

ANALYSES OF ROMAN POTTERY AND LAMPS FROM AQUINCUM AND INTERCISA

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Abstract: *Firmalampen and other ceramics from potters' workshops in Aquincum and Intercisa have been analysed by WD-XRF to establish reference groups for local products. The data were used to distinguish local and imported objects. Firmalampen with stamps of local names and with names from lampmakers in Modena have been locally made at both sites, imports were from Carnuntum, Poetovio and Modena. Moulds are not necessarily locally made.*

Keywords: *Aquincum, Intercisa, X-ray fluorescence analysis, reference groups, Firmalampen*

INTRODUCTION

The paper aims at characterizing local lamp production in Aquincum and Intercisa, two important Roman sites in Hungary. Finds of moulds indicate a local production of lamps. Can chemical analyses of these moulds prove their local production? How is this production connected to the production of other pottery types and, if there are imports of lamps, where did they come from? The chemical analyses should give new information on the organization of production and distribution of *Firmalampen* and to compare the results with studies of such lamps from other Roman sites¹.

AQUINCUM

Potters' tools and other finds from various workshop areas with potters' kilns in Aquincum were analyzed to establish a local reference group for provenance determination by chemical analysis. The excavated kiln sites date from the end of the 1st century to the middle of the 3rd century AD. The eastern industrial quarters of the civil town, the so called Gas Factory workshops, were believed to have been the place where terra sigillata was produced by the potter PACATVS. The workshops were shortly described by P. Zsidi (1992). Part of our analyses was used by Zsidi (2003) to discuss North Italian influences on the production of *Firmalampen* in Aquincum², also including a short description of the pottery workshops.

Chemical analysis was carried out by wavelength-dispersive X-ray fluorescence spectroscopy³. The analysed samples both from Aquincum and Intercisa are listed in Table 1. This table also shows to which chemical group the samples finally are attributed using multivariate cluster analysis and bivariate diagrams (e.g. Fig. 1). The individual data are given in Table 2 to offer a possibility to attribute later analyses. The precision may be demonstrated

by two analyses which later turned out to be fragments of the same mould (Table 3: C329, C321).

In spite of a large variation in calcium contents the samples from Aquincum with few exceptions may be attributed to one chemical group: Aquincum A (Fig. 1). In Table 4 the means, standard deviations and coefficients of variation (relative standard deviation in per cent) of the elemental concentrations are given. These were calculated after having removed some very differing values especially in cases where the deviating contents with a high probability are caused by secondary changes during burial of the sherds in the ground (e.g. P, Ba, Mn, Zn). The trace elements in brackets were determined only in samples exceeding one gram and with poor precision. In Table 3, however, the mean values are included to offer information for comparisons of data.

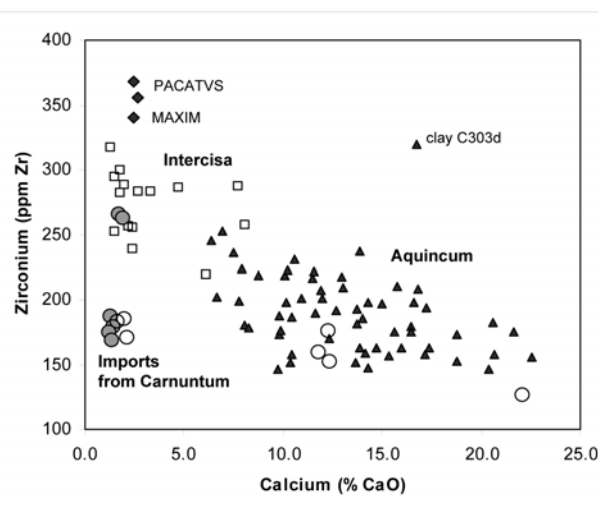


Fig. 1 Variation of calcium and zirconium of samples from Aquincum and Intercisa. Circles represent finds in Aquincum (respectively Intercisa) produced in Intercisa (respectively Aquincum) or Carnuntum.

Table 1 Analysed samples from Aquincum, Salla and Intercisa and their attribution to chemical groups. Catalogue numbers of published objects are given in the second column (Gas Factory, kilns 1 and 2: Póczy and Zsidi 1992; other samples from Aquincum: Zsidi 2003; Salla: Pongrácz 1990; Intercisa: Ujlaki Pongrácz 2006).

Lab.no.	publ.	Inv.nr	description	stamp	chem.group
Kilns in Buda:					
Laktanya Street					
C 302			kiln wall		?
Horvath Street					
C 303a			yellow clay		Aquincum A
C 303b			red clay		Aquincum A
C 303c			grey clay		?
C 303d			kiln wall or brick		Aquincum A
Aquincum:					
Military town (Kiscelli Street)					
C 328	1	51,338	upper part of mould for a lamp		Aquincum A
C 327	2	48,159	pattern with leaf decoration		Aquincum A
C 326	3	67,833	lower part of mould for <i>Firmalampe</i>	VRSVL (ret.)	Aquincum A
Military town (Bécsi road workshop)					
C 333	17	41,629	lower part of a mould for a lamp	LVCIVS/F	Poetovio
Aranyárok (military supply depot)					
C 338	4	32,848	mould for <i>Firmalampe</i>		Aquincum A
C 340	5	32,849	mould for <i>Firmalampe</i>		?
C 339	6	32,85	mould for <i>Firmalampe</i>		Aquincum A
C 337	7	32,856	mould for <i>Firmalampe</i>		Aquincum A
Potters's tools from Aquincum					
C 291		68.1.448	tool (?) with scrafitto		Aquincum A
C 292		50451 BTM 107	lamp mould with scrafitto		Aquincum A
C 293		50561	mould		Aquincum A
C 294		51148	mould (rabbit)		Aquincum A
C 295		50179	mould for lamp (palmette)		Aquincum A
C 296		50220	mould for a leaf, with scrafitto		Aquincum A
C 297		51358	large plate		Aquincum A
C 298		50774	mould for <i>Firmalampe</i>	MAXIM	Aquincum B
C 299		50558	mould		Aquincum A
C 300		54935	mould for mask, with scrafitto		Aquincum A
C 301		50435	stamp		Aquincum A
Gas Factory, kiln 1					
C 304		81.12.338	greenish waster		Aquincum A
C 305	368	81.12.330	waster		Aquincum A
C 306		81.12.360	Nigra		Aquincum A
C 307	321	81.12.308	mortaria		Aquincum A
C 308	333	81.12.307	mortaria		Aquincum A
C 309	323	81.12.300	mortaria		Aquincum A
C 310	286	81.12.280	handle of a jar		Aquincum A
C 311	312	81.12.205	bottom of a jar		Aquincum A
C 312		81.12.182	neck of a jar		Aquincum A
C 313	297	81.12.3.	local "Pompeian red" plate		Aquincum A
C 314	296	81.12.2.	local "Pompeian red" plate		Aquincum A
Gas Factory, kiln 2					
C 315		81.12.404	neck of a jar		Aquincum A
C 316		81.12.526	handle of a jar		Aquincum A
C 317		81.12.416	lid		Aquincum A
C 318		81.12.381	mortaria		Aquincum A
C 319		50,237	mould fo <i>Firmalampe</i>		Aquincum A
C 320		50,399	handle with stamp		Aquincum A
C 321		50,403	handle with stamp		Aquincum A
C 322	204	50,258	mould for sigillata	PACATVS	Aquincum B
C 323	203	50,259	mould for sigillata	PACATVS	Aquincum B

Table 1, continued

Lab.no.	publ.	Inv.nr	description	stamp	chem.group
Gas Factory					
C 336	8	32,181	mould for <i>Firmalampe</i>		Aquincum A
C 335	9	32,188	mould for <i>Firmalampe</i>		Aquincum A
C 334	10	32,197	mould for a lamp		Aquincum A
Papföld kilns					
C 329	12	41,622	mould for a lamp		Aquincum A
C 330		41,625	mould for a lamp		Aquincum A
C 331	11	41,623	mould for a lamp		Aquincum A
C 332		41,624	mould for a lamp		Aquincum A
<i>Firmalampen</i>					
C 341	20	32.152 (D95)	<i>Firmalampe</i>	[SE]XTI	Aquincum A
C 342	25	32.155 (D55)	<i>Firmalampe</i>	FORTIS	Aquincum A
C 343	23	32.111 (D45)	<i>Firmalampe</i> , stamp distorted	FORTIS	Poetovio
C 344	22	32.108 (Gd10)	<i>Firmalampe</i> , red	FORTIS	Modena
C 345	24	32.150 (D50)	<i>Firmalampe</i> , with slip	FORTIS	Aquincum A
C 346	19	32.061 (M31)	<i>Firmalampe</i> , with slip	SEXTI	Aquincum A
C 347	18	32.060 (D85)	<i>Firmalampe</i> , with slip	OCTAVI	Aquincum A
C 348	16	32.109 (Gd23)	<i>Firmalampe</i>	NERI	Aquincum A
C 349	21	32.067 (D93)	<i>Firmalampe</i>	SEXTI	Aquincum A
E 665		32117 (D100)	<i>Firmalampe</i>	[CDE]SSI	Aquincum A
E 666		32115 (D80)	<i>Firmalampe</i>	NERI	Intercisa
E 667		32118 (D111)	<i>Firmalampe</i>	STP[Aquincum A
E 668		32116 (D1)	<i>Firmalampe</i> , fragment		Aquincum A
E 669		32114 (D63)	<i>Firmalampe</i>	RTIS	Carnuntum B
E 670		32119 (D64)	<i>Firmalampe</i>	RTIS	Carnuntum B
E 671		32136 (D103)	<i>Firmalampe</i>	CASSI	Aquincum A
E 672		32146 (D53)	<i>Firmalampe</i>	FORT/S	Aquincum A
E 673		32177 (D33)	<i>Firmalampe</i>	FORTIS	Poetovio
E 674		32148 (D36)	<i>Firmalampe</i>	FORTIS	Carnuntum B
E 675		32103 (Gd20)	<i>Firmalampe</i>	FESTI	Intercisa
E 676		32140 (D22)	<i>Firmalampe</i>	CRESC/S	?
E 677		32149 (D117)	<i>Firmalampe</i> , with slip	[OCT]AVI	Aquincum A
E 679		32842 (D75)	<i>Firmalampe</i> , with slip	LVCIVS/F	Poetovio
E 680		32339	<i>Firmalampe</i> , with slip	OCTAVI	Aquincum A
E 681		32274	<i>Firmalampe</i>	CRESC/S	Carnuntum B
E 682		32116	<i>Firmalampe</i> with <i>palmette</i>	[L]VCIVS	Aquincum B
E 683		32235	<i>Firmalampe</i> , with slip	FORTIS	Aquincum A
E 684		32225	<i>Firmalampe</i> , with slip	FORT/S	Aquincum A
E 685		32229	<i>Firmalampe</i> , with slip	APRIO	Aquincum A
Salla					
C 324	275	87.3.207	<i>Firmalampe</i>	VIBIVS	Carnuntum B
C 325	33	78.39.10	<i>Firmalampe</i>	LNARI	Poetovio
Intercisa					
E 690		74.14.2	brick	LEG II AD	Aquincum A
E 691		74,762	brick	VRSVS	Aquincum A
E 694	493	77.116.3	mould for a round nozzle lamp		Aquincum A
E 693	494	DV1975/15	mould for handle with <i>palmette</i>		high silica
E 692	495	DV1975/15	mould for lamp		high silica
<i>Firmalampen</i>					
E 686	133	75.57.212	<i>Firmalampe</i>	VICT	Intercisa
E 687		75.57.31	<i>Firmalampe</i>	NTI	Intercisa
E 688	134	77.92.43	<i>Firmalampe</i>	VICT	Intercisa
E 689	18	77.185.2	<i>Firmalampe</i>	CDESSI	Intercisa
E 695		72.1384.1	<i>Firmalampe</i> , with slip	FORTIS	Aquincum A

Table 1, continued

Lab.no.	publ.	Inv.nr	description	stamp	chem.group
E 696	170	77.190.2	<i>Firmalampe</i>	VICTORIA	Intercisa
E 697	177	70.1249.2	<i>Firmalampe</i>	CTORIA	Intercisa
E 698	169	76.46.73	<i>Firmalampe</i>	VICTORI	Intercisa
E 699	175	81.51.10	<i>Firmalampe</i>	VICTO	Intercisa
E 700	74	80.19.1	<i>Firmalampe</i> , with slip	FORTIS	Carnuntum B
E 701	61	67.2.256.1	<i>Firmalampe</i>	FORTIS	Intercisa
E 702	56	67.2.178.3	<i>Firmalampe</i>	FORTIS	Intercisa
E 703	29	67.2.337.3	<i>Firmalampe</i>	CRESCES	Carnuntum B
E 704	137	81.46.108	<i>Firmalampe</i>	VICT	Intercisa
E 705	105	84.7.10	<i>Firmalampe</i> , with slip	QGC	Carnuntum B
E 706	90	79.32.1	<i>Firmalampe</i> , with slip	FORTIS	Intercisa
E 707	11	81.46.95	<i>Firmalampe</i>	BAEB	Intercisa

Subgroups within the group Aquincum A concluded from cluster analysis may be distinguished. These subgroups are mainly based on the largely varying calcium contents and, as well as the extremely low or high calcium contents, could not be interpreted in archaeological terms. They were therefore not regarded to be significant in terms of workshops or vessel types. Clay with varying calcium content probably was taken by the Roman potters accidentally from the same clay deposit. The combined group Aquincum A comprises workshop finds of potters' tools and three clay samples taken from workshops in the south of Buda some kilometres from Aquincum. One sample of a kiln wall (C302) does not match at all and another one (303d) has an aberrant zirconium content (**Fig. 1**). It is proved by the chemical data that two stamped bricks, as well as a mould for a lamp and one of the analysed lamps found in Intercisa turned out to have been made in Aquincum.

The potter's workshop in Aquincum often was identified as that of Pacatus. Two analysed moulds for terra sigillata with the stamp of this potter, however, showed a non-calcareous composition clearly differing from the calcareous clay of the other Aquincum ceramics. It also differs significantly in the concentrations of other elements (e.g. Ti, Na, Zr; **Fig. 1**). The use of non-calcareous clay in a sigillata workshop is unusual as shown from other centres of sigillata production, e.g. Arezzo, Lyon, La Graufesenque or Rheinzabern. The typical clay used for terra sigillata, also used for making the moulds, is calcareous with CaO contents between about 6 and 15%. Another analysed mould from Aquincum, also made from this non-calcareous clay, is stamped MAXIM. The composition of this non-calcareous Aquincum B reference group is similar to that of the local lamps made in Intercisa if zirconium is not regarded (**Table 2; Fig.1**). This difference in zirconium, however, is certainly significant and does not allow the attribution of the three stamped objects to a workshop in Intercisa. It is very probable that in Aquincum the clay

used by Pacatus for geological reasons may be similar to that available in Intercisa and geologically differs from the calcareous clay mainly used by the potters in Aquincum. From the limited number of our analyses it can not be said if the three moulds only represent a minor local reference group but it is clearly shown that potters in the Gas Factory workshop used at least two differing clays.

Eight samples of mortaria and jars from two kilns in the Gas Factory potter's settlement also had been analysed in a larger series by *Balla et al. (1999)* using neutron activation analysis. These eight analyses differ from each other in the same way as the most different samples within group Aquincum A and the analyses fall into the three subgroups which eventually may be distinguished. This means that the finds from the Gas Factory can not be distinguished from other workshop finds from Aquincum analysed by us, thus contradicting *Balla et al. (ibid.)* who found significant differences between mortaria from the Gas Factory workshops and other finds of mortaria in Aquincum⁴.

FIRMALAMPEN

For 25 of the analysed samples the result in archaeological terms was already discussed by *P. Zsidi (2003)*⁵. From another point of view, here some additional remarks may be made. Out of the six moulds for such lamps one clearly does not match the local composition and very probably represents an import thus showing that the interpretation of finds of moulds has to be handled with care and not always can be taken as evidence for local production. On the other hand, the mould with a stamp of Ursulus, who was the main potter producing *Firmalampen* in Poetovio (*Daszkiewicz & Schneider 1999*), is locally made in Aquincum indicating some kind of connection (*Zsidi 2003, p.204*). The North Italian names on lamps in Aquincum demonstrate such a

Table 2 Results of chemical analyses by WD-XRF, valid for ignited samples.

Lab. No.	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	V Cr Ni Zn Rb Sr Zr Ba (Ce)										I.o.i. %	orig. total
major elements (in per cent by weight)											trace elements (in ppm)											
Aquincum A																						
Moulds, potter's tools and local pottery:																						
C291	59,35	0,855	17,61	6,59	0,051	2,60	8,73	0,88	3,18	0,155	129	100	51	103	136	319	213	439	111	2,34	99,52	
C292	57,23	0,795	17,20	6,34	0,071	2,82	11,50	0,85	3,05	0,137	114	97	55	113	130	374	216	465	54	4,66	99,24	
C293	50,93	0,711	16,12	5,62	0,043	2,35	20,60	0,90	2,57	0,155	126	90	57	123	105	522	182	381	110	9,81	99,21	
C294	55,87	0,686	14,81	5,45	0,045	2,18	17,23	0,82	2,78	0,138	125	87	54	116	114	534	194	393	67	13,93	101,58	
C295	55,86	0,786	17,58	6,41	0,051	3,07	11,62	0,78	3,54	0,298	114	95	56	95	135	533	190	567	41	3,03	98,61	
C296	58,37	1,014	20,56	6,78	0,051	2,53	6,34	0,92	2,60	0,839	121	143	75	92	124	304	245	559	105	6,64	98,19	
C297	54,13	0,751	16,25	5,96	0,054	2,31	16,83	0,79	2,78	0,135	117	93	56	123	111	502	208	565	77	12,57	97,95	
C299	54,60	0,741	16,23	5,87	0,044	2,43	16,60	0,81	2,70	0,118	128	85	59	123	115	506	198	520	77	14,28	100,27	
C300	57,60	0,775	16,14	5,79	0,043	2,64	13,00	0,92	2,86	0,240	109	99	56	130	124	406	209	518	53	3,95	99,48	
C301	59,98	0,749	15,31	5,93	0,056	2,85	10,95	1,00	2,81	0,367	121	105	56	124	125	427	201	487	78	9,18	100,37	
C304	57,26	0,718	15,85	5,99	0,063	2,46	14,15	0,79	2,50	0,222	131	80	42	86	112	279	159	393	69	1,80	100,13	
C305	53,50	0,736	15,64	5,54	0,041	2,56	18,78	1,32	1,76	0,137	114	88	51	69	91	444	173	369	70	6,10	100,25	
C306	56,47	0,870	19,42	7,64	0,074	2,67	8,03	0,53	4,05	0,259	150	115	75	116	173	331	180	496	86	0,30	100,64	
C307	49,94	0,735	16,74	6,41	0,067	2,47	20,64	1,55	1,14	0,316	125	100	54	81	81	411	158	397	82	7,70	100,65	
C308	54,13	0,758	15,96	5,77	0,051	3,25	16,49	0,92	2,47	0,205	124	90	51	77	122	388	179	384	49	7,00	99,30	
C309	54,82	0,754	16,03	5,77	0,058	2,57	16,44	0,85	2,51	0,188	113	90	49	80	116	380	175	396	60	5,30	100,62	
C310	55,73	0,760	16,47	6,36	0,072	2,34	14,32	0,64	2,96	0,357	110	85	55	75	119	297	147	436	70	6,70	100,18	
C311	61,28	0,716	15,41	6,10	0,072	2,16	10,44	0,80	2,66	0,368	116	68	40	82	112	232	158	431	69	4,50	100,93	
C312	53,76	0,775	16,69	6,93	0,080	2,37	15,34	0,66	3,08	0,319	140	80	45	91	113	310	157	474	74	11,80	100,87	
C313	54,14	0,709	15,25	6,02	0,105	2,46	17,39	0,77	2,98	0,184	112	86	62	90	121	430	163	495	68	12,80	100,09	
C314	51,33	0,707	16,17	6,37	0,146	2,45	18,79	0,63	3,15	0,271	127	90	69	109	126	482	153	501	79	14,60	100,19	
C315	54,11	0,703	15,37	6,25	0,077	2,42	17,13	0,64	2,88	0,418	129	81	53	81	116	438	158	466	78	9,70	100,53	
C316	55,50	0,761	15,49	6,11	0,058	2,47	15,62	0,76	2,80	0,451	103	93	52	89	119	391	175	451	67	7,10	100,41	
C317	57,20	0,779	15,33	5,97	0,069	3,10	13,73	0,75	2,79	0,281	116	111	57	92	111	350	181	400	82	12,10	99,60	
C318	50,85	0,870	14,48	5,40	0,068	2,34	22,58	0,68	2,58	0,362	128	101	56	116	105	523	156	397	48	12,40	100,13	
C319	54,45	0,820	17,19	6,40	0,058	2,90	14,02	0,80	3,23	0,133	137	111	71	105	146	467	186	453	84	6,66	100,27	
C320	57,84	0,837	17,56	6,59	0,040	2,67	10,44	0,82	3,13	0,094	125	101	64	101	130	350	187	449	68	4,16	100,96	
C326	55,48	0,824	16,90	6,43	0,054	2,42	13,88	1,34	2,46	0,222	129	108	61	127	138	405	237	468	84	4,94	100,08	
C327	53,67	0,800	21,55	7,36	0,082	2,73	9,76	0,45	3,22	0,371	160	126	66	140	156	311	146	1016	82	12,27	99,47	
C328	56,98	0,803	17,28	6,33	0,055	2,66	11,58	0,92	3,25	0,147	143	93	60	148	141	413	222	505	89	6,69	100,79	
C329	59,61	0,867	17,72	6,75	0,081	2,97	7,89	0,94	2,97	0,210	113	103	52	911	138	349	224	1171	63	6,34	100,00	
C331	59,21	0,848	17,56	6,69	0,088	2,82	8,72	0,93	2,89	0,246	123	96	52	820	134	376	219	1082	104	5,79	99,76	
C330	58,05	0,851	17,21	6,33	0,058	2,77	10,54	0,93	3,04	0,215	120	92	56	1696	127	467	231	1336	63	8,15	99,57	
C332	56,82	0,838	18,28	6,44	0,058	2,79	10,09	0,84	3,53	0,324	136	103	56	164	151	364	219	604	97	5,25	99,31	
C334	57,39	0,772	17,07	6,18	0,063	2,47	11,91	0,80	3,00	0,339	122	94	47	119	125	337	207	568	79	6,46	100,07	
C335	55,79	0,746	16,08	5,88	0,051	3,34	14,27	0,87	2,83	0,144	128	97	58	108	126	430	198	506	82	12,71	99,32	
C336	54,89	0,766	17,33	6,37	0,074	2,58	13,72	0,95	3,15	0,174	136	98	60	113	125	452	193	447	96	5,02	100,10	
C337	55,78	0,815	17,22	6,43	0,046	2,37	12,97	0,86	3,32	0,197	136	81	57	128	131	424	218	475	82	4,35	99,53	
C338	57,81	0,970	19,87	6,77	0,041	2,81	7,47	0,81	2,67	0,784	116	112	61	104	101	327	236	571	91	7,17	100,46	
C339	61,48	0,897	17,48	6,61	0,048	2,26	6,90	0,84	3,02	0,461	135	102	58	120	143	247	253	537	80	3,28	98,49	
Firmalampen:																						
C341	50,51	0,685	15,38	5,63	0,040	2,52	21,63	0,68	2,56	0,355	93	90	55	97	97	571	175	843	77	12,46	99,96	
C342	53,77	0,800	17,43	6,16	0,054	2,68	15,01	0,83	2,99	0,288	103	114	60	101	136	518	197	613	71	5,99	99,40	
C345	54,36	0,783	18,71	6,57	0,088	2,42	12,66	0,66	3,53	0,226	132	114	70	120	163	474	192	568	108	5,31	100,10	
C346	56,99	0,847	17,84	6,54	0,040	3,24	10,24	0,83	3,33	0,114	138	105	65	137	147	313	223	526	74	6,71	99,87	
C347	55,79	0,801	18,14	6,37	0,055	2,49	11,97	0,73	3,24	0,422	116	105	55	125	152	426	201	579	83	5,11	100,33	
C348	61,87	0,787	16,83	5,69	0,040	2,77	7,75	0,95	3,09	0,224	119	104	56	158	145	287	199	546	45	6,57	100,54	
C349	53,24	0,784	17,18	6,21	0,048	2,50	15,75	1,07	2,99	0,223	124	113	59	86	189	481	210	554	61	6,03	100,35	
E665	56,99	0,898	18,77	6,68	0,048	2,68	9,80	0,76	2,71	0,666	100	119	63	65	83	354	173	584	72	7,16	99,21	
E667	57,58	0,858	17,93	6,62	0,037	2,66	9,82	0,87	3,42	0,222	110	114	61	81	148	284	188	542	57	3,45	99,43	
E668	60,24	0,875	17,04	6,36	0,048	2,65	8,24	1,02	3,04	0,489	110	106	55	76	112	296	178	696	54	4,21	99,34	
E671	56,26	0,770	16,47	5,97	0,050	2,42	13,83	0,84	2,86	0,519	96	106	52	74	139	422	163	719	97	6,22	100,04	
E672	58,00	0,853	17,79	6,56	0,036	2,75	9,89	0,83	2,99	0,316	139	118	48	72	107	297	176	584	101	1,90	101,02	
E677	55,29	0,785	17,24	6,22	0,054	2,55	13,63	0,77	3,01	0,458	116	107	44	67	99	415	152	638	40	6,35	99,33	
E680	56,25	0,809	18,51	6,53	0,051	2,83	10,33	0,88	3,45	0,354	137	104	55	71	120	378	152	678	86	3,98	99,47	
E682	51,69	0,724	15,77	5,52	0,048	2,19	20,41	0,74	2,64	0,252	115	104	50	67	83	386	146	522	85	1,00	99,60	
E683	54,51	0,767	16,28	5,86	0,041	2,76	15,97	0,77	2,75	0,299	100	95	39	75	147	399	163	621	82	8,26	99,90	
E684	56,65	0,824	16,97	6,27	0,047	2,52	12,34	0,83	3,16	0,404	105	100	45	67	131	359	170	666	117	5,86	99,79	
E685	54,74	0,774	17,09	5,43	0,051	2,20	14,69	0,73	3,61	0,699	126	106	49	72	151	433	163	692	92	5,87	100,20	
bricks found in Intercisa:																						
E690	54,73	0,841	18,12	6,91	0,065	2,84	12,25	0,73	3,35	0,157	123	107	83	88	148	393	176	443	65	6,01	99,24	
E691	55,11	0,824																				

Table 2, continued

Lab. No.	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	trace elements (in ppm)										I.o.i. %	orig. total
Intercisa A																						
<i>Firmalampen</i>																						
E686	62,44	0,991	19,09	6,80	0,119	2,92	2,38	1,55	3,47	0,243	103	120	60	102	144	136	239	706	63	1,35	100,87	
E687	63,04	0,994	19,08	6,57	0,077	2,77	2,42	1,75	3,09	0,219	129	118	66	103	123	157	256	707	81	1,99	99,46	
E688	62,55	1,004	19,31	7,08	0,070	2,87	2,16	1,53	3,22	0,211	133	128	64	101	153	125	257	686	132	1,68	100,04	
E689	59,04	0,924	18,72	6,60	0,122	3,28	6,12	1,41	3,34	0,441	120	111	69	95	155	171	220	705	102	2,33	101,09	
E696	65,45	1,028	17,94	6,51	0,071	2,44	1,76	1,71	2,87	0,230	126	121	54	92	151	134	300	640	102	1,03	100,85	
E697	63,36	0,997	17,79	5,99	0,069	2,60	4,72	1,64	2,62	0,217	124	114	58	82	135	173	287	634	107	3,32	100,75	
E698	62,15	0,945	16,44	5,49	0,081	2,64	7,70	1,60	2,67	0,290	127	97	57	88	144	198	288	606	113	4,97	99,80	
E699	65,02	1,018	17,48	6,05	0,077	2,43	3,27	1,71	2,73	0,223	114	113	56	88	151	154	284	609	106	0,33	101,43	
E701	60,23	0,952	17,02	6,05	0,084	2,99	8,03	1,66	2,76	0,235	93	104	55	78	134	188	258	688	123	4,38	99,66	
E702	63,52	1,059	19,33	7,02	0,063	2,70	1,47	1,53	3,13	0,178	130	126	64	98	172	136	253	624	104	0,93	98,48	
E704	65,73	1,023	17,57	6,35	0,085	2,37	1,99	1,73	2,88	0,276	118	123	55	97	134	126	289	581	127	1,61	100,19	
E706	66,35	0,999	17,22	5,64	0,072	2,37	2,67	1,65	2,75	0,272	111	100	51	87	153	158	284	565	145	0,99	100,64	
E707	65,12	1,009	18,17	6,38	0,097	2,60	1,77	1,63	2,95	0,277	128	127	53	99	121	137	282	668	126	1,45	100,68	
<i>Firmalampen found in Aquincum</i>																						
E666	64,51	1,057	18,97	6,35	0,085	2,60	1,66	1,62	2,92	0,230	112	133	45	102	147	138	266	671	90	1,45	99,55	
E675	63,64	1,042	18,42	7,53	0,088	2,35	1,91	1,58	3,12	0,330	120	128	54	83	120	164	263	684	139	1,05	100,05	
Intercisa B (moulds with differing composition)																						
E692	74,45	0,845	13,10	4,92	0,048	1,93	1,46	0,99	2,13	0,126	84	94	40	56	88	101	295	419	49	0,36	100,18	
E693	74,61	0,842	13,09	4,93	0,048	1,99	1,28	1,01	2,07	0,129	89	88	36	54	86	98	318	381	88	0,43	101,20	
Imports from Carnuntum B (finds of Firmalampen in Aquincum, Intercisa and Salla)																						
E669	67,50	0,789	17,52	6,66	0,142	1,81	1,27	1,00	3,11	0,202	117	117	93	90	144	83	188	601	53	0,56	99,83	
E670	66,00	0,802	18,08	7,47	0,155	1,83	1,37	0,92	3,18	0,212	138	118	73	83	117	92	179	688	80	1,16	100,40	
E674	66,41	0,801	18,34	7,08	0,122	1,84	1,22	0,89	3,08	0,216	128	114	73	76	120	99	175	655	76	1,42	100,18	
E681	66,70	0,801	17,84	6,83	0,117	1,81	1,30	0,93	3,20	0,474	124	115	90	88	173	113	169	710	73	2,08	99,38	
E700	66,55	0,789	17,42	6,48	0,113	2,03	1,96	1,01	3,35	0,314	127	105	80	77	148	116	186	638	70	1,69	100,78	
E703	66,11	0,810	17,90	6,89	0,146	1,86	1,61	0,89	3,55	0,244	126	121	94	90	163	94	183	645	110	0,49	101,06	
E705	66,09	0,789	17,41	7,01	0,170	1,82	2,12	1,01	3,17	0,421	128	100	97	83	128	111	171	696	100	1,47	101,93	
C324	67,37	0,814	17,40	6,56	0,103	1,87	1,61	0,75	3,30	0,215	123	101	56	126	144	116	209	632	65	1,55	98,19	
Imports from Poetovio (finds of Firmalampen in Aquincum and Salla)																						
C333	67,62	1,138	19,03	5,08	0,032	1,42	1,88	1,22	2,48	0,109	133	111	43	155	125	137	374	582	113	2,48	99,48	
C343	67,03	1,147	19,13	4,47	0,031	1,43	2,77	1,25	2,52	0,219	143	107	38	131	127	147	387	617	94	3,67	100,61	
E673	68,33	1,148	19,43	4,78	0,027	1,45	0,85	1,27	2,47	0,237	137	117	44	69	135	100	302	626	108	2,00	99,97	
E679	67,97	1,163	19,54	5,15	0,028	1,45	0,78	1,32	2,45	0,149	163	124	42	58	109	109	302	603	143	1,07	99,85	
C325	65,40	1,129	20,70	6,06	0,048	1,55	0,99	0,78	3,20	0,156	165	132	41	122	141	98	242	688	85	1,87	99,25	
Import from Modena (Firmalampe found in Aquincum)																						
C344	67,10	0,946	18,81	6,61	0,023	1,25	2,55	0,96	1,68	0,074	120	141	34	100	110	96	319	405	79	2,71	99,13	
non attributed samples																						
<i>mould and Firmalampe found in Aquincum</i>																						
C340	48,79	0,878	20,00	6,62	0,045	2,83	17,08	2,27	1,22	0,272	121	122	63	143	27	538	192	339	68	6,52	99,58	
E676	63,11	0,952	18,36	7,32	0,116	1,77	5,21	0,91	2,04	0,204	172	221	86	86	102	137	247	421	111	3,25	99,72	
<i>kiln wall and clay with very differing composition</i>																						
C302	52,09	0,637	12,23	4,51	0,092	7,07	19,62	0,98	2,59	0,191	86	69	33	74	95	309	201	354	61	29,30	99,81	
C303c	67,15	0,988	21,72	3,08	0,010	1,65	0,88	0,76	3,70	0,049	152	118	16	103	176	113	207	456	73	5,24	97,77	

connection with Modena. The stamps, however, can not prove an authorized local branch workshop e.g. of the lampmaker Fortis having his major workshop in Modena (*Schneider 1993*).

Some of the lamps of Fortis and other North Italian lampmakers in Aquincum by chemical analysis were detected as imports from Modena, Carnuntum and Poetovio.

Lamps stamped with the same names not necessarily indicate the same provenance as may show the analysed two lamps of Lucius, a potter known from Poetovio. One of these two lamps was made in Poetovio (E679) but the other one (E682) was made in Aquincum. The same name appears also on a mould (C333) made in Aquincum⁶.

The lamps were more or less randomly sampled without hypotheses of their provenances. Their number may be taken as rough estimation on the relation of imports to local lamps. Lamps made in Modena can mostly be recognized without chemical analyses by their quality, their typical red colour and their missing slip and they therefore were not sampled for analysis. So the only one analysed lamp (E344), already before analysis hypothesized as originating from Modena, does not represent the quantity of those imports.

INTERCISA

The analysed objects were illustrated and published in the catalogue published by *Zs. Ujlaki Pongrácz (2006)*. Her numbers are included here in **Table 1**.

Table 3 Means, standard deviations and coefficients of variation of the reference groups Aquincum, Intercisa, Carnuntum and Poetovio.

Reference group	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	V	Cr	Ni (Cu)	Zn	Rb	Sr	(Y)	Zr (Nb)	Ba (La)	(Ce)	(Pb)	(Th)			
	major elements (in per cent by weight)										trace elements (in ppm)														
Aquincum (n = 66)																									
mean	56,00	0,792	16,97	6,27	0,056	2,63	13,19	0,83	2,96	0,260	122	102	57	23	101	128	388	31	188	13	512	32	75	24	16
std ±	2,85	0,069	1,56	0,61	0,014	0,30	4,03	0,18	0,44	0,103	15	15	11	11	25	22	82	4	33	5	94	7	18	8	3
V %	5,1	8,7	9,2	9,7	24,5	11,3	30,6	22,4	14,8	39,4	12,1	15,1	19,5	48,8	24,9	17,4	21,2	14,1	17,4	38,4	18,3	22,3	24,1	31,6	18,3
Intercisa (n = 15)																									
mean	63,48	1,003	18,17	6,43	0,084	2,66	3,34	1,62	2,97	0,258	119	118	57	57	93	142	153	45	268	18	652	45	114	66	n.d.
std ±	2,03	0,039	0,91	0,55	0,017	0,27	2,23	0,09	0,25	0,063	11	11	6	12	8	15	22	4	22	3	47	9	19	12	
V %	3,2	3,9	5,0	8,5	20,5	10,1	66,8	5,5	8,5	24,5	9,3	9,3	11,0	21,2	8,8	10,2	14,7	9,7	8,1	14,9	7,2	20,2	16,3	18,5	
Carnuntum A (n = 37), non-calcareous																									
mean	67,08	0,798	17,57	6,67	0,152	1,89	1,51	0,84	3,24	0,236	123	118	85	30	97	153	107	42	192	14	664	35	72	29	19
std ±	0,95	0,022	0,48	0,41	0,038	0,15	0,38	0,24	0,14	0,079	9	9	16	6	10	13	12	5	17	1	61	5	14	7	2
V %	1,4	2,7	2,8	6,2	24,7	7,8	25,2	28,2	4,2	33,5	7,5	7,5	19,3	21,4	10,2	8,5	11,4	11,5	8,7	8,6	9,1	13,7	19,8	24,7	11,2
Carnuntum B (n = 37), calcareous																									
mean	60,50	0,747	15,97	5,85	0,118	3,13	9,59	0,83	2,99	0,244	120	123	68	46	101	148	263	27	172	11	542	42	68	20	16
std ±	1,63	0,037	0,75	0,59	0,025	0,28	1,73	0,12	0,12	0,066	13	14	9	21	10	9	43	2	14	3	98	14	9	6	3
V %	2,7	5,0	4,7	10,0	21,3	8,8	18,0	14,6	4,1	27,1	10,7	11,7	13,2	46,6	9,5	6,0	16,3	7,4	7,9	27,4	18,1	34,2	12,9	31,7	17,8
Poetovio A (n = 58)																									
mean	66,40	1,320	21,70	4,51	0,032	1,27	0,91	1,16	2,30	0,248	142	118	47	30	65	103	110	42	321	26	630	48	105	40	22
std ±	1,50	0,060	1,00	0,62	0,006	0,15	0,24	0,20	0,17	0,165	14	11	7	17	9	14	12	5	20	4	40	6	7	19	3
V %	2,2	4,4	4,5	13,8	19,3	11,8	26,6	17,1	7,4	66,3	9,8	9,1	14,0	58,0	13,0	13,0	11,0	11,0	6,4	14,0	6,3	12,0	7,0	46,0	11,0

Moulds for *Firmalampen* have not been found in Intercisa. However, three moulds for other types of lamps and two stamped bricks were analysed. The composition of these five samples differs significantly from that of the analysed *Firmalampen* from Intercisa. Therefore, a reference group for the local ceramics in Intercisa was established using the major compositional group of *Firmalampen*. This group includes all lamps with stamps Victor or Victoria and those from BAEB, which were believed to be local in Intercisa. Based on this assumption only the chemical group can be regarded as the local reference group.

The variation in calcium contents is very large (**Fig. 1**). Looking at other elements the group is quite homogeneous and clearly distinguishable from other groups of *Firmalampen* or pottery. In spite of the large variation of calcium from 1.5 to 8 % CaO the mean was calculated (**Table 3**). The very high coefficient of variation for calcium (67 %), however, indicates a non normal distribution. On the other hand, in many clay deposits calcium contents are largely varying and different contents do not necessarily prove a different geographic provenance.

Two stamped bricks and one mould for a lamp represent imports from Aquincum. Two other moulds have a very special composition with silica content much higher than in all analysed lamps or pottery from the region. The remaining elements therefore must have lower values compared to the reference group (dilution by silica)⁷. Probably these moulds were made from the same clay but with additional temper from quartz. This should be verified by thin section studies.

IMPORTS

Both in Aquincum and in Intercisa some of the *Firmalampen* could not be attributed to the local reference groups. Their provenance could be determined using available data from other lampmaking centres in Pannonia. In **Fig. 1** the samples not belonging to the local products are shown as circles. The imports from Poetovio are not included in the diagram because there is too much overlapping. These imports from Poetovio can easily be distinguished considering other elements e.g. titanium and magnesium (**Table 2**). Two samples from Aquincum lie within the field of Intercisa and four samples from Intercisa are within the Aquincum field (**Fig. 1**). The other non-matching samples form a homogeneous group corresponding to a production in Carnuntum.

Detected from our limited data it seems that besides Modena only Carnuntum and Poetovio were of importance as exporting lampmaking centres in Pannonia. In Carnuntum two different clays have been used (*Sauer & Gassner 1991*) resulting in a reference group (B) of calcareous lamps and pottery and a second reference group (A) of non-calcareous lamps (**Table 3**). The calcareous reference group includes two analyses of geological clay samples and one unfired sherd found in a kiln. The non-calcareous reference group besides *Firmalampen* includes only one pottery sherd from Carnuntum⁸. The reference group for lamps made in Poetovio is published by *Daszkiewicz and Schneider (1999)*.

The chemical difference between the calcareous lamps from Aquincum and the calcareous reference group from Carnuntum is small but sufficient to separate the two groups by means of multivariate methods. None of the

imported lamps in Aquincum belongs to the calcareous Carnuntum group. The lamps imported from Carnuntum bear names of lampmakers known to have worked in Modena (Fortis, Cresces, QGC). One of the two analysed *Firmalampen* from Salla/Zalalövő published by Pongrácz (1990, cat.nr. 275, a lamp stamped *Vibius*) turned out to be an import from Carnuntum. The question is whether these imports represent workshops making illegal copies of North Italian lamps can not be answered by chemical analyses and may only be made unlikely on a larger database.

In Aquincum the two imported *Firmalampen* from Poetovio were stamped Fortis and Lucius. A lamp with stamp L. Narius, one of the two lamps analysed from Salla (Pongrácz 1990, cat.nr. 33), was also identified as an import from Poetovio. One *Firmalampe* with stamp Cresces (E676) could not be attributed to any of the reference groups available to us. This is also true for one mould for a *Firmalampe* (C340) made from calcareous clay with low potassium and rubidium contents and certainly also representing an import in Aquincum. A kiln wall with an exceptional high magnesium content (C302) and a non-calcareous grey clay sample (C303c) differ from Roman ceramics in Aquincum.

CONCLUSIONS

The analysed pottery and *Firmalampen* yielded significant reference groups for the ceramics made in Aquincum and Intercisa, which can easily be distinguished e.g. from the reference groups Modena, Carnuntum and Poetovio (Table 3). These latter reference groups were used to detect imports in Aquincum, Intercisa and Salla. Ceramics produced in Aquincum included moulds for various objects including lamps and *Firmalampen* with names of potters known to have worked in Modena. In Intercisa the *Firmalampen* formed a local reference group to which moulds found in Intercisa could not be attributed. Two stamped bricks and one of the moulds for a lamp found in Intercisa have been made in Aquincum thus demonstrating the limited value of such finds to establish a local reference group. Two other moulds in Intercisa were probably locally made but from a raw material with higher silica content and thus significantly differ from all analysed local lamps.

A similar case was detected in Aquincum where a mould for a lamp and the two analysed moulds, believed to prove a local terra sigillata production of Pacatus, were made from non-calcareous clay which, as long as our analyses are regarded to be representative, had not been used for other pottery and lamps in Aquincum. These three objects may be the first indication of a second reference group Aquincum B. Was this clay used to make sigillata from Pacatus for which chemical data are not yet available? The moulds had been found in the same surrounding of the Gas Factory potters' workshop as the

other analysed pottery. Why two different raw materials had been used and why a non-calcareous clay was used in a sigillata workshop where calcareous clay is the usual and better choice? Beyond that, in spite of a large variation in composition, the chemical analyses did not allow to distinguish kilns or workshop areas in Aquincum.

In Intercisa all lamps believed to be local showed similar composition and are taken as the reference group for local production. The two analysed moulds do not prove this local production because their chemical composition, probably because of different temper, does not match that of the local lamps.

The organisation of production and distribution of *Firmalampen* is still an open question. From the chemical analysis the place where a lamp was made can be determined but it is not known if the potter's name represents his authorized products or just copies made by using an original lamp with this name to make a mould. Large series of analyses of finds at Vindonissa and at various other Roman sites⁹ showed that stamped lamps of good quality, independent from the name, came from only few workshops and are more probable to be the products of legal workshop branches than copies of many potters at different places. This is especially true for the 1st century AD in Vindonissa where only three lampmaking centres, Modena, Lyon and Trier supplied nearly all *Firmalampen*. Later on, local products, including products of workshop branches or copies of lamps with potters' names from Modena, are of more importance. This is now also confirmed in Aquincum and Intercisa where lamps with local names as well as lamps with north Italian names were made locally. The latter lamps were also found to be imports from other lampmaking centres e.g. from Poetovio and Carnuntum. Did they travel as illegal copies of original Modena lamps?

Most of the arguments against authorized workshop branches are connected to the method of production. *Firmalampen* are made out of a negative mould, which already bears the name. These moulds are made from a positive counter-die, which could be a purchased lamp including the stamped name or it could be a solid specimen not to be used as a lamp. Many of the moulds for lamps certainly were made from gypsum plaster and therefore rarely survived. For this reason lampmaking centres such as at Modena can not be proved by finds of moulds. All the arguments based on the process of lampmaking do not help to answer the question of illegal copies because the hypothesized unauthorized copies as well as the original products were made in the same way. The only chance is to study the real places of production and the distribution of the products to find new arguments. The results of the chemical analyses may contribute to such arguments.

NOTES

¹ Schneider and Wirz 1992a, 1992b; Schneider 1993; Daszkiewicz and Schneider 1999.

² The 25 analyses of *Firmalampen* published by P. Zsidi are included in table 2 to present the complete dataset.

³ Wavelength-dispersive X-ray fluorescence analysis (Philips PW1400) was used to determine the content of major elements, including phosphorus. It was also used to determine a series of fifteen trace elements, six of which (Cu, Y, Nb, La, Ce, Pb), however, could only be determined with poor precision and data for samples weighing less than 0.1 gram except Ce are not given. Total iron was calculated as Fe₂O₃. Samples were prepared by pulverising fragments weighing about 2 g, having first removed their surfaces and cleaned the remaining fragments with distilled water in an ultrasonic device. If this was not possible samples were taken by drilling with a tungsten carbide drill. The resulting powders were ignited for 1 hour at 880°C, melted with a lithium-borate mixture (Merck Spectromelt) and cast into small discs for measurement. The data are, therefore, valid for ignited samples but, with the losses on ignition (l.o.i.) given, may be recalculated to a dry basis. For easier comparison the major elements are normalised to a constant sum of 100%. The precision for major elements is below 1%, for trace elements this rises up to 20% depending on the concentrations (this may show the analyses of two joining fragments in table 3). The accuracy is tested by analysing international reference samples and exchange of samples with other laboratories. For major elements and the most important trace elements it lies between 5 and 10%.

⁴ The data were not published in the paper (in our opinion this should be done as a rule) but were kindly supplied by M. Balla to be compared with our analyses. As it should be, the values for the elements Fe, Na, K, Cr, Zn, Rb, Ba, Ce, the only elements determined with both methods (the important element Ca was missing in the NAA data), varied within acceptable limits.

⁵ These samples were illustrated and described in more detail by Zsidi (2003, figs. 4-8); the concordance of her catalogue with our laboratory numbers is given in **Table 1**.

⁶ Chemical analysis of a mould with the same stamp found in Poetovio showed a composition different both from Poetovio and Aquincum reference groups (Daszkiewicz and Schneider 1999, p.189 sample E569).

⁷ After correction with a calculated average dilution factor the agreement is acceptable except for Ti and Zr, probably because these elements are included in the temper.

⁸ Samples of Firmalampen have been selected by V. Gassner, the pottery samples by R. Sauer. The analyses by WD-XRF in Berlin were not yet published.

⁹ E.g. Trier, Frankfurt, Heidelberg, Regensburg, Carnuntum, Poetovio, Emona, Aquileia, Cosa, Rome and others (partly published in Schneider and Wirz 1992a, b and Schneider 1993).

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