Characterisation studies of Iron Age flint-tempered pottery in Hampshire

Alan Vince

Much of the pottery used in the Iron Age in Hampshire is tempered with abundant angular fragments of flint. The pottery is in the main extremely coarse in texture and appearance and since flint is readily available throughout the county there is no reason why these vessels could not have been produced at numerous sites throughout the county. Nevertheless, the visual appearance of these vessels is so similar from site to site that the possibility of centralised production must be considered. This paper is the results of a pilot project instigated by Helen Rees of Winchester City Museum in order to test the potential of petrological and chemical analyses for characterising this flint-tempered pottery.

Sampling

This pilot scheme had to be carried out on a limited budget in which only 23 samples could be afforded (Table 1). The three methods of study chosen were x20 binocular microscope survey, thin section analysis and chemical analysis using Inductively Coupled Plasma Spectroscopy.

Table 1

TSNO	Sitecode	trench	Context	REFNO	Action	Ware	class	Petrofabric
V1779	WINCM:AY46		327	1	TS;ICPS	saucepan style	POTTERY	flinty 1
V1780	WINCM:AY46		99	2	ICPS	saucepan style	POTTERY	flinty 1
V1781	WINCM:AY46		228	3	x20	daub	FCLAY	Tertiary gravel in brickearth
V1782	BWF 89	5309	729	4	ICPS	saucepan style	POTTERY	flinty 3
V1783	BWF 89	5395	1089	5	TS;ICPS	saucepan style	POTTERY	flinty 2
V1784	BWF 89		1034	6	TS;ICPS	daub/ burnt clay	FCLAY	clay with flints?
V1785	WINCM:ARCH 34.00.01			7	ICPS	saucepan style	POTTERY	flinty 2
V1786	WINCM:ARCH 34.00.01			8	ICPS	saucepan style	POTTERY	flinty 2
V1787	WINCM: ARCH 34.00.06			9	TS;ICPS	daub	FCLAY	clay with flints?
V1788	A1978.20, MARC 3 R17	3938	3939	10	ICPS	saucepan style	POTTERY	flinty 3
V1789	A1978.20, MARC 3 R17	5597	7214	11	ICPS	saucepan style	POTTERY	flinty 1

V1790	A1978.20, MARC 3 R17	3549	5590	12	x20	daub/ burnt clay	FLCAY	chalk brash
V1791	SOU 29		854	13	TS;ICPS	saucepan style	POTTERY	flinty 5
V1792	SOU 29		1023	14	ICPS	saucepan style	POTTERY	flinty 1
V1793	SOU 29		775	15	x20	loomweight fragment	FCLAY	brickearth?
V1794	A1988.31		12	16	ICPS	saucepan style	POTTERY	flinty 1
V1795	A1988.31		5	17	TS;ICPS	saucepan style	POTTERY	flinty 3
V1796	A1988.31		6	18	x20	daub	FCLAY	brickearth?
V1797	A1980.60, A/ODF75-6	2137	2645	19	ICPS	saucepan style	POTTERY	flinty 1
V1798	A1980.60, A/ODF75-6	239	362	20	ICPS	saucepan style	POTTERY	flinty 1
V1799	A1980.60, A/ODF75-6		973	21	x20	daub/ burnt clay	FCLAY	chalk brash
V1800	A1987.13, BHS (sites B and C)	6116	6137	22	TS;ICPS	saucepan style	POTTERY	flinty 4
V1801	A1987.13, BHS (sites B and C)	5098	5143	23	ICPS	saucepan style	POTTERY	flinty 1
V1802	A1987.13, BHS (sites B and C)		5407	24	TS;ICPS	daub/ oven	FCLAY	clay with flints?
V1803	A1979.1, DA 72, DA 75, DA88	337	10	25	ICPS	saucepan style	POTTERY	flinty 1
V1804	A1979.1, DA 72, DA 75, DA88	813	7	26	ICPS	saucepan style	POTTERY	flinty 1
V1805	A1979.1, DA 72, DA 75, DA88	356	4	27	x20	oven daub	FCLAY	chalk brash
V1806	A1980.30		736	28	ICPS;TS	LPRIA flint tempered	POTTERY	flinty 1
V1807	A1980.30		1008	29	ICPS	LPRIA flint tempered	POTTERY	flinty 1
V1808	A1980.30		695	30	x20	daub	FCLAY	brickearth?

Binocular microscope survey is quick and cheap and is able to record surface features of inclusions which are not visible in thin section. It is also useful for identifying rare inclusions which might be significant for characterisation but which because of their rarity might not be seen in a thin section. Thin section analysis, on the other hand, is essential for the identification of inclusions less than 0.5mm across which are difficult to reliably identify at x20 magnification as well as for recording details of the petrological characteristics of inclusions. In the case of the Hampshire flint-tempered pottery it was thought likely that the majority of the inclusions seen in thin section would be flint and that this flint would be weathered Upper Cretaceous flint from the chalk rather than fragments recycled into Tertiary or quaternary deposits. Chemical analysis of a coarse textured fabric such as this is subject to numerous problems. Firstly, fluctuations in the quantity of flint temper will have a major effect on the overall frequency of the measured elements even through flint itself is composed primarily of silica which is not measured by ICPS. Secondly, these vessels have numerous pores and laminae into which material could be introduced during burial. These materials usually comprise calcium carbonate, phosphatic concretions, iron and/or manganese staining or panning and organic compounds. Thirdly, sherds buried in acidic conditions are likely to be affected by the leaching of inclusions, principally any carbonate-based inclusions, such as chalk or shell.

Bearing all of these points in mind, the following sampling strategy was agreed:

Samples were chosen from a sites covering as wide a geographical range in the county as possible (Fig 1). These sites were located on differing geological strata ranging from Quaternary brickearths resting on Eocene clays and sands in Southampton to chalk, sometimes with overlying clay-with-flints or 'plateau gravels' at Silchester

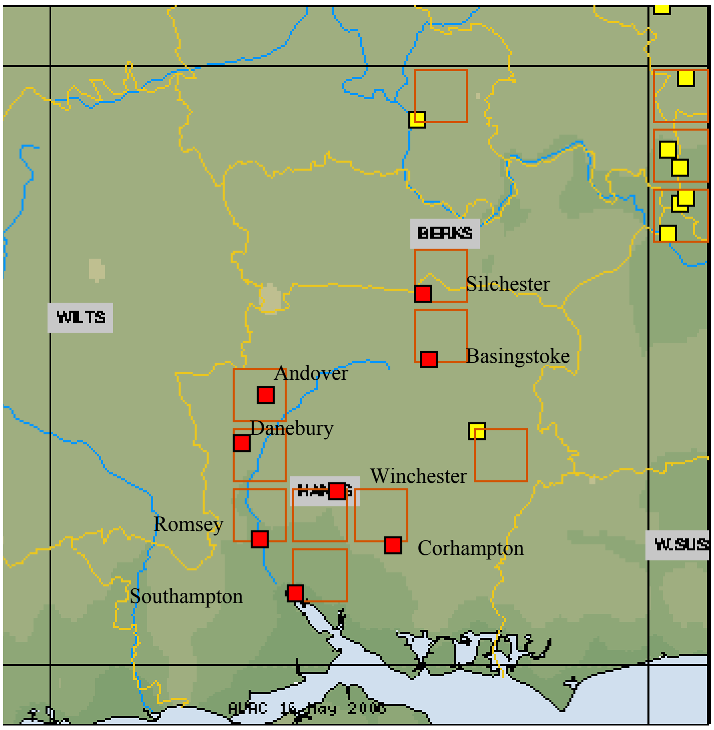

Figure 1

Wherever possible samples of clay loomweights or burnt clay from the excavation were collected for comparison with the pottery. It was reasoned that this would represent the most readily available clay and temper sources for any potters based in those settlements.

A greater number of samples of flint-tempered pottery than could afford to be sampled were collected from each site.

These samples were then examined by the author under x20 magnification (see below *Binocular microscope survey)*. Guided by the results of this survey a selection was made for thin section analysis. These samples included representatives of five subfabrics based on the characteristics of the fabric as seen under the microscope together with three samples of daub (see below *Thin section analysis*). Finally, subsamples of the thin sectioned samples and of 15 other pot samples were submitted for chemical analysis (see below *Chemical analysis*).

Binocular microscope survey

Even by eye at x20 magnification it was quite clear that most of the fired clay samples were very different from the flint-tempered pottery in the basic characteristics and that even with the addition of angular flint they would not have had a similar appearance to the flint-tempered pottery. These dissimilar fired clays can be classified into three groups: Brickearths (Silchester, Romsey, Southampton), chalk brash (Danebury, Andover and Winnall Down, Winchester) and gravel containing brown-stained flints typical of Tertiary deposits in a brickearth matrix (Oram's Arbour, Winchester).

This left three fired clay samples, each of which contained some rounded brown iron oxide inclusions, little visible quartz and some angular flint fragments (although in much lower quantities than in the pottery). These three samples came from Brighton Hill, Basingstoke (V1802), Corhampton Down (V1787) and Berwick Field, Winchester (V1784).

The pottery itself was also classifiable by eye into fabric groups. Five groups were identified, and given the codes FLINTY1 to FLINTY5 for the purposes of this study.

FLINTY1 contains abundant white angular flint fragments often several mm across in an inclusionless groundmass.

FLINTY2 was identical to FLINTY1 except for the grain size distribution of the flint fragments, which appeared to be better sorted than in FLINTY1.

FLINTY3 was similar to FLINTY1 and FLINTY2 except that the groundmass is variegated.

FLINTY4 was similar to FLINTY1 and FLINTY2 but with a sandier groundmass.

FLINTY5 was a quite different fabric, containing subangular brown-stained flint, shell, rounded quartz and possibly vegetal inclusions. This fabric is very similar, if not identical, to mid Saxon coarsewares from the Hamwic site ({Timby 1988 #9603}) and to late Saxon coarsewares from the site of medieval and later Southampton. This may be because it is actually a stray mid or late Saxon sherd or because it is Iron Age but made from the same raw materials as the later coarsewares. In either case, it should clearly not be grouped with these other flint-tempered wares, all of which share the same angular white flint temper.

Visual analysis therefore suggests that there is a major division of the flint-tempered wares into those with angular white flint temper and the mixed temper found in the FLINTY5 sample. This white flint gravel was examined carefully to see if there was any evidence for patination of the broken surfaces but none was seen. Furthermore, many of the fragments appeared to be cracked. It is unlikely that they were subjected to a sufficient thermal shock to bring about this cracking during firing and it is likely that this is evidence for the use of fire-cracked flint, perhaps brought about by throwing hot flints into water.

Thin section analysis

Nine samples were examined in thin section (Table 2). Initially, three samples of the clay samples made from Clay with Flints and one sample each of the five visually identified fabrics were analysed. Subsequently, as a result of the chemical analysis, a second sample of FLINTY 1, from Silchester, was sampled.

Table 2

TSNO	clay with flints?	flinty 1	flinty 2	flinty 3	flinty 4	flinty 5
V1779		1				
V1783			1			
V1784	1					
V1787	1					
V1791						1
V1795				1		
V1800					1	
V1802	1					
V1806		1				

In thin section some detail was visible that could not been seen by eye.

The samples of FLINTY1 and FLINTY2 proved to be identical in their petrological characteristics although grain size analysis of the flint temper was not carried out and it might prove possible to justify this division if this analysis was to be carried out. However, even it is indeed a real difference between the two fabrics it only reflects a cultural difference, perhaps the sieving of inclusions to remove the larger fragments, and not a difference in raw materials. No difference was noted between the two samples of FLINTY 1.

The sample of FLINTY4 did indeed contain moderate subangular quartz grains up to 0.3mm across and a single subangular fragment of chalk. The clay matrix was variegated, as was that of the FLINTY3 sample.

All of these flint-tempered samples contained rounded brown iron-rich pellets and streaks in the clay matrix of similar colour and texture. Two of the samples were variegated with poorly mixed light-firing and red-firing clays. However, this feature would not have been noticeable in the remaining sections because of the presence of carbon throughout the body, giving the groundmass a black colour.

The thin section of FLINTY5 contained: moderate subangular fragments of brown-stained flint, subangular and rounded brown chert, angular white flint up to 4.0mm across; Sparse rounded quartz grains, probably of lower Cretaceous origin; Voids from leached shell, up to 0.5mm long and rounded opaque grains up to 0.3mm across. The groundmass contains abundant fine quartz sand up to 0.2mm across.

The three fired clay samples each had some features in common with the main flint-tempered pottery group. V1784, however, contained sparse rounded quartz grains and moderate fine angular quartz sand up to 0.2mm across which distinguished it from the pottery group as well as having some larger iron-rich fragments. However, it did have a variegated matrix and did contain dark brown rounded iron-rich pellets as in the main pottery group. V1787 contained sparse angular and rounded quartz grains up to 0.5mm across, absent from the main pottery group, and contained rounded light-coloured clay pellets. It too had a variegated groundmass and the iron-rich pellets. V1802 contained sparse rounded quartz grains up to 1.0mm across and probably of lower Cretaceous origin in a groundmass containing angular quartz silt up to 0.1mm. It too had the iron-rich clay pellets but the groundmass was homogenous.

To summarise, the fired clay samples each contain rounded quartz grains which are absent from the main flint-tempered pottery group and since it is clear from the poorly mixed groundmass and the presence of the brown iron-rich pellets that the pottery clay had not been cleaned before use, none of the these three clays could actually have been the raw material used to make the flint-tempered pottery. However, the Winchester and Corhampton Down samples both have the variegated matrix found in the pottery (or at least in some samples) whereas the Basingstoke sample is clearly different in both its matrix texture and the presence of quartz silt. It is likely, therefore, that the parent clay used for making the main flint-tempered pottery group could be found in the Winchester and Corhampton Down areas, and no doubt elsewhere in central Hampshire. It is likely that this is an outcrop of clay-with-flints, despite the lack of flints in the three sampled fired clays. Furthermore, the variegated groundmass, found in both the pottery and the Winchester and Corhampton fired clays, is likely to be derived from the Reading Beds, the earliest of the Tertiary deposits in the Hampshire Basin, which at present outcrops well to the south of Winchester and Corhampton. However, the groundmass of clay-with-flints is derived partly from the insoluble residue of the chalk and partly from the remnants of Tertiary clays which are now totally eroded.

Because most of the samples were black, as a result of incompletely burnt out carbon diffusing through the body, it was not possible to determine whether or not the clays were all variegated either visually or in thin section. Since this characteristic seems to be distinctive small fragments of each sample were sawn from the main sample and re-heated at a temperature of 900 degrees C in an electric kiln. Six samples were too small to subsample and a further two disintegrated following refiring, as a result of their high calcareous content (CaCO3 breaks down to form CaO and CO2 at c.850 degrees C).

For the remainder, the refired sample was exampled at x20 magnification and the following features noted:

- Streaks or pellets of lighter coloured clay
- Black staining, either diffusing from a central point or as streaks along laminae
- Organic inclusions
- Coarse, ill-sorted quartz silt
- Find well-sorted quartz sand

The results are presented in Table 3. There were five samples which contained none of these features. They had previously been classified as FLINTY 1, FLINTY 2 and FLINTY 3 and came from sites in Winchester (x2), Corhampton, Romsey and Andover.

Twelve samples had variegated matrices, mostly hardly noticeable except under x20 magnification but in two cases quite noticeable and in one case very noticeable. Most of these samples had been classed as FLINTY 1 (x6) with single examples of FLINTY 2, FLINTY 3 and FLINTY 4. Two of the clay samples classed as Clay with Flints also had variegated matrices and one clay sample classed as a brickearth clay with Tertiary gravel temper. These samples come from sites in Basingstoke, Corhampton (x2), Danebury (x2), Romsey, Silchester (x2) and Winchester (x4). Three clay samples were present within these samples, from Corhampton and Winchester (x2).

The manganese staining, organic inclusions and coarse quartz silt were noted in five samples, all classed as Brickearth clays.

Finally, fine quartz sand was noted in three pot samples, FLINTY 1 (x2) and FLINTY 4, and in two clay samples, both classed as Clay with Flints. All but one of these samples also had a variegated matrix. These samples came from sites in Winchester, Corhampton, Basingstoke (x2) and Danebury.

In summary, the presence of variegated matrices shows no obvious geographical bias, nor does the presence of fine quartz sand in the matrix, such as might be expected if the pots were made from local outcrops of Clay with Flints with varying degrees of lighter coloured clay present. The variegated clay samples came from Winchester and Corhampton, close to the present day outcrop of the Reading Beds and where one might expect the Clay with Flints to contain the greatest amount of reworked Reading Beds.

Table 3

TSNO	varig?	mang?	organics?	coarse silt	fine sand
V1779			too small		
V1780	0	0	0	0	0
V1781	2	1	0	1	0
V1782	0	0	0	0	0
V1783			too small		
V1784	1	0	0	0	1
V1785	0	0	0	0	0
V1786	1	0	0	0	0
V1787	3	0	0	0	1
V1788	1	0	0	0	0
V1789	1	0	0	0	0
V1790			too small		
V1791			too small		
V1792			too small		
V1793	0	1	1	1	0
V1794	1	0	0	0	0
V1795	0	0	0	0	0
V1796	0	1	1	1	0
V1797			too small		
V1798	0	0	0	0	0
V1799			disintegrated		
V1800	2	0	0	0	1
V1801	0	0	0	0	1
V1802	0	1	1	1	0
V1803	1	0	0	0	0
V1804	1	0	0	0	1
V1805			disintegrated		
V1806	1	0	0	0	0
V1807	1	0	0	0	0
V1808	0	1	1	1	0

Chemical analysis

The samples were prepared by removing the outer surface and then grinding the residue to a fine powder. This power was then analysed at Royal Holloway College, London. The frequency of the major elements was calculated as percent oxides (App 1a) and that of minor and trace elements as parts per million (App 1b).

The dataset was first examined to see if any of the measured values were more than 4 standard deviations from the mean. Seven such samples were found. These consisted of two of the three daub samples, from Basingstoke and Corhampton, the two Late Iron Age vessels from Silchester and flint-tempered sherds from Winchester, Andover and Romsey. Of these, the daub samples are clearly of a very different composition from the remainder whilst the remaining samples mainly have just a single outlying value. The exception is one of the Romsey samples which has abnormally high values for eight trace elements.

To establish the likely origin of the various measured elements a Pearson correlation was carried out of all the measured elements with 'silica' (estimated by subtracting the oxide percentages from 100), Al2O3, which is taken to occur overwhelmingly in the clay fraction, CaO, which in the light of the thin section evidence is likely to be entirely post-depositional and P2O5, which is also likely to be post-depositional.

This correlation shows a strong correlation between Al2O3 and Fe2O3, TiO2, Sc, V and Zr. CaO is strongly correlated with Na2O and MnO whilst P2O5 is strongly correlated with Zn. Sr is equally correlated with CaO and P205 and presumably is therefore present in both calcareous and phosphatic concretions, or in a calcium phosphate.

A factor analysis was then carried out on the elements identified here as being probably present as a result of post-burial contamination: CaO, Na2O, MnO, P2O5, Zn and Sr. A single factor with an eigenvalue greater than 1 was found. High scores were assigned to the two Silchester samples and to the Romsey sample and strong negative scores were assigned to a Southampton and an Andover sample.

Next, a factor analysis was carried out using only the elements with strong correlations with Al2O5. This too only produced a single factor (Table 00). When compared with the binocular microscope fabric classification this provides support for the interpretation of FLINTY 5 and the daub sample as having a different source from the remainder.

Table 4

Factor scores 1	clay-with-flints?	FLINTY 1	FLINTY 2	FLINTY 3	FLINTY 4	FLINTY 5	Grand Total
<-2						1	1

-2--1					2			2
-1-0			4	2	1	1		8
0-1			6	1				7
1-2			2					2
2-3	1							1
Grand Total	1		12	3	3	1	1	21

When the same data is compared with the findspot (Table 2) there is no strong evidence for any correlation between factor score and findspot.

Factor scores 1	Andover	Basingstoke	Corhampton	Danebury	Romsey	Silchester	n	Winchester	Grand Total
<-2							1		1
-2--1					1			1	2
-1-0		2	1	1			1	3	8
0-1	1		1	1	1	1		2	7
1-2	1					1			2
2-3								1	1
Grand Total	2	2	2	2	2	2	2	7	21

Finally, a Pearson correlation was carried out on Fe2O3. Eleven elements had positive correlations with iron. These consist of Fe2O3, MgO, TiO2, Cr, Ni, Sc, V, Y, Zr, Yb and Co. A factor analysis was carried out on these elements and three factors were found.

A plot of F1 against F2 shows that the clay-with-flints Daub sample and the FLINTY 5 sample were clearly separated from the remainder but that there is no sign of patterning within the remaining date (Fig 2).

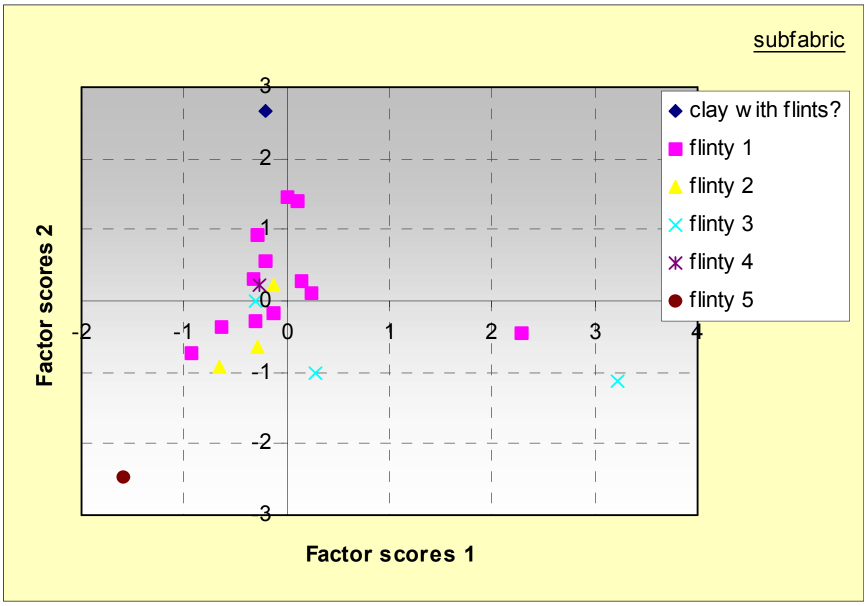

Figure 2

These differences and similarities are all based on a dataset in which 70-80% of the pot's weight is not accounted for. Most of this 'silica' will be flint but will also include any quartz grains. Table 2 shows the correlation of binocular microscope fabric group against 'silica'. This indicates that the two outlying samples have abnormally high and abnormally low quantities of 'silica'. To ensure that these samples were not similar excluded from the main cluster because of their flint content the ICPS data were normalised to Al2O3 and the factor analyses re-run.

Table 5

SiO2	clay-with-flints?	FLINTY 1	FLINTY 2	FLINTY 3	FLINTY 4	FLINTY 5	Grand Total
70-71	1						1
72-73		2					2
74-75		6					6
75-76		1		2			3
76-77		1	1	1			3
77-78			1		1		2
78-79		1	1				2
79-80		1				1	2

Grand Total	1	12	3	3	1	1	21

The re-run factor analysis produced a single factor (Table 3). The correlation with subfabric shows that the daub sample from Winchester has a score of 1.15, within the range found for the flint-tempered wares. The two Silchester Late Iron Age samples both have more negative scores than other FLINTY 1 samples although one of the FLINTY 3 samples has a more negative score.

Table 6

		FLINTY	FLINTY	FLINTY	FLINTY	FLINTY	
Factor scores 1	clay-with-flints?	1	2	3	4	5	Grand Total
-2--1.5				1			1
-1.5--1		1					1
-1--0.5		3	2				5
-0.5-0		6	1	1	1		9
0-0.5						1	1
1-1.5	1	1					2
2.5-3		1		1			2
Grand Total	1	12	3	3	1	1	21

Conclusions

In most cases where daub or other fired clay was available for comparison there were major differences between the fabric of this material and than of the flint tempered pottery. Only in the case of samples which appear to have been produced from outcrops of clay-with-flints was there any great similarity. These sites were Basingstoke, Corhampton and Winchester. Of these three, two,Basingstoke and Corhampton, had significant differences in chemical composition whereas the third, from Winchester, was similar but not identical. However, when the chemical data were transformed by normalising to Al_2O_3 and only elements correlated strongly with Al_2O_3 were compared the similarity in composition was much stronger. Furthermore, the pottery was divided into five subfabrics on the basis of visual examination at x20 magnification and three of those five subfabrics were present in samples from Winchester. There is a little evidence for the existence of geographically discrete subfabrics, single samples from Basingstoke and Southampton. However, neither of these samples shows any substantial difference in chemical composition from the remainder.

The conclusion of this pilot study is therefore that it is likely that the majority of the Iron Age flint tempered pottery found in Hampshire is indeed the products of a single industry and that this industry may have been located close to Winchester. This industry seems to have included three subfabrics which do not seem to have either geographical or chemical significance. In addition, there are a few samples which appear to be anomalous and might be made in separate industries. These include one of the two Southampton samples (FLINTY 5), one of the two Basingstoke samples (FLINTY 4) and, less certainly, the two Silchester Late Iron Age samples (both made in the main FLINTY 1 subfabric). In the case of the Silchester samples a thin section failed to find any difference between this sample and the other thin sectioned example and it is likely that any variation in the chemical composition of the Silchester examples is due to post-burial contamination.

Further work should concentrate on establishing the limits of this chemical/petrologically-defined industry by including samples of Wiltshire, Berkshire and Sussex flint tempered wares. The suggestion of a Winchester source should also be pursued, by further study of daub and other fired clay from sites in the area in an attempt to define the limit of clays with a similar chemical composition and petrological characteristics. Another possibility would be to undertake an more detailed study of the present samples, using ICP-MS. This method provides a more accurate count of some of the elements measured by ICP-AES as well as counting some elements not included in the present study.

Acknowledgements

The thin sections were produced by Steve Caldwell, Dept of Earth Sciences, University of Manchester. The ICPS analysis was carried out at the Department of Geology, Royal Holloway College, London, under the supervision of Dr N Walsh. The subsamples were refired by Andrew Macdonald of the Pot Shop, Lincoln.

Appendix 1

Appendix 1a: Major elements (percent oxides)

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1784	16.47	7.68	1	0.97	0.095	2.75	0.75	0.13	0.013
V1787	23.26	9.14	0.95	1.12	0.152	2.25	0.82	0.13	0.007
V1802	6.94	2.92	0.61	18.08	0.399	1.12	0.41	0.26	0.129
V1806	16.65	4.12	0.96	1.66	0.1615	2.44	0.49	0.83	0.027
V1807	16.12	3.42	0.9	1.9	0.171	2.46	0.48	2.09	0.024
V1779	13.93	5.85	0.63	2.41	0.0855	1.36	0.49	0.86	0.014
V1780	14.7	6.25	0.72	1.59	0.076	1.15	0.55	0.44	0.012
V1782	10.31	8.01	0.96	2.25	0.095	1.35	0.4	0.7	0.015
V1783	13.03	3.72	0.82	1.44	0.0855	1.23	0.48	0.42	0.011
V1785	13.16	5.61	0.53	0.8	0.0855	1.2	0.53	0.37	0.012
V1786	14.66	5.35	0.55	1.14	0.1045	1.15	0.56	0.17	0.011
V1788	13.94	5.76	0.7	2.03	0.1045	1.05	0.55	0.35	0.008
V1789	14.75	4.94	0.72	1.86	0.095	1.72	0.57	0.44	0.01
V1791	10.43	4.24	1.15	0.9	0.1995	1.87	0.49	0.74	0.006
V1792	10.82	5.2	0.99	0.49	0.1045	1.64	0.66	0.31	0.01
V1794	15.05	5.43	0.8	1.31	0.095	1.51	0.61	0.49	0.014
V1795	13.37	4.06	0.63	2.56	0.076	1.36	0.45	1.43	0.033
V1797	15.73	5.3	0.86	0.84	0.114	1.53	0.67	0.12	0.01
V1798	14.72	6	1.12	1.33	0.095	1.79	0.56	0.17	0.073

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V1800	13.72	3.84	0.66	1.58	0.1235	1.09	0.7	0.47	0.031
V1801	11.64	4.98	0.94	0.89	0.114	1.66	0.62	0.24	0.01
V1803	13.97	5	0.5	2.46	0.1045	1.29	0.61	0.32	0.014
V1804	13.54	4.78	0.61	1.92	0.1235	1.17	0.55	0.43	0.009

Appendix 1b: 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
V1784	403	98	22	37	32	16	74	121	21	134	34	52	35.532	2.796	0.9624	3.8	2.9	26.36	70	7
V1787	376	88	51	51	39	24	106	179	31	136	44	70	44.65	3.958	1.1602	3.5	3	29.28	56	8
V1802	228	39	13	32	23	7	248	47	29	93	37	48	39.104	5.724	1.0956	4.6	2.3	15.12	76	8
V1806	617	110	254	49	34	17	174	119	22	89	42	66	43.71	7.864	1.5116	4.5	2.6	31.5	159	7
V1807	695	104	41	36	34	16	290	115	19	86	42	67	43.24	6.774	1.2606	4	2.3	33.96	130	7
V1779	455	85	18	33	38	14	148	94	22	73	38	67	39.386	6.945	1.3905	3.9	2.2	38.44	68	9
V1780	430	92	26	51	48	13	84	102	22	81	43	72	44.744	5.925	1.4625	4.6	2.7	32.8	103	14
V1782	308	96	15	27	52	11	141	128	25	65	50	91	51.512	8.397	1.8393	4.8	2.4	26.48	68	14
V1783	327	78	20	39	37	12	92	91	15	82	33	49	33.558	4.684	0.8396	2.7	1.9	43.54	71	12
V1785	242	83	17	33	38	12	89	90	20	67	34	54	35.344	3.817	1.1073	3.6	2.1	49.88	60	11
V1786	309	89	19	44	44	14	72	101	20	77	30	47	31.396	2.895	0.9255	3.4	2.2	37.18	79	10
V1788	1247	93	18	25	38	13	152	102	19	75	24	36	25.38	2.172	0.7968	3	2.2	28.92	59	9
V1789	388	90	28	38	31	14	126	97	19	80	32	52	33.464	4.518	1.0542	3.6	2.4	30.6	60	9
V1791	322	77	17	29	19	9	63	82	8	57	20	32	20.586	1.528	0.5032	1.9	1.3	38.64	66	10

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V1792	254	94	24	34	41	10	36	126	11	78	17	29	17.86	1.64	0.536	2	1.7	41.66	51	16
V1794	316	98	25	65	60	14	92	119	17	82	27	46	28.482	2.771	0.9199	3.3	2.3	31.9	72	21
V1795	417	84	27	30	113	12	128	83	50	56	169	405	173.618	47.382	7.7158	15.7	4.1	43.66	129	34
V1797	297	100	24	38	39	15	70	108	23	100	36	65	38.164	6.01	1.429	4.6	2.7	53.14	65	14
V1798	377	93	29	42	77	14	77	116	32	77	46	127	50.76	11.8	2.48	8	3.9	35.66	114	56
V1800	268	89	13	59	35	11	103	95	22	91	30	60	32.148	6.148	1.1312	4.2	2.4	33.86	42	14
V1801	309	89	23	45	32	12	63	99	17	76	28	47	29.328	4.606	0.9514	3.2	2.1	28.12	68	10
V1803	295	95	24	29	33	13	122	104	22	79	29	48	30.738	4.2	0.95	3.7	2.4	30.16	54	8
V1804	280	83	22	24	33	12	118	90	22	78	39	65	40.42	6.266	1.2654	4	2.3	27.82	53	8