

Characterisation Studies of Selected Medieval and Post-Medieval Pottery from Low Fishergate, Doncaster (DNB93)

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As part of the post-excavation analysis and publication of the finds from the excavations at Low Fishergate, Doncaster, a series of samples were selected for thin section and chemical analysis (App 1).

The site appears to have been first settled in the Saxo-Norman period and the earliest levels on the site produced sherds identified visually as Grimston Thetford-type ware, some of which were selected for further study. Later levels probably dating to the 12th century, produced sherds of splash-glazed wares, some of which were identified visually as Doncaster products, similar to wasters from the Market Place, whilst others may be imports from Nottingham and Beverley.

Methodology

Thin sections were produced by Steve Caldwell, University of Manchester, and stained using Dickson's method (Dickson 1965). Samples for chemical compositional analysis using Inductively-Coupled Plasma Spectroscopy (ICPS) were analysed at Royal Holloway College, London. The data consisted of the values for a series of major elements, expressed as percent oxides (App 2) and the values for a series of minor and trace elements expressed in parts per million (App 3). The data were normalised to aluminium and mobile elements such as calcium, phosphorus, strontium, and those which could be present through glaze contamination, copper and lead, were excluded and the remainder examined using the Factor Analysis module of WinSTAT, an add-in for Excel (2002). The appendices, however, give the raw data.

Grimston Thetford-type ware (V4874 and V4883)

Grimston Thetford-type ware is distinguished in the hand by its relative coarse texture, compared with other Thetford-types wares, and the presence of polished, rounded quartz grains. In thin section, two sub-fabrics can be recognised Vince 2007a. Both contain altered glauconite grains, usually opaque but one group also contains ferroan calcite specks in the groundmass. The Low Fishergate sample has the rounded opaque grains but without the ferroan calcite in the groundmass.

The ICPS data for the Low Fishergate samples were compared with that from other Thetford-type industries (Fig 1; Norwich – THETN; Thetford – THETT; Kirstead – THETK; Grimston – THETG) and Early Medieval Handmade Ware (fabrics A and T). Factor analysis of this data indicates that the Low Fishergate Grimston Thetford-type ware sample compares well with

other Grimston Thetford-type samples although one of the waster samples is closer in composition to the other Thetford-type wares.

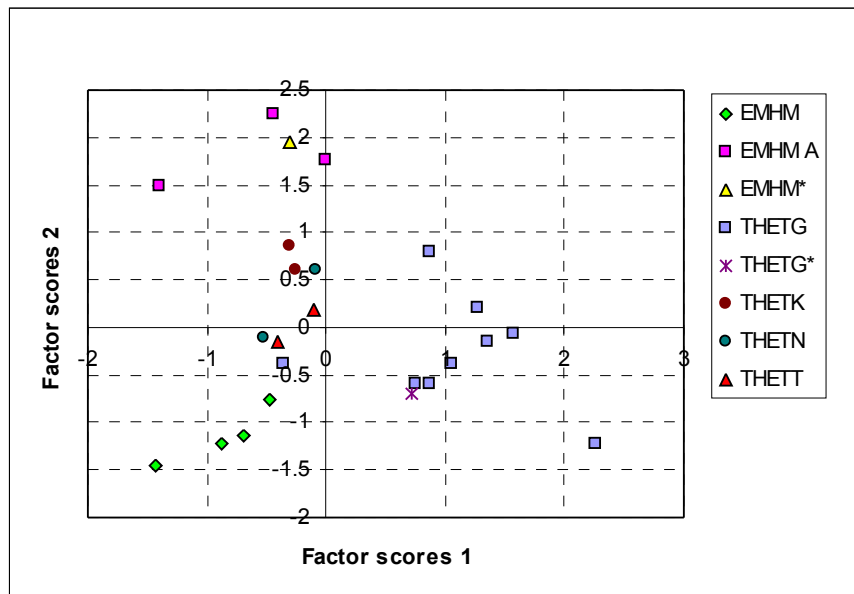


Figure 1

Early Medieval Handmade Ware (V4872)

Early Medieval Handmade Ware is a distinctive ware present on later 11th and 12th-century sites along the east coast. Thin section and visual analysis of examples from Lincoln suggested that the ware might have several sources (Young and Vince 2005). One group, EMHM A, is similar in fabric to Grimston Thetford-type ware whilst another, EMHM T contains similar quartz sand to that seen in Torksey ware. Thin section and chemical analysis of samples from Church Way, Doncaster, however, indicates that EMHM T is probably an East Anglian product whilst EMHM A is probably from Blackborough End, six miles south-west of Pott Row (Vince 2007a). The medieval tilery of Bawsey lies midway between these sites, suggesting that the whole area may be a single diffuse production region.

The Low Fishergate sample contains similar abundant opaque altered glauconite to the Grimston Thetford-type ware, together with a single rounded flint 2.0mm across and clay pellets containing altered glauconite. It is therefore an example of EMHM A and probably a Blackborough End product.

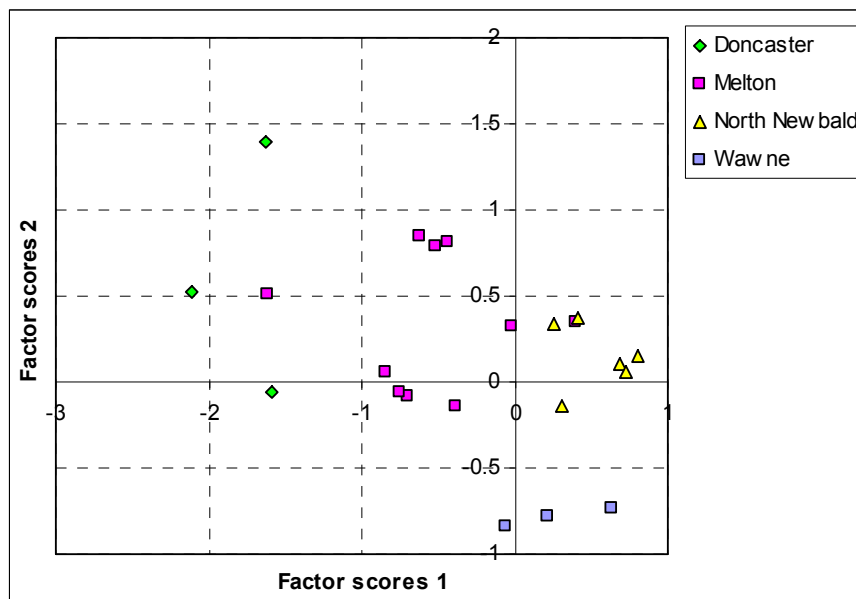
Factor analysis of the ICPS data was carried out alongside the data for the Thetford-type wares (see above, Fig 1). This shows that the EMHM Fabric A samples form a distinct group and that the Low Fishergate sample plots with the three other EMHM A samples (two from Doncaster and one from Hartlepool).

East Yorkshire Quartz and Calcareous-tempered ware (V4863 and V4866)

Two examples of handmade vessels with a mixed quartzose and calcareous sand temper from Low Fishergate were analysed. Both have a similar appearance in the hand, with a predominantly subangular quartz sand with sparse calcareous grains, most of which are leached out. In thin section one, V4866, contains a mixed sand consisting of angular quartz, organic mudstone, micaceous siltstone, fine-grained sandstone, basic igneous rock and fine-grained non-ferroan micrite. The latter is probably chalk but no microfossils were noted. The groundmass is composed of optically anisotropic baked clay with moderate dark brown grains up to 0.05mm across and sparse angular quartz inclusions up to 0.1mm. The groundmass is typical of some Jurassic clays and the combination of a Jurassic-derived clay and a sand composed of mixed sedimentary and basic igneous rock fragments is consistent with a source in East Yorkshire, possibly immediately west or south of the Wolds rather than the Beverley area (the source of Beverley Reduced Chalky ware, which contains common basic igneous rock fragments but has a more silty groundmass Watkins 1991; Vince 2004a). A coarseware with similar characteristics but lacking the high quantity of basic igneous rock fragments, East Yorkshire Quartz and Calcareous-tempered ware, is known from sites immediately west and south of the Wolds and an example has been found at Church Way, Doncaster and its identity confirmed by thin section and chemical analysis (Vince 2007a).

The other sample, V4863, has similar sand inclusions except for the lack of basic igneous rock and a similar groundmass. This is more typical of samples of East Yorkshire Quartz and Calcareous-tempered ware from Melton, North Newbald and Wawne (Vince 2006; Vince 2005; Vince 2004a).

The ICPS data from the two Low Fishergate samples was compared with that from other sites: Doncaster; Melton; Wawne and North Newbald and with data from the analysis of Reduced Chalky ware from Wawne and Beverley. This analysis indicated that the two groups formed distinct clusters. However, within the Early Yorkshire Quartz and Calcareous cluster sub-groups could be recognised. The three Doncaster samples form a separate group, along with one from Melton (Fig 2). This may be related to post-burial alteration of the chemical composition but it could indicate that there were several sources for this ware. The fact that the two Low Fishergate samples have similar compositions, despite their difference in petrology favours the former interpretation.



(Doncaster, York, Knaresborough and Ingmanthorpe). Factor analysis found four main factors and a plot of the first two factor scores (Fig 3) indicates that the York Gritty ware sample has a similar chemical composition to other York Gritty ware samples but that the two supposed Doncaster Gritty ware samples are clearly different from the other Doncaster Gritty ware samples. A plot of the third and fourth factors confirms this distinction (Fig 4). This difference is due to high lithium and titanium values for the Low Fishergate samples. Similar high values are found in Hallgate B ware and whitewares from Firsby and Rawmarsh (Fig 5). It may be, therefore, that these two samples were actually made from the same clay as Hallgate B wares or are products from Firsby. Factor analysis of the Doncaster Gritty ware samples with samples from Firsby and then with samples of Hallgate B wasters distinguishes the two samples from Firsby but not from the Hallgate B samples (Fig 6). This suggests that the two samples may be Hallgate products or were at least made from the same white-firing clay.

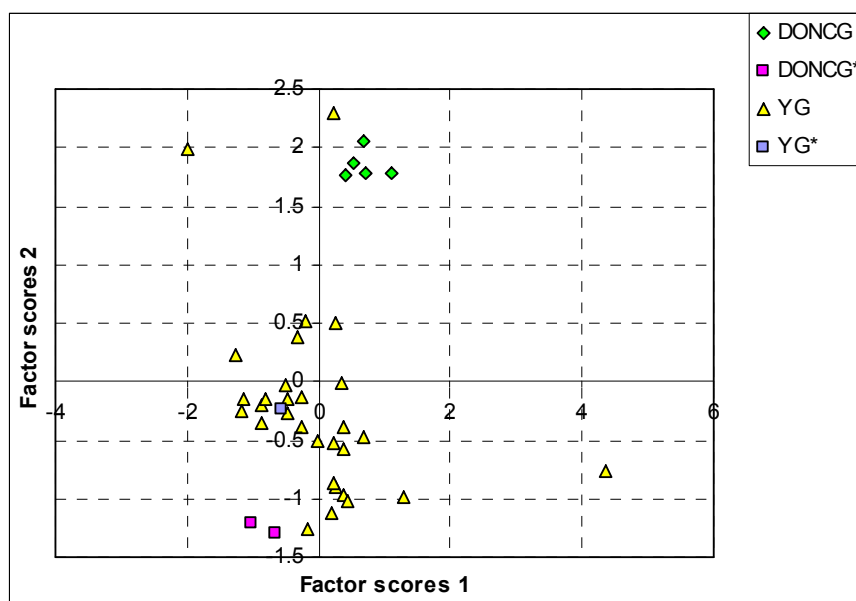


Figure 3

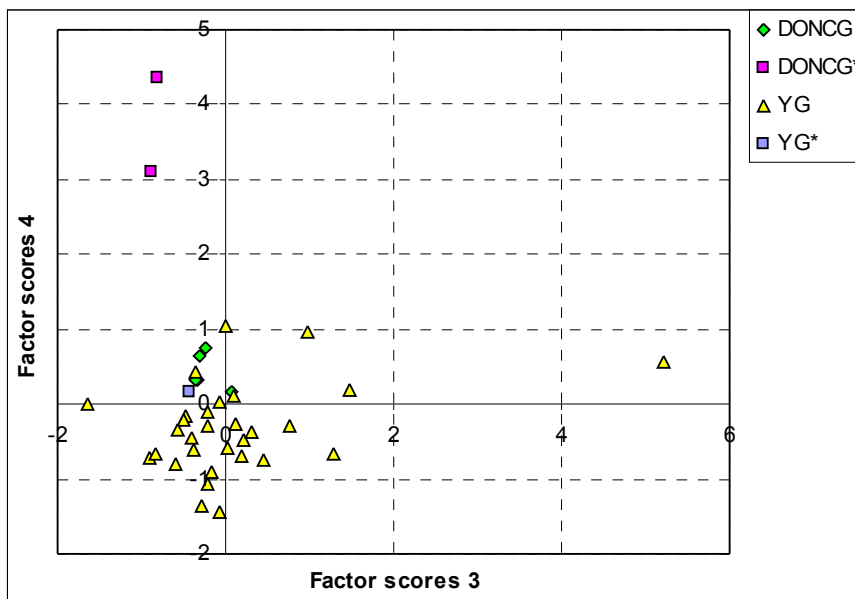


Figure 4

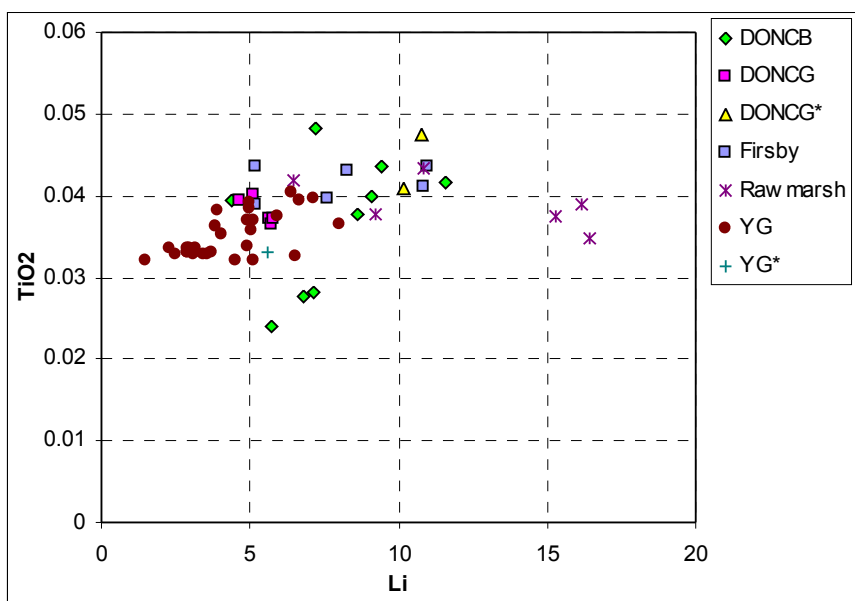


Figure 5

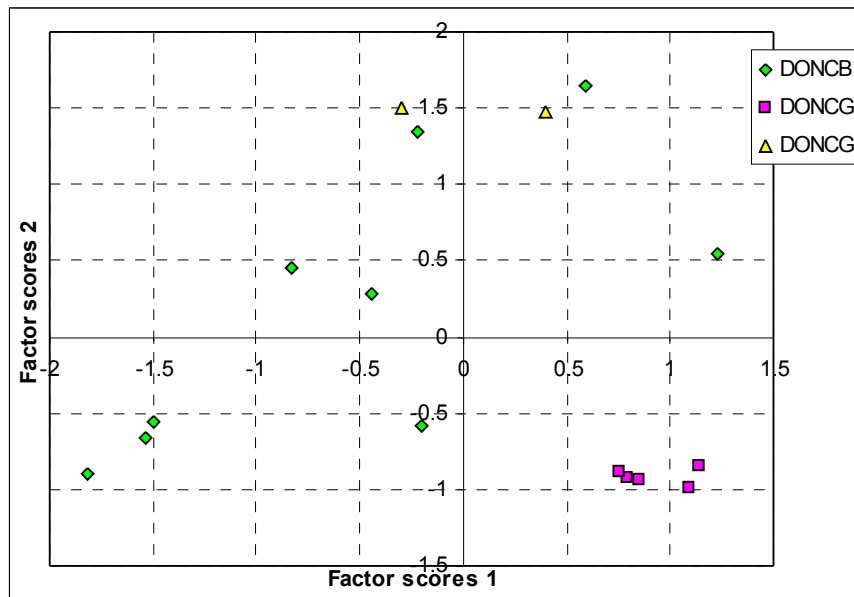


Figure 6

Nottingham Splashed Ware (V4858)

Nottingham splashed ware is found in Nottingham from the early 12th century onwards. its similarity in fabric to later Nottingham glazed wares, for which wasters are known from the city, suggests that it was produced there. As one of the earliest glazed wares in the East Midlands, other than Stamford ware, it is found over a wide area and occurs in Lincoln in deposits pre-dating the foundation of the local Lincoln glazed-ware industry in the early to mid 12th century (Young and Vince 2005, NSP).

The fabric contains fine well-sorted quartzose sand (less than c.0.3mm across) which in thin section is seen to include fragments of fine-grained sandstones and chert grains, probably all derived from the Triassic sandstones through which the Trent cuts in the Nottingham area (the Sherwood Sandstone, originally termed Lower Mottled Sandstone of the Bunter formation and some beds of the Waterstones formation of the Mercian Mudstone, originally termed Keuper Marl, Edwards and Trotter 1954, 64-65).

The Low Fishergate sample comes from the rim and shoulder of a wheelthrown splash-glazed jug with a squared rim and in thin section contains an abundant quartzose sand consisting of subangular quartz; well-rounded quartz; fine-grained sandstone with brown cement and chert fragments up to 0.3mm across in a groundmass of optically anisotropic baked clay. Grains of probable Coal Measures origin are absent, distinguishing this fabric from finer examples of the Doncaster glazed ware.

The ICPS data for this sample were compared with that from various Doncaster glazed red earthenwares using factor analysis. Five factors were found and a plot of the first two (Fig 7) shows that the sample is similar to the two mid 12th-century splashed ware samples (see below). This suggests that perhaps, despite its difference in sand content, this sample is

actually a Doncaster product. However, no ICPS data from Nottingham Splashed ware samples were available for comparison and so this possibility has to remain unexplored.

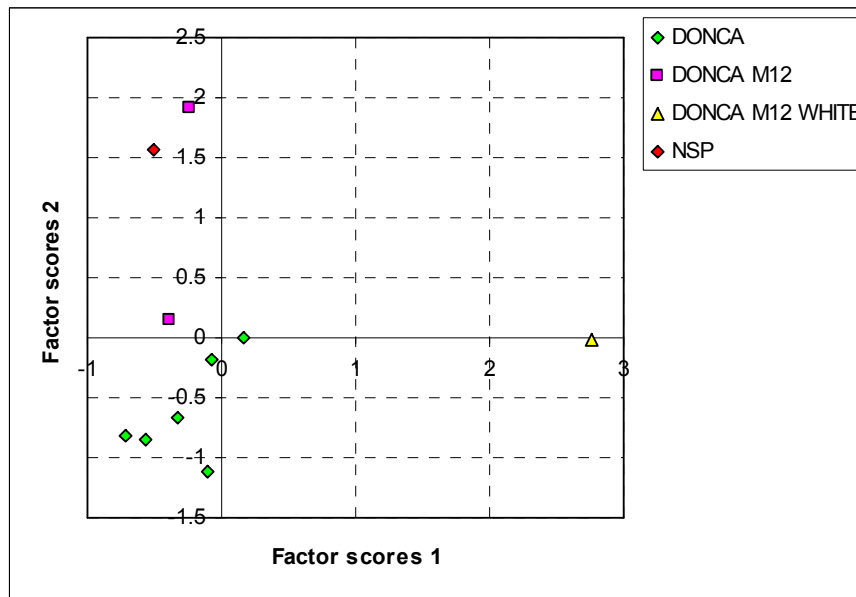


Figure 7

Beverley Glazed Ware (V4861, V4862, V4869, V4867 and V4876)

Wheelthrown, finely-potted glazed red earthenware was being produced in Beverley by the middle of the 12th century and continued to be produced until some time in the mid to late 14th century. Very similar wares are found in York but ICPS analysis suggests that these include vessels produced closer to York, since they have a similar composition to Humberwares produced at York and Holme-upon-Spalding Moor. In thin section, these York Beverley-type wares have a similar appearance to the Beverley vessels but never contain chalk, flint or basic igneous rock fragments. However, these inclusions are only common in the coarser, 12th-century vessels and 13th and 14th-century Beverley and York Beverley-type wares are indistinguishable in thin section (Vince 2004b).

Samples of four vessels from Low Fishergate were analysed. They consist of a highly decorated jug with applied pellets and applied strips arranged in a chevron pattern ((V4869); a vessel with a copper-green glaze and applied, triangular-sectioned vertical strips (V4876); a sherd from an aquamanile with pellet decoration on a wheelthrown body (V4862) and a sherd from a large jug with a plain dipped glaze and a salt-surfaced body. All are absolutely standard Beverley products. In thin section, all have very few inclusions over 0.1mm across and a groundmass containing abundant angular quartz, sparse to moderate muscovite laths, plagioclase feldspar and burnt-out calcareous inclusions, all up to 0.1mm across. The clay matrix is isotropic, indicating a high firing temperature, and some examples show the characteristic mottling found on high-fired ceramics made from calcareous clays.

The ICPS data from the Low Fishergate samples was compared with samples from the production site and occupation sites in Beverley, and with samples of “daughter” industries at York and Barton-upon-Humber (Fig 8). Two samples from Church Way include one which matched the Barton group and another which matched York but the four Low Fishergate samples all match the Beverley samples, two being close to the kiln wasters themselves.

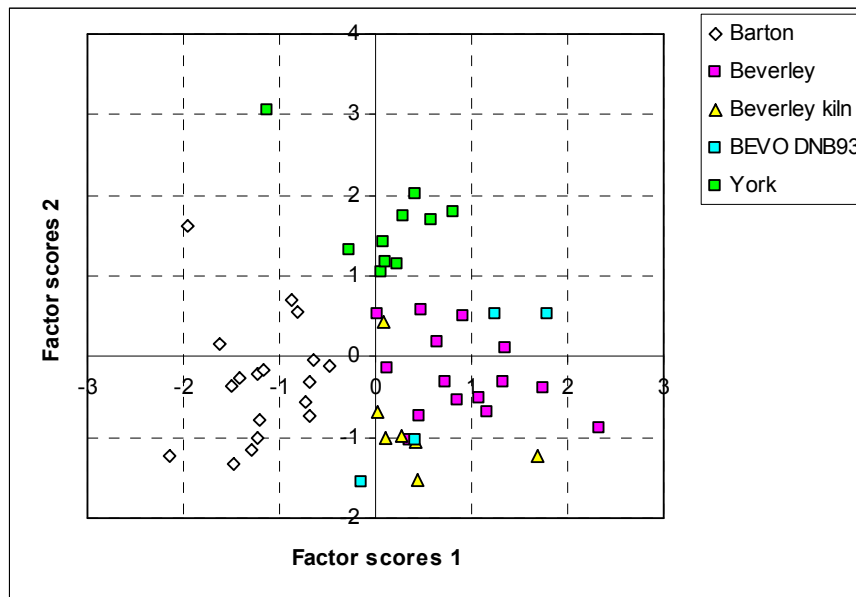


Figure 8

Doncaster Glazed Red Earthenwares (V4858, V4859, V4866, V4868, V4870, V4871 and V4877)

Pottery was made in Doncaster in the medieval period from two different types of clay – a light-firing clay and a red-firing clay – and tempered with two types of sand – a coarse sand containing well-rounded grains from the Sherwood Sandstone and large clay/ironstone pellets and a finer sand containing fragments of red sandstone of Coal Measures origin, clay/ironstone grains and quartz, some of which has the well-rounded profile found in Permian and Triassic sands. The Market Place wasters occur in both types of clay and have the coarse gravel temper (Doncaster C ware) whereas the Hallgate kilns also use both types of clay but the sand temper (Doncaster A is the red-firing ware and Doncaster B is the white-firing ware). In many instances, the firing temperature of the pottery is sufficient to vitrify the clay/ironstone and red sandstone inclusions, hindering identification of these in thin section.

Only vessels of types which are not represented on the two known production areas were sampled from Low Fishergate. These include three splash-glazed vessels: one wheelthrown splash-glazed jug with a strap handle luted to the top of the rim, a mid 12th-century feature (V4859); a second wheelthrown splash-glazed jug also with a wheelthrown strap handle applied to the top of the rim, and an applied snake on the back of the handle (V4868) and a wheelthrown splash-glazed collared rim pitcher, a late 11th to early 12th century type (V4857).

There are slight differences in the character of the sand inclusions (proportion of rounded grains to sandstone fragments, and the mean grain size) in each of the three samples and also differences in the clay matrix (that of V4868 is made from a clay with a low iron content, although this is masked by the black core, whereas the other two are made from similar red-firing clays). Nevertheless, all three share the same suite of inclusions as the sand found in Doncaster A and B wares. They are probably the products of a third Doncaster industry, pre-dating Hallgate and either contemporary with or later than the Market Place production.

One sample is probably a Hallgate product. It is the rim of a jug with a white slip inside and out and a plain lead glaze. The vessel was fired inverted, the standard technique in the medieval period, and brown vertical lines in the glaze probably indicate the presence of applied, iron-rich strips on the body (V4870).

The thin section indicates that the vessel was actually made from a fairly light-firing clay and that the sand contains no red sandstone fragments, only inclusions which could be of Triassic origin (siltstones, cherts and sparse well-rounded quartz grains).

Two other vessels have features which might indicate that they are later than the Hallgate production. One comes from a jug with a brown external slip and internal plain lead glaze (V4877). A separate sherd which might be from the same vessel has a vertical applied strip containing hammscale or ironstone inclusions and has splashes of white slip. The other is the rim of a jar with a sharply everted rim and a white slip inside and out (V4871). There is no glaze surviving on the sherd.

Both of these samples have similar petrological characteristics to the two red-firing splash-glazed samples and are most likely to be Doncaster products.

The ICPS data for these various Doncaster redwares was analysed using factor analysis (see above, Nottingham Splashed ware, Fig 7). The two splash-glazed redware vessels have higher F2 scores than samples of Hallgate A from Hallgate itself and with the two samples with red and white slips from Low Fishergate, both of which have similar compositions to the Hallgate samples. The splash-glazed vessel made from a lighter-firing clay has a higher F1 score than the redwares.

The analysis of the ICPS data suggests that the splash-glazed wares were made from different clays than those used at Hallgate, and that the red-firing and white-firing clays have different chemical compositions and should therefore be assigned different fabrics, despite the fact that visually the two groups look extremely similar and, to judge by both the Market Place and Hallgate production sites, both red-firing and white-firing clays were used on the same sites. The analysis also suggests that there is no difference between the samples with typologically late features and the Hallgate samples, and that sample V4870, which in thin section appears unusual also has a chemical composition consistent with the Hallgate products.

Doncaster Glazed Whiteware Ware (Hallgate B ware, V4875)

A single sample from Low Fishergate was similar to Hallgate whiteware (Doncaster B) in texture but was high-fired, leading to the vitrification of the iron-rich inclusions and the development of a purple external surface. In this respect, the vessel was more similar to those produced at Firsby and Rawmarsh. In thin section, the sample contained abundant quartzose sand, with vitrified fragments of red sandstone and clay/ironstone. No relict light-firing clay pellets were noted, a feature of both Firsby and Rawmarsh wares.

The ICPS data for this sample were compared with that from samples of Firsby and Rawmarsh wares. Factor analysis found four factors, and the first two show no clear patterning. However, the third and fourth factors separate the three production sites and place same V4875 in the Doncaster B group, alongside the two unglazed whiteware samples (marked here as DONCB FINE, Fig 9).

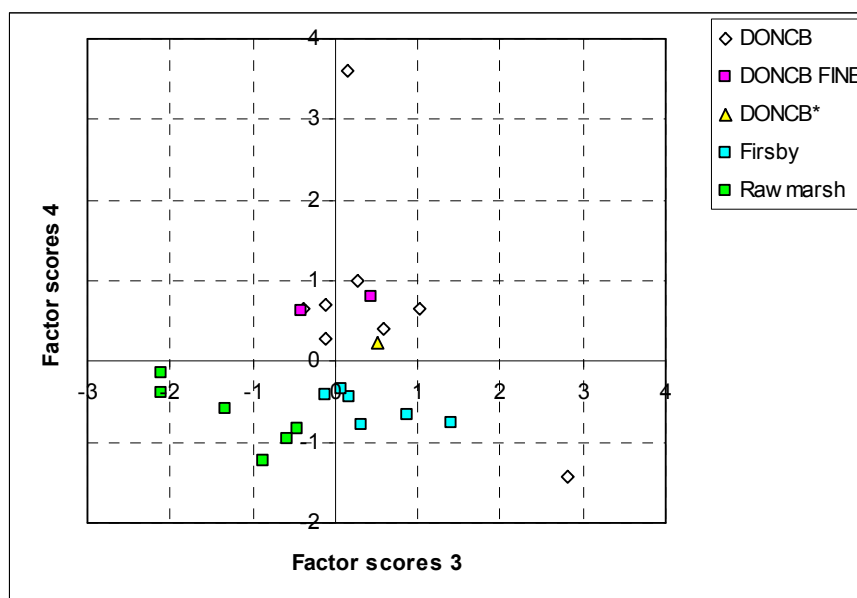


Figure 9

Coal Measures Whiteware (V4855, V4856 and V4865)

Two samples of Coal Measures Whiteware vessels from Low Fishergate were analysed. One of these, V4875, has a fine sandy, micaceous white groundmass, with sand inclusions which consist of sandstone and vitrified clay/iron fragments. Visually it appears similar to samples from Firsby. It is very crudely potted, perhaps by hand, and has a pale green glaze which might either be coloured through reduction or a slight addition of copper.

In thin section, V4856 contains large inclusions of quartz and minor feldspar (probably both derived from a coarse-grained sandstone); fine-grained sandstone; organic white-firing mudstone and inclusionless kaolinitic mudstone. The groundmass consists of white anisotropic baked clay with abundant well-sorted angular quartz grains and sparse

muscovite. These inclusions suggest the presence of Millstone Grit and finer sedimentary rocks which might be of either Millstone Grit or Coal Measures age. These suggest that this vessel may come from further west than either Firsby or Rawmarsh.

The second sample comes from a wheelthrown whiteware vessel which has a plain lead glaze inside and out (V4856). The vessel has been fired at a high temperature and the iron-rich inclusions have bled and blistered into the glaze. Visually, this is similar to Rawmarsh ware.

In thin section, V4855 contains fragments of quartz and red sandstone up to 0.5mm across, vitrified clay/ironstone and abundant large inclusionless kaolinitic mudstone up to 3mm across. These characteristics are consistent with a Rawmarsh source.

The ICPS data for these two samples was compared with that from a series of unsourced Coal Measures whitewares from Church Way (thought from their chemical composition to be Firsby ware); Doncaster B samples; Firsby wasters; Rawmarsh wasters and an unsourced roller-stamped whiteware which had a similar appearance in thin section to V4856 but without the coarse grit (BRUNS on Fig 10). Factor analysis of this dataset distinguished Rawmarsh from other samples and places V4855 outside the Rawmarsh group, but also outside the remaining group, consisting mainly of Firsby and Doncaster products. From this we can conclude that the sample is not a Firsby or Doncaster product, but since all the Rawmarsh samples come from the same waste pit, it might be a Rawmarsh product from some other production episode. Sample V4856 plots within the Firsby/Doncaster group and a second analysis, omitting the Rawmarsh samples and the unsourced samples, separates Doncaster and Firsby samples and places V4856 in the Firsby group. It is possible therefore that coarse gravel derived mainly from the Millstone Grit crops out at Firsby and was used with the same Coal Measures whiteware clay as was used for other Firsby products, or that the source is actually more distant and the match with Firsby is fortuitous. Only finding sherds of similar fabric at Firsby as wasters would confirm the identification.

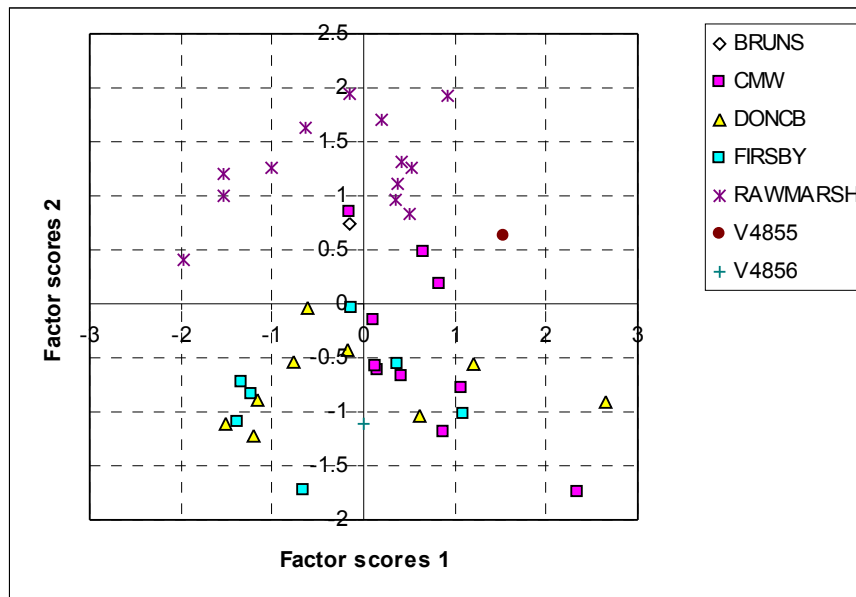


Figure 10

Post-medieval Wares (V4865 and V4867)

Two vessels of post-medieval date were sampled. One is from a vessel with a pink coloured body which appears to have had a red slip, which is now partially vitrified as a result of the high firing temperature (V4865).

In thin section, V4865 contains fragments of quartz and sandstone derived from red sandstones, of similar grade to those found in Doncaster products and much finer than those in V4856. The groundmass contains thin streaks of white-firing and red-firing clay, moderate angular quartz grains up to 0.1mm across and sparse muscovite.

The second sample is from a finely-potted vessel with a plain lead glaze through which the red and white-firing clays which make up the fabric can be seen (V4867). The use of poorly mixed clays of different colours is used in the post-medieval period as a decorative technique, Agate ware, but the similarity in colour of this vessel and the first sample, which also shows variegation which is invisible in the finished product because of the use of a red slip, suggests that the Agate ware appearance might be accidental.

In thin section, V4867 contains few inclusions over 0.1mm across apart from sparse rounded dark brown clay/iron grains up to 0.3mm across and has a variegated groundmass consisting of thin streaks of red-firing clay with few inclusions and white-firing clay containing abundant angular quartz.

The thin section evidence suggests that both samples could be made from the same clay with a quartzose sand derived from Coal Measures sandstones used to temper the coarser vessel.

No close comparanda for ICPS analysis are known and for this period the source need not be sought locally. However, the two samples were compared with Doncaster products (Doncaster A and B wares, both produced in the Hallgate kilns and elsewhere) and a clear separation from these two samples was found (Fig 11). This is support for the suggestion that the two samples come from the same source, which is not local to Doncaster (or at least exploited difference clay sources).

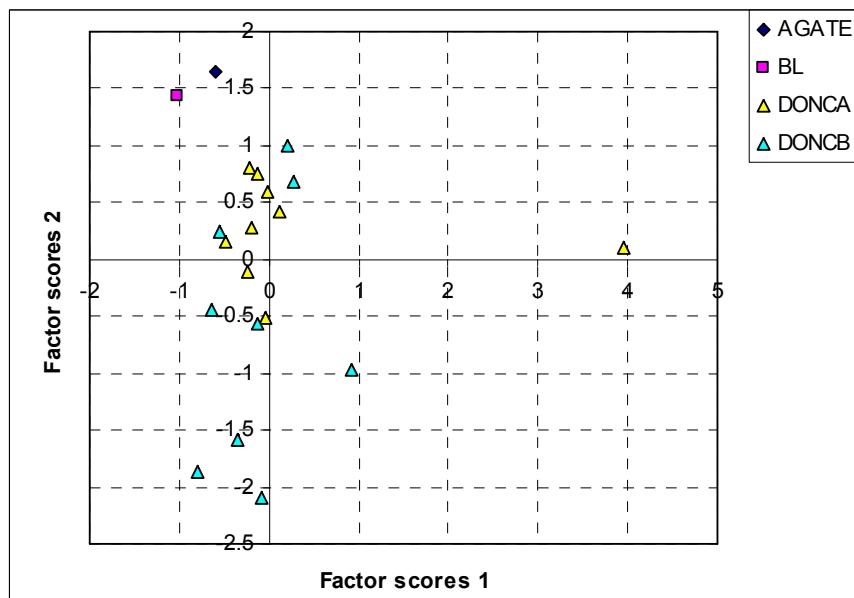


Figure 11

Conclusions

A combination of thin section and chemical analysis enabled the identification of several well-known wares produced outside of Doncaster to be confirmed. These include Grimston Thetford-type ware from Pott Row, Grimston, and Early Medieval Handmade /ware from Blackborough End. Both of these wares were probably exported from King's Lynn and their presence is evidence for coastal trade in the late 11th to early 12th centuries at Doncaster. Other wares whose source could be established were East Yorkshire Quartz and Calcareous ware, probably produced somewhere to the south of Market Weighton and north of the Humber, just to the west of the Chalk Scarp, and Beverley-type glazed ware, all four samples of which were probably Beverley products rather than one of the daughter industries. Finally, a sherd was identified as York Gritty ware, produced probably at Potterton.

Nottingham Splashed ware could not be positive identified, mainly because the characteristics in thin section do not exclude a local source and there are no ICPS analyses of confirmed Nottingham Splashed ware to compare.

The study indicated that there is a mid 12th century splash-glazed ware industry in Doncaster whose products are chemically distinct from those produced at Hallgate and which include both red-firing and white-firing fabrics. This industry may be contemporary with that at the

Market place, but is perhaps more likely to be slightly later, filling the gap between the Market Place industry and that based at Hallgate. Two unglazed whiteware vessels thought originally to be Doncaster Gritty ware and of later 11th to 12th century date were shown by their chemical composition to be made from the same white-firing clay as that used at Hallgate. They may be products of that industry which were more finely potted and less heavily tempered or may be products of yet another Doncaster industry. Other samples whose fabric is paralleled at Hallgate may extend the known range of types produced there or be products of yet another industry, perhaps post-dating Hallgate itself.

Finally, two samples of post-medieval date were analysed, a coarseware jar with a red slip and a fineware vessel. Both were shown to be made from similar clays and to be distinct from known Doncaster products. They were probably produced elsewhere and imported to Doncaster.

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Appendix 1

TSNO	Context	Form	Description	YAT Code
V4855	1415	JUG	PLAIN LEAD GL INT AND EXT WITH ABUNDANT IRON BLEEDING	PURPCM
V4856	1364	JUG	PLAIN SPLASH GL EXT	WHCM
V4857	2857		WT;COLLAR RIM;PLAIN EXT GL	SPL 1 3
V4858	2857	JUG	WT;SQUARED RIM;PLAIN EXT SPLASH GL	SPL 1 1
V4859	2857	JUG	STRAP HANDLE JOINING AT RIM;THUMBED ON EDGES;PLAIN EXT SPLASH GL	SPL 1 2
V4860	1100	JAR	WT;TRIANGULAR RIM	WHGW 7
V4861	2706	JUG	WT;EXT WHSL;DIPPED CUGL;VERTICAL NOTCHED APP	HALLA 10
V4862	1467	AQUA	SCALES;EXT CUGL	SCAR 5
V4863	1412	JAR	WT	OXSN 1
V4864	2996	JAR	WT;UNDERCUT RIM;GLOB BODY	WHGW 2
V4865	1378	JAR	WT;PLAIN GL INT AND EXT	LMOX 1
V4866	2930	JAR	WT;SQUARED RIM	SPLASH W 2
V4867	1098	CUP	WT;INT AND EXT PLAIN GL	SLIPW1
V4868	2848	JUG	WT STRAP HANDLE JOINING AT RIM; APPLIED SNAKE ON BACK OF HANDLE; PLAIN GL	HALLA 1
V4869	1100	JUG	APPLIED SELF-COLOURED TRIAPP ARRANGED IN CHEVRON AND CONTAINING SCALES	FNOX1
V4870	2626	JUG	WHSL INT RIM; EXT HAMMERSCALE-RICH VERT APP;PLAIN GL	HALLA26
V4871	2041	JAR	WT; EVERTED RIM;WHSL INT AND EXT	SLP1
V4872	2232	JAR	HM	EMHM1
V4873	1129	JAR	WT;GLOB BODY;RARE PLAIN GL SPLASH	WHGW6
V4874	2721	SJ	SAGGING BASE	TORKSEY WARE 1
V4875	1490	JUG	EXT PLAIN GL WITH IRON BLEEDING	PURPCM

The Alan Vince Archaeology Consultancy, 25 West Parade, Lincoln, LN1 1NW

<http://www.postex.demon.co.uk/index.html>

A copy of this report is archived online at

<http://www.avac.uklinux.net/potcat/pdfs/avac2008025.pdf>

V4876	2537	JUG	VERY THICK APPLIED WHITE SLIP EXT;VERTICAL TRIAPP CUGL	FRCD2
V4877	2626	JUG?	RED SLIP EXT;WHITE SLIP BLOBS OVER;PLAIN GL INT; HAMMERSCALE IN VERT APP STRIP	HALLA 28

Appendix 2

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V4855	20.95	3.95	0.75	0.17	0.27	2.45	0.90	0.07	0.025
V4856	24.30	4.44	0.60	0.15	0.21	1.70	0.91	0.15	0.044
V4857	19.17	7.40	2.47	2.27	0.35	3.16	0.73	0.38	0.180
V4858	19.16	6.54	2.17	2.21	0.37	3.41	0.73	0.26	0.116
V4859	18.07	6.19	1.43	0.30	0.34	2.98	0.69	0.14	0.054
V4860	26.12	3.48	0.69	0.12	0.26	1.96	1.07	0.09	0.032
V4861	20.20	7.12	1.35	1.38	0.62	2.21	0.98	0.19	0.032
V4862	16.50	7.35	1.23	1.58	1.25	2.45	0.82	0.20	0.062
V4863	15.90	5.66	1.06	2.60	0.45	2.41	0.61	0.34	0.045
V4864	21.42	4.49	0.77	0.36	0.20	1.95	0.71	0.18	0.035
V4865	18.95	6.16	0.74	0.17	0.29	2.61	0.87	0.06	0.033
V4866	16.07	6.62	1.26	3.09	0.40	3.00	0.70	0.24	0.069
V4867	20.52	5.55	0.65	0.20	0.25	2.29	1.05	0.18	0.021
V4868	20.26	5.79	1.27	0.32	0.43	2.51	0.72	0.18	0.154
V4869	17.98	6.66	1.55	1.74	0.77	2.68	0.88	0.29	0.045
V4870	23.10	7.97	1.55	0.30	0.36	3.32	0.98	0.11	0.056
V4871	22.07	7.42	1.49	0.27	0.48	3.22	0.94	0.10	0.053

V4872	14.28	13.88	1.08	0.87	0.21	2.29	0.60	0.76	0.119
V4873	24.19	3.57	0.68	0.14	0.35	1.97	1.15	0.05	0.039
V4874	17.09	6.35	1.33	0.87	0.21	2.73	0.78	0.47	0.061
V4875	22.87	5.36	0.66	0.19	0.27	1.94	0.95	0.09	0.060
V4876	18.99	4.32	1.19	0.91	0.68	2.52	0.92	0.33	0.030
V4877	21.65	7.17	1.40	0.30	0.41	3.09	0.91	0.10	0.064

Appendix 3

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V4855	464	81	41	288	36	19	117	149	27	103	46	86	47	9	2	4	3	3,358	54	11
V4856	389	100	24	172	35	19	68	132	15	86	39	68	39	5	1	2	2	209	38	12
V4857	513	93	34	151	55	15	176	100	26	66	50	92	52	9	2	5	2	1,219	109	17
V4858	503	97	31	147	52	15	172	88	22	60	50	91	51	9	2	4	2	373	118	16
V4859	516	95	24	93	52	14	100	112	25	59	49	84	50	10	2	4	2	129	102	17
V4860	484	107	25	266	47	20	83	154	14	67	43	73	42	7	1	2	2	92	41	15
V4861	594	114	23	111	45	17	133	146	22	70	54	96	54	10	2	4	2	485	68	16
V4862	563	82	101	83	50	14	126	113	27	72	47	74	48	10	2	4	3	1,823	68	16
V4863	475	90	22	87	40	15	134	147	16	62	36	73	36	6	1	3	2	40	82	15
V4864	581	113	21	120	29	16	83	117	19	53	44	77	44	6	1	3	2	30	34	10
V4865	423	97	29	119	23	17	94	124	17	75	38	70	38	7	1	2	2	385	49	11
V4866	378	88	21	77	46	16	145	160	20	93	37	80	38	6	1	3	3	27	102	16
V4867	497	96	24	174	36	17	244	122	23	105	48	84	48	9	1	3	2	832	60	12
V4868	1,273	112	29	119	82	22	113	124	52	79	54	94	59	17	3	9	4	2,107	119	16
V4869	626	109	38	96	61	17	137	116	34	87	52	95	53	11	2	5	3	530	88	20

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V4870	641	127	35	106	59	20	117	140	32	89	58	107	59	12	2	5	3	789	100	17
V4871	602	107	36	103	53	19	112	123	33	101	56	101	57	11	2	5	3	220	103	21
V4872	379	87	34	62	211	18	61	143	36	95	46	106	49	12	2	6	4	456	135	32
V4873	468	97	26	261	48	21	82	127	24	109	45	80	45	6	1	3	2	325	48	18
V4874	674	134	31	80	205	19	55	176	28	148	56	166	57	13	2	5	3	85	162	32
V4875	499	96	35	265	56	21	90	136	22	90	43	79	44	7	1	3	3	748	58	17
V4876	630	87	32	83	32	16	119	121	24	86	48	94	49	9	1	4	3	1,440	114	13
V4877	553	138	58	99	57	18	105	123	24	63	52	87	53	10	2	4	2	1,752	97	23