandstone.

Sparse rounded micrite fragments up to 1.0mm across.

Moderate laths of muscovite up to 0.5mm long.

The groundmass contains varying quantities of angular quartz of coarse silt to fine sand grade. In most cases this sand is evenly distributed through the sample but in a few sections it is variable, suggesting that the parent clay itself contains beds or lenses of clay which vary in their texture. In some cases there is very little quartz at all in the groundmass and it may be that this variant should be interpreted as a separate subfabric. However, the existence of samples with intermediate texture suggests that both are made using the same parent clay. A consistent feature is the presence of muscovite, ranging from the silt-sized laths in the groundmass up to large flakes. This suggests that the larger muscovite flakes may be present in the parent clay.

This fabric is virtually identical to the Anglian Handmade Subfabric F, including the presence of a variable fine sandy or inclusionless matrix.

Subfabric B

This subfabric has only been recognised in a single YAT thin section, from context 19634. The following inclusions were noted:

Sparse rounded and subangular quartz grains up to 0.5mm across. Some of these grains have a smooth outline but a poor sphericity, a characteristic of grains from the lower Cretaceous whilst others appear to be broken fragments of larger, spherical grains, more typical of the Permo-Triassic sands. There are, however, no fragments of Millstone Grit type.

Abundant angular, subangular and rounded quartz, mainly between 0.1mm and 0.2mm across. The sand includes some chert fragments but they are too small to tell if they are Carboniferous or Cretaceous in origin. A number of fragments, from their shape, are probably feldspars. Sparse chalcedonic grains are also present.

Sparse rounded altered glauconite grains up to 0.3mm across.

A single rounded pellet containing the same abundant sand as above in an opaque groundmass up to 1.5mm long. Perhaps a fragment of iron pan.

The groundmass consists of anisotropic baked clay with muscovite laths which overlap in size with the fine quartzose sand.

Glauconitic clays are rare in Yorkshire and the only example known to the author is the Speeton clay, which outcrops between Malton and the coast at Filey on the south side of the Vale of Pickering.

Table 2

Context	REFNO	cname	subfabric	Form	Action	TSNO	Period

19634	Not Illustrated	HM 1	B		TS(YAT)		
16836	Not Illustrated	HM 1	c		TS(YAT)		
30727	Not Illustrated	HM 1	d		TS(YAT)		
30575	1766	HM 1	a	JAR	TS(YAT)		P3
26471	1767	HM 1	a	JAR	TS(YAT)		P3
30549	1775	HM 1	a	JAR	TS(YAT)		P3
30038	1783	HM 1	a	JAR	TS(YAT);ICPS	V1582	P4B
26803	1786	HM 1	a	JAR	TS(YAT);ICPS	V1584	P4A
24916	Not Illustrated	HM 1	a		TS(YAT)X2		
20819	Not Illustrated	HM 1	a		TS(YAT)X2		
19326	Not Illustrated	HM 1	a		TS(YAT)X2		
19320	Not Illustrated	HM 1	a		TS(YAT)		
14626	Not Illustrated	HM 1	a		TS(YAT)		
19285	Not Illustrated	HM 1	a		TS(YAT)X2;ICPS	V1585	
30000	Not Illustrated	HM 1	a		TS(YAT);ICPS	V1583	

Five samples were analysed using ICPS. They have similar values for most elements but it is likely that two samples have phosphate enhancement (V1583 and V1586) whilst two samples have enhanced CaO values (V1583 and V1584). A search of the thin section for V1584 revealed a small amount of vivianite ($Fe_3(PO_4)2.8H_20$) infilling of pores and calcite deposition in and around one of the sandstone inclusions whilst V1583 had calcite lining in some pores and a rounded micrite inclusion. It is possible that these high values therefore reflect the presence of calcareous inclusions in these two samples which have been leached from the other samples. The phosphate, however, is likely to be entirely secondary and the presence of vivianite means that at least some Fe2O3 will also have been deposited after burial. It is also interesting that the MgO values for the two high-CaO samples are proportionately high, suggesting perhaps that the calcareous inclusions in this case might have been detrital Magnesian limestone. As Fig 3 shows, the chemical composition of HM1, excluding elements which are prone to post-burial alteration, is indistinguishable from that of the majority of the Fishergate Anglian handmade wares, the York D samples and three of the six York A samples.

Anglo-Scandinavian York ware (YORKA)

Six samples of Anglo-Scandinavian York ware (York A) were thin sectioned and analysed using ICPS. These samples have a much wider variability that the HM 1 samples and clearly include different subfabrics. It is possible that further work on the Coppergate York A wares would allow these subfabrics to be properly identified and characterised.

The petrology of York A ware has been studied by Dr Mainman who concluded that there were probably several sources of clay/temper used. A further seven thin sections of York A ware from Coppergate were produced by the author, who grouped them into three subfabrics, of which five samples were grouped into the first subfabric with two strays (V913 and V914). Samples of York A ware from Lurk Lane, Beverley, were also thin sectioned. Again, of the 6 thin sections five had basically the same fabric with one stray. The latter sample, V1900, had silt-sized spherical iron-rich nodules in the groundmass, a feature of York Gritty ware but absent from other York A samples. Finally, a sample of a putative vessel from Newcastle upon Tyne was thin-sectioned and shown to have the standard fabric.

Subfabric A (Standard Fabric)

This fabric contains abundant quartzose sand, mainly between 0.5mm and 2.0mm across in a matrix which may be totally light bodied but which is typically red-firing with light-coloured lenses of clay.

In addition to the quartzose inclusions, which are mainly coarse-grained sandstone and its constituents but include sparse well-rounded quartz grains, fragments of other sandstones, there are variably quantities of light-firing rounded clay pellets and dark brown laminated mudstones up to 2.0mm across (absent completely from sample V914). Some of these mudstones were organic and can have a dark core. The groundmass consists of anisotropic baked clay minerals with sparse quartz and muscovite silt inclusions. In a minority of samples these inclusions are more common (V1901 and V1902 from Beverley and V911 from York). On balance this difference is interpreted as evidence for a variable texture in the clay source rather than a difference in source.

The ware was probably made from a mixture of red- and light-firing clays and the rounded light-coloured clay pellets are probably relicts from the light-firing clay. On the other hand, the mudstone fragments are likely to be detrital grains although it is noticeable that they vary considerably in frequency. The inclusions, therefore, are a mixed sand derived probably from the Lower Carboniferous, Permo-Triassic strata (the well-rounded quartz grains and probably the finer-grained sandstone fragments) and perhaps Jurassic strata (the mudstone fragments). It is likely that all three constituents can be found in fluvioglacial sands in the Vale of York from Northalllerton southwards to and beyond York. In this interpretation, the groundmass would consist either of Jurassic light-firing clays, of the type used in the medieval and later pottery industries of the Hambleton Hills, or boulder clay derived from the transportation of such clay southwards. Another possibility, however, would be that the parent clay was a mixture of Coal Measures whiteware and redware clays, in which case the mudstones would be probably from a Coal Measures source. Light-firing relict clay pellets are a common feature of Coal Measures whiteware clays but they also occur in late medieval Hambleton ware made at Castle Howard, for example. The lack of silt-sized opaque nodules in the groundmass distinguishes this fabric from that of York Gritty ware, which also has a consistently lighter colour.

Subfabric B (V913)

This fabric differs in most respects from Subfabric A, although it too has a coarse quartzose temper the grains are mainly rounded, in some cases with the well-rounded profile typical of sand from the lower Cretaceous. Rounded non-ferroan micrite up to 0.5mm across is sparse but present. Furthermore, there is no sandstone in this subfabric, nor any relict clay or mudstone. The groundmass consists of light-firing anisotropic baked clay minerals with abundant angular and subangular quartz grains up to 0.2mm across.

The sand tempering probably came from the lower Cretaceous, of which the nearest outcrops are on the south side of the Vale of Pickering and along the west scarp of the Yorkshire Wolds. The groundmass, however, is not typical of Lower Cretaceous clays, which tend to be red-firing, micaceous or glauconitic, but is paralleled in the Jurassic strata of the Hambleton Hills. The two formations outcrop close together at the western end of the Vale of Pickering, close to the Romano-British pottery production area of Crambeck and this is the only place locally where this fabric could have been produced. However, this combination of Lower Cretaceous quartz sand and light-firing, silty clays is also found in northern France, for example the early glazed ware vessels found in 10th- and 11th-century contexts at Rouen.

The chemical composition of this sample is, in fact, more similar to Rouen whitewares than it is to either York A or York Gritty wares or to Hambleton Hills fabrics (Ryedale and Brandsby) (Fig 00).

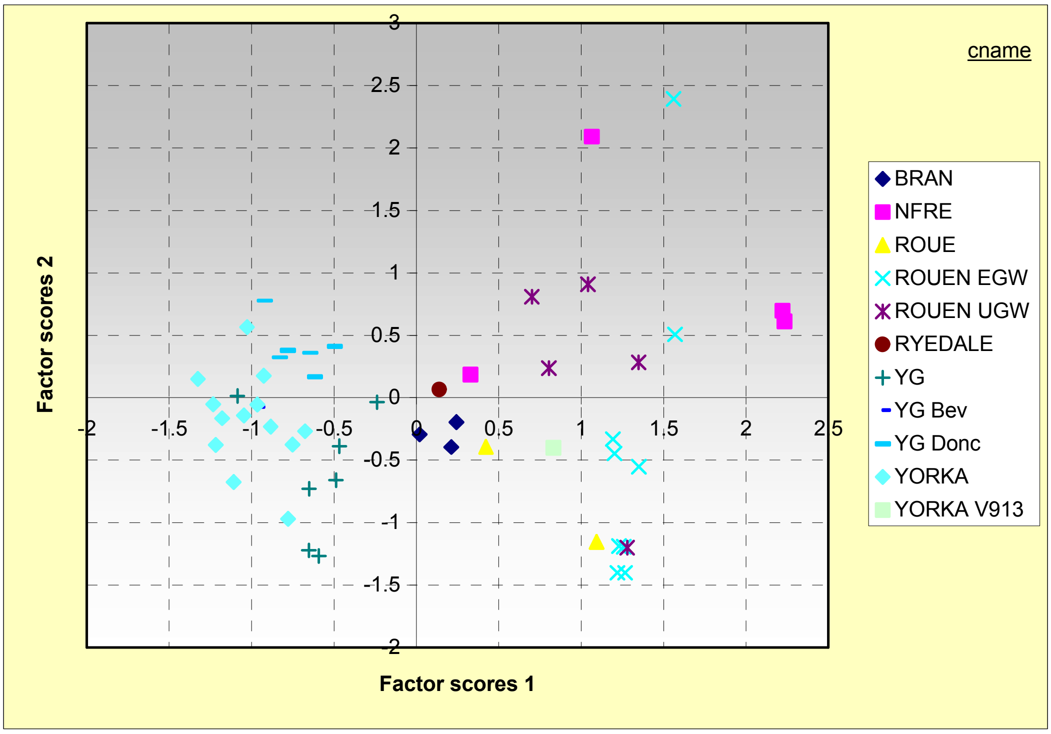

Figure 4

Subfabric C (Beverley, V1900)

In thin-section, the fabric of this sample is very similar to York Gritty ware. The fabric is tempered with subangular fragments of quartz and feldspar which are probably derived from Lower Carboniferous sandstone, although no sandstone fragments occur in the section. In addition there is a single large angular fragment of chert or flint, up to 1.5mm across. This fragment is cryptocrystalline with a sinuous outlined area of secondary silica deposition. It is almost colourless and more likely to be flint from the chalk than either Carboniferous or lower Cretaceous chert. There are no relict clay pellets or rounded red mudstone fragments in the section. The groundmass consists of anisotropic baked clay minerals and abundant opaque to brown rounded nodules. These are similar, though not identical, to the nodules see in York Gritty ware from York and in one of the Handmade Anglian Coarseware subfabrics.

The chemical composition of this sample is similar to that of the York Gritty ware and different from that of the other York A samples. Fig 00 shows a scatterplot of Factors 1 and 6 from a factor analysis of various light-firing wares. It shows that the Beverley sample is more similar to York Gritty (York and Doncaster fabnrics) than to York A ware or Hambleton Hills wares (BRAN and RYEDALE) or to Seine valley whtewares.

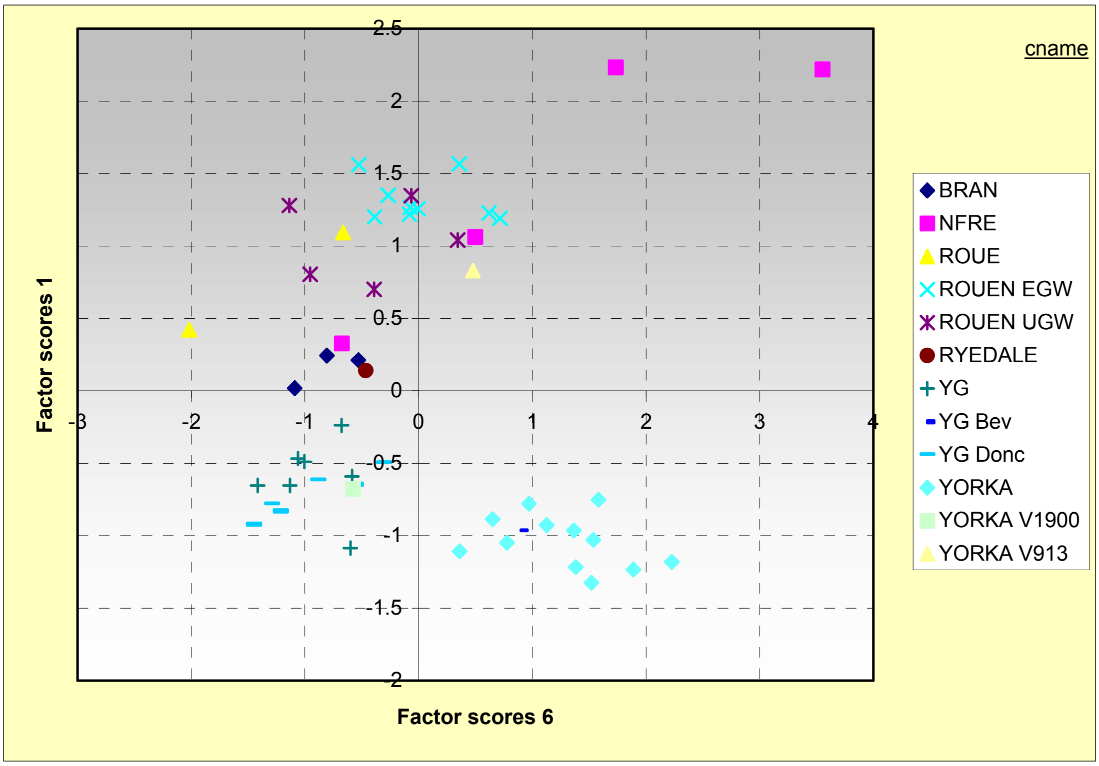

Figure 5

The Beverley sample comes from the primary fill of a 10th or early 11th-century ditch at Lurk Lane and the form of the vessel, a globular-bodied jar with a rolled-out, lid-seated rim, is paralleled at Coppergate in Period 3 and later. Thus there is no reason to suppose that the sherd is any later than other York A ware. It does suggest, however, that the raw materials exploited in the later 11th century to make York Gritty ware were already being used a century earlier.

Anglo-Scandinavian York D ware (YORKD)

Samples of York D ware were thin-sectioned by Dr Mainman and the results were included in the Coppergate monograph ({Mainman 1990 #20753}, p 414). These thin sections were loaned by YAT for this project and have been re-examined. In addition, samples were chosen for ICPS analysis, trying where possible to choose a sample from which a thin section had also been taken (Table 00).

In addition, samples have been taken for both thin section and chemical analysis from York D ware found at Lurk Lane, Beverley, and a site at Barton upon Humber excavated by Humberside Archaeology Partnership (BOH2000).

Torksey-type ware (TORK)

The fabric of Torksey wares from York has been studied in detail by Brooks and Mainman ({Brooks & Mainman 1984 #1993}). The thin sections produced for that project were examined by the author and included wasters from the Torksey kilns (although which kiln produced which sample was not noted) and samples of vessels from Coppergate and the Lloyds Bank site. Some of these samples were clearly made north of the Humber and contained a sand derived mainly from Millstone Grit. Although these samples have not been linked back to the originating sherds it is likely that this Millstone Grit fabric is responsible for the increase in coarseness in texture with time noted by Brooks and Mainman.

Torksey ware fabric is defined here as having a rounded quartzose sand in which fine-grained sandstone and rounded chert are minor elements. Large irregular shaped nodules of non-ferroan micrite are present in some of the samples although they are often too rare to be present in the thin section. Furthermore, some vessels obviously once contained such micrite but the inclusions have subsequently been leached.

Eighteen samples from Coppergate were selected for chemical analysis. The main aim of this analysis were (a) to test the assumption that the vessels were produced at Torksey rather than a separate, northern, source, (b) to look for evidence for a shift in composition through time and (c) to see if it is possible to assign roller-stamped Torksey ware to a specific kiln through its chemical composition. Table 00 lists the samples, their context numbers, catalogue numbers in Mainman's report and the period of the deposit they were found in. In one case, sample V1569, the sherd was clearly residual and had the sandy texture and reduced firing found on late 9th to mid 10th-century examples of Torksey ware.

Table 3

TSNO	Context	REFNO	group	Form	rsd	Period
V1572	27626	2003	early to mid	PTCH/SJ		P4A
V1566	34290	2019	early to mid	JAR	square	P4B
V1560	35264	2021	early to mid	JAR	diamond P4B	P4B
V1571	22574	2022	early to mid	JAR	diamond P4B	P4B
V1573	23366	2024	early to mid	JAR	diamond P4B	P4B

V1558	22590	2025	early to mid	JAR	square	P4B
V1565	22309	2026	early to mid	JAR	square	P4B
V1561	29926	2028	early to mid	JAR	square	P4B
V1563	22883	2032	early to mid	JAR	diamond P4B	P4B
V1559	24399	2036	Mid to late	BOWL		P4B
V1568	5772	2083	Mid to late	BOWL		P5B
V1564	21244	2088	Mid to late	BOWL		P5B
V1557	15291	2108	Mid to late	JAR		P5B
V1570	6434	2117	Mid to late	BOWL, INTURNED RIM		P5B
V1562	6440	Not Illustrated	Mid to late	JAR		P5B
V1569	20345	Not Illustrated	early to mid	BOWL, INTURNED RIM		P5B (BUT EARLIER)
V1556	2734	Not Illustrated	Mid to late	BOWL		P5B
V1567	14529	Not Illustrated	Mid to late	JAR		P5B

Factor analysis was carried out on a dataset consisting of Torksey ware and other late Saxon sandy wares from the Torksey kiln sites, Coppergate, Beverley, Flixborough, Doncaster and Barton-upon-Humber. Fig 00 shows a scatterplot of the two main factor scores by fabric. One sherd of Torksey-type ware from Doncaster and a putative sherd of Lincoln Late Saxon Sandy ware (LSLS) were chemically distinct but sherds of putative Lincoln Gritty ware and LSLS from Flixborough and sherds of Nottingham Early Splash Glazed ware (NESP) and Nottingham Late Saxon Sandy ware (NOTTS) from Doncaster were not chemically distinguished. It is likely, therefore, that similar wares made from the Mercian Mudstone with Triassic sandstone-derived sand would all have similar compositions.

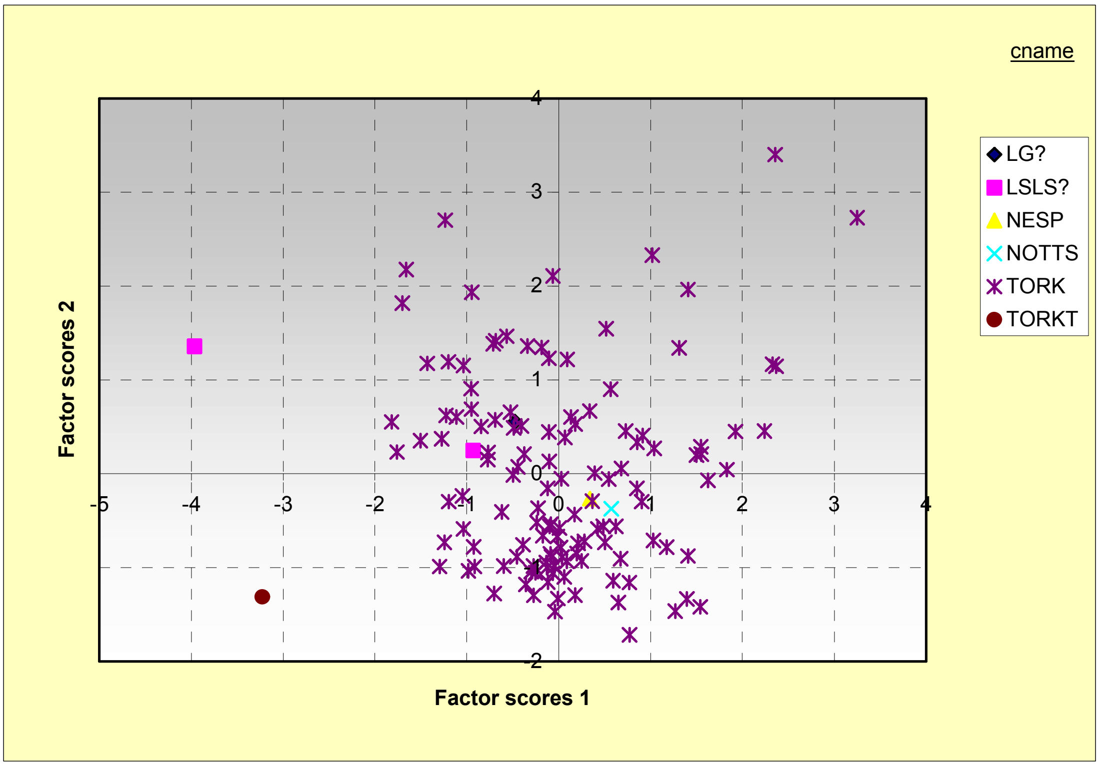

Figure 6

Fig 00 shows the same data as in Fig 00 but grouped by find locality. It can be seen that the Doncaster, Beverley, Barton and York samples have a more similar composition than those from the Torksey kiln sites or from Flixborough. Study of the underlying element weightings suggests that this difference is due to post-burial alteration of those samples exposed to chemical weathering through burial in shallow, sandy, probably acidic soils (or, alternatively, enrichment of the samples buried in organic-rich strata).

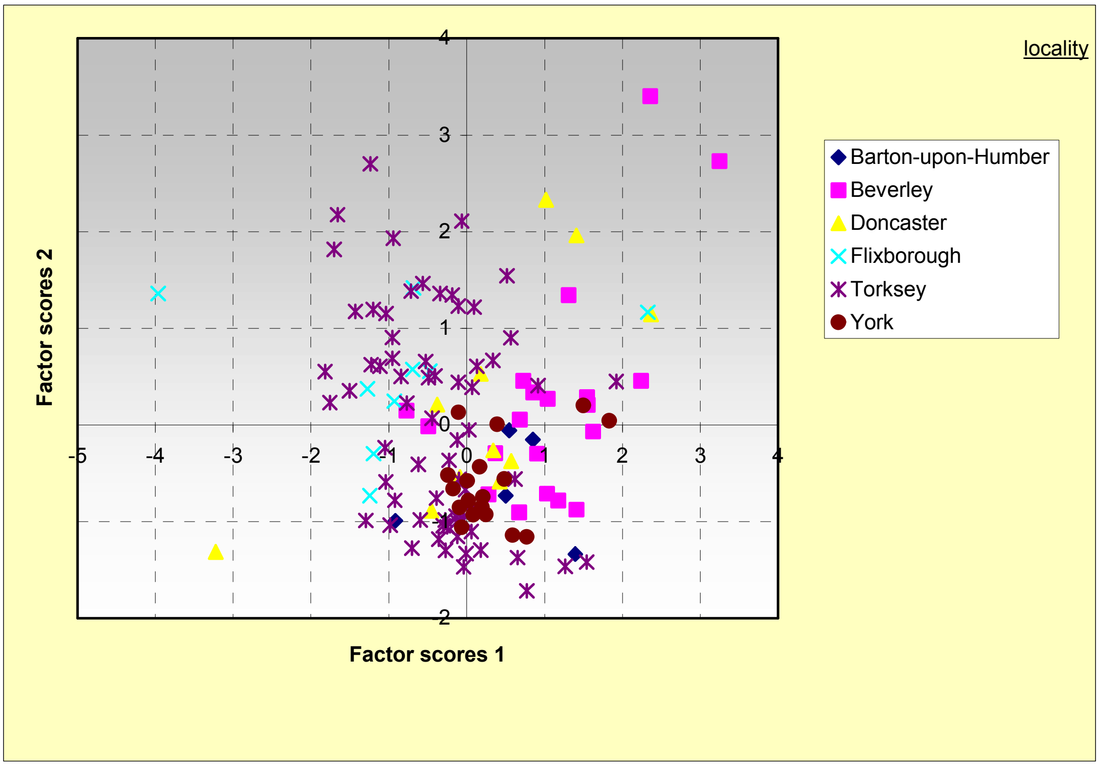

Figure 7

Factor analysis of the 18 ICPS analyses was carried out but no strong correlation was found between either the stratigraphic period and chemical composition or the typological dating and chemical composition. It is concluded, therefore, that there are no clear differences in chemical composition between mid 10th and mid 11th century Torksey wares from Coppergate. Unfortunately, only one sample was available from Period 4a and none at all from Period 3 and we cannot therefore say whether the earliest Torksey wares differ from these middle and late products.

Finally, the various roller-stamped Torksey ware samples from Coppergate were compared with samples from the kiln sites and a sample from Doncaster. The Torksey samples consisted of square-toothed roller-stamping from Kilns 2 and 4, with one stray, residual, sherd from Kiln 6, Diamond lattice roller-stamping from Kilns 3 and 4 and triangular roller-stamping from Kiln 4.

Factor analysis shows that there is no difference in chemical composition between the sherds with different stamp types from Kiln 4 and that both the Kiln 2 and Kiln 3 samples have slightly different compositions. The stray from Kiln 6 is similar in composition to those from Kiln 3. The Coppergate samples all come from Period 4B and are of square and diamond roller-stamping. Factor analysis shows that all of square-toothed samples have a very similar fabric, together with two of the diamond ones. The other two are slightly different, but in the same order of magnitude as was found within the samples from a single kiln at Torksey. It is likely, therefore, that all the Coppergate Period 4B samples came from a single kiln. Of the excavated Torksey kilns the closest in composition is Kiln 3, although diamond-lattice roller-stamping is not known on the waste products. Probably, therefore, another, unexcavated, kiln was the source of the York pieces. The Doncaster sample, likewise, is not close in composition to any of the excavated Torksey samples. The effect of post-burial alteration on these minor differences in composition, however, is likely to make such correlations extremely difficult.

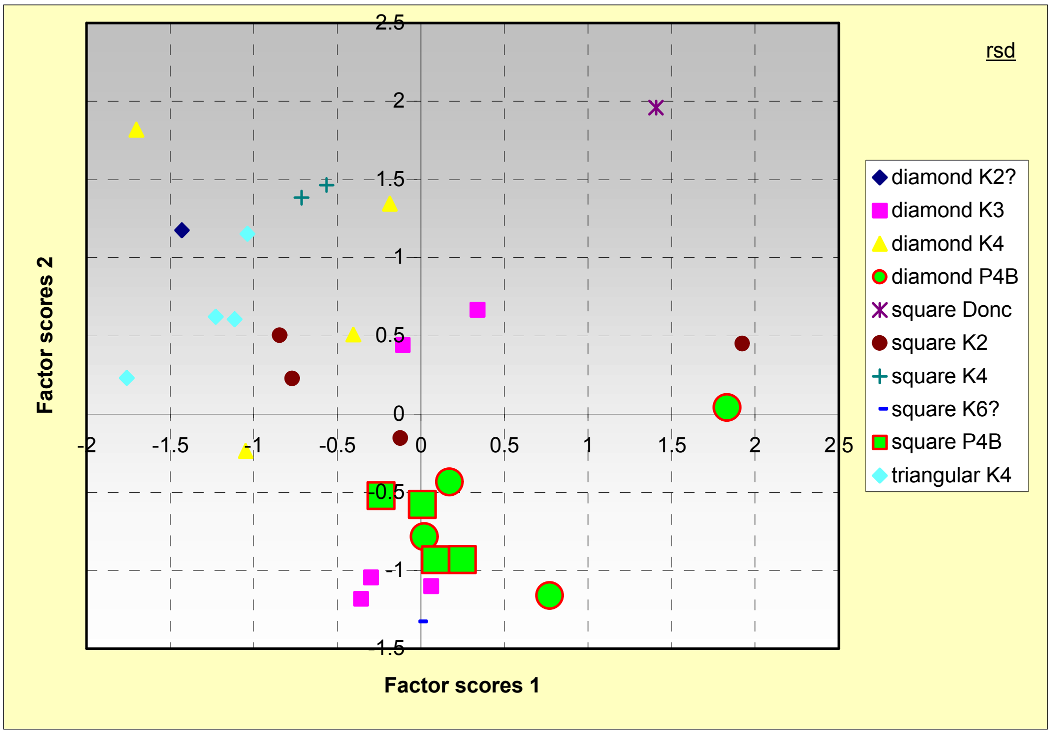

Figure 8

York Gritty ware (YG)

Five samples of York Gritty ware were sampled, AG339 to AG343. The samples were supplied by Dr A Mainman and the author has no knowledge of their stratigraphic date or typology. Although there is some variation in the range and details of the inclusion types and groundmass of the samples (Table 00) they are probably all from one source.

The sections all contain abundant fragments of a coarse-grained sandstone, with some orthoclase feldspar and some microcline and plagioclase grains. There is no difference in the character of loose grains and those found in the sandstone fragments and it seems that the temper is derived from a detrital sand dominated by Lower Carboniferous sandstone and its constituents. The clay is a quartz-free light-firing clay with variable quantities of clay pellets which range from being lighter in colour than the groundmass through red to almost opaque and finally to opaque iron ore, in some cases with light-coloured clay adhering. The clay pellets and iron-rich inclusions are probably part of the parent clay, which must therefore in its degree of plasticity. The presence of numerous small rounded iron-rich nodules in both the clay pellets and loose in the groundmass is distinctive. Such material has been noted as a feature of some of the Jurassic clays of central Lincolnshire and is interpreted as being faecal pellets or of bacterial origin. Similar inclusions were noted in the Handmade Anglian Coarseware, Subfabric A.

This fabric is clearly distinguished in thin-section from those found at Doncaster (YG DONC 1 and YG DONC 2). YG DONC 1 contains fine- to coarse-grained sedimentary rock fragments all of which contain haematite whilst the groundmass does not have the round nodules noted in the York samples and contains sparse quartz silt not seen in the York samples. YG DONC 2 has a similar sandstone sand temper to that in the York samples but is distinguished by abundant rounded organic shale fragments and by a micaceous groundmass.

Table 4

Inclusion type	AG339	AG340	AG341	AG342	AG343
Light-coloured clay pellets	M	No	M	No	S
Light-coloured mudstone <2.0mm	No	No	No	No	No
Mudstone with abundant rounded opaque nodules up to 0.05mm across	M	No	M	S	No
Red clay pellets	No	No	No	No	S
Coarse-grained sandstone	A	A	A	A	A
Microcline feldspar	S	S	S	S	S
Haematite-rich clay pellets	S	No	S	No	No
Light-coloured clay groundmass with small spherical iron-rich pellets	Yes	Yes	Yes	Yes	Yes
Muscovite laths <0.5mm	No	S	No	No	No
Non-ferroan micrite	No	No	No	No	S

nodules <1.0mm

The chemical analyses of the five York samples confirms their similarity. Despite the similarity in groundmass, the YG samples are not chemically similar to the Anglian Handmade Coarseware Subfabric 1 sample. Factor analysis demonstrates that the Doncaster subfabric 1 samples are clearly distinguished from the York ones whereas the subfabric 2 samples are not. Possibly these two Doncaster samples are of a variant of the York group, coming from a similar area. The Doncaster subfabric 1 samples, however, have been shown to be very similar in petrology and chemistry to handmade splashed wares produced at the Market Place in Doncaster in the late 11^{th} to mid 12^{th} centuries.

The York samples were also compared with samples of three Prudhoe Castle gritty fabrics (Prudhoe Fabric 4, Prudhoe Fabric 4 red-firing and Prudhoe fabric 11) and with a gritty ware from Lurk Lane in Beverley ({Armstrong & Evans 1991 #27073} Fig 64.82). The York samples can be differentiated from these samples both petrologically and chemically.

Finally, the York Gritty samples are chemically distinguishable from samples of medieval glazed wares from the Hambleton Hills area.

York Splashed ware – light bodied gritty variant (YSP)

A single sample of a splash-glazed ware vessel with a light-firing gritty body was sampled. The vessel was found at Fishergate. In thin section (AG338) the sample contained abundant subangular quartz grains up to 0.5mm across and sparse fragments of sandstone up to 1.0mm across with grains of similar size to the quartz grains in the matrix. Feldspars were not noted. The groundmass consists of light-coloured anisotropic baked clay minerals with abundant quartz and muscovite silt up to 0.1mm across. Thus, there are many differences between the fabric of this splash-glazed gritty ware and that of York Gritty ware and it is unlikely that the two fabrics were produced in the same centre. It is not possible, however, to make any further statements about the source on the basis of a single thin section.

Chemical analysis also indicates that the sample is not similar to the York Gritty ware but shows that it is close in composition to samples of various wares from the Hambleton and Howardian Hills area where pottery was produced from at least the late 13^{th} to the 17^{th} centuries (grouped as NYWW on Fig 00). Data from samples of unsourced wheelthrown whitewares from sites in Hartlepool (Tees Valley white on Fig 00) were included in the analysis. Some are similar to the Hambleton Hills wares but the YSP sample is closer in composition to the Hambleton Hills products. It is possible, therefore, that this is evidence for the existence of a potting tradition in that area before the first documented production, in the mid 13^{th} century. Two samples of York glazed ware included in this analysis did not group with any of the other samples, nor did they group together in this factor analysis (although they do if factors 3 and 4 are employed). York glazed ware too has claims to be a 12^{th} to early 13^{th}-century Hambleton Hills area product, not least in the typological and decorative links between the two groups. However, on this evidence neither group can be securely associated with the later Hambleton Hills fabrics.

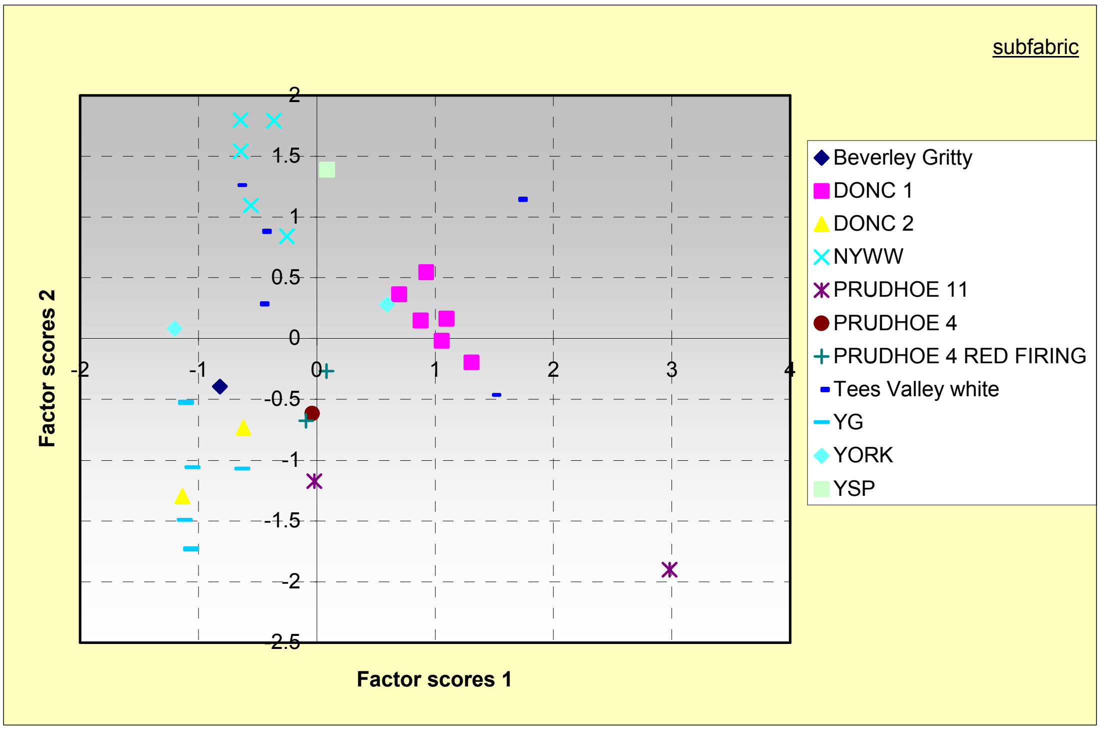

Figure 9

Discussion

A large amount of analytical work has taken place over the years on ceramics made in the York area. The author has been able to benefit considerably from the work undertaken by Dr Mainman, for example, and has been able to use various thin sections produced from samples of York Anglo-Scandinavian wares. There remains, however, some difficulty in matching these results with the local geology in detail because of the lack of samples of either clay, sand and gravel samples from known sources in and around York. Furthermore, although the chemical analyses reveal fine detail and enable comparisons to be made between otherwise indistinguishable fabrics there is also a need to have a body of data on the chemical composition of fired samples of local clays. Probably the most cost-effective way to collect this information would be to sample material from known kilns, of any age, in the York area. This could include waste from the Eboracum ware pottery and tile production on the west bank of the Fosse together with samples from the medieval potting waste from Fishergate, recently excavated by FAS, and from Walmgate.

Identification of parent clays

By convention, the fraction smaller than 0.1mm in a ceramic thin section is distinguished from the larger fraction. In some cases this distinction cleanly separates the parent clay from added temper, but in many cases naturally occurring clays suitable for potting contain inclusions coarser than 0.1mm. Determining which inclusions were present in the clay as dug and which were added as temper by the potters can be impossible without access to samples of unfired, unprepared potting clay from the production site. Since, in only one case do the wares discussed here actually come from a known and archaeologically investigated production site (Torksey) this approach is not possible. The approach here, then is simply to run through the potential parent clay deposits to be found within a short distance the city.

Coal Measures red and whiteware clays

In the late medieval and post-medieval periods the red and white-firing clays found in the Coal Measures were used extensively for potting. Characterising fabrics made from these clays is extremely difficult, despite the relative ease with which larger fragments of Coal Measures rocks can be identified, in some cases to a specific bed. The reason for this is that these geological identifications are based on a combination of macro-features, plant fossils and microfossils (such as spores). Few of these characteristics would survive preparation of the clay for potting or the subsequent firing.

Chemical analyses have been carried out of various white- and red-firing Coal Measure clays. These include samples from a clay pit at Mirfield chosen by Mr J Hudson to illustrate the wide range of textures and colours obtainable from a single exposure of Coal Measures clay together with Coal Measures whitewares from Brackenfield, Rawmarsh and Firsby.

A distinctive feature of these clays is the presence of unworked relict clay pellets. The microstructure of these pellets is not known but presumably they indicate that the clay is well-bonded. Other than these clay pellets, and the tendency for vessels made from these clays to have lenses of lighter or darker clay there are not any clear distinguishing features petrologically. The groundmass can be inclusionless but it can have a variable quantity of quartz and muscovite silt.

These features can all be explained by considering the conditions in which the Coal Measure clays were laid down. They were formed in tropical deltas in which the sediments were subjected to intense weathering, leading to depletion of many elements, most noticeably iron, which might therefore form a secondary panning horizon. In the most extreme cases, this leaching could also lead to the removal of silica, leading to the formation of kaolinitic clays, rich in Aluminium.

Cutting through these deltas were braided streams which would clog up with silt and organic debris which, with the vegetation which grew on top of the clays, later formed coal. There are no clear chemical signatures for “Coal Measure Clay” and within the sampled clays and waste products there are numerous differences between groups.

Permo-Triassic clays

In the York area the main clay of Permo-Triassic age is the Mercian Mudstone. Although this formation underlies the Vale of York for its entire length it is almost entirely obscured by Quaternary overburden. Nevertheless, it is possible that it might have been exposed, for example, in river banks. The Mercian Mudstone was deposited in very different circumstances to the Coal Measures clays, being formed in desert conditions subject to inland drainage and the deposition of evaporites. The extreme aridity of the depositional conditions lead to a lack of chemical weathering, a high proportion of feldspar in any silt formed, angularity on any fine sand and rounded, spherical, matt-surfaced larger grains.

Geochemically, signatures for Mercian Mudstone include high frequencies of Magnesium (from authigenic dolomite), Potassium (mainly from feldspar) and Strontium (from anhydrite and gypsum) (BGS 1996). There is some variation in the frequency of these elements between groups but in most cases there are alternative pathways by which these elements can be found in the sample, for example, detrital Magnesian Limestone, detrital plagioclase feldspar and in detrital calcitic limestone respectively. Only when the chemical data are examined alongside the petrology is it possible to establish the mineralogical source of the elements concerned.

Jurassic clays

There are several clay formations within the Jurassic strata which outcrop in the Vale of Pickering, the North Yorkshire Moors and the eastern flanks of the Vale of York. In the Lower Jurassic strata there is the Redcar Mudstone formation, seams of mudstone occur within Cleveland Ironstone formation and in the Whitby Mudstone Formation. These mudstones can be fossiliferous and organic. The Middle Jurassic consists mainly of coarser-grained rocks but includes organic shales laid down in fluvio-deltaic conditions. Finally, the Upper Jurassic strata consist of two large outcrops of clay, the Oxford Clay formation and the Ampthill and Kimmeridge Clay Formations, separated by coarser sedimentary rocks. The latter are organic and tend to be masked by Quaternary deposits, since they mainly outcrop in the Vale of Pickering. The light-firing clays used extensively in the Roman and medieval periods (for example at Crambeck, Brandsby and Scarborough) were probably obtained from beds in the Middle Jurassic although at Crambeck the Oxford Clay was also exploited.

Geochemically, the most distinctive features of the Jurassic sediments are elements bound to organics such as Titanium, Vanadium and Zircon (BGS 1996). Nickel is also enriched in some Jurassic clays, such as the Black Shales of the Kimmeridge Clay formation.

Cretaceous clays

Much of the Cretaceous outcrop in Yorkshire consists of Chalk rock but there is a thin band of clay in the Lower Cretaceous which outcrops along the northern edge of the Wolds, in the central and eastern parts of the Vale of Pickering. This clay, the Speeton Clay, is glauconitic, and has been recognised as the probable parent clay of one of the Handmade Anglo-Scandinavian ware subfabrics (HM 1, Subfabric B).

Quaternary clays

Most of the locally-available clays are, however, not part of the solid geology of the area but are Quaternary boulder clays and lacustrine deposits. These clays, to judge by the coarser fraction within them, are likely to contain a mixture of locally-derived and exotic material, obtained from outcrops further north. There are extensive areas of boulder clay in the Vale of York and along the east coast and lacustrine deposits in the middle of the Vale of York and in the Vale of Pickering. It is likely that such deposits were the main source of potting clay in the immediate York area.

Discussion

Of the various solid outcrops of clay which might have been used in York and its environs, there is only one which has been positively identified in a York Anglo-Saxon pot sample. Even this one example, the glauconitic clay used in HM1 subfabric B, is difficult to interpret since archaeological fieldwork in the putative source area, the southeastern part of the Vale of Pickering, has failed to find any evidence for pottery dating to the Anglo-Scandinavian period. The distinctive chemical signature of the Jurassic light-firing clays indicates that they were not used in the Anglo-Scandinavian period, unless for the Early Glazed Ware, nor is the clear evidence for the use of the Coal Measure whiteware clays. This leaves the source of most of the pottery unknown, even though some of the groundmasses of these clays are distinctive, as with the iron-rich ?faecal pellets found in York Gritty ware, an atypical York A ware vessel from Beverley (subfabric C) and Handmade Anglian Coarseware Subfabric A (which has a silty, micaceous matrix different from that of the other two wares). It is likely that a programme of analysis of other fired clays from the York area would be able to locate the source of these clays and perhaps some of the less distinctive clays as well.

Identification of temper

The identification of sources of temper relies for the most part on thin section analysis. Clastic inclusions can have a number of different origins which in theory can be determined by considering the size, sorting, composition and roundness of the grains. In practice, the size of the thin section in relation to the size of the inclusions means that for many of the samples the number of clastic grains available for consideration is very small. Furthermore, it is difficult to determine roundness for fragments of coarse-grained sandstone, such as the Millstone Grit. Thus, a sample of half a dozen or so sections is preferable before drawing conclusions from the study of the clastic grains in a fabric. For many of the subfabric groups identified here there are, as yet, insufficient samples to study.

Further work