

TECHNOLOGICAL SAMPLES FROM BARNARD CASTLE, CO DURHAM

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The material examined comprised Ancient Monuments Laboratory numbers 817085-104, 818065-144, 818171-204 & 820212-4. It consisted of metals, crucible fragments, glass, brick and stone, slags, coal, charcoal and clinker. The crucible fragments all came from areas 5 and 6, the inner ward of the castle.

All the crucibles are of a similar type, cylindrical, with near straight sides rising from a circular base which is flat on the outside but rounded inside. The rims are flat with some sort of a lip (see Fig 1) which can be of two types; either a small, pinched-out spout (see fig 2) or the whole side may be pulled out to form a larger, more triangular pouring lip (see fig 1 b). All but one of the lips are of the first type, 5511 BFB being the only example of the second.

The fabrics of the crucibles are either black or a buff/yellow colour. The black fabric is fine-grained with few inclusions and a slightly "glittery" appearance, possibly due to the inclusion of graphite. The buff fabric is medium-coarse grained with some larger inclusions. Two sizes of crucible are present in both fabrics. In the black fabric, crucibles are either 100mm in diameter, with walls 8-10 mm thick (thickening slightly at the top), or about 80mm in diameter, with walls about 12mm thick, (see figs 2 and 3). The buff/yellow crucibles are either 100mm diameter with walls 17-18mm thick, or 120 mm diameter with walls 10-11 mm thick (see figs 1 and 4). None survive intact, but the height of all the crucibles would probably have been between 200-300mm.

The metals found on the crucibles are all mixed copper alloys. They contain zinc, lead and tin, some show a significantly high proportion of tin, some of zinc, indicating that both bronze and brass were being melted, as well as gunmetals containing all the alloying elements. There was no correlation between the size or

type of crucible and the traces of metal which it contained. Analysis of the metals present was done using x-ray fluorescence analysis, which is a qualitative rather than quantitative method, but gives a good idea of the proportions of each element present within the alloy.

The copper alloy fragments have similar compositions to the traces in the crucibles; copper with lead, zinc and tin in all of them. Some were higher in zinc, others in tin. The same was true for the copper alloys found in the fuel ash slags.

The slags fall into three categories; iron tap slag, iron smithing slag and fuel ash slag. Iron tap slag is formed when the slag is run off from the bottom of a smelting furnace. The fluid nature of the molten material makes it flow and as it cools, the tap slag retains this "liquid" shape; bubbles inside the tap slag are large, where the gases were trapped. The slag is smooth and black in appearance. Very few fragments of tap slag were found; if any smelting had been done on the site, there would be great quantities of the slag, so these few pieces were probably brought in from elsewhere.

The iron smithing slag has a dark brownish-grey spongy appearance when broken. It is formed by the small droplets of slag that are squeezed out of the metal in the forge collecting in the base of the hearth. Some of the lumps of slag have a plano-convex shape, mirroring the shape of the hearth.

Another by-product of smithing is hammer scale, small magnetic flakes of iron oxide (some was found in sample 7251 EAA). An oxide layer forms on the surface of iron when it is heated in a forge, then flakes off as it is hammered. Hammerscale can be found as discrete flakes, but is also incorporated into the iron-rich fuel ash slags.

Fuel ash slags are produced at high temperatures when the (alkaline) ash from the fuel reacts with the silicates in stone, clay or earth to form a glassy slag. This is why glazed stones appear amongst the material from hearths. The fuel ash slag which is most commonly found from Barnard Castle is very spongy and porous, Pieces which have a more definite form include partially vitrified clay or earth from the lining of the hearth, which look like well fired daub with one glassy surface. Metals split during melting may be trapped in the slag; iron, lead and copper alloys were all found in the slags. Also found were "dribbles" and lumps of copper alloy, lead and iron, which had been dropped during the process of working them. One sample, 7103 ElS, is a tuyere, a piece of hearth lining that was shaped to take the end of the bellows which was directed into the fire. The diameter of the hole is 70mm, a larger size than is usually found.

As has been mentioned, some evidence for the melting of lead (as well as copper alloys) was found amongst the material. This may have been the reworking of lead for repairs, for example to roofs or pipes. One lump of what appeared to be partially-smelted galena was found, so it is just possible that lead ores were being smelted at Barnard Castle.

There is evidence that the metal working hearths were built of mortared brick and stone. There are two types of brick amongst the samples; one is a very coarse - grained pale yellow fabric, with large inclusions of grit. These bricks are very regular in size, being 55mm thick. One example of a specially shaped brick of this kind was found, being 53mm thick.

The other bricks vary in colour from pink-brown to a bright orange, depending upon the amount of firing they have had. They range in thickness from 49-52mm. Some of the bricks have mortar clinging to them, or are joined by mortar with fuel ash slag attached. Slag is also found formed in the shape of the outline of the bricks, indicating their proximity to the fire. Burnt stones and shaped natural stones

were also found; the shaped red sandstone was probably incorporated into the structure of a hearth. A couple of pieces of tile (22-24 mm thick) were also found, with incised grooves on them.

The fuel used in the fires was either coal or charcoal, samples of both have been found. Flecks of charcoal cling to the lead bearing fuel ash slag and some of the iron smithing slags. As well as the unused coal, part-burned coal, called clinker in the descriptions which follow, was also quite abundant. It is formed when the coal is roasted and not totally burnt and is very light and porous.

Metal objects from amongst this material included iron and copper alloys. A small button made of brass was found (copper, significant amounts of tin, zinc and lead). Iron objects were very corroded, and include nails, an egg-shaped loop or ring, and possibly a buckle.

The "glazed stone", "glass wasters" and "burnt daub" samples were given individual AM Lab Nos (81871-204) so these numbers rather than the site codes are used to identify individual samples. All the glazed stones (with the exception of AM 818173 which is a piece of hearth lining) were exactly that. They had acquired their glassy coating by being heated strongly in contact with the ash in a fire. The necessary high temperatures could have been found in a metal-working hearth or even perhaps in a fire that burnt down a building.

The "glass wasters" (AM 818184 - 200) were a less homogeneous group; individual descriptions are given in the table of identifications, below. They included three smallish pieces of blast furnace slag which are by-products of a more advanced iron smelting process than the tap slag mentioned above. The small quantity of material suggests they were imports to the site and should not be taken as evidence for on site smelting.

There were also two dribbles of glassy fuel ash slag but most of the rest of this group of finds appears to be deliberately made glass. The irregular shapes and range of colours are probably the results of accidental remelting eg. from burning rubbish or burning down a building. The colourless lead glass probably came from a lead crystal drinking glass (this type of glass was developed in England in the 17th century). The "colourless" glass is slightly greenish and could have been window glass or common vessel glass.

The "burnt daub" (AM 818201-4) were pieces of red-fired clay. No original surfaces were noted so no original shapes or uses can be suggested. AM818202 was very firable and not well fired, AM818201 and 818204 were a little harder and AM 818203 was of a much harder and coarser fabric; it could even have been a burnt stone fragment.

Three sherds, AM 820213-5 do not appear to have been used in metalworking; they are completely different from any of the other material examined. The fabric is too fine to be a crucible fabric, and they are not reduced fired. Sherds AM 820213 (BC78BPV) and AM 820214 (BC 78 BZH) are part of the same vessel. The fabric is pinkish-buff, with small-medium grains of a sandy inclusion. There is partial vitrification on the internal surfaces, with the appearance of a green-grey glaze.

The pot seems to have been wheel-turned and has a dished base, with an out-turned rim. The sides are curved, to give a rather bulbous shape to the pot. The external diameter is 47.5 mm and the walls 4mm thick. X-ray fluorescence detected high amounts of lead, traces of iron but no copper, zinc or tin on the internal surface. This suggests that the inside of the pot was lead glazed but overheating had caused the glaze to deteriorate.

Sherd AM 820215 (BC APV 4072) is a flat base from a pot of diameter 32mm. It is a white-pink fabric, even finer than that of AM 820213-4, with fewer inclusions and walls 2.8mm thick.

X-ray fluorescence detected no copper, zinc or tin, but traces of iron and a high amount of lead were present. The deposit on the inside of the pot is a thick, dullish grey vitreous layer. It is probably a lead glaze which has been overheated and has slid down the pot to settle at the bottom.

IDENTIFICATION OF SAMPLES FROM BARNARD CASTLE

Area 1

<u>Context No</u>	<u>Tray No</u>	<u>Identification and comments</u>
674	PE	Vitrified fuel ash slag
518	CD	Iron tap slag-Spherical "blob"
674	OF	Fuel ash slag-iron
551	JF	"Clinker"
536	EP	Iron smithing slag
678	SR	Fuel ash slag - iron
606	JO	Fuel ash slag - iron
678	RF	Fuel ash slag
520	BF	Iron smithing slag
679	RJ	Fuel ash slag - iron
562	FR	Fuel ash slag - iron
677	RG	Fuel ash slag - iron
547	EX	Fuel ash slag - from hearth base
526	BC	Fuel ash slag
668	OD	Iron smithing slag
680	SH	Coal

Area 2

1095	UT	Vitrified fuel ash slag
1133	YP	Fuel ash slag - iron

Great Moat

2124	ETC	Corroded iron fragments
2124	AQG	Fuel ash slag - stone incorporated
2116	AZH	Iron smithing slag
2127	ETD	Fuel ash slag
2120	AOT	Coal
2125	ANP	Coal
2124	ETC	Fuel ash slag

Wet Moat

76	DM	Coal
123	PT	Coal
126II	RX	Clinker

Middle Ward Gatehouse

3005	ACS	2 tiny frags. Fuel ash slag
3014	AMQ	Clinker and coal

Area 3

4089	ASV	Stone with vitrified surface; corroded iron frag
4003	ASF	1 frag. fuel ash slag; 1 frag Cu alloy
2208	DTO	Iron smithing slag
2256	DSM	Frag decayed iron (bone stuck to it)
2082	DMK	Corroded iron
2276	FDD	Corroded iron - possibly nail
2210	DXT	Fuel ash slag - iron
4076	AXC	Fuel ash slag

Area 3 contd

<u>Context No</u>	<u>Tray No</u>	<u>Identification and comment</u>
2270	DVN	Corroded iron - nail?
4060	ARG	Fuel ash slag
4003	AIR	Fuel ash slag
2206	DMM	Corroded iron
2214	DNI	Vitreous fuel and slag
2254	DTM	Corroded iron frag
2088	AHI	(Fuel ash slag (Traces Cu alloy - Traces Sn, Pb, Zn
Unstratified	DOA	Iron smithing slag
4089	ATD	Fuel ash slag
4003	ASH	Fuel ash slag and coal
4089	ASM	Fuel ash slag; cu alloy - Zn, Sn and Pb
4088	ASL	Fuel ash slag
2251	DSO	Corroded iron
4035	AVI	Fuel ash slag
4078	ASX	Iron tap slag
2254	DTA	Corroded iron
2254	DQL	Corroded iron and fuel ash slag
4046	AVU	Coal
4508	ATZ	Coal
2093	BAO	Coal
4074	DNN	Coal
Unstratified	FDT	Coal
2081	DOO	Coal
4060	ARG	Clinker
4114	AZD	Coal and Clinker
2210	DYT	Clinker
4039	APX	Clinker
4019	APD	Clinker
4030	AKV	(Bronze frags; small button, ("Lump" of Cu alloy (XRF: - Cu, Zn, Pb, significant Sn
4021	AJP	Fuel ash slag
4019	AKX	Fuel ash slag - Cu alloy
4030	AKS	Fuel ash slag; corroded bronze
4028	AJO	Fuel ash slag; metals Cu alloy
Unstratified	BAM	Fuel ash slag

Area 5

5516	BMO	3 frags. Crucible; 2 buff 18mm thick 1 black 6mm
5517	BIO	(Crucible - buff 17mm. Cu alloy
5516	BMP	(Crucible base (flat-based) (buff fabric - 18-19mm Cu alloy
5815	EIY	(Crucible lip - yellow buff fabric (Cu alloy; 8mm thick
5511	BFB	2 Part crucibles; a) whole base or part of sides, 11mm thick black fabric. Cu alloy b) side of crucible
(lip)		10mm thick. 136mm long
5509	BEO	Brick from furnace
5518	BGV	Corroded metals
5516	BIP	Fuel ash slag. Traces of metals
5516	BJV	Fuel ash slag; Traces of Cu alloy - Zn, Pb and Sn
5516	BNJ	Fuel ash slag; Cu alloy
5516	BFV	Fuel ash slag
Unstratified	CTY	Metals - Cu alloy, Zn, Pb, Sn detected

unstratified	CVA	(Fuel ash slag - shaped by bricks. Corroded Cu alloys.
5515	BGA	Iron lump - XRF; nearly all Fe
5532	BKA	(Fuel ash slag (Cu alloy
5266	ETP	iron object - very corroded
5255	ETG	Corroded iron
5091	BPK	Fuel ash slag
5527	BIY	Fuel ash slag - Lead
5176	DIK	Lead fragments
5165	BXM	Lead "dribbles"
5516	BFT	Iron smithing slag - shaped to hearth base; charcoal fragments
576		
5217	FCW	Iron tap slag
5656	EIW	Natural rocks

Area 6

6302	CSM	Crucible; part vitrified buff fabric 18mm thick. Cu alloy - high zinc, traces of lead and tin.
Unstratified	FDK	Crucible; black fabric 10mm thick. Cu alloy - high zinc and lead, traces of tin.
6533	FFU	Crucible; buff fabric 9-10mm thick. Cu alloy - Zn, Sn, Pb.
6545	FBA	Crucible; some frags in buff fabric, same in black; one frag is a lip. Cu alloy, Zn, Pb, Sn
Unstratified	EZK	Crucible - 1 frag of lip and 4 frags of black fabric Cu alloy
6303	CSP	numerous frags of crucible 2 buff frags of lip 3 other buff frags. partially vitrified 1 black fabric fragment Base - Cu alloy, high zinc
6301	CVA	Crucible, buff fabric 18mm
Unstratified	FBS	Crucible, black fabric 12-13mm
6303	CST	Crucible; Black fabric 10mm Cu alloy high Sn; Pb Zn
Unstratified	FCX	Crucible base - buff fabric, vitrified. Cu alloy; Zn, Sn, Pb.
6507	EVE	Crucible, black fabric
6505	EUA	Crucible, buff fabric, vitrified. Cu alloy high tin; Pb and Zn.
Unstratified	FAE	Crucible frags. buff and black fabrics. Also some fuel ash slag with traces Cu alloys
6507	EVN	Crucible frags.
397 6507	EVN	(Crucible frag. buff fabric (Cu alloy (with Zn, Sn, Pb)
392 6507	EVN	(Crucible frag. buff fabric (Cu alloy (with Zn, Sn, Pb)
398 6507	EVN	Part of Crucible base - buff fabric 18mm thick. Cu alloy (Zn, Sn, Pb)
6545	FB4	Brick; coarse pale fabric
6507	EWJ	2 metal "dribbles"
6319	CZH	Cu alloy ; high zinc, traces Pb and Sn Frag of spilt metals; very corroded and stuck to lump of fuel ash slag. An alloy (Pb, Zn, Sn)
6315	CZF	?Part smelted Galena - flecks of charcoal on the surface.
6031	CTX	Crucible - 1 frag black, very corroded. 1 frag buff, 17mm, Cu alloy; Pb, Zn, Sn.

Area 6 continued

6573	FCV	Fuel ash slag; visible traces Cu alloy (Zn, Sn, Pb)
6303	CST	Fuel ash slag; traces of metals - very high copper content
6315	CZO	Vitrified fuel ash slag. Traces of copper alloy.
6572	FBI	Fuel ash slag. Traces of copper alloy.
6507	EVE	Fuel ash slag with a very high lead content.
6507	EVE	Fuel ash slag no traces of metals.
405 6507	EVE	Fuel ash slag, with stone incorporated and a bag of coal
6545	FBA	8 pieces of brick and stone (see report on brick)
6561	EKB	15 Pieces of brick, tile, stone and some fuel ash slag. (see report on brick).
6206	EDQ	Fuel ash slag with Cu alloy
Unstratified	DKW	Fuel ash slag - Cu alloy (Zn, Sn, Pb)
6507	EZF	Vitrified fuel ash slag; brick-coarse, pale fabric with mortar. Traces of metals on fuel ash slag.
6507	EVW	Brick - 2 of coarse, pale fabric, 2 of red brick.
6507	EVT	Red-brown brick
6507	EWJ	Pink-brown brick
6507	FAR	1 piece of sandstone, 1 of brick
6516	EXO	Coal
6523	EWF	Coal
6525	EWW	Coal
6045	ELC	Charcoal
6368	EJE	Charcoal
6587	FEB	Coal
6158	DCI	Charcoal
Unstratified	ENE	Coal
Unstratified	FGI	Coal
6520	EVE	Coal
6586	EXW	Coal and Charcoal
6527	EXJ	Coal and Clinker
6527	EXB	Charcoal and Clinker
6515	EYX	Fuel ash slag; coal; Clinker
6001	EXS	Coal and corroded iron object
6016	DBS	Coal
6531	EZS	Coal
6507	EVN (5 bags)	Clinker, fuel ash slag with Copper alloy, coal, corroded iron nail, shell and charcoal
6507	EUK	Burnt stones
6531	EYZ	Coal and Clinker
6507	EWJ	Fuel ash slag
6587	FEA	Charcoal
6513	EUU	Clinker
6507	EVW	Fuel ash slag
6545	EZX	Fuel ash slag
6513	EXI	Clinker
6587	FFT	Charcoal and corroded iron object
6587	FDC	Clinker and Charcoal
Unstratified	EZE	Fuel ash slag with copper alloy
6540	EYS	Iron smithing slag and lump of coal
6507	EZI	Fuel ash slag and chalk frags and Cu alloy
6156	DHD	Very pale fuel ash slag
6528	EXA	Clinker, with traces Cu alloy
Unstratified	FAS	Fuel ash slag, traces Cu alloy
Unstratified	EEA	brick
6592	FDN	Clinker
6159	EQI	Clinker
6516	EYW	2 frags clinker and 1 of coal

Area 6 continued

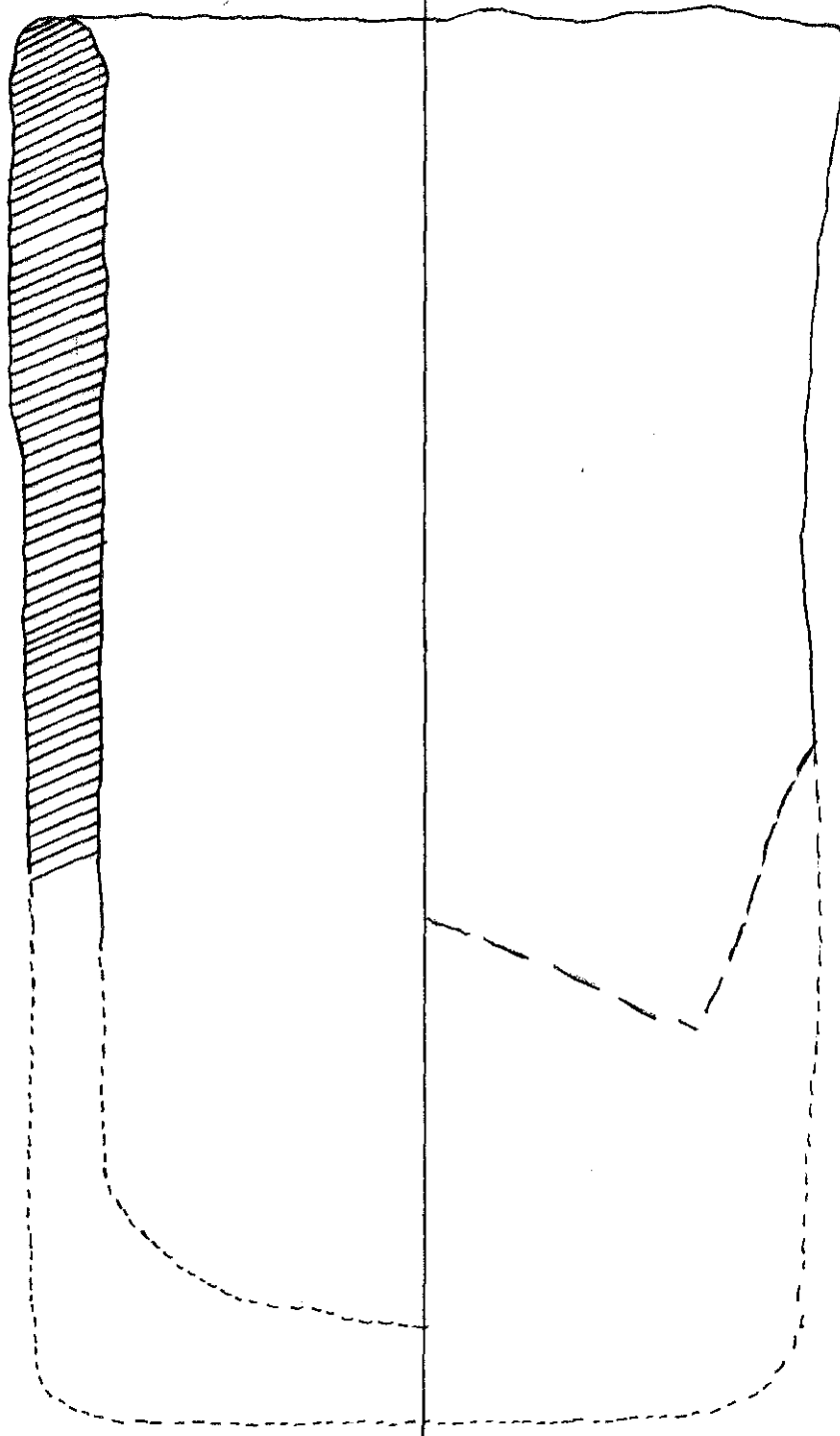
6531	EZH	1 frag clinker 1 of coal
6515	EZV	Fuel ash slag
6529	FAD	Fuel ash slag; traces Cu alloy
6516	EVG	Clinker
6513	EYM	Clinker
6303	CST	Fuel ash slag; out with large amount of copper alloy
6569	FBG	Fuel ash slag with a stone
6507	EZC	Fuel ash slag with copper alloy
6153	EFQ	Fuel ash slag
6513	EYT	Clinker
6363	EED	Fuel ash slag
6122	DCK	Very corroded iron object; possibly a ring?
6527	EXB	Iron object?
6513	EVY	Very corroded iron object
6587	FDC	Fuel ash slag (iron)
6171	EBM	Lead
6253	ERZ	Fuel ash slag (iron)
6215	ETU	Corroded iron and fuel ash slag (iron)
6587	FDP	Wood preserved by iron oxides fuel ash slag
6600	FEQ	Fuel ash slag - iron
6362	EEX	Iron object?
6628	FGL	Iron object
6343	EFC	Fuel ash slag and iron
6045	CZN	Iron object (very corroded)
6209	ETW	Fuel ash slag - iron
6053	CHG	Vitrified fire clay
6160	FAV	Fuel ash slag - iron and iron object
6315	CZG	Fuel ash slag - iron
6137	CTJ	Iron Tap slag
6159	ENS	Fuel ash slag
6587	FDP	Fuel ash slag
6120	CQG	Iron
406 6160	EWS	Iron Tap slag
497 6248	FBC	Fuel ash slag
498		Tap slag
7270	EBE	Fuel ash slag and metal (Cu alloy)
7265	EBB	Corroded Cu alloy Zn, Sn, Pb
7024	EAM	Small frags. corroded Cu alloy Zn, Sn, Pb
7034	CWH	Lump Cu alloy Zn, Sn, Pb
7103	EIS	Fuel ash slag an vitrified clay, showing the shape of the hole for bellows, 70mm diameter (Tuyere)
7285	EBG	Fuel ash slag
7230	DYP	Fuel ash slag
7024	EAM	Corroded iron object? nail
7175	DQW	Iron smithing slag
7265	EAT	Corroded iron object ? buckle
7009	DXG	Fuel ash slag and iron 2 corroded nails stuck together
7175	EBQ	iron smithing slag;
7103	DAJ	Iron smithing slag; characteristic "curved" shape of the hearth base
7079	DIM	Iron smithing slag
7231	DYB	Corroded iron ?nail with wood and fuel ash slag
7149	DNC	Iron smithing slag
7175	DUT	Iron smithing slag
7095	EBN	Iron smithing slag and lump of corroded iron
7231	DXN	Fuel ash slag; fire clay and iron- vitrified together

Area 6 continued

7034	DUU	Corroded iron ?nail
7270	EBE	Fuel ash slag
7103	DVQ	iron smithing slag
7248	DYY	Fuel ash slag
7201	DSJ	Corroded iron object
7282	EBJ	Corroded iron object
7095	EAY	Iron smithing slag
7251	EAA	Box full of fuel ash slag and few lumps of coal and a couple of pieces of shale. Also hammer scale (iron oxide) from the surface of iron being worked. These are hammered off during the smithing process.
7154	DNX	Iron smithing slag
7201	DYX	Burnt natural stone, covered in mud.
7216	DZL	Fuel ash slag
7154	DPT	Iron smithing slag
7175	DTZ	Fuel ash slag and frag of shale
7154	DUX	Iron smithing slag

<u>AM LAB NO</u>	<u>DESCRIPTION</u>
818184	Dribble of "colourless" glass
185	Droplet of colourless lead glass
186	Dribble of fuel ash slag
187	Droplet of "colourless" glass
188	1) Piece of blast furnace slag 2) Dribble of very bubbly green glass 3) Lump of milky glass
189	Weathered, irregular lump of "colourless" glass
190	Dribble of milky lead glass
191	Irregular piece of "colourless" glass
192	Distorted glass vessel sherd; brown in parts
193	Droplet of "colourless" glass
194	Piece of blast furnace slag
195	1) Stone with glassy coating 2) Irregular lump of olive glass, deeply weathered
196	Dribble of "colourless" glass
197	Dribble of dark olive brown glass
198	Dribble of fuel ash slag
199	Piece of blast furnace slag
200	Blue glass cabochon, probably a "stone" from eg a ring

BARNARD CASTLE - CRUCIBLES



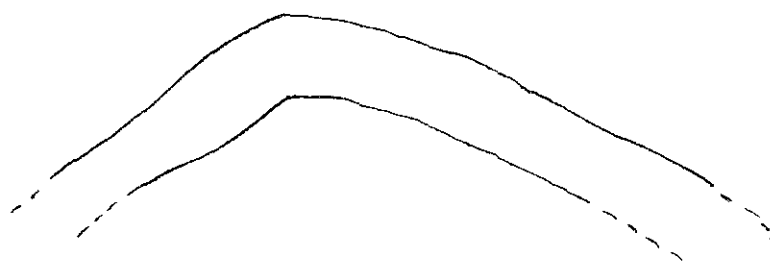
5511 BFB

yellow/buff fabric

10mm thick walls

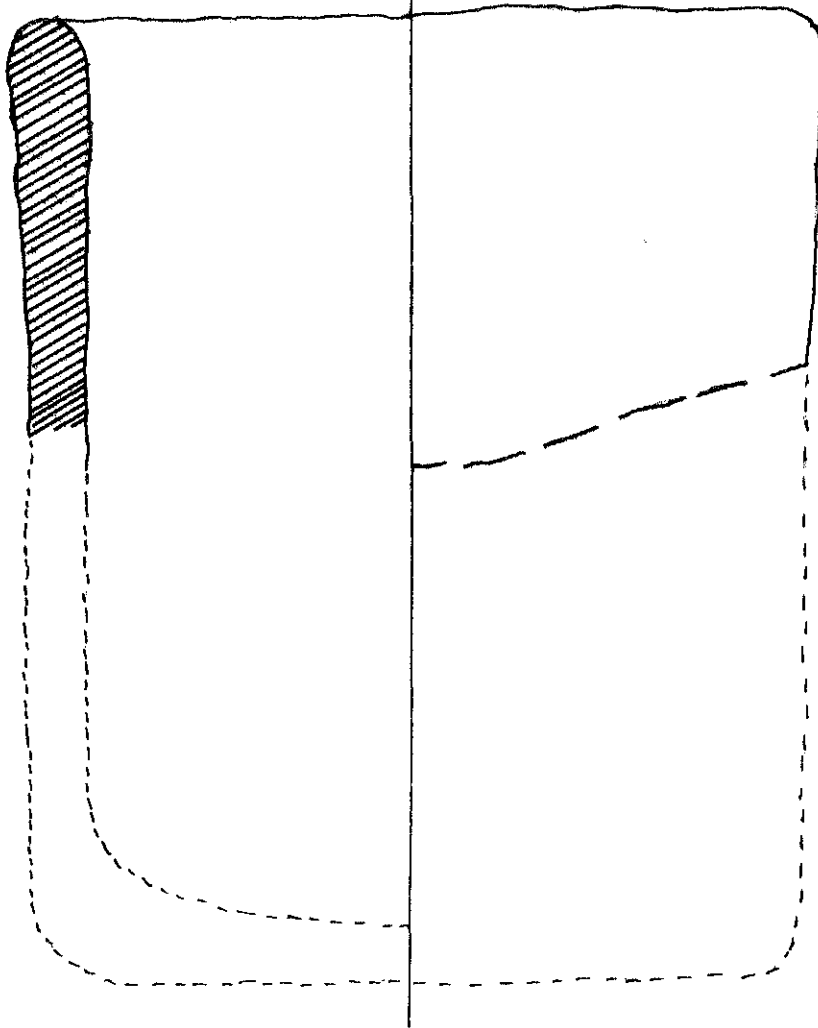
100mm diameter

1b.



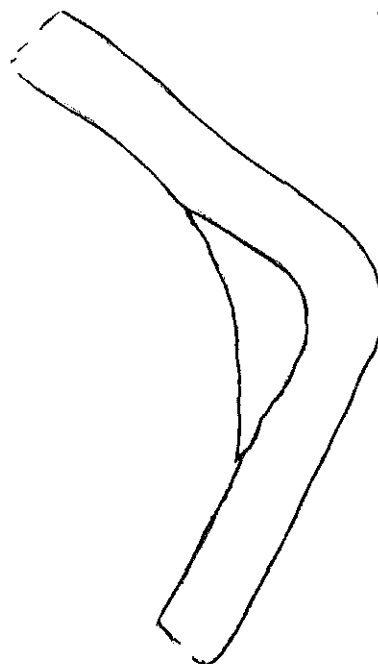
view from above of
crucible lip;
whole side is
pulled out
to form the
triangular shape

2

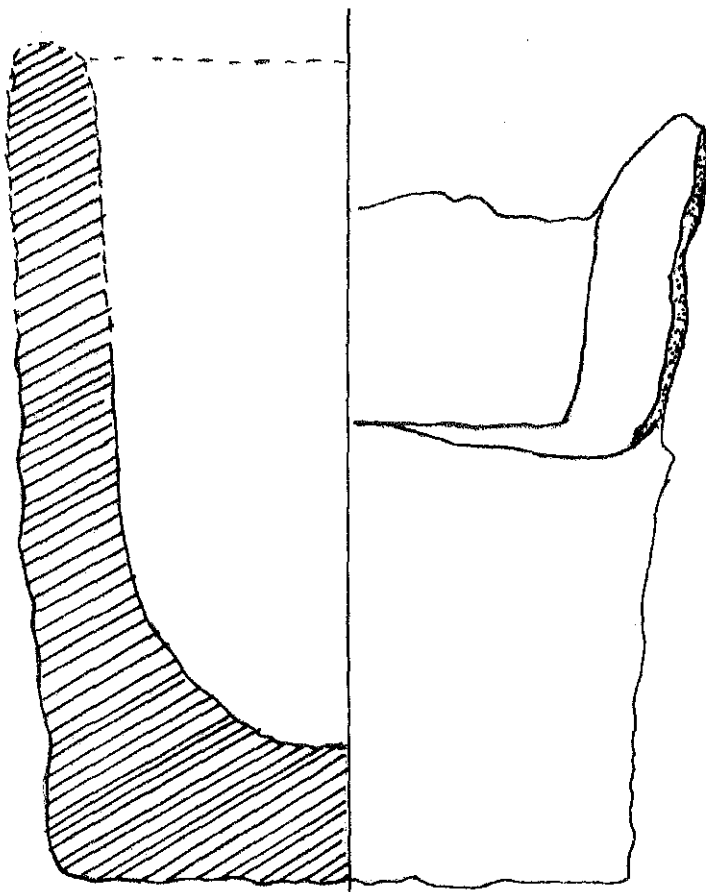


fine black fabric.
"pinched out"
lip for pouring
100 mm diameter
8 mm thick walls.

view from above of lip



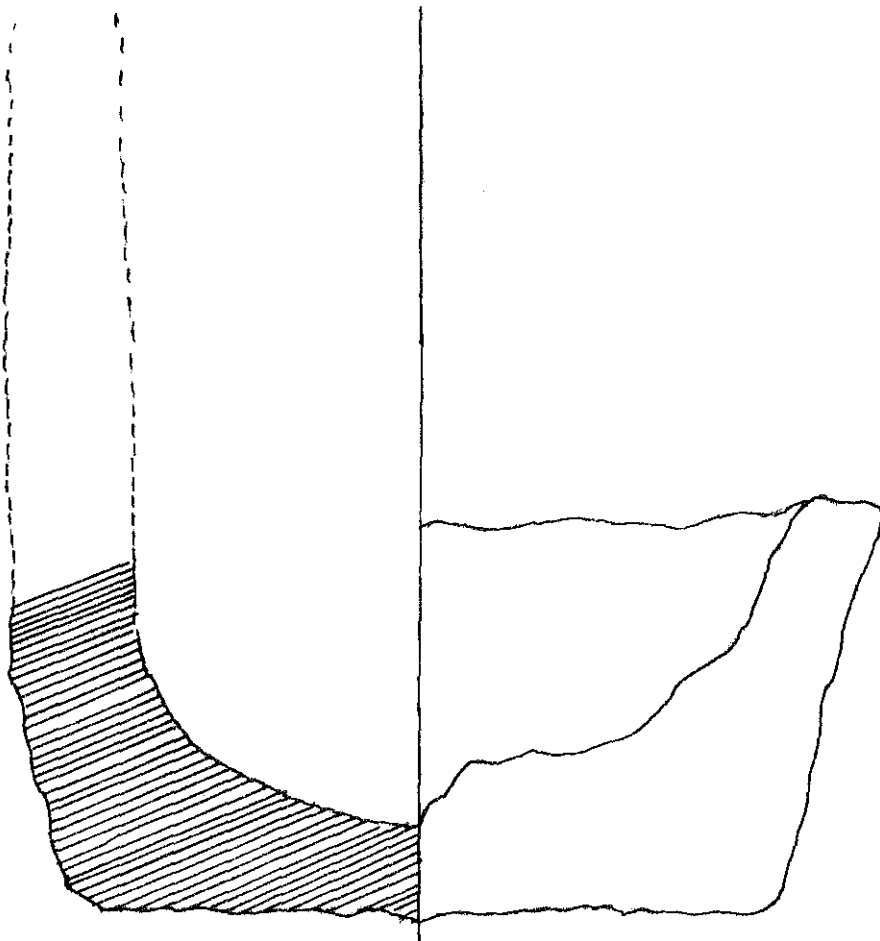
3



5511 BFB

fine, black fabric
80mm diameter
12mm thick walls.

4



6545 FBA.

yellow/buff coarser fabric
90mm diameter
18mm thick walls.