Further characterisation studies of pottery and ceramic building material from Broad Street, Ely

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Following the discovery of a post-medieval pottery kiln at Broad Street, Ely, samples were analysed of light-firing bichrome ware vessels thought to be produced in the kiln together with samples of local calcareous Kimmeridge Clay, which was mooted as a possible source of the clay. In addition, three samples were taken of a clay which occurs on site and which may have been the source of red-firing earthenwares produced in the kiln.

In a second batch of samples, a sample of the lead-glazed red earthenware from the kiln, an unglazed saggar and a fragment of yellow-firing "Cambridge brick", from a site in Cambridge were submitted. The latter was analysed for comparison with the Kimmeridge Clay, which when fired did not produce a close match to any of the light-firing bichrome ware samples but was visually extremely similar to yellow bricks used throughout Cambridgeshire.

Methodology

Samples from each submitted sherd were taken for thin sectioning. This was carried out by Steve Caldwell at the University of Manchester. Each section was stained using Dickson's method ({Dickson 1965 #44803}) in order to distinguish ferroan and non-ferroan calcite from dolomitic inclusions. A subsample was then prepared for chemical analysis. The margins of the sample were mechanically removed and about 2-3gm of the remaining sample was then crushed to a fine powder and submitted to Royal Holloway College, London, where the chemical composition was determined using Inductively Coupled Plasma Spectrometry. Both atomic adsorption and mass spectrometry were utilised, ensuring that a range of both major and minor elements were measured (Appendix One).

Petrological analysis

V2231 – Saggar

The following inclusions were noted in thin section:

- Abundant rounded quartz grains up to 0.3mm across. Mostly monocrystalline with a few polycrystalline grains showing strain and incipient new crystal development. These would be ultimately derived from a metamorphic source.
- Sparse rounded calcareous inclusions, now represented by voids up to 1.0mm across. Some of these are now filled with secondary calcareous silt, presumably the local soil matrix.

- Sparse rounded opaque inclusions up to 0.2mm across.

- Angular shell inclusions, represented by voids up to 1.0mm long. One of these appears to come from a punctate brachiopod and is more likely to be fossil Jurassic shell than recent.

The groundmass consists of isotropic yellow-firing calcareous clay (in which no calcareous matter survives) with abundant quartz silt up to 0.1mm across. Black to dark brown haloes surround some rounded voids and opaque inclusions. In addition, there are amorphous patches of black and dark brown matrix.

One possible interpretation of this fabric is that it consists of a mixture of a calcareous, quartz-free clay with a silty, red-firing clay containing rounded quartz sand, such as that found in the Broad Street clay samples.

V2232 – Glazed Red Earthenware

The following inclusions were noted in thin section:

- Sparse rounded quartz grains up to 0.3mm across.

- Rare rounded calcareous grains up to 0.3mm across. These are heat-altered and filled with alteration products.

- Rounded red clay pellets containing fine angular quartz grains c.0.1mm across.

The groundmass consists of isotropic red baked clay minerals, abundant well-sorted angular quartz c.0.1mm across, sparse muscovite laths up to 0.2mm long and moderate rounded opaque grains.

This fabric is similar to that of the Broad Street clay samples but differs in some minor respects: a) it contains a lot less rounded quartz, b) the silt inclusions in the clay samples are less well sorted and include appreciably more grains less than c.0.1mm across. Since we have three separate clay sample sections and they all have these characteristics it does seem that the source of the clay cannot be the clay found on site, but it is, nevertheless, very close. The characteristics of this fabric (excluding the rounded quartz grains) are found in lower Cretaceous clays, such as the Gault clay, and it is known that the such clays outcrop at the Ely. Samples of medieval pottery made from lower Cretaceous clay were thin sectioned at Fore Street, but these, in contrast, contain glauconite grains and have a lower silt content.

V2233 – Yellow Brick

The following inclusions were noted in thin section:

- Sparse rounded quartz up to 0.5mm across. Several of these grains have a brown coating.

- Sparse amorphous opaque matter Up to 0.5mm across. This consists of irregular specks and strings of opaque matter, surrounded by a brown halo.

- Sparse rounded altered glauconite grains up to 0.3mm across. Some of these grains have a zoned structure with a darker core.

- Sparse rounded sparry non-ferroan calcite or dolomite inclusions up to 1.0mm across. It is unclear whether these are original constituents of the clay or are secondary fills in pores.

The groundmass consists of isotropic calcareous clay with very little visible quartz. Almost all the calcareous matter is now altered to a yellowish ceramic.

The moulding sand, visible along one edge of the sample, consists of angular quartz grains, between c.0.1 and 0.2mm across, with moderate rounded opaque inclusions, sparse calcareous inclusions (all heat-altered), sparse muscovite laths and sparse altered glauconite, all of similar size.

This fabric is very similar in appearance to fired samples of Kimmeridge Clay from a clay pit in Ely supplied by David Hall. It is likely that the few inclusions noted were present in the parent clay.

Chemical analysis

The data from these three samples was compared to data from previously-analysed samples from medieval production sites in Ely (Fore Street and Potters Lane) and with the bichrome ware samples from Broad Street, which analysis has shown are of three different fabrics (Bichrome 1, 2 and 3), the Broad Street clay samples, and the Kimmeridge Clay samples.

The first stage was to calculate the percentage of silica present in the sample (which was not measured by ICPS). This was estimated by subtracting the sum of the major elements (as percent oxides) from 100%. The values for the three samples are shown in Fig 1 where it can be seen that the yellow brick has a higher silica content than the Kimmeridge clay samples whilst the remaining samples have silica contexts which overlap with those of most of the Ely products and the Broad Street clay samples. Bichrome ware fabrics 1 and 2, however, both contain a higher silica content.

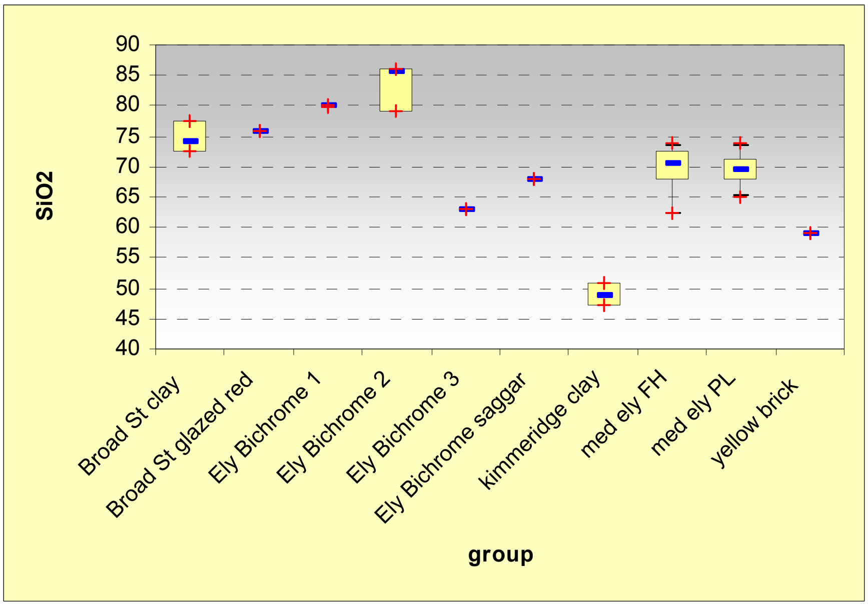

Figure 1

The data were then normalised, to take account of this difference in silica content, which may well be due to deliberate tempering. The method chosen was to divide each element's measured value by that of Al2O3.

A factor analysis was then carried out for the major elements. Two main factors were found, accounting for 33% and 18% of the variation in the dataset respectively.

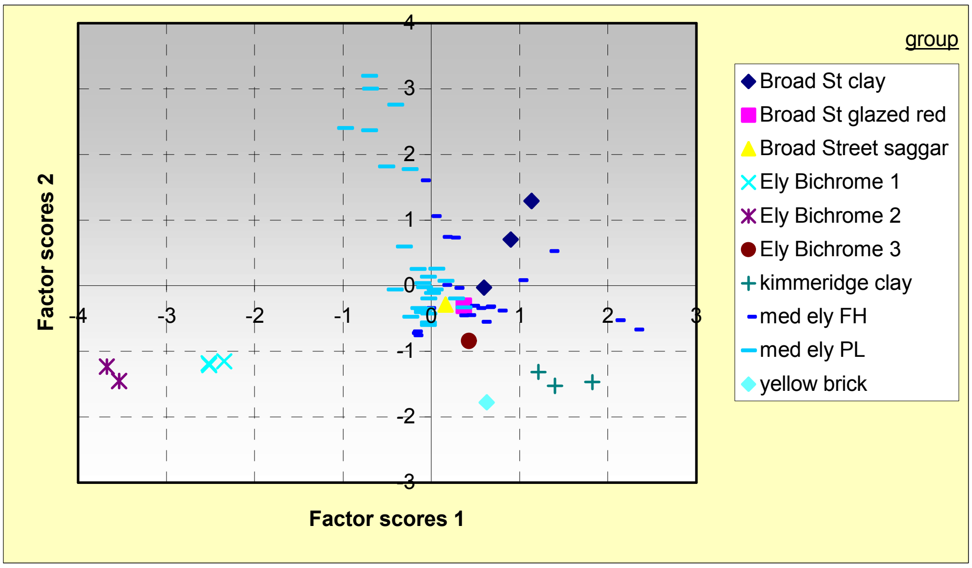

Figure 2

Fig 2 shows a bi-plot of these two factors and indicates that there are major differences in composition between two of the bichrome ware fabrics and the remainder and that the yellow brick and Kimmeridge Clay samples are both distinct in composition, both from each other and from the various Ely wares. The remaining samples, however, form a large diffuse cluster.

Re-running the factor analysis just for these Ely wares (including the Broad Street glazed red earthenware and saggar) indicates that there is difference between the Potters Lane and the remaining samples. Fig 3 shows a bi-plot from this analysis indicating that the saggar has a similar composition to samples from Fore Street but with a higher Factor 2 score than any Potters Lane samples. The glazed red earthenware sample has a composition which is found at both sites.

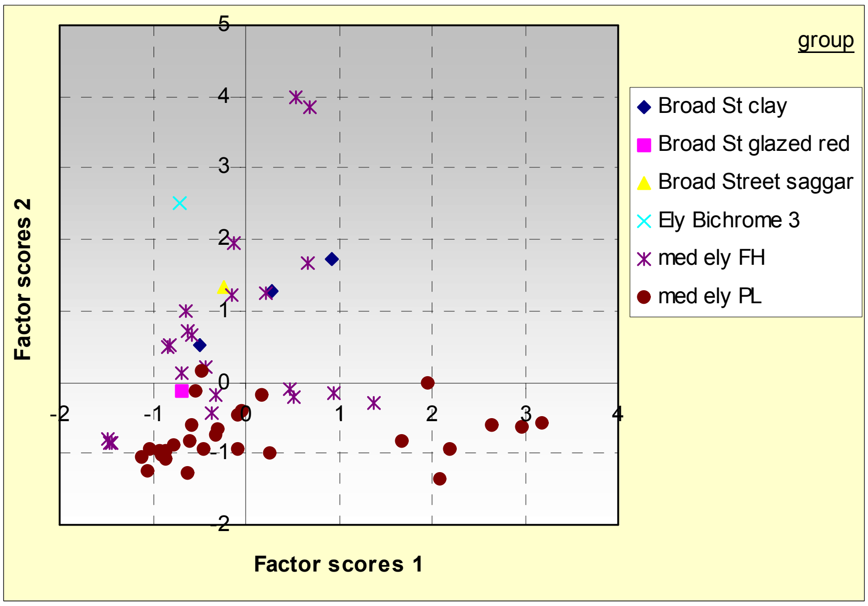

Figure 3

Discussion and Conclusions

The saggar

The interpretation of the thin section evidence is that the saggar was made from a mixture of calcareous silt-free clay, presumably the local Kimmeridge clay, and the silty, sand-tempered clay found on the site. From the factor analysis of the major elements, the composition is seen to be much closer to that of the Broad Street clay than to the Kimmeridge clay samples but when the element values are compared element by element there are a number of elements where the saggar value is either higher or lower than either of these two clays. These are shown in table 00. Clearly, the high lead content is due to contamination with lead glaze during firing. It is possible that some of the other enhanced elements are also present through glaze contamination. The Chromium and Vanadium values, however, cannot be explained in this way since they imply that the source clay (or clays) had lower values of these elements than either of the sampled clays. Furthermore, Chromium is lower in the Broad Street clay than in the Kimmeridge Clay whereas the opposite is true for Vanadium. The Cambridge yellow brick sample, however, is more similar to the saggar in both its Cr and V values. This suggests that the source of the calcareous clay is closer in composition to the Cambridge yellow brick than to the Kimmeridge clay samples.

Table 1

Element	Comment
Na_2O	Higher
MnO	Higher
Ba	Higher
Cr	Lower
Cu	Higher
V	Lower
Nd	Higher
Eu	Higher
Dy	Higher
Yb	Higher
Pb	Considerably higher
Co	Higher

Glazed red earthenware

The thin section evidence suggests that the glazed red earthenware made in the Broad Street kiln is not made from the clay found on site. This conclusion is supported by the chemical composition which indicates that the values of many of the measured elements lie outside the range for the three clay samples. The suggestion that they might have been using Gault clay rather than recent alluvium, based on the chemical composition, cannot be tested with existing chemical data. The fact that the pottery and saggar were made from different clay might support the idea that the glazed red earthenware clay was used sparingly.

Yellow Brick

The thin section analysis suggests that this brick was made from Kimmeridge Clay and the chemical analysis confirms that the brick and the Kimmeridge Clay samples are more similar to each other than they are to remaining samples. However, there are differences in the chemical composition of the clay samples and the brick which suggest firstly that the Ely clay pit is not the source of the clay used for the Cambridge brick and that it should be possible to characterise bricks and other ceramic building material made from these yellow-firing marls. Such items are at present impossible to characterise using thin sections and occur throughout eastern England, including in late medieval contexts where they are usually ascribed to a Flemish source.

Appendix One

ICPS Data for major elements (measured as percent oxides)

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V2233	15.41	4.12	1.45	16.73	0.2	2.1	0.67	0.1	0.028
V2232	12.73	6.04	0.92	1	0.33	2.56	0.52	0.14	0.044
V2231	13.43	5.93	1.01	7.64	0.44	2.39	0.67	0.35	0.062

ICPS Data for minor elements measured as parts per million

TSNO	Ba	Cr	Cu	Li	Ni	Sc	Sr	V	Y	Zr*	La	Ce	Nd	Sm	Eu	Dy	Yb	Pb	Zn	Co
V2233	309	78	29	103	60	14	568	64	20	77	33	75	33.934	7.028	1.1	3.1	1.9	90.49	62	13
V2232	300	84	106	46	44	13	90	108	22	59	37	74	38.164	7.376	1.6	3.6	2.3	1506.17	81	15
V2231	307	92	56	67	52	13	184	110	28	76	37	74	38.822	7.242	1.7	4.3	2.8	983.57	91	15