Characterisation of the Ceramic Building Material from Croft Castle, Croft, Herefordshire

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The archaeological excavations at Croft Castle, Croft, Herefordshire, produced a large quantity of ceramic building material, most of which consisted of fragments of brick. Samples of this material were analysed using thin section and chemical analysis in order to determine whether the material was made on site or elsewhere (Table 1).

Table 1

TSNO	Sitecode	Context	cname	Form	Action	Description	Comment
V3704	CC04	45005	BRED	FLOOR	ICPS	WHITE SLIP WORN	
V3705	CC02	U/S TR13	GM	FLOOR	TS;ICPS;DR	FOLIAGE DESIGNED ENCAUSTIC TILE	
V3706	CC02	17016	BRED	FLOOR	ICPS	DARK GREEN GLAZE WORN	
V3707	CC03	13020	GM	FLOOR	TS;ICPS;DR	CORNER OF ENCAUSTIC TILE WITH FLOWER/FOLIAGE	
V3708	CC03	13020	GM	FLOOR	TS;ICPS	DARK GREEN GLAZE	
V3709	CC04	44006	GEO?	GEO?	ICPS	COMPACTED SOIL?	
V3710	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	TS;ICPS		
V3711	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	ICPS		
V3712	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	ICPS		
V3713	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	ICPS		
V3714	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	ICPS		
V3715	CROFT ENVIRONS KILN SOUTH	U/S	PMTIL	BRICK	ICPS		
V3716	CROFT ENVIRONS KILN NORTH	U/S		BRICK	TS;ICPS	STRAW BACKED	
V3717	CROFT ENVIRONS KILN	U/S		BRICK	ICPS		

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	NORTH						
V3718	CROFT ENVIRONS KILN NORTH	U/S		BRICK	ICPS	SUCTION FROM MOULD; SLOPPY?	
V3719	CROFT ENVIRONS KILN NORTH	U/S		BRICK	ICPS		
V3720	CROFT ENVIRONS KILN NORTH	U/S		BRICK	ICPS		
V3721	CROFT ENVIRONS KILN NORTH	U/S		BRICK	ICPS		
V3722	CC03	U/S TR13	HERA10	BRICK	TS;ICPS	DIAMOND SHAPED BRICK FROM MOULD	
V3723	CC02	U/S TR18	PMTIL	BRICK	ICPS	SLOPPED INTO MOULD	
V3724	CC02	20005	PMTIL	BRICK	ICPS	GRITTY BACKED	
V3725	CC02	17038	PMTIL	BRICK	TS; ICPS	STRAW BACKED	A
V3727	CC02	17010	PMTIL	BRICK	ICPS	GRITTY BACKED	A
V3728	CC02	U/S TR17	PMTIL	BRICK	ICPS	SLOPPED INTO MOULD; LARGE ANIMAL PAW PRINT	
V3729	CC02	20009	PMTIL	BRICK	TS; ICPS	SLOPPED INTO MOULD	A
V3739	CROFT ENVIRONS KILN NORTH	U/S		FLAT	TS;ICPS	SMALL ANIMAL PRINTS	
V3740	CROFT ENVIRONS KILN NORTH	U/S		FLAT	ICPS		
V3741	CROFT ENVIRONS KILN NORTH	U/S		FLAT	ICPS		
V3742	CROFT ENVIRONS KILN NORTH	U/S		FLAT	ICPS		
V3743	CROFT ENVIRONS KILN NORTH	U/S		FLAT	ICPS		
V3744	CROFT ENVIRONS KILN NORTH	U/S		FLAT	ICPS		
V3745	CC03	U/S T13	HERA10	RIDGE	TS;ICPS	LARGE UNGLAZED	HERA10
V3746	CC04	20011	HERA10	RIDGE	ICPS	LARGE UNGLAZED	HERA10
V3747	CC03	13026	HERA10	RIDGE	ICPS	LARGE UNGLAZED	HERA10
V3748	CC02	19003	HERA10	RIDGE	ICPS	LARGE UNGLAZED	HERA10
V3749	CC02	17007	HERA10	RIDGE	ICPS	LARGE UNGLAZED	HERA10
V3750	CC02	16003	HERA10	RIDGE	ICPS	LARGE UNGLAZED	HERA10

V3757	CC03	U/S T31	PMTIL	FLAT	TS;ICPS	NIB AT MIDDLE TOP, PART OF MOULD; 35 BY 6 THICK BY 11 ABOVE TILE	HERA10
V3758	CC02	19001	PMTIL	FLAT	ICPS	NIB AT MIDDLE TOP, PART OF MOULD	HERA10
V3759	CC04	29041	PMTIL	FLAT	ICPS	NIB AT MIDDLE TOP, PART OF MOULD; 35 BY 8 THICK BY 8 ABOVE TILE	HERA10
V3760	CC04	U/S TR39	PMTIL	FLAT	ICPS	NIB AT MIDDLE TOP, PART OF MOULD; 40 BY 16 THICK BY 8 ABOVE TILE	HERA10
V3761	CC02	19003	PMTIL	FLAT	ICPS	NIB AT MIDDLE TOP, PART OF MOULD; 47 BY 17 THICK BY 17 ABOVE TILE	HERA10
V3762	CC03	13026	PMTIL	FLAT	ICPS	NIB AT MIDDLE TOP, PART OF MOULD; 34 BY 10 THICK BY 8 ABOVE TILE	HERA10
V3763	CC02	U/S TR13	PMTIL	RIDGE	TS;ICPS	LARGE GLAZED	HERA7D?
V3764	CC03	13026	PMTIL	RIDGE	ICPS	LARGE GLAZED	HERA7D?
V3765	CC04	40003	PMTIL	RIDGE	ICPS	LARGE GLAZED	HERA7D?
V3766	CC02	16002	PMTIL	RIDGE	ICPS	LARGE GLAZED	HERA7D?
V3767	CC03	U/S TR27	PMTIL	RIDGE	ICPS	LARGE GLAZED	HERA7D?
V3768	CC03	29025	PMTIL	RIDGE	TS;ICPS	WHITE SLIP UNDER CU GLAZE	HERA5
V3769	CC03	29041	PMTIL	FLAT	TS;ICPS	SQUARE PEG HOLE 9 BY 9 TOP; 5 BY 5 BACK; ONE HOLE IN TOP CENTRE? POSS 165 WIDE	HERA10?
V3770	CC02	16012	PMTIL	HIP	TS;ICPS	TOP 85; TWO HOLES 23 DIA VERT FROM MIDDLE TOP	HERA10?
V3771	CC04	U/S TR40	HERB5	RIDGE	ICPS		HERB5

The results indicate the presence of material from the Malvern area; the North Herefordshire potteries, based in Lingen Forest; and unknown sources in central or north Herefordshire. However, the majority of the brick and flat tile, as well as some of the ridge tiles, were probably produced on the Croft estate. The sites of two brickworks are known and samples were collected from these, analysed and compared with the excavated material.

Methodology

Thin sections were produced by Steve Caldwell, University of Manchester, and stained using Dickson's method (Dickson 1965). The sections were then examined and compared with those prepared for the author's postgraduate research (Vince 1984),

some of which were described in print as part of the Hereford City Excavations publications (Vince 1985).

Samples for chemical analysis were cut from each object and the outer surfaces removed mechanically. The resulting core was then crushed to a fine powder and submitted for analysis at Royal Holloway College, London, using Inductively-Coupled Plasma Spectroscopy (ICP-AES). The ICPS data consists of the frequency of a range of major elements (App 1) and minor elements (App 2).

The frequency of silica was estimated by subtraction of the total major element counts from 100%. The data was then normalised to aluminium and analysed using the WinSTAT® for Excel add-in (Fitch 2001). The Croft data were analysed both on their own, to establish whether the various groups of samples were made from chemically-distinguishable materials, and alongside samples from other sources.

Description

Medieval ceramic building material

A small quantity of ceramic building material dating to the 13th to 16th centuries was present in the excavations. It consists of glazed ridge tiles and plain-glazed and slip-decorated floor tiles.

Samples were taken of two ridge tiles, one of which contains a fine siltstone/sandstone sand temper (Hereford A5) and is decorated with white slip under a copper-mottled green glaze (V3768, from Trench 29 [29025]) whilst the other is a late Malvern Chase product (HERB5), and four floor tiles. The floor tiles include two mid/late 15th-century Malvern School slip-decorated tiles similar to those which are now relaid in Croft (V3705, Trench 13 [US] and V3707, Trench 13 [13020]), a plain tile of similar fabric and size to the Malvern School tiles (V3708, Trench 13 [13020]), and two worn examples of Bredon-type floor tiles (Hereford A9), both plain. One had a dark green glazed (V3706, from Trench 17 [17016]) and the other a white slip (V3704, from Trench 45 [45005].

Chemical analyses for comparison with these samples are not numerous, but include two groups of floor tiles from Abbey Dore (Vince 1997), one of which is a calcareous fabric used to produced relief tiles, probably made close to the abbey, and the other is a group of Bredon-type tiles, of early 14th-century date (Vince and Wilmott 1991); a single sample of a Bredon-type tile from Leominster; and two samples of Great Malvern tiles from the Lady Chapel at Gloucester Cathedral. The latter were probably one of the latest pavements to be made by the Great Malvern tiles and the pavement includes no tiles stamped with dies used on mid/late 15th century pavements, either made at Great Malvern or one of the temporary kilns set up the tilers at Monmouth or Lenton Priory, Nottingham. The remaining comparanda consist of samples of floor tiles from

Tewkesbury abbey, which are either of local origin (Fabric 1) or from the Worcester area (Droitwich-type and Canynges-type tiles).

Thin Section Analysis

Thin sections were produced of the three Malvern School tiles and the Hereford A5 ridge tile

Malvern School Floor Tiles

All three sampled tiles have a similar appearance in thin section. The following inclusion types were noted:

- Rounded quartz. Sparse rounded grains up to 0.5mm across.
- Mudstone. Moderate to abundant inclusionless pellets up to 0.5mm across.
- Chert. Rare rounded grains up to 0.5mm across.
- Acid igneous rock. Sparse angular fragments, mostly coarse-grained and composed of quartz and feldspar with some heat-altered dark brown ferro-magnesian minerals (such as hornblende).
- Clay/iron Concretions. Sparse rounded concretions with a similar texture to the groundmass but either completely stained black or with a black crust and core of similar colour and texture to the groundmass.

The groundmass consists of poorly mixed lenses of optically isotropic baked clay minerals, varying in their silt content (but all containing abundant angular quartz and probably feldspar with sparse muscovite).

The rounded quartz and chert are typical of Severn Valley terrace sands, ultimately being derived from Triassic deposits in the northwest midlands. The mudstone fragments are also clearly detrital and probably come from exposures of Triassic Mercian mudstone (aka Keuper Marl) which outcrop in the Great Malvern area. The acid igneous rock fragments are derived from the Malvern Hills and the groundmass and clay/iron concretions indicate the use of a silty mudstone, probably also within the Mercian Mudstone formation.

These features are paralleled precisely with samples of floor tiles from the Great Malvern kiln, held by the British Museum (Vince 1984) and are different from the fabric of floor tiles which were probably produced alongside pottery in the Malvern Chase and from the fabric of Malvern School floor tiles from the Lady Chapel at Gloucester Cathedral, which were probably made at Great Malvern, but after an interval of up to 20 years (i.e. in the 1480s). The thin sections therefore indicate that the Croft tiles were produced at Great Malvern during the main period of use of the tilery, i.e. the 1450s-60s.

Hereford A5 Ridge Tile

The following inclusion types were noted in thin section:

- Sandstone. Sparse subangular fragments of illsorted sandstone, containing quartz and amorphous grains (a greywacke), up to 0.5mm across.
- Siltstone. Moderate rounded fragments of siltstone up to 1.5mm across, containing abundant quartz, muscovite and biotite laths. Some of these grains have a dark-stained crust.
- Quartz. Sparse grains of subangular and angular monocrystalline quartz up to 0.5mm across.
- Biotite. Sparse laths of altered biotite, up to 0.4mm long. Some retain their pleiochroism in plane-polarised light.
- Calcareous grains. Sparse heat-altered grains, of subangular outline, up to 0.5mm across.
- Clay/iron concretions. Amorphous areas of dark brown to opaque staining and nodules with one or more concentric dark brown to opaque zones and a groundmass similar to that of the main fabric.

The groundmass consists of optically anisotropic baked clay minerals, abundant angular quartz, sparse muscovite and biotite.

The mixed sandstone/siltstone/limestone sand is typical of pots produced in the Middle Wye Valley around Hereford. However, biotite is not a noted element in those fabrics (Hereford A2 and A9). Hereford A5, by contrast, does not contain calcareous inclusions or siltstone. It is possible, therefore, that this tile is a rare example of a Hereford A9 ridge tile, produced alongside the Hereford A9 floor tiles, examples of which have been found at Croft.

Chemical analysis

Factor analysis of the medieval tile samples from Croft found six significant factors. A plot of F1 against F2 separated the Malvern School floor tiles and HERB5 ridge tile and, less clearly, the Hereford A5 ridge tile from the remainder but failed to separate the remaining samples (Fig 1). A plot of F3 against F4 (Fig 2) separated the HERB5 sample from the remainder but again did not distinguish the Bredon-type floor tiles from the local brick and tile samples.

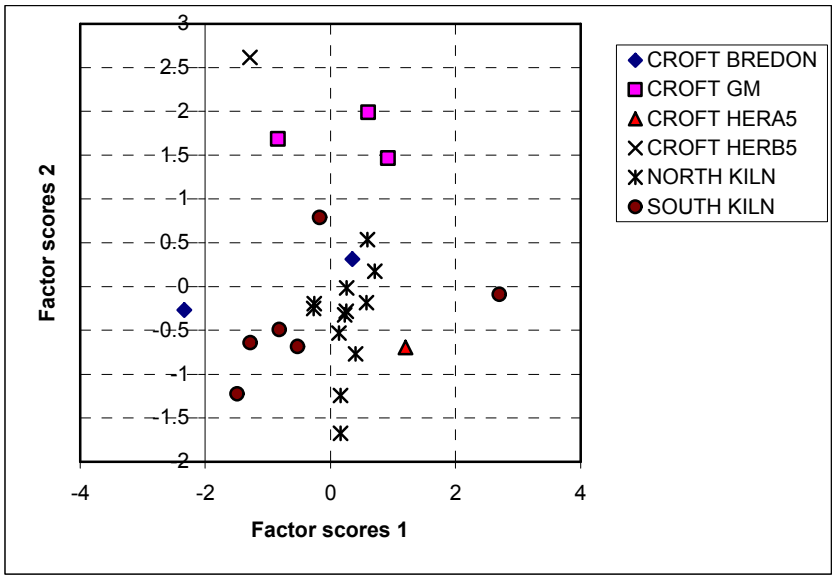

Figure 1

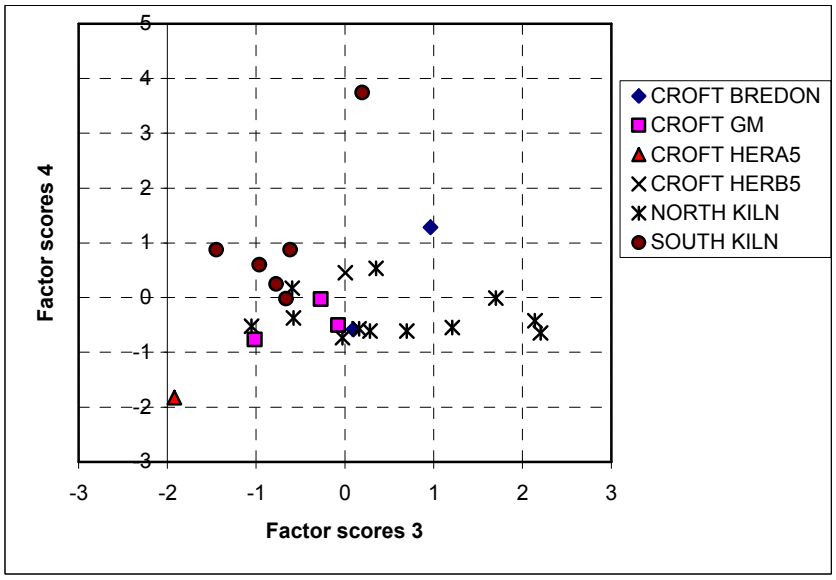

Figure 2

The plot of two remaining factors (not illustrated) distinguishes the Hereford A5 ridge tile but not the remaining samples.

The data were then amalgamated with the comparanda and another factor analysis carried out. This analysis found four significant factors. A plot of the first against the second factor (Fig 3) clearly separated the Abbey Dore relief tiles from the remainder whilst the remaining samples formed a large cluster, with the Hereford A5 sample as an outlier.

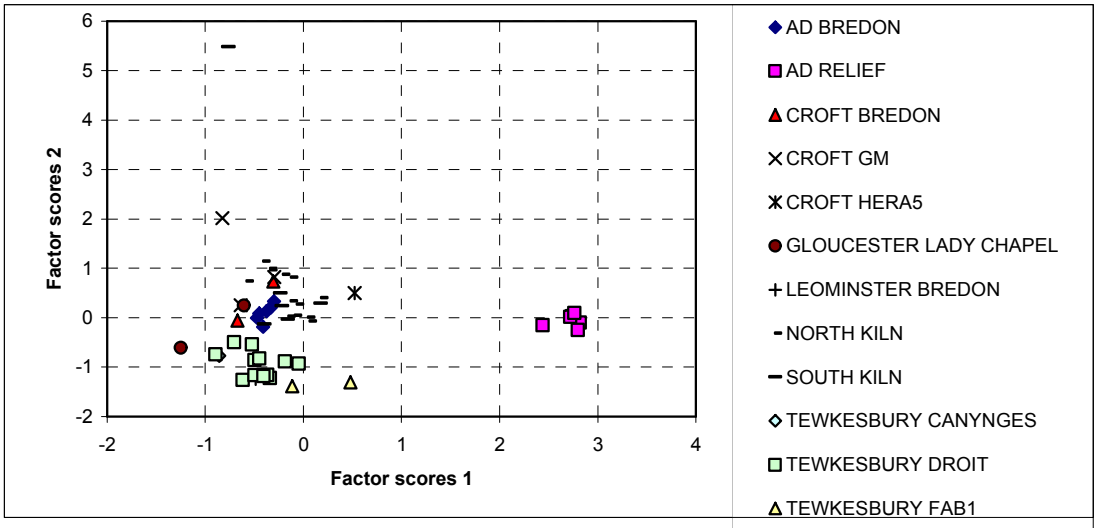

Figure 3

A plot of the third and fourth factors (Fig 4) shows the three Croft Malvern School tiles, the HERB5 ridge tile and the Gloucester Cathedral tiles all have high F3 scores, but that the Gloucester samples also have high F4 scores.

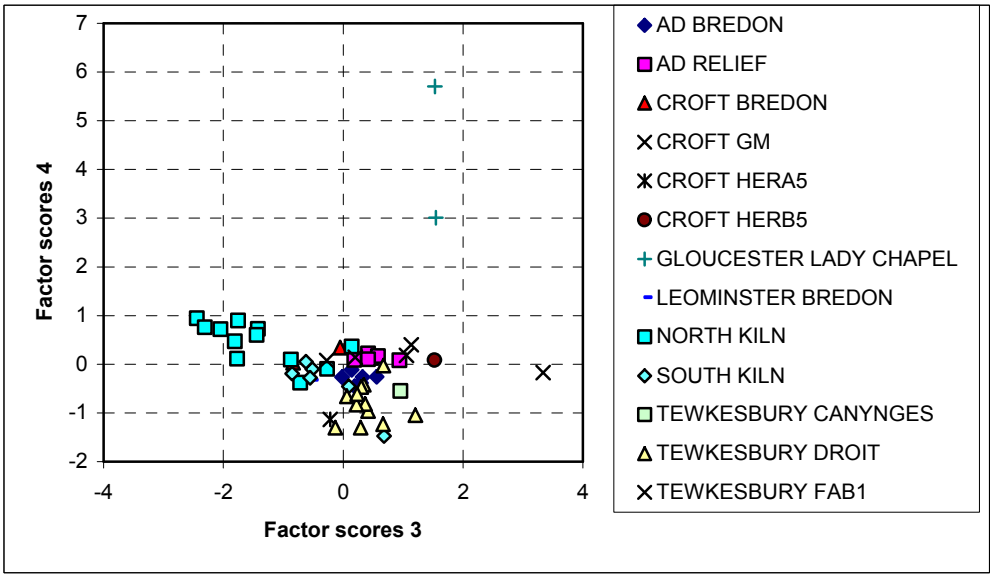

Figure 4

The consequence of including fabric groups with very different chemical compositions is that the groups which have more similar compositions are pushed together and elements which might distinguish them are given low weightings. Therefore, the analysis was repeated excluding those samples which were clearly distinguished in the preceding study (the Gloucester and Croft Malvern School tiles, the HERB5 ridge tile and the relief tiles from Abbey Dore). Factor analysis of this dataset produced five factors but only the two first factors distinguish any of the groups. A plot of these two factors separates the Tewkesbury samples from the remainder but fails to separate the different groups of

Bredon-type tiles from the Croft post-medieval brick and tile kiln samples, although within this general Herefordshire cluster individual groups do form discrete clusters, so that the two Croft brick kilns can be distinguished, as can the Abbey Dore Bredon-type tiles. The fact that within this cluster the two Croft Bredon-type tiles plot at some distance is probably not significant, since similar differences exist between the samples from the two brick kilns.

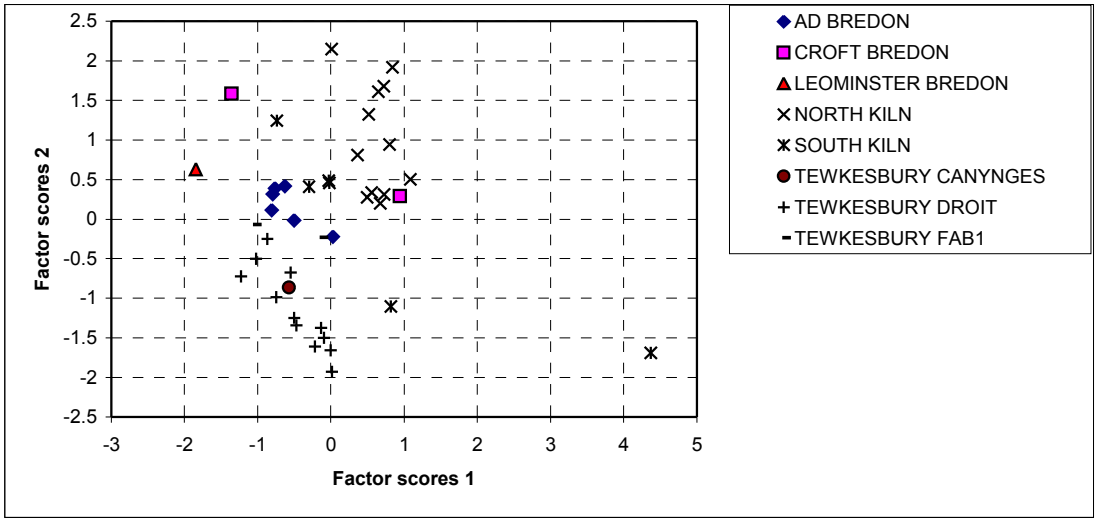

Figure 5

Post-Medieval ceramic building material

The post-medieval samples from Croft consist of bricks and flat roof tiles from the North brick kiln; bricks from the south brick kiln; bricks of varying types, including one moulded brick from a window mullion; a peg tile; a hip tile; nibbed tiles; glazed thick ridge tiles, probably of Hereford A7D and made in the North Herefordshire potteries in the Lingen forest; and a group of large thick unglazed ridge tiles (or, conceivably some sort of garden furniture, such as a rhubarb forcer). Finally, a sample of burnt clay or daub from the excavation was analysed.

There is as yet no useful comparanda from other sites, such as the various North Herefordshire potteries.

Thin Section Analysis

Eleven thin sections were produced. All have a similar range of inclusions but differences in texture allow two main fabrics to be identified together with three unique sections.

The main fabric, Fabric 1, includes samples of the hip tiles, peg tiles and nib tiles (from the excavations and from the north kiln) as well as a sample of the large unglazed ridge tiles.

Fabric 2 includes samples of bricks from the north and south kilns and one of the bricks from the excavations (that which appears to have been made by the slop-moulding technique.

The ungrouped samples consist of a brick from the excavations made in a straw-lined mould; the mullion and a brick made in a coarse sand-lined mould.

Fabric 1

The following inclusion types were noted:

- Siltstone/mudstone. Sparse angular to subangular fragments of siltstone and mudstone up to 1.5mm across. The texture of these fragments forms a continuum from clay-rich to quartz-rich fragments. Quartz and muscovite up to 0.1mm across are the main constituents of the siltier examples and bedding is visible in the fragments, sometimes separating layers of different texture.
- Quartz. Sparse subangular and angular monocrystalline grains up to 0.3mm across.
- Clay/iron concretions. Sparse diffuse areas of dark brown to opaque staining and discrete nodules with one or more dark brown to opaque concentric zones surrounding a silty groundmass, similar to that of the main fabric.
- Sandstone. Sparse fragments of ill-sorted sandstone, up to 0.5mm across, containing quartz grains up to 0.3mm across.

The groundmass consists of poorly mixed lenses of optically anisotropic baked clay minerals, abundant angular quartz, sparse muscovite and dark brown clay pellets, all less than 0.1mm across.

It is likely that the clay was mainly derived from the erosion of a deposit of fine-grained sedimentary rock containing beds of siltstone and mudstone. The clay/iron concretions probably formed within the mudstone. The sparse sandstone and quartz grains probably both originated in a sandstone. It is also likely that the mixing of these three constituents (mudstone, siltstone, sandstone) took place naturally and that the parent clay is either a colluvial deposit derived from the erosion of local rocks or, possibly, a till derived from further afield.

Croft Castle is situated on outcrops of Silurian siltstone and mudstones also occur within the Silurian outcrop. However, the coarser sandstone is probably of younger age, from the Old Red Sandstone (Earp and Hains 1971, 58-81) and there are micaceous siltstones and silty mudstones in the Old Red Sandstone.

Fabric 2

The following inclusion types were noted:

- Siltstone. As in Fabric 1

- Mudstone. Finer than in Fabric 1, often with no visible inclusions.
- Biotite. Moderate laths up to 0.5mm long.
- Clay/Iron concretions. As in Fabric 1.
- Quartz. Moderate subangular grains up to 0.4mm across. A few are polycrystalline with undulose extinction (metamorphic origin).

The groundmass is poorly mixed and has lenses of almost inclusionless clay and lenses containing the subangular quartz laths and biotite laths. The sample from the north kiln is more similar to fabric 1.

Since Fabric 2 was being produced on the same sites as Fabric 1 (the north and south brick kiln complexes) it is tempting to interpret the differences between the fabrics as being due to differences in preparation of the same clay. However, this does not seem to be the case. The correlation of fine mudstone and the coarser micaceous sand suggests that the two rocks outcrop together, probably being interleaved. This might suggest a deltaic environment, which would favour a Silurian source.

Fabric 3 (mullion)

The following inclusion types were noted:

- Clay pellets. Abundant rounded pellets, similar in texture to the groundmass but including both lighter and darker examples, up to 2.0mm across.

The groundmass consists of optically anisotropic baked clay minerals, abundant angular quartz silt and dark brown clay pellets, up to 0.1mm across. The texture is finer than Fabric 1 and micas are rare or absent. Nevertheless, the general character of the fabric suggests a local source.

Fabric 4 (strawed brick)

The following inclusion types were noted:

- Mudstone. As in Fabric 2
- Biotite. As in Fabric 2
- Quartz. Subangular grains, mostly along one edge and derived from the moulding sand.
- Micaceous sandstone. Sparse subangular and rounded fragments with subangular quartz up to 0.2mm across, muscovite and biotite laths up to 0.3mm long and an amorphous light brown to opaque matrix.

The similarity of this fabric to Fabric 2 suggests that they probably have the same origin but that the batch of clay from which this brick was made contained micaceous

sandstone, lacking in Fabric 2. Micaceous sandstones are present in both the Silurian and Old Red Sandstones of North Herefordshire. It is noteworthy that the thin section demonstrates the use of a moulding sand alongside the straw noted by eye.

Fabric 5 (sanded brick)

The following inclusion types were noted:

- Clay pellets. Rounded pellets up to 1.0mm across.
- Quartz. Subangular monocrystalline unstrained grains up to 0.5mm across.
- Mudstone. Rounded inclusionless pellets up to 1.0mm across.
- Sandstone. Moderate rounded fragments including one 5.0mm across. The sandstone contains quartz, muscovite and amorphous grains in a dark brown to opaque groundmass.
- Muscovite. Sparse laths up to 0.3mm long.
- Siltstone. Sparse rounded fragments up to 1.5mm across.
- Voids. Sparse rounded voids up to 1.5mm across.

The groundmass consists of poorly mixed lenses of optically isotropic baked clay minerals, subangular quartz, dark brown clay pellets, varying in texture but generally coarser than in Fabrics 1 to 4.

The range of inclusions present is consistent with a north Herefordshire origin, but the dissimilarity in texture points to a separate source, either somewhere else on the Croft estate or elsewhere.

Chemical Analysis

Estimated silica content for these samples varies from 64.2% to 78.5%. There is a trend for the bricks to have more silica than the roof tiles (Fig 5) but there is considerable overlap and the moulded window mullion has a silica content comparable with that of the roof tiles rather than the other bricks.

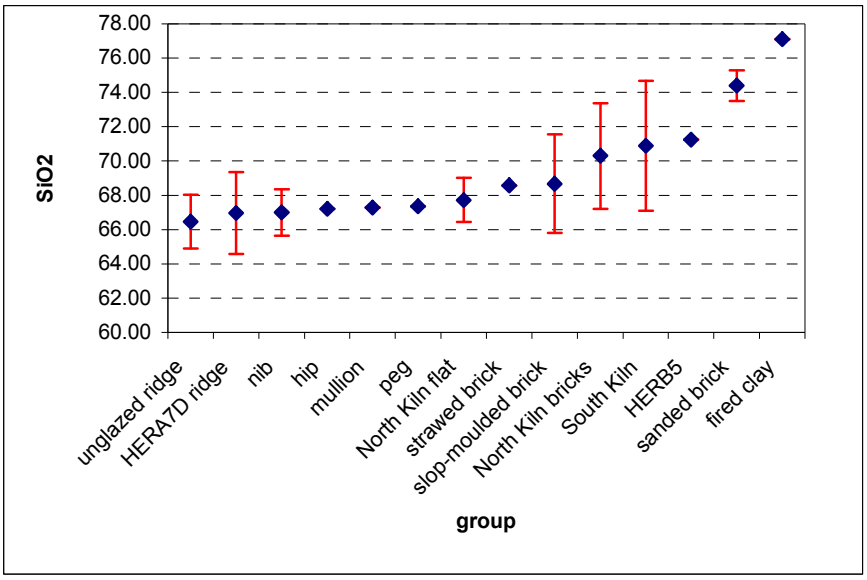

Figure 6

The difference between silica content may be due to the levigation of the clay before use.

Factor analysis was carried out on the normalised ICPS data (omitting calcium and phosphorus) and four significant factors were found.

A plot of F1 against F2 (Fig 6) reveals a single large cluster. Within this cluster, the samples form groups and it is possible to extract information about the similarity of the different sample groups:

a) the north and south kiln brick samples can be separated by their F2 scores.

b) there is a difference in composition between the tiles and bricks from the north kiln, reflected in their mean F2 scores, which are higher for the bricks.

c) the moulded mullion plots with the North kiln samples

d) the two bricks made in sanded moulds are more similar to the South kiln samples, as are the three slop-moulded bricks and the brick made in a strawed mould

e) the nibbed flat roof tiles, the peg tile and the hip tile all have similar chemical compositions and are all similar to the North kiln samples

f) the unglazed ridge tiles all have a similar and compare well with the North kiln.

g) the glazed ridge tiles include four which are not similar to either kiln whilst two are more similar to the north kiln.

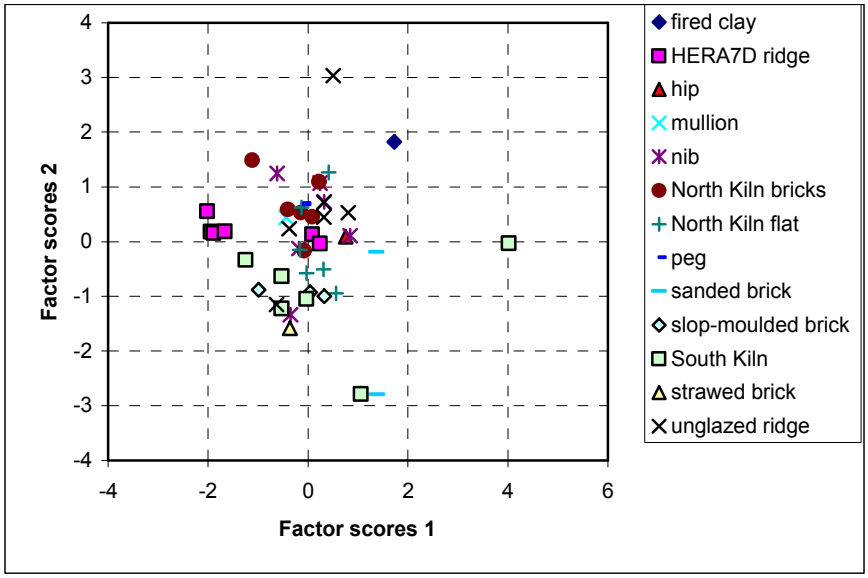

Figure 7

A plot of the third against the fourth factor (Fig 7) does not separate the two kilns, although the north kiln flat tiles have negative F3 scores whilst the bricks from both sites have positive F3 scores. Nevertheless, it is still possible to determine the similarity of the various groups to the three groups of kiln waste:

a) The moulded mullion plots with the North kiln bricks

b) The sanded bricks have higher F4 scores than the two kilns and are comparable with the HERA7D ridge tiles.

c) The slop-moulded bricks and the straw-moulded have a similar composition to both the north and south kilns

d) The peg tile, nibbed tiles and hip tile all have a similar composition to the north kiln flat tiles

e) The unglazed ridge tiles have a similar composition to the North kiln flat tiles

f) The glazed HERA7D ridge tiles have higher F4 scores than either of the two groups of kiln samples.

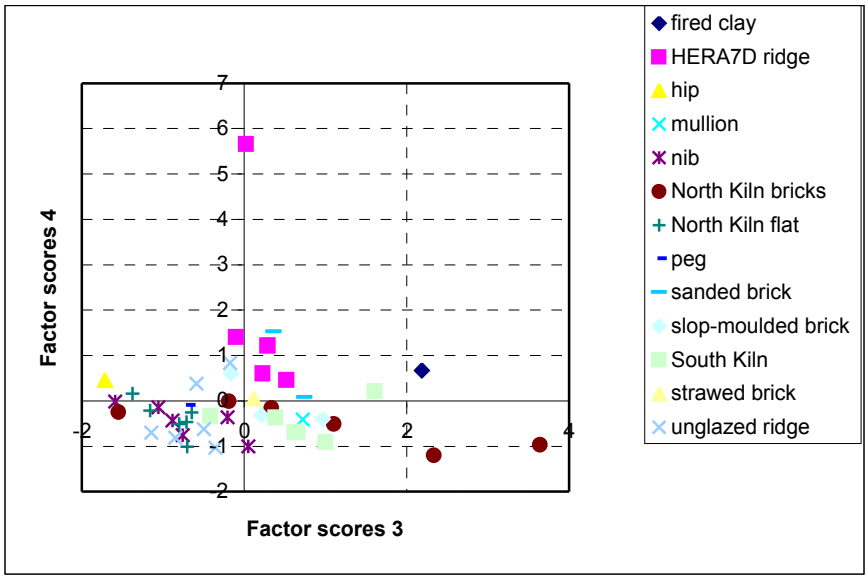

Figure 8

Combining the conclusions drawn from the two figures, it is probable that the HERA7D tiles were not made on the estate but that all the other types were. If we could assume that there were only ever the two kilns and that the samples adequately represented the composition of all of their products (both dubious assumptions), then we could say that the roof furniture (nib and peg tiles, hip tile and unglazed ridge tiles) was produced in the north kiln as was the mullion. The slop-moulded and straw-moulded brick samples may have been produced in the south kiln but the sanded bricks are not precisely matched by either kiln.

Conclusions

The medieval tile samples indicate that the decorated tile floor relaid in Croft Church is a product of the Great Malvern tilery and was therefore probably produced at a similar time to the pavements at Great Malvern and Abbot Sebroke's pavement at Gloucester Cathedral, in the 1450s or 1460s. The samples also confirm that the Gloucester Cathedral Lady Chapel pavement, although a Mavernian product, was probably not made in the same tilery, or at least a different clay pit was utilised.

The 14th-century Bredon-type tile is similar to a sample from Leominster Priory but not to those found at Abbey Dore. This suggests that the this industry, like the later Great Malvern one, sometimes supplied tiles from a central tilery and sometimes set up a temporary tilery at the site where the tiles were to be used. The Croft tile was probably at the same, unknown, production site which supplied the pavements at Ludlow, Leominster, Hereford and Bredon (Vince and Wilmott 1991).

The sample of white-slipped ridge tile does not match the published definition of Hereford Fabric A5 and although it may be a product of the Bredon-type industry the chemical

analysis suggests that it is from a different source from any samples so-far analysed from Herefordshire.

The analysis of the post-medieval tiles indicates that a variable clay source was used at the north and south brick kiln complexes. There is no petrological difference between the products of the two centres and using petrological evidence we can assign most of the sampled unglazed post-medieval ceramic building material to the Croft Estate. These include both flat roof tiles with nibs and those with pegholes, hip tiles and large unglazed ridge tiles. They also include bricks made using the slop-moulding technique as well as those made in a straw-lined mould.

Only one sample, a brick made in a sanded mould, is sufficiently different to suggest that it was made elsewhere, and the chemical analysis suggests that it is similar to the Croft products. The chemical analysis indicates differences between the north and south kiln samples, but does not seem to separate the coarser fabrics (Fabric 2 and 4) from the finer ones (Fabrics 1 and 3). The mullion, the one brick sample for which a late 16th or 17th-century origin is certain, has a fabric which distinguishes it from the north and south kilns, but which is probably a fine variant of Fabric 1.

Finally, the glazed ridge tiles, also made from a fine, micaceous red earthenware fabric are chemically distinct from the Croft products and were probably made alongside pottery vessels in the Lingen forest potteries.

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Appendix 1

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V3704	16.81	5.81	2.38	0.46	1.03	2.58	0.91	0.15	0.061
V3705	13.93	5.87	2.85	2.72	0.82	3.08	0.72	0.09	0.065
V3706	16.14	6.54	2.64	0.81	1.14	3.39	0.81	0.33	0.082
V3707	14.06	5.88	3.27	1.44	0.79	3.07	0.73	0.1	0.099
V3708	12.49	4.94	2.8	3.76	0.74	2.86	0.64	0.17	0.081
V3709	11.87	4.44	1.85	0.45	1.24	2.04	0.7	0.19	0.12
V3710	16.52	7.84	2.19	0.31	1.21	2.66	0.84	0.08	0.098
V3711	16.3	6.24	1.98	0.31	1.25	2.56	0.93	0.09	0.112
V3712	16.78	6.4	2.3	0.31	1.33	2.56	0.88	0.06	0.203
V3713	17.1	6.71	1.82	0.27	1.19	2.65	0.92	0.09	0.065
V3714	10.59	3.44	1.48	0.49	2.25	2.11	0.78	0.24	0.136
V3715	16.42	6.58	1.81	0.27	1.21	2.59	0.9	0.09	0.163
V3716	20.22	7.84	2.12	0.46	0.58	3.22	1.06	0.04	0.035
V3717	14.23	6.27	1.63	0.3	0.9	2.83	0.75	0.12	0.066
V3718	15.67	7.03	1.71	0.29	0.88	3.19	0.87	0.06	0.083
V3719	14.71	6.1	1.61	0.39	0.9	2.85	0.8	0.12	0.07
V3720	16.51	6.1	1.88	0.42	0.83	2.88	0.91	0.05	0.055
V3721	15.82	5.49	1.68	0.44	0.87	3.18	0.86	0.21	0.068
V3722	16.59	7.94	2.16	0.65	0.74	3.56	0.87	0.11	0.091
V3723	16.18	5.94	2.29	0.38	1.25	2.73	0.93	0.09	0.082
V3724	13.89	5.01	1.83	0.6	1.59	2.33	0.81	0.11	0.073
V3725	16.45	7.26	2.42	0.36	1.1	2.78	0.85	0.08	0.121
V3727	13.05	5.22	1.74	0.37	1.31	2.18	0.77	0.1	0.231
V3728	19.02	7.16	2.56	0.4	1.21	3.15	0.96	0.07	0.098
V3729	15.7	6.3	2.09	0.38	1.34	2.47	0.9	0.14	0.14
V3739	16.47	7.1	1.85	0.31	0.69	3.13	0.86	0.04	0.038
V3740	16.33	7.55	1.89	0.3	0.72	3.32	0.86	0.04	0.054
V3741	17.66	7.34	1.88	0.38	0.77	3.36	0.9	0.04	0.034
V3742	17.66	7.45	2.03	0.33	0.64	3.44	0.94	0.04	0.039
V3743	17.7	8.53	1.96	0.29	0.74	3.51	0.92	0.04	0.052
V3744	18.89	7.27	2.07	0.49	0.56	3.06	0.99	0.04	0.038
V3745	18.73	8.65	1.98	0.56	0.56	3.02	0.95	0.07	0.057
V3746	18.31	7.08	1.95	0.37	0.75	3.02	0.99	0.06	0.05
V3747	17.73	6.48	1.94	0.42	0.73	3.03	0.96	0.04	0.033
V3748	19.14	7.94	2.72	0.39	1.19	3.37	0.93	0.07	0.096
V3749	19	7.38	1.95	0.47	0.69	3.14	1.01	0.05	0.047
V3750	18.05	7.6	1.89	0.32	0.82	3.38	0.91	0.04	0.034
V3757	17.39	7.5	1.87	0.53	0.66	3.37	0.87	0.02	0.033
V3758	18.34	7.77	1.97	0.79	0.68	3.07	0.98	0.06	0.059
V3759	19.2	7.66	2.07	0.54	0.57	3.14	1	0.03	0.051
V3760	18.18	7.13	2.4	0.37	1.35	3.03	0.9	0.09	0.078
V3761	18.67	7.34	2.02	0.35	0.74	3.47	0.98	0.03	0.035
V3762	18.03	5.66	1.82	0.37	0.65	3.05	0.97	0.03	0.029

V3763	17.35	7.71	2.44	0.31	1.02	3.28	0.84	0.18	0.04
V3764	17.7	7.32	2.62	0.36	1.08	3.61	0.87	0.04	0.033
V3765	17.9	7.89	2.73	0.34	1.05	3.55	0.87	0.1	0.033
V3766	15.23	5.88	1.94	0.49	1.58	2.77	0.86	0.15	0.059
V3767	18.06	8.07	2.87	0.33	1.03	3.57	0.89	0.08	0.044
V3768	16.46	5.45	2.16	1.01	1.34	2.83	0.82	0.25	0.062
V3769	17.9	7.23	2.12	0.3	0.74	3.31	0.98	0.03	0.032
V3770	18.41	6.65	2.21	0.37	0.69	3.34	1.04	0.03	0.041
V3771	14.2	5.52	3.51	0.37	0.65	3.52	0.79	0.11	0.089

Appendix 2

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V3704	412	137	29	48	61	15	65	96	17	91	41	74	41	7	1	3	2	206	81	19
V3705	446	102	33	68	38	13	101	78	18	52	37	71	38	7	1	4	2	151	80	20
V3706	496	119	31	50	64	15	95	81	30	90	48	95	50	10	2	5	3	86	85	19
V3707	441	98	30	70	47	13	92	74	26	67	43	84	45	10	1	5	2	95	83	21
V3708	487	86	64	57	40	11	320	63	22	58	37	91	39	9	1	4	2	1,013	86	18
V3709	378	88	25	37	40	11	61	68	33	151	42	81	45	9	2	6	3	51	69	15
V3710	452	113	26	42	47	16	69	89	21	93	49	91	50	9	1	4	2	29	85	18
V3711	461	118	30	47	50	16	63	97	22	93	45	87	46	9	1	4	2	24	82	19
V3712	519	119	37	52	48	17	68	108	22	67	47	96	50	10	2	6	2	46	84	28
V3713	464	116	36	43	51	16	59	92	23	104	37	74	38	8	1	4	3	24	89	18
V3714	398	84	16	23	32	10	85	48	20	75	46	102	48	10	1	5	2	22	51	13
V3715	476	119	30	46	51	16	59	98	21	98	37	74	40	7	1	5	3	19	87	19
V3716	421	196	17	49	94	19	54	105	40	185	56	109	58	12	2	6	4	43	81	24
V3717	418	108	63	32	45	13	49	81	24	106	43	80	44	8	1	4	3	22	95	15
V3718	402	112	19	44	49	14	56	82	25	84	48	92	49	9	1	4	2	30	71	18
V3719	463	107	47	29	46	13	56	82	25	88	48	90	49	9	1	4	2	27	82	16
V3720	405	143	18	39	69	15	55	79	34	159	50	101	52	10	2	5	3	38	74	20
V3721	491	116	33	36	48	15	60	89	31	113	49	92	51	10	2	5	3	19	84	19
V3722	631	120	24	36	60	16	65	103	30	98	48	90	50	10	2	5	3	20	84	17
V3723	437	120	33	52	50	17	72	89	24	72	45	86	46	10	1	4	2	31	80	20
V3724	620	121	22	55	42	13	84	82	30	54	42	79	44	10	2	5	3	55	78	19
V3725	491	113	30	50	47	17	69	103	19	67	43	83	44	8	1	4	2	46	86	21
V3727	413	91	25	42	38	11	65	78	13	45	36	73	38	7	1	5	2	46	71	23
V3728	568	119	32	54	50	18	77	108	26	103	46	91	47	9	1	5	3	40	89	21
V3729	463	104	30	43	44	14	71	84	22	82	43	79	45	8	1	5	2	37	78	19
V3739	359	124	17	47	68	16	55	108	27	90	49	97	51	11	2	5	3	57	69	24
V3740	369	118	16	40	67	16	54	101	27	93	50	101	52	11	2	5	3	35	69	21
V3741	360	108	18	40	60	17	57	97	31	120	51	104	53	11	2	5	3	61	66	24
V3742	372	148	17	39	69	17	52	91	32	149	51	104	53	11	2	5	3	38	71	21
V3743	392	150	17	41	69	17	58	103	30	104	50	101	52	11	2	5	3	32	70	21
V3744	394	180	17	51	86	18	51	80	42	172	59	119	61	13	2	6	4	30	75	21
V3745	414	137	17	53	79	18	53	86	42	146	67	126	69	14	2	7	4	38	75	22
V3746	390	122	20	51	72	17	56	90	37	197	59	120	61	13	2	6	3	27	74	20

V3747	5,817	151	19	47	74	17	173	81	52	171	58	115	60	13	2	6	5	56	71	21
V3748	604	131	27	64	59	19	85	116	27	66	46	89	48	10	2	5	3	35	91	22
V3749	399	125	17	50	76	18	58	93	38	174	62	123	64	13	2	6	3	32	75	20
V3750	386	110	16	42	59	17	58	91	34	149	51	108	53	11	2	5	3	35	66	20
V3757	354	112	17	37	61	17	71	87	39	195	49	104	51	11	2	5	4	29	65	19
V3758	400	166	18	49	77	18	59	88	38	185	57	118	59	12	2	6	4	38	77	23
V3759	401	158	18	48	84	17	52	85	41	174	61	116	64	13	2	7	4	33	76	21
V3760	520	115	27	50	49	17	84	99	22	60	49	88	50	11	2	5	2	34	84	21
V3761	370	130	19	41	69	17	56	98	33	146	51	102	53	11	2	5	3	42	70	25
V3762	366	154	17	51	70	18	52	86	33	136	61	118	62	13	2	5	3	34	67	20
V3763	465	136	26	51	61	17	68	93	19	117	40	70	41	6	1	3	3	106	88	18
V3764	483	140	26	58	60	16	82	103	18	94	41	71	41	6	1	3	2	137	88	17
V3765	473	143	27	60	60	17	79	97	19	124	41	77	41	6	1	3	3	102	89	16
V3766	579	112	23	46	48	14	89	76	25	64	44	83	45	10	1	4	3	67	74	17
V3767	476	144	27	62	61	18	79	101	20	129	42	78	42	6	1	3	3	46	90	20
V3768	822	115	24	54	45	16	97	83	42	90	51	99	54	12	2	7	3	54	81	15
V3769	381	151	17	41	71	17	54	88	33	154	52	106	54	11	2	5	3	29	72	20
V3770	416	179	17	46	85	18	53	99	33	135	56	109	58	13	2	5	3	40	76	24
V3771	569	102	21	79	36	13	72	75	17	43	36	67	37	7	1	4	2	75	87	20