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Summary

Historical documents show that the glassworks at Nailsea were established in 1788 and continued until1874. An assemblage of glass and glass working waste (2.8kg) was submitted for examination and subsequent analysis. Samples to represent the range of colours, forms and sizes present were selected for chemical analysis. It was determined from these analyses that colourless glass was produced on site. The glass is a soda lime silicate glass.

Keywords

Glass
Post Medieval

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Introduction

Nailsea (ST 465 695) is some 12km south west of Bristol. The Nailsea glass works were established in 1788 and began producing glass bottles, moving on to produce crown and sheet glass until its demise in 1874. It was ideal for the production of glass for two reasons; it had access to a local source of coal, also worked during the medieval period, and was near enough Bristol to feed from its success. The site was excavated during the 1980s and 1990s when a number of environmental samples were taken. Thirty-one of these samples were submitted for examination and subsequent analysis (see Table 9, Table 10, Table 11 and Table 12). A number of samples contained significant amounts of various glass fragments and debris from the glassworks.

History

The historical evidence for the production of glass at Nailsea is extensive and a small book has been published on the subject (Thomas 1987). The site was chosen in 1788 and two cones (cover buildings for furnaces) stood on the site from 1790. A further cone 'Lily', was constructed by the early 1840s. During the life of the Nailsea glassworks the production of glass at the works went through phases with the primary product shifting from bottle glass through crown glass and, later, cylinder window glass. The presence of swing pits provide evidence that cylinder glass was produced, most likely using the improved cylinder method described briefly below. This development dates from the late 1830s.

By the 1860s sheet glass was the main product, the Old House making cylinder and crown glass and the New House making cylinder glass. The 'Lily' cone was producing plate glass. Crown glass was produced from 1788 to 1862 when the melting furnace in the Old House collapsed. In the 1860s coloured sheet glass of 'Cathedral type' glass was also made (see Painted and blue glass).

Due to bankruptcy and the faltering local coal supply production of glass on the site the works were finished in 1874 when the site was put up for sale. It was never sold and went from decay to dereliction.

Glass production

Charles Coathupe, a manager at Nailsea –1836/37, kept a notebook, which, along with wages and so forth provides us with several recipes for the production of glass (Thomas 1987), one of which is shown in (Table 1). These weights can be converted into percentages and compared with the results from the analysis (see Table 6).

Table 1: Recipe for sulphate of soda mixture (quantities used in one week)

	Cwt	Qr	Lbs
Prepared sand	284	2	11
Sulphate of soda	106	2	25
Prepared lime	88	3	21
Prepared charcoal	7	2	14
Prepared manganese	0	2	17
Prepared arsenic	1	2	0

Cullet was also added to this mixture to aid the initial melting and also to cut on costs to produce the glass charge. This was common practice. Arsenic was added to glass batches to decolourise the glass that had a variable iron content (from the sand) and therefore variable colour (Parkin 2000); manganese is also known to decolourise glass. The materials, whether the ones above or not were melted in pots measuring 5 feet high and 70 inches across (Thomas 1987).

Excavation

The New Cone was excavated in 1983/87 and bags of samples collected. These are listed in tables 9-11. In the excavation records there is a description of a pit that had a clinker fill (A10) followed by an ashy layer (A14), providing a possible chronology. The site diary records that the layer may have built up during the use of this pit as a swing pit. This is to the east of the furnace in the New House cone.

The samples detailed in Table 10 were all taken from the New House cone to the west of the Nailsea complex. All samples except SA06 and SA03 were taken from an area close to the cone (NGR ST47692 70841) labelled as clinker and ash on a sketch plan of the excavations.

To the east of New House cone, Old House cone was partly excavated in the 1990s and further samples were collected (see Table 12).

Terms used

Crown glass was produced in England between 1696 and 1872 but by 1832 it was in decline as a technique for the manufacture of glass panes (Burgoyne and Scoble 1983). This is the method where glass is blown into a small bulb and then spun to produce a circle of glass four or five feet in diameter, which is called a table. The main disadvantage is that the cutting of the table result in relatively small panes of glass due to the bullion or bull's eye in the centre that was considered waste. The replacement for this technique was the **improved cylinder method** (cylinder glass). This involves blowing a cylinder of glass which is then split whilst still malleable. Swinging the cylinders in a swing pit made them longer. Both methods were certainly in use at Nailsea (see below). Colourless glass was found which had a distinctive ridged surface; this is described as **ridged glass**.

Aims

- To determine the chemical composition of the glass being made at Nailsea, and whether this changes over time
- To see if the composition of the vessel and ridge glass show that they could have been made on site
- To compare Coathupe's recipe (see Table 1) with analyses of waste glass from the site
- To see if coloured glass has the same composition as the colourless glass, but with added colorant(s)

Processing of samples

Wet and dry sieving was undertaken on one of the larger bags of material [cone area (301) sample number 801] to determine the most efficient way of extracting glass production waste. The sieves used had 1.4, 2, 4 and 5 mm mesh. The <1.4 mm portion of material recovered during dry sieving was too small to be useful, consisting of very small fragments that cannot be identified as production waste (Dungworth 2002); this portion of the sample was discarded. The other material can be placed into categories according to the sieve size (5mm, 4mm, 2mm, 1.4mm).

It was found easier to sort the wet-sieved than dry sieved residues so all further processing was by wet sieving. All the available samples were examined, and sub-samples of those that contained glass or glassworking debris were processed (see tables 9-12). From this it was clear that burnt waste, glass waste and colourless glass were the dominant materials to be found (see Table 2). This material was in most contexts along with debris from buildings, which, for convenience has been labelled **ceramic building material** (CBM).

Several contexts contained only one type of material. These were only visually processed, examined both in hand specimen and under low-powered binocular microscope, their characteristics noted and a classification applied. These were ashy material, clay, stones, soil and mortar. The mortar was tested with dilute hydrochloric acid. A positive result (fizzing) indicated that it contained calcium carbonate and was mortar.

A single fragment of blue glass was recovered.

No crucible fragments were found in the material sieved. However one small fragment of ceramic material was found and has a vitreous surface or a drip of glass.

Table 2 :Material recovered from all contexts

	Weight (g)	%
Waste from burning (clinker, coal, coal ash)	741	26.5
CBM (mortar, brick fragments, unidentifiable stones)	345	12.3
Patterned window glass (red)	2	0.1
Colourless curved or flat glass	806	28.8
Colourless ridged glass	25	0.9
Glass waste (moils, lumps, chips)	664	23.7
Runs drips and threads	104	3.7
Brown bottle glass	48	1.7
Blue glass	<1	0.0
Green bottle glass	64	2.3
Other (wood, shell)	1	0.0
	2800	

Non-glass waste makes up 38.8% of the total material recovered. The most rare material recovered was coloured glass which, including the painted glass, only accounts for around four percent of the total.

The categories 'other' and blue glass were less than 0.1% of the total. A more detailed breakdown of material type by context can be found in Table 14.

Selection of samples for analysis

Samples for analysis were selected to represent the range of colours, forms and sizes of glass and glass waste. A number of larger pieces found during the excavation (see Table 13) were also sampled and analysed, these came from various key areas of the site. Each sample was mounted in acrylic resin, polished and examined with a scanning electron microscope (SEM) and analysed using an energy dispersive X-ray detector (EDS). Preliminary analysis was done on cleaned surfaces using an X-ray fluorescence spectrometer (XRF). These both give quantified percentage compositions.

Table 3: Samples taken for SEM-EDS analysis

Number	Context	Description
1	802 Nr building 260	Brown bottle glass
2	802 Nr building 260	Colourless drip
3	802 Nr building 260	Colourless lump
4	802 Nr building 260	Colourless ridge glass
5	802 Nr building 260	Green bottle glass
6	802 Nr building 260	Painted glass
7	Bag 301 cone area	Cylinder glass
8	Bag 304 [cone area]	Misshape glass fragment
9	NG 83 A (10) 8	Colourless glass, flat
10	NG 83 A (10) 8	Colourless glass, part of moil
11	NG 83 A (10) 164	Colourless glass, lump
12	NG 83 A (10) 184	Colourless glass, lump
13	NG 83 A (14) 9	Colourless glass, flat
14	NG 83 A (14) 9	Colourless glass drip
15	NG 83 A (14) 177	Colourless glass, lump
16	NG 83 A (14) 200	Colourless, lump
17	NG 83 A (14) 206	Colourless glass, lump

Glass and glassworking waste

Large lumps of frothy waste (figure 1) were only found in context (301) [801]. Smaller fragments of this material were also found throughout this context.

Figure 1: Frothy glass waste

Colourless glass was found in most contexts. Some of these fragments were unidentifiable while others were remains of cylinder glass or moils, fragments cracked off from the blowing iron leaving a dark iron-rich layer on the curved surface (see the left of Figure 2). Bottle and coloured glass was most commonly found in context (260) [802].

Figure 2: Colourless glass

Figure 3: Coloured glass fragments (green on the left, brown on the right and blue in the middle)

In addition to the material above there were many larger fragments which had been picked out during the excavation. Selections of these from the same contexts as the sieved material (see Table 13) were also analysed. These included what is described as 'clay ring fragment'. This was probably part of a gathering ring, which floated on the surface of the molten glass allowing the gatherer to rest the blowing iron while he collects enough glass to produce the beginnings of a crown. The rings were placed in the bottom of a pot, the batch was then added and the ring was allowed to float to the surface. These rings were made of the same material as the pots and made in the same way (Parkin, 2000). The composition of the glass on the ring should have a similar chemistry to that of the glass produced at Nailsea, though with contamination from the ceramic material. Therefore a sample of this ring and the adhering glass was taken and a profile produced of the glass layer-ceramic interaction.

Analytical results

Qualitative XRF was undertaken on rough cleaned surfaces to aid sampling the large amount of glass recovered, the elements where reported are the ones that were most significant for each sample. From these results it was determined that most of the colourless glass and glass waste was of the same composition. Below is a summary table of the EDS results for each sample. These are the results illustrated by the graphs (see Figure 4, Figure 5 and Figure 6).

Table 4 : Average composition of material determined by EDS

Sample No	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	As_2O_3	Total
2	10.3	0.2	1.1	68.8	0.2	15.2	0.1	0.0	0.3	0.3	97.3
3	8.0	0.3	1.5	66.7	0.6	19.1	0.1	0.0	0.4	0.4	98.3
4	12.4	0.0	0.9	70.1	0.1	13.5	0.0	0.0	0.3	0.5	98.9
7	15.3	0.2	0.6	68.1	0.0	12.6	0.1	0.0	0.3	0.3	98.5
8	11.3	0.1	0.8	69.7	0.1	12.3	0.1	0.2	0.2	0.3	95.9
9	14.3	0.3	0.7	69.4	0.1	13.1	0.0	0.1	0.2	0.2	99.0
10	12.9	0.2	0.6	67.8	0.1	13.0	0.0	0.1	0.1	0.1	95.7
11	14.6	0.4	0.8	70.1	0.2	13.3	0.1	0.0	0.2	0.3	100.6
12	14.8	0.4	0.7	70.1	0.1	12.8	0.1	0.0	0.3	0.2	100.0
13	12.4	0.1	0.6	66.1	0.1	12.4	0.2	0.0	0.2	0.2	92.9
14	12.6	0.2	0.8	68.0	0.0	12.9	0.2	0.0	0.2	0.2	96.1
15	14.5	0.3	0.7	70.7	0.1	13.3	0.1	0.1	0.2	0.2	100.7
16	13.4	0.2	0.7	68.4	0.1	12.8	0.2	0.1	0.2	0.2	96.9
17	16.2	0.4	0.7	71.2	0.1	13.4	0.0	0.1	0.2	0.1	103.2
1 (brown)	7.1	6.1	3.7	56.0	1.0	16.5	0.2	3.9	2.1	0.1	97.6
5 (green)	4.5	2.6	4.4	59.5	1.4	19.9	0.2	0.2	2.9	0.1	96.8
6 (painted)	2.0	0.0	0.3	76.8	9.7	7.0	0.0	0.0	0.1	0.3	96.8
All colourless (average)	13.1	0.3	0.8	69.0	0.1	13.5	0.1	0.1	0.2	0.2	98.2

Frothy glass waste

The surface appearance (Figure 1) suggests the glass is heavily weathered, which is born out by the high silica and low soda values in (Table 5). The material was not selected for further analysis for this reason. The other values are consistent with and indistinguishable from the other colourless glass analysed. Therefore this waste is likely to have been a primary product or waste material from producing the finished glass fragments found. The results shown are from four different pieces of this waste. There is no significant difference in composition between discoloured and colourless glass.

Table 5: XRF surface analyses of frothy waste glass from context 301

Na_2O	3.4	2.8	3.3	4.3
Al_2O_3	1.9	2.0	2.0	1.7
SiO_2	81.3	80.9	82.4	80.2
SO_3	0.7	0.7	0.7	0.7
K_2O	0.1	0.2	0.1	0.1
CaO	12.1	12.8	11.0	12.4
TiO_2	0.1	0.1	0.1	0.1
MnO	<0.1	<0.1	<0.1	<0.1
Fe_2O_3	0.2	0.3	0.2	0.2
As_2O_3	0.2	0.2	0.2	0.2
SrO	<0.1	<0.1	<0.1	<0.1

Colourless glass

Rough surface analysis was undertaken with no sample preparation to select a suitable sub-set for EDS analysis. The results of the XRF analysis showed a very tight clustering suggesting that the glass may have been produced using the same recipe with tight control of the quality and source of the raw materials. The EDS results also showed a tight clustering with some variability introduced from weathering of the alkalis. There is no evidence for chronological variation within the colourless group. The colourless lump has a different composition but not significantly so. It contains higher amounts of calcium and slightly higher alumina (see Table 4). The spread of alumina, iron, manganese and magnesium values is less than 1% in the colourless glass studied (see Figure 4). The colourless glasses are from both cone areas and various contexts, suggesting that there is no variation in the type of flux used over time for the colourless glasses, though the samples analysed may all come from relatively late phases of use of the site.

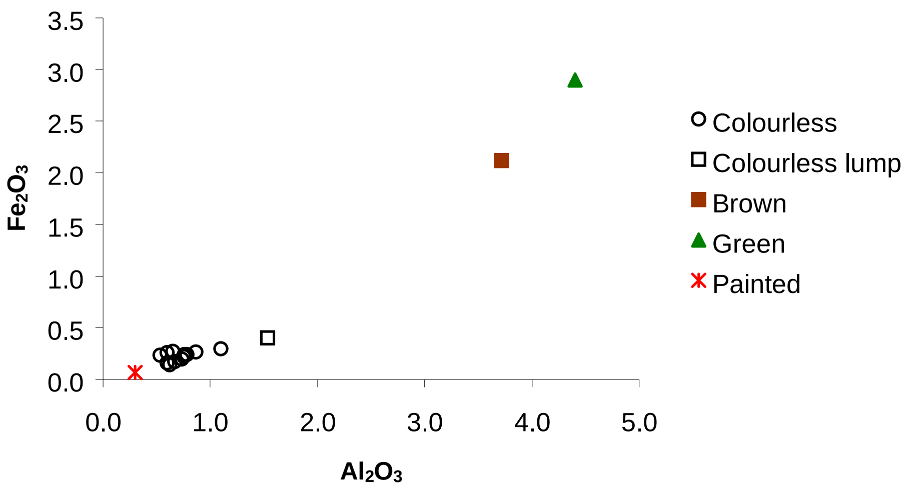

Figure 4: EDS results for Al_2O_3 and Fe_2O_3

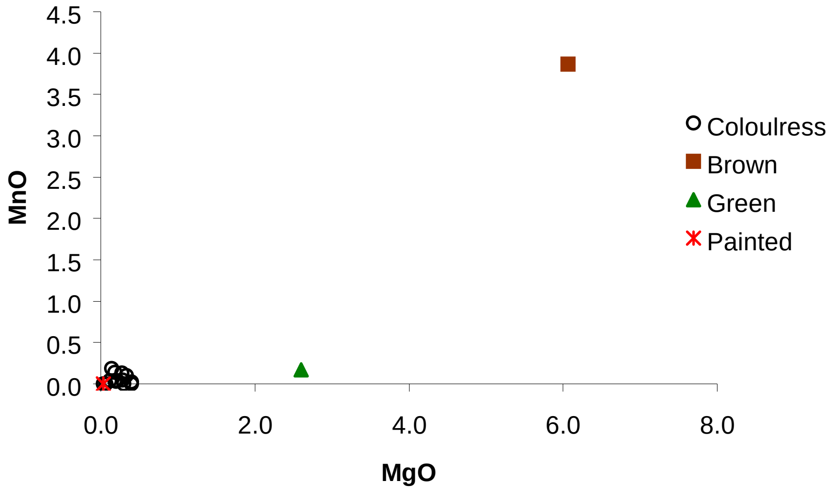

Figure 5: EDS results for MnO and MgO

The recipe given in Table 1 has been converted into the weights in kilograms of the oxides assumed in modern analysis of glass, and then into percentages (see Table 6). This composition can then be compared to the chemical data obtained by SEM-EDX (the last two columns in Table 6) which shows a good match, though with slightly more lime and less decolourisers than in the recipe.

Table 6: Nailsea glass recipe in kilograms and percent

	Kg	%	Average colourless glass	Normalised
SiO_2	14458.4	72.2	68.8	72.1
Na_2O	2667.9	13.3	13.0	13.6
CaO	2530.2	12.6	13.3	13.9
C	387.4	1.9		0.0
MnO	33.1	0.2	0.1	0.1
As_2O_3	76.2	0.4	0.2	0.2

Coloured glass

XRF analyses of the brown and green bottle glass fragments showed significantly higher magnesia, alumina and iron than in the colourless glass, with the brown glass also being high in manganese. The glass is also lower in arsenic. XRF suggested all the glass of the same colour had similar composition so only one sample of each colour was subjected to EDS analysis to determine if the colourless glass was used as a base glass or if they were of a separate composition (see data Table 4 and Table 15).

The EDS results show that the most significant shift in elemental composition, compared to the colourless glass, is both brown and green being higher in potash magnesia and iron. The brown glass also contains significantly more manganese and magnesia than the green (see Table 4 and Figure 5), confirming the results suggested by the XRF analysis.

Figure 6 shows the relationship between soda and potash in the glasses studied. As can be clearly seen there is a separation between the high soda/low potash colourless glass samples and the coloured glasses, which are slightly higher in potash and lower in soda. This suggests different sources of flux were used for the colourless and coloured glasses.

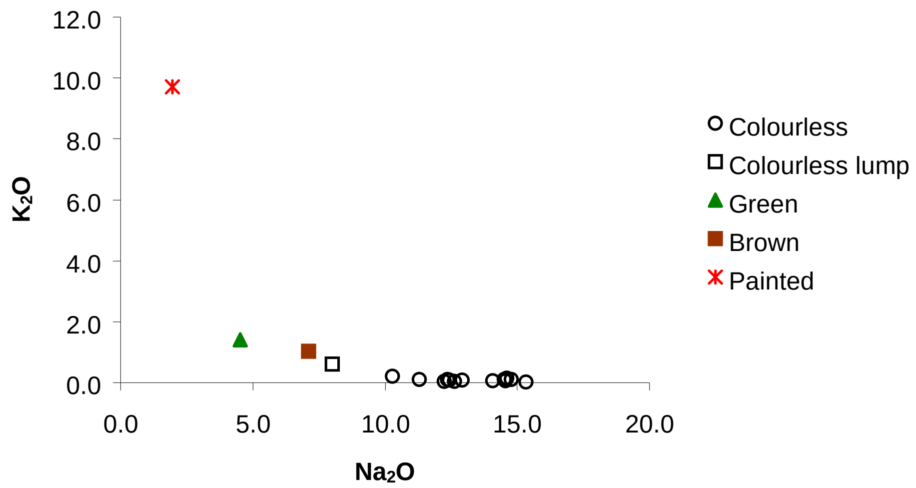

Figure 6: EDS results for soda and potash

Painted and blue glass

A single piece of colourless glass with a very thin layer of what appears to be red paint was examined. With the XRF and the EDS it was not possible to resolve a small enough area to determine the composition of the paint layer in cross-section, nor was it possible to determine its composition when surface analysis was undertaken due to its thinness. However the composition of the bulk glass was determined using EDS. As can be seen the painted glass is distinctly different from both the colourless and coloured glasses (Figure 6) as it is high in potash, suggesting another source for the flux. Examining the entire contents of the bag from 260 near building 802 only three further small pieces of this red-covered glass were found.

Three small pieces of blue glass were recovered but were not considered a significant product on site so only XRF was undertaken on one of them. As can be seen from the results of XRF on the surface of the blue glass (three areas on the sample piece of glass) the glass is heavily weathered resulting in low values for alkalis (soda and potash).

Table 7: Blue glass XRF values

Na_2O	3.7	3.8	3.4
Al_2O_3	2.8	2.8	2.9
SiO_2	81.6	81.1	81.0
SO_3	0.7	0.6	0.7
K_2O	0.5	0.5	0.6
CaO	10.1	10.5	10.7
MnO	<0.1	<0.1	<0.1
Fe_2O_3	0.2	0.2	0.2
CoO	0.2	0.2	0.2
Ni_2O_3	0.1	0.1	0.1
CuO	<0.1	<0.1	<0.1
ZnO	<0.1	<0.1	<0.1
As_2O_3	0.2	0.2	0.2
SrO	<0.1	<0.1	<0.1

Clay ring fragment

EDS was carried out on a polished section of the clay ring fragment (NG83e (3)-69) to determine the chemistry of the clay as well as the adhering glass. The ceramic was found, as expected, to be high in silica and alumina. The glass was found to be higher in alumina where it had interacted with the ceramic (Table 8).

Table 8 :EDS values of clay ring fragment and adhering glass

	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	As_2O_3	SrO	Total
Glass	10.3	0.1	4.1	69.7	0.3	11.9	0.1	0.1	0.5	0.1	0.4	97.4
Interaction	11.1	0.0	14.9	68.4	0.5	3.3	0.7	0.0	1.0	0.0	0.4	100.3
Ceramic	0.0	0.3	20.2	74.8	0.8	0.1	1.2	0.0	1.5	0.0	0.2	99.1

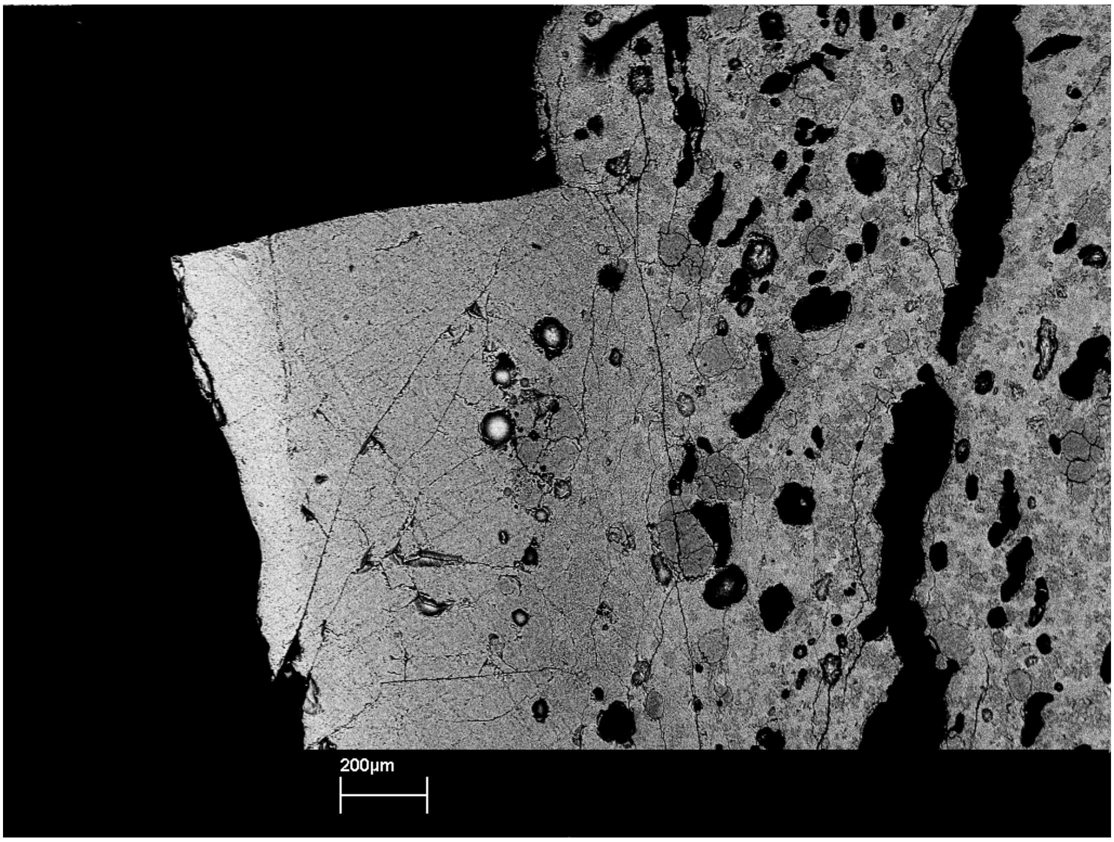

Figure 7 :Backscatter electron image of a cross section of the clay ring fragment. The black areas are voids.

Figure 7 shows the glass (paler on the left) adhering to the clay body (right, containing slightly darker grey quartz particles) with an interaction between the glass and the clay (areas with lower average atomic number look darker in backscatter electron images). The interaction causes a change in composition and therefore in backscatter contrast. The glass gets darker from left to right as lighter elements such as alumina are introduced into the glass from the ceramic by diffusion. It is likely that the composition of the glass is contaminated even at the edge by the clay-glass interaction due to the long time for which the gathering ring will have been subjected to high temperatures.

In light of these results, the possible drip adhering to a ceramic material found in when sieving sample [801] cone area (301) was re-examined. Under a binocular microscope the drip appears to be adhering to a mortar-like matrix that does not appear to have enough quartz grains to be of the same material that forms the clay ring. This was confirmed using XRF and dilute hydrochloric acid (the mortar fizzed). This drip was probably adhering to the furnace structure.

Conclusions

The analytical results show a tight clustering of compositions for the colourless glass. Because the samples were taken from two different cones and some taken from two different levels within the swing pit (on the west side of the New House Cone), it is likely that this lack of variation can be explained by the careful control of the raw materials used to produce the colourless glass. Though the majority of the glass working debris may only be from one main phase of operation of the site, the stratigraphic relation ships of samples A10 and A14 does show that there was little variation over the period of use of the swing pit. Unfortunately at the current time we do not know how long a period these layers represent. However, these layers have to be after the introduction of cylinder glass to Nailsea (late 1830s) as finds were from a swing pit, essential for the manufacture of cylinder glass. We can also suggest that the recipe shown in Table 1 could have been the one used to produce the glass at Nailsea which has been analysed (although it dates to 30 years earlier than the last use of the site) as we find only low potash levels and traces of arsenic in the colourless glasses.

There is not a lot of coloured glass recovered from the material studied but it does suggest a bias towards brown bottle glass. This is unlikely to be colourless glass (of the type analysed) with the addition of a colorant but the colorant does introduce high levels of manganese, magnesium and iron. There is no coloured glass waste in the assemblage, suggesting that these pieces of bottle glass were not made at Nailsea. Further, a bottle base, brown in colour, was found that has BRI… imprinted in the glass. This clearly came from Bristol and is of a similar composition to the brown glass analysed, which may therefore also have been made in Bristol.

The compositions found for the colourless glass are that of the glass produced at Nailsea as we have primary glass waste. These may be isolated to one period of production, but are more like to have been from at least two. The glass is characteristic in that it contains a significant amount of arsenic, suggesting that it was, indeed produced using the materials suggested in the recipe (see Table 1).

There is no evidence in this assemblage for the manufacture of 'Nailsea type' glass at Nailsea.

It is also clear from the waste that coal was used as the source of fuel, as was suggested by the documentary evidence and siting of the glass works.

Further work

If there are identifiable pieces of cylinder glass and crown glass from secure contexts it may be possible to determine the composition of the glass and say for certain whether there was a compositional change over time.

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Appendix

Table 9: Samples from box 5 NG83.

Box 5 Bag	NG86	Sample	Weight (g)	Comments
5G	Ashy layer above brick floor area A above pit	2	270	Sieved and sorted (wet 270g)
5H	Soil and mortar from above brick floor area A	1	473	Fizz with HCl
5I	Ash or soot from hole 'drain' area C	3	286	Ash/coal ash
5P	A(10) area A sample of material from fill of pit	5	324	Stones/ash
5Q	A(10)	8	1662	Sieved and sorted (wet 500g)
5R	A(14)	9	1011	Sieved and sorted (wet 500g)
5T	Mortar from wall W9	4	430	Fizz with HCl

Table 10: Samples from NG86

Sample	Context	Plan No	Grid ref	Date		Level	Weight (g)	Comments
(SA04?) A	31	13	280(-)010	02/12/1986	DC		882	Nothing of interest
(SA03?) B	31	13	330(-)005	02/12/1986	DC		1168	Nothing of interest
SA11	45	19	290-010	22/01/1987	PB		299	Soil
SW Airway below context 18+26	27	4+8	004-008	18/10/1986	DMC		682	Compacted soil
SA23				29/05/1987	PB		153	Burnt coal
SA22				29/05/1987	PB		189	Coal/burnt coal
SA010	44	19	297-004	26/01/1987	PB		105	Soil
SW Airway bottom of fill cont. 18	26	4+8	004-008	18/06/1986	DMC		1172	Sieved and sorted (wet 500g)
SA06	31	13	330(-)005	08/12/1986	PB		652	Soil
	24	?		18/11/1986	PB		128	Soil
SA09	43	?	290-010	26/01/1987	PB		386	Soil
SA01	29	8	290-010	27/11/1986	PB	31-882	383	Sieved and sorted (wet 383g)
SA07	33	15	270-010	09/12/1986	PB		179	Soil
SA02	30	8	290-010	27/11/1986	PB		435	Sieved and sorted (wet 215g)
SA08	42	?	279-002	06/01/1987	PB		28	Soil/ash

Table 11: Samples from NG 88

Sample	Context	Date	Weight (g)	Comments
SA27	Channel beneath extant floor (south/west)	23/02/1988	2276	Sieved and sorted (wet 500g)
SA(25)	338 water channel mortar	10/02/1988	95	Fizz with HCl
SA26	Clay from within covered water channel	15/02/1988	233	Clay
SA24	Sample from mortar (wall by lifted floor)	12/01/1988	417	Fizz with HCl

Table 12: Samples collected from 1990's excavation

Sample No	Context	Weight (g)	Comments
801	Cone area (301)	2465	
801	Cone area (301)	2607	Sieved and sorted (big lumps removed dry 455g; wet 465g)
801	Cone area (301)	1980	
802	Near building 2	2824	Sieved and sorted (wet 500g)
	Building 2	3151	
	Cone area (304)	2708	Sieved and sorted (wet 500g)
	Sample (278)	173	
	Sample (348)	256	Sieved and sorted (wet 256g)

Table 13: Material analysed that was removed from the general bags of finds

Description	Context
Ceramic ring	NG 83c (3)-69
Curved glass	Bag 301 cone area
Glass lump	Bag 304 cone area
Curved glass	NG 83 A (14)-178
Crazed glass	NG 83 A (14)-200
Thick curved	NG 83 (10) 158
Curved thin	NG 83 (10) 184
Thick colourless with bubbles	NG 83 (10) 160
Thin colourless	NG 83 (10) 206
Thick curved	NG 83 (10) 164

Table 14: Breakdown of materials found by context (weight g)

	Waste from burning	CBM	Patterned window glass (red)	Colourless curved or flat glass	Colourless ridged glass	Glass waste	Runs drips and threads	Brown glass	Blue glass	Green glass	Other	Total
Cone area 301 #801 wet	101	17				61				<1		**179**
Cone area 301 #801 dry	152	10				72	8				1	**243**
Cone area 304	54	23		152		43	72				<1	**344**
260 Nr building 802	42	25	2	53	25	14	9	48	<1	61		**279**
NG 82 A (10) 8	78	3		344								**425**
NG 83 A (14) 9	22	18		205		211	7			1		**464**
278	53	19		5		54						**131**
348	125	10				6						**141**
SA 27	16	97		47		102	7				<1	**269**
SW Airway bottom of fill		83				8						**91**
SA02	61	4										**65**
SA01	18	1				72	1					**92**
Bag 5G	19	35				21				2		**77**
Total	**741**	**345**	**2**	**806**	**25**	**664**	**104**	**48**	**0**	**64**	**1**	**2800**

Table 15: EDS results

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	NiO	ZnO	As_2O_3	SrO	
A (14) 200	12.0	0.1	0.5	67.1	0.3	0.6	0.0	12.7	0.1	0.0	0.2	0.0	0.0	0.0	0.2	94.0
A (14) 200	12.1	0.0	0.5	67.8	0.0	0.5	0.0	12.7	0.2	0.0	0.2	0.0	0.0	0.2	0.0	94.4
A (14) 200	12.6	0.1	0.6	68.2	0.2	0.6	0.1	12.9	0.1	0.0	0.3	0.0	0.1	0.3	0.1	96.0
Bag 301 cone area cylinder	17.6	0.4	0.7	70.0	0.0	0.7	0.0	12.6	0.1	0.0	0.3		0.0	0.2		102.6
Bag 301 cone area cylinder	17.6	0.3	0.6	70.0	0.1	0.6	0.1	12.5	0.1	0.0	0.3		0.0	0.0		102.1
Bag 301 cone area cylinder	14.1	0.2	0.6	66.9	0.2	0.6	0.0	12.7	0.1	0.1	0.2	0.0	0.0	0.5	0.3	96.4
Bag 301 cone area cylinder	13.8	0.1	0.5	66.8	0.3	0.7	0.0	12.6	0.0	0.0	0.2	0.1	0.0	0.2	0.2	95.6
Bag 301 cone area cylinder	13.6	0.1	0.6	66.8	0.2	0.7	0.0	12.6	0.0	0.1	0.3	0.0	0.1	0.4	0.2	95.7
Colourless drip 802 Nr building 260	10.5	0.3	1.0	68.3	0.1	0.6	0.2	15.0	0.2	0.1	0.3	0.0	0.0	0.2	0.0	96.9
Colourless drip 802 Nr building 260	10.1	0.1	1.1	69.3	0.2	0.5	0.2	15.3	0.1	0.0	0.3	0.0	0.0	0.4	0.0	97.7
Colourless drip 802 Nr building 260	10.2	0.2	1.2	68.7	0.1	0.6	0.2	15.2	0.1	0.0	0.3	0.0	0.1	0.2	0.1	97.2
Colourless lump 802 Nr building 260	8.1	0.3	1.6	67.3	0.1	0.9	0.6	19.2	0.1	0.0	0.4	0.0	0.0	0.4	0.1	99.3
Colourless lump 802 Nr building 260	7.7	0.3	1.5	66.4	0.1	0.8	0.6	19.0	0.0	0.0	0.4	0.0	0.1	0.3	0.3	97.4
Colourless lump 802 Nr building 260	8.2	0.3	1.5	66.5	0.1	0.8	0.6	19.0	0.1	0.0	0.4	0.0	0.0	0.4	0.3	98.3
Colourless ridge 802 Nr building 260	12.6	0.0	0.9	70.2	0.2	0.6	0.1	13.6	0.1	0.0	0.3	0.0	0.0	0.5	0.4	99.4
Colourless ridge 802 Nr building 260	12.5	0.1	0.8	71.2	0.1	0.6	0.1	13.7	0.0	0.0	0.3	0.0	0.1	0.5	0.3	100.2
Colourless ridge 802 Nr building 260	12.0	0.0	0.9	69.0	0.2	0.6	0.1	13.3	0.0	0.0	0.2	0.1	0.0	0.5	0.2	97.1
Mis shape bag 304 [cone area]	11.5	0.1	0.7	69.4	0.0	0.5	0.1	12.4	0.1	0.2	0.2	0.0	0.1	0.3	0.1	95.7
Mis shape bag 304 [cone area]	10.9	0.0	0.7	69.1	0.2	0.5	0.1	12.2	0.1	0.2	0.2	0.0	0.0	0.3	0.3	94.7
Mis shape bag 304 [cone area]	11.4	0.1	0.8	69.8	0.1	0.4	0.1	12.2	0.0	0.2	0.3	0.0	0.0	0.3	0.0	96.0
Mis shape bag 304 [cone area]	11.0	0.2	0.6	67.1	0.2	0.3	0.1	12.1	0.1	0.2	0.3	0.0	0.0	0.4	0.2	92.9
Mis shape bag 304 [cone area]	11.0	0.2	0.7	68.6	0.2	0.6	0.1	12.2	0.1	0.1	0.3	0.0	0.1	0.2	0.1	94.4
Mis shape bag 304 [cone area]	11.6	0.2	0.9	71.9	0.2	0.3	0.1	12.3	0.1	0.2	0.2	0.1	0.0	0.4	0.1	98.7

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	NiO	ZnO	As_2O_3	SrO	
Mis shape bag 304 [cone area]	11.6	0.2	0.9	71.9	0.1	0.5	0.1	12.5	0.1	0.2	0.2	0.0	0.1	0.5	0.1	99.0
NG 83 A (10) 164	15.4	0.3	0.7	69.9	0.0	0.6	0.2	13.4	0.1	0.0	0.2		0.1	0.3		101.1
NG 83 A (10) 164	14.8	0.5	0.8	70.4	0.0	0.6	0.1	13.2	0.1	0.0	0.2		0.0	0.4		101.3
NG 83 A (10) 164	14.6	0.3	0.8	70.1	0.0	0.6	0.2	13.3	0.1	0.1	0.2		0.0	0.4		100.5
NG 83 A (10) 164	13.6	0.5	0.7	69.9	0.0	0.6	0.1	13.4	0.1	0.0	0.3		0.1	0.1		99.3
NG 83 A (10) 184	15.6	0.5	0.7	70.6	0.1	0.5	0.1	12.7	0.1	0.0	0.3		0.1	0.2		101.4
NG 83 A (10) 184	15.3	0.4	0.7	69.7	0.1	0.5	0.1	12.8	0.1	0.0	0.3		0.1	0.1		100.1
NG 83 A (10) 184	14.3	0.4	0.6	70.2	0.1	0.4	0.1	13.0	0.2	0.0	0.3		0.1	0.2		99.7
NG 83 A (10) 184	13.9	0.3	0.6	70.0	0.1	0.5	0.1	12.8	0.1	0.0	0.2		0.0	0.2		98.8
NG 83 A (10) 206	16.3	0.4	0.7	71.5	0.0	0.5	0.1	13.5	0.0	0.1	0.2		0.0	0.1		103.3
NG 83 A (10) 206	16.3	0.4	0.7	70.9	0.1	0.6	0.0	13.4	0.1	0.2	0.2		0.0	0.0		102.9
NG 83 A (10) 206	16.0	0.5	0.8	71.2	0.1	0.6	0.1	13.4	0.0	0.0	0.2		0.1	0.3		103.3
NG 83 A (10) 8 colourless glass	11.7	0.0	0.6	66.5	0.1	0.4	0.1	12.5	0.0	0.2	0.1	0.0	0.0	0.4	0.0	92.6
NG 83 A (10) 8 colourless glass	12.0	0.2	0.6	67.5	0.1	0.5	0.0	12.6	0.1	0.2	0.2	0.0	0.1	0.4	0.0	94.4
NG 83 A (10) 8 colourless glass	13.3	0.3	0.5	67.3	0.0	0.7	0.1	12.7	0.1	0.1	0.1	0.1	0.0	0.2	0.0	95.4
NG 83 A (10) 8 colourless glass	12.9	0.1	0.8	69.0	0.3	0.6	0.0	12.9	0.0	0.1	0.2	0.0	0.2	0.0	0.1	97.1
NG 83 A (10) 8 part of moil	12.8	0.1	0.6	67.7	0.0	0.5	0.0	13.0	0.0	0.1	0.2	0.0	0.1	0.0	0.0	95.1
NG 83 A (10) 8 part of moil	13.4	0.0	0.6	69.2	0.0	0.6	0.1	13.2	0.0	0.1	0.1	0.1	0.0	0.0	0.0	97.3
NG 83 A (10) 8 part of moil	12.4	0.2	0.7	67.9	0.2	0.5	0.1	13.1	0.0	0.1	0.1	0.2	0.1	0.0	0.0	95.6
NG 83 A (10) 8 part of moil	12.2	0.2	0.6	65.4	0.0	0.4	0.1	12.8	0.1	0.2	0.1	0.0	0.0	0.2	0.0	92.4
NG 83 A (10) 8 part of moil	13.8	0.4	0.6	69.0	0.1	0.5	0.1	13.0	0.1	0.2	0.2	0.0	0.0	0.1	0.0	98.2
NG 83 A (14) 177	15.6	0.4	0.7	70.5	0.0	0.5	0.1	13.3	0.1	0.0	0.2		0.1	0.3		101.8
NG 83 A (14) 177	15.8	0.4	0.9	70.2	0.0	0.6	0.1	13.4	0.0	0.1	0.2		0.0	0.2		101.9
NG 83 A (14) 177	14.8	0.3	0.7	70.1	0.1	0.5	0.1	13.3	0.1	0.1	0.2		0.0	0.1		100.3
NG 83 A (14) 177	14.7	0.5	0.7	70.1	0.0	0.5	0.1	13.3	0.1	0.1	0.2		0.0	0.0		100.4

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	NiO	ZnO	As_2O_3	SrO	
NG 83 A (14) 177	12.7	0.1	0.7	70.3	0.2	0.4	0.1	12.9	0.1	0.0	0.2	0.0	0.0	0.2	0.2	98.2
NG 83 A (14) 177	13.4	0.0	0.7	72.8	0.0	0.4	0.1	13.3	0.1	0.0	0.2	0.0	0.0	0.3	0.0	101.3
NG 83 A (14) 200	12.0	0.2	0.6	64.9	0.1	0.4	0.1	12.1	0.1	0.1	0.2	0.0	0.0	0.1	0.1	90.9
NG 83 A (14) 200	16.0	0.4	0.9	71.4	0.0	0.6	0.0	13.3	0.2	0.1	0.3		0.0	0.1		103.4
NG 83 A (14) 200	15.7	0.4	0.8	71.1	0.1	0.6	0.1	13.2	0.2	0.1	0.2		0.0	0.3		102.7
NG 83 A (14) 9 colourless glass	12.5	0.0	0.7	65.5	0.0	0.6	0.0	12.3	0.2	0.1	0.1	0.0	0.1	0.1	0.0	92.1
NG 83 A (14) 9 colourless glass	12.7	0.3	0.5	65.6	0.1	0.6	0.1	12.5	0.1	0.0	0.1	0.0	0.1	0.0	0.0	92.6
NG 83 A (14) 9 colourless glass	12.0	0.0	0.5	65.9	0.1	0.6	0.1	12.5	0.1	0.0	0.3	0.0	0.1	0.2	0.0	92.6
NG 83 A (14) 9 colourless glass	11.9	0.2	0.6	66.5	0.0	0.4	0.1	12.5	0.2	0.0	0.1	0.0	0.0	0.4	0.0	93.0
NG 83 A (14) 9 colourless glass	13.0	0.1	0.7	67.0	0.0	0.4	0.1	12.3	0.2	0.1	0.2	0.1	0.1	0.1	0.0	94.3
NG 83 A (14) 9 glass drip	13.0	0.1	0.8	67.8	0.1	0.7	0.1	12.7	0.2	0.0	0.3	0.1	0.0	0.1	0.0	95.8
NG 83 A (14) 9 glass drip	12.6	0.4	0.7	67.9	0.1	0.7	0.0	13.0	0.1	0.2	0.2	0.0	0.1	0.4	0.1	96.4
NG 83 A (14) 9 glass drip	12.5	0.0	0.7	67.2	0.1	0.6	0.0	12.9	0.1	0.0	0.3	0.0	0.0	0.0	0.5	94.8
NG 83 A (14) 9 glass drip	12.4	0.3	0.7	68.3	0.0	0.5	0.0	12.8	0.2	0.0	0.1	0.1	0.2	0.1	0.0	95.5
NG 83 A (14) 9 glass drip	12.6	0.1	1.0	69.0	0.2	0.8	0.1	12.9	0.2	0.0	0.3	0.1	0.0	0.5	0.0	97.8
Painted	1.8	0.1	0.3	76.5	0.2	0.1	9.7	7.0	0.0	0.0	0.1	0.0	0.1	0.2	0.1	96.2
Painted	2.1	0.0	0.3	76.7	0.4	0.2	9.7	7.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	97.3
Painted	2.0	0.0	0.3	77.1	0.2	0.2	9.7	7.0	0.0	0.0	0.1	0.0	0.0	0.3	0.1	97.0
Green 802 Nr building 260	4.9	2.5	4.5	59.7	0.1	0.7	1.4	19.9	0.2	0.1	2.9	0.0	0.0	0.1	0.1	97.2
Green 802 Nr building 260	4.3	2.6	4.3	59.2	0.3	0.7	1.4	19.8	0.2	0.2	2.9	0.0	0.0	0.1	0.3	96.5
Green 802 Nr building 260	4.4	2.7	4.4	59.5	0.1	0.7	1.4	20.0	0.2	0.2	2.9	0.1	0.0	0.0	0.1	96.8
Brown 802 Nr building 260	7.1	6.2	3.7	56.1	0.2	0.6	1.0	16.5	0.1	3.9	2.1	0.0	0.0	0.1	0.3	98.1
Brown 802 Nr building 260	7.4	6.0	3.7	56.1	0.2	0.6	1.0	16.6	0.2	3.8	2.2	0.0	0.2	0.1	0.2	98.3
Brown 802 Nr building 260	6.6	5.9	3.6	56.0	0.1	0.6	1.1	16.4	0.2	3.9	2.1	0.0	0.1	0.3	0.1	96.8
Brown 802 Nr building 260	7.2	6.1	3.8	56.0	0.2	0.6	1.1	16.5	0.2	3.9	2.1	0.0	0.0	0.0	0.1	97.8

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	NiO	ZnO	As_2O_3	SrO	
Brown 802 Nr building 260	7.2	6.1	3.8	56.0	0.1	0.6	1.0	16.5	0.2	3.9	2.1	0.0	0.0	0.1	0.2	98.0
Brown 802 Nr building 260	7.1	6.1	3.7	55.5	0.0	0.5	1.0	16.3	0.2	3.8	2.1	0.0	0.0	0.1	0.1	96.7

All values in this table represent an individual analysis. Blank portions of the table indicate that this element was not sought. A summary of these values can be found on page 7 (Table 4).