

# Characterisation Studies of Anglo-Saxon and Medieval Pottery from Cambridgeshire: South Cambridgeshire and Essex wares

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A series of samples of medieval pottery of types which are thought to have been made in southeastern Cambridgeshire or Essex were submitted for analysis using thin sections and Inductively-Coupled Plasma Spectroscopy. Alongside these Cambridgeshire samples, pottery from the production sites at Castle Hedingham and Harlow were also analysed (App 1).

The wares were assigned by Dr Spoerry into a series of fabric groups based on the visual appearance of the fabric (Table 1):

*Table 1*

Fabric Code	Number of Samples	Diagnostic features
GROG SW	2	Light-coloured grog fragments
HEDIC	3	
MEDIEVAL HARLOW	1	
MICFSW	15	Can be divided into glauconitic and a glauconite-free groups
MICSW	14	Can be subdivided into coarse and fine groups based on the size range of the quartz sand inclusions
MICSWT	1	
MSW	4	
MSWT	5	

## Thin Section Analysis

Each section was examined and the presence, absence and character of a series of inclusion types were recorded (App 2):

- Rounded quartz. Three samples contained only sparse rounded quartz inclusions whilst the remaining sections contained moderate to abundant quartz. The inclusions could be divided into a fine group, where the largest grains were less than 0.3mm

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across and a coarse group, where the largest grains ranged up to 1.0mm across. In five sections the abundant coarse quartz grains had an opaque or dark brown coating (all MSWT). In no other cases was there a strong correlation of visual group and the character of the quartz sand.

- Chert. In 30 of the 46 samples, sparse rounded fragments of chert were recorded. In all cases it is likely that these are of Carboniferous origin rather than Lower Cretaceous or Tertiary, the other potential sources to be expected in ceramics from the Cambridgeshire/Essex area. The size of the chert grains follows that of the rounded quartz and it is clear that the chert entered the pottery alongside the quartz sand.
- Flint. Ten sections contained rare or sparse flint and in no case was the flint large enough to establish its character (staining, rounding).
- Glauconite. Twenty-two sections contained glauconite or altered glauconite ranging up to 0.2 or 0.3mm across. In fifteen of these, the glauconite was moderately abundant.
- Muscovite. Thirty-five sections contained some laths of muscovite and these were moderate and up to 0.4mm in length in 20 sections.
- Biotite. Sparse laths of biotite were noted in seven sections.
- Angular quartz silt. Fragments of angular quartz silt were present in 41 of the thin sections and in 40 they were moderate or abundant.
- Light-coloured grog. In two sections, both GROG SW, moderate fragments of light-coloured group were recorded. They are the most distinctive visual characteristic of GROG SW.
- Calcareous inclusions. In nine sections, calcareous inclusions of various sorts were present. In two of these, one GROG SW and one MICFSW, they consist of nacreous shell fragments pressed into the external surface of the vessel.
- Matrix iron content. In two samples the groundmass has a light colour indicative of a low iron content (MICSW and MSW) but in all others the colour range is similar.
- Opaque grains. Sparse rounded opaque grains were present in 43 sections.
- Clay/iron. Clay pellets with a higher iron content than the groundmass were present in 31 sections. In some cases they could be seen to be concretions with an oolitic structure, formed in the parent clay, and in the remainder their origin could not be determined.
- Acid igneous. Sparse acid igneous rock fragments were present in one section.
- Basic igneous. Basic igneous rock fragments were present in two sections.

- Organics. Sparse organic inclusions, probably rootlets, were present in 18 sections.

## Interpretation

The quartz and chert sand is probably derived ultimately from Triassic deposits in the east midlands and the Vale of York but is found throughout the midlands and East Anglia as a result of glacial and pre-glacial sedimentation. The division into coarse and fine sand is not an indication of source but reflects a choice by the potters. It is therefore an important cultural factor but cannot be used to characterise the pottery. The micaceous quartz silt found in most of the samples could have several origins: Lower Cretaceous deposits; Tertiary clays; glacial re-working of either of these deposits or post-glacial fenland silts. Glauconite and altered glauconite is indicative of Lower Cretaceous clays, although it does occur in some Tertiary clays in southeast Essex (REF). Biotite is commonly noted in fenland silts, presumably reflecting the reworking of glacial tills. Acid igneous rock fragments could occur in glacial and later deposits throughout the two counties but basic igneous rocks probably indicate a glacial or post-glacial source of northern origin. However, such erratics are mainly restricted to the northern parts of East Anglia and the eastern parts of Lincolnshire and Cambridgeshire.

The light-coloured clays could be of Middle Jurassic (e.g. Estuarine Beds) or Tertiary origin (e.g. Reading Beds).

None of these rules of thumb produces clear-cut groupings within the 46 samples,

## Chemical analysis

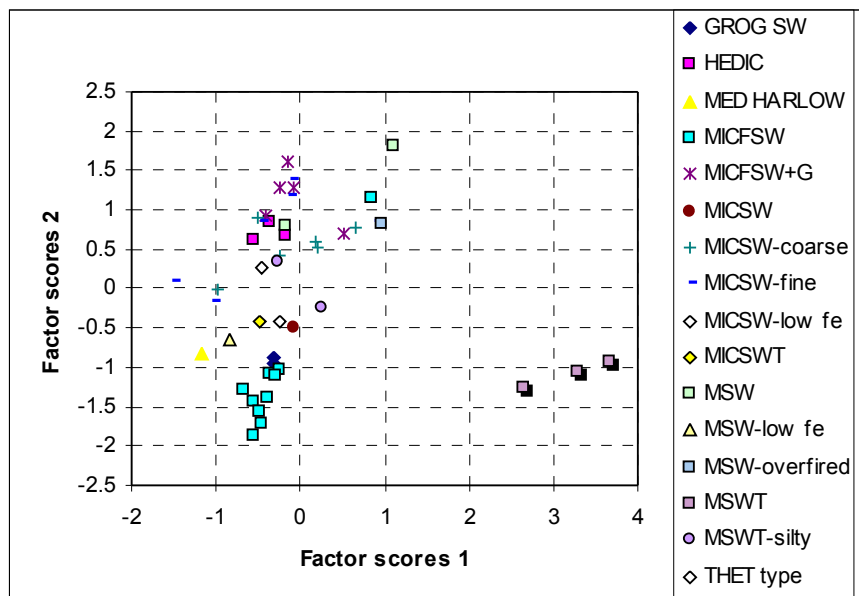
The estimated silica content of the samples was examined by modified fabric group. All samples have quite high silica contents, ranging from 67% to 78%. The mean value is 72.86% and the mean and standard deviations by fabric group show no obvious patterning (Table 2).

*Table 2*

Group	N	Mean	Std.Dev.
GROG SW	2	71.39	0.10
HEDIC	3	74.41	1.86
MED HARLOW	1	71.30	----
MICFSW	10	70.72	1.06
MICFSW+G	5	73.58	3.15
MICSW	1	73.17	----
MICSW-coarse	6	72.83	2.84
MICSW-fine	6	74.01	3.45
MICSW-low fe	1	78.38	----
MICSWT	1	78.23	----

MSW	2	71.82	1.04
MSW-low fe	1	77.24	----
MSW-overfired	1	71.81	----
MSWT	3	73.00	0.44
MSWT-silty	2	71.66	6.30
THET type	1	73.39	----
Entire sample	46	72.86	2.80

Factor analysis of the normalised ICPS data found five factors and the first factor separates the three MSWT samples from the remainder. The second factor separates all but one of the MICFSW samples from the remainder. The GROG SW samples have similar F1 and F2 scores to the MICFSW ones but all the remaining samples form a single cluster, albeit one with probable patterning within it (Fig 1).



**Figure 1**

Omitting these three groups and re-running the factor analysis produced no clear groupings.

## Discussion and Conclusions

Since the four groups recognised in the factor analysis of the ICPS data are also discernable in thin section it seems likely that they reflect real differences in source.

The first group, the three MSWT samples, contains no silt and has an iron-coated quartz sand. Two samples originally included in MSWT contain abundant quartz silt and have been separated into MSWT-silty. Their chemical composition shows no similarity to the MSWT group. The fine-textured groundmass suggests the use of a Jurassic clay but the identity of the iron-coated quartz is not known. Iron-cemented sandstones occur in the Middle Jurassic (e.g. the Northampton Sands).

The second group, the MICFSW samples, has a variable quantity of fine rounded quartz sand and is characterised by abundant silt and some muscovite with no glauconite. None of the samples have any traits in thin section which could help to localise the production area but the difference between this group and the remaining silty wares (which include the Hedingham samples) suggests a different source. Sample V4327 was transferred to this group from MSW because of its similarity in thin section and the ICPS analysis.

The third group, the two GROG SW samples, is grouped on the basis of the light-coloured grog inclusions and the similarity of the two samples to each other in chemical composition. There are, however, differences in thin section between the two samples.

The fourth group consists of all the remaining Cambridgeshire samples, and the three Hedingham samples. This group includes several modified visual fabric groups (Table 3). The fact that the three Hedingham samples fall into this group suggests an Essex origin but it should be noted that the Hedingham samples are unusual within this group in having no altered glauconite inclusions.

**Table 3**

subfabric	Total
HEDIC	3
MICFSW+G	5
MICSW-coarse	6
MICSW-fine	6
MSW	2
MSW-overfired	1
MSWT-silty	2
THET type	1
Grand Total	26

The single Medieval Harlow ware sample forms an outlier as do the two samples with low iron content clays and the MICSW and MICSWT samples.

## Appendix 1

TSNO	Sitecode	Context	REFNO	Action	locality	Description	subfabric
V4289	HINHH93	2026	101	TS;ICPS	Hinxton	Mid-brown/grey bs from jar	MSW
V4290	HINHH93	2470	102	TS;ICPS	Hinxton	Orange/buff finger impressed jar rim	MSW-low fe
V4291	HINHH93	2026	103	TS;ICPS	Hinxton	Grey/brown jar rim with int bead	MSW
V4292	HINHH93	2623	104	TS;ICPS	Hinxton	Dark red-brown/grey rolled bowl rim	MSWT
V4293	HINHH93	2026	105	TS;ICPS	Hinxton	Buff/l grey ext thickened small jar rim with larger quartz grains	MSWT
V4294	HINHH93	1467 1475	106	TS;ICPS	Hinxton	mid brown/grey jar rim with some shell externally	MSWT
V4295	HINHH93	2026	107	TS;ICPS	Hinxton	Oval-sectioned handle from jug in orange-brown fabric – pink quartz	MSWT-silty
V4296	HINHH93	2769	108	TS;ICPS	Hinxton	Orange-brown/grey jar rim – larger quartz	MSWT-silty
V4297	HINHH93	115	109	TS;ICPS	Hinxton	Sooted bs in light grey fabric with clear quartz and mica	MICSW-coarse
V4298	HINHH93	2175	110	TS;ICPS	Hinxton	Light grey/buff bs with clear and brown quartz and flint	MICSW-low fe
V4299	HINHH93	1311	111	TS;ICPS	Hinxton	mid-grey jar rim with clear quartz and fine mica	MICSW-coarse
V4300	HINHH93	59	112	TS;ICPS	Hinxton	mid grey jar rim with coarse quartz and fine mica	MICSW-coarse
V4301	HINHH93	131	113	TS;ICPS	Hinxton	mid-grey jar rim; clear quartz and fine mica	MICSW-fine
V4302	HINHH93	1607	114	TS;ICPS	Hinxton	Red-brown/grey bowl rim medium quartz and fine-medium mica	MICSW-fine
V4303	HINHH93	1664	115	TS;ICPS	Hinxton	mid-brown/grey jar rim medium quartz and occasional fine mica	MICSW-fine
V4304	HINHH93	2026	116	TS;ICPS	Hinxton	?hand-made grey bs with variable sized white quartz and fine mica.	MICSWT
V4305	HINHH93	2718	117	TS;ICPS	Hinxton	mid-brown/grey bs from jar; moderate fine-medium quartz and common fine mica	MICFSW
V4306	HINHH93	2731	118	TS;ICPS	Hinxton	mid-brown/mid-grey bs from jar; rounded quartz and occasional fine-medium mica	MICFSW
V4307	HINHH93	2469	119	TS;ICPS	Hinxton	Buff/brown jar rim common fine-medium quartz and common v fine mica	MICFSW
V4308	HINHH93	2280	120	TS;ICPS	Hinxton	mid/dark brown bowl rim; occasional fine-med quartz and occ. Fine mica (flint)	MICFSW

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V4309	HINHH93	2103	121	TS;ICPS	Hinxton	Hand-made grey jar rim common fine-med quartz and fine mica	MICFSW+G
V4310	HINHH93	1627	122	TS;ICPS	Hinxton	Light grey bs from jar ; fine medium quartz and abundant fine mica.	MICFSW+G
V4311	HINHH93	1607	123	TS;ICPS	Hinxton	mid-grey jar base; occ. Fine-med quartz and common fine mica	MICFSW
V4312	HINHH93	2150	124	TS;ICPS	Hinxton	Ext shell dusted red-brown/grey jar rim; medium quartz and common v fine mica	MICFSW
V4313	HINHH93	1594	125	TS;ICPS	Hinxton	Red-brown/dk grey jar rim; fine-med quartz and possibly occ. Fine mica	MICFSW
V4314	HINHH93	1607	126	TS;ICPS	Hinxton	Grey neck sherd, poss. hand-made; fin-med quartz and fine mica *rather like IPSWICH ware	MICFSW
V4315	HINHH93	1480	127	TS;ICPS	Hinxton	Int shell-dusted red-brown/grey jar rim; fine-med quartz and fine mica	MICFSW
V4316	HINHH93	115	128	TS;ICPS	Hinxton	Storage jar rim inn mid-grey/red-brown fabric with variable sized quartz, occasional flint and grog. H	GROG SW
V4317	HINHH93	1594	129	TS;ICPS	Hinxton	Jar rim in orange-brown/mid-grey fabric; medium quartz, fine mica, occasional flint, shell and common grog; spalling – rather like Grimston Thetford ware	GROG SW
V4318	HINHH93	1475	130	TS;ICPS	Hinxton	Storage jar rim; mid-brown/mid grey. Fine-medium clear quartz, occ. v fine mica	THET type
V4319	GE 65	Ditch 1	131	TS;ICPS	Great Easton	No. 8 red-brown/grey jar rim; abundant med quartz	MSW-overfired
V4320	GE 65	Ditch 1	132	TS;ICPS	Great Easton	No. 11 Shell-dusted red-brown/grey jar rim; abundant med quartz and occ. Fine mica	MICSW
V4321	GE 65	Ditch 1	133	TS;ICPS	Great Easton	No. 13 brown/grey finger-impressed jar rim; common med quartz and common fine-med mica.	MICSW-coarse
V4322	GE 65	Ditch 1	134	TS;ICPS	Great Easton	No. 15 buff-brown/grey flanged jar rim; occasional med quartz and fine mica	MICSW-coarse
V4323	hedingham kilns	us	135	TS;ICPS	Hedingham	Grey base with wavy line dec; occ medium quartz	HEDIC
V4324	hedingham kilns	us	136	TS;ICPS	Hedingham	L grey rilled bs with occ medium quartz	HEDIC
V4325	hedingham kilns	us	137	TS;ICPS	Hedingham	Buff/red-brown jar rim with occ fine-med quartz	HEDIC
V4326	harlow kilns	us	138	TS;ICPS	Harlow	red-brown with abundant fine-med quartz	MED HARLOW
V4327	BURRR01	703	139	TS;ICPS	Burwell	Jar rim in mid-brown/grey fabric	MICFSW
V4328	BURRR01	2859	140	TS;ICPS	Burwell	Bs of ?jar mid-brown and sooted/burnt with fine quartz and fine mica	MICSW-fine
V4329	BURRR01	1286	141	TS;ICPS	Burwell	Bs from ?storage jar in mid-brown/grey fabric with fine mica, medium quartz and wavy line dec (like Middleborough product?)	MICSW-fine

V4330	BURRR01	266	142	TS;ICPS	Burwell	Bs from ?storage jar in mid-brown/red-brown fabric with fine mica and coarse quartz	MICSW-coarse
V4331	BURRR01	704	143	TS;ICPS	Burwell	Bs from jar in light grey/red-brown fabric with fine mica and fine quartz	MICFSW+G
V4332	CAX GR 99	67	144	TS;ICPS	Caxton	Mid-brown/grey neck sherd from jug with rilling with fine quartz and fine mica	MICFSW+G
V4333	CAX GR 99	197	145	TS;ICPS	Caxton	Buff/red-brown rilled jar bs with fine mica and quartz	MICFSW+G
V4334	CAX GR 99	28	146	TS;ICPS	Caxton	Bs from ? jar in mid-grey fabric, sooted, with medium quartz and fine mica	MICSW-fine

## Appendix 2

TSNO	show	RQ	CHERT	FLINT	GLAUC	MUSC	ANG SILT	WHITE GROG	CALC	MATRIX IRON CONTENT	OTHER
V4289	gp4	a <1.0	s<1.0mm	n? or s r	m altered<0.2mm	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4290	outlier	a <1.0	s<1.0mm	n	s altered<0.3mm	m <0.4mm	m	n	n	low	clay/iron;opaques
V4291	gp4	a <1.0	s<1.0mm	n	s altered<0.3mm	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4292	gp1	A <1.0 fe-coated	s<1.0mm	n	n	n	n	n	n	mod	clay/iron;opaques
V4293	gp1	A <1.0 fe-coated	s <1.0mm	n	n	n	n	n	n	mod	clay/iron;opaques
V4294	gp1	A <1.0 fe-coated	s <1.0mm	n	n	n	n	n	n	mod	clay/iron;opaques
V4295	gp4	A <1.0 fe-coated	s <1.0mm	n	n	s	a	n	n	mod	clay/iron;opaques
V4296	gp4	A <1.0 fe-coated	s <1.0mm	n	n	s	a	n	n	mod	clay/iron;opaques
V4297	gp4	a <1.0	s <1.0mm	n	m altered<0.2mm	m <0.4mm	a	n	n	mod	clay/iron;opaques;organics
V4298	outlier	m <0.3	s <0.3mm	s	n	n	m	n	s	low	opaques;organics



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V4299	gp4	a <1.0	s <1.0mm	s	s altered<0.2mm	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4300	gp4	a <1.0	s <1.0mm	n	m altered<0.2mm	m <0.4mm; also s biotite	a	n	n	mod	opaques;organics
V4301	gp4	a <0.3	s <0.3mm	n	m altered<0.2mm	m <0.4mm	a	n	n	mod	oolitic clay/iron;opaques
V4302	gp4	a <0.3	s <0.3mm	n	m altered<0.2mm	m <0.4mm; also s biotite	m	n	n	mod	opaques;organics
V4303	gp4	a <0.3	s <0.3mm	n	s altered<0.2mm	s	m	n	n	mod- isotropic	opaques;organics
V4304	outlier	m		s	n	r	m	n	fossil	mod	acid ig;basic ig
V4305	gp2	a <0.3		r	n	s	m	n	n	mod	oolitic clay/iron;opaques;organics
V4306	gp2	a <0.3		s	n	s	a	n	n	mod	oolitic clay/iron;opaques;organics
V4307	gp2	a <0.3		n	n	s-m	a	n	n	mod	basic ig; oolitic clay/iron;opaques
V4308	gp2										
V4309	gp4	a <0.3		n	s altered<0.2mm	s-m	a	n	n	mod	opaques;organics
V4310	gp4	s <0.3		s	m altered<0.2mm	s;also s biotite	a	n	none	mod	opaques
V4311	gp2	s <0.3		r	n	n	a	n	r	mod	light clay pellets;oolitic clay/iron;opaques
V4312	gp2	s <0.3		n	n	s	a	n	nacreous bivalve shell on surface	mod	light clay pellets;oolitic clay/iron;opaques
V4313	gp2	s <0.3		n	n	n	a	n	s	mod	clay/iron;opaques
V4314	gp2	s <0.3		r	n	n	a	n	s	mod	clay/iron;opaques
V4315	gp2	s <0.3		n	n	n	a	n	n	mod	clay/iron;opaques

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V4316	gp3	s <0.3	n	n	s altered<0.2mm	s	a	m	n	mod	oolitic clay/iron;opaques;organics
V4317	gp3	m<0.3	s <1.0mm	n	n?	n	m	m	nacreous bivalve shell on surface	mod	oolitic clay/iron;opaques;organics
V4318	gp4	a <0.3	s <0.3mm	n	s altered<0.3mm	m <0.4mm	a	n	n	mod	opaques
V4319	gp4	a <0.3	s <0.3mm	n	n?	s	s	n	s	mod-isotropic	opaques
V4320	outlier										
V4321	gp4	a <1.0	s <1.0mm	s	m altered<0.2mm	m <0.4mm	m	n	n	mod	clay/iron;opaques;organics
V4322	gp4	m <1.0	s <1.0mm	s	m altered<0.2mm	m <0.4mm; also s biotite	a	n	none	mod	clay/iron;opaques;organics
V4323	gp4	m <0.3	s <0.3mm	n	n?	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4324	gp4	m <0.3	s <0.3mm	n	n?	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4325	gp4	m <0.3	s <0.3mm	n	n?	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4326	outlier	m <0.3	s <0.3mm	n	n?	m <0.4mm	a	n	n	mod	clay/iron;opaques
V4327	gp2	a <0.3	s <0.3mm	n	n?	m <0.4mm	a	n	n	mod	oolitic clay/iron;opaques;organics
V4328	gp4	a <0.3	s <0.3mm	n	m altered<0.2mm	m <0.4mm	a	n	s leached unless post-burial	mod	opaques;organics
V4329	gp4	m <0.3	s <0.3mm	n	m altered<0.2mm	m <0.4mm	a	n	n	mod	oolitic clay/iron;opaques;organics
V4330	gp4	m <1.0	s <0.3mm	n	m altered<0.2mm	m <0.4mm	a	n	n	mod	oolitic clay/iron;opaques;organics
V4331	gp4	s <0.3		n	m altered<0.2mm	s;also s biotite	a	n	n	mod	opaques
V4332	gp4	a <0.3		n	m	s;also s	a	n	n	mod	opaques

					altered<0.2mm	biotite						
V4333	gp4	s <0.3		n	m altered<0.2mm	s;also s biotite	a	n	n		mod	opaques
V4334	gp4	m<0.3	s <0.3mm	n	m altered<0.2mm	m <0.4mm	a	n	n		mod	oolitic clay/iron;opaques;organics

### Appendix 3

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V4289	13.54	7.63	1.46	1.22	0.30	2.12	0.78	0.32	0.077
V4290	12.75	4.75	1.06	0.82	0.26	2.05	0.69	0.37	0.014
V4291	13.57	7.64	1.47	2.11	0.31	2.16	0.76	0.81	0.085
V4292	14.88	6.35	1.14	1.08	0.15	2.34	0.57	0.26	0.024
V4293	15.16	6.75	1.11	1.12	0.16	2.34	0.57	0.27	0.028
V4294	13.89	6.72	1.11	1.58	0.17	2.30	0.54	0.35	0.035
V4295	12.64	5.41	1.46	1.02	0.33	2.22	0.70	0.09	0.016
V4296	13.61	12.95	1.65	0.96	0.27	2.23	0.66	0.43	0.034
V4297	13.99	6.18	1.40	0.84	0.40	2.36	0.79	0.16	0.017
V4298	12.61	4.01	0.71	1.42	0.35	1.61	0.64	0.25	0.024
V4299	13.66	6.37	1.50	1.28	0.35	2.27	0.81	0.42	0.041
V4300	13.04	5.56	1.47	1.16	0.42	2.46	0.76	0.15	0.022
V4301	14.31	7.52	2.17	1.13	0.37	2.49	0.85	0.19	0.047
V4302	11.42	4.84	1.21	1.11	0.36	1.89	0.67	0.27	0.016
V4303	12.36	5.54	1.12	0.61	0.31	2.12	0.69	0.10	0.016
V4304	12.32	3.57	0.80	1.89	0.42	1.78	0.61	0.36	0.020

V4305	14.90	6.96	1.18	1.87	0.35	2.11	0.69	0.55	0.109
V4306	16.13	7.81	1.26	1.34	0.46	2.52	0.76	0.16	0.161
V4307	15.28	7.07	1.09	1.24	0.45	2.37	0.73	0.20	0.143
V4308	13.58	6.50	0.98	2.00	0.38	2.17	0.66	0.54	0.121
V4309	11.21	4.93	1.28	0.92	0.38	2.07	0.70	0.12	0.018
V4310	13.97	6.75	1.73	1.48	0.40	2.45	0.87	0.54	0.032
V4311	15.99	7.71	1.14	1.51	0.43	2.15	0.75	0.32	0.177
V4312	15.60	7.01	1.07	2.25	0.45	2.25	0.71	0.62	0.136
V4313	14.60	6.90	1.14	2.05	0.35	2.08	0.66	0.94	0.075
V4314	15.78	7.59	1.16	1.49	0.39	2.26	0.78	0.18	0.124
V4315	15.82	6.86	1.01	1.71	0.49	2.37	0.74	0.50	0.143
V4316	14.81	7.04	1.03	1.61	0.50	2.21	0.70	0.54	0.102
V4317	14.38	6.56	0.92	2.54	0.40	2.07	0.65	1.06	0.098
V4318	14.14	6.13	1.35	0.98	0.35	2.52	0.84	0.28	0.018
V4319	14.45	7.07	1.62	1.33	0.23	2.38	0.76	0.29	0.063
V4320	13.79	7.78	1.35	0.64	0.25	2.09	0.73	0.18	0.020
V4321	12.11	5.87	1.26	1.03	0.38	2.03	0.72	0.48	0.021
V4322	15.67	7.93	1.98	0.61	0.39	2.80	0.95	0.21	0.026
V4323	12.51	6.62	1.47	0.74	0.32	2.58	0.79	0.11	0.026
V4324	14.44	6.82	1.76	0.61	0.40	2.53	0.90	0.14	0.025
V4325	12.36	5.44	1.29	0.65	0.39	2.55	0.75	0.54	0.015
V4326	14.74	7.32	1.55	0.93	0.39	2.55	0.78	0.36	0.081
V4327	14.99	7.90	1.68	1.25	0.38	2.17	0.86	0.22	0.068

V4328	13.45	5.16	1.12	1.15	0.39	1.91	0.82	0.07	0.017
V4329	14.35	7.89	1.74	0.92	0.40	2.70	0.91	0.18	0.034
V4330	15.37	7.76	1.86	1.31	0.34	2.68	0.90	0.39	0.046
V4331	12.96	6.27	1.52	0.98	0.49	2.31	0.84	0.12	0.018
V4332	13.15	6.87	1.54	1.02	0.44	2.48	0.84	0.45	0.024
V4333	14.80	7.30	1.56	1.12	0.49	2.92	0.96	0.71	0.082
V4334	14.81	7.34	1.66	1.02	0.41	2.59	0.92	0.19	0.058

#### *Appendix 4*

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V4289	398	102	32	60	60	17	91	169	26	64	36	79	38	6	2	4	3	22	91	20
V4290	351	91	25	40	26	14	109	117	18	49	32	58	32	5	1	2	2	19	62	11
V4291	352	108	32	62	60	19	127	170	52	60	51	105	55	9	2	7	5	20	86	20
V4292	403	93	28	49	70	15	108	121	64	49	45	110	53	23	6	12	5	24	107	26
V4293	414	95	30	43	73	15	105	125	56	48	44	103	51	20	5	10	5	25	105	28
V4294	399	86	32	39	59	14	125	115	59	38	41	108	49	24	6	11	5	19	107	23
V4295	320	95	30	53	38	15	81	135	23	49	37	62	38	6	1	3	2	398	75	14
V4296	347	108	30	72	57	15	95	146	31	41	40	80	42	8	2	5	3	26	95	17
V4297	368	115	34	54	37	17	81	149	18	51	29	55	29	5	1	2	2	19	72	12
V4298	451	94	30	43	34	13	90	105	33	48	46	79	47	7	1	4	2	22	77	10
V4299	480	104	32	46	51	16	100	149	38	53	44	92	47	9	2	6	3	22	90	21
V4300	363	113	30	53	37	17	88	163	20	50	34	70	35	7	1	3	2	19	79	14
V4301	357	121	37	74	62	19	88	174	28	65	37	76	39	7	2	4	3	17	99	21
V4302	406	101	28	37	34	15	89	123	20	46	27	54	28	5	1	3	2	13	66	12
V4303	345	106	23	41	31	15	74	126	17	51	28	54	28	4	1	2	2	28	66	11
V4304	463	88	24	35	31	13	104	101	31	46	43	75	43	7	1	3	2	22	64	9

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V4305	616	94	25	49	60	15	133	134	29	56	43	79	45	7	2	5	3	20	101	16
V4306	423	100	27	70	69	15	100	145	31	51	47	93	50	8	2	6	3	26	113	21
V4307	460	109	22	59	48	14	99	131	25	48	41	85	44	7	1	5	3	23	121	21
V4308	430	84	22	51	58	14	137	121	28	48	42	86	44	7	2	5	3	25	92	17
V4309	323	102	29	39	33	14	73	127	26	58	31	56	32	6	1	3	2	22	74	12
V4310	638	118	29	48	46	17	118	161	25	60	29	64	31	5	1	4	3	19	82	15
V4311	403	116	27	68	72	16	106	144	33	49	49	106	52	9	2	7	3	32	99	24
V4312	593	97	26	58	68	15	144	132	32	53	44	102	47	8	2	6	3	24	97	21
V4313	496	93	25	55	55	15	152	131	28	50	42	82	43	7	1	4	3	23	98	15
V4314	363	117	26	72	64	15	95	145	35	53	46	86	48	8	2	6	3	22	99	20
V4315	618	107	24	54	58	15	139	127	29	67	42	89	45	8	1	6	3	23	95	19
V4316	474	107	25	55	59	15	136	129	30	53	43	109	45	8	2	5	3	29	98	20
V4317	555	102	24	50	57	14	183	123	30	54	42	82	44	7	2	5	3	20	92	16
V4318	377	119	31	39	38	17	88	152	25	54	37	70	38	5	1	3	2	23	81	13
V4319	309	110	35	67	67	18	81	179	41	57	47	104	50	10	2	6	4	25	97	44
V4320	287	99	31	54	49	15	69	156	29	47	35	65	37	7	1	4	3	17	82	16
V4321	364	99	26	32	43	14	97	128	29	47	32	63	34	6	1	4	3	19	82	15
V4322	342	121	35	68	51	19	88	180	28	61	39	78	41	8	2	4	3	23	93	19
V4323	345	107	33	43	34	16	66	144	18	48	28	55	29	5	1	3	2	20	70	16
V4324	342	124	36	51	38	18	77	159	25	58	34	60	35	6	1	3	2	23	80	15
V4325	414	103	31	27	41	15	67	126	21	49	28	51	29	5	1	3	2	18	76	13
V4326	393	122	27	56	40	17	88	126	16	54	29	55	30	4	1	3	2	78	79	15
V4327	479	116	37	48	83	19	96	197	46	62	46	117	49	10	2	6	4	19	105	31
V4328	448	108	31	77	38	16	97	149	20	58	27	51	28	4	1	3	2	14	63	12
V4329	348	123	36	65	55	18	79	174	28	64	36	74	38	7	2	4	3	20	95	21
V4330	489	100	38	63	66	19	111	170	32	61	43	76	45	8	2	5	3	22	99	24
V4331	455	94	36	42	39	17	100	145	24	53	35	67	36	7	1	3	3	18	73	13

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V4332	440	92	36	39	36	17	108	146	25	59	31	59	32	6	1	3	3	20	81	14
V4333	540	102	38	41	53	17	117	153	34	57	37	68	40	8	2	5	3	17	108	26
V4334	379	105	41	54	69	18	86	155	41	57	43	111	46	10	2	6	4	22	102	28