Appendix: Characterisation studies of Medieval Ely Wares and Comparanda

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In 1999 the author undertook a study of medieval pottery fabrics found at Forehill, Ely, excavated by Cambridge Archaeological Unit in 1995 (Vince 1999;Hall 2003). This study found that the pottery could be divided into three petrological fabric groups, A, B and C. Fabric C has a high glauconite content and no calcareous inclusions and is quite possibly not an Ely product.

This study was followed by petrological and compositional studies of the fabrics produced at Potter's Lane (Vince 2000) and similar studies of medieval Ely wares and potential medieval Ely wares from consumer sites in Ely and elsewhere in Cambridgeshire and of samples from the south Lincolnshire production sites of Bourne and Baston, whose products are visually similar to medieval Ely wares (Vince 2001).

In total, one hundred and two samples have been examined, all with both thin section and chemical analyses (Table 1).

Table 1

Project	locality	Total
Ely Comparanda	Baston	5
	Bourne	5
	Ely	11
	Huntingdon	5
	Kings Lynn	5
	Orton Longueville	3
	Peterborough	3
	Ramsey	5
	Swavesey	5
	Wisbech	5
Ely Comparanda Total		52
Ely Forehill	Ely	22
Ely Forehill Total		22
Ely Potters Lane	Ely	28
Ely Potters Lane Total		28
Grand Total		102

Visual classification

The Medieval Ely ware samples were visually classified into four groups: Medieval Ely ware (MEL), Calcareous Medieval Ely ware (CMEL), Late Medieval Ely ware (LMEL) and Calcareous Late Medieval Ely ware (CLMEL). In addition, a coarse, gravel-tempered variant was present, COARSE MEL. A distinctive feature of LMEL is the presence of a black, carbon-rich core, with a sharp boundary between this core and the margins and surfaces but this core is also present in the other groups. Similarly, although CMEL and CLMEL fabrics have a more prominent calcareous content the thin sections reveal that all of these fabrics have or had a calcareous content. The COARSE MEL fabric is similar to Forehill fabric A whereas the MEL and CMEL fabrics are similar to Forehill fabric B.

Petrology

Sand and Gravel inclusions

All Medieval Ely ware samples contain moderate to abundant sand or gravel inclusions. The following inclusion types are present:

Subangular quartz sand: subangular to rounded quartz grains, less than 0.5mm across. These occur in all the MEL, CMEL, LMEL and CLMEL fabrics, but are absent from the COARSE MEL fabric.

Rounded quartz sand: Well-rounded, polished grains, of lower Cretaceous origin, up to 1.0mm across. Some have iron-stained veins. These grains are common in COARSE MEL and present in small quantities in the other Medieval Ely ware fabrics.

Rounded, stained flint: Brown-stained, rounded grains of flint, probably all of upper Cretaceous origin, are common in COARSE MEL and sparse but always present in the other Medieval Ely ware fabrics.

Fresh flint: Angular fragments of fresh flint are present in COARSE MEL.

Rounded opaque grains: Rounded opaque grains, red and with a matt surface in the hand specimen, are common in COARSE MEL and sparse in the other Medieval Ely ware samples.

Rounded chalk: Rounded fragments of chalk, identified by their spherical microfossils, are present in small quantities in both the COARSE MEL and the other Medieval Ely ware samples.

Glauconite: Fresh glauconite is present in some of the LMEL sections but is otherwise absent. Altered glauconite is present in MEL, LMEL and CLMEL.

Other inclusions: Fish bone, sparry ferroan calcite, ferroan calcite echinoid shell, non-ferroan calcite bivalve shell, including large flat shells similar to *inoceramus*, Greensand chert, sandstone with bivalve shell and glauconitic sandstone are all present in small quantities in the sections.

The differences between COARSE MEL and the remaining fabrics are probably due to variations in the size of the various inclusion types present in the Ely sand/gravel used as tempering material and it is likely that the sand is naturally sorted into coarse and finer beds rather than having to be sieved by the potters.

The wide range of inclusions present in the sand is consistent with a Quaternary origin and includes some Jurassic material (mainly fossiliferous limestones), a higher quantity of lower Cretaceous material (glauconite, rounded quartz, chert), and small quantities of inclusions of upper Cretaceous date (chalk and fresh flint) and of Tertiary date (rounded, stained flint). The presence of the Tertiary flint suggests that the source of this sand is a fluvio-glacial deposit derived from the north rather than a Holocene river gravel derived from the southwest.

The Bourne and Baston samples also generally have a calcareous sand temper but no examples of chalk, nor quartz grains or chert of definite lower Cretaceous origin were noted.

The samples of Bourne ware come from a known kiln site and were chosen so as to cover the visual range of textures present in the kiln's products. Those from Baston, on the other hand, were found on excavation of a domestic plot and recognised as wasters or seconds because of the presence of warping or glaze over broken edges. There is thus a likelihood of the Baston sherds being atypical of the Baston industry (which is known to have existed through documentary records) and certainly all five Baston samples have isotropic clay matrices. This relatively high firing temperature also makes it difficult to study the calcareous inclusions although none appear to have been completely burnt out, which places an upper limit on the original firing temperature.

There are four quite distinct fabrics present within the Bourne/Baston samples, approximately but not completely corresponding to the two separate sources:

a) Abundant very fine sand (ie up to 0.2mm across) and little calcareous material V901, V902, V903, V905, V908

b) Moderate rounded sand and little calcareous material V904

c) Abundant very fine sand and abundant calcareous material V909

d) Moderate rounded sand and abundant calcareous material V906, V907 and V910

The rounded sand includes a few fragments which have a cement of non-ferroan micrite still adhering to them and it is clear that some, if not all of this rounded sand is derived from a calcareous sandstone. Angular flint is not found in these samples and the rounded cryptocrystalline silica grains which are present (but not common) are more probably cherts. Similarly, the rounded opaque haematite grains which characterise Medieval Ely wares are either absent or rare in the Bourne and Baston sections and where they do occur they are less well-rounded and often have a spongy texture. Instead, small silt-sized fragments, probably of TiO, occur in all of these samples, even in sections where very fine sand is absent. Thus they are likely to have been present in the clay itself rather than the fine sand. There is no chalk and no glauconite in any of the sections. Almost all of the sections contained one or two large rounded pellets of laminated clay (clay relicts). The calcareous inclusions are in the main purple-stained micrite with some nacreous bivalve shell. Some appear to be calcareous nodules, with a vaguely concentric structure. However, one section contained an echinoid spine (V903). However, the fragments of *inoceramus* shell found in the medieval Ely wares was not found in these sections.

Groundmass

The distinctive carbon-rich core of the LMEL and CLMEL fabrics is probably the result of using an organic clay which had not been allowed to weather before use rather than to the use of clay from a different source to the COARSE MEL, MEL and CMEL wares. None of these fabrics contain quartz or muscovite silt and most have some evidence for calcareous microfossils or a general fine-grained calcareous content. Samples of Kimmeridge clay collected by David Hall from Ely have a much higher calcareous content but the Kimmeridge clay, and other Upper Jurassic clays, are know to have organic facies and it is likely that Medieval Ely potters used an Upper Jurassic clay. Those samples without an organic core were either made from a non-organic facies of the same clay or, more likely, from a weathered version of the same clay. This therefore suggests that by the late medieval period the clay was being quarried from deeper pits than those used in the earlier period.

There is no strong evidence for the use of a glauconitic clay and even the fresh glauconite found in some sections is likely to be detrital.

By contrast, the Bourne and Baston wares also sometimes have carbon-rich cores, but without a calcareous content. They too are typical of Jurassic clays, probably also of Upper Jurassic age.

Discussion

In summary, the petrological evidence suggests that the medieval Ely ware potters exploited an outcrop or outcrops of Kimmeridge clay with a high organic content and low, but appreciable, calcareous content. This clay may initially have been taken from superficial, weathered outcrops but was later probably quarried and used fresh. The pottery was tempered with a Quaternary sand, derived from either a boulder clay or fluvioglacial deposit, containing material ranging from the Jurassic to Tertiary origin, but mainly derived from lower Cretaceous strata.

Medieval Ely wares can be distinguished from Bourne/Baston wares in thin section by the presence of chalk and quartz derived from lower Cretaceous deposits.

Petrology of possible Ely wares from consumer sites

In most cases, the thin sections of possible Ely wares from consumer sites confirmed the identification with no difficulty, indicating the presence of rounded chalk together with other calcareous inclusions of Jurassic origin and a silt-free, possibly organic and possibly calcareous groundmass. In a few cases, this identification could not be confirmed (Table 2). Only one of these samples appears to be of Bourne/Baston ware (V817) whereas three are probably from other, unknown sources (V825, V839 and V852). In the main, however, the visual identifications are consistent with the petrological evidence, indicating the transport of Ely wares throughout the fens. Samples identified visually as being of Bourne/Baston type from Orton Longueville were shown in thin section to be probably of Ely origin.

Samples of so-called Grimston Software from King's Lynn have the same petrological characteristics to those of Medieval Ely wares, suggesting that Ely is probably the source of this ware.

Table 2

TSNO	Locality	Chalk?	Other diagnostic inclusions	Conclusion
V817	Peterborough	Not present	Rounded flint, rounded opaques, carbon-rich body, laminated clay pellets, calcareous fine-grained sandstone, nacreous bivalve shell, ferroan calcite.	Could be Bourne/Baston ware

V824	Ely, Lisle Lane	Some rounded voids may once have contained chalk	Rounded flint, Rounded opaques, some limestone fragments (ferroan calcite) but generally low in calcareous inclusions.	Probably MEL
V825	Ely, Lisle Lane	Not present	No flint, no rounded opaques (but silt-sized TiO-rich minerals are present), sparse quartz silt in groundmass	Not MEL and no evidence for likely source area
V835	Hunting don	Not present	Rounded flint, no rounded opaques, calcareous inclusions include echinoid shell fragments	Probably MEL
V839	Wisbech	Not present	Not a calcareous fabric. No flint or rounded opaques	Not MEL and no evidence for likely source area
V842	Wisbech	Not certain - heat altered		Probably MEL
V846	Ramsey	Not certain - heat altered		Probably MEL
V847	Ramsey	Not certain - heat altered		Probably MEL
V848	Swaves ey	Not certain - heat altered		Probably MEL

V852	Swavesey	Not present	Possibly no Greensand quartz, no flint, and quartz sand is finer than normal. Echinoid shell is present.	Probably not MEL and no evidence for likely source area
V853	Wisbech	Not present	Rounded flint, no rounded opaques (TiO silt present). One large rounded calcareous nodule.	Not MEL and no evidence for likely source area

Chemical analysis

All of the samples were analysed at Royal Holloway College, London, under the supervision of Dr J N Walsh. The following major elements were measured as percent oxide weight: Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, MnO. A range of minor and trace elements were measured as parts per million weight. These are: Ba, Ce, Co, Cr, Cu, Dy, Eu, La, Li, Nd, Ni, Sc, Sm, Sr, V, Y, Yb, Zn and Zr. Zirconium is likely to be only partially dissolved during the sample preparation process and the Zr count is therefore only a minimum.

Lead was also measured, mainly as a guide to possible glaze contamination. Fig 1 indicates the lead for each ware and shows a strong correlation with LMEL with isolated glaze contamination of CLMEL and the Bourne/.Baston samples (BOUA).

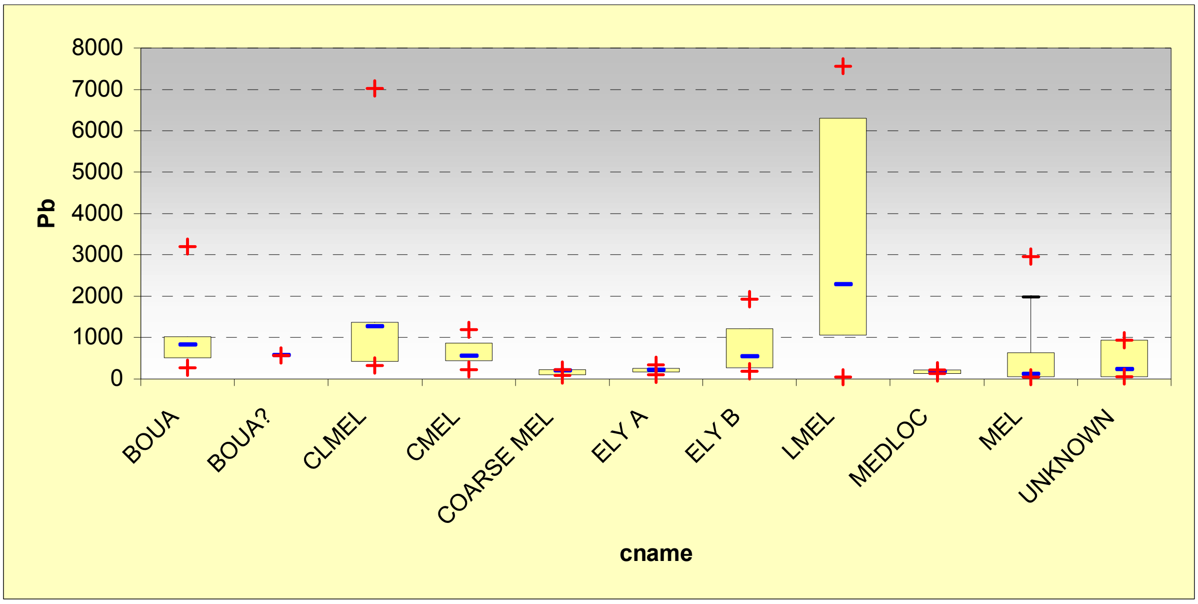

Figure 1

In order to estimate the amount of silica present in the sample the total percent oxides count was subtracted from 100% to give a notional SiO2 value. This will, however, include other unmeasured elements, such as chemically combined water and organic matter. Thus, we might expect samples with a high organic content to have a higher "SiO2" value that the equivalent oxidized sample.

Fig 2 indicates the SiO2 values for the measured groups. This shows no such difference, indicating that the organic content is low in comparison to that of silica.

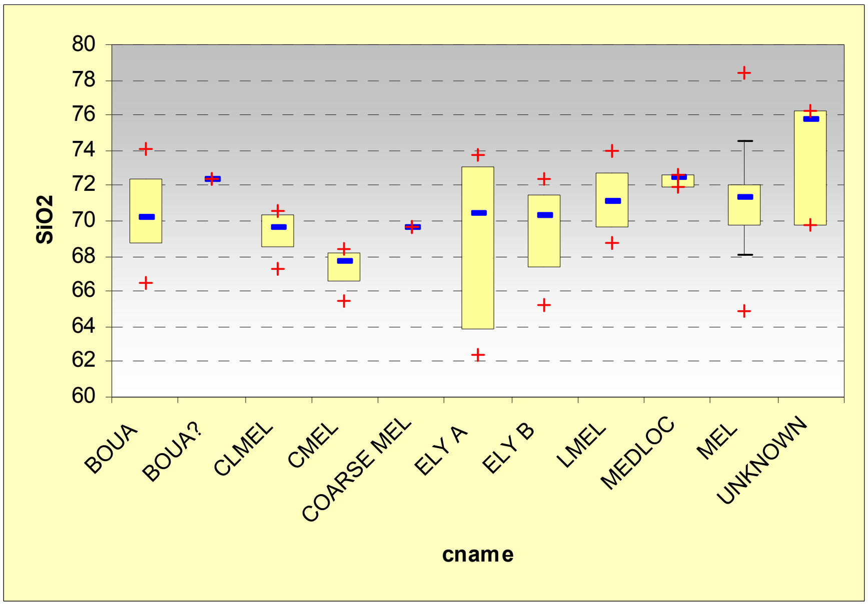

Figure 2

The data were then normalised by expressing each element value as a ratio with Aluminium, which is present mainly in clay minerals and feldspars. The Forehill A samples show a wide range in silica content and this is mainly explained by the high calcium content of three of the samples (Fig 3). With their exception, there is no obvious correlation of calcium content and whether or not they were identified visually as being calcareous. This may, however, be due to the firing out or leaching of calcareous inclusions.

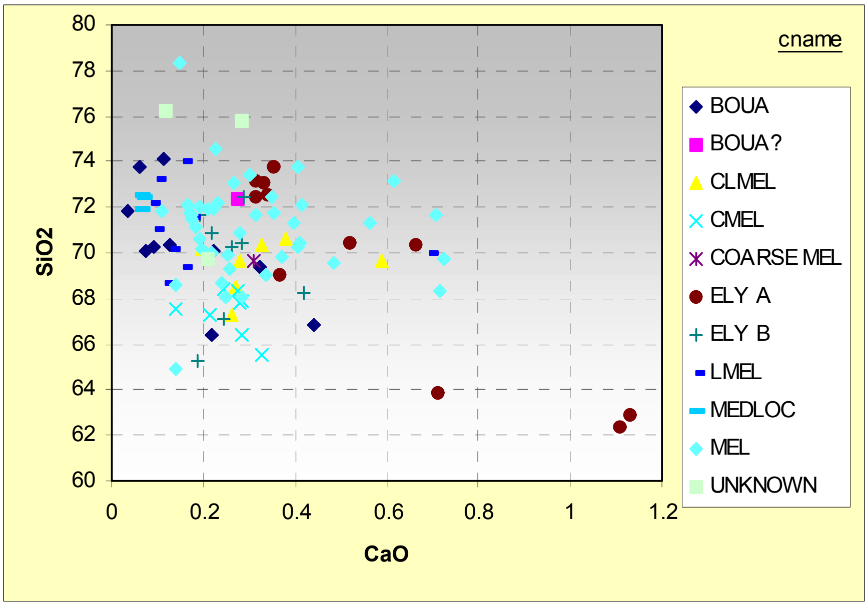

Figure 3

Factor analysis was then undertaken of the entire dataset using just the main elements, excluding CaO (for the reasons described above).

A single significant factor was found (explaining 35% of the variance in the data, compared with only 10% for the next factor). A plot of the Factor 1 scores against Silica content (Fig 4) separates the Bourne/Baston wares from the Ely wares and indicates that the Peterborough sample (BOUA?) is indeed likely to be a Bourne or Baston product. One of unknown samples has a different factor score whilst the other two are similar to the Ely wares, as are the three glauconitic samples from Forehill (marked as MEDLOC). The three highly calcareous Forehill samples have similar Factor 1 scores to the remaining Ely wares and are only separated in Fig 4 by their lower Si02 samples. High factor 1 scores indicate high values for K2O, Fe2O3 and MgO whilst negative Factor 1 scores indicate high TiO2 values. This is illustrated graphically by a plot of TiO2 against K2O values. This plot not only indicates the clear distinction between the majority of the Bourne/Baston and Ely wares but also reveals that the Forehill A samples fall into two groups, distinguished by their K2O values. All three 'unknown' samples plot peripherally to the medieval Ely group. When the same data are grouped by findspot, the Ramsey samples are distinguished from the remaining Ely wares by their low K2O and high TiO2 values (Fig 6). This suggests that the Ramsey samples might come from a different source, although clearly closer in composition to the medieval Ely wares than to the Bourne/Baston wares.

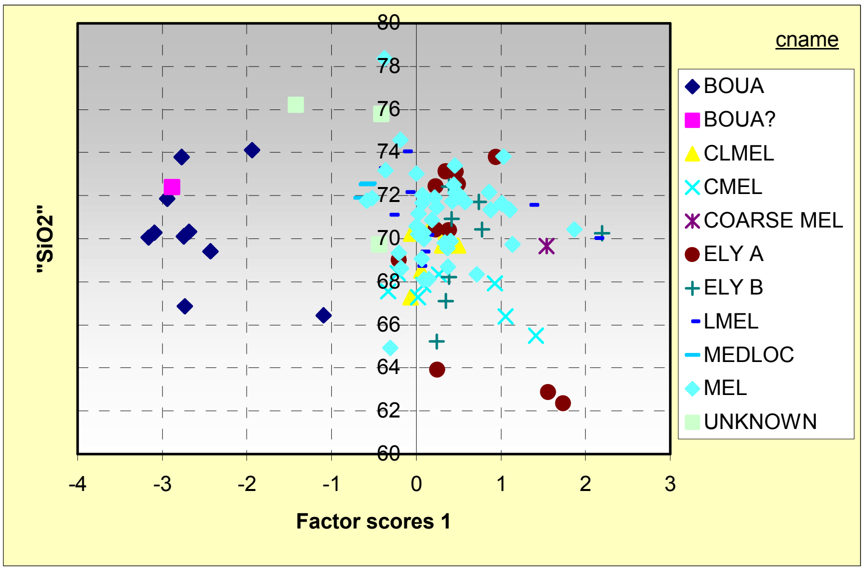

Figure 4

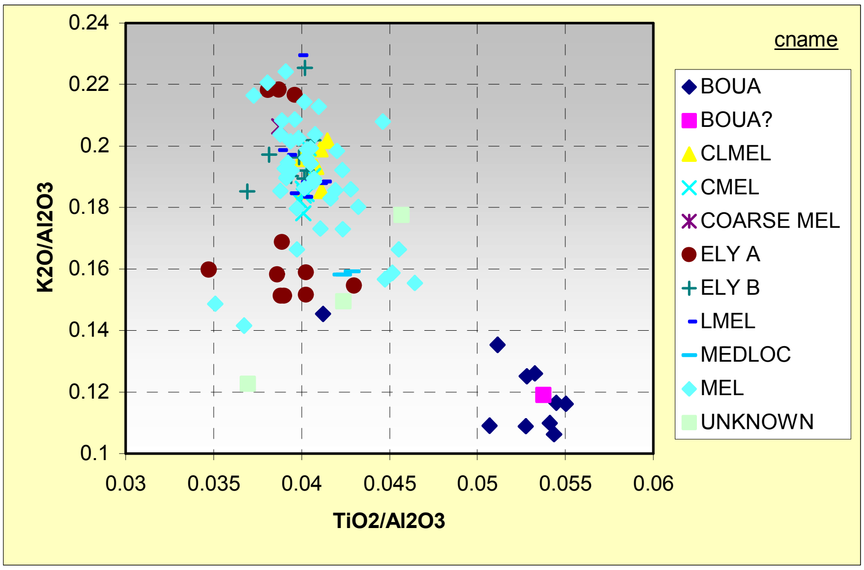

Figure 5

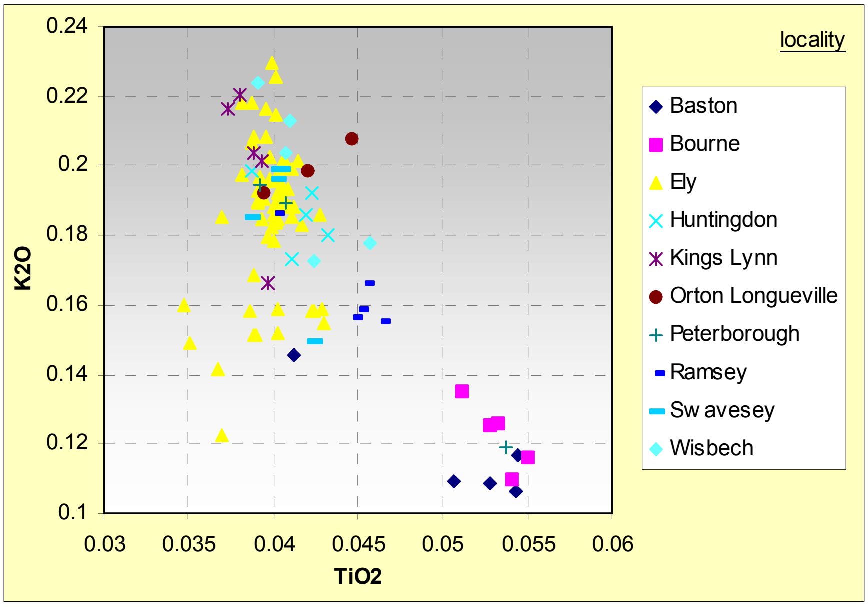

Figure 6

Factor analysis of the minor and trace elements was carried out but appears to reveal differences which are due to calibration variation rather than variations in the actual chemical content. This is shown in Fig 7 where the rare earth elements alone were including in a factor analysis. Therefore, the analysis was carried out again excluding the rare earth elements, which occur close to the detection limit of the analytical technique. The results for this dataset also show some possible correlation with batch (Fig 8). However, they are also consistent with the archaeological evidence and appear to show that the Forehill A fabric is distinguishable from the remainder but that Forehill B, the Potters Lane samples and the majority of the consumer site finds have indistinguishable compositions, although this also includes the three samples which thin section analysis rejects as Ely products (Fig 9). The COARSE MEL samples plot within this general Ely group rather than with the Forehill A samples. A further detail revealed in this analysis is a distinction between the Bourne and Baston samples, which were analysed in the same batch. If this slight difference is reliable, it would indicate that the Peterborough sample is actually a Baston rather than a Bourne product (Fig 10).

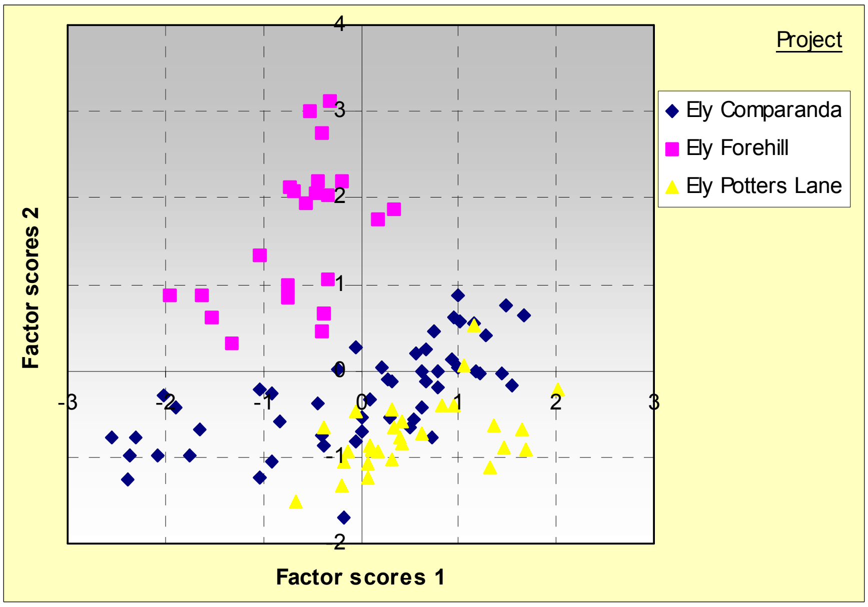

Figure 7

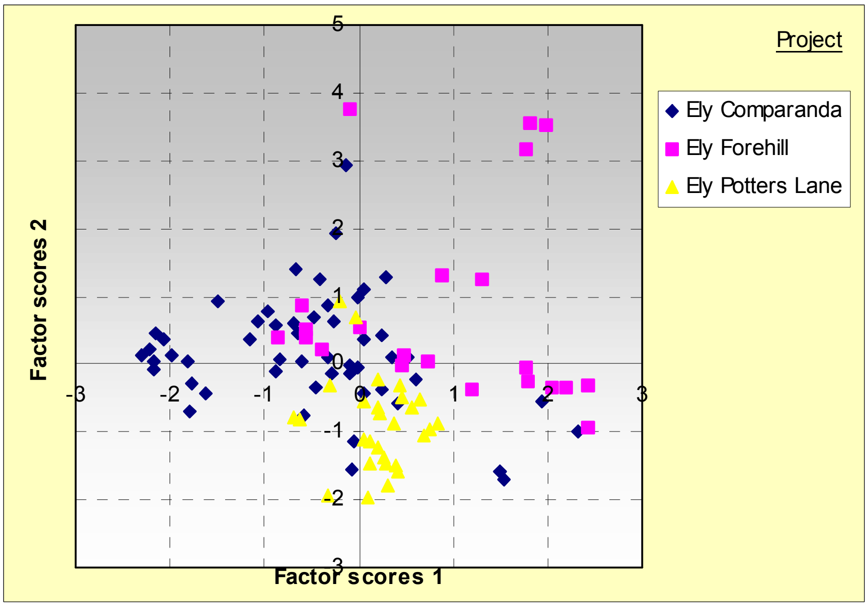

Figure 8

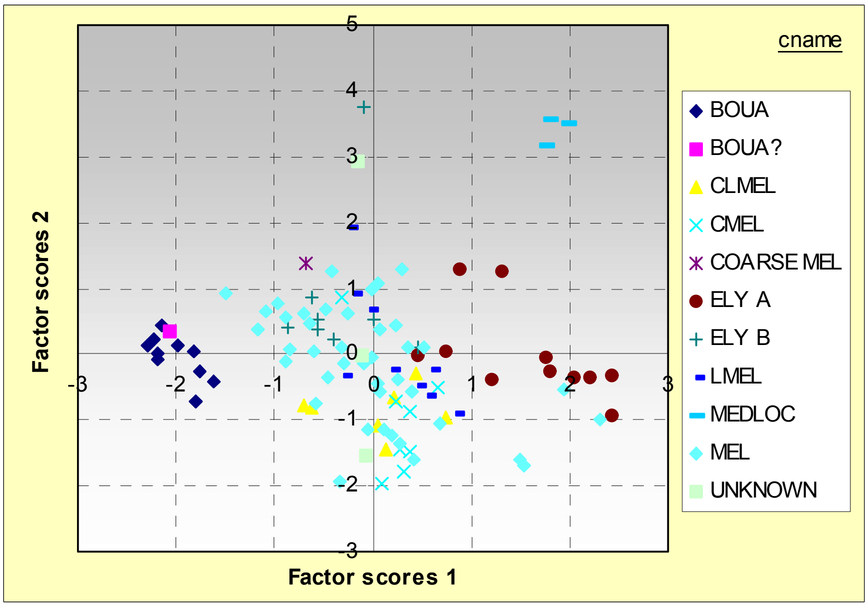

Figure 9

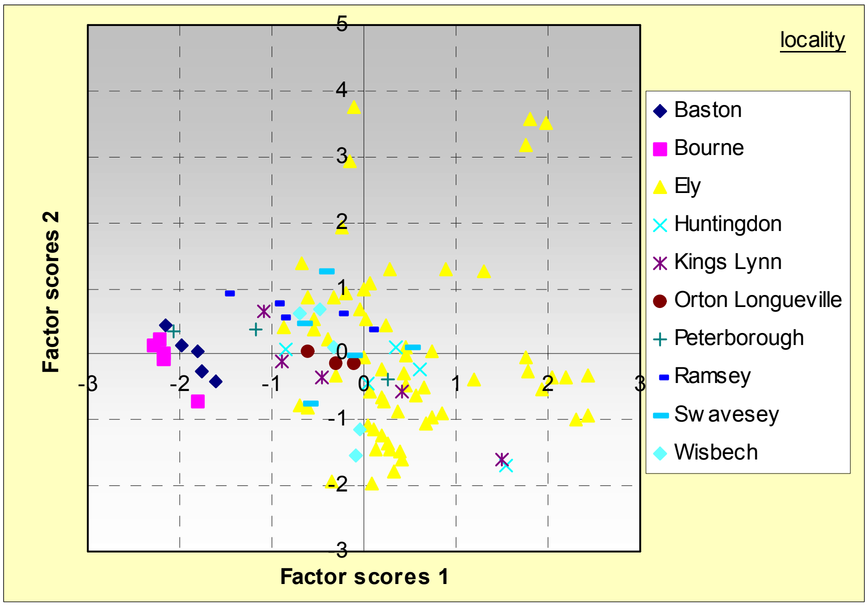

Figure 10

Conclusions

Thin section analysis indicates differences between Bourne/Baston and medieval Ely wares and also indicates that one sample from Peterborough is of Bourne/Baston ware. Three of the samples from consumer sites are unlikely to be medieval Ely ware but cannot be provenanced.

The chemical analysis confirms this distinction between Bourne/Baston and medieval Ely wares as well as hinting at a difference in the minor and trace element composition of Bourne and Baston wares. This difference would identify the Peterborough sample as a Baston product.

Forehill fabric A is chemically distinct from the remaining medieval Ely wares whereas Forehill fabric B has the same composition as the Potters Lane and consumer site samples. Forehill fabric C was produced from a glauconitic clay and is unlikely to be an Ely product.

“Grimston software” from King’s Lynn has a similar composition and petrology to medieval Ely ware and is probably an Ely product and there is only slight evidence for differences in composition between the medieval Ely ware samples from different consumer sites, indicating perhaps that the Ramsey samples come from a different source, based on their titanium and potassium contents.

Bibliography

Alan Vince (1999) *Petrographic and Chemical Analysis of Medieval Pottery from Ely, Cambridgeshire*. AVAC Reports 1999/47 Lincoln, Alan Vince Archaeology Consultancy.

Alan Vince (2000) *Characterisation studies of medieval pottery from Potter's Lane, Ely 1995*. AVAC Reports 2000/1 Lincoln, Alan Vince Archaeology Consultancy.

Alan Vince (2001) *Petrological analysis of Medieval Ely wares from consumer sites*. AVAC Reports 2001/2 Lincoln, Alan Vince Archaeology Consultancy.

Appendix: ICPS data for major elements (percent oxides)

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V0041	12.6	5.78	1.51	13.99	0.24	2.75	0.48	0.22	0.07
V0042	12.62	6.31	1.04	3.94	0.3	1.91	0.49	0.22	0.05
V0043	12.09	5.45	0.97	8	0.28	2.04	0.47	0.25	0.06
V0044	12.56	6.62	1.04	4.27	0.31	1.9	0.49	0.23	0.06
V0045	12.96	5.41	1.01	4.27	0.43	2.07	0.45	0.24	0.06
V0046	12.95	5.68	1.06	6.71	0.34	2.05	0.5	0.24	0.05
V0047	14.63	5.98	1.16	6.15	0.22	2.71	0.54	0.35	0.04
V0048	13.8	6.12	1	3.93	0.23	2.71	0.55	1.19	0.06
V0049	17.68	7.41	1.38	3.35	0.22	3.35	0.71	0.64	0.04
V0050	13.52	4.77	1	3.89	0.23	2.73	0.55	0.8	0.08
V0051	14.64	5.47	1.19	3.2	0.25	2.81	0.59	0.87	0.06
V0052	12.69	8.26	1.31	3.35	0.24	2.86	0.51	0.46	0.07
V0053	14.15	6.07	1.09	2.73	0.22	2.79	0.54	0.62	0.08
V0054	16.24	6.85	1.28	3.95	0.24	3.09	0.64	0.56	0.04
V0055	14.66	6.05	1.22	10.41	0.51	2.33	0.59	0.23	0.1
V0056	16.1	5.92	1.25	1.04	0.24	2.56	0.69	0.29	0.02
V0057	12.14	4.85	0.98	4.29	0.45	2.65	0.47	0.33	0.06
V0058	15.63	5.94	1.2	0.99	0.23	2.47	0.66	0.3	0.02
V0059	14.42	6.76	1.05	5.26	0.3	2.23	0.62	0.28	0.06
V0060	12.37	5.69	1.42	13.97	0.23	2.68	0.49	0.21	0.08
V0061	15.57	5.98	1.19	1.12	0.22	2.46	0.66	0.28	0.02
V0062	12.92	6.47	1.05	4.06	0.31	1.96	0.52	0.23	0.05
V0626	13.7655	5.56	0.97	5.2	0.18	2.66	0.56	0.42	0.07
V0627	16.4115	5.96	1.1	4.3	0.15	3.17	0.67	0.93	0.04
V0628	12.663	5.08	0.82	7.46	0.16	2.52	0.52	1.02	0.09
V0629	14.7525	6.28	1.18	4.14	0.16	2.89	0.59	0.3	0.04
V0630	13.986	5.46	0.87	4.6	0.14	2.82	0.58	1.12	0.09
V0631	15.3195	6.35	1.07	2.98	0.23	2.84	0.63	0.32	0.05
V0632	15.708	5.94	1.11	4.22	0.49	2.91	0.63	0.42	0.05
V0633	16.1385	6.35	1.11	4.01	0.18	3.11	0.63	0.3	0.07
V0634	14.5635	5.36	1.09	4.07	0.12	2.95	0.58	0.34	0.07
V0635	14.5635	5.74	0.98	2.77	0.13	2.76	0.57	0.39	0.07
V0636	19.1625	6.99	1.35	2.68	0.22	3.61	0.78	0.24	0.04
V0637	15.6555	5.38	1.05	1.73	0.16	2.91	0.67	0.53	0.03

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V0638	16.863	6.82	1.17	2.33	0.15	3.03	0.67	0.31	0.04
V0639	14.6475	5.81	0.84	2.56	0.1	2.68	0.61	1.12	0.16
V0640	17.4615	7.12	1.14	2.44	0.17	3.11	0.7	0.27	0.03
V0641	15.8865	6.56	1.12	4.42	0.17	2.93	0.64	0.34	0.09
V0642	14.4375	8.23	0.79	4.12	0.11	2.67	0.58	0.97	0.16
V0643	15.477	7.81	0.94	4.37	0.11	2.88	0.62	1.18	0.23
V0644	14.763	9.16	0.83	4.83	0.11	2.81	0.6	1.2	0.21
V0645	16.695	6.88	1.17	3.58	0.17	3.07	0.67	0.41	0.07
V0646	16.0545	6.43	1.06	3.93	0.19	2.93	0.64	0.34	0.03
V0647	17.01	6.69	1.24	2.03	0.12	3.14	0.67	0.31	0.08
V0648	15.33	4.79	1.16	1.53	0.12	2.89	0.62	0.28	0.02
V0649	16.338	5.46	1.28	1.58	0.11	3.07	0.67	0.37	0.03
V0650	15.729	6.6	1.18	2.09	0.15	2.96	0.63	0.48	0.03
V0651	13.692	5.73	0.96	2.18	0.1	2.51	0.55	0.22	0.03
V0652	13.503	7.14	0.92	2.38	0.09	2.66	0.53	1.04	0.17
V0653	15.288	6.15	1.14	1.34	0.11	2.88	0.63	0.26	0.04
V0817	15.63	3.36	0.71	4.28	0.26	1.86	0.84	0.65	0.02
V0818	14.99	5.84	0.96	3.29	0.17	2.84	0.61	1.31	0.02
V0819	14.28	5.91	1.04	2.97	0.2	2.78	0.56	0.32	0.04
V0820	15.21	6.08	1.02	2.92	0.2	2.92	0.6	0.44	0.03
V0821	13.81	5.33	1.12	5.61	0.24	2.74	0.58	0.28	0.03
V0822	13.22	5.31	0.99	6.41	0.31	2.75	0.59	0.81	0.06
V0823	13.07	5.58	0.93	2.95	0.24	1.85	0.48	0.3	0.03
V0824	11.03	6.45	1.2	7.66	0.18	2.53	0.44	0.46	0.06
V0825	14.34	3.89	0.54	1.66	0.15	1.76	0.53	0.87	0.04
V0826	13.11	5.67	0.92	4.58	0.29	1.95	0.46	0.4	0.12
V0827	15.35	6.62	1.12	4.22	0.19	3.06	0.62	0.45	0.04
V0828	12.37	6.66	1.02	5.08	0.16	2.58	0.49	1.05	0.16
V0829	13.2	6.18	0.94	3.06	0.16	2.83	0.53	0.9	0.05
V0830	15.55	6.51	1.17	4.44	0.18	3.02	0.63	0.35	0.04
V0831	13.42	6.54	0.9	4.14	0.14	2.77	0.52	1.79	0.13
V0832	15.58	5.89	1.15	3.04	0.2	2.96	0.61	0.33	0.04
V0833	12.34	6.52	0.88	4.88	0.21	2.57	0.48	0.73	0.05
V0834	16.52	5.84	1.29	2.56	0.22	3.28	0.64	0.25	0.03
V0835	11.44	4.35	0.8	8.09	0.38	1.98	0.47	0.6	0.26

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V0836	13.94	6.05	1.02	2.34	0.35	2.68	0.59	0.88	0.07
V0837	12.88	5.39	0.87	4.54	0.2	2.39	0.54	1.41	0.05
V0838	13.65	6.01	1.26	3.04	0.34	2.46	0.59	0.7	0.05
V0839	11.6	5.38	0.74	3.31	0.15	2.06	0.53	0.41	0.02
V0840	11.47	5.86	0.71	6.47	0.19	2.44	0.47	1.03	0.03
V0841	11.51	5.28	0.81	8.33	0.22	2.58	0.45	1.06	0.03
V0842	15.21	5.03	1.18	2.81	0.21	3.1	0.62	0.65	0.02
V0843	13.57	7.87	0.78	4.54	0.26	2.11	0.63	1.11	0.06
V0844	14.44	6.85	1.06	3.63	0.17	2.69	0.58	0.66	0.04
V0845	12.74	6.04	0.8	3.37	0.28	2.12	0.58	0.97	0.07
V0846	14.75	6.16	1.02	2.48	0.27	2.31	0.66	0.56	0.03
V0847	15.06	6.78	1.25	3.89	0.29	2.39	0.68	0.26	0.07
V0848	15.38	6.71	1.2	3.69	0.2	3.06	0.62	0.42	0.04
V0849	12.34	5.3	0.81	5.12	0.17	2.46	0.5	1.15	0.02
V0850	13.92	5.95	0.94	5.17	0.16	2.58	0.54	0.91	0.04
V0851	11.67	4.93	1.17	4.74	0.37	2.29	0.47	0.51	0.05
V0852	15.58	6.75	1.13	3.29	0.27	2.33	0.66	0.21	0.06
V0853	11.57	4.17	0.85	7.14	0.26	2	0.49	0.32	0.03
V0874	12.87	4.89	0.87	3.88	0.23	2.84	0.49	0.53	0.02
V0875	12.61	5.19	0.89	9.02	0.24	2.73	0.47	0.48	0.04
V0876	14.98	5.39	1.09	2.64	0.29	3.02	0.59	0.3	0.03
V0877	12.08	3.86	0.8	1.79	0.38	2.01	0.48	0.16	0.07
V0878	13.4	5.11	0.8	4.22	0.2	2.73	0.52	1.23	0.08
V0901	19.45	4.31	0.97	1.48	0.25	2.26	1.07	0.13	0.02
V0902	17.99	4.89	0.88	2.31	0.27	2.25	0.95	0.11	0.03
V0903	18.85	4.81	0.91	1.75	0.21	2.07	1.02	0.1	0.02
V0904	16.52	4.55	0.72	1.04	0.22	2.08	0.88	0.17	0.03
V0905	14.86	5.25	0.68	1.67	0.35	2.01	0.76	0.25	0.06
V0906	16.37	5.74	0.81	7.21	0.15	1.74	0.89	0.21	0.02
V0907	18.43	5.89	1.26	4.01	0.28	2.68	0.76	0.24	0.01
V0908	18.01	5.51	0.76	0.63	0.21	1.96	0.95	0.11	0.01
V0909	17.16	5.05	0.8	3.81	0.21	1.87	0.87	0.12	0.01
V0910	15.79	5.77	0.91	5.09	0.16	1.84	0.86	0.16	0.02

Appendix: ICPS data for minor and trace elements (ppm)

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0041	279	98	29	66	70	13	286	138	18	60	33	71	31.5	6.3	1	2.9	1.5	106	98	20
V0042	267	87	19	114	74	13	160	126	17	52	42	84	42	7	1.1	3.1	1.4	210	69	17
V0043	314	79	23	88	77	12	237	116	17	55	41	85	41.25	7.1	1.1	3.1	1.5	172	72	20
V0044	266	87	20	118	73	13	163	129	17	51	43	85	42.75	7	1.1	2.9	1.4	252	69	20
V0045	263	82	24	87	105	13	151	116	18	67	44	88	44.25	7.2	1.2	3.1	1.5	189	78	20
V0046	301	85	20	131	78	13	224	113	17	54	44	88	44.25	7.5	1.2	3	1.4	238	72	20
V0047	315	108	31	75	70	14	160	137	19	52	47	83	45	7.5	1.2	3.1	1.5	1930	107	20
V0048	445	102	28	54	64	12	230	124	18	68	41	74	41.25	6.4	1.1	2.9	1.6	366	106	17
V0049	384	140	47	86	69	16	195	164	21	81	49	89	46.5	7.7	1.2	3.2	1.9	286	129	17
V0050	395	103	35	51	52	13	203	120	21	70	45	82	45	7.6	1.1	3.4	1.9	1349	112	16
V0051	384	109	29	50	51	13	205	137	21	71	45	82	43.5	7.2	1.1	3.3	1.9	701	101	15
V0052	317	130	33	51	62	13	161	180	21	79	43	79	43.5	6.7	1.1	3.4	1.7	189	120	18
V0053	389	107	34	63	77	13	149	136	19	63	42	79	43.5	6.9	1.1	2.8	1.7	261	109	18
V0054	361	125	42	70	63	15	180	154	19	55	47	82	45.75	7.5	1.2	3	1.5	831	120	17
V0055	344	109	14	95	60	13	251	152	17	65	45	82	39.75	6.8	1	2.7	1.4	135	86	22
V0056	306	157	35	87	189	17	78	163	21	114	50	152	56.25	10.1	1.5	4.1	1.9	124	125	30
V0057	332	78	20	74	77	12	159	102	17	56	41	87	41.25	6.3	1.1	2.9	1.5	254	70	18
V0058	333	157	35	82	200	17	81	162	20	111	50	153	56.25	10	1.5	3.9	1.8	218	121	30
V0059	310	105	19	89	56	13	146	143	15	57	44	81	40.5	6.4	1.1	2.5	1.2	165	97	20

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0060	277	97	22	64	74	13	280	131	17	57	33	70	33	6.7	1	2.9	1.5	245	88	23
V0061	325	156	34	82	192	17	81	158	21	116	52	152	55.5	10.1	1.5	4	1.9	165	122	29
V0062	279	89	21	117	77	13	163	128	18	58	44	89	45	7.4	1.1	3.2	1.5	337	70	20
V0626	304	82	38	81	63	12	151	139	22	55	35	61	44	5.848	2	3.7	1.9	1371.372995	120	14
V0627	522	101	35	67	61	15	188	139	24	65	39	67	40.25	5.168	2.3	3.9	2.1	322.9961024	101	13
V0628	421	72	27	76	54	11	223	117	22	49	34	57	38.35	7.564	1.9	3.5	1.7	430.1526661	80	10
V0629	270	92	37	93	62	14	133	166	19	60	34	59	34.65	4.524	2.2	3	1.7	7022.617721	89	13
V0630	547	80	39	55	51	13	214	116	22	62	33	58	39.5	5.718	2	3.7	1.9	586.4561533	94	12
V0631	361	86	28	76	86	14	117	141	21	54	38	66	38.55	4.105	2.2	3.7	2	1253.865803	100	21
V0632	362	89	33	83	66	14	157	152	21	52	38	68	44.45	5.102	2	3.4	1.9	1264.374307	106	14
V0633	327	89	44	88	70	15	138	133	24	60	39	68	44.975	5.005	2.3	3.8	2	866.5613171	95	15
V0634	348	88	38	73	71	13	138	131	20	69	33	59	32.825	4.888	1.9	3.3	2	1201.304875	94	16
V0635	311	82	33	77	61	13	126	132	19	58	34	61	33.075	3.742	1.8	3.3	1.9	515.4178246	81	14
V0636	433	100	39	93	73	16	133	153	21	59	41	69	48.3	2.717	2.3	3.7	2.1	554.7929616	101	15
V0637	339	86	47	68	70	14	118	141	22	57	40	69	44.675	4.354	2.1	3.7	2	1936.743138	88	18
V0638	345	89	40	95	76	15	113	152	21	54	41	72	43.175	3.406	2.3	3.7	2	1532.563337	95	17
V0639	474	87	41	73	86	13	142	126	25	64	37	66	36.6	4.023	2.2	4.3	2.3	1228.201956	86	20
V0640	352	97	39	96	80	15	115	145	23	54	43	67	40.9	2.096	2.4	3.7	2	730.9233897	95	17
V0641	332	94	38	103	72	14	137	135	21	53	38	65	39.95	4.248	2.1	3.8	1.9	571.3949377	97	14
V0642	438	89	39	68	73	13	148	136	23	62	36	62	41.7	2.309	2.4	3.9	2.2	438.7976261	83	16

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0643	545	96	40	78	94	15	169	139	27	66	42	72	49.075	3.423	2.4	4.9	2.5	543.0949998	103	19
V0644	486	92	35	75	82	13	168	122	24	62	38	65	40.925	1.828	2.6	4.4	2.2	911.7388293	105	19
V0645	350	92	38	89	74	15	136	144	25	58	41	72	45.05	4.304	2.6	4.1	2.1	449.6927179	100	16
V0646	311	87	34	88	68	13	128	129	19	50	39	67	45.175	4.269	2.2	3.5	1.7	1183.590682	93	16
V0647	330	113	32	79	53	16	123	165	21	67	40	68	39.925	3.227	2.2	3.9	2.2	7556.597752	92	15
V0648	352	98	35	87	75	14	93	152	21	65	40	71	43.175	4.057	2	4.1	2.3	1883.096078	91	17
V0649	325	103	31	77	71	15	104	171	21	68	43	73	42.05	3.618	2.3	4.2	2.1	976.9323864	98	19
V0650	351	101	33	125	66	14	122	162	20	65	39	66	42.775	2.78	2.2	3.5	2	7536.347346	88	16
V0651	252	126	27	69	56	12	97	149	17	59	34	59	33.55	3.259	2	3.1	1.8	1151.810672	76	14
V0652	350	103	36	64	65	12	133	155	19	68	32	57	35.05	2.162	2	3.9	2.1	5047.879444	85	15
V0653	290	93	28	89	71	14	88	153	24	74	40	69	42.65	3.245	2.4	4.1	2.4	2286.431076	77	16
V0817	359	102	30	40	20	14	175	122	15	110	36	65	28.72	4.992	0.8312	2.5	1.4	563.709232	64	11
V0818	339	113	39	52	45	14	186	130	20	72	32	62	32.71	6.048	1.2328	3.1	1.9	348.6345837	94	11
V0819	333	105	31	88	62	13	118	127	22	62	36	69	35.03	7.027	1.3272	3.5	1.9	652.6319474	86	14
V0820	379	107	35	69	61	14	117	134	26	78	38	72	40.08	7.276	1.4136	4	2.4	80.40208143	86	14
V0821	342	102	30	81	50	13	156	126	19	59	34	65	38.39	6.101	1.3736	3.2	1.6	353.6043351	84	12
V0822	390	101	24	55	49	13	172	87	26	63	35	64	40.59	6.507	1.2752	3.6	1.9	55.46503801	101	12
V0823	251	78	22	142	82	13	138	116	23	75	32	75	35.05	7.026	1.6536	3.8	1.9	74.39075281	72	15
V0824	353	96	22	53	46	11	186	125	20	69	28	59	36.34	6.065	1.284	3.2	1.7	47.80547404	82	12
V0825	412	112	20	84	28	19	158	179	18	104	26	54	25.34	4.433	0.9888	3	2.1	932.2100573	65	10

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0826	359	74	24	101	101	13	176	112	22	79	32	87	37.42	7.599	1.5464	3.8	1.8	80.78090045	74	20
V0827	486	116	37	67	67	15	154	155	23	78	36	72	40.78	7.214	1.3704	3.6	2.2	221.1461702	109	16
V0828	514	90	31	64	67	12	179	134	21	69	30	62	30.92	5.802	1.2672	3.8	2	82.73107976	112	15
V0829	498	97	34	57	78	13	173	142	24	79	32	65	31.94	6.046	1.4056	3.8	2.2	79.75650022	108	19
V0830	348	114	30	88	73	15	142	147	26	79	38	73	37.56	7.047	1.4792	4.1	2.3	227.5744298	118	17
V0831	642	106	38	59	54	13	271	147	22	76	30	59	27.86	5.438	1.2768	3.4	2	168.2292384	113	14
V0832	381	114	29	87	67	14	128	157	24	70	36	70	36.96	6.833	1.2288	3.8	2	72.99357981	99	14
V0833	392	93	30	64	57	12	162	127	24	70	32	68	36.12	6.744	1.3784	3.6	2	96.6493043	109	14
V0834	361	117	39	109	78	15	117	147	24	82	37	73	40.44	6.648	1.5328	3.8	2.1	5071.42145	107	21
V0835	494	57	23	91	64	11	311	77	20	58	28	63	32.91	4.995	0.952	3.5	1.4	115.5329084	72	18
V0836	524	98	34	70	74	13	150	123	23	73	32	63	31.66	6.085	1.116	3.7	2	63.29775578	96	20
V0837	689	94	34	61	50	12	253	107	21	68	30	60	36.46	5.683	1.3688	3.2	1.8	649.6428601	90	11
V0838	510	89	24	77	53	13	167	111	24	70	36	66	35.96	6.697	1.3192	3.5	1.9	60.23819731	90	15
V0839	343	80	190	76	41	10	107	82	22	60	32	62	32.69	5.486	1.2696	3.2	1.6	232.476738	66	11
V0840	405	76	29	53	50	11	169	113	19	63	28	59	32.53	5.342	1.1312	2.8	1.6	217.8478695	109	12
V0841	376	83	36	54	48	11	227	103	20	60	27	56	32.67	5.016	1.1776	2.9	1.5	97.2445211	110	10
V0842	364	110	30	70	58	14	132	140	25	71	33	67	36.19	6.491	1.2976	3.6	2	1478.74293	107	15
V0843	472	93	24	52	36	12	248	134	17	89	28	54	25.46	4.939	1.1704	2.3	1.5	59.38806052	108	12
V0844	435	114	33	74	58	14	165	143	22	69	31	58	32.37	5.545	1.152	3.3	1.8	2965.107638	96	13
V0845	470	85	22	55	33	12	200	114	16	86	27	54	26.63	3.988	0.8168	2.4	1.5	57.01778715	91	15

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0846	365	103	21	76	38	13	168	142	19	92	33	67	34.52	5.752	1.2072	2.7	1.7	43.876798	108	14
V0847	412	101	22	91	56	14	166	142	22	91	39	80	40.11	6.766	1.3576	3.6	1.9	47.51288944	113	19
V0848	392	112	29	94	72	15	142	146	31	74	38	74	39.31	6.787	1.4632	4.2	2.2	152.1493096	113	16
V0849	630	95	40	54	67	12	241	120	22	68	30	61	36.88	5.31	1.276	3.1	1.8	53.36649763	125	15
V0850	529	103	42	69	61	13	246	130	23	73	30	59	35.83	5.315	1.424	3.2	1.9	44.63514826	112	11
V0851	497	71	23	58	41	10	180	85	18	59	28	56	33.26	4.521	1.3056	2.9	1.4	50.65932988	97	14
V0852	340	111	19	100	49	13	141	151	20	85	34	67	35.71	5.975	1.36	3.4	1.9	51.68749845	106	18
V0853	273	83	21	65	44	10	164	76	22	53	31	57	34.86	5.949	1.2664	3.2	1.5	237.8906345	65	11
V0874	338	94	37	57	45	12	142	110	18	52	31	53	24.18	5.333	1	3.3	1.7	121.7611062	89	8
V0875	298	93	225	67	55	12	175	111	21	58	34	57	32.47	5.443	1.4	3.6	2	628.925473	93	9
V0876	368	102	33	80	79	14	107	127	26	58	40	71	33.04	7.083	1.6	4.3	2	350.8472516	105	16
V0877	386	66	21	88	54	11	116	79	16	58	29	66	20.315	5.342	1	3	1.4	102.3498119	67	24
V0878	323	102	36	50	50	13	208	118	20	56	33	62	25.67	5.467	1.3	3.7	1.9	55.75567067	120	9
V0901	367	130	25	52	26	17	147	149	16	119	50	76	34.52	5.276	0.9414	2.9	1.8	868.2726455	99	11
V0902	337	109	27	50	31	16	136	128	15	96	46	72	35.69	5.544	1.1066	2.9	1.5	514.5863383	142	11
V0903	333	121	26	48	25	17	146	144	14	107	50	74	37.25	5.476	1.0114	2.8	1.6	822.9540278	74	8
V0904	344	108	25	43	20	15	116	124	13	102	41	64	24.96	4.58	1.027	2.4	1.5	953.0281329	67	7
V0905	349	91	24	47	29	12	118	99	14	81	38	64	30.33	4.6	0.985	2.8	1.5	814.7242951	86	12
V0906	297	106	25	45	31	14	149	132	20	87	43	67	40.79	6.304	1.2556	3.4	1.8	271.0607826	90	10
V0907	371	130	36	62	36	18	149	113	17	69	51	81	43.99	5.844	1.3466	2.9	1.7	474.8379418	103	9

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V0908	355	113	27	52	27	17	111	132	17	101	47	70	31.37	4.796	1.0694	3.4	1.8	1246.516367	101	12
V0909	310	107	32	53	27	15	137	125	21	106	46	71	42.19	6.28	1.097	3.5	1.9	3195.215134	172	13
V0910	289	102	27	48	27	14	129	123	15	83	43	65	33.91	5.392	0.9538	2.8	1.5	810.0459678	119	10