Characterisation Studies of Post-medieval Ceramic Building Material from Meadow Lane, North Hykeham, Lincolnshire

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Waste from archaeological investigations on the site of a post-medieval ceramic building material production site at North Hykeham, Lincolnshire, was assessed by Jane Young for APS Ltd. As part of this assessment, she recommended analysis of the products and fired clay used on the site in order to investigate several related questions:

a) Are the various ceramic types found on the site all likely to have been made there?

b) Can we say anything about the choice of raw materials used?

c) Can we establish which preparation methods were employed?

d) Are there any diagnostic features to the fabric which might serve to identify products found on other sites?

Methodology

Table 1

TSNO	Sitecode	Context	class	cname	Form	subfabric	Action
V3177	mlnh02	413	FCLAY	FCLAY	KILN		ICPS;TS
V3187	mlnh02	412	CBM	PMTIL	FLOOR		ICPS;TS
V3188	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3189	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3190	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3191	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3192	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3193	mlnh02	413	FCLAY	FCLAY	KILN		ICPS
V3171	nhm04	51	CBM	PMTIL	NIB	NH1	ICPS;DR
V3172	nhm04	31	CBM	PMTIL	NIB	NH1	ICPS
V3173	nhm04	02	CBM	PMTIL	PNR	NH1 + shale	TS;ICPS;DR
V3174	nhm04	29	CBM	PMTIL	PNR	NH1	ICPS
V3175	nhm04	55	CBM	PMTIL	NIB	NH1	ICPS;DR
V3176	nhm04	47	CBM	PMTIL	NIB	NH1	ICPS
V3178	nhm04	47	CBM	PMTIL	FLOOR	NH1	TS;ICPS
V3179	nhm04	47	CBM	PMTIL	BRK	NH1	ICPS
V3180	nhm04	47	CBM	PMTIL	FLOOR	NH1	ICPS
V3181	nhm04	31	CBM	PMTIL	BRK	NH1	TS;ICPS

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V3182	nhm04	31	CBM	PMTIL	BRK	NH1	ICPS
V3183	nhm04	55	CBM	PMTIL	BRK	NH1	ICPS
V3184	nhm04	51	CBM	PMTIL	FLOOR	NH1	ICPS
V3185	nhm04	47	CBM	PMTIL	BRK	NH1 + very large pebbles	TS;ICPS
V3186	nhm04	55	CBM	PMTIL	BRK	NH1	ICPS
V3194	nhm04	47	CBM	PMTIL	NIB	NH1	TS;ICPS
V3195	nhm04	01	CBM	PMTIL	RID	NH1;fine	TS;ICPS
V3196	nhm04	31	CBM	PMTIL	NIB	NH1	ICPS
V3197	nhm04	32	CBM	PMTIL	NIB	NH1	ICPS

The waste was found in two excavations, with site codes MLNH02 and NHM04. Twenty-seven objects were sampled (Table 1). The former site produced a large unglazed floor tile (1 sample, V3187) and a collection of fired clay (samples V3177, V3188-93). The latter is interpreted as being part of the superstructure of a kiln. The latter site produced fragments of nibbed flat roof tile (samples V3171-76, V3194, V3197), bricks (samples V3179, V3181-83, V3185-86), unglazed large floor tiles (samples V3178, V3180, V3184) and a possible fragment of ridge tile (sample V3195).

Each sample was sub-sampled for Inductively-Coupled Plasma Spectroscopy, carried out under the supervision of Dr J N Walsh, Royal Holloway College, London and a sample of each object type was thin sectioned. The sections were prepared by Steve Caldwell, University of Manchester, and stained using Dickson's method (Dickson 1965) in order to distinguish the various carbonates which might be present (ferroan and non-ferroan calcite and dolomite).

Ceramic Petrology

Nine thin sections were prepared. Each was examined semi-quantitatively, noting the presence/absence and rough frequency of each inclusion type. The same range of inclusions was found in each section although there was considerable variation in texture as a result of the poor mixing of the clay.

The following inclusion types were noted:

- Quartz. Sparse to abundant sub-rounded and rounded grains up to 0.4mm across. Some are clearly well-rounded grains which have cracked and then been subject to further rounding. The grains are mainly monocrystalline and unstrained but include strained, polycrystalline grains. Well-rounded grains with a high sphericity, up to 1.5mm across are also present but sparse.
- Clay pellets. Moderate to abundant rounded fragments of clay were present, up to 2.0mm across. These grains vary from a very light brown to dark brown in plain

polarised light and in several cases show distinct laminations. Black staining is also common. These fragments are similar in colour and texture to the groundmass and are therefore relict clay, fragments of the parent clay. The laminations indicate that the parent clay is a weathered shale or mudstone. The black staining is probably the result of iron or manganese concretion.

- Chert. Sparse rounded fragments up to 0.4mm across.
- Sandstone. Sparse rounded fragments of fine-grained sandstone (and coarse siltstone) up to 0.4mm across.
- Opaques. Sparse angular and subangular fragments up to 2.0mm across.
- Ferruginous sandstone. Sparse angular fragments with an opaque matrix and subangular quartz grains up to 0.2mm across.

The groundmass consists of poorly mixed lenses of optically anisotropic baked clay varying in colour and quartz silt content.. Some lenses contain abundant inclusions of quartz, with minor chert and sandstone, as described above, whilst others contain no inclusions greater than c.0.1mm across. Some of the lighter-coloured lenses are more birefringent that the more common red-firing ones.

In two of the sections the core of the sample was reduced, isotropic and any iron-rich inclusions had vitrified (VC3178 and V3194).

Chemical Analysis

The frequency of a range of elements were measured by ICPS. These included major elements, measured as percent oxides (Appendix 1) and minor and trace elements, measured as parts per million (Appendix 2).

Although silica was not measured directly by ICPS, it could be estimated by subtracting the sum of all measured oxides from 100%. The mean and standard deviations of these estimates are shown in Fig 1, which shows that the bricks and kiln fabric have a higher silica content than the flat roof tiles, the floor tiles and the ridge tile.

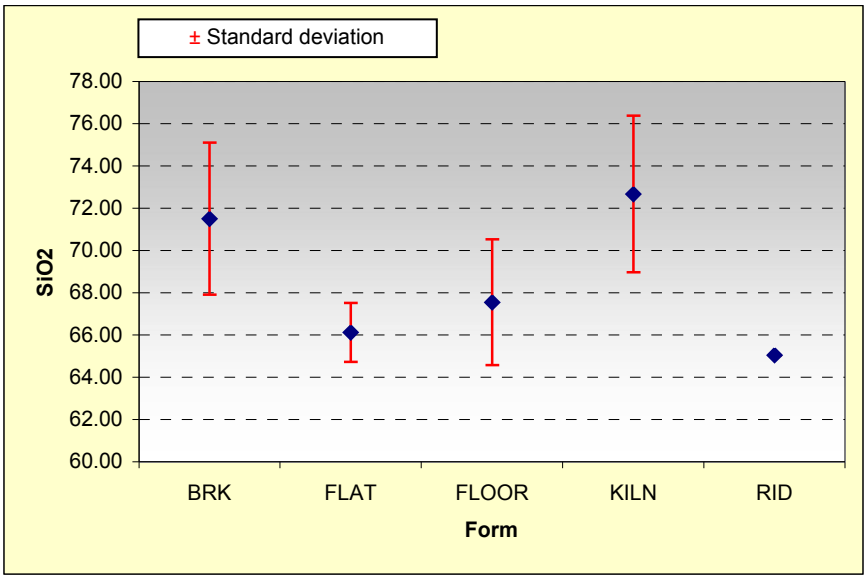


Figure 1

Since high silica content depresses the values of other measured elements, the values of all measured elements were normalised to Aluminium and the resulting dataset was then analysed using factor analysis (). Six factors were found and the variations and similarities in the sample compositions were explored by examining plots of Factor 1 versus Factor 2, Factor 3 versus Factor 4 and Factor 5 versus Factor 6.

Differences were found between the samples from the 2002 site and those from the 2004 site, but these seem to be due to the fact that the 2002 samples were mainly of kiln fabric. Otherwise, the principal variations were between different object types.

The plot of F1 against F2 indicate that the kiln fabric samples have negative F1 scores whereas those of the other types have a wider range of F1 scores (Fig 2). The ridge tile sample has a higher F2 score than the remainder. The negative F1 scores could be due to lower Rare Earth Element values or higher Potassium and Sodium values. Potassium and Sodium is likely to have been present in rare feldspar grains, present in the quartzose sand. The high F2 score of the ridge tile sample seems to be a consequence of high values for two Rare Earth elements (Lanthanum and Neodymium), Scandium, Chromium, Titanium, Potassium and Magnesium.

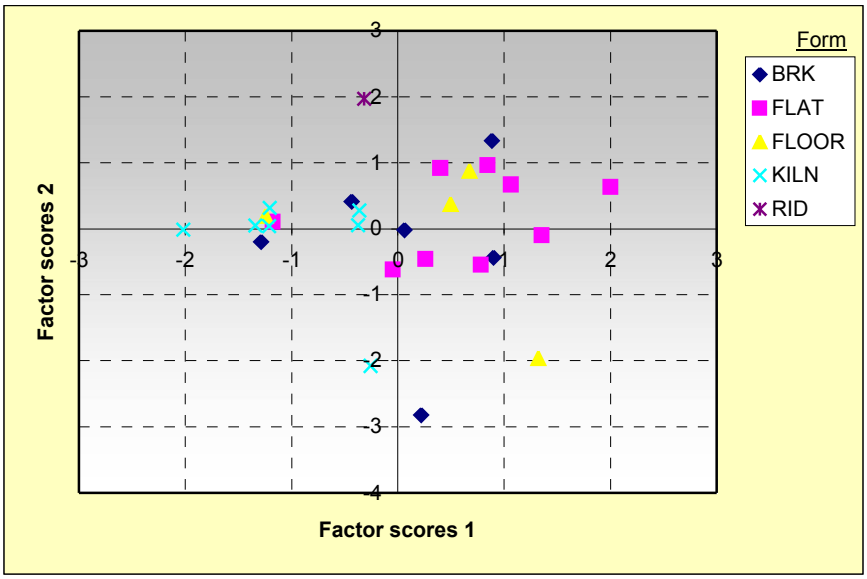


Figure 2

The same pattern is seen in the plot of F3 against F4 (Fig 3). In this case, the difference in composition of the ridge tile and the remainder is clearer than in Fig 1.

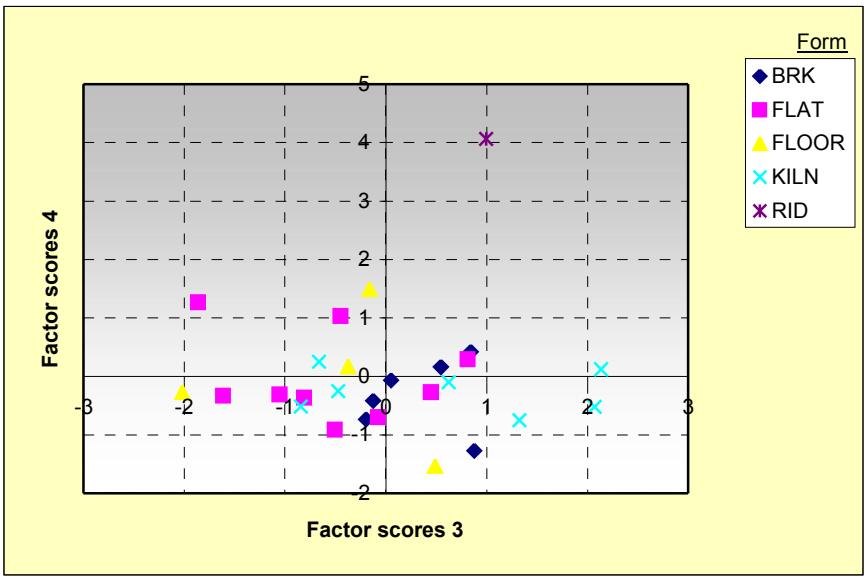
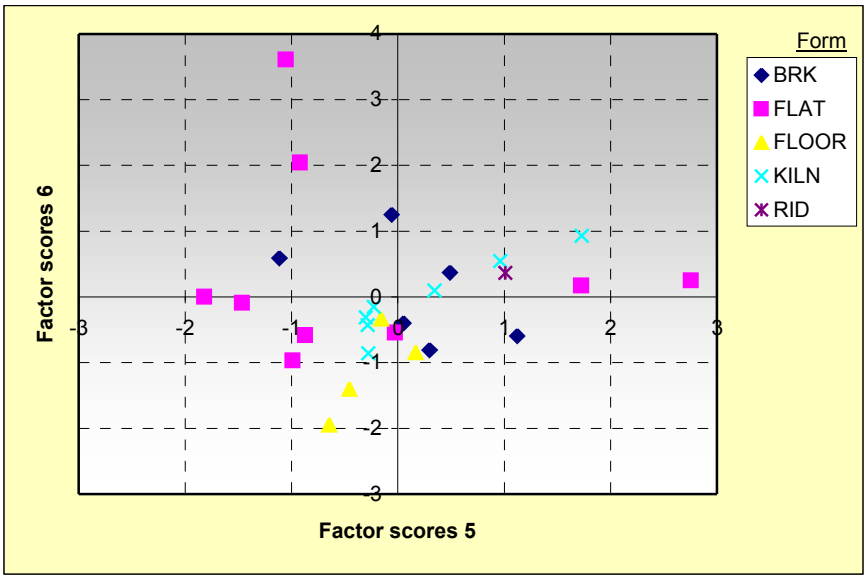


Figure 3

The plot of F5 against F6 scores does not differentiate the ridge tile from the remainder, but does reveal that the various object types form overlapping clusters (Fig 4). The floor tiles have a lower F6 mean than the remainder, perhaps due to a lower iron content, whilst the bricks and kiln fabric samples have mean F5 and F6 scores centring on zero. The flat roof tiles may form two clusters, one with high F5 scores and the other with low F5 scores. The reality of these groups cannot be proven given the small number of samples taken.



Discussion

The petrological and chemical analyses provide some answer to the found questions posed at the start of the analysis.

It is likely that the bricks, flat roof tiles and floor tiles were all produced at the site. The attribution of the ridge tile is doubtful, and this is consistent with the fact that only one fragment of this form was present.

The raw materials used appear to be a shaley clay which contains a mixture of light-firing and red-firing bands or lenses. This is likely to be the Grantham formation (1980), although Kent states that this formation is absent in the Lincoln area. However, sufficient light-firing clays existed at South Carlton to allow mortaria and white-firing finewares to be produced there in the Roman period and similar clay was used at St Marks, in Lincoln, in the late medieval period to produce finewares (although given the small quantities made, the clay might have been imported from a clay pit to the north or south of Lincoln. However, it is clear that this clay does not outcrop at North Hykeham, where the solid geology consists of Lower Lias, which does not contain light-firing bands, having been deposited under marine conditions. It is likely that the clay source used was obtained locally, however, and this suggests that the clay used was a till, derived from an exposure of the Grantham formation to the north of Lincoln. The large fragments of opaque ironstone and ferruginous sandstone are likely to come from the Northampton sand, which underlies the Grantham formation.

The quartzose sand noted in all the sections is typical of that found in Trent valley sands and is mainly derived from Triassic deposits, the larger grains being likely to come from the Sherwood Sandstone (aka Bunter sandstone). The sand varies considerably in texture and the finer fraction is often found in the windblown cover sands overlying the Jurassic limestones on the Lincoln Edge, but in this case the grains include larger grains absent from the cover sands and the most likely source is a terrace sand in the Trent valley.

The poor mixing which is evidence in every section indicates that the clay was not levigated (i.e. dried, crushed, sieved, reconstituted as a slip and finally dried to a plastic state). Instead, the raw clay was crudely mixed in a plastic state, allowing fragments of the parent clay to survive. The variation in quartz content indicates that the kiln structure and the bricks were tempered with terrace sand, which was also present in the other products, but to a lesser extent.

It is at present difficult to determine whether examples of these North Hykeham products could be recognised on other sites, since little comparative data exists. Lenses of fine-textured, light-firing clay are a notable feature of medieval flat roof tiles produced in Lincoln and of similar (but not identical) tiles found on consumer sites in the Witham valley, including Boston. Similar tiles have also recently been noted at Torksey. However, whether there are any differences between these tile fabrics and that produced at North Hykeham and Lincoln cannot be determined until comparative samples are available.

Conclusions

The products of the ceramic building material industry at North Hykeham include bricks, floor tiles and flat roof tiles. They may not include ridge tiles, since the one example from the site has differences in chemical composition, although its fabric as seen in thin section is identical to North Hykeham products. Thin section and chemical analysis also shows that quartzose sand from a local terrace sand was added to all the products, but was added in larger quantities to the bricks and kiln furniture. The chemical analysis further suggests that the floor tiles may have slight differences in composition from the flat roof tiles, despite similar quantities of sand temper, and that these may indicate that the floor tiles were produced at one time, from the same batch of clay, whereas there may be two distinct groups of flat roof tiles. However, these differences are small and would need to be confirmed by analysis of a larger sample of tiles.

The fabric used at North Hykeham contains pellets and lenses of light-firing clay, derived in this case from the Grantham Formation. Such light-firing clays are limited in their outcrop in Lincolnshire to the Grantham Formation (which underlies the Lincolnshire Limestone, along the scarp slope of the Lincoln Edge) and the Upper Estuarine Beds which overlies the Lincolnshire Limestone (i.e. on the dip slope of the Jurassic scarp). Their presence at North Hykeham is postulated here to be due to the use of a glacial till (or perhaps Quaternary head, formed by slumping of deposits from the scarp) and extends the potential source area for such light-firing clays.

Bibliography

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Fitch (2001) Winstat for Microsoft (r) Excel. Fitch, Robert K. 2001.

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Appendix 1. ICPS Data for Major Elements (measured as percent oxides)

TSNO	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO
V3171	21.59	5.93	1.42	0.83	0.26	2.62	0.92	0.1	0.071
V3172	19.21	6.48	0.92	0.88	0.24	2.34	0.81	0.4	0.05
V3173	20.84	5.33	1.28	0.46	0.21	2.83	0.83	0.17	0.018
V3174	19.13	10.8	0.95	1.11	0.2	2.13	0.79	0.22	0.085
V3175	21.76	6.93	1	0.85	0.19	2.46	0.93	0.11	0.065
V3176	21.06	7.14	1.38	0.78	0.23	2.63	0.86	0.11	0.048
V3177	18.56	5.65	1.01	0.31	0.22	2.34	0.75	0.09	0.02
V3178	20.53	6.77	1.26	0.53	0.25	2.5	0.77	0.1	0.046
V3179	16.62	5.49	0.94	0.36	0.22	2.27	0.62	0.08	0.019
V3180	19.93	6.85	1.21	0.54	0.23	2.44	0.82	0.11	0.064
V3181	18.04	6.61	1.13	0.65	0.24	2.35	0.74	0.18	0.051
V3182	17.59	7.74	0.76	0.64	0.22	2.1	0.72	0.09	0.04
V3183	14.27	5.35	0.53	0.3	0.19	1.91	0.59	0.09	0.039
V3184	22.46	8.1	1.33	0.46	0.23	2.46	0.9	0.1	0.033
V3185	17	6	0.93	0.27	0.21	2.19	0.67	0.08	0.023
V3186	20.48	6.67	1.38	1.3	0.24	2.65	0.84	0.17	0.096
V3187	18.2748	5.87	0.81	0.57	0.2	2.08	0.79	0.09	0.094
V3188	18.4	6.75	1.06	0.35	0.33	2.65	0.74	0.12	0.032
V3189	20.53	6.74	1.16	0.34	0.27	2.59	0.81	0.09	0.017
V3190	14.44	4.85	0.78	0.26	0.21	2.01	0.57	0.08	0.033
V3191	15.38	5.12	0.83	0.25	0.22	2.04	0.59	0.08	0.035
V3192	14.52	5.08	0.52	0.3	0.19	1.86	0.59	0.08	0.053
V3193	17.99	5.83	0.98	0.32	0.22	2.19	0.73	0.08	0.032
V3194	22.5	6.58	1.46	0.7	0.24	2.64	0.93	0.09	0.069
V3195	20.2	8.12	1.75	0.62	0.24	2.96	0.91	0.12	0.046
V3196	22.16	6.48	1.21	1.02	0.24	2.59	0.95	0.15	0.07
V3197	18.77	9.58	0.93	1.07	0.21	2.29	0.73	0.18	0.087

Appendix 2 ICPS Data for Minor and Trace 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
V3171	376	132	32	162	80	18	114	208	25	95	44	100	46	9	1	5	3	77	104	25
V3172	351	112	28	105	71	16	117	191	23	87	35	75	37	6	1	5	3	63	82	20
V3173	343	125	25	174	47	18	90	109	19	77	37	69	39	6	1	4	2	46	85	17
V3174	339	106	30	119	92	16	86	224	27	78	42	82	44	5	1	5	3	36	148	25
V3175	433	127	31	148	76	19	75	212	24	92	41	78	43	6	1	5	3	31	105	19
V3176	409	131	32	173	83	17	115	238	22	58	43	84	45	7	1	5	3	53	105	21
V3177	340	111	24	112	44	15	78	154	17	65	36	61	37	4	1	3	2	50	81	14
V3178	390	124	28	160	72	17	101	225	24	70	44	75	46	8	2	5	3	74	105	25
V3179	336	98	23	122	44	14	80	174	17	53	33	58	34	4	1	3	2	67	79	17
V3180	356	126	30	149	71	17	96	219	23	75	39	83	41	5	1	4	3	45	104	22
V3181	349	114	24	122	59	15	94	162	20	77	34	67	35	5	1	4	3	50	93	16
V3182	365	112	28	117	62	15	77	181	23	77	34	63	36	5	1	4	3	45	107	19
V3183	355	89	25	80	45	12	49	143	18	73	18	48	20	4	1	3	2	42	75	14
V3184	351	141	31	158	61	19	97	228	18	65	41	68	42	6	1	4	3	46	112	17
V3185	322	104	24	118	40	14	76	167	14	54	30	55	31	4	1	3	2	54	77	15
V3186	347	130	29	155	78	17	122	219	21	60	43	79	45	9	1	5	3	45	107	24
V3187	442	113	51	152	73	16	68	171	22	85	29	69	31	6	1	4	3	46	108	19
V3188	328	113	23	96	42	15	79	193	16	61	36	61	37	3	1	3	2	65	98	17
V3189	342	125	23	82	46	17	84	219	14	61	36	61	37	5	1	3	2	49	97	16
V3190	322	91	21	86	34	12	69	96	13	54	29	54	30	6	1	3	2	51	68	16

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V3191	319	95	22	97	37	13	69	136	14	56	29	59	30	6	1	3	2	72	76	15
V3192	371	86	22	108	38	12	54	129	14	65	22	50	24	5	1	3	2	43	66	13
V3193	327	79	24	93	41	15	76	133	16	66	35	59	36	5	1	3	2	47	79	16
V3194	396	106	32	185	87	19	113	252	27	82	48	92	50	8	2	5	3	59	111	27
V3195	361	129	33	97	63	19	89	132	21	75	46	83	47	6	1	4	3	38	99	21
V3196	370	134	30	130	96	18	123	245	24	92	38	76	40	6	1	5	3	34	102	30
V3197	431	105	28	130	83	16	91	213	23	75	37	71	39	6	1	4	3	47	116	27