Characterisation Studies of some Romano-British pottery from Elloughton, East Yorkshire (OSA02 EX08)

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As part of the assessment of the Romano-British pottery from the rural settlement of Elloughton all of the pottery was examined at x20 magnification by Ms B Precious, who stated that several of the coarsewares appeared to have distinct fabrics which might allow their sources to be defined by the use of petrological and/or chemical analysis. Consequently, a sample of 21 sherds was selected for further analysis (Table 1).

Table 1

TSNO	Context	Sub-fabric	REFNO	cname	Form	Action	Description
V2107	1274			CALC	JHUNV	TS;ICPS	RIM NO GROOVE; POSS BHUNV;TS?
V2108	1211	S		LOOL		TS;ICPS	BS W ROCKS;TS?
V2109	1077	S		DWSH	JDW	TS;ICPS	RIM SHLDR TS?
V2110	1271			CALC	CLSD	TS;ICPS	BS; POSS HUNT TYPE;TS?
V2111	1113	S		DWSH	JDW	TS;ICPS	BASE BSS THICK; TS?
V2112	1076			COAR	L?	TS;ICPS	BSS W LOOL TS
V2113	1076			COAR	J	TS;ICPS	BASE W LOOL TS
V2114	1020	D		SHEL		TS;ICPS	BS W GROG? LIMESTONE TS?
V2115	1020	M		SHEL	JBEV	TS;ICPS	RIM OXID SOME OOL TS?
V2116	1113	S	D21	DWSH	JDW	TS;ICPS	RIM SHLDR BSS W OOLITHS?;TS
V2117	1113	C		DWSH	JDW	TS;ICPS	BSS NECK; SOME OOLITHS?; TS?
V2118	1077	D		LOOL	CLSD	TS;ICPS	BS RDBN
V2119	1257			GROG	CLSD	TS;ICPS	FLAT BASE
V2120	1077		D23	COAR	JCUR	TS;ICPS	RIM; OOLITHS; TS
V2124	1077			COAR	CLSD	TS;ICPS	BASE BSS; OOLITHS; TS
V2125	1111	C	D15	DWSH	JDW	TS;ICPS	RIMS SHLDR BSS; W FOSSILS TS
V2126	1113	C	D21	DWSH	JDW	TS;ICPS	BSS NECK; BASE BSS SHLDR PROF RIM MISS
V2127	1107	C	D17	DWSH	JDW	TS;ICPS	REM? <1>
V2128	1077	C	D24	LOOL	JCUR	TS;ICPS	RIM NECK
V2129	1107	C	D14	DWSH	JDW	TS;ICPS	RIMS; BSS FRAGS CORDON W
V2130	1148		D18	CALC	CLSD	TS;ICPS	NOTCH;UNUSUAL

Methodology

Each of the samples was sub-sampled for thin-section and chemical analysis. The thin sections were prepared by Peter Hill and produced by Steve Caldwell of Manchester University. They were stained using Dickson's method (Dickson 1965) to distinguish ferroan and non-ferroan calcite from dolomite.

Each thin section was then systematically examined having first scanned the whole collection to establish the range of inclusion types present. For each inclusion type the frequency, size, roundness and, if sufficient examples were present, the sorting, were noted along with a description of any unusual characteristics. In this report only those features which may help to provenance the pottery or which may aid identification of the fabric are noted.

The samples for chemical analysis were also prepared by Peter Hill. This involved the mechanical removal of the outer surfaces and potentially contaminated broken edges of the sample and the crushing of the remainder, about 1-2gm, to a fine powder. This powder was then submitted to Dr J N Walsh, Royal Holloway College, London, and analysed using Inductively-Coupled Plasma Spectroscopy. The lab's standard program of analysis was carried out, with the addition of lead (Pb) which is measured routinely for AVAC samples to test for contamination by lead glaze (obviously not relevant in this instance). The measured elements include major elements, measured as percent oxides (Appendix 1a), and minor and trace elements measured as parts per million (Appendix 1b). An estimate of the quantity of silica in the sample was calculated by subtracting the total of measured major elements from 100% (Table 2). This indicates, as expected, that the COAR fabric, which is tempered with a quartzose sand has a higher silica content than the remaining samples. The exceptionally low values for some of the DWSH samples is a reflection of the use of limestone and shell temper.

Table 2

cname	55-60	60-65	65-70	70-75	75-80	Grand Total
CALC		1	2			3
COAR				3	1	4
DWSH	1	3	3	1		8
GROG			1			1
LOOL		1	1	1		3
SHEL		1	1			2
Grand Total	1	6	8	5	1	21

The chemical data were transformed by dividing each measured value by that for $Al2O_3$, since this reduces the dilution effect caused by quartz sand and calcareous inclusions. The transformed dataset was then analysed using Factor Analysis where a number of factors are calculated which allow the similarity of the samples to each other to be portrayed graphically and related back to the underlying chemical differences. The first factor is always the most important in terms of accounting for similarity, then the second and so on. For the Elloughton samples it was found that high Factor 1 values were mainly due to a range of rare earth elements, and a corresponding lack of Strontium (Sr). The former are usually found in the clay fraction since they bind to clay minerals whereas the latter is present mainly in Calcite where it substitutes for Ca. High F2 values are associated with high K_2O and TiO_2 values and low Li, Ni, Cu, and Fe_2O_3. High K_2O probably indicates a high mica content (or clay minerals of the mica family) although it is also present in detrital feldspar and in glauconite, TiO_2 is

present usually as Titanium oxides such as rutile and Lithium (Li) is mainly present in sediments in illite, a clay mineral.

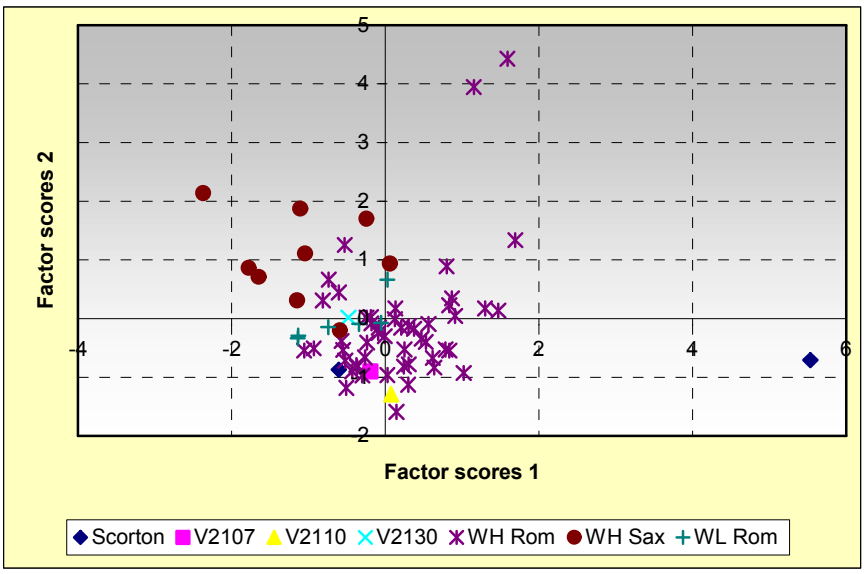
Once the relationships between the chemical composition of the samples had been calculated, the data could then be compared with those of samples from other sites.

Description

Calcite-tempered ware (CALC)

Three samples of calcite-tempered ware were analysed. All three contain fragments of sparry calcite and rare chalk through which the calcite veins ran. Two of the samples (V2107 and V2110) also contained rounded opaque inclusions, probably haematite replacing glauconite, and the third (V2130) contained sparse glauconite and no haematite. There is difference in the texture of the groundmass between the two groups. The first contains little silt and the second contains moderate quartz and muscovite silt. Sample V2130 is similar to samples from West Heslerton in the Vale of Pickering which is the likely source of much of this ware. However, no samples with the rounded opaque grains were seen at West Heslerton nor in other samples of this ware examined in thin section. Nevertheless, it is likely that the parent clay was still a lower Cretaceous clay and such clay only outcrops locally along the south side of the Vale of Pickering, since along the west side of the Yorkshire Wolds the chalk rests unconformably on Jurassic strata.

Factor analysis of a range of calcite-tempered samples, including Anglo-Saxon examples from West Heslerton, indicates that chemically all three of the Elloughton samples are comparable with the Vale of Pickering samples, however (Fig 1). Fig 1 shows a plot of F1/F2 for this dataset which can be interpreted to suggest that one of the Scorton samples is not from this group and that there is a chemical difference between some of the Anglo-Saxon and Roman samples which are, nevertheless, probably all from the Vale of Pickering.



Coarse Sand-tempered ware (COAR)

Four samples of COAR were analysed. All four have a similar appearance in thin section. They indicate the use of a coarse rounded sand or gravel temper of mixed origin and a groundmass which contains little or no silt but abundant subangular opaque inclusions up to 0.1mm across. Similar coarse sand temper has been noted in several samples of East Yorkshire Anglo-Saxon pottery, but usually these contain sparse to moderate fragments of rounded basic igneous rock, which is absent from the Elloughton samples. Brown-stained subangular flint is present in only one sample, V2112, whilst both chalk and an oolitic limestone are present in all samples. Fine-grained sandstones, some with a cement of ferroan calcite, are present in all samples.

To try and localise the potential production area, the ICPS data for these samples was combined with data from all the samples available to the author from East Yorkshire and northern Lincolnshire. By a repeated series of analyses all those samples which were clearly different in composition from the Elloughton samples were excluded and a fresh factor analysis carried out. This eventually left 86 samples, including those from Elloughton, which had similar chemical compositions. These included only one Lincolnshire sample, of Oxford Clay from the Roman pottery production site at Market Rasen, the actual products of that industry all had differing compositions. The remaining samples included a range of Anglo-Saxon and medieval coarsewares found at sites throughout the county, from Sewerby in the north to Easington at the southern end of the Holderness peninsula. In no case, however, is the actual place of manufacture of these samples known. The large number of samples from Sancton is perhaps only a reflection of the size of the Anglo-Saxon pottery collection from the site and samples of clay collected in the Sancton area failed to match.

cname	Beverley	Driffield	Easington	Elloughton	Elmswell	Garton Slack	Kingston upon	Mappleton	Market Rasen	Sancton	Sewerby	Wawne	Grand Total
CLAY SAMPLE								1	1				2
CLSST										7			7
COAR				4									4
ECHAF			1							4			5
ERRA			6		2					4			12
ESGS										1			1
FE		1								1			2
GROG				1									1
LIM										3			3
LSAXX	2												2
LSLOC	1												1
NLQC	1						5						6

REDC	3											6	9
ROUND			6		1					6	4		17
SST			1			1				7	3		12
SSTMG										2			2
Grand Total	7	1	14	5	3	1	5	1	1	35	7	6	86

The microscopic opaque inclusions seen in the thin sections appear to be rounded or oval in outline and might be of biological (e.g. faecal pellets) or authigenic origin (e.g. nodules formed *in situ* through precipitation from solution). Similar clays have been noted in the Jurassic and in the Tertiary clays of the Thames Basin but the most likely source is the Oxford clay, which outcrops in a triangular shaped area north of the Humber, as well as forming the bedrock of the Vale of Ancholme to the south. No similar clays outcrop to the east of the chalk and in any case the lack of basic igneous rock in any of the four samples argues against an origin in the boulder clays of East Yorkshire, where erratics are very common in the sand fraction. The coarse sand temper includes material of Jurassic and Cretaceous origin, whilst the stained flints probably come from Quaternary gravel deposits. In conclusion, we can probably define the potential source of this ware to a small area north of the Humber or to somewhere in the Ancholme Valley.

Dales-type Shell-tempered ware (DWSH)

The source or sources of Dales Shelly ware has been studied by Loughlin (Loughlin 1977) and more recently by Firman (Firman 1991). The conclusion of Loughlin's study, which was based on a combination of thin section and heavy mineral analysis, was that the shelly component could be of Jurassic origin whereas the heavy mineral suite was dominated by anhydrite, for which a Permo-Triassic origin was likely. Loughlin therefore suggested a source at the junction of these two strata, where the desert conditions of the Triassic were being replaced by the marine conditions of the Jurassic and pointed to the Rhaetic as a possible origin for both the clay and the shell temper. Firman (1991) suggests that the anhydrite found in Loughlin's HMA samples is likely to have been formed through the dehydration of gypsum during firing, a reaction which takes place at temperatures above 220 degrees C. However, both authors, for different reasons, favoured the same geographical location, on the lower slopes of the river Trent escarpment between Alkborough and Burton Stather as being a likely source. Loughlin favoured a mixture a mixture of Mercian Mudstone and Rhaetic clays whilst Firman argued for a solely Rhaetic source, somewhat further upslope.

Eight samples of Dales-type shell-tempered ware from Elloughton were sampled. The thin sections were recorded alongside those of the two other shelly wares, LOOL and SHEL, since a large amount of similarity was found in the petrological characteristics of all three groups.

In the assessment, Barbara Precious identified several fabric groups in the shell-tempered wares from Elloughton. The first was standard Dales Shelly ware (DWSH), mostly lid-seated jars. A second appeared to contain limestone rather than shell (LOOL in assessment archive) and a third contained shell but could not be positively identified as Dales Shelly ware (SHEL in assessment archive).

As a result of the subsequent analysis it was determined that although there were in fact four fabric groups, identifiable through their petrological characteristics and from their chemical composition (see below), that the degree of similarity between them, and the difficulty in identifying the fabric groups by eye, mean that it is better to treat all as sub-fabrics within the Dales Shelly group. However, this ware is often used as a chronological indicator, especially in York where it is only found in the 3rd century. At Elloughton, however, there are sherds of shell-tempered ware associated with late Iron Age or early Roman wares whilst many of the Dales ware sherds are associated with Calcite-tempered ware of probable 4th/early 5th-century date. Extending the ware definition to cover vessels with the same fabric but different technology or typology may therefore create one confusion whilst solving another. Any hope that the three sub-fabrics might differ in date was dashed by the fact that the three samples from 1st/2nd-century deposits belong to three different sub-fabrics.

To try and deal with this problem, the shell-tempered wares from the site were re-examined and the following criteria applied: LOOL = shell-tempered ware with no clear evidence for being Dales-types ware form or rim type, DWSL = standard Dales-type ware. At Lincoln a third group, also classed there as a Dales-type ware, mirrors the typology of the 4th/5th century Calcite-tempered ware jars and may include some wheelthrown examples. This group, which seems to have slightly different petrological characteristics as well, is not present at Elloughton. The four sub-fabrics were assigned letter codes: D (dolomitic), M (marly), S (silty) and C (Cretaceous).

Sub-fabric D

Two samples (V2114 and V2118) contained abundant fragments of rounded sparry dolomite (or non-ferroan calcite, since there is a very faint pink stain) up to 2.0mm long together with sparse to moderate rounded fragments up to 2.0mm long of a limestone with a mixed clay/ferroan calcite matrix and containing bivalve shell fragments. Echinoid spines were noted in one section, sparse rounded quartz in the other. In both sections the groundmass was free from silt inclusions and consisted of anisotropic baked clay minerals.

It is possible that the two limestones occur together and that the sparry fragments either originate as concretions or fossils. Dolomitic limestones occur in the Permian rocks which outcrop well to the west of Elloughton but the Hydraulic Limestones of the Lower Lias should also be considered as a potential source (1980) as should the Rhaetic. The Hydraulic limestones outcrop to the west of Elloughton and in the Trent valley and are described as ‘shelly or argillaceous, partly concretionary limestones’ (Kent 1980, 25). The ferroan limestone is very similar to that found in the other sub-fabrics. It should be noted that all the inclusions, with the possible exception of the echinoid spines, are detrital but the limited variability and their size does not suggest that the sand from which they came was located at any great distance from the source.

Sub-fabric M

A single sample has been assigned to this sub-fabric on the basis of its groundmass, which uniquely in the shelly ware samples, is calcareous, containing specks of ferroan calcite, and also contains abundant rounded opaque grains less than 0.1mm across, similar to those observed in the Coarse sand-tempered ware sections. The larger inclusions consist of moderate rounded quartz sand, less than 0.5mm across, moderate rounded opaque grains up to 0.5mm across, moderate rounded fragments of limestone with a marly ferroan calcite micrite groundmass with bivalve shell inclusions up to 1.5mm across, and sparse rounded micrite grains up to 1.0mm across with a very faint pink stain (i.e. either non-ferroan calcite or dolomite).

Sub-fabric S

Four samples have a silty, micaceous groundmass which is noticeable visually and chemically. In the main, however, the range of inclusions in these samples is the same as that in the main fabric, C. These inclusions consist of sparse non-ferroan punctate brachiopod shell, sparse fragments of nacreous bivalve shell, including pieces of large ornamented shells (some of these are definitely from a limestone, having ferroan calcite cement surrounding them), variable quantities of echinoid spines, from none to moderate in frequency, sparse rounded ferroan calcite echinoid shell fragments. One of the samples, V2108, contains moderate rounded quartz grains up to 0.5mm across, sparse rounded chert grains and sparse rounded chalk fragments up to 1.0mm across. Two of the other fragments also contains rounded micrite which might be chalk although the diagnostic microfossils were absent. All four samples contained moderate rounded opaque grains up to 0.5mm across and two contained sparse rounded fragments of marly limestone, as in sub-fabric M.

Sub-fabric C

Six samples had a similar range of inclusions to those in sub-fabric S but had an inclusionless groundmass. The larger inclusions consist of sparse rounded oolitic limestone, noted in only one sample (V2128), sparse punctate brachiopod shell, surrounded by a ferroan calcite cement (also noted only in V2128), sparse nacreous bivalve shell (moderate in V2125), sparse echinoid spines (only in two samples, V2126 and V2129), sparse rounded ferroan calcite echinoid shell, moderate to abundant rounded quartz up to 0.5mm across, sparse rounded chert (V2117 only), sparse rounded micrite, definitely chalk in three samples, moderate rounded opaque grains up to 0.5mm across (only sparse in V2129), sparse rounded fragments of marly ferroan calcite with shell and other fossil inclusions (moderate in V2129) and sparse angular flint up to 1.0mm across, together with a single rounded brown-stained flint fragment in V2128.

The source(s) of Dales Shelly ware

The size of the calcareous inclusions in these samples makes it difficult to establish the nature of the rock or rocks from which they came. This is especially difficult since it is clear that the inclusions are detrital and from more than one geological source. There is a suite of Cretaceous inclusions, (chalk, fresh angular flint and possibly quartz) present in six of the samples, which has a distinct bearing on the

potential source of the ware (or wares). Rounded chalk and flint are the main constituents of gravels to the west of the chalk scarp to the north of Elloughton and are also major constituents of the sand on the foreshore of the modern Humber downstream of the point where the river cuts through the chalk. However, they are absent, not unsurprisingly, from sands in the Trent valley. This then, is potential evidence in support of a Humberside origin for the Dales Shelly ware from Elloughton. The remaining calcareous inclusions could come from a single limestone with a marly, ferroan calcite cement. The brachiopod shell, the nacreous bivalve shell, the echinoid shell and the rounded opaque pellets all include some examples with a ferroan calcite cement attached, even though in many cases this cement has not survived (perhaps because it consisted of clay rather than calcite in those cases). This hypothetical rock is not likely to be Rhaetic and includes no fish bone or phosphate nodules at all, both of which are distinctive features of the Rhaetic limestone. However, these features are paralleled in the lower Jurassic strata of north Lincolnshire and East Yorkshire. The Hydraulic limestone includes a marine fauna of foramenifera, ostracods, echinoids and bivalves and forms a strong feature of the area around North Cave. The ornamented bivalve shells noted in three of the sub-fabric S samples have a similar pattern to that of *pseudopecten equivalvis.* The opaque rounded grains sometimes have a fragment of shell at their core and are likely to be ferruginous ooliths, which are also noted in the lower Jurassic strata of north Lincolnshire and east Yorkshire, in the rocks pre-dating the Frodingham Ironstone (Kent 1980, 28). These rocks outcrop in the Trent valley, just to the east of the modern course of the Trent, and to the north of the Humber. This area is occupied by a number of potteries in the Roman period, from Little London, next to Torksey, to Knaith and shelly ware has been found on some of those sites. However, there is no proof that it was being made at those sites and the presence of chalk and flint discounts a Trent valley origin for many of the samples. Furthermore, the sands in the Trent valley have a small but consistent rounded chert content and only one of the Elloughton samples had any rounded chert inclusions whilst the rounded silica-cemented fine-grained siltstone or sandstone which is also a feature of those sands is completely absent. Thus, there may well be production of Dales Shelly ware in the Trent valley, but it is unlikely that any of the Elloughton samples are from that source. It is unknown at present whether the two main clay types represented in sub-fabrics S and C, silty and inclusionless respectively, represent completely different sources or simply the exploitation of clays in an area where both micaceous silty and fine-textured clays outcrop. The silty clay is much less silty than the recent Humber estuary silt, used for the production of loom weights in Mid Saxon Flixborough and for pottery and tiles in medieval Beverley, and there are possible candidates in the Jurassic strata of north Lincolnshire/East Yorkshire, particularly in the lower Lias strata above the Frodingham ironstone. The description of some of these as forming lenses and intercalations with more argillaceous deposits would fit the suggestion that the same potters could have been exploiting both clays whilst the association of the silty groundmass with the pecten-like ornamented bivalve shells requires more samples to prove.

We are therefore led back to a very similar source area to that suggested in 1977 by Loughlin. North Lincolnshire, or East Yorkshire, in the Humber valley in an area from North Cave and the junction with the Trent westwards. It remains, however, to consider the other strand of evidence for the source or sources of this ware, the heavy mineral suite dominated by anhydrite. Firman has made the point that it

is quite likely that the anhydrite identified by Loughlin was formed during firing from either gypsum or selenite. Whereas anhydrite and gypsum are limited in the east midlands to Permo-Triassic strata, selenite concretions are reported from Jurassic clays. However, this study did not include heavy mineral analysis and it is not known which of the petrological sub-fabrics identified here were sampled by Loughlin.

Following the examination of the Elloughton sections, the author examined thin sections made by Ann Woods and housed at the University of Leicester Archaeology Department and those made of the type fabric series of Dales Shelly ware from Lincoln (Table 3). No further samples of Sub-fabric D were noted but examples of the other three fabrics were present, together with a number of samples of a new and rather different fabric, here given the sub-fabric code T (for Trent). This fabric contains a mixture of rounded quartzose sand and shelly inclusions. The sand includes a moderate proportion of rounded chert and fine-grained sandstone fragments, both of which were sought and not found in any of the Elloughton samples (nor in the comparanda listed in Table 3). The shell fragments are mainly thick-walled nacreous bivalve shells composed of non-ferroan calcite, together with fragments of a sparry ferroan calcite cement, sometimes adhering to the shell fragments. The quartzose sand is typical of that found in sand-tempered vessels made in the Trent and Witham valleys whilst the shell temper is similar to samples of the Great Oolite, which outcrops on the dip slope of the Lincoln Edge and is exposed at the Witham Gap. This sub-fabric occurs at Thorpe by Newark and four samples from various sites in Lincoln.

A single comparative sample of sub-fabric M was noted, from a site at Hasholme, near Holme-upon-Spalding Moor. This site apparently has two phases of occupation, an early Roman agricultural phase and a 4th-century pottery production phase.

Samples of sub-fabric S were noted at Lincoln, Doncaster and on a site near to the Gask Frontier in Scotland. Furthermore, the sample thin-sectioned for the National Roman Fabric Reference Collection can be identified from its published description as being of this sub-fabric and it has also been identified visually at York. It is clear that the majority of Dales Shelly ware belongs to this sub-fabric. Sub-fabric C, however, has one positive and one possible identification, both from sites in Lincoln.

Table 3

Sample Number	Provenance	Sub-Fabric	Comments
LUAD P188	Not Known	S	Typical fabric containing most of the inclusion types listed in the fabric description.
LUAD P189	Not Known	None	Contains no quartz inclusions, has inclusionless mudstone/relict clay pellets. More like Harrold Shelly ware
LUAD P831	Thorpe by Newark	T	Contains a rounded quartz sand with moderate rounded chert. The shell component consists almost entirely of nacreous bivalve shell and there are no echinoid shell or spine fragments and no calcareous microfossils. Only sparse quartz and muscovite silt. Probably made in the Trent Valley.
LUAD P249	Hasholme Hall, Spalding Moor	?	
CLAU L191	Grantham Place 1981 (GP81)	C	
CLAU L192	Grantham Place 1981 (GP81)	S	
CLAU L193	Grantham Place 1981 (GP81)	S	
CLAU L194	Grantham Place 1981 (GP81)	T	
CLAU L1606	Hungate 1983-6	T	
CLAU L1607	Lincoln	S	
CLAU L1619	Hungate 1983-6	C?	Contains a similar range of calcareous inclusions to subfabric C but the quartzose sand contains moderate rounded chert, as in P831
CLAU L1641	Lincoln	T	This sample is from a double-lid-seated jar of 4th-century type
CLAU L1650	Brayford Wharf East 1982	S	The sample is from a triangular-rimmed bowl
CLAU L1679	Brayford Wharf East 1982	T	
AVAC V1326	Peel (Gask Frontier)	S	Typical fabric with abundant opaque pellets
AVAC V1931	Church Way, Doncaster	S	Typical fabric

Finally, the chemical data might be able to shed some light on the source and on the question of whether we are looking at samples from several distinct sources or one source exploiting variable clay deposits. A factor analysis of the Elloughton and data from ceramics from Lincolnshire whose parent clay was known was carried out. This indicated that Vanadium and Chromium were particularly high in the Dales Shelly ware and that there was a difference in the ratio of these two elements between the

S and C sub-fabrics. It also indicated that the other two sub-fabrics had V and Cr frequencies similar to those of other wares. The geochemical associations of these two elements suggests that they are both commonly found in organic shales, are associated with Fe-Ti-rich resistate minerals and that they co-precipitate with iron. Given that there is no correlation between either Cr or V and TiO2, nor with Sc, which tends to be present in clay minerals, it is likely that they are present in the opaque rounded inclusions thought to be ferruginous ooliths. A plot of $Fe2O_3$ against V (Fig 00) suggests that subfabric S has a higher iron content that sub-fabric C and that there is indeed a strong correlation between the incidence of the two elements. This plot also shows that wares made from the Oxford clay at Market Rasen, which is organic, have a higher ratio of V to Fe_2O_3 than others with the same iron content, such as Torksey ware, Maxey wares and Beverley-type wares, but that the Dales Shelly ware samples have higher Fe_2O_3 and V values than these samples.

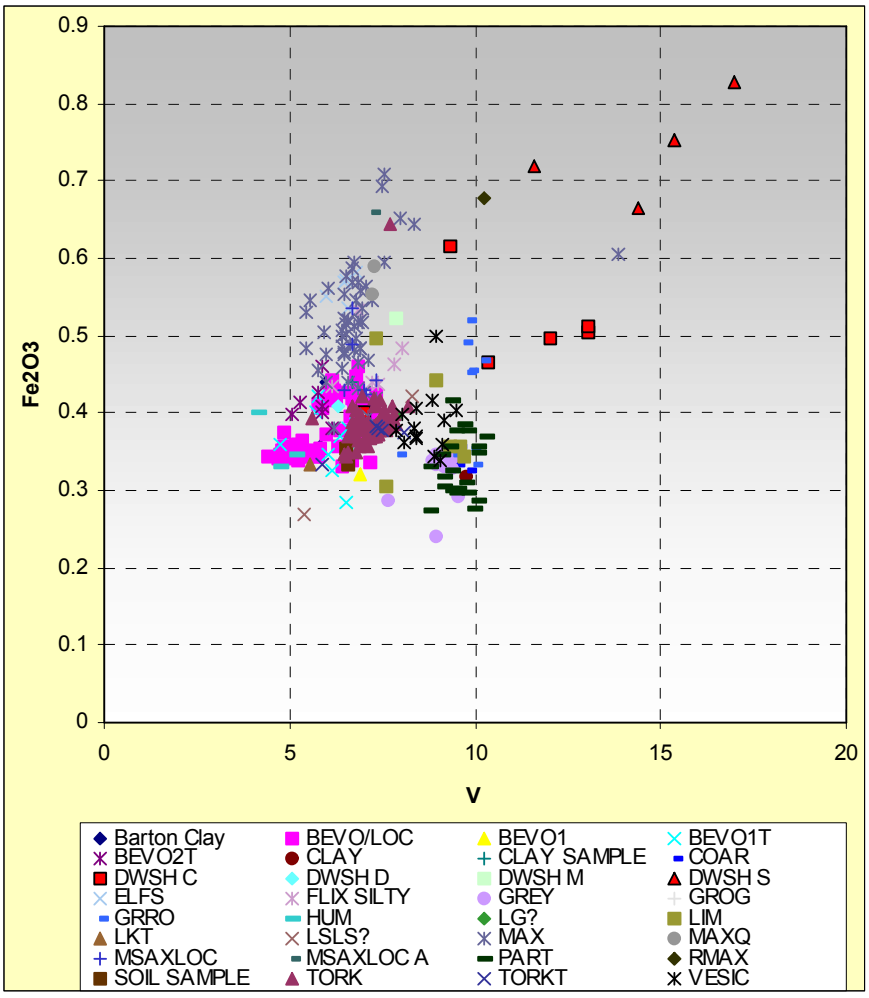


Figure 1

The correlation of higher iron content with higher silt content is consistent with the Lower Jurassic geology and might suggest that the sub-fabric S vessels were made on sites further to the east, either just above or below the Frodingham Ironstone. The remainder might be made on sites further to the west, or from one of the more argillaceous beds in this same locality. A study of the geological map

shows that one would not expect Cretaceous chalk and flint in superficial deposits overlying the lower Jurassic strata in the Trent valley south of the Humber because these strata are too far west whereas on the north site of the Humber the outcrop is much narrower, giving only a small potential source area. It is still possible that the area pinpointed by Loughlin and Firman is indeed a source of this ware, since the Lower Jurassic strata overlie the Rhaetic deposits on the south bank of the Humber between Alkborough and Trent Falls. If the subfabrics represent different sources then one, sub-fabric C, might be located immediately north or south of the Humber and another, sub-fabric S, further to the south, in the Trent valley. The possibility that sub-fabric D was made further west still, in the area of the Hydraulic limestone outcrop around North Cave, or in the Trent valley immediately east of the river should be explored by examining samples of this limestone and associated clays. Sub-fabric T was clearly a Trent valley product, perhaps made in the Lincoln area. Finally, without further samples it is impossible to interpret sub-fabric M. This study suggests strongly that in addition to a single large-scale production centre making Dales ware jars and other forms somewhere in north Lincolnshire, situated to the southeast of the junction of the Trent and the Humber, there were other centres in Lincolnshire and possibly East Yorkshire producing superficially similar fabrics and forms.

Grog-tempered ware (GROG)

A single sample of grog-tempered ware was analysed. The thin section confirms that it is tempered with grog varying in colour and firing temperature but almost all tempered with a rounded quartz sand, up to 0.3mm across which is also present in the body of the vessel. Moderate rounded opaque grains similar to those in the Dales Shelly ware (sub-fabrics S and C) was also present. A single rounded fragment of marly clay with ferroan calcite mixed with clay suggests that the sample could have been produced in a similar area to the Dales Shelly wares and factor analysis of the chemical data (omitting elements likely to be present in calcareous inclusions) indicates a similar chemical composition to the Dales-type ware. Analysis therefore suggests that this vessel too may have been locally produced, although production to the south of the Humber in the Trent valley cannot be discounted.

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