The Characterisation of Anglo-Saxon Pottery from Catterick Triangle 1987-8, North Yorkshire

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[summary of Wilson's site analysis and Evans' pottery study]

Fifty-five sherds of Anglo-Saxon pottery from the Catterick Triangle 1987-8 excavations were examined under x20 magnification. They represented no more than 35 vessels. From these, a sample of 22 sherds was selected for further analysis (Table 1).

Table 1

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
V1438	5563	72	22B	CHARN	BOWL	TS;ICPS	FLATTENED RIM;DEPO INT
V1439	5563	72	29	SST	JAR/BOWL	TS;ICPS	ROUNDED BASE;OXID EXT
V1432	5563	6	20B	CHARN	JAR	TS;ICPS	ROUGHLY FORMED;EVERTED ROUNDED RIM;SOOTED INT AND DEPO INT
V1433	5563	6	20A	CHARN	JAR	TS;ICPS	ROUGHLY FORMED;EVERTED ROUNDED RIM;SOOTED INT AND DEPO INT;OXID EXT
V1434	5563	16	24	SST	JAR/BOWL	TS;ICPS	ROUNDED RIM;BURNISHED EXT
V1436	5563	40	16	SST	JAR	TS;ICPS	ROUNDED EVERTED RIM;EXT BURNISHED?;INT OXID AND WEATHERED
V1437	5563	72	22A	SST	JAR	TS;ICPS	ROUGHLY FORMED;ROUNDED EVERTED RIM
V1440	5563	72	21A	SST	JAR	TS;ICPS	SAGGING BASE;FLATTENED RIM;BURNISHED EXT;APPLIED PAD EXT;WORN INT
V1441	5563	75	30A	SST	JAR	TS;ICPS	BURNISHED INT AND EXT;OXID EXT MARGIN;BLACKENED SURFACES;ROUNDED EVERTED RIM
V1442	5563	75	32	CHARN	JAR	TS;ICPS	ROUNDED RIM
V1443	5563	6	20C	CHARN	JAR/BOWL	TS;ICPS	OXID EXT;BURNISHED INT
V1444	5563	12	19	CHARN	JAR	TS;ICPS	BURNISHED INT;OXID EXT

TSNO	Sitecode	Context	REFNO	cname	Form	Action	Description
V1445	5563	72	13	EMSAX	JAR	TS;ICPS	BURNISHED AND SOOTED EXT
V1446	5563	72	18	SST	JAR	TS;ICPS	ROUGHLY FORMED;OXID AND ABRADED INT;THICK WALLED
V1447	5563	72	21B	SST	JAR	TS;ICPS	BURNISHED INT AND EXT
V1448	5563	75	30B	CHARN	JAR	TS;ICPS	
V1449	5563	75	23	ESAX?	JAR	TS;ICPS	OXID INT AND EXT;SOOTED EXT
V1450	5563	75	23	ESAX?	JAR	TS;ICPS	ABRADED SURFACES
V1451	5563	341	35	CHARN	JAR	TS;ICPS	BURNISHED INT AND EXT
V1452	5563	341	17	CHARN	JAR	TS;ICPS	ROUGHLY FORMED;OXID INT;BLACKENED EXT;THICK WALLED
V1435	5563	35	38	CHARN	JAR	TS;ICPS	ROUNDED RIM;OXID EXT

By eye, the pottery was assigned to five groups (Table 2). These were defined as follows:

- containing biotite and granitic inclusions (CHARN)
- unidentified inclusions (EMSAX)
- basic igneous rock fragments (ERRA). This sherd was extremely abraded and is interpreted as being of Bronze Age to Iron Age (or early Roman) date
- sherds of possible early Anglo-Saxon date (ESAX?), both selected for further study.
- Containing moderate to abundant fragments of Millstone Grit-type sandstone

Table 2

Cname		TS;ICPS	Grand Total
CHARN	6	20(10 samples)	26
EMSAX		1 (1 sample)	1
ERRA	1		1
ESAX?		2(2 samples)	2
SST	8	17 (8 samples)	25
Grand Total	15	40	55

Petrological Analysis

Analysis of the thin sections showed that the samples could be divided into seven subfabric groups.

Subfabric 1 (SSTMG)

Abundant fragments of Millstone Grit-type sandstones in a groundmass of baked clay minerals and angular quartz of fine sand grade (up to 0.3mm across).

Subfabric 2 (CHARN)

Approximately equal quantities of biotite granite fragments and Millstone Grit-type sandstone in a groundmass of baked clay minerals and angular quartz of fine sand grade (up to 0.3mm across).

Subfabric 3 (CHARN)

Moderate to abundant angular fragments of biotite granite and its constituent minerals in a groundmass of baked clay minerals and angular quartz of fine sand grade (up to 0.3mm across).

Subfabric 4 (SSTMG)

Moderate angular fragments of Millstone Grit-type sandstone in a groundmass of baked clay minerals with sparse angular quartz of silt grade, up to 0.1mm across.

Subfabric 5 (ESSLAG)

Abundant angular fragments of hammerscale, fayalite slag and slagged clay in a groundmass of baked clay minerals and angular quartz of fine sand grade (up to 0.3mm across).

Subfabric 6 (SST)

Moderate rounded fragments of a fine-grained sandstone and inclusionless brown clay pellets in a groundmass of baked clay minerals up to 1.5mm across and angular quartz of fine sand grade (up to 0.3mm across).

Subfabric 7 (FE)

Moderate subangular opaque fragments in a groundmass of baked clay minerals and angular quartz of fine sand grade (up to 0.3mm across).

Discussion

The groundmass in most of these sections is extremely similar in composition and texture and strongly suggests that all of the subfabrics were produced from the same parent clay with differing materials being added. The presence of smithing debris in Subfabric 5 is significant. This material cannot be naturally present and must therefore be a deliberate temper. Without these inclusions the sample would contain simply the fine quartz sand found in the majority of samples. This suggests that in those samples too the inclusions are deliberate additions. The inclusions in Subfabric 6 are rounded and presumably come from a detrital sand. Those in Subfabric 7 may owe their shape to weathering or it may reflect the natural habit of the iron compound from which they are derived.

The only potentially non-local sample is Subfabric 4, which contains the same sandstone gravel as Subfabric 1 but in a much finer matrix.

Chemical Analysis

Samples were prepared by P Hill, who removed all potentially contaminated surfaces from an offcut c.1-2gm in weight. The remaining sample was ground to a fine powder and submitted to Royal Holloway College, London, for chemical analysis under the supervision of Dr J N Walsh.

The frequency of a range of major elements was determined as percent oxides (Appendix 1a) and minor and trace elements were measured as parts per million (Appendix 1b).

The data were first examined to establish if any outliers were present in the dataset (ie samples where an element's frequency was more than 4sd from the mean value in the dataset). Two samples had outlying values (Table 2). Both samples were visually different from the majority and these values therefore probably reflect a real difference in composition.

Table 3

Element	TSNO	Value	N*Sigma >4	P <0
Fe2O3	V1445	30.29	4.257369937	0.000217166
MnO	V1450	0.32	3.614423015	0.003155928
Yb	V1445	2.7	2.950429794	0.032796478
Co	V1445	47	4.285107187	0.000191766

Figure 1

The dataset was then examined using Factor Analysis (Principal Components method). This method attempts to explain the variance seen in a dataset by calculating a series of factors each of which consists of loadings or weightings applied to the observed frequency. In this way, the complexity of the relationships between the samples can be reduced. Five factors with an Eigenvalue greater than 1.0 were found, explaining in total 83% of the variance in the dataset (Table 3). The factor loadings produced for these five factors are showing in Appendix 2.

Table 4

Factor	Eigenvalue	Variance (percent)	Percent cumulative
1	12.38751024	42.71555257	42.71555257
2	5.402417831	18.629027	61.34457957
3	3.525338755	12.15634053	73.50092011
4	1.562256781	5.387092349	78.88801246
5	1.429535893	4.929434113	83.81744657

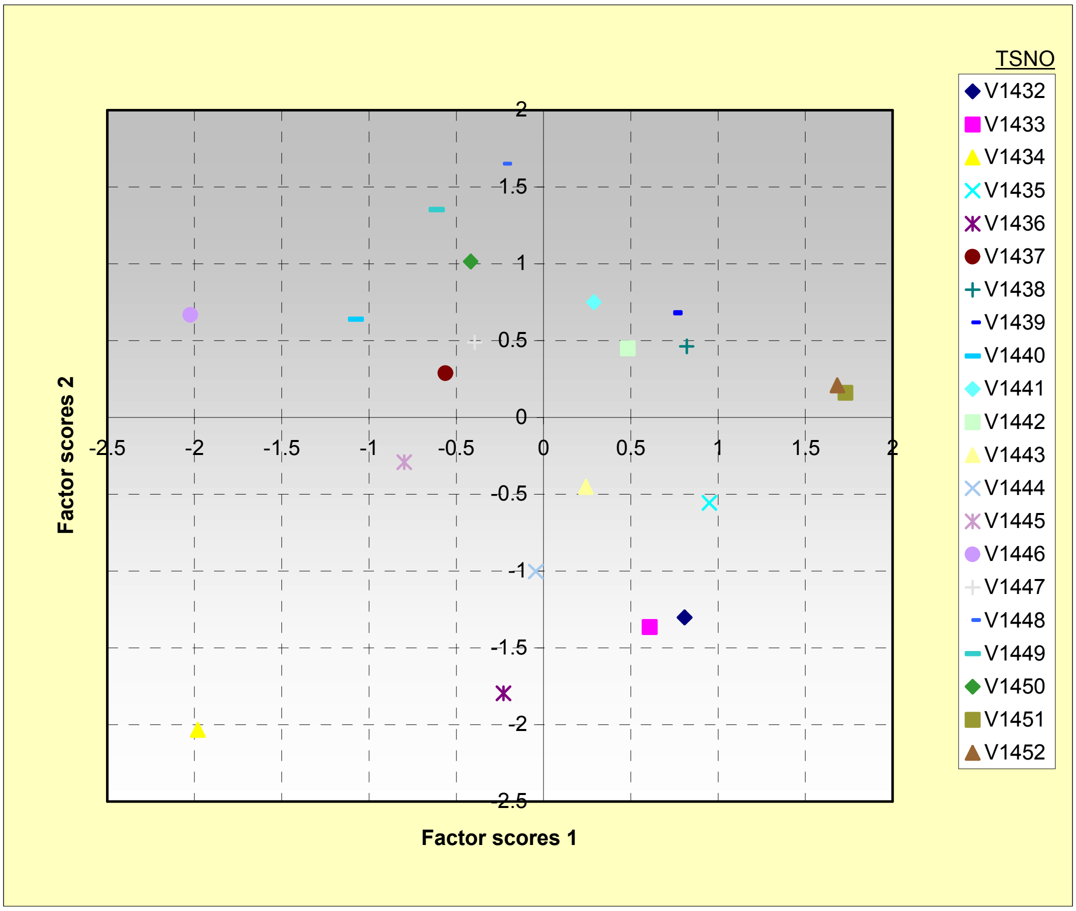
TSNO
V1432
V1433
V1434
V1435
V1436
V1437
V1438
V1439
V1440
V1441
V1442
V1443
V1444
V1445
V1446
V1447
V1448
V1449
V1450
V1451
V1452
Factor scores 1
Factor scores 2
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

Figure 2

A plot of Factor 1 against Factor 2 (Fig 2) shows no clear groupings, apart from the close similarity of V1451 and V1452, both of which have high F1 scores. Another sample, V1434. appears somewhat isolated, having strong negative scores for both factors.

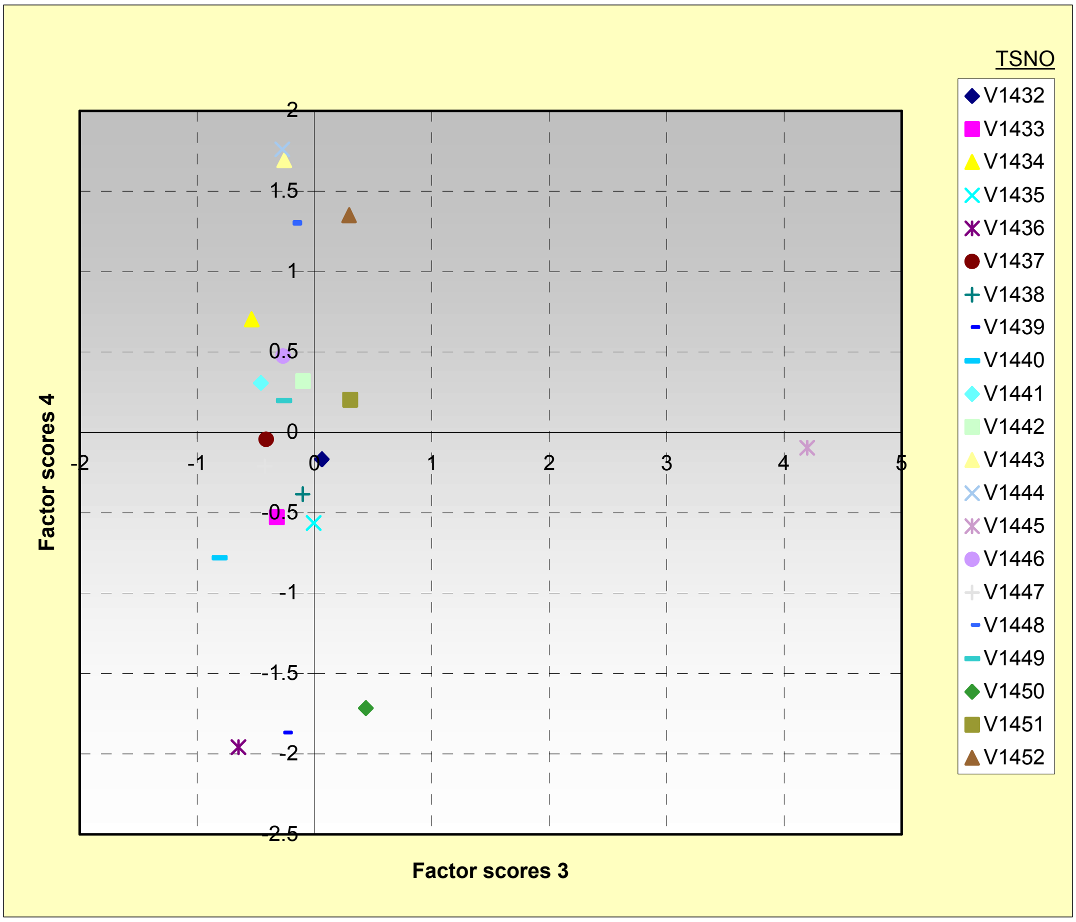

Figure 3

A plot of Factor 3 against Factor 4 shows that only one sample has a high score for F3, V1445. Factor 4 scores vary considerably, however, and there is a group of three samples with strong negative scores (V1436, V1439 and V1450) and another group with high scores (V1443, V1448 and V1452).

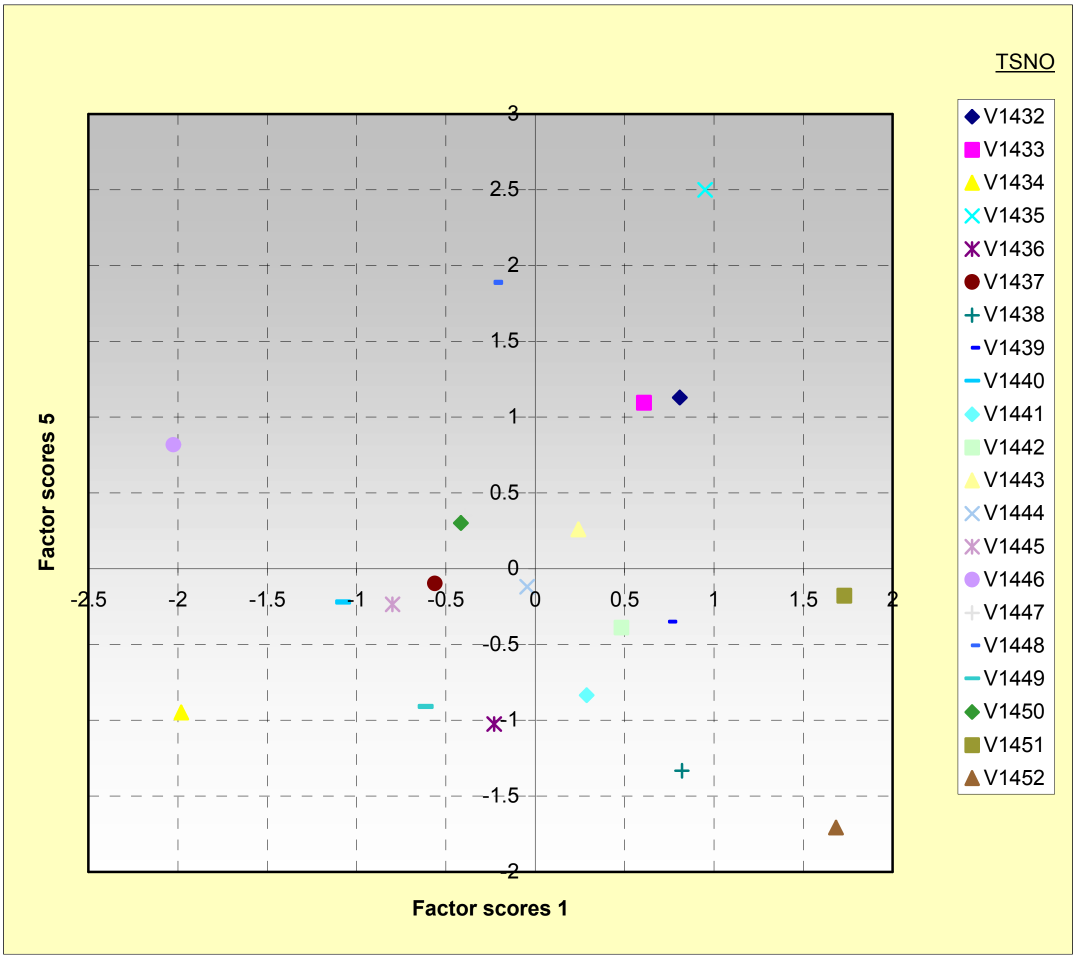

Figure 4

For Factor 5 (Fig 4) three samples have high scores (V1435, V1448 and V1432) and three have strong negative scores (V1452, V1438 and V1436).

Discussion

A plot of the first two Factors grouped by petrological subfabrics (Fig 4) shows some correlation between the composition of the inclusion types and the chemical composition of the samples. However, this correlation is neither complete nor extreme. One sample of subfabric 3 has a high Factor 2 score whilst the sample of subfabric 45 has a high Factor 1 score. There is a possibility that the two samples have in fact been accidentally swapped or mislabelled but for the remaining three Factors, the scores assigned to the two samples are consistent with their subfabric groups.

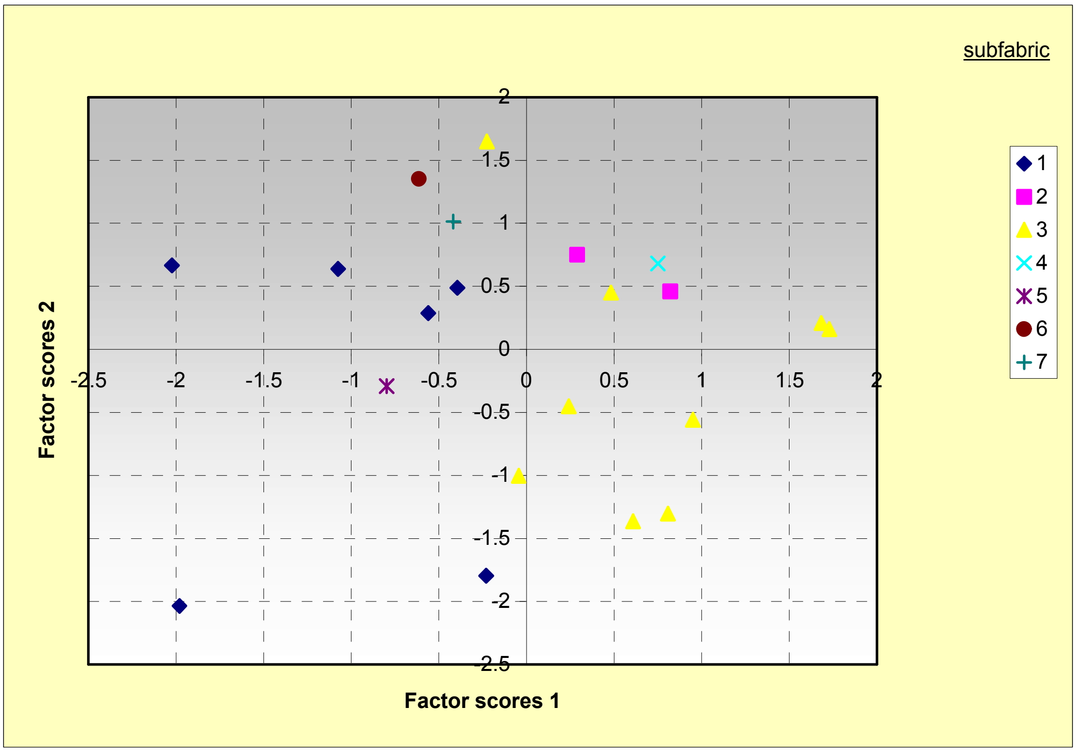

Figure 5

Factor 3 shows a correlation with subfabric, with the samples with iron-rich inclusions having the highest scores and the Millstone Grit tempered samples the lowest. The correlation is less clear for Factor 4 although those samples with biotite granite inclusions have higher scores than the remainder. For this factor, however, the samples with iron-rich inclusions have low or negative scores. For factor 5 there is no clear correlation with petrological composition.

Further understanding of the chemical composition of the samples comes from examining the factor scores. For factor 1 the highest scores were assigned to Ce, Al2O3, Sc and Cr. This suggests perhaps that the high Al2O3 values are due to the feldspar content of subfabrics 2 and 3 but to the clay content of subfabric 4. The highest weightings for Factor 2 were assigned to Sr, P2O5, Ba and CaO. Sr and CaO are often strongly correlated. No carbonate inclusions were noted in any of the thin sections and so it is likely that these elements were present in a phosphatic mineral. This might be detrital apatite, since if it was a post-burial concretion there would be no reason for any correlation with subfabric to be present. In Factor 3 the highest scores come from Fe2O3 and Co. The cobalt, therefore, is almost certainly present in the iron-rich inclusions. For factor 4 the highest score is for Pb, which is therefore likely to be present in the granitic inclusions.

Comparison with Catterick Bridge 1983

As might be expected, there is considerable similarity between the fabrics found at Catterick Triangle and those found at Catterick Bridge, since the two sites are so close geographically. What is more unexpected, however, is that the fabrics do not appear to be identical.

Only four subfabrics were recognised at Catterick Bridge, termed for convenience here CB1 to CB4. CB1 has a similar groundmass to subfabric 1 here, but neither the rounded inclusionless clay pellets nor the rare fragments of finer grained sandstone found at Catterick Bridge were noted in the Triangle sections. CB2 was a chaff-tempered version of CB1, with less sand or gravel inclusions. CB3 is equivalent to subfabric 3 and CB4 is equivalent to subfabric 4 here. Possible differences between the sites are that CB3 was thought to have a lower quantity of fine sand inclusions than CB1 and CB2 whereas at the Triangle site there seems to be no difference whilst sheaves of muscovite were noted in samples of CB3 but not in those from the Triangle.

A cluster analysis of the chemical data from both sites using Ward's method showed a major division into two groups with at least six distinct subgroups (Fig 6).

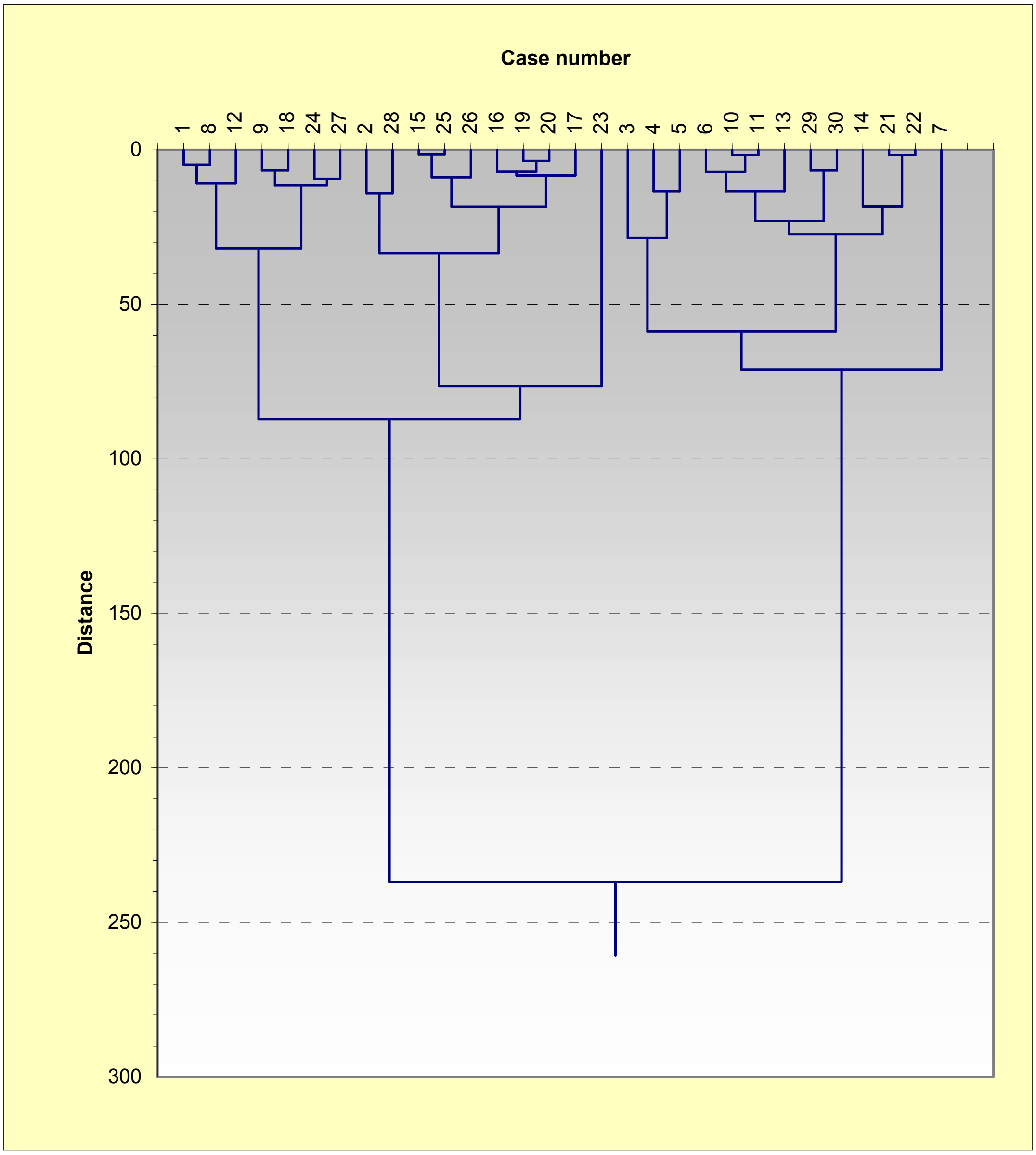

Figure 6

Based on a study of Fig 6 it was thought that six clusters might be appropriate and the correlation of these with the fabric groups derived from thin section analysis is shown in Table 4.

Cluster 1 consists of sandstone-tempered vessels with fine sandy matrices. Cluster 2 also contains sandstone-tempered vessels from both sites, together with two of those with biotite granite inclusions from the Triangle site and that with iron-rich inclusions from the Triangle. Cluster 3 contains the two biotite granite tempered vessels from CB and one of the SSTMG samples from that site. Cluster 4 contains 7 of the biotite granite-tempered samples from the Triangle, and single sandstone-tempered samples from both sites. Cluster 5 contains the other SSTMG sample from CB and cluster 6 contains the slag-tempered sample from the Triangle. The broad split places clusters 1, 2 and 6 in one group and clusters 3, 4 and 5 in the other. Whilst this groups approximates to the division between sandstone-tempered and granite tempered wares it is by no means a perfect correlation.

Table 5

petrofabric group	1	2	3	4	5	6	Grand Total
CB1	3	1					4
CB2				1			1
CB3			2				2
CB4			1		1		2
CT1	3	2		1			6
CT2		2					2
CT3		2		7			9
CT4		1					1
CT5						1	1
CT6	1						1
CT7		1					1

A factor analysis of the joint dataset shows four significant factors. A plot of F1 against F2, grouped by Site (Fig 7) shows no clear separation between the material by site. There is therefore no obvious site-based post-burial contamination. Furthermore, there is no evidence for the two sites being supplied with pottery of distinctly different composition.

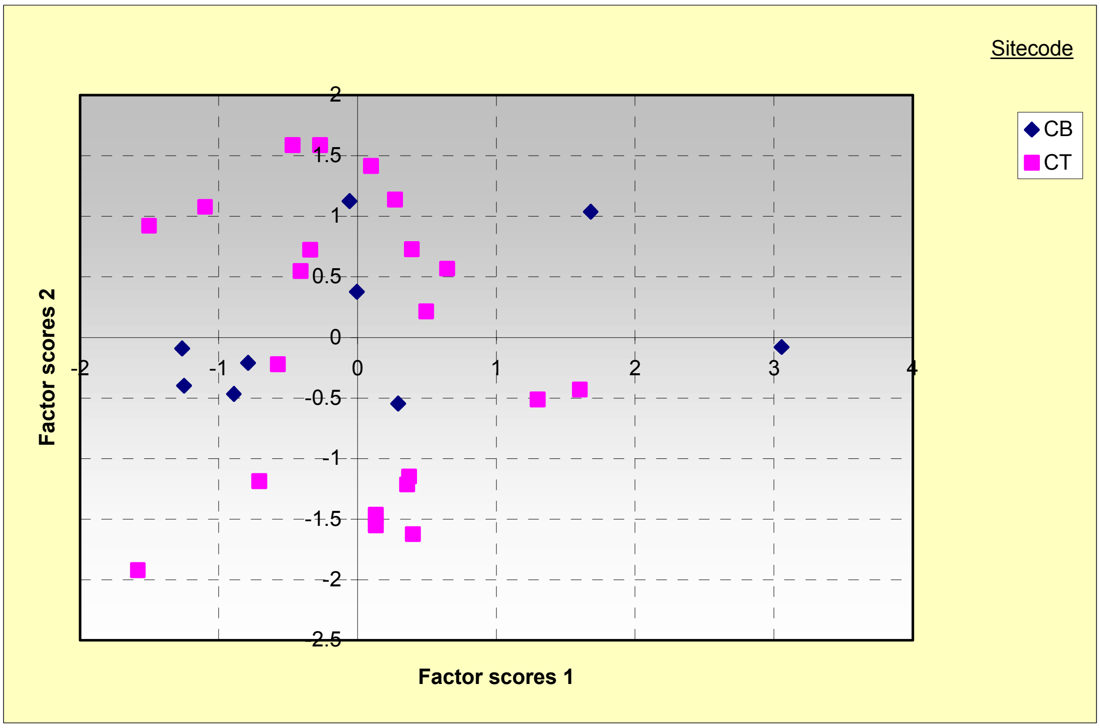

Figure 7

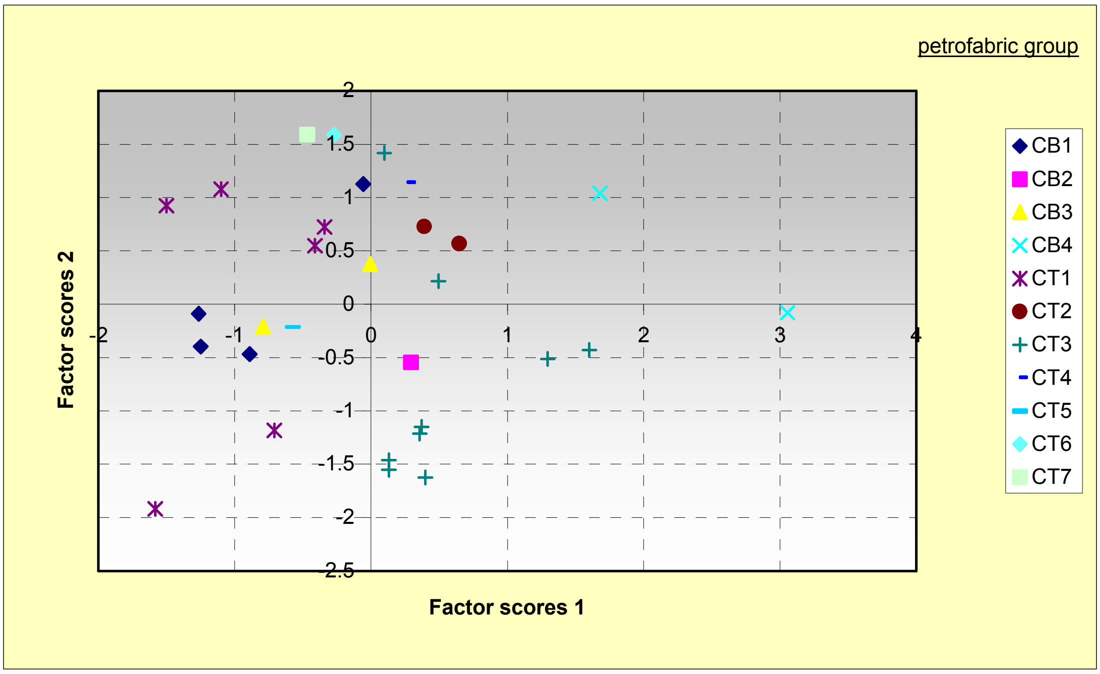

Figure 8

When the same data is plotted grouped by petrological subfabric (Fig 8) it can be seen that there is no close correlation between the subfabrics from either site. All of the samples appear to be similar in composition with the exception of the two CB4 samples, which have high scores for Factor 1. The weightings for Factor 1 indicate that it is mainly emphasising Al203 and the rare earths: Nd, Ce and La. This is probably due to the inclusionless matrix in this fabric group, which increases the amount of clay in the sample. However, the equivalent sample from the Triangle, subfabric 4, is not similarly separated. A plot of F3 against F5 shows that three outliers: the single CT5 sample and the two CB3 samples force all the remaining samples to cluster close to the origin (Fig 9). Factor 3, which separates the CB3 samples, has a high score for MgO and a strong negative score for Pb. Factor 4 has high weighting for Fe2O3 and Co, derived, as noted above, from the metalworking debris used to temper the sherd. However, even omitting these samples and replotting the data does not reveal any clear structure within the data, except for a high Factor 4 score for the subfabric 7 sample. Even this is within the range for the remaining samples.

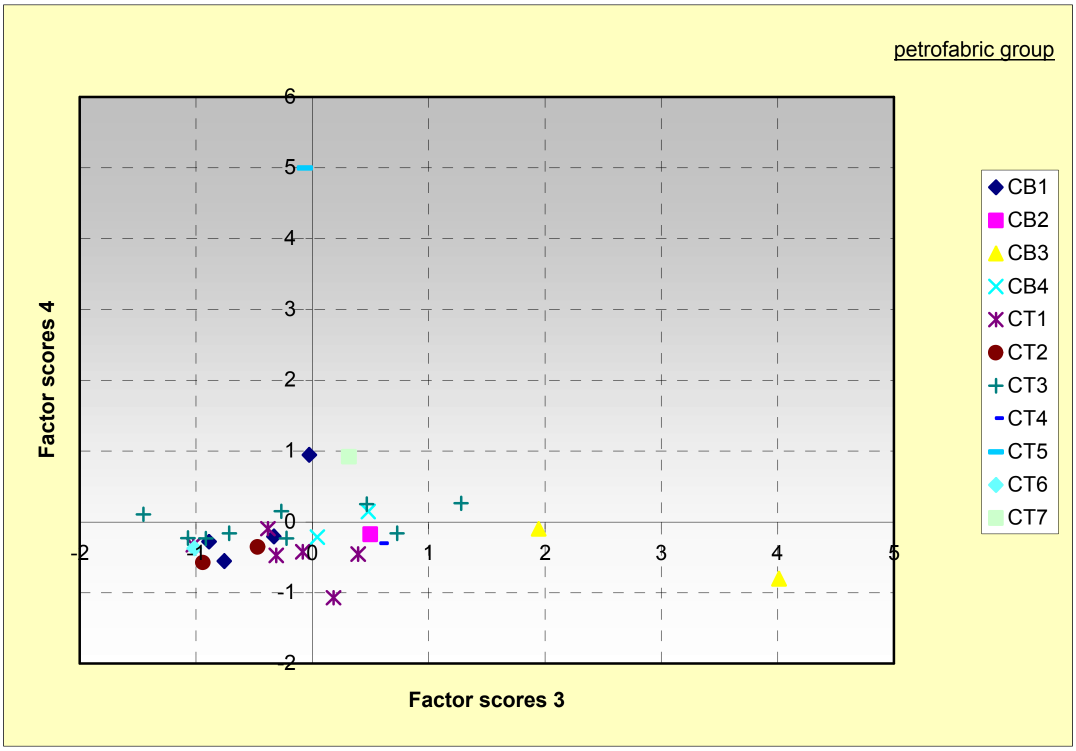

Figure 9

Conclusions

Twenty two samples from Catterick Triangle were examined in thin section and using ICPS. The results suggest that most of the samples were made from the same parent clay but that this clay was tempered with a range of different materials: Millstone Grit-type sand, Biotite Granite, smithing debris, a rounded fine-grained sandstone (and possibly mudstone?) sand and iron-rich inclusions. A comparison of the results with those from Catterick Bridge suggests that CB3 and CB4 come from different sources from each other and from the remaining samples and that CB1 and CB2 probably share the same parent clay as the majority of samples from Catterick Triangle. Detailed petrological comparison suggests that CB1 and CB2 cannot be correlated with any of the 7 fabric groups identified at Catterick Bridge and that, at the very least, nine fabric groups can be identified, each of which is likely to be of local origin. In the study of the Catterick Bridge samples it was suggested that the inclusions found in these fabrics might have been naturally present erratics in a boulder clay. The Catterick Bridge samples, and especially that containing hammerscale and slag, suggest that this is not the case, and that the parent clay is relatively free from large inclusions but contains abundant angular quartz sand, c0.2 to 0.3mm across. Such material has been observed in the banks of the Swale by the author but in that particular instance the quantity of clay in the alluvium was too little for pottery production.

Acknowledgements

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The samples were prepared by Peter Hill. Thin sections were made by Steve Caldwell, Department of Earth Sciences, University of Manchester. ICPS analyses were carried out in the Department of Geology, Royal Holloway College, London, under the supervision of Dr J N Walsh.

Bibliography

Appendices

Appendix 1a. ICPS Major Elements, measured as percent oxides

TSNO cname	petrofabric group	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1432CHARN	CT3	16.13	3.81	1.16	0.72	0.99	2.10	0.66	0.13	0.02
V1433CHARN	CT3	16.26	3.85	1.23	0.86	1.06	2.02	0.66	0.20	0.02
V1434SST	CT1	11.51	2.74	0.76	0.35	0.42	1.36	0.46	0.40	0.01
V1435CHARN	CT3	15.69	3.27	1.07	0.57	1.08	2.74	0.61	0.70	0.02
V1436SST	CT1	14.50	3.34	0.95	0.37	0.41	1.47	0.56	0.74	0.01
V1437SST	CT1	13.32	3.14	0.95	1.49	0.52	1.38	0.45	2.04	0.02
V1438CHARN	CT2	13.98	3.09	1.05	1.42	0.48	1.66	0.53	1.87	0.01
V1439SST	CT4	14.95	3.91	0.98	1.28	0.38	1.63	0.56	1.99	0.05
V1440SST	CT1	12.40	3.02	0.80	1.41	0.46	1.32	0.47	2.97	0.01
V1441SST	CT2	14.43	2.97	0.77	1.10	0.47	1.53	0.56	2.68	0.02
V1442CHARN	CT3	14.31	3.43	0.92	0.89	0.84	1.95	0.47	1.80	0.02
V1443CHARN	CT3	15.12	3.23	0.87	0.87	1.32	2.20	0.63	0.81	0.02
V1444CHARN	CT3	15.37	3.42	0.91	0.67	1.19	2.37	0.63	0.53	0.02
V1445EMSAX	CT5	11.48	30.29	0.95	1.36	0.35	1.27	0.46	1.85	0.20
V1446SST	CT1	10.28	5.81	0.72	1.30	0.35	1.09	0.38	3.00	0.08
V1447SST	CT1	13.53	3.35	0.92	1.40	0.59	1.48	0.49	2.52	0.01
V1448CHARN	CT3	14.01	3.91	1.03	1.98	0.93	1.88	0.48	3.25	0.03
V1449ESAX?	CT6	12.70	4.90	0.65	0.97	0.38	1.32	0.39	3.31	0.04
V1450ESAX?	CT7	12.82	8.68	0.83	1.18	0.47	1.32	0.52	3.34	0.32
V1451CHARN	CT3	16.38	3.89	0.97	0.68	0.95	2.44	0.67	1.29	0.01
V1452CHARN	CT3		4.24							

	17.17		0.92	1.11	1.04	2.77	0.68	0.88	0.06

Appendix 1b. ICPS Minor and Trace Elements, measured as parts per million

TSNO	cname	petrofabric group	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1432	CHARN	CT3	623	82	31	90	46	13	121	86	23	44	39	92	41	7.5	1.4	4.3	1.9	47	81	10
V1433	CHARN	CT3	634	86	27	78	45	13	117	83	22	40	39	89	41	7.3	1.3	4.1	1.7	41	89	9
V1434	SST	CT1	473	63	16	66	33	8	79	55	13	34	31	73	32	5.5	0.8	2.6	1.1	53	120	9
V1435	CHARN	CT3	690	78	39	67	52	13	106	72	28	45	43	97	45	7.6	1.3	4.8	2.4	44	193	8
V1436	SST	CT1	642	83	23	80	50	12	81	73	16	33	36	85	37	6.3	1.1	3.4	1.4	42	215	8
V1437	SST	CT1	1027	71	24	75	38	10	219	60	19	33	38	84	39	7.3	1.1	3.5	1.4	42	219	8
V1438	CHARN	CT2	1058	78	26	95	45	12	185	66	21	33	54	93	54	8	1.3	3.8	1.5	45	216	10
V1439	SST	CT4	1341	84	32	79	46	13	200	71	22	30	42	90	43	8.3	1.5	4.2	1.6	35	327	10
V1440	SST	CT1	1203	66	37	59	45	9	245	56	16	25	35	77	36	6.5	0.9	2.9	1.1	35	245	8
V1441	SST	CT2	1015	79	29	74	37	12	221	67	20	27	42	95	43	7.8	1.4	3.9	1.4	50	200	8
V1442	CHARN	CT3	967	80	30	86	40	11	195	65	22	31	43	99	44	8.2	1.4	4	1.6	47	217	9
V1443	CHARN	CT3	681	81	29	67	39	11	154	71	20	34	44	91	45	7.2	1.2	3.7	1.5	55	80	10
V1444	CHARN	CT3	627	79	23	70	37	11	136	73	18	32	39	92	40	7	1.2	3.4	1.4	57	68	11
V1445	EMSAX	CT5	1145	66	33	73	50	9	155	66	20	40	32	69	34	10	1.3	3.7	2.7	38	239	47
V1446	SST	CT1	1492	60	26	42	37	9	240	50	18	27	29	53	30	6.2	0.9	3.4	1.4	47	198	12
V1447	SST	CT1	1196	73	27	68	42	11	221	64	20	32	36	82	37	7.1	1.2	3.7	1.5	45	246	10
V1448	CHARN	CT3	1410	69	31	62	38	11	316	64	22	36	36	81	38	7.6	1.2	4.2	1.7	51	225	11
V1449	ESAX?	CT6	1911	74	30	70	41	10	285	59	18	24	36	82	37	7.3	1.2	3.4	1.4	47	220	10
V1450	ESAX?	CT7	1652	71	35	61	49	10	218	62	18	31	37	80	39	7.7	1	4.7	1.6	36	327	12
V1451	CHARN	CT3	906	88	42	94	52	13	157	76	23	38	47	110	48	9	1.6	4.5	1.8	56	162	9

V1452 CHARN CT3	999	87	31	111	48	13	193	74	19	33	53	110	54	7.9	1.4		4	1.5	60	115	14

Appendix 2. Factor Analysis. Quartimax Factor Loadings

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Commu-nality
Ce	0.920600014	-0.063158531	-0.160490257	0.128605042	-0.168804231	0.922284634
Al2O3	0.917102423	-0.2354196	-0.193069113	0.109069409	0.085514525	0.952983794
Sc	0.912519104	-0.110851558	-0.164036338	-0.143339304	0.141775402	0.912533524
Cr	0.901022061	-0.217326596	-0.158751335	-0.06154336	-0.133240043	0.905814085
Nd	0.880245072	0.095660326	-0.0786466	0.11540484	-0.222313221	0.852909018
Eu	0.863389608	0.106029447	0.216754161	0.013509291	-0.005335205	0.803877191
La	0.852754038	0.102183915	-0.109576879	0.122421921	-0.27222076	0.838729364
TiO2	0.794288865	-0.431770442	-0.058943408	0.101203934	0.09456034	0.839978735
K2O	0.789382529	-0.241688744	-0.066319116	0.3862824	0.225226696	0.885877609
V	0.784665051	-0.446319153	0.076591306	-0.040256294	0.179065293	0.854451205
Li	0.782782254	-0.168758627	0.091685771	0.028926769	-0.425006693	0.831101259
Dy	0.7009222	0.229029454	0.193307248	-0.218282877	0.463612202	0.843697802
Y	0.683769565	0.141791623	0.158049993	-0.051841755	0.579576858	0.851222385
MgO	0.58878684	-0.33362903	0.123337609	-0.148909919	0.401218599	0.656340967
Na2O	0.581273329	-0.275698074	-0.12275855	0.537322582	0.393730626	0.872697135
Ni	0.53159293	-0.054857675	0.388096278	-0.515934567	0.099490408	0.712305948
Cu	0.468382039	0.394386327	0.275904229	-0.209194388	0.291637947	0.579860437
Sr	-0.188008782	0.945034052	-0.089991831	0.1314227	0.017056201	0.954098031
P2O5	-0.388958529	0.904115148	0.006475587	-0.159152906	-0.025145835	0.994716832
Ba	-0.26194025	0.859071409	0.113640024	-0.197732885	-0.05500777	0.861654584
CaO	-0.148993644	0.714251571	0.153944346	-0.000586052	0.088218068	0.563836046
Fe2O3	-0.211436373	0.019029032	0.976772742	-0.082437038	-0.023090488	1
Co	-0.166267923	-0.010328424	0.974056256	0.045554473	-0.069197143	0.983400743
Yb	0.326920688	-0.068723069	0.767364475	-0.116034394	0.469381615	0.934231315
Sm	0.551108052	0.317135399	0.713214193	-0.066759403	-0.009988761	0.917526025
MnO	-0.19604218	0.247520466	0.527233213	-0.273919063	0.047109369	0.454924724
Pb	0.266674806	-0.163284938	-0.187072639	0.782355779	-0.154997907	0.768878512
Zn	-0.207741933	0.627389694	0.141367154	-0.650926433	-0.053484984	0.883325077
Zr*	0.427071346	-0.516736125	0.364416455	0.007328249	0.53391183	0.867321056
Sum of Squares	11.30388665	4.853712934	4.03273544	2.133709394	1.983015084	24.3070595
Percent of Variance	38.97891947	16.73694115	13.90598427	7.3576186	6.837983047	83.81744655