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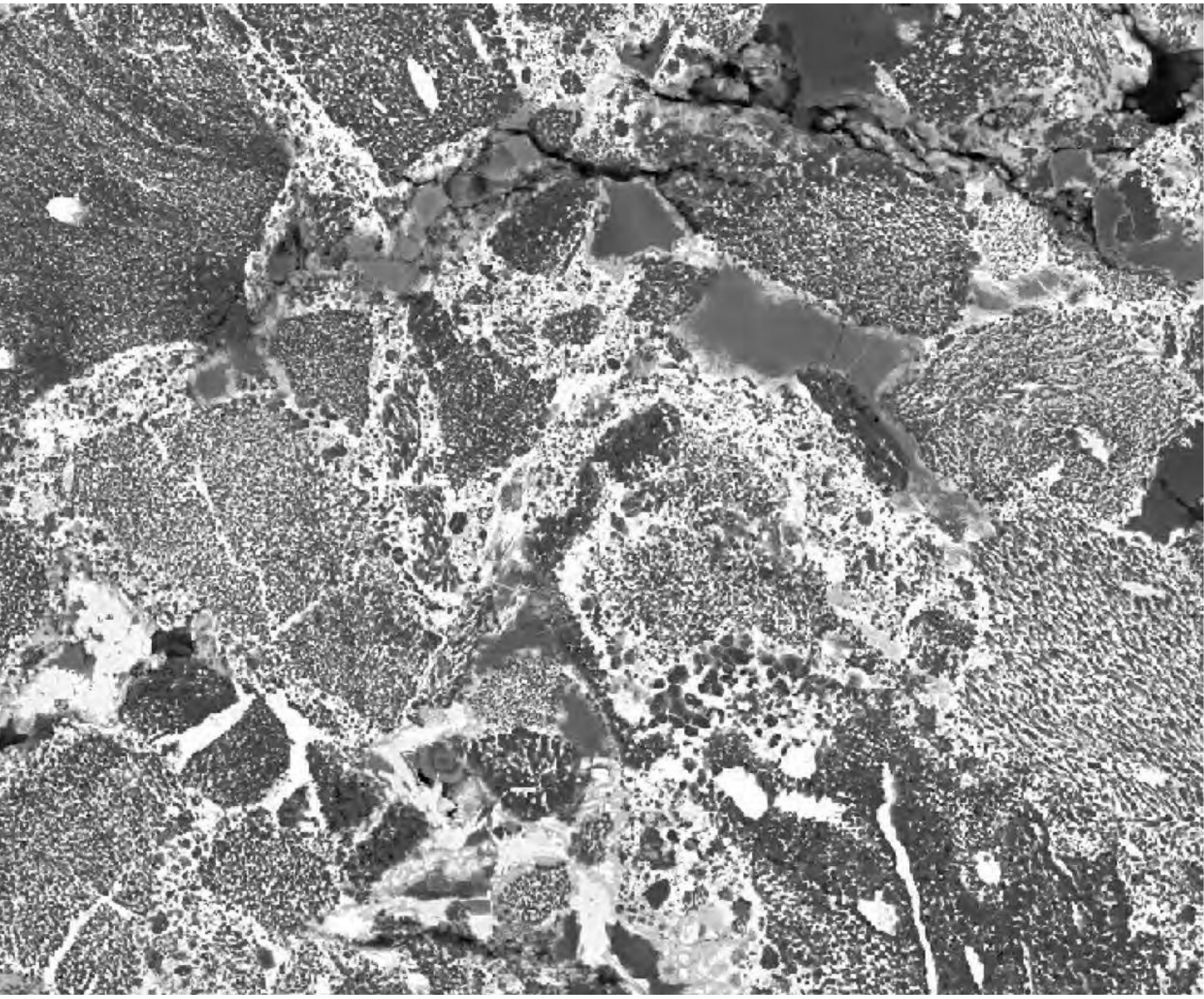
GRANGE ROAD, BERMONDSEY, LONDON
SCIENTIFIC EXAMINATION OF THE CUPELS

TECHNOLOGY REPORT

Harriet White



ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

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Harriet White

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SUMMARY
A number of cupels were recovered from pre-1860s agricultural and horticultural levels during archaeological excavations on a plot of land in Bermondsey, Southwark, London. They were examined using XRF and SEM-EDS to investigate raw materials used in their manufacture and reasons for their use. They were shown to be composed of pure bone ash, and were used for the cupellation of silver in which copper was the main containment.

ACKNOWLEDGEMENTS
Acknowledgements are owed to Robin Densem for making the material available for study.

ARCHIVE LOCATION
The cupels are archived at London Archaeological Archive and Research Centre (LAARC), Mortimer Wheeler House, 46 Eagle Wharf Road, London N1 7ED. The mounted sample is archived at Fort Cumberland, Fort Cumberland Road, Portsmouth, PO4 9LD.

DATE OF RESEARCH
2010

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INTRODUCTION

A collection of ten cupels was recovered from pre-1860s agricultural and horticultural levels during archaeological excavations on a plot of land in Bermondsey, Southwark, London. The excavated area is surrounded by Grange Road to the south and south-west, Alscot Road to the east, Canon Murnane Road to the north and Bermondsey Spa Gardens Recreation Ground to the north east (central NGR TQ 337 790).

This research presents the results of scientific investigations of the cupels undertaken to establish their methods of manufacture and reasons for use, and explores possible explanations for their presence in the archaeological deposits at Grange Road, Bermondsey.

BACKGROUND

Cupels are specialist ash-based vessels used for small-scale cupellation, the metallurgical process by which noble metals are refined and assayed (Bayley 1991, 125; Martinón-Torres *et al* 2009, 436). Impure gold or silver, or a precious metal-carrying ore is melted with lead in oxidising conditions in the cupel. The lead oxidises to litharge (lead oxide) which in turn oxidises the base metal impurities and forms fusible compounds with them. These are absorbed into the porous cupel body by capillary action, leaving behind a discreet button (or *regulus*) of pure gold or silver on the surface.

From as early as the 16th century metallurgical texts such as Ercker's *Treatise on Ores and Assaying* (Sisco and Smith 1951), Agricola's *De Re Metallica* (Hoover and Hoover 1950) and Biringuccio's *Pirotechnia* (Smith and Gnudi 1959)) document the cupellation process, and provide instruction on the manufacture of cupels. According to the authors cupels were manufactured using ground and washed ash that is moistened with a binder and beaten into a mould with a wooden stamp to produce a small vessel with a shallow cavity on the upper surface. The cavity is then faced with finely ground bone ash. Though a variety of ashes (plant, bone and horn), and other raw materials such as clay were used, bone ash was thought to be the most effective material for cupel manufacture. Bone ash was still recommended as the most suitable raw material by the 19th century (Ure 1844, 71). Prior compositional analyses of archaeological cupels reflect these variations. Reported raw materials used by assayers include pure bone ash (the Legge's Mount and Pymont cupels (White 2010; Martinón-Torres *et al* 2009), and bone ash and wood ash mixtures (the Oberstockstall and Montbéliard cupels (Martinón-Torres *et al* 2009, 440).

Cupels are recognised from a growing number of archaeological contexts, and in particular are best known from mints such as Legge's Mount, the Tower of London and Pymont, France, and al/chemical laboratories, for instance the Oberstockstall assemblage, Austria, where they were used for assaying or refining precious metals (Martinón-Torres *et al* 2003; Martinón-Torres and Rehren 2005; Martinón-Torres *et al* 2009; White 2010).

They are also associated with mining sites, such as the Montbéliard cupel, France, where cupellation was undertaken to test the quantity of precious metal carried in an ore (Martinón-Torres *et al* 2008). Additionally, they have been recovered from sites in which they occur as secondary to the primary industry. 45 cupels were, for example, excavated from the 19th-century Isleworth porcelain pottery works, Hounslow, London. In this case it is suggested the unimpregnated ash component of used cupels was recycled, and added as an ingredient to the porcelain paste (Blakelock 2005).

The Grange Road cupels were recovered from fills of agricultural and horticultural features that pre-date the construction of mid 19th-century terrace houses (Maloney 2001). 17th- and 18th-century maps show few properties in the area. Buildings associated with the post-medieval leather industry of Bermondsey (tan yards, fellmongers, glue manufactories and so on) are shown to the north of the present day Spa Road (Roque (1745), reproduced in Whitfield (2006)), and a line of tenement properties (Parker's Buildings) are shown to the east (Horward (1799), reproduced by Douglass (2006)). Greenwood and Greenwood's 1827 map shows more development in the vicinity, with buildings noted as the 'telegraph buildings' to the south and an 'engine manufactory' to the south east, while further domestic properties are shown running parallel to Parker's Buildings. The excavated area was still agricultural land during this period (Greenwood and Greenwood (1827), reproduced by Douglass (2006)). By the 1860's the area had been developed. The 1863/73 Ordnance Survey 25" map shows tenement properties fronting onto Grange Road, Alscot Street, Alfred Street (present day Keyse Road) and Ernest Street (present day Canon Murnane Road). There are therefore no obvious industries or associations within the Grange Road area which may explain the presence of cupels in the deposits.

METHODOLOGY

Exploratory quantitative energy dispersive X-ray fluorescence analysis (ED-XRF) of each of the cupel surfaces revealed them to be lead-rich calcium phosphate, with traces of copper and silver present. A single cupel (GEC00(24), Appendix 1) was sampled for more detailed analysis using a scanning electron microscope with attached energy dispersive X-ray analytical facilities. Sample preparation followed the standard protocol of mounting the cupel section in epoxy resin and polishing the surface to a 1µm finish. The SEM used was a FEI Inspect F which was operated at 25kV with a beam current of approximately 1.2nA. The X-ray spectra were detected using an Oxford Instruments X-act SDD detector, the elements quantified using the Oxford Instruments INCA software and a cobalt standard was used to calibrate the spectra. Since ED X-ray spectrometry provides no direct information on the valence states of the elements present in the analysed material, appropriate valence states were selected and the oxide weight percents were calculated stoichiometrically. Spectra were collected from areas approximately 1 x

1.5mm in size in points from the top centre of the cupel to the cupel base. Analytical totals were normalised to 100wt%.

RESULTS

Table 1 shows the bulk chemical composition of the cupel. Oxides on the left-hand side are associated with raw materials used in manufacture and those on the right-hand side are contaminants related to use. Lead oxide is the primary metal oxide related to use, making up to 43wt% of the total cupel composition. It is more concentrated in the cupel centre (Table 1, Areas 4 and 5; Figure 1, top). Copper and silver are also present in trace amounts (<1.0wt%) confirming that silver with copper as the main impurity was being refined. Other element oxides, such as arsenic, tin and antimony oxides, which have been detected in used cupels in past analyses (for example Martinón-Torres *et al* 2009) were absent.

Microscopic examination of a small unimpregnated area at the base of the cupel revealed it to be composed of angular to sub-rounded fragments of calcined bone, up to 300µm in size in a fine ash matrix (Figure 1, bottom). Further investigations were carried out to determine if the bone ash was mixed with an 'excipient' such as wood ash or clay, and to establish whether the composition is consistent through the cupel body. The standard method to resolve raw material compositions of used cupels is to subtract the element oxides related to use from the total composition and normalise the remaining element oxides to 100% (for example Martinón-Torres *et al* 2009, White 2010). While analytical error may be intensified using this method, the re-normalised composition should approximate the original cupel composition. In applying this method to the Grange Road cupel, it can be seen that it is composed of >96.8wt% calcium phosphate. (Table 2), and so was manufactured using pure bone ash. Additions of a plant ash or clay excipient would increase significantly concentrations of element oxides such as silica, alumina and magnesium oxide (for example Martinón-Torres *et al* 2009, 440; White 2010, 6). The minor increase in magnesium, aluminium and iron oxides at the cupel base in comparison to its upper surface is more likely to be the result of experimental error, than any real difference in raw materials through the cupel body.

Table 1. Composition of cupel GEC00(24), determined by SEM-EDS.

	Oxides related to cupel manufacture							Oxides related to contamination through use		
Area	Na_2O_3	MgO	Al_2O_3	SiO_2	P_2O_5	CaO	Fe_2O_3	CuO	Ag_2O	PbO
1 (top)	0.2	0.2	0.1	0.7	30.1	40.5	–	0.6	0.8	26.9
2	0.2	0.1	–	0.6	26.4	34.5	–	0.9	0.9	36.3
3	0.2	0.2	0.1	0.5	23.7	34.5	–	0.8	0.5	39.6
4	0.2	0.2	–	0.7	21.8	33.1	–	0.6	0.2	43.1
5	0.2	0.2	0.1	0.8	21.2	33.9	0.1	0.5	–	43.2
6	0.3	0.2	0.1	0.7	22.3	33.3	–	0.6	–	42.6
7	0.1	0.2	0.1	0.7	23.9	35.9	0.0	0.6	–	38.5
8	0.2	0.3	0.2	0.6	27.2	35.5	0.3	0.3	–	35.8
9	0.4	0.3	0.2	0.7	28.7	37.8	0.4	0.2	–	31.3
10 (base)	0.3	0.4	0.4	0.9	35.3	46.6	0.5	0.1	–	15.6
Mean	0.2	0.2	0.1	0.7	26.1	36.6	0.1	0.5	0.2	35.3
Sdev	0.1	0.1	0.1	0.1	4.4	4.2	0.2	0.2	0.4	8.7

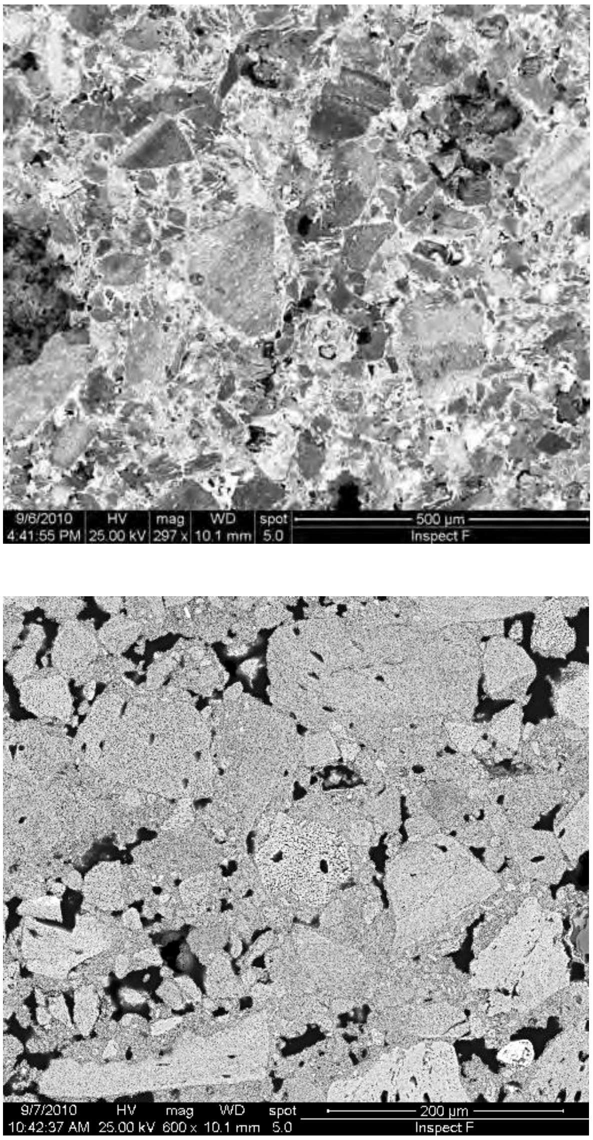

Figure 1. SEM micrographs of cupel GEC00(24). The top image shows the impregnated cupel with the light-coloured, inter-granular areas rich in lead. The scale bar is 500µm. The bottom image shows the unimpregnated base area, with calcined bone grains visible in a fine bone-ash matrix. The scale bar is 200µm.

Table 2. Recalculated cupel composition of the original cupel matrix. The last column gives calcium phosphate concentrations.

Area	Na_2O_3	MgO	Al_2O_3	SiO_2	P_2O_5	CaO	Fe_2O_3	CaO+ P_2O_5
1(top)	0.3	0.2	0.1	1.0	41.9	56.4	0.0	98.3
2	0.3	0.2	0.0	1.0	42.7	55.8	0.0	98.4
3	0.3	0.4	0.2	0.8	40.1	58.2	0.0	98.3
4	0.4	0.4	0.1	1.2	38.9	59.0	0.0	97.9
5	0.3	0.4	0.1	1.4	37.6	60.1	0.1	97.7
6	0.4	0.3	0.1	1.2	39.2	58.7	0.0	97.9
7	0.1	0.3	0.2	1.1	39.3	59.0	0.0	98.3
8	0.2	0.5	0.4	0.9	42.4	55.3	0.4	97.6
9	0.5	0.5	0.6	1.1	41.8	55.0	0.5	96.8
10 (base)	0.4	0.5	0.4	1.1	41.9	55.2	0.6	97.0
Mean	0.3	0.4	0.2	1.1	40.6	57.3	0.2	97.8
Sdev	0.1	0.1	0.2	0.2	1.8	1.9	0.2	0.6

DISCUSSION

The analytical results show the Grange Road cupels were manufactured from pure bone ash without additional excipients, and were used to refine silver whose main contaminant was copper. As previously noted, cupels are diagnostic of precious metal assaying or refining (in this case silver) and are normally recognised from specific sites such as mints, al/chemical laboratories or mining sites. Since the Grange Road cupels were excavated from agricultural and horticultural levels a point of interest with this collection is who the users might have been. The cupels were recovered from several different contexts (Table 3). They were found within fills of pits and in deposits below them demonstrating their disturbance through agricultural activities from their original place of deposition. A cartographic review showed there were few buildings in the immediate vicinity of the excavated site during the 18th century, and certainly nothing is apparent that might be related to precious metal working activities.

Table 3. Contexts descriptions for the Grange Road cupels.

Cupel GEC00:	Context	Description
2	100	Trench cleaning
3, 22, 25	116/141/212	Contexts 116/141/212 are interpreted as being the same fill of a large pit cut (117/211) which measured 10.8m x 2m wide x 0.9m deep (feature and fill was exposed in two trenches).
20, 23	157	Layer below 117 interpreted as garden soil
27	273	Post-medieval earth sealed by several layers and a garden wall, and truncated by feature 211
26	286	Deposit adjacent to cut 117, but with no definite relationship. The deposit is interpreted as plough soil.
24	203	Fill of pit cut 217
28	327	Layer below pit cut 217

There are, however, two possible sources for the cupels slightly further afield. The first is a sub-mint, supplementary to the Tower of London mint that was established at Suffolk Place in 1545. The Suffolk Place mansion fronted Borough High Street which is approximately 1.6km to the north-west of the excavated area, and the estate had substantial enclosed lands. The mint lasted only six years, closing in 1551 (Maldon 1912; Darlington 1955). Like the Grange Road cupels, the cupels from the Tudor mint at the Tower of London were manufactured using pure bone ash, and were used for assaying silver with copper as the main contaminant (White 2010). Though some distance from the site of the main buildings of the estate, it is possible the cupels from the Grange Road area residual from an episode of dumping of industrial waste from the sub-mint.

By the late 17th and early 18th centuries, the Suffolk Place estate was built up with tenements and cottages and had become a notorious slum area known as The Mint. The inhabitants of The Mint claimed immunity from liability of arrest within the bounds of the area due to its status as a ‘liberty’, and had a reputation as a resort of coiners and thieves (Malden 1912, Darlington 1955). Coiners illegally clipped the edges of gold and silver coins and the metal would be melted down and to make new money. Thus illicit precious metalworking was carried out within a mile of the Grange Road site, and may also be a source for the cupels. Possible evidence for unlawful precious metalworking has previously been recognised in London by the presence of early 19th-century gold-melting crucibles in a sealed cesspit within the infamous Wild Court slum (Dungworth 2010).

The analytical results presented are consistent with prior analyses of archaeological cupels, and some possible explanations have been provided for their presence in an atypical archaeological context.

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Appendix I

Catalogue of Grange road cupels.

Sample: GEC00(2)
Colour: grey body with white base
Diameter: 27.5mm
Max. Height: 17.1mm
Weight: 20.12g
Comment: the surface and walls are hard and smooth, the base is flat, hard and granular. A circular mark is visible in the centre of the upper surface. The cupel is used but not fully impregnated.

Sample: GEC00(3)
Colour: pale grey body with white base
Diameter: 27.9mm
Max. Height: 20.7mm
Weight: 26.04g
Comment: the surface and walls are hard and smooth and a circular mark is visible in the centre of the upper surface. The base is flat, smooth and friable. The cupel is complete and used but not fully impregnated.

Sample: GEC00(20)
Colour: grey body with white base
Diameter: 27.3 mm
Max. Height: 16.6mm
Weight: 20.35g
Comment: the surface and walls are hard and smooth, the base is rounded, hard and granular. The cupel is used but not fully impregnated.

Sample: GEC00(22)
Colour: grey body with white base
Diameter: 27.8 mm
Max. Height: 16.0mm
Weight: 16.96g
Comment: the surface and walls are hard and smooth, the base is rounded, granular and friable. The cupel is used but not fully impregnated.

Sample: GEC00(23)
Colour: grey body with white base
Diameter: 29.6mm
Max. Height: 15.2mm
Weight: 19.08g
Comment: the surface and walls are hard and smooth, the base is flat, granular and friable. A circular mark is visible in the centre of the upper surface and the cupel is cracked throughout its body. It is used but not fully impregnated.

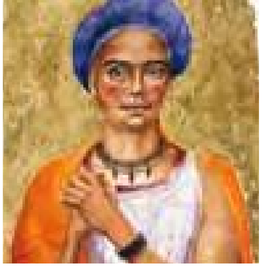
Sample: GEC00(24)
Colour: grey body with white base
Diameter: 29.6mm
Max. Height: 13.2mm
Weight: 19.93g
Comment: the surface and walls are hard and smooth, the base is flat, granular and friable. A circular mark is visible in the centre of the upper surface. The cupel is used but not fully impregnated.

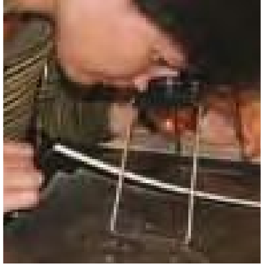
Sample: GEC00(25)
Colour: grey body with white base
Diameter: 28.1mm
Max. Height: 18.3mm
Weight: 23.59g
Comment: the surface and walls are hard and smooth, the base is flat, granular and friable. A circular mark is visible in the centre of the upper surface. The cupel is used but not fully impregnated.

Sample: GEC00(26)
Colour: grey body with white base
Diameter: 28.0mm
Max. Height: 21.4mm
Weight: 23.23g
Comment: the surface and walls are hard and smooth, the base is rounded, granular and friable. A circular mark is visible in the centre of the upper surface. The cupel is used but not fully impregnated.

Sample: GEC00(27)
Colour: grey body with white base
Diameter: 27.8mm
Max. Height: 29.2mm
Weight: 23.09g
Comment: the surface and walls are hard and smooth, the base is angled, flat, granular and friable. A circular mark is visible in the centre of the upper surface. The cupel is used but not fully impregnated.

Sample: GEC00(28)
Colour: grey body with grey base
Diameter: 27.8mm
Max. Height: 11.0mm
Weight: 16.02g
Comment: the surface and walls are hard and smooth, the base is flat, granular and hard. The cupel is used, and what survives is fully impregnated.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