Torksey Ware Reviewed from the North

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In 1984 Cathy Brooks and Ailsa Mainman produced a paper for Maurice Barley's festschrift which has become the standard view on Torksey ware (Brooks and Mainman 1984). Their work was based on thin section analysis of samples of waste from the pottery kilns excavated by Barley at Torksey (Barley 1964;Barley 1981) and from sherds from excavations in York. Their conclusion was that whilst some of the York sherds matched the Torksey samples closely others were distinguishable, for example by grain size. A neutron activation analysis study of the same samples also indicated that there were differences in the chemical composition of the York and Torksey samples.

Since then, the study of the pottery fabrics of the east midlands and northern England has intensified, for example over 600 thin sections were analysed as part of the programme of post-excavation analysis of the 1973-87 excavations in Lincoln (2006) and a survey of the Anglo-Saxon pottery of northern England, funded by English Heritage, has given an opportunity to revisit the problem of Torksey ware in the north.

Binocular microscope study of Torksey ware from the kiln sites indicates that the sand is almost entirely composed of rounded grains and that at sufficient magnification many of these can be seen to have a matt surface, indicative of creation in desert conditions. Thin section analysis further indicates that a minority of the grains consist of rounded chert and rounded grains of fine-grained sandstone/coarse siltstone. Unleached sherds can also contain large (up to 3.0-4.0mm across) calcareous nodules. Unfortunately, these are usually leached and survive as amorphous voids or have been heat-altered. It is therefore uncertain if they are detrital lumps of limestone or concretionary limestone present in the raw clay. The groundmass contains sparse angular quartz and muscovite, but again it is not clear how much of these fine inclusions were present in the raw clay and how much was added as part of the sand tempering.

When the York thin sections were re-examined, it was clear that several have exactly a sand temper with exactly the same characteristics as those of the Torksey wasters whilst others contain fragments of overgrown quartz, probably originating in the Millstone Grit. Such grains are common in the fluvio-glacial sands of the Vale of York as well as in the eastern foothills of the Pennines. No sherds with body shapes, rim forms or decoration typical of Torksey ware have been seen in northern England with these Millstone Grit-derived quartz grains and it would be tempting to conclude that in Brooks and Mainman's study their York samples were a mixture of genuine Torksey ware and other, later, locally-made sandy types.

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However, excavations in Newark have revealed the presence of wasters of a ware which is visually very close to Torksey ware. In thin section it contains more muscovite in the groundmass but is tempered with exactly the same sand. Furthermore, in her studies of pottery on sites in Lincolnshire, Jane Young has recognised wheelthrown greyware jars which are not quite the same as the Torksey products. These, she has termed Torksey-type ware. The Trent Valley sand which was used to temper the Torksey and Newark wares occurs up and down the Trent valley and throughout Nottinghamshire, being derived mainly from Triassic sands and sandstones which outcrop extensively throughout that county. Very similar sands also occur as windblown cover sands on the sides and top of the Jurassic ridge, and in the Witham terrace sands. Similar sands also occur in the central clay vale/Ancholme Valley and in boulder clays and fluvio-glacial sands on the north and east sides of the Lincolnshire Wolds. There are therefore a large number of potential sources of Torksey-type wares south of the Humber. To the north of the Humber, however, no sands have been seen by the author with exactly the same characteristics (the closest being the Permian Yellow sands of northeastern England). It is therefore likely that all vessels with a sand temper similar to that found in the Torksey wasters in Yorkshire are either Torksey products (Torksey ware) or produced in another centre in Lincolnshire or Nottinghamshire (Torksey-type ware).

Chemical Analysis

Samples of Torksey ware and Torksey-type ware from York, Doncaster and Beverley were chosen for chemical analysis together with samples from the seven kilns excavated by Barley. Details of the samples are given in Appendix 1. These were compared with samples of Newark Torksey ware wasters collected by C Cumberpatch for the South Yorkshire and North Derbyshire Medieval Pottery Type Series (Cumberpatch 2004) and samples from Flixborough, in North Lincolnshire and a putative Torksey ware import from Viborg, in the centre of the Jutland peninsula, Denmark. The Torksey and Yorkshire samples were chosen to be as representative as possible of the Torksey ware present at the sites concerned (i.e. no sherds which would have required thin section analysis to confirm their identity were included) but included a higher proportion of roller-stamped vessels than was present in the site collection as a whole.

The samples were prepared in Lincoln by Peter Hill. A subsample of the sherd, usually c.200-300 cubic mm, was taken and the edges and outer margins were removed, to minimise the amount of post-burial contamination of the sample included. The remainder was milled to a fine powder and submitted to Royal Holloway College, London, where they were analysed using Inductively Coupled Plasma Spectroscopy under the supervision of Dr J N Walsh, Dept of Geology.

The resulting data consist of the frequencies of a range of major elements, measured as percent oxides (App 2). And a range of minor and trace elements, measured as parts per million (App 3).

Silica

Silica was not measured in this ICPS analysis and forms a high proportion of the ceramic body. An estimate of the silica content can be obtained by subtracting the total of the major element oxides from 100%. This estimate will include organic matter, sulphur and other unmeasured elements, but these are likely to have formed only a few percent of the sample.

Fig 1 shows the estimated silica content for the different Torksey kilns, the Yorkshire samples and other comparanda. This shows that the Viborg sample has a higher silica content than any of the other samples and is therefore unlikely to be a Torksey production. The remainder have silica contents ranging from a mean of 68.56% to a mean of 72.44%. There are differences between the various sampled groups but no systematic difference between Torksey kiln samples, the Newark Torksey ware and the material from the Yorkshire consumer sites.

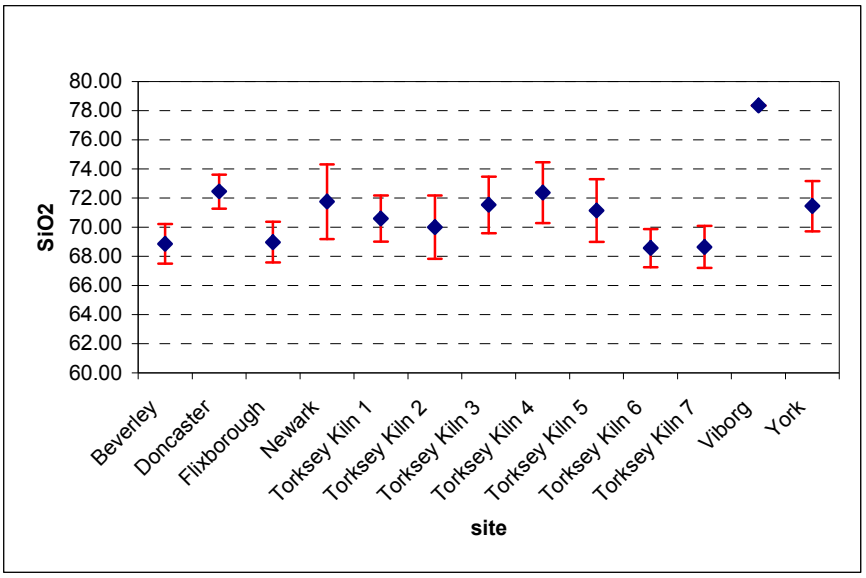

Figure 1

Normalisation

Because of the varying silica content, which is probably due to the amount of quartz sand temper added to the clay, the data were normalised to Aluminium before further analysis.

Comparison of Torksey and other samples

Factor analysis was carried out on the normalised data and six factors were identified. Fig 2 shows a plot of Factor 1 versus Factor 2 scores and makes it clear that the Viborg and Newark samples have a different chemical composition from the remainder. The remainder

form a large diffuse cluster, within which the samples from Torksey kilns 6 and 7 form a discrete sub-cluster.

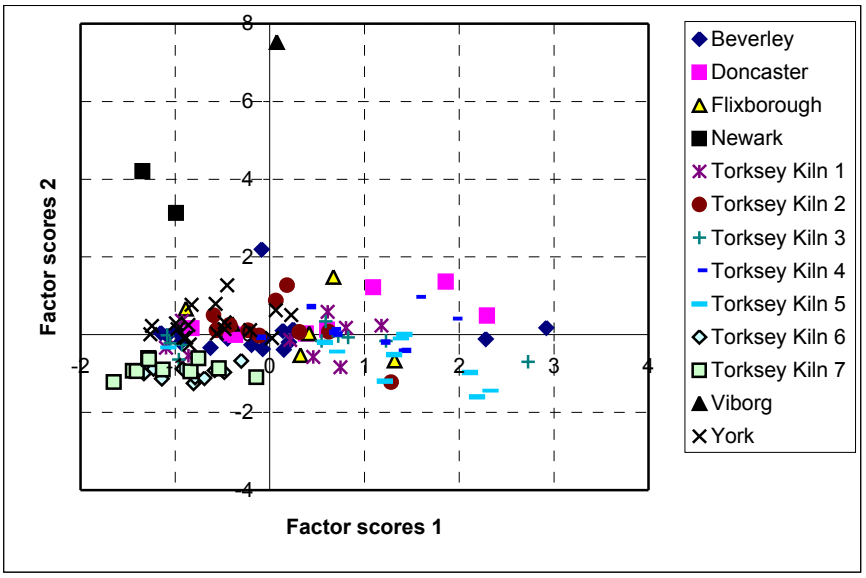

Figure 2

The plot of F3 against F4 scores (Fig 3) differentiates the Flixborough samples from the remainder. The remainder form a large cluster with the Newark samples plotting on the fringe. The Viborg sample plots in the centre of the cluster. The separation of the Flixborough samples appears to be due to their low Rare Earth element (REE) content.

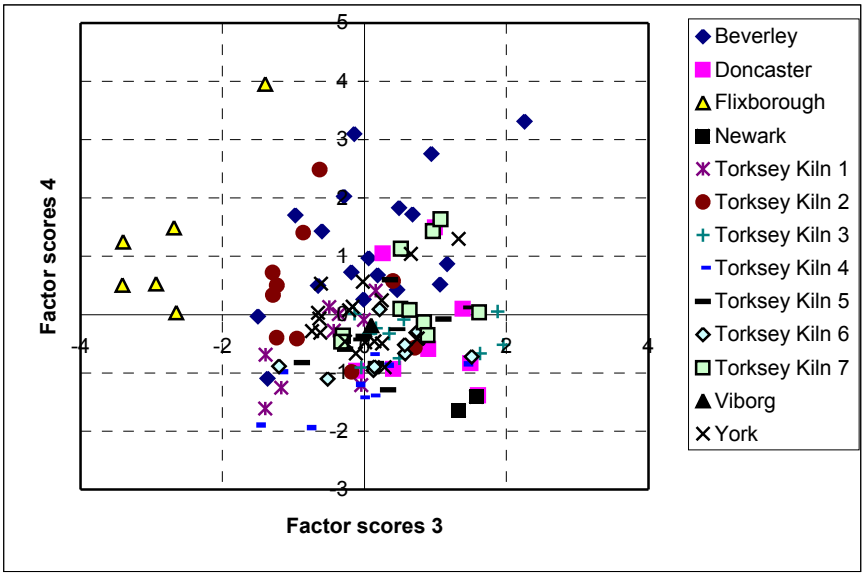

Figure 3

Finally, the plot of F5 against F6 scores (Fig 4) again separates the Viborg and Newark samples from the remainder but also shows that the three groups of Yorkshire samples all have lower F6 scores than the remainder.

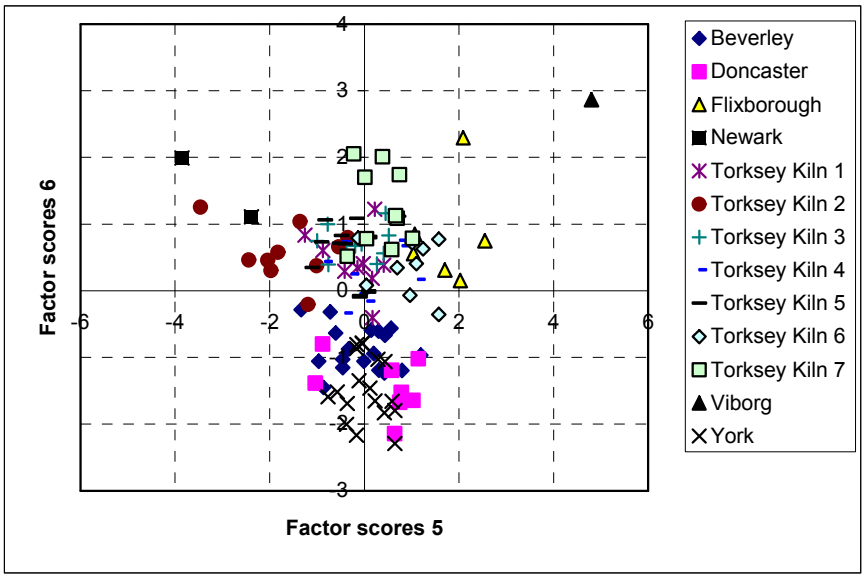

Figure 4

These results probably indicate that the Viborg and Newark samples were not made at Torksey and therefore incidentally confirm that Newark Torksey-type ware is chemically distinguishable from Torksey-type ware. The differences between the remaining samples are likely to be affected by post-burial concretion in the vessel pores and voids, leaching and adsorption of elements from the groundwater.

Variation in Torksey ware chemical composition

To investigate these Torksey wares further, the Newark and Viborg samples were excluded from further analysis and a restricted range of elements, those which are least likely to be affected by post-burial alterations, were then analysed using factor analysis. This reduced list, Sodium, Titanium, Chromium, Lithium, Vanadium, Zirconium and Cobalt, produced only a single factor and therefore the estimated Silica and Aluminium values were included. This produced three factors. Fig 5 is a plot of F1 against F2.

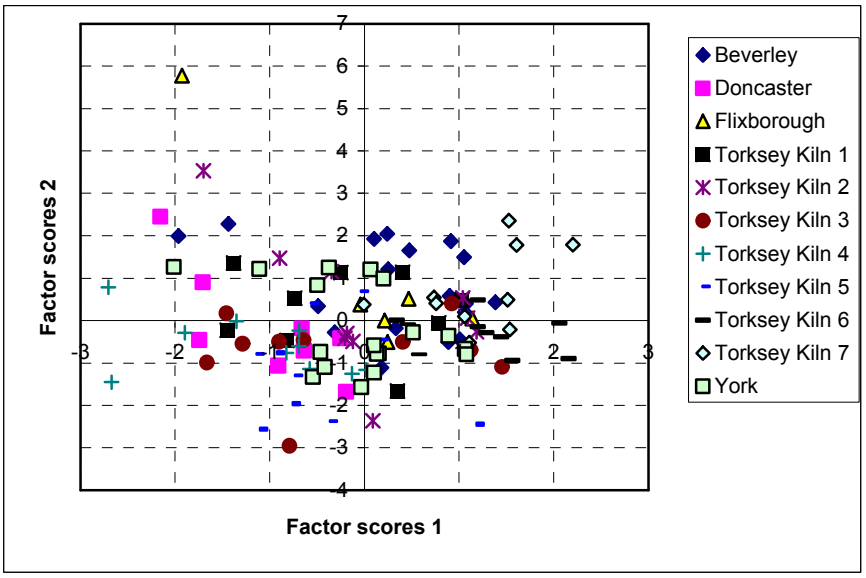

Figure 5

The F2 scores show no variation in their mean values between groups but the F1 scores do. Fig 6 shows the mean and standard deviation of the F1 scores for each group and indicates that Kilns 6 and 7 have higher scores than the remainder. These two kilns are of different dates (mid/late 10th and late 10th/early mid 11th century respectively) but were located in the same area and either shared the same clay source or were subjected to the same post-burial environments. The latter is unlikely since there are differences in the composition of the samples from kilns 4 and 5, which were also located in the same area (Fig 7) although there are no differences between the composition of the samples from Kilns 1 and 2, which were located together, some way to the southeast of the other kilns excavated by Barley and which date to the end and beginning of the Torksey industry respectively.

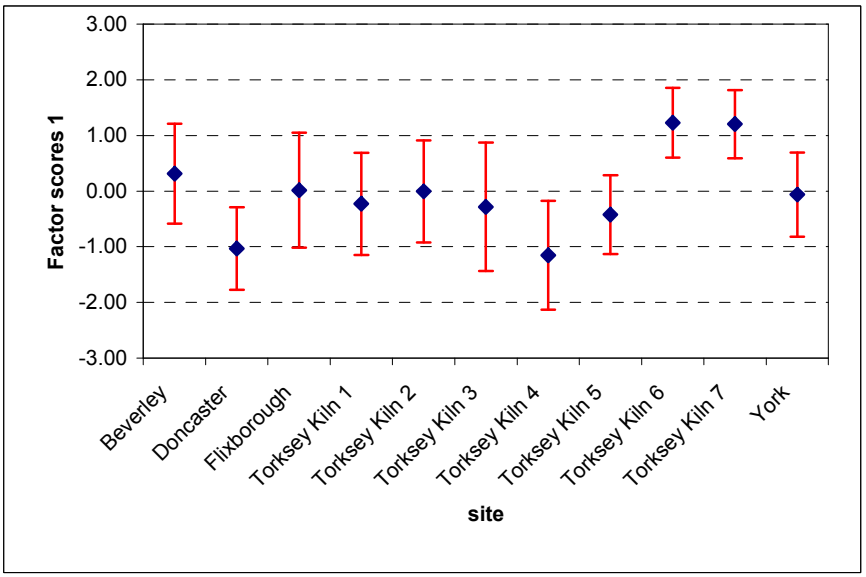

Figure 6

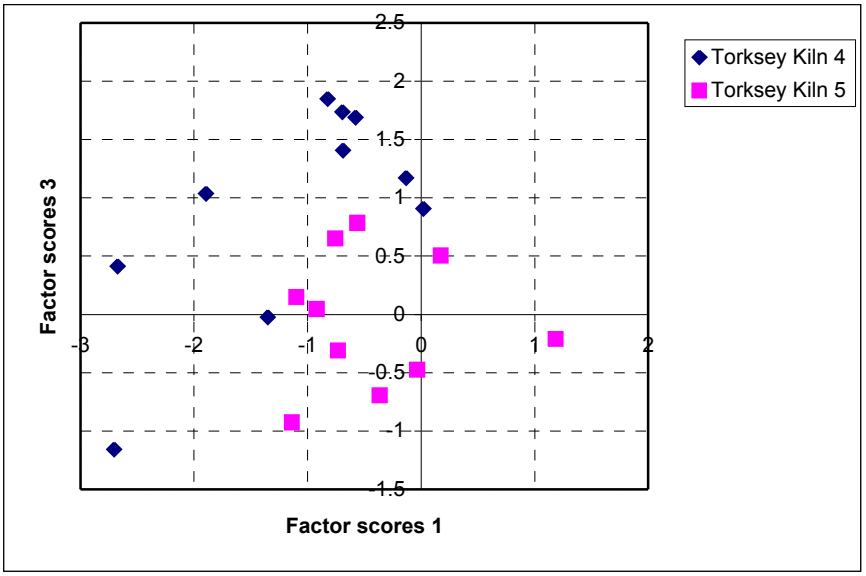

Figure 7

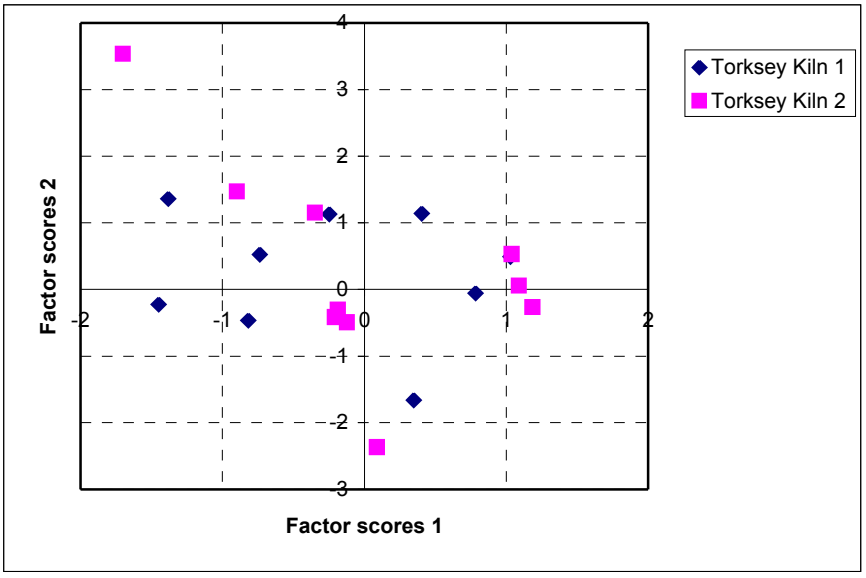

Figure 8

Fig 9 groups the Torksey kiln samples by date, confirming that differences in composition are not chronological.

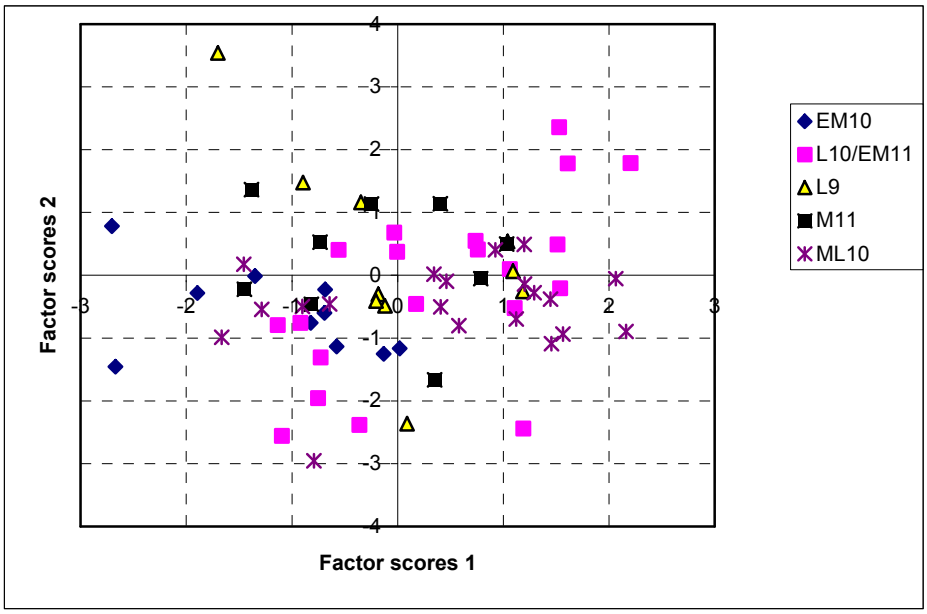

Figure 9

Figure 10 shows a plot of F1 against F3 scores for roller-stamped samples. There is no clear separation of any of the groups although the mean F3 scores suggest that the roller-stamped vessels from Doncaster and York are more likely to have come from kilns 3, 4 or 6 than kiln 2. Typologically, this is certainly the case, as the Kiln 2 jars have an everted rim not seen on later vessels (and not so far seen outside of Torksey).

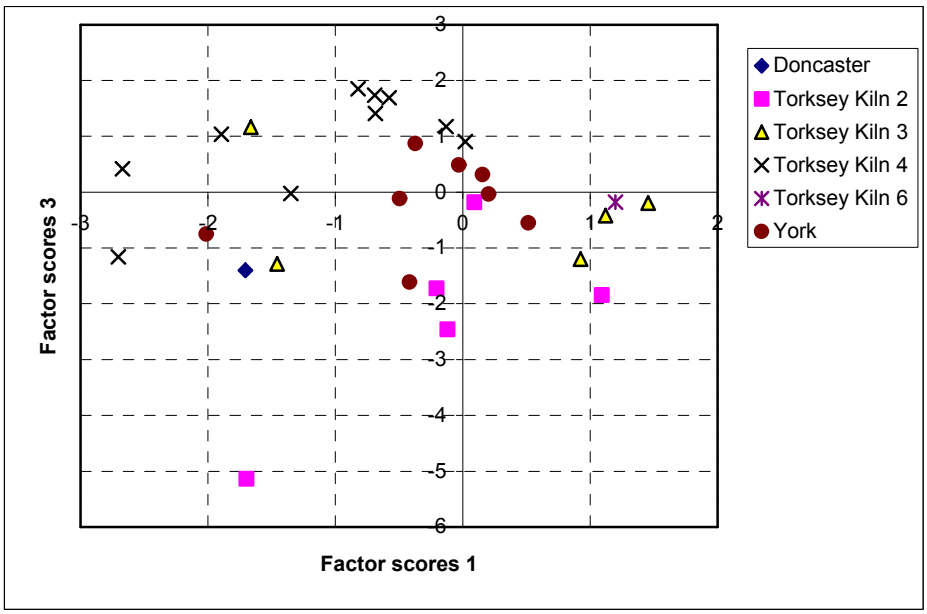

Figure 10

Figure 11 shows a plot of F1 against F3 for vessels with thumbed decoration. Such vessels were produced in kilns 5 and 7 whilst a single piece from kiln 6 is possibly an early example

or intrusive from kiln 6. One of the Beverley sherds, on this evidence, might have been produced in kiln 7 whilst the remainder are more similar to the kiln 5 samples.

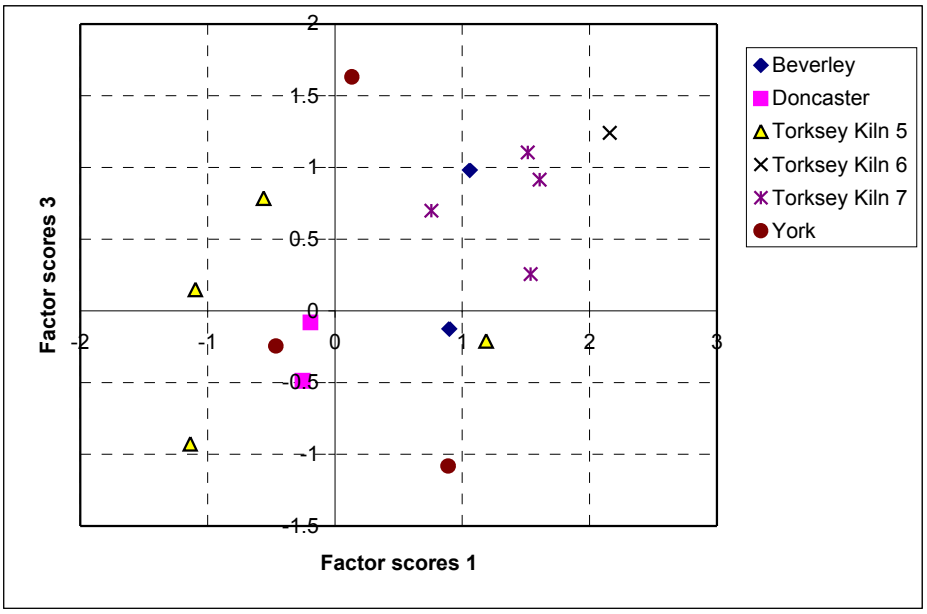

Figure 11

Torksey-type ware

Only one sample of Torksey-type ware from Yorkshire has been analysed chemically. The sample comes from Doncaster and visually appears somewhat finer in texture than standard Torksey ware. In addition, a group of samples from Barton-upon-Humber were identified by Jane Young as being of Torksey-type ware, although visually they have an indistinguishable fabric from those from Torksey.

The data from these samples was compared with that of the Torksey ware (kiln waste and consumer vessels), the Newark samples and samples of other sand-tempered clays from Lincolnshire. The latter consist of post-medieval ceramic building material from a production site at North Hykeham and clay samples from Barton-upon-Humber and Grimsby. The same restricted set of elements as was used to search for variation in the Torksey ware data was employed and four factors were found. The first two factors separated most of the non-Torksey samples from the Torksey ware, with the exception of the North Hykeham samples. However, Fig 12 is a plot of F3 and F4 scores for this data which clearly shows that the Torksey type ware is distinguishable from the other sand-tempered wares with the exception of the Barton-upon-Humber Torksey-type wares. This result probably indicates that the Doncaster Torksey-type ware sample is from another source whilst the Barton-upon-Humber samples are actually Torksey products.

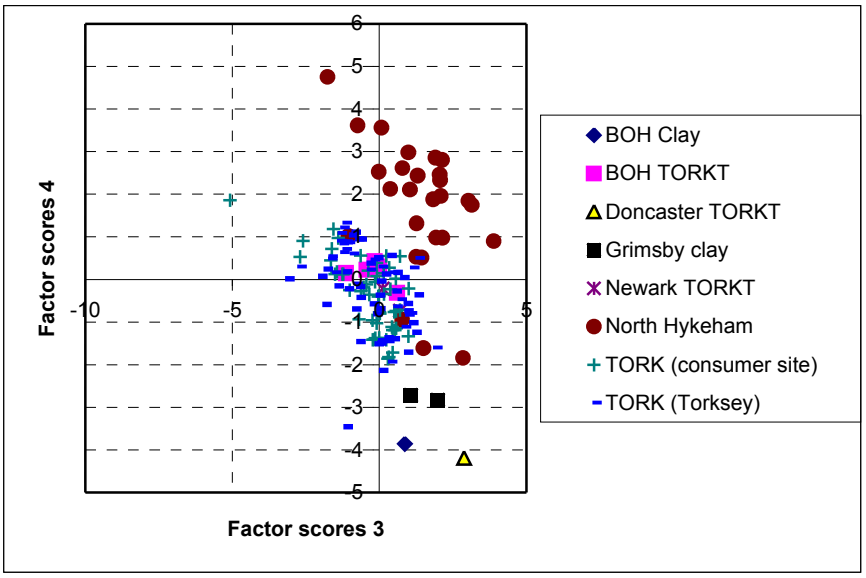

Figure 12

Discussion

From this study of the chemical composition of Torksey ware and Torksey-type ware from Yorkshire, Nottinghamshire and Lincolnshire, it seems likely that all the Torksey ware sampled from Yorkshire was actually made at Torksey. A single sample from Doncaster probably comes from another source whilst samples from Barton-upon-Humber are probably Torksey products.

The analysis further indicates that the Torksey potters probably used similar raw materials throughout the potting community although it is likely that clay was obtained on site, so that the products from kilns 3 and 6, which are contemporary and situated close to each other, are distinguishable whereas the products of kilns 6 and 7, which were on the same site but differ in date, are not distinguishable.

This lack of chronological variation in the clays used means that it is not possible to use chemical analysis to refine the dating of Torksey wares above the level of precision available from typology although it does suggest that none of the sampled roller-stamped vessels from York or Doncaster came from Kiln 2, which is the earliest kiln found so far at Torksey. This is consistent with the typological identification by Jane Young, which suggests that the products of this early phase have yet to be found away from the kiln site.

TSNO	Sitecode	Context	REFNO	Form	locality	Description
V1354	t61/2	BG		THUMBED BOWL	Torksey	
V1355	t61/2	AS		THUMBED BOWL	Torksey	
V1356	t61/2	AY		THUMBED BOWL	Torksey	
V1357	t61/2	AY		THUMBED BOWL	Torksey	

V1358	t61/2	BB	THUMBED JAR	Torksey	
V1359	t61/2	BE	STORAGE JAR	Torksey	
V1360	t61/2	BE	ME DIUM JAR	Torksey	
V1361	t61/2	BE	MEDIUM JAR	Torksey	
V1362	t61/2	BE	MEDIUM JAR	Torksey	
V1363	t60	BJ	MEDIUM JAR	Torksey	SQUARE-TOOTH RSD
V1364	t60	AP	STORAGE JAR	Torksey	
V1365	t60	BJ	STORAGE JAR	Torksey	
V1366	t60	BC	MEDIUM JAR	Torksey	WIRE-CUT BASE
V1367	t60	AW	MEDIUM JAR	Torksey	SQUARE-TOOTH RSD
V1368	t60	BQ	MEDIUM JAR	Torksey	WIRE-CUT BASE
V1369	t60	AW	SMALL BOWL	Torksey	LINCOLN GRITTY FORM;SQUARE-TOOTH RSD
V1370	t60	BQ	MEDIUM JAR	Torksey	SQUARE-TOOTH RSD
V1371	t60	BQ	MEDIUM JAR	Torksey	
V1372	t60	PH	SMALL BOWL	Torksey	LOOKS WRONG - POSSIBLE FROM LATER OCCN?;DIAMOND RSD
V1373	T67	DT	MEDIUM JAR	Torksey	UNDECORATED
V1374	T67	DC	INTURNED RIM BOWL	Torksey	DIAMOND RSD
V1375	T67	EL	INTURNED RIM BOWL	Torksey	DIAMOND RSD
V1376	T67	EL	MEDIUM JAR	Torksey	DIAMOND RSD
V1377	T67	DO	INTURNED RIM BOWL	Torksey	DIAMOND RSD
V1378	T67	DD	MEDIUM JAR	Torksey	UNDECORATED
V1379	T67	EF	RING VASE	Torksey	
V1380	T67	DR	LARGE BOWL	Torksey	UNDECORATED;ROUNDED RIM
V1381	T67	DD	PITCHER?	Torksey	BOSSED AT GIRTH
V1382	T67	EL	INTURNED RIM BOWL	Torksey	DIAMOND RSD
V1383	T65	EA	MEDIUM JAR	Torksey	DIAMOND RSD ON RIM AND SHOULDER
V1384	T65	EA	MEDIUM BOWL	Torksey	DIAMOND RSD ON RIM
V1385	T65	EA	MEDIUM JAR	Torksey	DIAMOND RSD ON RIM AND SHOULDER
V1386	T65	EP	INTURNED RIM BOWL	Torksey	DIAMOND RSD ON RIM
V1387	T65	EA	LARGE CURVED BOWL	Torksey	TRIANGULAR RSD ON BODY
V1388	T65	DX	SMALL JAR	Torksey	TRIANGULAR RSD ON RIM AND SHOULDER
V1389	T65	EA	LARGE CURVED	Torksey	TRIANGULAR RSD ON RIM AND SHOULDER

				BOWL		
V1390	T65	EP		LARGE CURVED BOWL	Torksey	TRIANGULAR RSD ON RIM AND SHOULDER
V1391	T65	EP		SMALL JAR	Torksey	SQUARE RSD ON RIM AND SHOULDER
V1392	T65	DQ		LARGE CURVED BOWL	Torksey	SQUARE RSD ON RIM
V1393	T67 KILN 5	T65 DP		MEDIUM JAR	Torksey	UNDECORATED
V1394	T67 KILN 5	DF		PITCHER?	Torksey	THUMBED APPLIED STRIP DOWN BACK OF HANDLE
V1395	T67 KILN 5	T65 EQ		BOWL	Torksey	WHEELTHROWN HANDLE
V1396	T67 KILN 5	T65 EV		BOWL	Torksey	THUMBED RIM
V1397	T67 KILN 5	EZ		MEDIUM JAR	Torksey	UNDECORATED
V1398	T67 KILN 5	EQ		STORAGE JAR	Torksey	THUMBED APPLIED STRIP
V1399	T67 KILN 5	EU		SMALL DISH	Torksey	
V1400	T67 KILN 5	BN		SPRINKLER	Torksey	CIRCULAR HOLES PIERCED IN BASE PRE-FIRING
V1401	T67 KILN 5	T65 CY		BOWL	Torksey	THUMBED RIM
V1402	T67 KILN 5	CX		SMALL DISH	Torksey	
V1403	k6	K6		MEDIUM JAR	Torksey	SQUARE TOOTH RSD
V1404	k6	K6		MEDIUM JAR	Torksey	
V1405	k6	K6		MEDIUM JAR	Torksey	
V1406	k6	K6		MEDIUM JAR	Torksey	
V1407	k6	K6		MEDIUM JAR	Torksey	THUMB PRESSED RIM
V1408	k6	K6		FLANGED RIM BOWL	Torksey	
V1409	k6	K6		FLANGED RIM BOWL	Torksey	
V1410	k6	K6		PITCHER	Torksey	
V1411	k6	K6		PITCHER	Torksey	THUMBED STRIP AROUND NECK
V1412	k6	K6		PITCHER	Torksey	WHEELTHROWN SPOUT
V1413	T68	K7		MEDIUM JAR	Torksey	
V1414	T68	K7		MEDIUM JAR	Torksey	
V1415	T68	K7		SMALL JAR	Torksey	
V1416	T68	K7		MEDIUM JAR	Torksey	THUMBED RIM
V1417	T68	K7		MEDIUM JAR	Torksey	
V1418	T68	K7		MEDIUM JAR	Torksey	THUMBED RIM
V1419	T68	K7		SMALL SPOUTED BOWL	Torksey	
V1420	T68	K7		PITCHER?	Torksey	THUMBED RIM AND THUMBED STRIP AT NECK
V1421	T68	K7		SMALL BOWL	Torksey	FLANGED RIM
V1422	T68	K7		LARGE BOWL	Torksey	THUMBED RIM
V1520	bll79	604.13	Fig 61.31	MEDIUM JAR	Beverley	
V1521	bll79	771.2	Fig 61.32	MEDIUM JAR	Beverley	THUMBED RIM

V1522	bll79	1641.12	Fig 61.33	MEDIUM JAR	Beverley	
V1523	bll79	1641.11	Fig 61.34	BOWL	Beverley	
V1524	bll79	942.35	Fig 61.36	BOWL	Beverley	
V1525	bll79	306.28	Fig 61.43	SMALL JAR	Beverley	
V1526	bll79	306.34	Fig 61.44	MEDIUM JAR	Beverley	
V1527	bll79	306.30	Fig 61.45	SMALL JAR	Beverley	
V1528	bll79	959.1	Fig 61.46	MEDIUM JAR	Beverley	THUMBED RIM
V1529	bll79	1122.35	Fig 61.49	SMALL JAR	Beverley	
V1530	bll79	1122.36	Fig 61.50	MEDIUM JAR	Beverley	
V1531	bll79	1122.30	Fig 61.52	MEDIUM JAR	Beverley	THIN-WALLED;OXID CORE;BLACK SURFACES
V1532	BLL79	1178.13	Fig 61.54	MEDIUM JAR	Beverley	
V1533	BLL79	1660.6	Fig 61.55	SMALL JAR	Beverley	
V1534	bll79	818.21	Fig 61.57	BOWL	Beverley	
V1535	bll79	818.22	Fig 61.58	BOWL	Beverley	
V1536	bll79	1594.1	Fig 61.59	BOWL	Beverley	
V1537	bll79	1567.5	Fig 61.60	SPOUTED BOWL	Beverley	
V1556	COPPERGATE	2734	Not Illustrated	BOWL	York	P5B
V1557	COPPERGATE	15291	2108	JAR	York	P5B
V1558	COPPERGATE	22590	2025	JAR	York	P4B
V1559	COPPERGATE	24399	2036	BOWL	York	P4B
V1560	COPPERGATE	35264	2021	JAR	York	P4B
V1561	COPPERGATE	29926	2028	JAR	York	P4B
V1562	COPPERGATE	6440	Not Illustrated	JAR	York	P5B
V1563	COPPERGATE	22883	2032	JAR	York	P4B
V1564	COPPERGATE	21244	2088	BOWL	York	P5B
V1565	COPPERGATE	22309	2026	JAR	York	P4B
V1566	COPPERGATE	34290	2019	JAR	York	P4B
V1567	COPPERGATE	14529	Not Illustrated	JAR	York	P5B
V1568	COPPERGATE	5772	2083	BOWL	York	P5B
V1569	COPPERGATE	20345	Not Illustrated	BOWL, INTURNED RIM	York	P5B (BUT EARLIER)
V1570	COPPERGATE	6434	2117	BOWL, INTURNED RIM	York	P5B
V1571	COPPERGATE	22574	2022	JAR	York	P4B
V1572	COPPERGATE	27626	2003	PTCH/SJ	York	P4A
V1573	COPPERGATE	23366	2024	JAR	York	P4B
V1928	DT	ABN	No.435	SMALL JAR	Doncaster	SQUARE RSD
V1932	DQ	AQ	No.439	SMALL JAR	Doncaster	
V1933	DQ	AQ	No.442	BOWL	Doncaster	FLANGED RIM;POST-FIRING HOLES IN BODY
V1934	DT	85	No.2	SMALL JAR	Doncaster	L10TH/E11TH C
V1936	DT	BDU	No.441	LARGE JAR	Doncaster	THUMBED RIM

V1946	DT	13	No.20	SMALL JAR	Doncaster	EVERTED RIM;10TH/11TH
V1953	DR/CJ	PIT 2		SPBOWL	Doncaster	EVERTED RIM;10-EM11C
V1958	DT	105	No.12	BOWL	Doncaster	L10TH/M11TH;THUMBED BOWL RIM

Appendix 1

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1354	15.64	6.05	1.25	0.84	0.23	2.43	0.67	0.91	0.09
V1355	15.92	6.21	1.47	0.98	0.22	2.27	0.65	1.28	0.05
V1356	16.80	6.85	1.36	1.15	0.24	2.38	0.70	0.99	0.11
V1357	17.30	6.30	1.38	1.06	0.21	2.16	0.65	1.43	0.04
V1358	18.39	6.99	1.47	0.95	0.24	2.54	0.77	0.29	0.08
V1359	14.81	5.90	1.42	0.77	0.20	2.19	0.62	0.66	0.04
V1360	17.40	6.75	1.61	0.72	0.23	2.61	0.74	0.10	0.08
V1361	17.31	6.54	1.54	0.77	0.21	2.45	0.69	0.14	0.06
V1362	15.30	6.18	1.38	0.90	0.21	2.23	0.63	1.24	0.08
V1363	16.09	5.62	1.43	1.66	0.32	2.46	0.63	0.84	0.08
V1364	15.30	5.92	1.41	0.79	0.23	2.48	0.64	0.36	0.06
V1365	16.03	6.07	1.43	0.78	0.20	2.50	0.65	0.41	0.06
V1366	15.44	5.90	1.54	3.20	0.32	2.59	0.65	0.40	0.11
V1367	14.49	5.71	1.54	2.45	0.28	2.52	0.60	0.46	0.13
V1368	17.99	6.87	1.69	2.04	0.31	2.70	0.70	0.53	0.12
V1369	17.10	5.87	1.48	1.22	0.35	2.50	0.66	1.05	0.08
V1370	18.09	6.33	1.66	2.17	0.37	2.74	0.72	0.56	0.13
V1371	18.33	6.37	1.75	2.14	0.33	2.80	0.72	0.28	0.10
V1372	15.90	5.67	1.24	1.11	0.19	2.15	0.57	1.48	0.06
V1373	15.38	6.30	1.51	1.55	0.22	2.48	0.61	1.07	0.09
V1374	13.72	5.61	1.26	0.94	0.19	2.34	0.53	0.81	0.08
V1375	17.86	6.38	1.66	0.93	0.22	2.59	0.72	0.13	0.07
V1376	17.69	6.48	1.70	1.14	0.23	2.58	0.71	0.13	0.09
V1377	14.50	5.47	1.24	0.92	0.21	2.27	0.55	0.78	0.08
V1378	15.10	5.86	1.41	1.33	0.20	2.35	0.59	0.98	0.10
V1379	14.61	5.45	1.37	1.49	0.19	2.48	0.41	2.35	0.04
V1380	14.58	5.72	1.41	1.16	0.21	2.32	0.60	0.86	0.06
V1381	16.54	6.12	1.54	0.78	0.24	2.44	0.66	0.14	0.06
V1382	18.17	6.55	1.64	0.90	0.21	2.61	0.71	0.16	0.06
V1383	15.62	6.05	1.35	0.88	0.22	2.42	0.64	0.70	0.04
V1384	12.37	4.70	1.09	0.97	0.21	2.03	0.45	1.41	0.03
V1385	15.73	6.02	1.47	0.99	0.24	2.47	0.62	1.09	0.10
V1386	15.39	5.98	1.41	1.29	0.24	2.30	0.58	1.79	0.12
V1387	14.28	5.52	1.12	0.98	0.26	2.35	0.58	1.05	0.08
V1388	15.45	6.14	1.28	1.23	0.23	2.53	0.58	1.44	0.07
V1389	14.12	5.57	1.19	0.77	0.28	2.31	0.58	0.53	0.07
V1390	15.49	5.96	1.42	1.11	0.26	2.34	0.61	1.42	0.05
V1391	14.51	5.45	1.33	1.19	0.62	2.37	0.53	1.68	0.06
V1392	16.36	6.33	1.49	1.29	0.22	2.53	0.60	1.43	0.08

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1393	15.84	6.16	1.38	0.81	0.25	2.32	0.63	0.17	0.04
V1394	13.84	5.12	1.11	1.00	0.19	2.27	0.54	1.19	0.05
V1395	14.90	5.51	1.31	1.45	0.18	2.12	0.56	1.48	0.05
V1396	15.80	6.67	1.30	1.20	0.22	2.44	0.65	1.07	0.08
V1397	15.29	5.93	1.21	1.36	0.20	2.45	0.48	2.20	0.06
V1398	17.51	6.39	1.46	1.46	0.22	2.83	0.57	2.04	0.08
V1399	15.47	5.88	1.39	1.35	0.29	2.45	0.58	1.41	0.09
V1400	15.21	5.47	1.26	1.63	0.20	2.27	0.45	1.95	0.16
V1401	14.28	5.39	1.08	1.47	0.19	2.16	0.42	2.38	0.05
V1402	16.57	6.35	1.53	1.71	0.22	2.79	0.68	2.06	0.10
V1403	17.86	6.76	1.45	0.89	0.22	2.44	0.75	0.15	0.10
V1404	17.21	6.60	1.35	0.89	0.23	2.24	0.71	0.59	0.06
V1405	19.05	7.04	1.27	0.85	0.24	2.41	0.76	0.30	0.10
V1406	18.84	7.05	1.44	0.90	0.23	2.41	0.78	0.44	0.07
V1407	18.33	6.85	1.46	0.90	0.23	2.45	0.76	0.40	0.06
V1408	17.11	6.48	1.37	1.00	0.21	2.17	0.70	0.40	0.05
V1409	17.71	6.71	1.40	0.94	0.23	2.26	0.73	0.42	0.10
V1410	19.75	7.31	1.55	0.86	0.23	2.52	0.81	0.30	0.10
V1411	19.53	7.28	1.61	0.81	0.23	2.57	0.81	0.16	0.06
V1412	18.77	6.96	1.40	0.90	0.23	2.37	0.75	0.33	0.06
V1413	19.19	7.19	1.63	1.01	0.22	2.59	0.80	0.10	0.16
V1414	18.18	6.90	1.43	0.95	0.23	2.45	0.76	0.27	0.09
V1415	17.93	6.96	1.43	1.14	0.23	2.45	0.74	0.37	0.10
V1416	18.47	7.60	1.62	0.87	0.23	2.69	0.78	0.09	0.13
V1417	18.49	7.77	1.63	0.88	0.27	2.72	0.78	0.11	0.20
V1418	18.23	7.58	1.63	0.85	0.22	2.68	0.77	0.09	0.18
V1419	16.98	6.43	1.56	0.76	0.21	2.53	0.69	0.17	0.07
V1420	18.58	6.90	1.48	0.79	0.26	2.48	0.75	0.25	0.08
V1421	16.36	6.34	1.33	0.97	0.21	2.02	0.63	0.54	0.09
V1422	17.79	6.83	1.43	0.92	0.25	2.53	0.75	0.47	0.10
V1520	16.44	6.38	1.52	1.21	0.29	2.61	0.64	0.61	0.11
V1521	17.71	6.89	1.73	1.09	0.21	2.60	0.73	0.24	0.12
V1522	16.39	5.39	1.42	1.55	0.28	2.41	0.63	0.54	0.07
V1523	16.65	7.52	2.00	1.09	0.26	3.16	0.71	0.42	0.03
V1524	13.29	6.60	1.26	2.94	0.22	2.23	0.52	2.05	0.10
V1525	17.26	6.55	1.42	1.91	0.35	2.57	0.70	0.66	0.13
V1526	17.59	6.63	1.67	1.79	0.26	2.71	0.75	0.32	0.10
V1527	16.88	6.25	1.58	1.27	0.22	2.46	0.68	0.24	0.06
V1528	17.38	6.65	1.70	1.04	0.22	2.62	0.72	0.22	0.09
V1529	17.41	7.09	1.44	1.67	0.26	2.52	0.72	1.00	0.11
V1530	16.88	6.58	1.45	3.66	0.25	2.52	0.73	0.75	0.14
V1531	18.13	6.51	1.55	3.43	0.29	2.60	0.73	0.23	0.08
V1532	17.34	6.37	1.48	3.63	0.25	2.57	0.74	0.45	0.09
V1533	17.12	6.82	1.44	1.54	0.27	2.52	0.73	0.80	0.09

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1534	14.41	6.96	1.35	3.08	0.22	2.38	0.58	1.85	0.13
V1535	16.72	6.59	1.58	2.30	0.29	2.66	0.71	0.54	0.11
V1536	15.68	6.54	1.40	1.43	0.27	2.51	0.63	0.88	0.08
V1537	17.56	6.55	1.67	1.31	0.24	2.60	0.72	0.56	0.08
V1556	15.42	6.39	1.44	1.73	0.26	2.49	0.63	0.44	0.11
V1557	17.68	6.05	1.60	1.83	0.21	2.53	0.69	0.12	0.07
V1558	16.37	5.78	1.54	1.19	0.24	2.44	0.65	0.24	0.05
V1559	16.10	6.09	1.48	1.13	0.23	2.48	0.68	0.23	0.05
V1560	15.95	6.39	1.58	1.96	0.28	2.44	0.65	0.82	0.13
V1561	15.56	5.09	1.42	0.96	0.24	2.44	0.61	0.26	0.03
V1562	18.50	6.57	1.67	1.33	0.28	2.70	0.75	0.78	0.07
V1563	16.39	5.97	1.52	0.83	0.25	2.51	0.69	0.13	0.08
V1564	16.16	6.08	1.46	0.81	0.25	2.57	0.69	0.10	0.11
V1565	17.31	6.21	1.56	0.96	0.28	2.55	0.70	0.11	0.08
V1566	15.43	6.05	1.38	0.90	0.24	2.36	0.66	0.11	0.08
V1567	15.89	5.58	1.47	0.82	0.23	2.33	0.65	0.10	0.05
V1568	18.30	5.50	1.63	0.90	0.29	2.77	0.77	0.25	0.06
V1569	15.58	4.83	1.56	1.26	0.24	2.64	0.62	0.28	0.06
V1570	16.67	4.93	1.49	1.01	0.27	2.52	0.64	0.23	0.06
V1571	14.09	5.35	1.34	0.96	0.32	2.44	0.59	0.17	0.08
V1572	15.64	5.41	1.45	1.13	0.26	2.47	0.63	0.68	0.07
V1573	16.34	5.96	1.58	1.09	0.29	2.65	0.67	0.21	0.06
V1928	14.20	5.43	1.67	1.91	0.31	2.55	0.57	1.21	0.16
V1932	14.92	5.67	1.33	0.73	0.25	2.27	0.63	0.14	0.06
V1933	15.06	5.38	1.30	1.00	0.23	2.26	0.59	0.93	0.05
V1934	13.69	4.95	1.59	1.78	0.27	2.42	0.57	0.87	0.18
V1936	16.45	5.73	1.54	0.86	0.24	2.40	0.64	0.33	0.05
V1946	16.01	5.84	1.44	1.00	0.27	2.45	0.63	0.33	0.09
V1953	13.76	5.84	1.46	1.60	0.23	2.27	0.51	1.72	0.08
V1958	16.21	5.86	1.45	1.44	0.24	2.47	0.67	1.13	0.10

Appendix 2

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1354	520	94	22	68	57	14	108	106	17	58	36	73	37	6	1	4	2	36	76	17
V1355	516	95	20	54	50	15	133	109	18	71	36	68	37	7	1	3	2	32	85	15
V1356	534	101	22	68	63	16	128	112	20	59	42	85	43	8	1	4	2	31	103	21
V1357	555	101	20	58	52	16	132	118	17	60	37	72	38	7	1	3	2	26	87	14
V1358	420	105	26	104	60	16	88	128	21	58	44	89	45	8	1	4	2	36	86	21
V1359	471	89	24	54	51	13	83	102	14	67	28	62	29	5	1	3	2	32	108	14
V1360	377	90	27	93	60	16	86	121	19	52	41	83	42	8	1	4	2	39	95	20
V1361	351	91	20	105	56	16	85	126	20	46	42	81	43	8	1	4	2	44	74	17
V1362	657	93	23	45	58	14	113	104	15	63	28	72	29	6	1	3	2	31	107	22
V1363	457	94	16	95	49	15	141	106	17	55	34	74	35	6	1	3	2	29	76	15
V1364	455	76	24	77	56	14	87	102	20	48	40	81	41	7	1	4	2	38	74	18
V1365	403	85	19	80	49	15	84	122	20	56	39	78	40	8	1	4	2	37	77	15
V1366	381	86	19	92	47	14	149	113	18	46	36	72	37	7	1	4	2	43	69	16
V1367	446	77	19	56	44	13	95	81	19	39	38	81	39	7	1	4	1	56	84	24
V1368	470	103	20	115	57	16	149	121	18	49	40	85	41	8	1	4	2	45	86	20
V1369	605	96	18	61	51	15	121	112	17	54	37	75	38	7	1	4	2	37	104	16
V1370	437	103	19	124	53	16	157	123	17	54	42	83	43	8	1	4	2	40	76	18
V1371	374	100	21	109	54	16	144	119	18	51	41	89	42	8	1	4	2	40	74	17
V1372	452	95	21	77	45	15	201	110	17	53	37	71	38	7	1	3	2	31	93	11
V1373	455	93	21	68	50	15	143	119	22	62	41	84	43	8	1	4	2	26	94	14
V1374	387	83	19	65	45	13	106	100	20	61	35	71	36	7	1	4	2	26	92	11
V1375	358	104	24	133	58	17	94	127	22	67	41	91	42	8	1	4	2	41	73	18
V1376	348	99	24	128	57	16	97	127	20	61	41	93	42	8	1	4	2	46	77	22
V1377	421	85	18	61	46	13	111	97	17	56	34	70	35	6	1	3	2	30	94	18

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TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1378	507	92	19	58	51	14	154	114	19	61	35	75	36	7	1	4	2	34	117	16
V1379	388	89	22	46	45	14	209	104	18	50	33	68	34	6	1	3	2	27	105	12
V1380	420	87	21	58	46	14	124	111	22	64	37	76	38	7	1	4	2	26	88	13
V1381	361	99	22	111	53	15	90	121	19	51	40	83	41	8	1	4	2	30	75	16
V1382	382	108	23	130	60	17	98	128	22	58	45	91	46	8	1	4	2	30	80	17
V1383	400	94	21	88	44	14	97	117	17	54	33	71	34	7	1	4	2	30	80	10
V1384	408	73	15	40	33	11	132	92	13	56	24	51	25	4	1	2	1	29	95	10
V1385	429	96	23	70	58	15	105	122	19	68	32	76	33	7	1	4	2	25	112	18
V1386	404	95	20	63	47	15	152	120	20	68	34	74	36	8	1	4	2	131	106	16
V1387	385	84	14	62	38	13	115	105	13	48	30	62	31	5	1	3	1	33	87	13
V1388	425	93	18	65	41	14	152	121	16	60	33	70	34	6	1	4	2	32	99	13
V1389	351	86	16	52	37	13	81	106	13	58	26	58	27	5	1	3	1	24	89	12
V1390	375	95	22	69	49	15	128	122	17	63	33	76	34	6	1	3	2	33	90	15
V1391	456	86	18	63	49	13	143	106	17	59	35	69	36	6	1	3	2	33	111	13
V1392	435	99	20	65	51	15	157	121	18	56	38	79	39	7	1	4	2	25	142	15
V1393	350	94	25	129	52	15	84	113	19	51	39	81	40	8	1	4	2	51	77	19
V1394	406	81	16	76	44	12	136	94	15	48	32	66	33	6	1	3	1	29	81	12
V1395	406	89	25	60	43	14	127	108	17	62	35	74	36	6	1	3	2	28	110	11
V1396	402	97	26	67	52	14	111	110	18	56	32	71	34	7	1	4	2	28	106	16
V1397	446	92	23	62	52	14	165	104	16	59	33	75	34	7	1	3	2	28	121	17
V1398	440	103	26	95	56	16	212	123	22	53	42	89	44	9	1	5	2	68	100	13
V1399	532	92	21	60	53	14	152	111	19	61	35	66	36	7	1	4	2	28	108	14
V1400	504	90	21	61	51	14	184	106	18	47	37	77	38	7	1	4	2	34	107	14
V1401	410	88	20	35	48	13	149	99	14	44	31	64	32	6	1	3	2	32	89	12
V1402	412	97	25	67	54	15	198	121	23	64	43	84	45	8	1	5	2	25	111	15
V1403	377	106	23	135	59	16	78	128	20	54	43	95	44	8	1	4	2	32	82	21

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1404	546	108	24	99	62	16	79	126	19	66	32	75	34	7	1	4	2	33	92	20
V1405	412	113	23	105	63	17	80	125	18	62	37	83	38	8	1	4	2	31	84	21
V1406	471	116	26	114	64	18	87	137	22	64	44	97	46	8	1	5	2	29	84	20
V1407	436	111	24	107	61	17	91	135	23	58	44	89	46	9	1	5	2	35	79	20
V1408	439	105	22	110	59	16	90	127	19	65	39	83	40	7	1	4	2	26	82	16
V1409	472	108	25	90	72	17	85	126	22	68	38	94	40	8	1	4	2	28	82	20
V1410	423	121	26	144	63	19	85	144	23	68	49	105	50	9	2	5	2	34	87	24
V1411	398	120	28	160	64	18	82	144	25	72	48	89	50	10	2	5	2	31	86	18
V1412	449	116	25	121	63	18	85	136	20	60	42	93	44	9	1	4	2	28	87	18
V1413	394	114	22	181	70	18	84	140	22	51	49	120	51	9	1	5	2	52	83	31
V1414	464	112	25	121	65	17	92	131	22	66	47	96	48	9	1	4	2	33	85	21
V1415	464	110	24	99	67	17	103	132	22	63	45	108	46	9	1	4	2	30	88	23
V1416	377	112	29	161	67	18	79	135	26	68	44	97	46	10	2	5	2	35	86	20
V1417	393	113	23	162	73	17	80	135	23	48	48	113	50	10	2	5	2	38	91	28
V1418	378	112	29	162	74	17	78	136	24	49	47	121	49	10	2	5	2	32	91	26
V1419	353	100	22	136	57	15	86	126	21	46	42	90	43	8	1	4	2	31	70	15
V1420	387	113	24	141	60	17	83	134	19	57	44	92	45	8	1	4	2	31	81	20
V1421	487	100	21	117	58	15	98	116	17	64	36	80	37	7	1	4	2	32	101	22
V1422	423	109	25	120	60	17	92	129	22	68	44	95	45	9	1	4	2	29	83	21
V1520	504	99	23	79	56	15	126	126	26	65	38	73	39	8	2	4	2	51	102	17
V1521	419	96	27	111	60	16	98	140	26	60	42	81	44	8	2	5	2	52	81	21
V1522	465	96	23	80	50	14	125	115	17	46	34	59	35	6	1	3	2	41	81	15
V1523	430	107	35	95	30	16	99	118	17	54	37	68	37	6	1	3	2	59	109	10
V1524	748	80	26	63	44	12	206	92	21	50	35	52	36	6	1	3	2	51	112	15
V1525	577	103	27	94	63	16	124	121	25	53	43	76	45	8	2	4	2	62	129	26
V1526	383	106	30	116	61	16	102	125	21	43	43	74	44	8	2	4	2	58	91	24

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1527	383	102	24	106	51	15	102	125	20	41	38	66	39	8	2	3	2	64	84	16
V1528	397	103	28	107	57	16	94	138	23	44	40	78	41	8	2	4	2	52	80	19
V1529	586	103	31	83	59	16	132	130	23	58	39	77	40	8	2	4	2	48	113	27
V1530	495	100	36	108	60	15	143	128	22	42	44	75	45	8	2	4	2	71	111	23
V1531	388	106	30	105	59	16	106	128	21	44	43	73	44	8	2	4	2	55	96	21
V1532	485	103	32	106	56	16	130	130	24	54	45	72	46	8	2	4	2	57	105	19
V1533	534	104	29	93	61	16	118	130	23	61	38	70	39	8	2	4	2	47	111	22
V1534	793	88	27	64	56	13	202	102	26	58	43	66	44	8	2	4	2	47	99	19
V1535	455	100	27	106	65	15	115	118	23	42	40	70	41	8	2	4	2	57	101	21
V1536	520	94	26	68	52	14	126	120	22	47	36	64	37	7	2	4	2	42	83	15
V1537	443	107	28	103	58	16	122	131	22	53	40	67	41	8	2	4	2	44	95	17
V1556	619	89	28	62	55	14	85	114	23	60	35	60	36	7	2	4	2	55	82	19
V1557	412	103	27	109	60	16	87	123	21	64	39	79	40	7	2	4	2	46	78	22
V1558	469	99	33	81	48	15	75	119	21	64	35	58	36	7	1	4	2	43	78	13
V1559	386	98	25	96	49	14	83	126	21	57	34	52	35	7	1	4	2	39	75	13
V1560	369	94	28	93	58	14	120	126	24	61	37	75	39	8	2	4	2	54	85	21
V1561	494	92	22	84	50	13	81	103	19	55	33	62	34	6	1	3	2	41	81	15
V1562	821	109	27	86	61	16	125	130	24	63	42	77	44	8	2	4	2	36	89	17
V1563	331	99	27	103	59	14	84	123	20	46	36	78	37	8	2	4	2	54	83	22
V1564	358	96	25	100	55	14	78	123	19	44	33	74	34	7	1	4	2	56	73	21
V1565	433	104	26	108	60	15	88	120	22	58	37	71	38	7	2	4	2	41	82	18
V1566	359	92	26	90	49	14	72	111	18	47	32	64	33	6	1	3	2	44	73	17
V1567	393	96	26	97	52	14	87	111	19	44	34	60	35	6	1	3	2	57	83	15
V1568	523	109	29	98	60	17	72	123	23	59	41	78	42	8	2	4	2	41	83	20
V1569	417	90	26	75	49	14	77	106	22	65	36	61	37	7	1	4	2	30	64	15
V1570	476	98	25	77	55	14	80	110	18	53	36	65	37	7	1	3	2	40	84	18

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1571	387	83	20	60	42	12	75	102	16	52	28	57	29	5	1	3	2	39	65	17
V1572	737	93	25	73	47	14	103	114	20	56	31	59	32	6	1	4	2	41	73	15
V1573	468	96	28	111	44	14	82	123	20	60	33	61	34	6	1	3	2	61	74	13
V1928	566	84	30	63	51	13	156	93	18	56	31	59	32	6	1	4	2	47	128	16
V1932	346	93	24	95	50	14	74	115	17	52	30	56	31	6	1	3	2	57	75	14
V1933	611	88	24	68	49	14	90	102	20	59	31	55	32	6	1	3	2	44	77	13
V1934	460	81	25	71	52	12	128	83	19	60	29	54	31	6	1	4	2	41	114	23
V1936	354	98	31	97	55	15	90	115	23	79	36	61	38	7	1	4	2	43	94	14
V1946	381	96	25	89	56	14	75	112	21	74	34	65	36	7	1	4	2	49	83	16
V1953	652	81	29	63	46	12	99	102	20	62	30	50	31	6	1	4	2	44	167	12
V1958	527	95	29	85	52	15	116	112	22	71	34	63	36	7	1	4	2	123	113	16

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