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Evaluation of Archaeometallurgical residues from the M7/M8 Contract 2: Lismore-Bushfield 1 (E2220)

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Abstract

This site has produced strong evidence for both iron smelting and the subsequent stage of bloom refining. However, there is fairly good evidence that the two activities were not contemporary. Of the total slag assemblage of approximately80kg some 62% by weight is attributable to the smithing and 38% to the smelting.

The iron smelting was undertaken in a cluster of five slagpit furnaces which lay just outside the ringfort. They yielded good assemblages of iron smelting slags (approximately 35% of the total slag assemblage) typical of those produced in a low-shaft slagpit furnace. The furnaces appear to have been simple single furnaces, with no arch (at least no arch below ground level) and a rather large diameter slagpit. Pit sizes based on the quoted dimensions of the slag- and charcoal- rich fill are 0.44 x 0.38m, 0.50 x 0.45m, 0.62 x 0.48m, 0.60 x 0.49m and 0.54 x 0.50m for furnaces 1 to 5 respectively. Such dimensions fit well with a furnaces dated to the earlier part of the Iron Age (1st-4th centuries BC), a date supported by a 14C date on alder charcoal from furnace 3 of 90BC to AD80.

There is no evidence for later iron smelting contemporary with the ringfort, but the large size of some of the smithing slag cakes (SHCs) from a large pit in the fort interior and from the enclosure ditch suggests that primary bloomsmithing was likely to have been carried out on the site. The size of the large cakes may be indicative of the size of blooms being smithed. The SHC assemblage, although small, is remarkable for having a very narrow size range, suggesting that the site may have specialised in bloom refining and that there may have been no "end-user" blacksmithing on the site on all.

There was no evidence for non-ferrous metalworking on the site, with both items previously suggested to be crucibles proving to be misidentifications.

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Methods

All investigated materials were examined visually, using a low-powered binocular microscope where necessary. All significant materials were summarily described and recorded to a database (Table 1). As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

Results

Iron smelting

Residues from iron smelting on this site are mainly flow slags, which are indicative of slag flow into the basal pit of a non-slag tapping low shaft slagpit furnace. Such furnaces are now widely recognised across Europe (Pleiner 2000) and provide a better model for the cut features than the older ideas of "bowl furnaces" (e.g. Scott 1990). These slags are formed of small prills and flows that have solidified within the fuel bed of the smelting furnace. The prills are of varying size

from a few millimetres diameter up to flows of 20mm across. In general, within the slagpit the individual prills will be those that have penetrated towards the base. All of the furnaces yielded these sorts of isolated prill.

At a higher level the small flows will be coalesced, and the block of amalgamated flow slag from just below the bloom may be known as a furnace bottom (C91 and C106) although this term may best be avoided because of its associations with dense slag cakes). The "furnace bottom" fragments from the current site are large pieces, but none the less small parts of the whole. The largest piece is a 4.3kg block from C106 and shows similar textures to complete blocks from Tullyallen (Young 2003b) and Adamstown (Young 2006c) which weighed 11 and 19kg respectively. In the Adamstown example almost all the residues in the slagpit were incorporated within the "furnace bottom", but at Tullyallen there was a further 6kg of slag pieces in the pit. This situation resembles the finds from Lismore-Bushfield 1, where several kilograms of smaller slag pieces occur in each furnace. Where this "furnace bottom" meets the furnace wall, just below the blowhole, the iron rich melt will react with the wall and erode it, creating a dense slag lump known as a burr (e.g. material from C093, C098 and C108). Larger volumes of slag flow on the blowing wall may result in larger slag flows then the small prills below the bloom. The large flows on the blowing wall often penetrate to the foot of the wall and may preserve moulds of the large wood pieces commonly used to pack the slagpit before the smelt (e.g. material from C91 and C98 which have large wood/charcoal moulds to at least 50mm). Flow slags of the various kinds comprise 33.4kg of the total assemblage (approximately

More distal parts of the base of the slagpit may receive rather lower volumes of melt, with the slag solidifying to form isolated blebs and spheroids (often dimpled from contact with the fuel to form a "coffee-bean" spheroid). Such assemblages are recorded from C91, C93, C96, C98 and C100. Such assemblages only comprise approximately 80g of the total collection.

Fines (including slag, but also ore dust and charcoal dust) may accumulate on the floor of the pit and become indurated to form a sinter-like material. This facies of residue has been recorded from C87, C91, C93, C96, C98, C104 and C108. Approximately 1kg of the assemblage was provided by sinter and associated materials.

The interpretation of the origin of the assemblages is less clear. The dominance of the fine grained slag material suggests that much of the slag in the assemblages may be more or less in-situ, being the slag fines in the base of the slagpit that were incompletely cleaned out. The presence, however, of large broken fragments of "furnace bottom" and burr is much more suggestive of pieces of slag being dumped back into a disused furnace pit. The assemblages are likely therefore to be a blend of both taphonomic processes.

Iron working

The residues from iron working are mainly smithing hearth cakes (SHCs) and fragments thereof. Approximately 60% by weight of the total slag assemblage from the site was from SHCs. The assemblages containing the SHCs contained few other residues and an unusually low proportion of indeterminate slags; perhaps a reflection of a good state of preservation and a low degree of fragmentation of the SHCs.

The size distribution of the SHC assemblage is narrow (details are presented in table 2) ranging from 426g to 4390g for the 23 examples for which the original weight is known or can be estimated. The mean weight of the SHCs is thus very high, at 1737g.

The SHCs are generally dense and compact, with just a few examples showing evidence for deformation on removal from the hearth when hot. One example shows the possible limits of a 70mm diameter tuyère tip. The SHCs typically have dense bowl, with only a few examples with a thin crust. One small chip of vitrified ceramic, quite possibly from the tip of a tuyère, was recovered (but had been misidentified as crucible).

Distribution

The distribution of the residue types is given in Table 3. The distribution is remarkable for its marked dichotomy between the smelting slags in the furnaces and an adjacent gully on one hand, and the smithing slags in the pits inside the ringfort and in parts of the adjacent enclosure ditch. No smelting slags were recovered in deposits directly associated with the enclosure.

Non-ferrous metalworking

The stratigraphic report refers to finds of two crucible fragments: C5 #2 and C47 #1. Neither is in fact a crucible fragment. The piece from C5 is a somewhat curiously shaped, strongly concavo-convex small piece of slag, whereas the piece from C47 is ceramic, but is a mainly oxidised fragment of hearth ceramic, or more likely, a piece from the vitrified tip of a tuyère. There is no further evidence for non-ferrous metalworking on the site.

Interpretation

The smelting residues and structures on the site provide good evidence for iron smelting in slagpit furnaces. The details of the furnaces would be well worth revisiting in order to determine, if possible, the cut dimensions and to confirm whether the pits were lined, or as more often seems to be the case, the apparent lining is actually the fired natural subsoil.

The nature of the "gully" lying between the furnaces is also worthy of further investigation as it might shed further light on the structure of the furnaces or their ancillary facilities.

At face value, however, the furnaces would appear to terminate in simple pits, with no evidence for furnace arches. The working volume of the pits (leaving aside the issue of whether or not the pit margin corresponds to the actual cut) can be determined through the dimensions of the fills arising from use of the furnaces. The dimensions are 0.44 x 0.38m, 0.50 x 0.45m, 0.62 x 0.48m, 0.60 x 0.49m and 0.54 x 0.50m for furnaces 1 to 5 respectively.

These dimensions are quite substantial for Irish slagpit furnaces, but there is a growing corpus of examples of a similar size. Of these, the best preserved examples are those with the complete slag cake left in-situ after smelting at Tullyallen, Co. Louth (Young 2003b) and Adamstown, Co Waterford (Young 2006c). Unfortunately, neither of these is dated. However, several others with equivalent dimensions are now dated:

- Carrickmines Great, Co. Dublin (Young 2003a): 360-110 cal. BC

- Cherryville, Co. Kildare (Young 2008a): 400-200 cal. BC.

- Cloncollig, Co. Offaly: very large (0.55x0.60m), 360-90 cal. BC (Young 2008c)

- Clonrud 4: 2 moderately large slagpit furnaces (0.41m x 0.39m and 0.46m x 0.41m). 4th -1st century BC based on 14C date on willow charcoal (there is also an older date on oak charcoal; Young 2008f)

- Morrett D, N6 Co. Laois (Young 2005b): 170 cal. BC-30 cal AD and 770-410 cal. BC for charcoal pits, 370-110 cal BC and 400-200cal BC for ring-ditches.

- Newrath Site 35, N25 Co. Kilkenny (Eogan *pers. comm.* 2006) : 400-200 cal. BC and 350-40 cal. BC

The Lismore-Bushfield 1 examples are dated by a 14C date on alder charcoal from furnace 3 of 90BC to AD80. This is apparently slightly younger than most of the examples of this size of slagpit, but is broadly similar.

It is suggested therefore that the iron smelting predates the enclosure by a considerable period, which explains why no smelting slag at all was recovered from contexts associated with the enclosure.

The iron-working residues in contrast, not only occur in large quantities in pits within the enclosure (pits which also contain medieval small finds), but also in small quantities in the enclosure ditch itself. This provides reasonable evidence for the iron working being much later (by many centuries), than the iron smelting. No actual smithing hearth was found in the area of the enclosure that was excavated. The process of dumping the slags into the pits may itself have introduced a size bias into the assemblage, which none the less has an extreme size distribution.

The SHC assemblage does not contain exceptionally large SHCs (although some fragments of large cakes were found), with a maximum recorded size of approximately 4.4kg. The mean weight is very high, at 1.7kg, and is thus the highest mean weight so far recorded for an SHC assemblage in Ireland. The proportions of the SHCs that were over 1kg and over 3kg are also the highest. The statistics for Lismore-Bushfield 1 need using with some caution, because only 23 SHCs were measurable. However, the distribution certainly appears to be different to that at other sites. The large SHCs are probably indicative of bloom smithing (bloom refining), with the narrow size range indicating that the same sort of process and size of bloom was being repeated, and also indicates that the iron was apparently not being used on site.

It has been argued (Young 2009h) that in some instances the refining of a single bloom may have resulted in the production of just a single SHC. In such circumstances the maximum size of the SHCs in an assemblage may give a clue as to the maximum size of the blooms being smithed. In this instance it would suggest raw blooms of 4-5kg.

It would appear that at two distinct periods this site was utilised by those engaged in the production of iron. In the Iron Age it was used for primary smelting and in the (probably) early medieval period the enclosure was used a place for the secondary process of bloom refining.

Evaluation of potential

Both phases of iron production on the site are significant and have well-preserved residues. Further analysis of representative suites of material would add significantly to current understanding.

For the smelting, the superficial similarity of the residues to the poorly dated assemblages at Tullyallen (Young 2003b) and Adamstown (Young 2006c) would make their analysis very useful. A similar style of smelting was being employed, but in a very different part of the country with possibly rather different resources.

For the bloomsmithing, analysis of a tight assemblage such as this (accumulation of a large assemblage in a single pit suggests a relatively short timespan too) would be useful in providing evidence for the process at this period (additional dating to clarify what that period was exactly would also be useful). Other early medieval assemblages which include probable bloomsmithing SHCs also contain smithing residues from other parts of the *chaîne operatoire*. This assemblage has the great advantage of possibly being involved with just a single activity.

In view of the significance of the site for further analysis it is recommended all residues be retained.

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F	find	sample	context wt	wt	no	notes		
1		445	612	612	1	slab of dense crust, quite thin, from very large SHC		
4		408	1195	568	1	rounded irregular slag lump - probably a burr from a large cake which has been heavily reworked and eroded		
4		424	248	248	1	very weathered slab of SHC crust		
5		409	373	364	1	irregular ?twisted vesicular slag mass - probably a smithing slag piece?		
5	2			9	1	Curiously-shaped bowl –like fragment of slag. Not a crucible.		
6		410	186	186	1	flow slag with large moulds		
11		411	788	788	1	highly weathered crust of SHC -possibly might be whole of original so tentatively given, 120x140x50 deeply hollow on top	1	788
26		412	314	314	21	small slag pieces embedded in ash - some may be flown . But most not obviously so.		
31		413	218	218	12	pieces of well-rotted probably low-density slags in concretionary ashy charcoal-rich matrix		
47		463	14	6	19	small ashy concretions, lots of charcoal , some slag films		
47	1			8	1	Vitrified ceramic, mainly oxidised fired in body, reduced just below dark green glaze, irregular face, hearth wall or tuyère face		
50		414	1190	1190	1	Highly-weathered triangular SHC - straight edge may be fracture or original attachment. 130x150x50, bowl 35	1	1190
64		415	1430	1430	1	conical SHC, 130x150x80, slightly straight on proximal side, plano-convex	1	1430
64		416	2615	2615	1	proximal part of large SHC, (130)x180x120 of which bowl 60 , dollop of material on top of neat plano-convex bowl at proximal end, crust to 15 in broken section, approx 80%	0.8	3269
64		417	459	459	1	irregular block of charcoal-rich slag		
64		418	1025	1025	1	slab of crust from v large SHC		
64		419	2236	778	1	130x110x50 of which bowl 30, transverse SHC with flat top and slab of lining slag above	1	778
64		419	2236	546	1	massive lump of amorphous fine SHC material - twisted?		
64		419	2236	348	1	massive lump of amorphous fine SHC material - twisted?		
64		419	2236	564	1	massive lump of amorphous fine SHC material - twisted?		
65		420	920	920	1	poorly compacted convex prilly SHC, has slab of lining material in upper part - a very odd cake - 120x130x100 of which bowl 50	1	920
65		421	2325	2325	1	part of large irregular SHC so hard to estimate size, crust thin bowl well formed in only small part of cake, upper part very fine grained hash of comminuted charcoal, 190x150x100	0.6	3875
65	3	422	22159	1505	1	majority (90%?) of SHC (145)x160x65 of which bowl 45. Crust 20 where seen.	0.9	1672
65	3	422	22159	2440	1	SHC, 160x180x130 of which bowl 65, lots of slag mounded on top so almost symmetrical, rather triangular in plan	1	2440
65	3	422	22159	558	1	90x100x70 skew shaped double layer SHC, bowl flat, 25mm deep	1	558
65	3	422	22159	256	1	elongate probable SHC fragment		
65	3	422	22159	458	1	(100)x(100)x40, 60% of flat SHC, bowl 25	0.6	763
65	3	422	22159	2780	1	210x140x90, flat topped probably transverse SHC	1	2780
65	3	422	22159	1235	1	amorphous rounded elongate block of smithing slag		
65	3	422	22159	1240	1	130x150x70 bowl 40, skewed double layer SHC	1	1240
65	3	422	22159	530	1	slab of crust from large SHC		
65	3	422	22159	386	1	tip of small SHC (100)x90x50, slightly curved on extraction- could be most of small cake		
65	3	422	22159	2010	1	block from a large complex SHC, possible with multiple bowls		
65	3	422	22159	2420	1	SHC, 120? X 180x 90 of which bowl 70. Double layer - lower rectangular, upper small, skewed to right	1	2420
65	3	422	22159	2800	1	170x180x70 largely complete flat topped SHC, minor bits missing on proximal side	1	2800
65	3	422	22159	1085	1	irregular block - probably about half an SHC with slag adhering to base - or pendent slag		
65	3	422	22159	426	1	80x130x50 possibly complete small transverse SHC	1	426
65	3	422	22159	186	1	irregular fragment		

65	3	422	22159	760	1	most (c80%?) of flat SHC, 110x150x50 bowl 20	0.8	950
65	3	422	22159	576	1	large SHC fragment		
65	3	422	22159	508	1	large SHC fragment		
65		423	1738	1660	1	neat plano-convex SHC, broken on probable proximal attachment, 130x150x70	1	1660
65		423	1738	78	1	burnt stone		
67		425	2055	2055	1	190x190x75 of which bowl 55, SHC with slight double bowl, but second extends out of preserved piece, rather square in plan. Top not well preserved and unclear if anything missing	1	2055
67		425	2120	2120	1	very oddly shaped SHC - good burr on one end (or maybe just sediment contact) 210x160x60, possible contact might be the tip of 70mm radius tuyère	1	2120
68		426	972	864	1	110x150x70, irregular SHC	1	864
68		426	972	108	1	vesicular slag fragment		
68		445	58	58	c100	concretions - mainly tubular in grey clay with charcoal		
72		427	664	552	1	130x140x40 plano-convex SHC	1	552
72		427	664	112	1	indeterminate lump of lobed slag		
74		428	4390	4390	2	210x250x90 somewhat weathered and slightly damaged SHC, base very neat, with possibly two bowls, top rather ridged - may be damage	1	4390
87		429	592	592	12	flow slags - mostly in complex massive aggregates		
87		430	550	550	30	flow slags		
87		446	78	64	49	flow slag		
87		446	78	10	15	ash etc		
87		446	78	1	1	sinter		
87		454	24	23	c70	pieces of indurated ash fired clay		
87		454	24	1	1	dense slag fragment		
89		431	1124	182	5	flow slags		
89		431	1124	502	7	dense broken slag fragments		
89		431	1124	440	5	vitrified oxidised furnace wall (vertical grooves)		
89		433	2440	1025	8	flow slag		
89		433	2440	1165	30	more massive slags - related to wall and/or floor		
91		435	3610	1645	1	dense slag block - presumably from central part of cake, but needs cleaning to be certain. It is made up of small flow lobes - and could just be from near the wall		
91		435	3610	1965	49	flow slags in large pieces		
91		436	3500	3500	42	flow slag, including material with wood 50mm across, right up to top lip of cake		
91		459	306	220	c100	flow slag		
91		459	306	80	37	slaggy sinter (good)		
91		461	50	10	17	coffee bean spheroids and other flowed material		
91		461	50	38	84	dull slags grading into sinter		
93		437	1855	280	6	flow slag		
93		437	1855	1575	1	large block from burr area of "furnace bottom" with wall attached, small pendent prills below, massive dense slag makes up most of piece		
93		447	240	128	88	sinter		
93		447	240	82	35	flow slag and coffee bean spheroids		
93		447	240	10	2	dull slags		
93		447	240	10	6	reduced fired clay or indurated ash		
93		447	240	1	1	oxidised fired lining with vitrified surface		

96	438	1885	1195	18	flow slags
96	438	1885	690	26	ashy and/or sintery floor material
96	448	112	112	c80	dull poorly flowed slags, with charcoal moulds, a few poorly developed coffee beans
96	455	6	6	c50	small blebs, slag fragments, some sinter and some stones
97	449	2	2	3	fragments of dense slag blebs
98	434	4735	4020	1	large block from burr area of "furnace bottom" with wall attached, pendent prills below, large charcoal moulds on base
98	434	4735	642	20	bits of above plus matrix
98	439	768	68	1	vitrified oxidised furnace wall (vertical grooves)
98	439	768	500	14	flow slags
98	439	768	200	4	?slaggy sinter from floor
98	450	98	42	c40	coffee bean spheroids, blebs and prills, dense
98	450	98	18	5	indurated ash/clay
98	450	98	38	15	slaggy sinter (good)
98	456	94	93	c80	fired clay/ash with stones
98	456	94	1	3	coffee bean spheroids
100	457	32	4	12	coffee beans and other spheroids
100	457	32	28		gravelly residue with small ash, fired clay and slag fragments
104	440	872	784	19	flow slags in fairly large pieces
104	440	872	92	6	sinter
104	441	418	226	4	flow slags in fairly large pieces
104	441	418	192	6	ashy slaggy sinter
104	451	288	186	63	dense flow slags
104	451	288	80	40	dull slags and sinter
104	451	288	22	2	oxidised lining with adhering slag - curved - possibly hood?
104	460	210	46	83	good sinter of small rounded particles
104	460	210	10	15	small prill fragments and coffee bean spheroids
104	460	210	154	c150	mainly fired clay and indurated ash
106	442	4310	4310		large block plus bits broken off - a good flow slag block similar to Adamstown or Tullyallen - needs washing
106	443	1785	1785	42	flow slags in fairly large pieces
108	444	558	444	1	burr with flows on lower edge
108	444	558	114	2	flow slags in fairly large pieces
108	452	6	6	c30	small blebby slag fragments with charcoal, some probable sinter

Table 1.Summary catalogue by contest and sample.

interval	count
0-100	0
100-200	0
200-300	0
300-400	0
400-500	1
500-600	3
700-800	2
800-900	1
900-1000	2
1000-1100	0
1100-1200	1
1200-1300	1
1300-1400	0
1400-1500	1
1500-2000	2
2000-3000	4
2500-3000	2
3000-4000	2
4000-5000	1

Table 2. Count of SHCs for which the original weight is measurable or may be estimated, in weight intervals.

N = 23, total weight = 39940g, mean = 1737g.
Minimum weight = 426g, maximum weight = 4390g

4% of SHCs are less than 500g
39% of SHCs are less than 1000g
13% of SHCs are of more than 3000g

		SHC	Flow slag	Indeterminate slag	lining	stone	concretion	ash	sinter	fines	***total***
topsoil		***612***									***612***
deposits associated with F003		***1968***		***9***							***1977***
minor pits etc. Zone B				***538***	***8***						***546***
Pit F050, Zone B											
	50	1190									
	64	7306		459							
	68	864		108			58				
	65	26878		186		78					
	67	4175									
	74	4390									
	72	552		112							
	total	***45355***		***865***		***78***	***58***				***46356***
Furnace 1											
	87		1206	1				33	1		
	97			2							
	total		***1206***	***3***				***33***	***1***		***1243***
Furnace 2											
	89		2372	502	440						
	106		6095								
	total		***8467***	***502***	***440***						***9409***
Furnace 3											
	91		7330						118	10	
	100									4	
	total		***7330***						***118***	***14***	***7462***
Furnace 4											
	93		1937		21				128		
	104		1196		22			154	410	10	
	total		***3133***		***43***			***154***	***538***	***10***	***3878***
Furnace 5											
	96		1307						696		
	98		5162		68			111	238	43	
	total		***6469***		***68***			***111***	***934***	***43***	***7625***
fill of channel f080			**558**							**6**	***564***
modern drain f007			***186***								***186***
	total	***47935***	***27349***	***1917***	***559***	***78***	***58***	***298***	***1591***	***73***	***85313***

Table 3. Summary of distribution of residue type by feature (and by context within the major features)

	Mucklagh	Coolamurry	Navan	Moneygall	Carrigoran	Trumra 4	Clonmacnoise (NG)	Ballykilmore	Woodstown 6	Clonmacnoise (WWS)	Clonfad	Lismore/ Bushfield 1
date	C18/19	C10-12	E. Med.	E.Med-Med.	C10?	C5/6	C7-10	C15/17	C9-10	C10?	C7-9	
SHC count	66	41	17	22	18	57	117	43	140	38	513	23
SHC min. wt	98		60	114		92	100	80	68			426
SHC max. wt	1206	2588	2990	1800	3866	3163	7815	4033	6310	5540	11000	4390
SHC mean wt	373	386	507	527	553	727	843	898	1060	1087	1153	1737
% <500g	77%	83%	82%	55%	72%	47%	50%	51%	40%	39%	29%	4%
% <1000g	95%	95%	88%	95%	89%	75%	78%	74%	71%	68%	64%	39%
% >1000g	5%	5%	12%	5%	11%	25%	22%	26%	29%	32%	36%	61%
% >3000g	0%	0%	0%	0%	6%	2%	3%	7%	7%	8%	7%	13%
Modal 100g interval	100-200	100-200	100-200	200-300	100-200	100-300	400-500	300-400	200-300	300-400	300-400	500-600

Table 4: Comparison of the Lismore-Bushfield 1 SHC assemblage with other Irish smithing assemblages. Ordered by mean SHC weight.

Mucklagh from Young 2008d; Moneygall from Young 2008e; Navan Site 1 from Young 2007; Carrigoran from Young , 2006d; Trumra 4 from Young 2008g; Coolamurry from Young, 2008b; Ballykilmore from Young 2006b;Clonfad from Young, 2006a; Clonmacnoise Waste Water Scheme from Young 2005a; Woodstown from Young, 2006c; Clonmacnoise New Graveyard site from the author's work in progress.

The assemblages from Mucklagh, Moneygall, Navan, Carrigoran and Coolamurray are interpreted as being dominantly blacksmithing residues. The assemblages from Ballykilmore, Clonfad, Clonmacnoise and Woodstown are interpreted as including bloomsmithing residues.

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