Characterisation Studies of Mid-Saxon Pottery from Fishtoft, Lincolnshire, and comparanda

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As part of a study of the finds from the mid-Saxon settlement at Fishtoft, Lincolnshire, a series of samples of the mid- and late-Saxon pottery types found at the site were selected for analysis using thin sections and chemical composition analysis. These were compared with data from existing analyses carried out on mid-Saxon pottery from Flixborough and other sites in north Lincolnshire and with data collected for this project from sites in central and south Lincolnshire.

Table 1

TSNO	Sitecode	Context	REFNO	cname	Form	Action	locality	subfabric
V4662	fcr03	2845	sample 139	RMAX	?	TS;ICPS	Fishtoft	
V4663	fcr03	2443		RMAX	?	TS;ICPS	Fishtoft	
V4664	fcr03	2443		RMAX	?	TS;ICPS	Fishtoft	
V4665	fcr03	2618		RMAX	?	TS;ICPS	Fishtoft	
V4666	fcr03	2595		RMAX	large vessel	TS;ICPS	Fishtoft	
V4667	fcr03	2776		RMAX	?	TS;ICPS	Fishtoft	
V4668	fcr03	2573		RMAX	lugged jar	TS;ICPS	Fishtoft	
V4669	fcr03	1999	DR17	RMAX	lugged vessel	TS;ICPS	Fishtoft	
V4670	fcr03	2776	DR15	RMAX	jar	TS;ICPS	Fishtoft	
V4671	fcr03	2768		RMAX	jar	TS;ICPS	Fishtoft	
V4672	fcr03	2589	DR21	RMAX	lugged vessel	TS;ICPS	Fishtoft	
V4673	fcr03	2415	sample 57	MAX	?	TS;ICPS	Fishtoft	light firing shelly
V4674	fcr03	2768		MSAXX	?	TS;ICPS	Fishtoft	shell + erratic ?
V4675	fcr03	2168		MSAXX	?	TS;ICPS	Fishtoft	shell
V4676	fcr03	1129	DR19	MSAXX	jar	TS;ICPS	Fishtoft	shelly
V4677	fcr03	1003		LSAXX	jar	TS;ICPS	Fishtoft	greyware
V4678	fcr03	0414		ESAX		TS;ICPS	Fishtoft	
V4679	fcr03	2332		MAX	jar ?	TS;ICPS	Fishtoft	B
V4680	fcr03	2219		MAX	jar	TS;ICPS	Fishtoft	B
V4681	fcr03	2286		MAX	?	TS;ICPS	Fishtoft	B
V4682	fcr03	2231		MAX	lugged vessel	TS;ICPS	Fishtoft	B
V4683	fcr03	2032	DR13	MAX	small jar	TS;ICPS	Fishtoft	B
V4684	fcr03	2202	DR09	MAX	large lugged vessel	TS;ICPS	Fishtoft	B
V4685	fcr03	2313	DR06	MAX	jar	TS;ICPS	Fishtoft	B
V4686	fcr03	2654	DR10	MAX	lugged jar	TS;ICPS	Fishtoft	B
V4687	fcr03	2034	DR11	MAX	jar	TS;ICPS	Fishtoft	B

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V4688	fcr03	1999	DR16	MAX	jar	TS;ICPS	Fishtoft	B
V4689	fcr03	2087	DR24	MAX	jar	TS;ICPS	Fishtoft	B
V4690	fcr03	2293		MAX	large vessel	TS;ICPS	Fishtoft	C
V4691	fcr03	2332		MAX	?	TS;ICPS	Fishtoft	C
V4692	fcr03	1135	DR18	MAX	large jar ?	TS;ICPS	Fishtoft	C
V4693	fcr03	2618		MAX	?	TS;ICPS	Fishtoft	E
V4694	fcr03	2148		MAX	?	TS;ICPS	Fishtoft	E
V4695	fcr03	2499		RMAX	?	TS;ICPS	Fishtoft	E
V4696	fcr03	2334		MAX	?	TS;ICPS	Fishtoft	F
V4697	fcr03	2166	sample 127	MAX	?	TS;ICPS	Fishtoft	F
V4698	fcr03	2807		MAX	?	TS;ICPS	Fishtoft	F
V4699	fcr03	2876		MAX	?	TS;ICPS	Fishtoft	F
V4700	fcr03	2493		MAX	jar	TS;ICPS	Fishtoft	F
V4701	fcr03	1104		MAX	?	TS;ICPS	Fishtoft	F
V4702	fcr03	2334		MAX	jar ?	TS;ICPS	Fishtoft	U + quartz
V4703	fcr03	2631		MAX	?	TS;ICPS	Fishtoft	U + quartz
V4704	fcr03	2631		MAX	?	TS;ICPS	Fishtoft	U + quartz
V4705	fcr03	2146	sample 119	MAX	?	TS;ICPS	Fishtoft	U + quartz
V4706	fcr03	2034	DR12	MAX	lugged jar	TS;ICPS	Fishtoft	U
V4707	fcr03	2046	DR20	MAX	large lugged vessel	TS;ICPS	Fishtoft	U + quartz
V4708	fcr03	0402		MAX		TS;ICPS	Fishtoft	U + quartz
V4709	fcr03	2097		RMAX	?	TS;ICPS	Fishtoft	
V4710	fcr03	2768		MAXQ	?	TS;ICPS	Fishtoft	
V4711	fcr03	2334		MAXQ	?	TS;ICPS	Fishtoft	
V4712	lh84	A7	L11	MAX		ICPS	Lincoln	A
V4713	la85	US		MAX		TS;ICPS	Lincoln	A
V4714	lh84	D10	L19	MAX		ICPS	Lincoln	B
V4715	lh84	A2		MAX		TS;ICPS	Lincoln	A
V4716	l86	5		MAX		TS;ICPS	Lincoln	B
V4717	l86	5		MAX		TS;ICPS	Lincoln	B
V4718	gos92	205	DR9	RMAX		TS;ICPS	Gosberton	
V4719	gos92	203	DR8	RMAX		TS;ICPS	Gosberton	
V4720	gos92	121	DR4	RMAX		TS;ICPS	Gosberton	
V4722	gos92	578	DR6	RMAX		TS;ICPS	Gosberton	
V4723	gos92	111	DR2	RMAX		TS;ICPS	Gosberton	
V4726	qch93new	0215/169		MAXQ		TS;ICPS	Quarrington	
V4727	qch93new	1400		MAXQ		TS;ICPS	Quarrington	
V4728	qch93new	1396		MAXQ		TS;ICPS	Quarrington	
V4729	qch93new	0195/109		MAXQ		TS;ICPS	Quarrington	
V4731	qch93b	1036	DR15	RMAX		TS;ICPS	Quarrington	
V4732	qch93b	1025	DR13	RMAX		TS;ICPS	Quarrington	
V4733	qch93o	721	DR49	RMAX		TS;ICPS	Quarrington	
V4734	qch93b	1050	DR9	RMAX		TS;ICPS	Quarrington	

V4735	qch93o	+		RMAX		TS;ICPS	Quarrington	
V4736	qch93p	87	DR2	MSAXLOC		TS;ICPS	Quarrington	
V4737	F72			MAX		TS;ICPS	Lincoln	M
V4738	MAX62 II			MMAX		TS;ICPS	Maxey	MMAX
V4739	MAX62 II			MSAXLOC		TS;ICPS	Maxey	NOP-B COARSE SHELL
V4740	fcr03	2083		LSAXX	lamp/industrial	TS;ICPS	Fishtoft	reduced med sandy

The majority of the samples come from shell-tempered wares which have the generic name "Maxey-type ware" (Addyman 1964; Addyman and Whitwell 1970). These were subdivided by the author and Jane Young in the 1990s into Northern and Southern Maxey-type ware, based on the character of the shell inclusions. A third type was recognised by Jane Young at Quarrington, Lincolnshire and given the code MAXQ.

In addition, samples of a possible Early Anglo-Saxon vessel and four possible non-local Mid-Saxon vessels were included.

Thin-Section Analysis

Northern Maxey-type ware (MAX)

Northern Maxey-type ware is characterised visually by the presence of nacreous bivalve shell and the absence of punctate brachiopod shell. Variations in the frequency, size and sorting of the shell fragments have been used to subdivide the fabric into subfabrics (Subfabrics A to C), as has the presence of sparse echinoid spines (Subfabric E). Of these, subfabrics B, C and E were identified at Fishtoft. In addition, a sample with a lighter-firing groundmass than normal (V4673), five samples of a subfabric with sparse to moderate rounded quartz inclusions (Fabric U) and five samples with fine-textured abundant shell (Subfabric F) were sampled.

All the samples contain a similar range of inclusions with the following inclusion types being noted:

- Bivalve shell. Abundant fragments of nacreous bivalve shell are present in every sample. The shell is often partially coated with ferroan calcite, usually in the form of a single thickness of prismatic crystals, c.0.1mm thick. Boreholes are often present in the shell and are usually filled with a brown clay lighter in colour than the groundmass.
- Ferroan calcite. Abundant fragments of sparry ferroan calcite are present in every sample.

- Marl. Sparse rounded fragments of brown clay with abundant ferroan calcite inclusions are present in some samples. In some cases, the marl occurs in the same fragments as the sparry ferroan calcite.
- Rounded quartz. Sparse rounded fragments up to 0.5mm across are present in some samples. Some examples have brown-stained veins and are probably of lower Cretaceous origin.
- Subangular and angular quartz. Moderate fragments ranging from c.0.1mm to 0.2mm were noted in all the subfabric U samples.
- Flint. Rare rounded, brown-stained grains up to 1.0mm across. Noted only in two samples (V4691, subfabric C, and V4705, subfabric U).
- Calcareous sandstone. Rare subangular fragments up to 1.0mm across containing angular quartz grains c.0.2mm across in a ferroan calcite groundmass. Present in subfabric U.
- Echinoid spines. Rare examples up to 0.5mm across. Present in subfabric U (no examples noted in the two sections of Subfabric E but presumably present as rare examples).
- The groundmass consists of dark brown optically anisotropic baked clay minerals with few inclusions.

Southern Maxey-type ware (RMAX)

Southern Maxey-type ware is identified in the hand by the presence of punctate brachiopod shell. In thin section, not only is this shell present but also echinoid shell. These three inclusion types occur in every sample of the fabric and clearly distinguish this ware from the Northern Maxey-type ware.

The following inclusion types were noted in thin section:

- Bivalve shell. Moderate fragments of nacreous bivalve shell up to 1.5mm long. Some fragments show de-lamination with both brown clay and ferroan calcite filling the laminae.
- Punctate brachiopod shell. Moderate fragments up to 1.5mm across. The punctae are filled with a mixture of brown clay and ferroan calcite.
- Echinoid shell. Moderate fragments of ferroan calcite echinoid shell up to 1.0mm across.
- Limestone. Sparse rounded fragments up to 1.5mm across consisting of bivalve shell and echinoid shell up to 0.5mm across in a matrix of sparry ferroan calcite.
- Quartz. Sparse subangular and rounded grains up to 0.3mm across.

- Opaques. Rare rounded fragments up to 2.0mm across.
- Echinoid spine. Rare fragments up to 0.3mm across.
- The groundmass consists of dark brown optically anisotropic baked clay minerals, moderate ferroan calcite specks and moderate dark brown to opaque rounded grains up to 0.05mm across.

Quarrington-type Maxey-type ware (MAXQ)

Quarrington-type Maxey-type ware is identifiable in thin section through the abundant presence of ferroan calcite fragments. The following inclusion types were noted in thin section:

- Limestone. Abundant angular fragments composed mainly of sparry ferroan calcite with sparse non-ferroan calcite nacreous bivalve shells. Some of these fragments come from large thickwalled species but examples with shells c.0.5mm long and c.0.05mm thick are also present (but may be fragments of the larger shells). Thin lenses of clay, with a preferred orientation, also occur but may be secondary infill of pores.
- Rounded quartz. Sparse well-rounded grains up to 0.5mm across.
- Clay/iron. Rare subangular dark brown grains up to 1.0mm across.
- The groundmass consists of brown optically anisotropic baked clay minerals, abundant specks of ferroan calcite and moderate rounded dark brown grains up to 0.05mm across.

Early Anglo-Saxon? (ESAX)

A single sample of possible early Anglo-Saxon date was thin-sectioned (V4678). In thin section it was seen to contain abundant angular fragments of basic igneous rock. A similar fabric noted in the Lindsey Marshes in the late Bronze Age and Iron Age but not in the early Anglo-Saxon period. However, in thin section the fragments are seen to be different from the erratics found in local fabrics and it is likely that this rock is Niedermendig lava. Examples of early Anglo-Saxon pottery tempered with crushed lava of this type are known. The following inclusion types were noted:

- Basic igneous rock. Angular subangular fragments of a rock composed of laths of feldspar (sanidine?) and zoned pyroxene up to 0.3mm long in a groundmass of glass feldspar laths and euhedral opaque grains up to 0.05mm across. Irregular voids up to 0.3mm across occur within the rock.
- Organics. Sparse long thin carbonised inclusions up to 3.0mm long and c.0.1mm wide surrounded by a darkened halo.

- Quartz. Sparse subangular grains up to 0.2mm across.
- The groundmass consists of brown optically anisotropic baked clay, moderate angular quartz grains up to 0.1mm across and sparse muscovite laths up to 0.1mm long.

Mid-Saxon Local (MSAXLOC)

A single sample of a shell-tempered fabric which also contains sparse fragments of basic igneous rock and quartz sand was sampled. In thin section, the fabric is very similar to one of the Northern Maxey-type ware groups (Fabric U). The following inclusion types were noted:

- Bivalve shell. Moderate fragments of nacreous bivalve shell up to 1.5mm long and 0.5mm thick, some of which have a ferroan calcite coating.
- Ferroan calcite. Sparse sparry calcite fragments up to 0.3mm across.
- Rounded quartz. Moderate fragments up to 0.3mm across.
- Basic igneous rock. Sparse subangular fragments up to 0.5mm across containing plagioclase feldspar in a dark brown fine-grained groundmass.
- Angular quartz. Moderate subangular fragments, some apparently overgrown, up to 0.2mm across.

The groundmass consists of dark brown optically anisotropic baked clay with few visible inclusions.

Late Saxon Non-Local (LSAXX)

Two sections of possible late Saxon sand-tempered wares were noted. One of these has parallels in northwest Norfolk and may be an example of a late Saxon or Saxo-Norman wheelthrown ware whilst the other (V4740) has a fabric which is consistent with a local, Lindsey Marshes, origin. Given that no tradition of wheelthrown sandy ware production is known in this area in the late Saxon to Saxo-Norman periods, it is likely that this is actually a Romano-British sherd. However, the form suggests that it might be a specialised vessel form, either a lamp or an industrial vessel of some sort.

V4677

The following inclusion types were noted:

- Quartz. Abundant, well-rounded grains up to 1.0mm across. The larger grains have a low sphericity and contain brown-stained veins whilst the smaller grains, c.0.1mm to 0.2mm, include subangular grains.
- Flint. Sparse rounded grains up to 1.5mm across. Three examples are present in the section. One is heavily brown-stained and the other two are unstained. The latter are

less-well rounded and both include microfossils surviving as spherical pores lined with chalcedony.

- Opaques. Moderate, well rounded grains up to 0.3mm across.
- Sandstone. Rare rounded fragment 1.0mm long, containing abundant subangular quartz, muscovite and biotite laths in a groundmass of fine-grained silica.
- Plagioclase feldspar. Sparse subangular grains up to 0.3mm across.
- The groundmass consists of brown optically anisotropic baked clay minerals and abundant rounded dark brown to opaque grains up to 0.1mm across.

V4744

The following inclusion types were noted:

- Quartz. Abundant fragments ranging from c.0.1mm to 1.0mm. Some are well-rounded but some of the largest grains are angular and most of the finer grains are subangular and appear to be overgrown.
- Chert. Sparse rounded fragments up to 0.4mm across.
- Plagioclase feldspar. Sparse subangular fragments up to 0.1mm across.
- The groundmass consists of brown optically anisotropic baked clay minerals, moderate angular quartz up to 0.1mm across and sparse muscovite laths up to 0.1mm long.

Chemical Analysis

Sixty-two samples were analysed used Inductively-Coupled Plasma Spectroscopy (ICP-AES). The analysis was carried out under the supervision of Dr J N Walsh at Royal Holloway College, London, in the Department of Geology. A range of major elements was measured and the results presented as percent oxides (App 1). A range of minor and trace elements was measured and the results presented at parts per million (App 2). Silica was not measured but was estimated by subtracting the total measured oxides from 100%. The data were then normalised to aluminium to discount the dilution effect caused by the deliberate addition of quartz to some fabrics and the leaching of calcium carbonate.

The estimated silica content varies from 53.34% for Quarrington-type Maxey-type ware to 78.76% for one of the late Saxon non-local samples (Table1). Within the Maxey-type wares the subfabric U with rounded quartz samples have a significantly different silica content to the remainder but there is little different between the rest.

Table 2

Group	N	Mean	Std.Dev.
MAXQ	6	53.34	2.618472277
MAX F	6	53.38	1.143133311
MAX E	2	53.83	0.149906638
RMAX	19	54.97	3.084767483
MAX B	9	55.58	1.436074607
MAX A	3	56.39	3.481726009
MAX C	2	56.82	1.584626297
MSAXLOC	1	58.93	----
MAX U + rounded quartz	5	61.72	1.399660566
ESAX	1	62.84	----
LSAXX V4677	1	68.62	----
LSAXX V4740	1	78.76	----

The normalised Fishtoft data for the various Northern and Southern Maxey-type ware samples were examined using the Factor Analysis option in WinSTAT for Excel (Fitch 2001). Omitting those elements correlated with calcium (CaO, P2O5, Ba and Sr), the analysis revealed four factors which cumulatively explained 77.66% of the variance in the data.

Factor 1 does not distinguish any of the groups whilst Factor 2 separates all of the southern Maxey-type ware samples (Fig 1). This is due mainly to the iron and vanadium content, which is enhanced in the Southern Maxey-type ware samples (Fig 3). Cobalt and zirconium are also enhanced in the Southern Maxey-type ware samples (Fig 4). Since these differences are present in samples from various contexts on the same site, and were

analysed in two separate batches in which both Northern and Southern Maxey-type wares were present there is no possibility that they are due to either post-burial contamination or any laboratory errors.

The third and fourth factors reveal differences in composition between some of the Northern Maxey-type ware samples (Fig 4). In particular, the subfabric U samples, with rounded quartz sand, and the subfabric B samples are distinguished from the subfabric F and subfabric A and E samples through their F4 scores. These differences are due mainly to variations in the relative frequencies of titanium and magnesium (Fig 5) and sodium and potassium (Fig 6). Here again, because all the samples come from the same site and there is no correlation with processing batches there is no doubt that the variations are due to the use of different raw materials.

The chemical analysis therefore confirms that the visual differences found in the Northern Maxey sherds from Fishtoft do reflect differences in source.

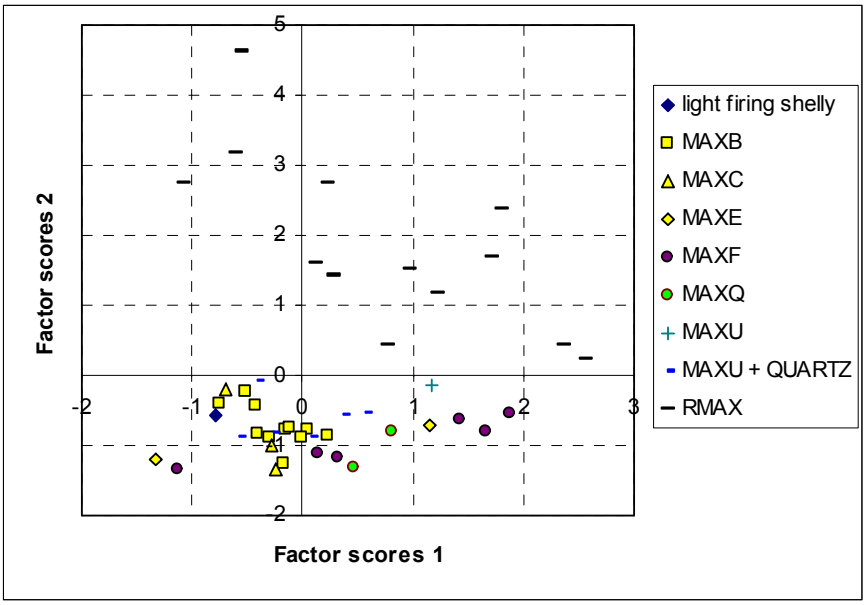

Figure 1

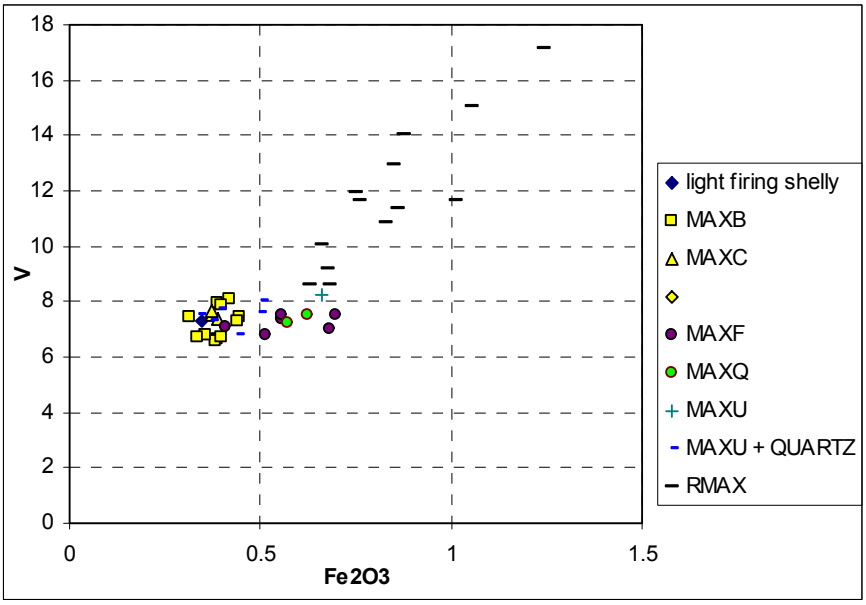

Figure 2

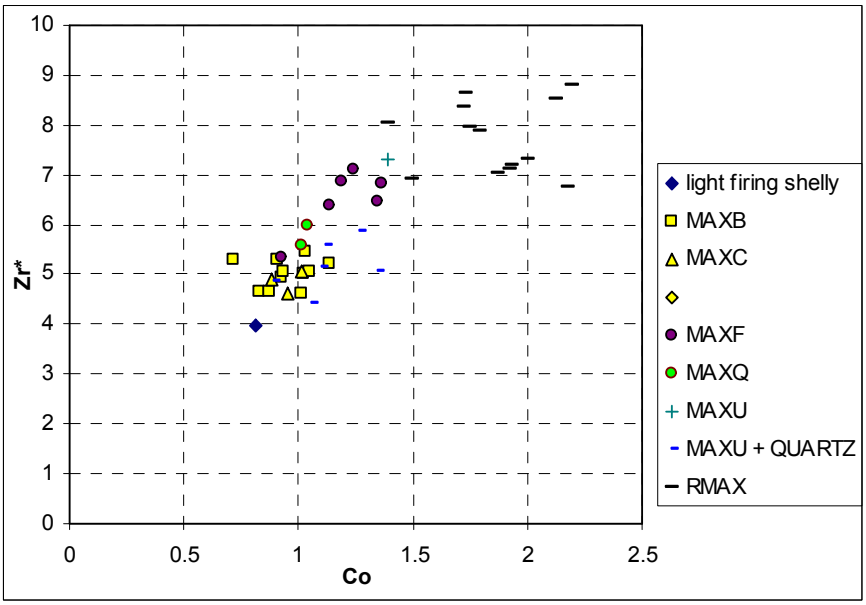

Figure 3

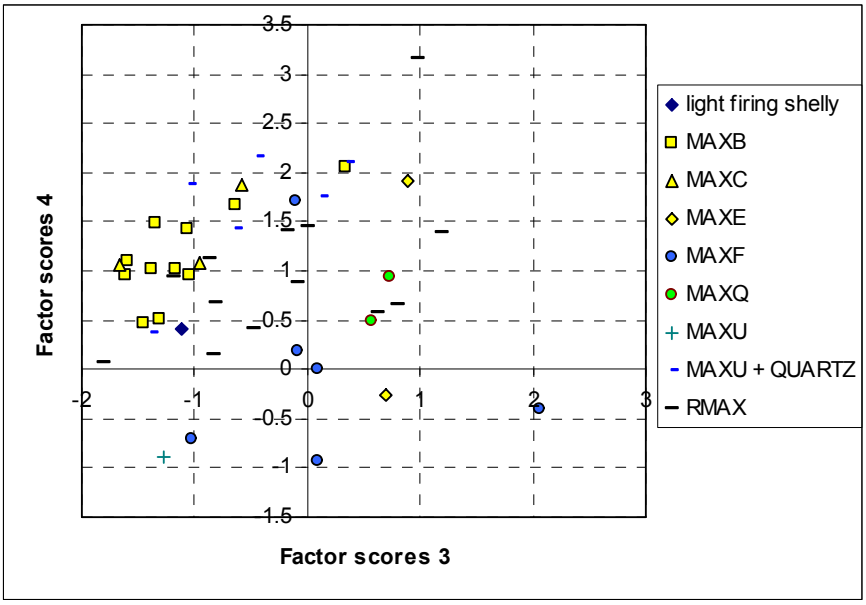

Figure 4

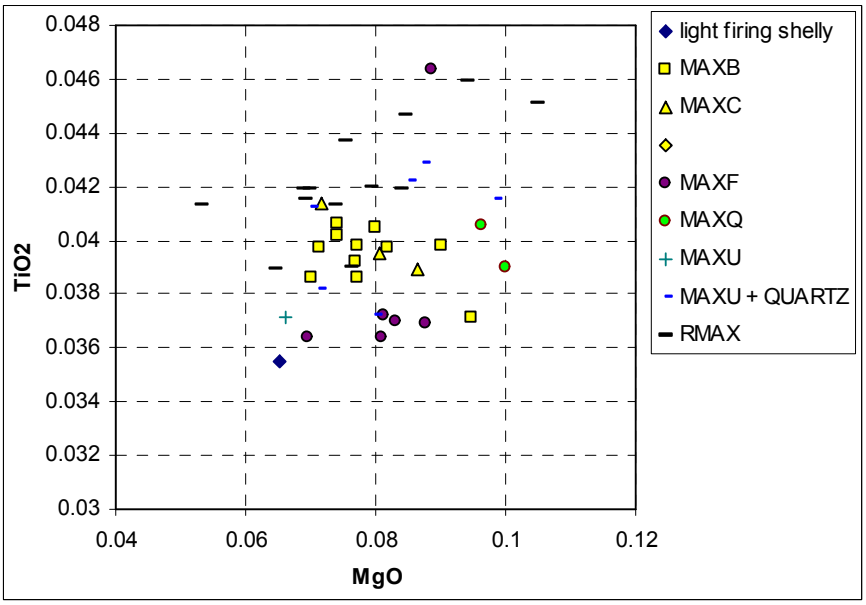

Figure 5

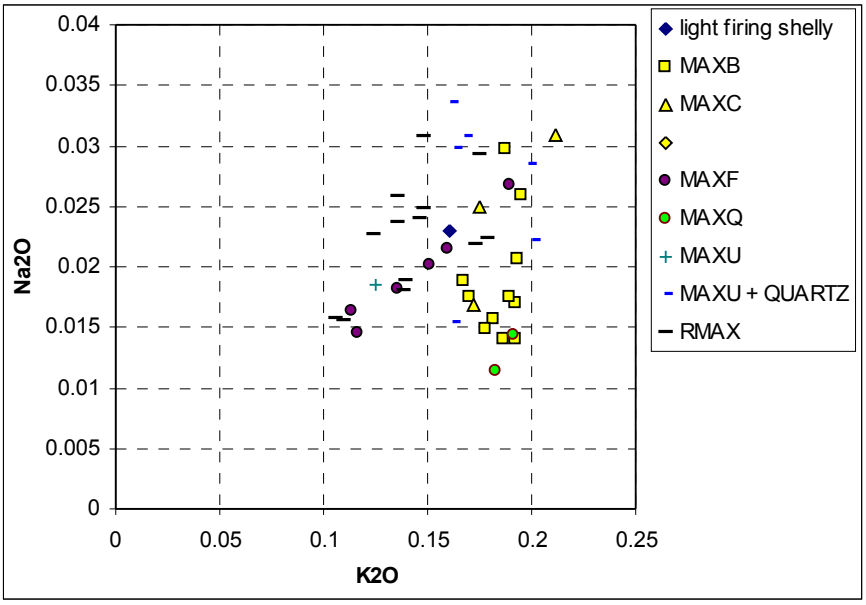

Figure 6

The ICPS data for the southern Maxey-type ware samples were then compared with that from a series of samples of shell-tempered wares from sites in Cambridgeshire, Bedfordshire and Buckinghamshire which share the mixed shell sand found in Southern Maxey-type ware. Like southern Maxey-type ware, these wares are characterised in thin section by the presence of a mixed shell sand, containing bivalve shell, punctate brachiopod and echinoid shell fragments and include samples from kiln sites of Roman and medieval date, as well as unsourced St Neot's-type ware and Developed St Neot's-type ware, both from an occupation site close to Peterborough.

Factor analysis, however, shows that the Fishtoft and Quarrington samples of Southern Maxey-type ware are distinguishable from these south midlands shelly wares (Fig 7), again mainly because of their higher iron and vanadium contents (Fig 8). However, samples of Southern Maxey-type ware from sites at Gosberton and Willingham (Cambs) are more similar to the comparative material. This suggests that the southern Maxey-type ware at Fishtoft was obtained from a source in central Lincolnshire whereas the southern Maxey-type ware from sites further south in the Cambridgeshire and Lincolnshire fens was obtained from the south-east Midlands. However, since the Quarrington samples are from a consumer site it is not possible to say where their source might have been, except that it was presumably somewhere with middle Jurassic geology, which limits the potential source area to the fen edge and further west.

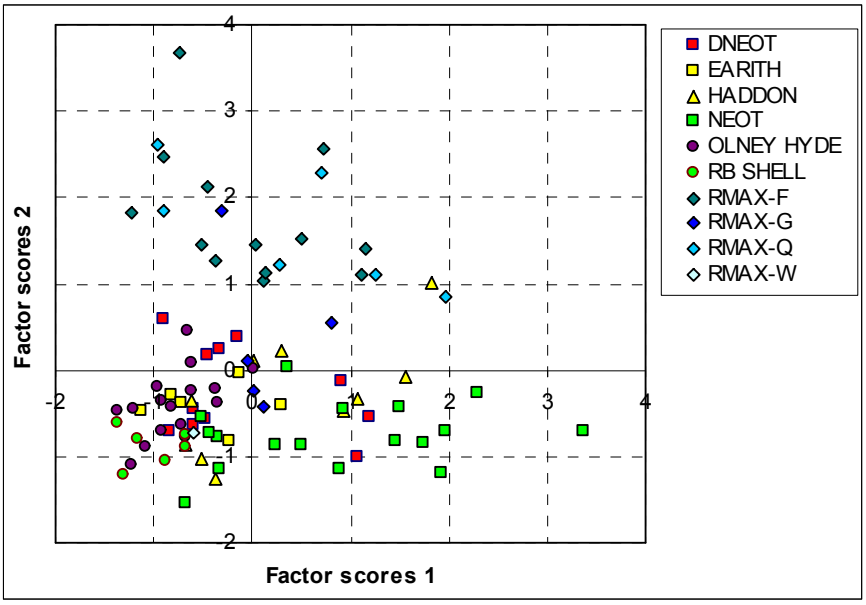

Figure 7

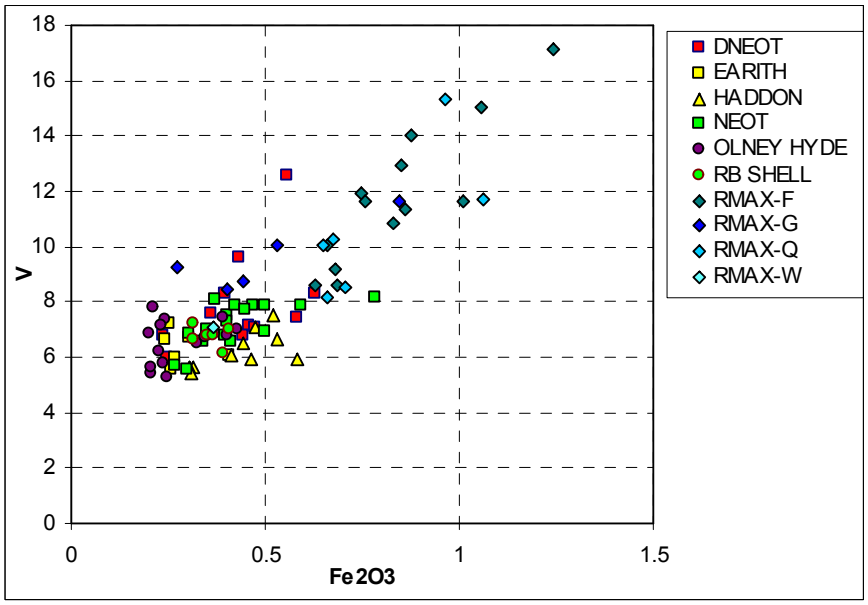

Figure 8

The Northern Maxey-type ware ICPS data from Fishtoft were compared with those from a series of analyses of Northern Maxey-type ware sherds from sites in central and northern Lincolnshire, and some from Yorkshire, from Fishergate, York. Factor analysis found four factors of which the first two show a clear division into two, slightly overlapping, clusters. Samples from Fishtoft all have high F2 and low F1 scores as do most of the samples from Lincoln, Belton and York. All the remainder have no match with Fishtoft and these all come from sites in Northern Lincolnshire: Barton-upon-Humber; Bottesford; Flixborough; Goltho; Holton-le-Clay; Normanby-le-Wold; Riby and Thornton-le-Moor. This result suggests that there were at least two sources of Northern Maxey-type ware; one in central Lincolnshire,

perhaps around Lincoln itself, and the other further north. It also indicates that the central Lincolnshire source supplied the Fishtoft site. A further analysis of the data, including only the Belton, Lincoln, York and Fishtoft samples, indicates patterning within this group (Fig 10). A group of samples with high F2 scores and low F1 scores includes the Fishtoft B, C, U plus quartz and the Lincoln subfabric A samples, but none from Belton or York. The subfabric F samples from Fishtoft have similar F1 and F2 scores to those from Belton and York and the remainder of the Lincoln samples. It is possible to interpret this result as being the result of two sources; one closer to the Witham gap and the other further to the north, both of which supplied Lincoln and Fishtoft but only the more northerly of which supplied Belton and York.

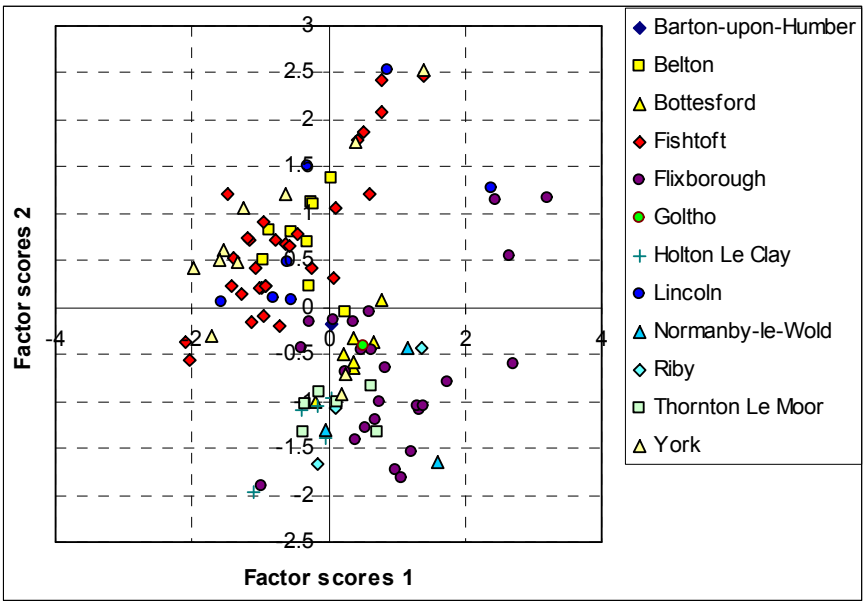

Figure 9

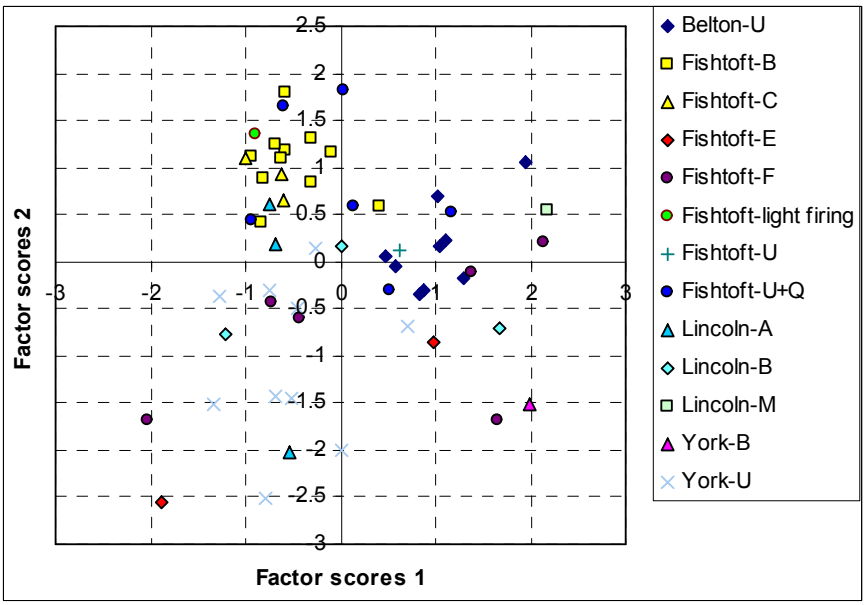

Figure 10

Conclusions

The ICPS data show that there are differences in the chemical composition of RMAX, MAX and MAXQ and that these confirm the petrological analysis which indicates that the three groups were made from difference raw materials. It furthermore indicates that despite the similarity in thin section the southern Maxey-type ware is made in at least two centres, only one of which supplied Fishtoft, whilst the Northern Maxey-type ware might have been produced in at least three centres, two of which were supplying Fishtoft. Again, the sources represented at Fishtoft were probably located in central Lincolnshire. It is possible that some of these patterns could also be interpreted as being due to changes in composition in the output of a single area over time but a larger sample of material of known date would have to be analysed to test this.

Nevertheless, the results are already clear in showing that Fishtoft was probably not receiving Maxey wares through coastal trade but through transport either overland or using the Witham and the Old Slea. Further details of the source of these wares and the routes by which they arrived at Fishtoft could be recovered by analysis of more groups of Maxey ware from the area between Gosberton and Quarrington and between Lincoln and Bottesford.

The remaining samples include a possible example of a lava-tempered fabric, a possible Norfolk sand-tempered ware and a probably local, Romano-British vessel.

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Winstat for Microsoft (r) Excel. Fitch, Robert K. 2001

Appendix 1 ICPS Analysis of major elements, expressed as percent oxides

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V4662	11.46	10.02	0.79	21.40	0.26	1.42	0.48	1.17	0.074
V4663	10.41	8.98	0.77	25.28	0.25	1.52	0.43	1.51	0.111
V4664	11.28	14.02	0.86	18.58	0.29	1.53	0.44	1.66	0.085
V4665	12.85	13.55	0.83	19.39	0.20	1.41	0.50	1.00	0.080
V4666	10.72	8.15	0.85	24.05	0.33	1.59	0.45	1.56	0.094
V4667	12.27	9.18	0.85	18.59	0.29	1.66	0.51	1.41	0.109
V4668	9.30	9.40	0.78	22.61	0.23	1.38	0.39	2.32	0.085
V4669	10.02	8.32	0.70	25.16	0.18	1.39	0.42	1.48	0.097
V4670	10.07	6.64	0.76	24.04	0.19	1.40	0.44	1.06	0.069
V4671	13.31	11.29	0.71	18.17	0.21	1.41	0.55	1.20	0.065
V4672	7.54	5.12	0.79	24.60	0.22	1.32	0.34	1.23	0.099
V4673	13.52	4.68	0.88	23.04	0.31	2.17	0.48	1.14	0.057

V4674	10.00	7.05	0.86	18.21	0.34	1.82	0.41	2.27	0.111
V4675	12.67	4.94	1.07	19.91	0.35	2.26	0.48	1.27	0.098
V4676	9.60	5.09	0.93	16.37	0.27	1.95	0.51	0.30	0.063
V4677	14.60	8.14	1.11	3.21	0.19	2.25	0.65	1.15	0.080
V4678	20.27	4.89	1.81	3.41	1.35	3.07	1.38	0.91	0.072
V4679	12.08	5.40	0.99	21.05	0.36	2.27	0.48	0.87	0.068
V4680	11.40	4.44	0.88	23.06	0.20	1.94	0.44	1.38	0.067
V4681	10.76	4.52	1.02	24.16	0.28	2.10	0.40	1.34	0.082
V4682	12.80	5.64	0.95	19.52	0.20	2.32	0.52	1.49	0.068
V4683	12.07	4.07	0.86	23.21	0.18	2.15	0.48	0.70	0.062
V4684	10.55	4.22	0.95	23.10	0.18	2.03	0.42	0.86	0.073
V4685	10.63	3.78	0.85	23.18	0.22	2.05	0.43	0.77	0.057
V4686	11.14	3.52	0.78	21.84	0.21	1.86	0.43	0.69	0.047
V4687	12.80	4.90	0.99	18.05	0.18	2.39	0.51	0.97	0.083
V4688	12.75	4.97	0.98	17.77	0.18	2.45	0.50	0.99	0.073
V4689	11.45	4.54	0.85	22.20	0.20	2.17	0.46	0.67	0.061
V4690	12.60	4.89	1.09	21.15	0.39	2.67	0.49	0.94	0.080
V4691	12.41	4.60	1.00	20.19	0.31	2.17	0.49	0.83	0.059
V4692	11.85	4.44	0.85	18.95	0.20	2.04	0.49	0.55	0.066
V4693	8.49	4.64	0.62	29.27	0.20	1.16	0.33	1.20	0.158
V4694	10.19	4.28	0.93	26.83	0.26	2.07	0.46	1.12	0.140
V4695	8.49	5.81	0.80	26.75	0.19	1.52	0.39	1.28	0.121
V4696	8.87	4.56	0.72	27.89	0.19	1.42	0.33	0.81	0.099
V4697	7.31	5.10	0.64	32.31	0.12	0.83	0.27	1.06	0.184
V4698	7.57	4.21	0.63	33.04	0.11	0.88	0.28	0.37	0.091
V4699	7.42	5.04	0.60	31.96	0.15	1.12	0.27	0.44	0.083
V4700	9.70	3.96	0.86	29.26	0.26	1.84	0.45	0.80	0.097
V4701	8.79	4.90	0.61	28.64	0.16	1.19	0.32	0.85	0.069
V4702	12.32	4.20	0.88	19.44	0.19	2.00	0.47	0.75	0.051
V4703	11.90	5.90	1.04	15.84	0.40	1.92	0.51	0.88	0.128
V4704	10.91	4.79	0.93	18.13	0.31	2.17	0.46	0.75	0.084
V4705	10.42	3.88	0.73	17.99	0.23	2.09	0.43	0.68	0.092
V4706	8.61	5.69	0.57	30.38	0.16	1.08	0.32	0.78	0.065
V4707	10.75	4.22	0.86	18.64	0.32	1.76	0.40	0.77	0.064
V4708	11.08	5.56	1.09	15.95	0.34	1.86	0.46	1.05	0.109
V4709	8.74	5.50	0.74	26.63	0.19	1.51	0.39	1.63	0.119
V4710	7.69	4.78	0.77	31.75	0.11	1.47	0.30	0.70	0.094
V4711	7.89	4.53	0.76	31.67	0.09	1.44	0.32	0.75	0.099
V4712	8.92	4.75	0.79	27.97	0.16	1.47	0.39	0.99	0.132
V4713	11.05	5.40	0.65	25.75	0.17	1.25	0.43	0.90	0.064
V4714	8.40	5.00	0.57	30.99	0.14	1.10	0.31	0.61	0.060
V4715	13.35	5.13	0.92	16.78	0.29	2.26	0.51	0.31	0.038
V4716	9.67	4.83	0.68	27.46	0.12	1.47	0.36	0.45	0.057
V4717	7.60	3.54	0.73	31.16	0.12	1.59	0.33	0.65	0.069
V4718	11.10	3.02	0.89	23.89	0.27	1.24	0.51	0.49	0.058

V4719	12.27	5.45	0.94	20.12	0.26	1.42	0.64	0.60	0.065
V4720	13.58	7.24	1.06	14.36	0.24	1.64	0.63	0.44	0.043
V4722	10.15	8.60	0.86	24.21	0.30	1.43	0.44	0.86	0.147
V4723	12.46	4.99	0.93	20.64	0.26	1.43	0.64	0.30	0.058
V4726	7.45	4.66	0.73	31.74	0.09	1.18	0.30	0.56	0.072
V4727	10.88	6.66	0.82	26.03	0.12	1.60	0.42	1.10	0.075
V4728	10.73	6.13	0.86	20.87	0.14	1.60	0.42	0.63	0.096
V4729	6.83	4.18	0.66	35.23	0.08	1.02	0.28	0.42	0.082
V4731	9.72	6.32	0.76	23.25	0.17	1.29	0.42	0.68	0.074
V4732	10.79	7.11	0.63	20.89	0.17	1.10	0.47	1.03	0.076
V4733	15.18	16.12	0.87	13.89	0.29	1.75	0.65	0.72	0.106
V4734	9.02	6.35	0.75	25.12	0.20	1.08	0.42	1.16	0.083
V4735	13.60	13.13	0.67	17.44	0.16	1.30	0.54	1.23	0.056
V4736	10.98	3.86	0.80	21.87	0.21	1.93	0.41	1.02	0.079
V4737	8.76	6.31	0.71	25.15	0.22	1.34	0.35	0.78	0.081
V4738	13.51	4.89	0.76	11.18	0.26	1.61	0.70	1.29	0.029
V4739	13.16	5.63	0.90	21.63	0.17	1.81	0.55	1.37	0.073
V4740	11.44	5.32	0.70	0.87	0.23	1.91	0.54	0.21	0.024

Appendix 2 ICPS Data for minor and trace elements, expressed as parts per million

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V4662	299	84	21	43	56	13	411	161	30	91	31	58	33	7	2	4	3	20	152	20
V4663	401	69	20	37	54	11	487	118	28	74	33	74	35	8	1	4	3	20	141	20
V4664	393	88	28	33	70	14	429	193	28	96	29	61	31	6	1	4	4	30	193	24
V4665	513	93	23	44	63	13	412	193	27	101	30	61	32	7	1	4	4	23	189	23
V4666	529	74	24	40	56	11	541	125	22	74	33	72	34	7	1	4	3	18	132	16
V4667	404	82	25	35	60	13	426	146	26	86	34	71	36	7	1	4	3	31	169	23
V4668	687	62	26	24	67	11	566	108	29	67	35	73	37	8	2	4	3	17	195	18
V4669	449	80	21	33	52	11	486	109	28	88	36	77	39	9	1	5	3	13	113	22
V4670	339	83	23	34	43	11	429	101	23	81	36	66	38	8	1	4	3	11	115	14
V4671	431	111	25	43	63	13	432	172	19	115	30	54	31	6	1	3	4	14	123	23
V4672	387	57	20	28	37	7	485	69	20	63	27	42	29	5	1	4	2	11	106	13
V4673	490	86	29	56	51	12	554	99	19	54	33	57	33	5	1	3	2	16	117	11
V4674	666	62	23	35	63	8	564	86	17	60	32	64	33	6	1	3	2	30	176	20
V4675	545	76	37	44	50	12	471	91	18	60	35	76	36	4	1	3	2	20	149	12
V4676	311	75	20	24	29	9	249	73	27	52	35	62	37	7	1	4	3	14	46	13
V4677	667	142	22	72	105	15	189	171	23	82	48	111	49	9	1	4	3	24	121	18
V4678	654	117	32	27	29	22	451	190	22	170	60	100	59	7	1	3	3	16	81	20
V4679	379	79	21	34	37	11	400	90	18	64	33	58	33	5	1	3	2	14	93	11
V4680	425	77	23	45	38	11	491	91	16	53	27	52	28	5	1	2	2	13	81	10
V4681	381	72	39	43	53	11	482	87	18	53	30	57	31	5	1	3	2	17	101	10
V4682	447	85	21	41	39	12	434	93	23	59	38	73	39	6	1	3	2	14	104	13
V4683	343	76	18	43	31	11	401	81	18	56	31	60	32	5	1	3	2	14	79	10

V4684	357	74	19	42	31	10	357	83	18	55	29	60	30	5	1	3	2	13	105	12
V4685	340	82	20	37	32	10	373	72	16	58	30	58	31	6	1	3	2	7	95	11
V4686	254	87	24	46	39	10	400	83	15	59	29	56	30	5	1	2	2	5	76	8
V4687	450	95	20	42	42	11	360	84	19	65	34	59	35	6	1	3	3	11	107	12
V4688	460	98	20	41	44	11	344	85	21	64	34	59	35	6	1	3	3	7	108	13
V4689	316	85	17	38	39	10	379	77	17	58	32	53	33	6	1	3	2	6	70	12
V4690	422	74	26	49	46	11	421	93	17	58	37	69	37	6	1	3	2	16	90	12
V4691	362	78	26	48	44	11	416	93	17	61	35	70	35	5	1	3	2	12	90	11
V4692	337	94	20	37	39	11	353	91	14	60	28	49	29	5	1	3	2	8	77	12
V4693	511	51	20	22	41	8	564	60	15	55	33	70	34	5	1	3	2	14	106	12
V4694	381	59	41	22	31	8	383	75	12	54	21	33	22	3	1	3	2	11	126	9
V4695	408	53	27	24	53	10	474	73	31	62	35	77	37	7	1	4	3	18	126	17
V4696	312	50	20	23	28	8	469	60	13	63	25	56	26	4	1	3	2	10	96	11
V4697	413	41	18	20	32	7	541	55	14	50	29	67	31	5	1	4	2	11	118	10
V4698	178	42	17	22	28	8	467	56	15	52	31	65	32	5	1	3	2	12	102	9
V4699	183	42	13	23	37	8	432	52	19	48	32	64	33	5	1	3	2	11	69	10
V4700	358	55	24	21	22	8	387	69	12	52	20	38	21	3	0	2	2	11	89	9
V4701	263	49	18	21	29	7	506	66	12	56	28	47	28	4	1	2	2	10	65	10
V4702	334	81	22	53	44	11	361	93	17	60	34	63	34	5	1	2	2	12	85	11
V4703	636	72	24	42	50	11	366	90	24	60	37	68	39	7	1	4	3	14	127	16
V4704	499	71	21	43	42	10	390	74	22	56	32	56	33	6	1	3	2	19	89	12
V4705	387	68	20	40	35	9	342	76	14	46	26	49	27	4	1	3	2	14	99	11
V4706	277	57	14	21	37	8	505	71	15	63	35	57	35	6	1	3	2	4	88	12
V4707	238	87	23	47	43	10	420	83	15	60	31	60	32	5	1	3	2	7	74	12
V4708	445	69	23	48	44	11	335	89	23	65	36	79	37	6	1	4	3	14	120	14
V4709	420	53	23	23	53	10	469	75	31	59	35	80	37	8	2	4	3	19	146	19
V4710	257	45	26	22	27	8	311	58	15	46	27	51	28	5	1	3	2	12	104	8
V4711	271	44	24	21	25	7	325	57	14	44	26	51	27	4	1	2	2	6	99	8
V4712	252	55	39	18	26	9	364	69	14	47	23	45	24	3	1	3	2	11	67	9
V4713	337	62	20	26	38	10	459	75	15	67	35	72	35	6	1	2	2	10	83	12
V4714	212	47	21	19	46	8	421	62	29	54	29	54	31	5	1	4	3	18	124	15
V4715	304	83	31	42	54	12	295	109	23	57	32	63	33	6	1	3	3	20	108	14
V4716	155	54	23	24	34	9	445	66	13	65	36	83	36	6	1	2	2	10	80	10
V4717	182	46	19	19	18	7	350	54	11	42	18	36	19	2	0	2	2	11	47	6
V4718	320	75	18	39	23	11	552	103	24	74	34	79	36	9	2	4	3	13	113	14
V4719	456	80	20	48	39	13	476	107	25	86	39	92	41	9	2	4	3	19	136	19
V4720	254	93	27	53	73	15	300	136	34	85	55	117	57	13	2	6	4	14	134	23
V4722	685	69	21	33	57	10	512	118	23	74	32	68	34	6	1	4	3	20	204	18
V4723	483	57	20	46	36	12	459	105	24	80	40	99	41	9	2	4	3	22	163	14
V4726	186	47	24	22	43	8	260	56	16	47	28	52	28	6	1	2	2	10	53	12
V4727	394	63	25	25	39	11	272	77	19	60	33	65	34	6	1	3	2	14	64	11
V4728	371	62	28	26	38	10	238	76	22	59	39	75	40	7	1	3	2	10	68	11
V4729	234	38	23	20	22	7	351	47	14	40	26	47	26	4	1	2	2	12	58	7
V4731	252	63	18	41	57	12	303	98	40	80	39	91	41	9	2	5	3	18	94	22
V4732	339	68	18	32	71	12	360	88	54	71	50	106	53	11	2	7	4	29	136	25

V4733	263	105	29	57	89	16	262	178	26	105	37	76	38	8	2	4	4	25	140	30
V4734	418	56	23	29	54	10	391	77	26	64	30	65	31	6	1	3	2	18	113	20
V4735	377	106	28	44	80	15	331	208	24	105	33	69	34	7	1	3	4	23	146	30
V4736	384	89	22	46	39	11	415	87	16	63	31	55	32	5	1	3	2	10	107	9
V4737	176	59	22	38	46	10	330	75	22	61	31	66	32	5	1	3	2	16	120	14
V4738	462	92	22	33	23	13	211	109	14	81	32	57	32	4	1	2	2	18	58	10
V4739	362	84	24	61	40	13	344	88	20	63	38	77	39	7	1	3	2	12	78	13
V4740	310	79	24	29	24	12	68	98	13	44	32	59	32	5	1	2	2	22	57	8