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WILD COURT ROOKERY, CITY OF LONDON SCIENTIFIC EXAMINATION OF EARLY 19TH-CENTURY CRUCIBLES

TECHNOLOGY REPORT

David Dungworth







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WILD COURT ROOKERY, CITY OF LONDON

SCIENTIFIC EXAMINATION OF EARLY 19TH-CENTURY CRUCIBLES

David Dungworth

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SUMMARY

Four crucibles from an early 19th-century cess pit were examined using a scanning electron microscope. One has an interior vitrified surface which contains significant amounts of sodium, chlorine and silver. This suite of elements suggests that the crucible had been used to separate silver from a gold alloy using salt parting. The presence of base metal and silver sulphide droplets in this crucible may be due to the refining of gold using sulphur parting. Salt parting and sulphur parting in early 19th-century London would be unusual as both of these technologies had been superseded by the use of strong acids at least 50 years before. The remaining three crucibles had all been used to melt alloys containing gold.

ARCHIVE LOCATION

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DATE OF RESEARCH 2005–2009

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INTRODUCTION

The Wild Court Rookery was an infamous early 19th century slum in London (NGR TQ 3056 8126). Excavations by the Museum of London Archaeology Service revealed cesspits that had been back-filled and sealed in 1855. The lower fill [57] of cesspit 1, which accumulated during the first quarter of the 19th century, contained a number of crucibles fragments. Some of these crucibles contained traces of gold (see Figure 1). The 1851 census does not describe any of the occupants of Wild Court as gold workers.



Figure 1. Crucible <153> (base diameter = 38mm) with traces of gold visible (cf Figure 3)

AIMS

Four fragments of crucible were selected for detailed scientific examination to

- confirm that they had been used for gold working, and
- characterise the nature of the gold working.

TECHNOLOGICAL BACKGROUND: TRIANGULAR CRUCIBLES

The Wild Court Rookery crucibles are small, wheel-thrown ceramic vessels; circular at the base but triangular at the rim. The form became very popular in the post-medieval period with many millions being manufactured for small scale metallurgy, alchemy and chemistry. The crucibles are often referred to as 'Hessian' because many of them were made there, however, similar crucibles were made in Bavaria and Austria (Martinón-Torres *et al* 2003) as well as England (Cotter 1992). Triangular crucibles (dubbed 'Hessian') were first manufactured in England by John Dwight at Fulham (Freestone 1991; Green 1999, 95–6). In the 18th century triangular crucibles were used for a wide range of activities, including the melting and refining of precious metals (McLees 1996; Rehren 1996), for alchemical pursuits (Martinón-Torres *et al* 2003) and chemical experiments (Salter in Hull 2003).

TECHNOLOGICAL BACKGROUND: REFINING GOLD

The scientific examination of the crucibles reported below will show that the crucibles had been used to melt and purify gold. In order to make the results more intelligible this section summarises the evidence for the technologies employed in gold refining.

The political and economic importance of precious metals has meant that the technologies for refining gold are of considerable antiquity and have often been recorded in considerable detail. Gold has rarely been used in a completely pure state as it is a rather soft metal. It has commonly been alloyed with silver and copper. On its own, silver gives gold a whitish colour, while copper gives a reddish colour. By alloying gold with silver and copper, it is possible to maintain a golden colour.

There are extensive early documents which provide details of gold refining. The earliest documents are Egyptian (second century BC) and describe salt parting (Notton 1974). Further details are provided by a number of Roman writers (eg Pliny and Strabo). There are several important medieval and post-medieval sources, such as Theophilus (Hawthorne and Smith 1979) and Agricola (Hoover and Hoover 1950), which can be used to trace the introduction of new technologies (eg sulphur parting and parting using mineral acids). Some of the techniques employed have been confirmed by the examination of artefacts and residues recovered from archaeological excavations (eg Bayley 1991a; 1991b; 1992; 1996; 1999; Rehren 1996).

The principal documentary source used to understand the gold refining techniques attested by the crucibles from Wild Court Rookery is William Lewis's *Commericum-Philosophico-Technicum* (Lewis 1765). This contains a long and detailed section on gold which was still being praised over a century later (Hunt 1981). Additional

information can be found in 19th century encyclopaedias and dictionaries, such as Rees's *Cyclopaedia* (Cossons 1972), Muspratt's *Chemistry* (Muspratt 1860) and Ure's *Dictionary* (Ure 1844).

The relevant technologies used to refine gold can be separated into those used to remove base metals and those used to remove silver. The removal of base metals was usually achieved by *cupellation*; the metal was melted under oxidising conditions which would produce a slag (containing the base metals) and a regulus (containing the precious metals). The separation of silver from gold-silver alloys has been achieved in many different ways (eg salt parting, sulphur parting and acid digestion). In Britain the earlier techniques for separating silver from gold were largely replaced by the use of strong acids (eg nitric acid) by the 18th century.

Acid parting

A number of different techniques were employed for removing the silver from goldsilver alloys. Lewis (1765, 147) recommends the use of nitric acid. The gold-silver alloy was added to nitric acid which would dissolve the silver but leave the gold. Acid parting is attested by numerous post-medieval authorities but is unlikely to have been used before the 13th century (the earliest reference to the manufacture of nitric acid). By the 18th century nitric acid was cheap enough to allow acid parting to become the standard technique for assaying and refining gold (Cossons 1972; Lewis 1765; Muspratt 1860; Ure 1844).

Sulphur parting

Where the object was to recover gold from a silver-rich alloy, acid parting would be expensive due to the large quantity of acid required. In this situation it was more common for gold to be recovered by sulphur parting (Lewis 1765, 161–4; Muspratt 1860). The silver-gold alloy was melted and then sulphur was added which would form silver sulphide, leaving the gold unaltered. A variant on this technique was the use of antimony sulphide (Hawthorne and Smith 1979, 147; Hoover and Hoover 1950, 451; Lewis 1765, 156–8; Rehren 1996). Sulphide parting is mentioned from the 12th century onwards (Hawthorne and Smith 1979, 147) but does not appear to have been known in the ancient world. No archaeological evidence for sulphur parting has been reported previously (Bayley 1991a, 20).

Salt parting

The earliest technique for refining gold-silver alloys was salt parting (Craddock 1995, 118–9). The finely-divided gold-silver alloy was placed in a ceramic vessel with a 'cement' made from salt and crushed brick (Hawthorne and Smith 1979, 108–9). The

vessel would be sealed and then heated which allowed the chlorine in the salt to react with the silver. Silver chloride is volatile but is absorbed by the cement and the ceramic parting vessel (Bayley 1991a), leaving the pure gold unaltered. The vessel would be sealed to ensure that the silver chloride vapour was not lost. The parting cement and vessels would normally be crushed and smelted to extract the silver. Ercker recommended the use of salt parting for gold-silver alloys that are rich in gold (Sisco & Smith 1951, 180). Examples of used parting vessels have been recovered from Roman, Saxon and medieval archaeological contexts (Bayley 1991a; 1991b; 1999).

By the 18th century salt parting was increasingly being supplanted by acid parting. According to Lewis, 'The process indeed appears upon the whole to be incommodious, whether considered as a method of purifying gold or of ascertaining its purity; and accordingly, though once in much esteem, it is now rarely practised.' (Lewis 1765, 155). Rees's early 19th-century account of gold refining (see Cossons 1972), while largely derived from Lewis (1765), makes no mention of salt parting. Ure provides details only on forms of acid parting (Ure 1844), and, while Muspratt (1860) describes salt parting, he makes it clear that it was no longer used in Europe. Boussingault was astonished to see the process used in Colombia in the 1830s, and described it as 'sixteenth century metallurgy' (Hunt 1976, 28).

DESCRIPTION OF CRUCIBLES

Table I.	Description	of the four	crucibles	sampled
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Find	Context	Description
153	57	Base sherd, with specks of gold. Base \emptyset = 38mm.
154	57	Rim sherd.
157	57	Base sherd, with speck of gold. Base \emptyset = 35mm.
188	57	Base sherd. Base Ø = 54mm.

The four crucibles examined include three circular base sherds and a single rim sherd. The size, shape and fabrics suggest that they are all parts of triangular crucibles (Cotter 1992). The inner surface of crucible <153> has a band of vitrification which forms a pronounced ridge 5–10mm above the internal base (Figures 1 and 3). The form of this vitrification indicates the extent of the molten charge or *regulus*. The *regulus* was the metallic residue left after smelting or refining an ore or alloy (also called the *assay bead* or *button*).

METHODS

The four crucibles were sectioned and mounted in epoxy resin. The sections were polished to a 1-micron finish and carbon-coated before being examined using a scanning electron microscope. Chemical analyses were carried out on areas, inclusions and points using an energy dispersive X-ray detector attached to the scanning electron microscope. The results of the chemical analyses were normalised to 100% and can be found in Appendices 1–3.

CRUCIBLE FABRIC

The crucible fabrics consist of silica grains in a clay matrix with some porosity (see Figure 2). Some regions show large inclusions of reused ceramic ('grog', see Figure 2). The grog has the same composition as the rest of the vessel which suggests that old crucibles were used as grog. The clay between the silica grains has started to vitrify and in some cases has begun to react with the silica grains but there are very few indications of new crystals (eg mullite) forming. This suggests that the crucibles were not exposed to temperatures above 1200°C (cf Eramo 2005).



Figure 2. SEM photo of the ceramic fabric of crucible <188>

The four crucibles share very similar chemical compositions (Appendix I); the variation between samples is less than analytical precision. They were all probably obtained from the same source. The composition of the crucibles is typical for post-medieval refractory ceramics: they are rich in alumina and silica and contain low levels of fluxes (eg soda, potash and iron oxide). The clay used to make the crucibles can be described as a stoneware.

The chemical composition and microstructures of the crucibles suggests they were heated to temperatures in the region 1000–1200°C.

THE SURFACES OF THE CRUCIBLES

The examination and analysis of cross-sections through the four crucibles shows that a number of different processes was carried out. Each crucible is described in turn, below. The chemical analyses of the different areas on each crucible can be found in appendices 2 and 3.

Crucible <153>



Figure 3. Photograph of a cross-section through crucible <153> with a drawing showing the pronounced band of vitrification and the presumed limits of the molten metal (regulus) (cf Figure 1)

Crucible <153> has a pronounced band of vitrification (zone 2) which indicates the size of the regulus (see Figures 1 and 3). Tiny droplets of gold are visible in Zone 3 (Figure 1, Appendix 2).

The surfaces of this crucible have undergone post-depositional changes; in particular there are areas on the interior surface where calcium salts have been deposited. The evidence for post-depositional alteration introduces some uncertainty over the origins of some of the surface layers.

The surface in zone 1 is very thin (~20 microns) but is clearly vitrified and contains occasional crystals of wollastonite which suggests the crucible was exposed to temperatures around 1200°C. This vitrified layer also contains small amounts of silver, copper and lead — these were probably minor components of metal melted and were preferentially oxidised and thus incorporated into the crucible slag.

Zones 2 and 3 have surfaces rich in calcium and XRD analysis confirms the presence of calcite (CaCO₃). It has been suggested that calcite (and calcium phosphate) layers can form on the surfaces of archaeological ceramics after they have been incorporated into a burial environment (Freestone *et al* 1985). Calcium salts may be sufficiently mobile in burial environments that they are absorbed by ceramics (ibid). A single gold-silver droplet was observed in zone 3.

It is certain that this crucible was used to melt a charge of gold or gold alloy. The probable post-depositional accretion of calcium salts makes further interpretation difficult.

Crucible <154>

The very thin vitrified layers on the interior surface of this crucible rim sherd (Figure 4) provide evidence for the refining of gold using two separate techniques: salt parting and sulphur parting.

In area I (see Figure 5) the vitrified layer (see Figure 5 spot 7) contains high levels of sodium and chlorine. The sodium and chlorine concentrations are higher than would be expected if glass had been used as a flux. They are probably due to the use of a salt cement for parting. The sodium to chlorine ratio is much higher than in salt because chlorine (unlike sodium) has limited solubility in most vitreous materials (Bateson and Turner 1939). Sodium is also present in the vitrified layer in area 2 but at lower levels. The composition of the soda-rich vitrified inner surface (Area I spot 7, see Appendix 3) suggests that this layer would form at temperatures as low as 900°C (cf Levin *et al* 1956, fig 206).

This crucible has a number of metal and metal-sulphide particles on the interior and exterior surfaces. In area 1 (see Figures 4 and 5) a fairly large droplet of gold (Figure 5 spot 5) is surrounded by a film of copper-iron sulphides (spot 2). An inclusion within the gold droplet (spot 6) also consists of mixed metal sulphides. The presence of a sulphide inclusion within the gold droplet suggests that these sulphides are not formed by post-depositional processes. There are also a number of very small (<20 microns) gold alloy droplets present (eg Figure 5 spot 1). All of the metal and sulphide droplets in area 1 (ie spots 1–6) are outside the soda-rich vitrified layer (Figure 5 spot 7) and so presumably were deposited after the vitrified layer formed.



Figure 4. Photograph of a cross-section through crucible <154>

In area 2 (see Figure 4) there are very small (<2 microns) metal droplets trapped within the vitrified layer (see Figure 6 spot 4). Quantitative chemical analysis of the droplets using SEM-EDS in spot mode was not possible as they are smaller than the

electron beam interaction volume. In spot mode, analysis of the droplets detected a range of elements that are likely to derive from the surrounding vitreous material. Nevertheless, spot mode analysis shows that these droplets are silver-rich and did not detect any gold.



Figure 5. SEM photo of section through the inner surface of area 1 on crucible <154> (cf Figure 3)

Within a crack in the vitrified layer in area 2 there are two droplets of metal and metal sulphides (see Figure 6). The first droplet (spot 1) consists of laths of silver sulphide in a copper sulphide matrix. The second droplet has a core (spot 2) of gold (approximating to 21 carat) surrounded by mixed metal sulphides (spot 3). The relatively low sulphur content of these sulphide droplets compared to the sulphides in area 1 is probably due to the presence of divalent silver sulphide (Ag₂S).

The lip and area 3 of crucible <154> have vitrified surfaces which contains high levels of calcium but do not have the raised levels of soda seen on the interior surface. Area 3 has two mixed metal sulphide droplets within the calcium-rich vitrified surface (spots 1 and 2). The remaining outer surface of this crucible shows no sign of vitrification and/or glazing.

The arrangement of vitrified layers, inclusions and droplets in crucible <154> shows a sequence of activities. The earliest appears to be the formation of a soda- and chlorine-rich vitrified layer which occasionally contains tiny silver-rich droplets. This composition and microstructure resembles the descriptions of salt parting for refining gold-silver alloys. Salt parting was an archaic technology by the early 19th century in London. Subsequently, the crucible was used to refine gold using sulphur parting which left the mixed metal sulphide droplets. The two processes may have been carried out consecutively on the same gold alloy with the sulphur parting after the salt parting. The fact that two different gold parting technologies were successively carried out in the same crucible is perhaps surprising.



Figure 6. SEM photo of section through inner surface of area 2 on crucible <154> (see Figure 4)

Crucible <157>

This crucible fragment is similar to <153> and the interior surface has been divided into three zones (1, 2 and 3) in a similar way (cf Figure 3). A number of gold particles were visible in zones 1 and 3 and an attempt was made to section the crucible so that the gold particles could be viewed in section. Unfortunately the gold droplets became dislodged during sectioning but they were retained and analysed. Much of the interior surface of this crucible is covered by two calcium-rich layers (Figure 7). The outer layer contains high levels of calcium and phosphorus (with almost no other elements detected, while the inner layer contains high levels of calcium with



Figure 7. SEM photograph showing the calcium and calcium-phosphate rich surfaces in zone 2 on the interior surface of crucible <157> (Area 2). The Linescans in Figure 8 were carried out along the line AB



Figure 8. Line scan along the line AB shown in Figure 7 showing the proportions of calcium and phosphorus

little phosphorus (cf Figure 8). An XRD analysis of this material showed the presence of calcite but could not identify any calcium phosphates. While the layers appear to be restricted to the interior surface it is likely that they are post-depositional accretions.

No metal particles were detected in the crucible section and analyses of the crucible ceramic close to the interior surface indicated essentially the same composition as the rest of the crucible. The two gold droplets from crucible <157> which became dislodged during sample preparation have high gold contents (approximately 22 carat, Appendix 2). The gold droplets suggest that the crucible was used for goldworking and the simplest explanation is that this took the form of melting.

Crucible <188>

Crucible <188> has undergone post-depositional alteration with the deposition of material (largely tin and lead corrosion products) at the surfaces and in cracks. The deposition of this material has occurred across most of the interior surface and on one of the fracture surfaces. Beneath the accretions of tin and lead corrosion there is a thin band of vitrification which contains elevated levels of sodium, chlorine and calcium. The sodium and chlorine might indicate salt parting but the absence of silver and base metals is puzzling. The presence of occasional laths of wollastonite in the vitrified layer suggest that it formed at temperatures around 1200°C. Metal droplets were identified in zones I and 3 (see Appendix 2). These were gold-silver-copper alloys with a high gold content (approximately 22–23 carat). The presence of gold droplets shows that the crucible was used for goldworking and, while salt parting is possible, the simplest explanation is that the vessel was used for melting.

SUMMARY OF ANALYSIS

The four crucibles all share the same chemical composition and were made from refractory clays. The microstructure of the crucibles indicated that they had probably been exposed to a maximum temperature of approximately 1200°C. This is consistent with the temperature needed to melt or refine gold which has a melting point of 1064°C. The interior surfaces of the crucibles all showed varying degrees of vitrification, sometimes with the presence of metallic droplets. The composition of the droplets and the vitrified layers provides evidence of the uses to which some of the crucibles were put. In most cases layers were present which are certainly or likely to be post-depositional accretions which obscure the technical use of the crucible.

Melting

The presence of gold particles in all crucibles shows that they were used to work gold alloys. In the case of crucibles <153>, <157> and <188> there is no firm evidence for the use of any other technical processes and the simplest explanation is that they were used for metal melting. The analyses in Appendix 2 suggest that the gold was of good purity (18–23 carat).

Parting

Crucible <154> had been used for parting gold. The evidence for this consists of the vitrified interior surface and droplets of metal and metal sulphides adhering to the interior surface. The high levels of sodium and chlorine in the interior vitrified surface and the presence of small amounts of silver suggest that this crucible had been used for parting silver from gold using a salt cement. Contemporary documentary sources suggest that salt parting was an archaic technology in London in the early 19th century. The presence of gold droplets surrounded by films of copper and silver sulphides suggests that crucible was later used for sulphur parting.

CONCLUSIONS

The crucibles recovered from an early 19th-century cess-pit at Wild Court Rookery provide evidence for the refining and melting of gold alloys. Some of the crucibles show evidence for the removal of the silver from silver-gold alloys (a process called parting). Crucible <154> shows evidence of both salt and sulphur parting. The use of salt and sulphur parting in early 19th-century London were anachronistic: acid parting would be the usual technique. The use of an archaic technology, and the context in which it was carried out (a slum), suggest that the gold working might have been an illicit activity.

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APPENDIX I: ANALYSES OF CRUCIBLE FABRICS

sf	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K₂O	CaO	TiO ₂	Fe ₂ O ₃	Rb ₂ O	SrO	ZrO ₂
< 53>	0.8	0.9	24.4	67.0	2.6	0.4	0.9	2.7	0.02	0.01	0.04
< 54>	0.4	0.7	25.I	67.3	2.4	0.4	1.0	2.4	0.02	0.02	0.04
< 57>	0.6	0.7	25.5	66.7	2.3	0.3	1.0	2.9	0.02	0.01	0.04
< 88>	0.3	0.7	24.4	68.2	2.3	0.4	1.0	2.4	0.02	0.02	0.04

Normalised average of 8 separate area analyses for each crucible

APPENDIX 2: ANALYSES OF METALLIC AND SULPHIDE DROPLETS

Normalised results. For the location of the analysed areas and spots see the figures in the report. A range of other metallic elements (eg tin, zinc, antimony and arsenic) were sought but were not detected.

sf	Area	Spot	S	Fe	Ni	Cu	Ag	Au
<1525			<0.2	<0.1	<0.2	<0.2	7.4	02 (
<122	3	I	<0.3	NU.1	< 0.2	<0.2	7.4	92.6
<154>			<0.3	<0.1	<0.2	10.4	16.0	73.6
<154>	Ι	2	34.7	34.2	0.8	29.4	0.6	<0.5
<154>	Ι	3	<0.3	<0.1	<0.2	<0.2	100.0	<0.5
<154>	I	4	<0.3	<0.1	<0.2	2.9	12.2	84.9
<154>	I	5	<0.3	<0.1	<0.2	3.0	10.0	87.0
< 54>	I	6	30.9	20.5	1.6	27.7	10.9	8.4
<154>	2	I	20.8	0.2	<0.2	22.7	52.4	4.0
<154>	2	2	<0.3	<0.1	<0.2	1.9	13.1	85.0
<154>	2	3	14.8	0.3	<0.2	8.0	61.5	15.4
<154>	3	I	13.3	5.6	<0.2	2.3	78.8	<0.5
< 54>	3	2	24.3	0.2	<0.2	37.6	37.9	<0.5
<1575	2		0.9	2.6	<0.2	0.0	20	00.0
<157>	3	2	<0.9	3.6 0.6	<0.2	0.8	5.0 5.2	93.5
107		_	0.2	0.0	0.2	0.7	0.2	70.0
< 88>	I	I	<0.3	<0.1	<0.2	1.3	2.8	95.9
< 88>	I	2	<0.3	<0.1	<0.2	1.3	1.4	97.3
< 88>	I	3	<0.3	<0.1	<0.2	1.8	1.1	97.I
< 88>	I	4	<0.3	<0.1	<0.2	2.5	1.7	95.8
< 88>	3	I	<0.3	<0.1	<0.2	1.7	2.3	96.0
< 88>	3	2	<0.3	<0.1	<0.2	4.8	3.0	92.2

APPENDIX 3: ANALYSES OF VITRIFIED SURFACES OF THE CRUCIBLES

sf	Zone	Spot	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	SO3	CI	K₂O	CaO	TiO₂	MnO	Fe ₂ O ₃	CuO	AgO	SnO ₂	РЬО
< 53>	I	I	5.3	0.6	22.6	59.6	<0.2	<0.2	<0.2	2.9	7.0	1.0	<0. I	4.9	1.5	0.3	<0.5	<0.5
< 53>	2	I	<0.5	0.9	10.9	35.8	9.7	1.2	1.4	3.2	8.9	1.1	<0.1	13.4	8.8	0.9	0.8	3.1
< 53>	2	2	0.5	1.2	11.9	39.6	11.5	0.6	1.1	3.7	7.8	0.6	<0.1	12.3	4.2	0.4	0.8	3.9
< 53>	2	3	<0.5	0.7	6.I	17.3	20.4	1.2	2.5	2.1	9.3	0.4	<0.1	11.3	25.3	0.4	0.6	2.5
< 53>	3	I	<0.5	1.6	17.6	56.7	1.1	6.7	<0.2	5.6	5.2	0.6	<0.1	4.0	0.3	0.4	<0.5	<0.5
< 53>	3	2	0.8	1.6	17.0	58.4	1.8	5.8	<0.2	5.5	5.2	0.5	<0.1	3.1	0.2	0.2	<0.5	<0.5
< 53>	3	3	0.5	0.8	15.3	63.5	2.5	1.4	0.3	6.5	6.3	0.4	<0. I	1.4	0.2	0.9	<0.5	<0.5
<154>	I	7	18.1	1.3	18.6	47.0	<0.2	0.2	1.8	4.7	3.2	0.8	<0.1	4.4	<0.2	<0.2	<0.5	<0.5
< 54>	2	4	6.8	2.7	27.0	44.9	1.7	0.2	0.2	2.4	7.1	0.8	0.1	3.0	0.9	2.2	<0.5	<0.5
< 54>	3	3	2.3	4.7	13.6	35.9	2.2	<0.2	0.3	1.1	35.9	0.7	1.5	1.8	<0.2	<0.2	<0.5	<0.5
<157>	I	I	<0.5	1.0	30.5	60.7	<0.2	<0.2	<0.2	2.0	0.8	1.1	<0. I	3.9	<0.2	<0.2	<0.5	<0.5
<157>	I	2	<0.5	0.7	22.7	70.2	0.5	<0.2	<0.2	1.9	0.7	1.0	<0. I	2.4	<0.2	<0.2	<0.5	<0.5
<157>	2	I	1.0	0.8	0.8	0.3	39.8	2.5	0.2	<0.I	53.4	<0.1	<0.1	1.3	<0.2	<0.2	<0.5	<0.5
<157>	2	2	1.7	0.9	7.6	19.6	15.2	1.2	0.9	0.6	49.9	0.3	<0.1	2.2	<0.2	<0.2	<0.5	<0.5
<157>	2	3	1.2	0.7	28.2	62.9	<0.2	<0.2	<0.2	2.7	0.3	1.3	<0.1	2.6	<0.2	<0.2	<0.5	<0.5
< 57>	3	I	0.8	0.6	20.8	71.8	0.4	<0.2	<0.2	1.4	0.7	0.8	<0.1	2.6	<0.2	<0.2	<0.5	<0.5
< 88>	I	Ι	7.3	1.1	9.7	46. I	0.2	0.5	3.0	0.4	30. I	0.4	<0. I	1.2	<0.2	<0.2	<0.5	<0.5
< 88>	I	2	6.8	1.0	10.0	48.0	0.3	0.5	2.3	0.8	28.4	0.4	<0.1	1.6	<0.2	<0.2	<0.5	<0.5
<188>	I	3	7.2	1.3	14.1	52.8	0.3	0.5	2.7	1.0	18.8	0.8	<0. I	0.6	<0.2	<0.2	<0.5	<0.5
< 88>	I	4	4.6	0.8	26.9	51.2	<0.2	0.3	1.0	0.2	14.4	0.5	<0.1	0.3	<0.2	<0.2	<0.5	<0.5
< 88>	2	I	8.1	1.3	13.7	44.9	<0.2	0.4	2.4	0.4	26.3	0.6	<0.1	1.9	<0.2	<0.2	<0.5	<0.5
< 88>	2	2	6.9	1.3	11.1	44.8	<0.2	0.8	2.7	0.4	29.5	0.5	<0.1	2.1	<0.2	<0.2	<0.5	<0.5
< 88>	3	I	8.1	1.1	12.7	47.I	<0.2	0.5	2.4	0.6	24.5	0.5	<0.1	2.6	<0.2	<0.2	<0.5	<0.5
<188>	3	2	8.6	1.1	12.8	45.7	<0.2	0.6	2.4	0.3	26. I	0.5	<0. I	1.9	<0.2	<0.2	<0.5	<0.5
<188>	ext	I	0.6	0.7	27.8	62.6	<0.2	<0.2	<0.2	3.9	0.2	1.0	<0. I	3.2	<0.2	<0.2	<0.5	<0.5
<188>	ext	2	0.5	0.8	37.1	54.6	<0.2	<0.2	<0.2	3.9	0.2	1.3	<0. I	١.7	<0.2	<0.2	<0.5	<0.5
<188>	ext	3	<0.5	0.7	31.0	62.7	<0.2	<0.2	<0.2	2.9	0.2	1.1	<0. I	1.5	<0.2	<0.2	<0.5	<0.5

Normalised results. For the location of the analysed areas, zones and spots, see the figures in the report

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