Petrological and Chemical Analyses of Anglo-Saxon Pottery from Glebe Farm, Brough (GFB)

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The Anglo-Saxon pottery from Glebe Farm, Brough (GFB) excavated by TPAU has been studied by H Jones. Fabric classification was based on visual identification of the major inclusion types. As a result of a visit in 2002 the author identified some modifications to this fabric classification which would bring it into line with that used in the East Midlands Anglo-Saxon Pottery Survey and subsequent work undertaken by himself and Jane Young of Lindsey Archaeological Services.

Subsequently, a sample of each fabric was thin-sectioned and submitted for chemical analysis. This report contains both results of these analyses and a guide for the identification of these fabric groups visually.

Methodology

A thin-section of each sample was prepared at the University of Manchester, Department of Earth Sciences. The sections were stained using Dickson's method in order to distinguish different types of carbonate (dolomic, non-ferroan calcite and ferroan calcite). A sub-sample of c.1-2gm was prepared by mechanically removing any visually-stained or contaminated clay from a piece of the pot and crushing the remainder to a fine powder (in which no grit could be felt when a sample was rubbed between thumb and index finger). This powder was sent to Royal Holloway College, London, Department of Geology where is was analysed using Inductively-Coupled Plasma spectroscope using their standard analytical program with the addition of lead (Pb).

Table 1

TSNO	cname
V1633	CLSST
V1634	LIM
V1635	CLSST
V1636	ECHAF
V1637	CHARN
V1638	FE
V1639	SSTMG
V1640	SSTMG
V1641	ESAXLOC
V1642	CHARN
V1643	CHARN
V1644	CHARN

TSNO	cname
V1645	CHARN
V1646	SSTMG
V1647	FE
V1648	ESAXLOC

Description

Petrological Description

Fabric 1 (V1633)

Fabric 1 was distinguished visually by the presence of large rounded voids. Under x20 magnification the fabric can be seen to consist of angular fragments of acid igneous rock up to 3.0mm across, a rounded quartzose sand with grains up to 1.0mm across, angular iron-rich fragments up to 2.0mm across and rounded voids up to 3.0mm across. The groundmass is a fine-textured clay with a micaceous glitter.

In thin-section, fine-grained sandstones not initially noted by eye can be seen, together with rounded quartz, rounded chert, angular fragments of a biotite granite, rounded voids, subangular clay pellets with iron-staining and organic inclusions. The clay matrix is fine-textured without muscovite but with sparse angular quartz inclusions.

Combining the evidence from these two approaches, it seems likely that the 'micaceous' glitter noted under x20 magnification is actually from sparse quartz silt. The subangular clay pellets may be relict clay.

Fabric 1b (V1634)

Fabric 1b was separated from Fabric 1 because of its smoother texture and higher quantity of voids. Under x20 magnification numerous rounded voids are visible together with moderate rounded quartz sand grains. The groundmass is a fine-textured clay with a micaceous glitter.

In thin-section the fabric is seen to contain, in addition to numerous rounded voids up to 1.0mm across, a rounded quartzose sand with grains less than 0.5mm across. These grains are mainly quartz but include fine-grained sandstones and chert. Some of the voids are filled or lined with secondary phosphate.

Fabric 1d (V1635)

Fabric 1d was separated from Fabric 1 on the basis of the presence of sandstone fragments of varying lithologies. These include poorly-cemented brown sandstones with grains up to0.5mm across and coarser-grained sandstones similar in appearance to those found in the Millstone Grit. Under x20 magnification, these sandstones are indeed present together with rounded voids up to2.0mm across, a rounded quartz sand similar to that in Fabric 1 and iron-rich fragments. The groundmass is fine-textured with a micaceous glitter.

In thin-section, the sample contains rounded fragments of sandstone of various lithologies (including coarse-grained examples with the characteristics of Millstone Grit), rounded quartz up to 1.0mm across, rounded feldspar, rounded voids up to 0.4mm across and organic inclusions. No examples of acid igneous rock were noted.

Fabric 1e (V1636)

Fabric 1e was distinguished from Fabric 1 by the presence of moderate chaff inclusions. Under x20 magnification, the presence of chaff fragments is confirmed and rounded quartz sand, a single fragment of subangular ?altered feldspar, iron-rich inclusions of varying appearance and rounded voids were noted. The groundmass is fine-textured with a micaceous glitter.

In thin-section, rounded quartz, fine-grained sandstones and chert were present, together with organic inclusions, partially filled with secondary phosphate. Rounded clay pellets with quartz inclusions were also noted.

Fabric 2 (V1637)

This fabric was distinguished by the presence of biotite granite inclusions and angular fragments of red grog.

Under x20 magnification, it can be seen to contain in addition to the granite and grog, sparse rounded quartz grains, quartz sandstone fragments, rounded dark brown to black clay pellets, similar in colour and texture to the groundmass, which is fine-textured with a micaceous glitter.

In thin-section, rounded quartz, sandstones, biotite and composite igneous rock fragments were observed. Rounded grog fragments, containing rounded quartz sand in a higher frequency that the clay body were present. Some of these grains had optically isotropic clay matrices, which indicates a higher firing temperature than that of the surrounding clay. Rounded clay pellets with a concentric structure were also noted.

Fabric 4 (V1638 and V1647)

Fabric 4 was distinguished by the presence of abundant iron-rich inclusions. A variant fabric was noted with a lighter coloured matrix (V1638).

Under x20 magnification, these iron-rich inclusions vary in colour and texture and have a subangular outline. Some of these inclusions are inclusionless but others contain rounded quartz grains, up to 0.5mm across. Sparse rounded quartz sand, with grains up to 1.5mm across are also present. The groundmass is fine-textured with a micaceous glitter.

In thin-section the following inclusions were noted: rounded quartz, rounded fine-grained sandstone fragments, rounded chert, and opaque grains, some of which were inclusionless and some with rounded quartz inclusions. The clay matrix contained sparse muscovite and quartz silt. There was no noticeable difference in either the inclusions or groundmass between the ‘variant’ and standard fabrics.

Fabric 5 – Sandstone (Millstone Grit?) tempered (V1639 and V1640)

Fabric 5 was distinguished by containing abundant quartz temper. It has been subdivided into fabrics containing rounded quartz sand and fabrics containing sand derived from a coarse-grained sandstone.

Under x20 magnification, the sample contains inclusions of rounded quartz, rounded brown iron-rich material, sandstone fragments, quartz grains with overgrowth and flakes of muscovite up to 1.0mm across. The sandstone fragments vary in texture and colour but include some which contain overgrown quartz grains. The groundmass is fine-textured.

In thin-section the following inclusions were noted: rounded quartz, rounded fine-grained sandstones, rounded feldspar, fragments of coarse-grained sandstone and sheaves of muscovite up to 1.0mm long. The coarse-grained sandstone fragments contain euhedral quartz grains which have overgrown *in situ*. There is, however, no sign of the original grain boundaries. Kaolinite is present in some of the interstices in these fragments. These characteristics suggest that the sandstone fragments originated in the Millstone Grit.

Fabric 5 - Sandstone (Millstone Grit?) tempered plus chaff (V1646)

This variant on Fabric 5 was distinguished by the presence of abundant organic inclusions in addition to coarse-grained sandstone sand.

Under x20 magnification no chaff inclusions are noticeable although the casts of organic inclusions are visible on the outer surface and the core of the sample is rich in carbon.

In thin-section the following inclusions were noted: rounded quartz, rounded chert, coarse-grained sandstone as in V1639 and abundant organic inclusions throughout the body.

Fabric 6 (V1641 and V1648)

Fabric 6 is distinguished by a fine-textured quartzose sand temper.

Under x20 magnification, inclusions of sandstones of varying lithologies (including those with overgrown quartz grains) and rounded quartz sand up to 1.0mm across can be seen. The groundmass is fine-textured with a micaceous glitter.

In thin-section the following inclusions were noted: rounded quartz, rounded fine-grained sandstones (some with well-sorted grains c.0.2mm across), a fragment of angular feldspar, a subangular, stained flint fragment and rounded clay pellets.

Fabric 7 (V1642 and V1643)

Fabric 7 was originally classified as Fabric 1a. It contains abundant angular fragments of biotite 'granite' together with moderate rounded voids.

Under x20 magnification, fragments of biotite and composite rock fragments up to 6.0mm across are visible together with brown iron-rich fragments, rounded voids and sparse rounded quartz sand. The groundmass is fine-textured with a micaceous glitter.

In thin-section, the following inclusions were noted: rounded quartz, coarse-grained sandstone with rounded grains, biotite, composite acid igneous rock fragments, rounded voids (V1642 only), rounded clay pellets and rounded opaque grains with angular and rounded quartz inclusions.

Fabric 7a (V1644)

Fabric 7a contains moderate fragments of biotite-rich acid igneous rock together with abundant rounded quartz sand.

Under x20 magnification, the igneous rock fragments appear as angular composite rocks with a relatively fine grain size (less than 1.0mm on average), not typical of those from the Charnwood inlier. In addition to the rounded quartz inclusions there are subangular brown iron-rich inclusions up to 2.0mm across. The groundmass is fine-textured and has a micaceous glitter.

In thin-section, the following inclusions were noted: rounded quartz, rounded, fine-grained sandstone fragments, rounded chert, angular composite acid igneous rock fragments, rounded clay pellets and sparse muscovite.

Fabric 7b (V1645)

Fabric 7b also contains moderate fragments of igneous rock, together with rounded quartz sand. However, the quartz grains include a high proportion of polished grains, which suggest a source in lower Cretaceous rocks.

Under x20 magnification, the igneous rocks are seen to include biotite sheaves and composite rocks with a high ferro-magnesian mineral component. As with Fabric 7a, the rocks are not typical of the biotite granite/granodiorite rocks of the Charnwood area. Polished quartz grains up to 2.0mm across can be seen, together with finer subangular quartz and sparse fragments of a quartzose sandstone with a pink powdery cement. The groundmass is fine-textured.

In thin-section, the following inclusions were noted: rounded quartz, angular acid igneous rock fragments (including a fragment with zoned feldspars, typical of the Mountsorrel granodiorite) and organic inclusions. No examples of the polished quartz grains (which have a distinctive cross-section in thin-section) nor the sandstone with pink powdery cement were noted.

Chemical Analysis

The major elements were measured as percentage oxides: Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5 and MnO (Appendix 1a). The remaining elements were measured as parts per million (Appendix 1b).

The data from Brough were first examined using Principal Components Analysis (PCA) on the raw data. It was suspected, however, that variations in amount of silica resulting from the sand tempering might be obscuring differences in chemical composition of the clay body since silica and any other unmeasured elements (such as carbon) account for a high proportion of the samples. For fabric 4 the unmeasured elements account for 56-60% climbing to 72-78% in fabrics 5 and 6. Consequently, the data were normalised as a percentage of the measured oxides and PCA repeated. This showed that there was little systematic variation in composition within the samples except for Fabric 4, which not only had abnormally high quantities of iron, but also a correlation with MnO and Co, presumably trace elements within the iron-rich inclusions. The lack of separation of Fabrics 5 and 7 from the samples containing only inclusions which are available locally would be consistent with these fabrics being made from similar raw materials to the remainder. However, it was observed during the thin-section analysis that many of the sections had evidence for secondary phosphate deposition in pores. The most porous samples are those with voids (Fabric 1) or organic inclusions (Fabric 1e, 5 and 7b) but in such coarse fabrics as these even the laminae within the groundmass can amount to a significant proportion of the sample. The PCA analysis indicates a correlation between P_2O_5 and MnO, CaO, Sr, Co, Na_2O and Fe_2O_3. The frequencies of these elements in the samples may therefore be due in part to post-burial contamination (and it was noted visually that much of the pottery was coated with iron panning).

The PCA was repeated for the Brough data excluding these potentially contaminated elements (P_2O_5, MnO, CaO, Sr, Co, Na_2O and Fe_2O_3). It shows no obvious groupings. In other words, there are variations in chemical composition but they appear to have no correlation with the petrologically-defined fabrics. The remaining elements show some correlation, in particular the Rare Earth elements (Eu, Ce, Dy, La, Nd, Sm, V, Y and Yb). None of the other elements show such strong correlation.

To test the model that all of these fabrics were produced locally but with varying amounts and kinds of temper added, the Brough samples were compared with three other datasets: pottery from the Torksey kilns; pottery from an Anglo-Saxon settlement at Dunholme north of Lincoln and from a similar settlement near to Ruskington (HAT00). These samples include a number with acid igneous rock inclusions and ?Millstone Grit sandstone inclusions similar to those from Brough. A PCA analysis for this dataset, excluding the suspect elements noted above, shows that there is a separation between the four groups. This is particularly clear when PC3 is plotted against PC4 (Fig 1). The elements responsible for this separation are shown in Fig 2. All elements are capable of some mobility in groundwater but Zircon and Titanium oxides (such as Rutile), which are correlated with one of these groups (HAT00) are most likely to be found in the silt or sand fraction of these samples and are thus most likely to reflect original differences in composition.

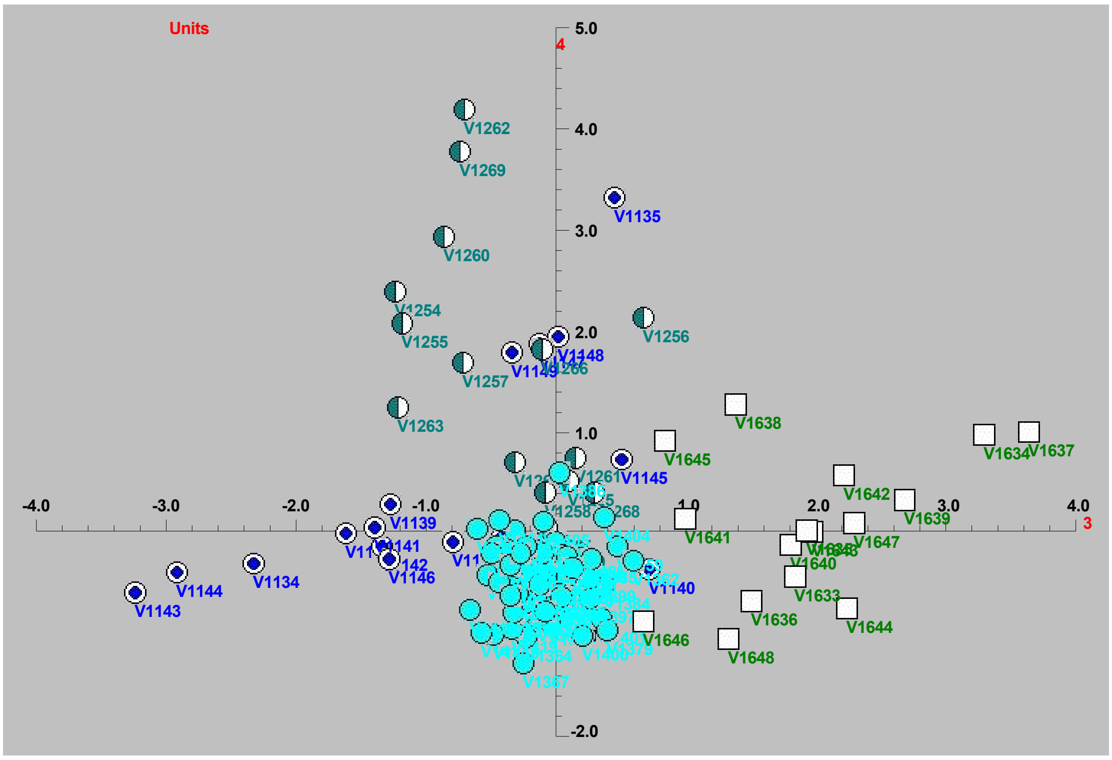

Figure 1

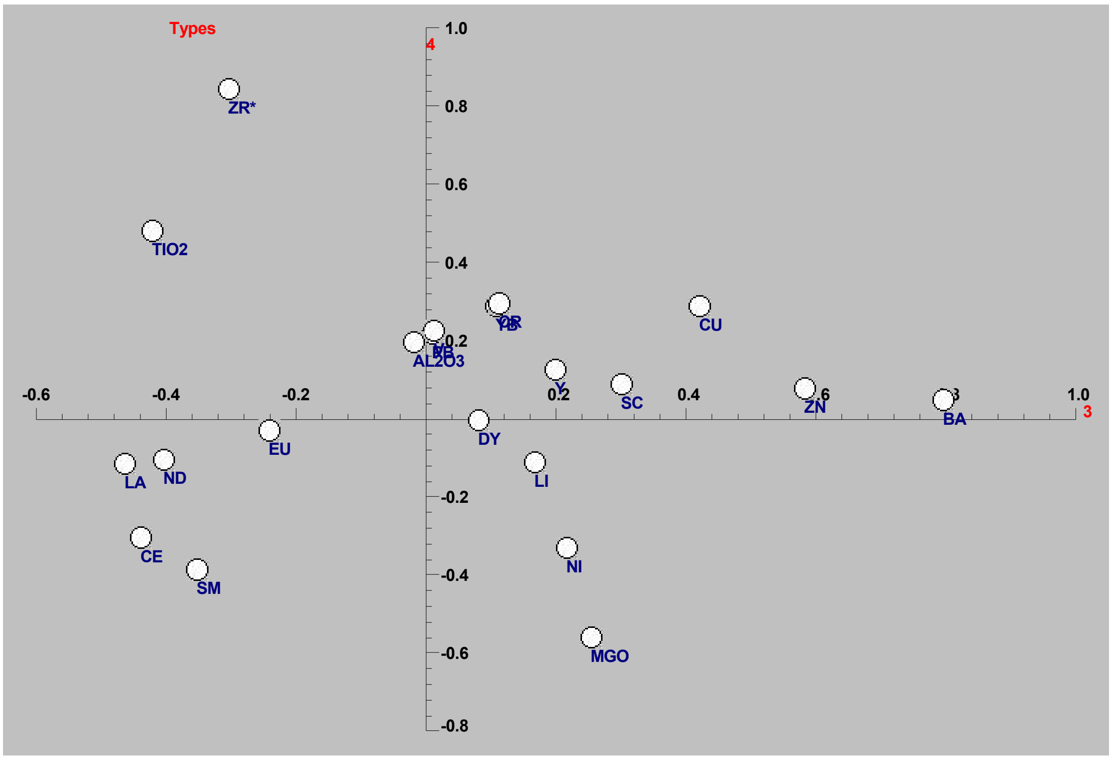

Figure 2

Discussion

Following detailed binocular microscope study and thin-section analysis the interpretation of the petrological data seems to be problematic. On the one hand, features such as the abundant polished quartz grains seen in Fabric 7b would seem to discount a local source since such grains only occur extremely rarely in Trent valley sands, and no sands have every been observed by the author in the valley which contain quantities of acid igneous rock fragments such as those seen in fabrics 1, 1d, 2, 7, 7a and 7b. Despite close observation, there is no evidence in any of these fabrics for these grains being detrital. The fragments of coarse-grained sandstone observed in the Fabric 5 samples probably occur in local fluvio-glacial sands although they are extremely rare in the terrace sands found in the Trent valley. On this evidence, fabrics 1, 1d, 2, 5, 7, 7a and 7b would not be local products.

On the other hand, numerous inclusion types occur in many fabrics, including these 'non-local' ones. These inclusions are: rounded quartzose sands, present in all the samples, although varying considerably in frequency; rounded voids, which occur in fabrics 1, 1b, 1d, 1e and 7; iron-rich clay fragments, present in 7 of the samples although only common in Fabric 4, and iron-stained clay pellets. Furthermore, most of the samples have a similar, inclusionless clay matrix in which muscovite is either absence or sparse. Such clays form the bedrock of the Trent valley (eg the Lower Lias clay) and would have been exposed in valley sides and streams where overlying gravels are absent. Many of these inclusion types have a wide natural distribution in the Trent valley. For example, the Anglo-Scandinavian wares produced at Torkey, to the north of Brough, have a similar groundmass, quartz sand and rounded voids (albeit not in the frequency seen at Brough). Iron-rich fragments are not present in the Torksey wares.

Finally, in fabric 2 thin-section analysis confirms the visual identification of grog, including fragments which had previously been fired to a sufficiently high temperature to produce an isotropic groundmass. This material is extremely unlikely to be present simply as a result of natural processes and implies that the potters were mixing materials, some of them, as in this case, artificial ones, to produce their potting clay.

It may be significant that a visually-identical granite-and-grog tempered ware has recently been noted from an early Anglo-Saxon site near Thetford (KIL00 V1679). At the very least, this suggests a widespread tradition for using this recipe but it is also supporting evidence for the idea of this ware, and by implication, others, being produced at a single source and 'traded' over considerable distances.

Combining the evidence from thin-sections, visual examination and chemical analysis suggests that the Brough vessels may well have been made from local clays and sands to which inclusions, which may well be of non-local origin, were added.

Identification Guide

If it is accepted that not all of the inclusions seen in Anglo-Saxon pottery fabrics were either naturally-occurring in the clay nor present in locally-available sands then the recording of pottery fabrics becomes difficult. If inclusions, such as the grog in Fabric 2, were deliberately added then their presence may well have been a significant feature of that pottery for the maker and user, even through at present we are unable to say what the significance might have been.

Furthermore, if we compare the results of detailed x20 binocular microscope examination by the author, who is a trained petrologist, with the author's same analysis of the thin-sections, we see that there are differences. No matter how well-trained a researcher might be, it is unlikely that binocular microscope examination of these wares can reveal the entire petrological composition of the fabric. However, it is also clear that the reverse is true. Thin-section analysis on its own will not reveal either the rarer inclusions, or details of the surface ornamentation of inclusions which are visible in section. Both methods are required.

For the purposes of identification of the Brough Anglo-Saxon pottery fabrics the inclusions can be divided into 11 groups (Table 2).

Rounded Voids (RV)

Rounded voids occur in several of the Brough fabrics. There are two possible explanations for these voids in the Brough case. Either they might have been nodules present in the parent clay or the voids once contained detrital limestone fragments. Limestones outcrop extensively in Lincolnshire and within the Trent valley. Potential sources are the Rhaetic, the lower Lias, the Lincolnshire limestone, the Cornbrash and the chalk. Of these, the Rhaetic and the Lias are most likely in terms of proximity to Brough.

Rounded quartz sand (RQ)

Rounded quartz sand is present in all of the fabrics and is therefore not a diagnostic inclusion. Rounded quartz grains vary from c.0.2mm across to c.1.5mm across. Those present in the Trent valley sands probably originated mainly in the Triassic strata of Nottinghamshire and the larger grains show the well-rounded, egg-like appearance which typifies the sands of the Sherwood Sandstone. In addition to quartz, fine-grained siltstones/fine sandstones and cherts are present in these sands but cannot be identified by eye.

Fine-grained sandstones (SST)

Sandstones which are visible under x20 magnification will have a grain size in excess of 0.25mm. Given that in many cases the maximum size of inclusions is less than 2.0mm, most of these inclusions will be too small for any precise identification. However, in contrast to the Millstone Grit-type sandstones (see below), these sandstones may have iron-rich cement and may contain rounded or subangular grains. There is undoubtedly potential in furthering precision in the characterisation and description of East Midlands Anglo-Saxon pottery if these sandstones could be identified, if not to outcrop then at least to broad period (eg Jurassic versus Triassic). Some of the sandstones seen in fabrics containing acid igneous rocks may, for example, be Charnian or Carboniferous rocks which outcrop in northeast Leicestershire.

Angular fragments of acid igneous rock and its constituents (AI)

Acid igneous rock fragments are composite rock fragments containing ferro-magnesian minerals (dark coloured, crystalline), feldspars (white or pink crystalline with pronounced cleavage (ie looking somewhat like the pages in a book) and quartz (less than 20% by volume). Magnetite is an accessory mineral which is easily identified (black, cubic). In the Mountsorrel granodiorite the main ferromagnesian mineral is biotite, which often has a eudedral habit (looking like a stack of 8-sided biscuits!). Biotite is Black Mica, but in many cases it is not black. Nevertheless, it is the most easily identified element in the acid igneous rocks found at Brough. The precise identification of such rocks is difficult and in particular it is possible to confuse Millstone Grit sandstones, which can have a high feldspar content, and basic igneous rocks (which however contain little or no quartz). Without thin-section analysis it is impossible to positively identify Mountsorrel granodiorite and even then in many cases it is possible to demonstrate that a rock has characteristics which do not occur in NE Leicestershire but not to prove that a feldspar-biotite-quartz rock is definitely from that source.

Iron-rich material (FE)

In thin-section there is a sharp distinction between this iron-rich material and iron-rich clay pellets, in that these fragments, whatever their colour or surface texture, are optically opaque. A range of textures is present, from completely inclusionless through abundant quartz angular silt/fine sand inclusions to examples with rounded quartz inclusions (or a mixture of rounded quartz with quartz silt inclusions). By eye, these inclusions vary in appearance from black glossy surfaced blocks to brown rounded grains with a matt surface. These are likely to be either fragments of an iron oredeposit, such as the Northampton Sands, which outcrops half-way up the Jurassic scarp to the east of Brough, or an iron pan deposit. The shape and condition of the fragments indicates that some are likely to have been crushed whilst others appear to be whole. Whether they were present in the parent clay or added is uncertain although fieldwork in the Brough area might be able to establish if such iron-rich material occurs naturally in the area. There is no evidence that the inclusions are associated with iron working since there is no sign of fuel ash or fayalite slag.

Millstone Grit-type sandstone (SSTMG)

These inclusions are identifiable primarily through the overgrowth of the quartz grains, which give rise to a distinctive glitter in the hand specimen. However, these overgrowth quartz grains could be mistaken for feldspar. Two distinguishing features are: 1) the clarity of most of the grains (most of the feldspar present in the Brough fabrics is partially altered and therefore opaque), 2) the lack of cleavage (broken fragments have conchoidal fractures whereas broken fragments of feldspar break along cleavage lines). This sandstone is composed mainly of quartz and, in some instances, feldspar. Biotite, for example, is absent.

Millstone Grit-type sandstone outcrops in the lower Carboniferous strata of the Pennines but Millstone Grit and its constituents make up much of the detrital sand found in the Vale of York. It is likely that sheets of similar sands occur much further south, since vessels tempered with such sands occur as far south as the Thames valley. Nevertheless, at present there are no identified sources for this sand south of the Humber. A minor element in the Vale of York sands are Permian sand grains. These grains are almost completely spherical and have a distinctive matt surface. Should they be identified at Brough it would suggest strongly a Yorkshire source.

Water-worn quartz (GSQ)

These grains are typically between 0.5mm and 3.0mm in diameter and usually have a low sphericity but a high degree of roundness (ie they appear gnarled, or knobbly). The surface of these grains is polished, which together with the purity of the quartz gives a very distinctive inclusion type. Such grains occur in strata in the lower Cretaceous and in detrital sands derived from them. In Lincolnshire, these sands only occur between the Wolds, the river Ancholme and the fens. Similar sands occur in Yorkshire on the east side of the Vale of York, west of the Wolds, and at various localities in the fens and on the fen edge. However, there are few localities where one might expect these quartz grains to occur alongside biotite granite or similar material. The Vale of York is a possibility, however, since igneous erratics have been recorded along the eastern side of the vale.

Muscovite (MUSC)

Muscovite of two sizes occurs in the Brough Anglo-Saxon vessels. In one case laths of muscovite, looking like thin silver plates, were noted. Muscovite of this size is a common detrital mineral but is rare in the Trent valley. It occurs extensively in Yorkshire in association with Millstone Grit type sandstone and it is in Fabric 5 that it occurs at Brough.

Much smaller muscovite laths occur more widely, for example in the Middle and Upper Lias which oucrop to the east of Brough. The low frequency in which these laths occur in the Brough fabrics is consistent with the lower Lias.

Rounded clay (CLAY)

The thin-section analysis of the Brough fabrics indicates that the parent clay contained relict clay nodules with a concentric structure and varying iron content. These do not seem to be relict clay (ie clay left over when the clay was being kneeded during preparation) but rather were probably present in the parent clay.

Chaff and other organic matter (ORG)

To positively identify chaff-tempering requires the noting of rachis and glume fragments. These are, indeed, present in most chaff-tempered Anglo-Saxon organic tempered pots. It is not usually possible to distinguish chaff-tempering from dung-tempering since the dung itself contained chaff. In addition, organic inclusions are often present in low-fired earthenwares. These can be either roots or material introduced into clays through the burrowing action of invertebrates, such as earthworms.

Flint (FL)

A single fragment of flint was noted. Distinguishing flint from other cherts can be difficult and is best achieved by thin-section analysis where the texture of the cryptocrystalline matrix and the presence of spherical microfossils can allow a positive identification. At Brough it is likely that any flint present has been carried south from the Yorkshire Wolds during the Quaternary period.

Table 2

Fabric	VOIDS	RQ	SST	AI	FE	SSTMG	GSQ	MUSC	CLAY	ORG	FL
1	X	X	X	X	X				X		
1b	X	X									
1d	X	X	X			X				X	
1e	X	X			X				X	X	
2		X		X					X		
4		X			X						
5		X			X	X		X			
5+chaff		X				X				X	
6		X	X	?		X			X		X
7	X	X	X	X	X				X		
7a		X		X	?				X		
7b		X	X	X			X			X	