Characterisation of Medieval Pottery from Newcastle-upon-Tyne

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As part of a project to study and publish the medieval pottery from various excavations at the Castle at Newcastle-upon-Tyne by Andrew Sage and Jenny Vaughan, a study of the pottery fabrics was instigated. The pottery was first divided into "ware groups" by Andrew Sage (consisting of vessels with a similar visual fabric, firing and appearance) and samples of these groups, amounting to 62 samples in total, were submitted to the author for thin-section and chemical analyses.

The thin sections were prepared by Steve Caldwell, University of Manchester, and stained using Dickson's method (Dickson 1965). This staining distinguishes between ferroan and non-ferroan calcite and dolomite and in the event no inclusions of these types were present. The samples were given codes in the AVAC reference series (V3180 to V3141).

Chemical analysis was carried out at Royal Holloway College, London, under the supervision of Dr J N Walsh. The samples were prepared in Lincoln by Peter Hill and consist of the crushed core of an offcut of 1-2gm of pottery, from which all surfaces had been mechanically removed to a depth of c.1.0mm. Taking such a large sample may help to guard against the presence of a single inclusion with a high amount of a particular element skewing the results.

The Geological Background

Newcastle-upon-Tyne lies on Carboniferous rocks which form part of the Durham Coalfield. The coalfield rocks consist of sandstones, siltstones, mudstones and coals. Immediately underlying the coals are seatearths, which are the fossil soils in which the Carboniferous vegetation grew. The sub-tropical deltaic conditions in which they were formed gave rise to kaolinitic clays which fire off-white and which have been sought out for pottery production from the Roman period onwards.

The coal measures are cut by dykes of fine-grained basic igneous rocks. To the east and southeast of the city at South Shields and Sunderland, Permian deposits overlie the Carboniferous rocks. These consist, at their base, of fossil sand dunes, instantly recognisable in thin section and the hand specimen because of the "millet grain" quartz. These sands were overlain by finer sandstones and limestones, the latter composed of dolomitic limestone.

Extensive deposits of boulder clay cap these earlier deposits except where cut through by the Tyne and, further west, the Derwent. The boulder clays contain, in addition to redeposited

Coal Measures, fragments of coarse acid igneous rocks from the Scottish border, notable for their biotite content. Lakes filled these river valleys during the ice age and early Holocene period. The lacustrine deposits consist of varved clays derived ultimately from the Coal Measures and fine angular sands, of similar origin.

The Tyne and Derwent mainly drain the Durham Coalfield (with its superficial boulder clay capping) but their headwaters originate in the Pennines, composed predominantly of sandstones of Millstone Grit type.

The Geochemical Background

The geochemistry of the north east of England has been exhaustively studied by the British Geological Survey ({BGS 1996 #45483}). However, in the area immediately around Newcastle sampling was not possible because of the amount of human disturbance. Nevertheless, the general character of the geochemistry can be inferred from measurements taken in the surrounding area, especially south of the Tyne and northwest of Sunderland. The BGS survey includes several elements which are measured by the RCHL ICPS analysis but it is difficult to make a direct comparison between the ICPS results and the BGS data because the former is a measure of total content (clay, silt and sand) whereas the latter is based on a sieved sample, so that clasts larger than 150 microns were excluded. Nevertheless, there is no strong discrepancy between the range of those elements measured by both the BGS geochemical survey and those measured in the ICPS analyses of the pottery samples (Appendix 1). Study of the distribution of those elements suggests that some elements are present primarily in the sand fraction whilst others are mainly present in the silt and clay fraction, with some hints that the wider the range of values found, the coarser the material bearing the element.

Petrological Analysis

A quick survey of the 62 thin sections indicates that there are several variations in texture, composition, redox conditions and, possibly, organic content. However, it is difficult to divide the sections into groups, as there appear in most cases to be gradations from one mode to another, rather than discrete fabric groups. A further complication is that the colour and firing temperature affect the visibility of certain inclusion types and groundmass traits. Therefore, the range of inclusion types present in the entire collection are described here followed by a summary of groundmass characteristics.

Inclusion Types

Millstone Grit sandstone

A high proportion of the sectioned samples contain fragments of a coarse-grained sandstone, composed mainly of overgrown grains of monocrystalline quartz with some fine-grained white matrix, which might be silicious or kaolinite. Some have traces of dark brown cement but it is unclear whether this was present in the original rock or is a subsequent coating. The grain size ranges from c.0.5mm to c.2.0mm. In several cases, all the inclusions larger than c.0.2mm are of this sandstone or its composite grains.

The sandstone is very similar in grain size, overgrowth and quartz characteristics to the Millstone Grit, but similar grit stones occur in the Coal Measures of the Durham Coalfield. Whether this sand originated in the Millstone Grit or the more local Coal Measures, it is likely that the grains are detrital. It is quite likely that within local Quaternary and recent sands the composition of the sand varies with size grade and that this particular sand denotes the use of a coarse sand to find gravel as tempering.

Calcareous inclusions

Calcareous inclusions were absent in the sections, but a few examples contained voids which might well have once contained limestone or , less likely, shell. In that the voids were not surrounded by a darkened halo which would indicate the former presence of an organic-rich inclusion.

Mudstones

As defined here, the term mudstone is used for argillaceous inclusions which have evidence for horizontal bedding, and perhaps variations in composition, but which have do not have an extremely platey shape (which would have been classed here as shale). Mudstone fragments are not particularly common in the samples and where present usually show some evidence for rounding. In some examples the mudstone has a similar colour and texture to the groundmass, suggesting the use of a clay formed by the *in situ* weathering of a mudstone whereas in others there is a contrast in colour and texture, suggesting that the mudstone fragments are detrital grains. Several of the mudstones were clearly organic and retain a dark colour, and sometimes opacity, whilst others are light-firing, sometimes varying from light to a brown firing in the same fragment. Examples with lenses and laminae of organic matter (presumably coal in these cases) were present but not common.

Chert

Small, rounded fragments of chert were present in a number of sections. They have a similar size range to the accompanying quartz sand grains and are interpreted as detrital fragments of Carboniferous chert. A few larger examples appear to have been present in the Millstone Grit-type sand and it is also possible that some of the smaller grains (less than c.0.3mm across) are weathered fragments of cement deriving from this sandstone.

Coal Measures sandstones

A number of sections contain small fragments of a finer-grained sandstone, composed of quartz grains between 0.1mm and 0.4mm across. Some of these have overgrowth and some have an opaque or dark brown cement. They have been interpreted here as being of Coal

Measures origin. In those samples, and in several others where no sandstone fragments were observed, there was a high frequency of quartz grains of similar size and shape. These probably originated in similar sandstones but were recorded separately.

Coal Measures siltstones

In nine sections, rounded fragments of siltstone were noted. These were mainly less than 0.5mm across and were always sparse. They are interpreted as detrital fragments of siltstone of Coal Measures origin.

Basic igneous rock

Rounded fragments of fine-grained basic igneous rock, composed mainly of interlocking laths of feldspar up to 0.3mm long in a dark finer-grained groundmass, were rare but present in four or five sections. The shape and frequency of these grains shows that they are detrital.

Opaque inclusions

Opaque inclusions were noted in many of the sections. They were rarely greater than c.0.3mm across and in some cases have been vitrified during firing, incorporating surrounding clay groundmass to form vesicular rounded inclusions. In some cases it seems that the source of these opaque inclusions is an iron-rich concretion, whilst in other cases the grains are clearly detrital and have a sharp rounded boundary whilst in other cases the opaque material is present as lenses and laminae in the groundmass. In the latter cases it is possible the iron formed as panning, perhaps in association with organic matter, but whether this took place in the Carboniferous period or the Quaternary or recent period is unclear without a detailed survey of local clay sources.

Clay pellets

Clay pellets were present in between a third and a half of all sections. In some cases they appear to have been present as concretions in the parent clay, especially where they have dark brown or black mottling or an oolitic structure. In others, they may have been formed during clay preparation, as relict clay lumps not completely broken down during working of the clay. The latter are usually of similar colour and texture to the groundmass. There is a gradation from the latter type of pellet to the mudstone fragments, which are either more indurated or the clay less well-prepared.

Permian sand

Well-rounded quartz grains with a high sphericity were present in only five sections, and in none of these were the grains common. This is in contrast with samples from the Dogbank kiln and sherds of similar appearance from consumer sites in Newcastle (Vince REF). These grains probably derive from the Permian Yellow Sand, which outcrops to the south-east of Newcastle. However, their presence in the Dogbank fabrics suggests either that traces of the

Permian sand survived to the north and west of their current outcrop before and during the Ice Age or that the sand was partly derived from drainage of land to the southeast of Newcastle.

Muscovite

Laths of muscovite are present in the majority of samples, although in the higher-fired samples and some of those with reduced firings they are less common or invisible than in others. This is probably due to alteration during firing.

In some cases, the muscovite forms large laths, up to 0.5mm long, and these tend to be present in the samples with a high proportion of Millstone Grit-type sand grains. Indeed, in a few instances sandstone fragments including such laths were noted. However, the incidence of muscovite in the sandstone must have been very low (perhaps in the order of a few percent at most). Finer-grade laths were much more common and were present in some of the mudstone fragments, indicating that they were present in the parent clay from which those samples were made.

Groundmass Characteristics

There are clearly several different groundmass types present in the samples, as defined by the colour and texture of the groundmass (which here is taken to include all matter less than 0.1mm across). Classifying the groundmass in each and every instance was difficult. In some cases this was due to variations in the thickness of the sections, indicating that quartz and muscovite grains less than 30 microns across were present in some samples. In a standard thickness section the groundmass would appear to be inclusionless whereas in slightly thin samples a variable quantity of quartz and muscovite would be observed. For classification purposes three groundmass types were denoted and these were used as a basis for a fabric classification.

Group A

This is a distinctive texture characterised by the mixture of laminae and lenses of slightly differing colour and texture clays, including some dark brown to opaque streaks. None of these laminae were free from quartz and muscovite inclusions nor were any of the laminae off-white in colour in plane-polarised light. The samples from the Dogbank kiln and comparable material from consumer sites have a similar groundmass and this was interpreted by Whittingham and others as being alluvial or lacustrine clay of Quaternary or recent origin. A similar, Tyne valley or esturarine source is presumably likely for these samples. Ten thin sections were classified as having a Group A groundmass, although in three the laminae were not visible in section and the sections were added to the group on the basis of overall colour and textural similarity. Six of the ten samples had a reduced groundmass and no examples with a high organic content were noted.

Group B

This group is recognisable because of the almost complete absence of inclusions less than 0.1mm across visible in thin section. Some of these 29 samples have an off-white colour in plane-polarised light whilst others have a light brown colour and in yet other samples the colour is obscured by the survival of organic matter after firing and/or the reduction of the iron oxides present in the clay. In most cases the groundmass consists of optically anisotropic baked clay and this lack of vitrification, combined with the range of firing colours and the low magnesium content suggests that kaolinite is the main clay mineral present.

Thirteen samples were classed on visual examination as having an offwhite groundmass whilst sixteen had a brown groundmass. Six of the samples either had a high organic content or were reduced. The difficulty in finding a precise cut-off between these two groups, and their otherwise similar range of inclusions and chemical composition means that all have been grouped together here.

This group is interpreted as being Coal Measures in origin, but may include some samples formed from re-worked Coal Measures clays as well as freshly-dug clay weathered *in situ*. Few of the samples are sufficiently light-coloured to suggest that they formed as seat earths and they may include marine clays as well as deltaic clays.

Group C

This group is composed of 23 samples whose groundmass contains a proportion of quartz and muscovite, but combined with a similar range of colours as seen in the Group B samples. Some sections show fabrics with a higher proportion of muscovite to quartz than others and it is unlikely that this could be due solely to variations in muscovite survive after firing, although this is probably a factor.

These samples are interpreted as coming from weathered Coal Measures mudstones. The scarcity of siltstone fragments suggests that the parent rock was in most cases a silty mudstone rather than a mudstone with siltstone banks or lenses. Five examples had a high organic content or were reduced.

Chemical Analysis

Silica content

Although silica is not measured directly in the ICPS analysis the frequency of silica can be estimated by subtracting the total measured oxides from 100%. This estimate will also include organic matter and other un-measured elements, most of which are probably numerically unimportant. Fig 1 shows the mean and standard deviation of the estimated silica content grouped by groundmass type. There is no appreciable difference between the mean silica content of each group and a range of values within each group. Thus, despite the visual variation in texture, the overall silica content in the samples is very similar. Nevertheless, in order to compare the chemical composition of the samples the data needs to be transformed and this has been attempted by dividing each element value by that of Aluminium, which in these samples is overwhelming present in the clay fraction of the samples.

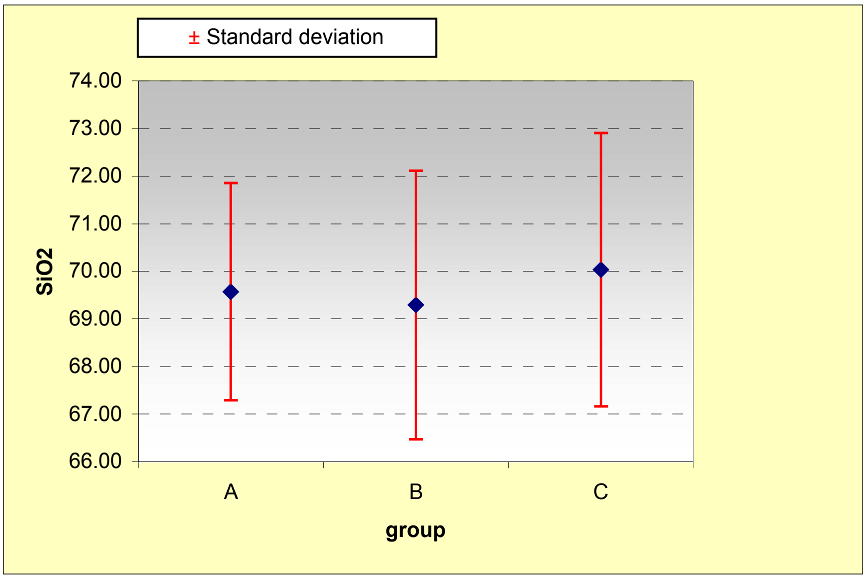


Figure 1

Internal variation in chemical composition

The transformed data was then analysed using factor analysis which attempts to simplify the relationships between the samples by replacing the individual element values with factors which are calculated by assigning weightings to each element. Calcium and Potassium were omitted from this analysis, since both elements are liable to post-burial alteration (leaching of calcareous inclusions and the infilling of voids and laminae with phosphate). Since the Rare Earth elements are attracted to phosphorus they too have been omitted.

This analysis found four factors which together account for 55% of the variability in the dataset. Table 1 shows the weightings for the elements included in the analysis, sorted by the size of the first factor weightings. It shows that Factor 1 is mostly determined by Cobalt, Magnesium and Iron values.

Table 1

Element	Factor 1	Factor 2	Factor 3	Factor 4
Co	0.845877561	-0.026738136	0.327671149	-0.181781369
MgO	0.807090388	0.362405162	0.069548972	0.222861198
Fe2O3	0.752871715	0.156758759	-0.074154038	0.088776942
TiO2	0.643994151	-0.242351999	-0.130342923	0.208815907
Na2O	0.60808256	0.471735061	0.074512056	0.071120136
Ni	0.585260451	0.244901073	0.482955681	0.280094273
K2O	0.50279815	0.502724918	-0.074195418	0.132817511
Zr*	0.502140459	0.415074159	0.201464918	0.375357287
V	0.239754308	-0.110761826	0.013879539	0.514332092

MnO	0.192406981	0.12027392	0.377241565	-0.403231637
Cu	0.18316235	0.122733413	0.076260785	0.561025902
Sr	0.146487106	0.759743232	0.060483284	0.111777717
Cr	0.071066535	0.050205562	0.085496517	0.548465774
Y	0.05274455	0.041774875	0.66019023	0.052382946
Zn	0.033975542	0.68394233	0.124211487	0.024238173
Li	0.009874222	-0.150169923	0.024561695	-0.461871014
Ba	-0.001993162	0.397322112	0.625353113	-0.224545764
Sc	-0.077080791	-0.121765347	0.777430567	0.45860537

A plot of the F1 scores against the F2 scores, with the samples grouped by groundmass type (Fig 2) shows that there is no clear separation of the three groups but that the Group A samples have higher F1 scores and negative F2 scores(low Strontium and Zinc and high Titanium). There is also a tendency for the Group C samples to have negative F1 and F2 scores (probably as a result of lower values for most elements, relative to Aluminium, which is consistent with the depleted nature of white-firing Coal Measures clays).

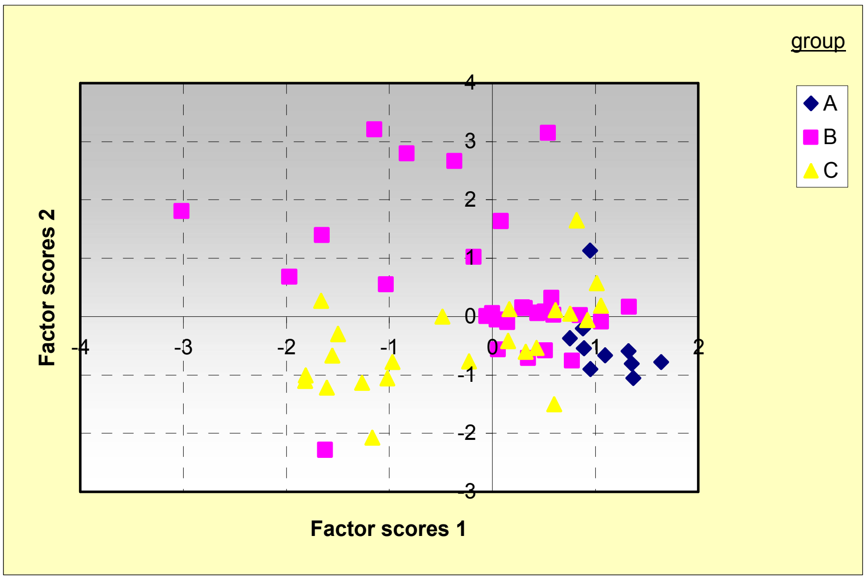


Figure 2

The F3 and F4 scores, by contrast, show little sign of difference between the three groundmass groups (Fig 3).

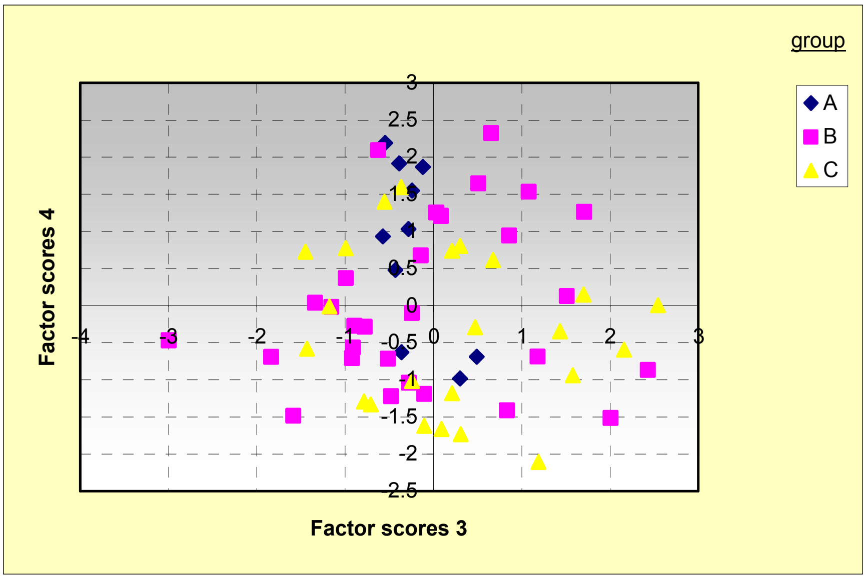


Figure 3

To examine the internal variability further, each sample was assigned a fabric code, based on a combination of groundmass and inclusion characteristics.

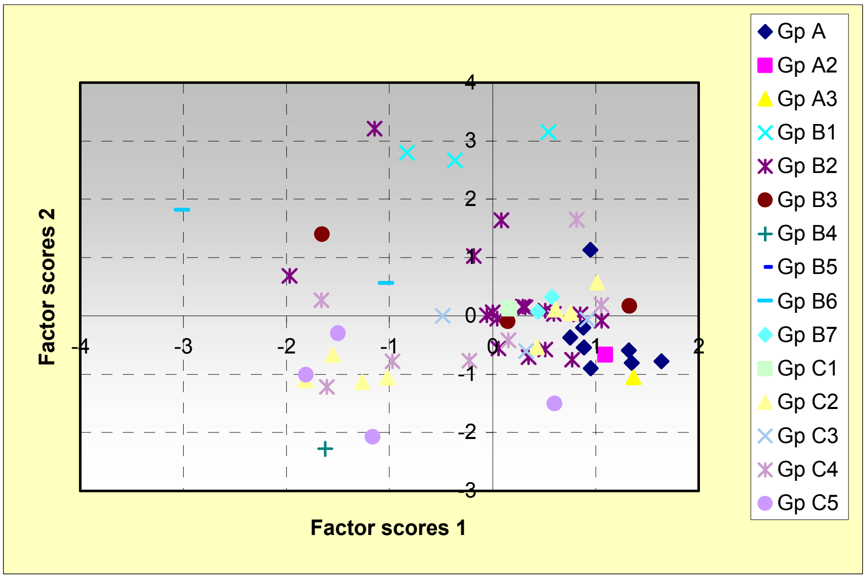
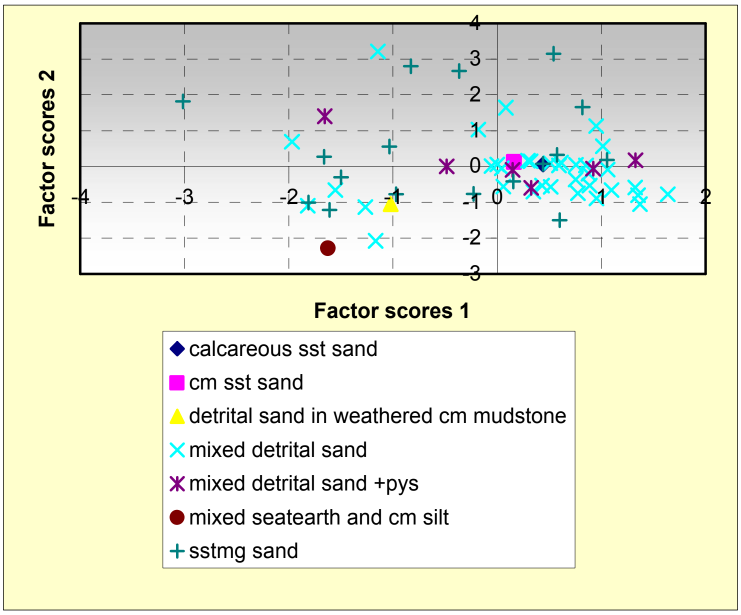


Figure 4

Fig 4 shows the plot of F1 against F2 scores, grouped by these petrological groupings. A group of three samples characterised by a predominantly Millstone Grit-derived sand and a group B groundmass (Gp B1) is distinguished by having high F2 scores. Two samples with a Millstone Grit temper and a brown-coloured Group B groundmass are distinguished by low or negative F1 scores (Gp B6). A sample which appears to have been made from poorly mixed Coal Measures white-firing clay (Gp B4) has high negative scores for both F1 and F2. A group of four samples with white mudstone inclusions and a micaceous Group C groundmass also have low or negative F1 and F2 scores (Gp C5). Three of these samples have mixed sands and one has a predominantly Millstone Grit-type sand. Fig 5 shows the same data plotted by interpretation of the inclusion suite. It shows that the samples with a Millstone Grit type sand (sstmg sand) tend to have higher F2 and lower or negative F1 scores than the remainder, but again with no clear boundaries.



Comparison with Dogbank ware

The data were then compared with previously-collected data on the chemical composition of samples of waste from the Dogbank production site in Newcastle and from two kilns at Aldin Grange, which produced later medieval sandy whitewares. Only four samples of Dogbank waste were analysed, representing the four fabrics identified by Bown in her report ({Bown 1988 #46243}). In addition, however, sherds from consumer sites in Newcastle which were visually similar were also analysed. Factor analysis found four factors and a plot of F1 against F2 shows that the four samples from the Dogbank kiln have higher F1 scores than either the Dogbank ware from consumer sites or the present batch of Newcastle samples (Fig 4). This is mainly the result of high Cobalt, Nickel and Magnesium values. The samples from the consumer sites, however, have similar scores to the present Newcastle samples.

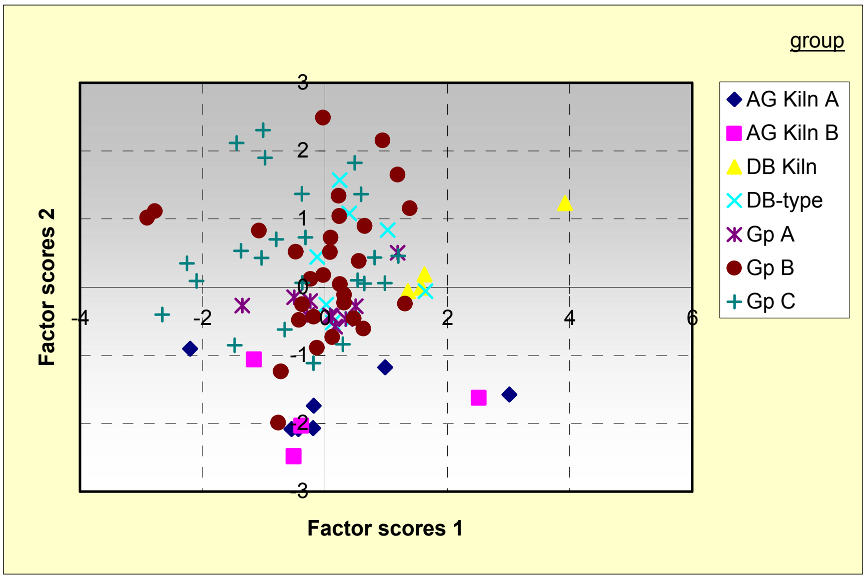


Figure 5

A plot of F3 against F4 scores shows that most of the samples have similar scores, with the exception of one of the Dogbank waste samples, which has high negative values for both factors (perhaps as a result of high Manganese values).

The obvious interpretation of the data is that the Dogbank kiln samples were contaminated after burial and that their original composition was more similar to the other Newcastle samples. However, a factor analysis of just the major element values, unlikely to have been affected by post-burial alteration, still shows three of the Dogbank kiln samples as having a different composition to the remainder (Fig 6), as a result of high F1 scores (which in this case indicate high weightings for Magnesium and Iron) combined with slightly negative F2 scores (due in this case to high weightings for Phosphorus and Calcium, and therefore potentially affected by burial conditions). It therefore seems that the Dogbank kiln samples are indeed chemically different to the majority of medieval pottery used in Newcastle, including that which visually and petrologically is indistinguishable from them.

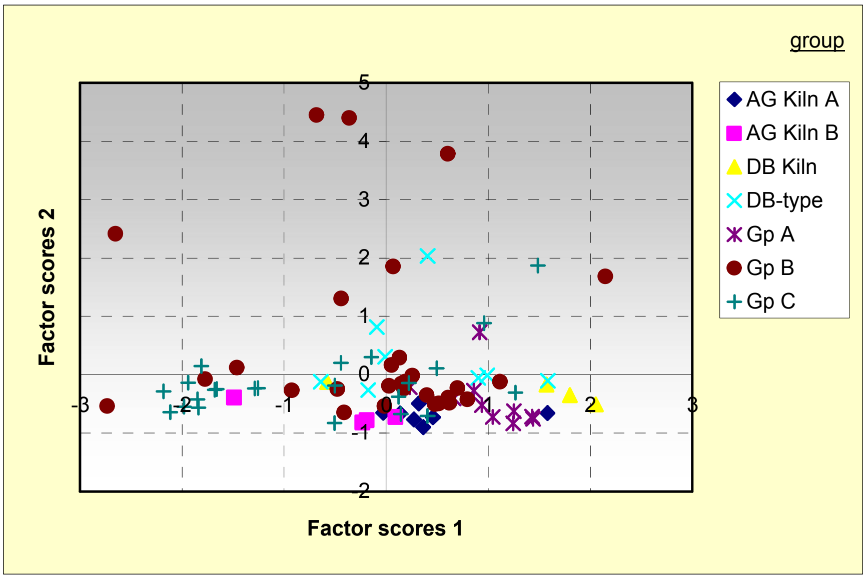


Figure 6

The data for the Rare Earth Elements, Calcium, Phosphorus and Lead were analysed, to see if they showed any evidence for contamination. The results indicate two main factors, with no strong weightings for Lead but with strong F2 weightings for Calcium and Phosphorus. This plot shows that a small number of samples, of all groups, have high F2 scores, almost certainly as a result of post-burial contamination, but that a group of samples with a Group C groundmass have high F1 scores, which are due to high Rare Earth Element weightings. These are of petrological groups C2 (mixed sand with a silty micaceous groundmass) and C4 (Millstone Grit sand with a silty micaceous groundmass). It is likely, therefore, that in these cases the Rare Earth Elements were present in the raw clay. Having established this, the factor analysis was carried out using all the measured elements except for Calcium, Phosphorus and Strontium (a proportion of which is certainly correlated with Calcium). A plot of the first two factors (Fig 7) shows most of the Newcastle samples as a single cluster, with a number of the Group C samples being separated, presumably mainly as a result of their Rare Earth Element scores. The Group A samples form a tight cluster within this larger cluster, distinguishable from both the Dogbank samples and the Dogbank-type samples.

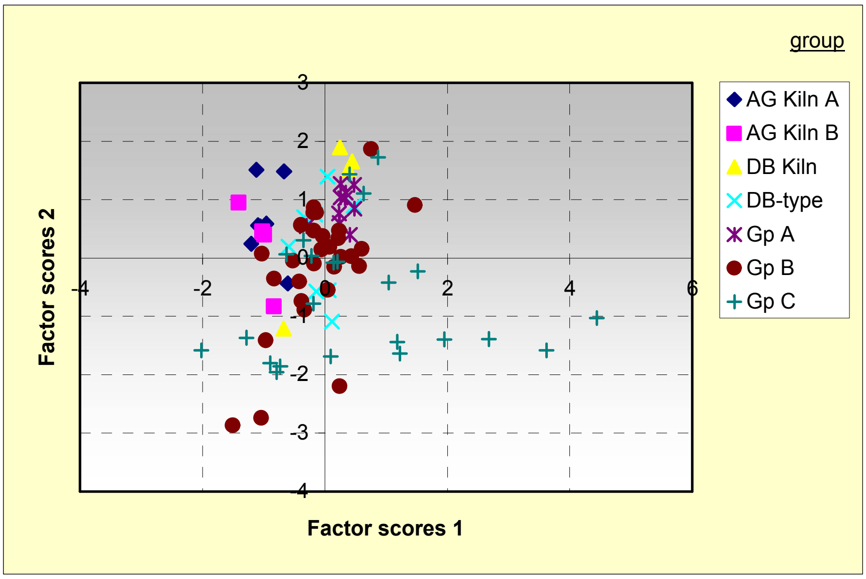


Figure 7

Comparison with Aldin Grange ware

A group of samples of wasters from the fill of two medieval kilns excavated at Aldin Grange, on the outskirts of Durham by Northern Archaeology Associates. From the 14th century onwards there is evidence for coal mining in this area ({Simpson 2004 #46253}) and it is possible that there was a connection between the two industries. The chemical data from these two kilns was included in the same factor analyses as the Dogbank ware samples discussed above. In the plot of F1 against F2 scores (Fig 5) the Aldin Grange samples have high negative F2 scores which distinguish them from any of the sampled Newcastle pottery.

In the analysis of the major oxides on their own the Aldin Grange samples plot close to the majority of Newcastle samples, but have slightly more negative F2 scores. In addition, this plot allows the two groups of kiln waste to be distinguished, by their differing F1 scores. In the factor analysis which included the Rare Earth Elements (Fig 7) the Aldin Grange samples have scores which overlap with the Newcastle samples but are mainly clearly separated by their negative F1 scores.

These data show quite clearly that none of the sampled Newcastle pottery has a comparable chemical composition to the Aldin Grange samples.

Comparison with material from consumer sites at Prudhoe Castle and Durham

In addition to material from production sites, the Newcastle data was compared with two groups of pottery of 11th/12th-century date from the area. The first consists of samples of the earlier medieval pottery fabrics from the Prudhoe Castle excavations and the second consists of samples from the Saddler Street excavations in Durham.

Factor analysis of the dataset was carried out and a plot of F1 against F2 scores showed that the Aldin Grange and Durham samples have similar compositions and the Prudhoe Castle and Newcastle samples have similar compositions. A plot of the F3 and F4 scores in addition differentiated the Aldin Grange from the Durham samples.

Having established without doubt that the Durham samples are chemically different from the Newcastle and Prudhoe samples, the analysis was repeated, omitting the Durham and Aldin Grange samples. This analysis confirmed that there is little difference in composition between the samples from the two localities.

The thin-sectioned Prudhoe samples mainly have groundmasses similar to Groups B and C and are tempered with coarse gravel which contains Millstone Grit-type, Coal Measures-type, and fine-grained basic igneous inclusions, similar to those found in the Newcastle samples, However, there is a much higher proportion of rounded and cracked, rounded quartz grains, probably of Permian origin, in the Prudhoe samples, more similar to those found in the Dogbank and Dogbank-type samples. These can be grouped together as Prudhoe Coarse wares. The Prudhoe Fabric 7 and 11 samples, however, form a distinctly different group, having white-firing Group C groundmasses with moderate fragments of white-firing mudstone. They can be discussed together as Prudhoe white gritty wares. A third group is represented by a single section, of Prudhoe Fabric 5, which has a Group C groundmass and a fine sandy temper, again comparable to several of the Newcastle samples.

In a factor analysis the Prudhoe coarsewares have similar F1 and F2 scores to those of the Newcastle samples (and the other Prudhoe samples) but have high Factor 4 scores similar to those of the Dogbank kiln samples, whereas the Prudhoe white gritty ware samples have negative F4 scores, similar to those of the C5 and B6 samples.

Discussion and Conclusions

Sixty-two samples were examined in thin section and using chemical analysis. All have characteristics which are consistent with an origin in the Newcastle area. However, there is a clear petrological difference between the coarsewares sampled here and those from Newcastle and Prudhoe Castle, in that the current samples contain few or no well-rounded quartz grains of Permian origin. Without knowing the incidence of Permian-derived sand grains in local sands it is impossible to say how significant this absence might be, but it does point to the majority of the samples come from a different source. However, without further work it is not possible to say if this is a separate source in Newcastle, its suburbs, or at some distance from the town, in a village in its hinterland.

A limit can be given to this distance, in that it is clear that the Durham coarsewares of the 11th and 12th centuries come from a different source. Furthermore, none of the later medieval Aldin Grange whitewares are present amongst the samples. Therefore, pottery made from similar clays and tempered with similar sands and gravels but made about 15 miles away from Newcastle can still be distinguished from the pottery used in the town itself.

There is considerable variation in the texture, colour and firing of these Newcastle samples. Some of this variability is probably the result of potters choosing clays with particular properties to suit their intended products (as with the later medieval reduced wares) but the lack of clear groupings within the chemical data, and the overlap in temper types between samples with different groundmass characteristics, suggests that these differences need not imply that the vessels were made at any great distance from each other.

Perhaps the strongest candidate for a discrete group of samples comes from those which have a Group A groundmass. This, it is suggested here, may be a lacustrine clay (derived ultimately from the Coal Measures) and if so then perhaps its source lies close to or in the Tyne valley. On the evidence of their petrological characteristics, none of the Group B or C samples need be so localised and it is possible that some may turn out to have been made in a similar circumstances to those at Aldin Grange, where coal and weathered light-firing mudstone outcrop close together and might both have been exploited at the same time.