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The Use of Dilatometry in Determining the Manner of Selecting Ossuary Vases: The Case of *Lugdunum* During the Early Roman Empire

Le recours à la dilatométrie pour déterminer le mode de sélection des vases ossuaires : le cas de Lyon durant le Haut-Empire romain

Valérie Thirion-Merle[a], Cécile Batigne Vallet[a], Christine Bonnet[b] et Alain Bernet[a]

Abstract: A recent synthesis of Lyon/*Lugdunum*'s ossuary ceramic ware showed that, typologically, the ceramics used to collect the residues of burnt bone were the same as those used in the city's kitchens (Bonnet *et al.,* 2016). The forms are indeed strictly the same. Nevertheless, some ossuary pots from the only two funerary areas known from the Augusto-Tiberian period show particular traces totally unknown on domestic ceramics, such as slits, crumbling peeled surfaces, manufacturing flaws and other characteristics suggesting insufficient firing temperature. The authors propose the hypothesis of an opportunistic use of these pots unsuitable for culinary use. In order to check if these pots were truly under-fired, we have measured about thirty ossuary ceramic ware *apparent* firing temperatures with a dilatometer. The elemental compositions were also determined by X-Ray fluorescence spectrometry to identify the provenance of the pots. This paper will present the results of this study and offer some interpretations of the transfer of these objects from a domestic to a funerary context.

Résumé : *Une récente synthèse sur les vases ossuaires de Lugdunum a permis de montrer que typologiquement les vases utilisés pour recueillir les restes d'os brûlés étaient les mêmes que ceux utilisés dans les cuisines de la ville (Bonnet* et al.*, 2016). Les formes sont en effet les mêmes. Mais certains vases ossuaires de deux ensembles funéraires de la période augusto-tibérienne montraient des traces inconnues en contexte domestique, telles que des fentes, des surfaces desquamées, des couleurs inhabituelles ou d'autres défauts de fabrication évoquant une température de cuisson insuffisante. Les auteurs en ont déduit une utilisation opportuniste de vases impropres à une utilisation culinaire. Pour vérifier que ces vases étaient insuffisamment cuits, des mesures de températures de cuisson par dilatométrie ont été réalisées sur une trentaine d'objets. De façon à en préciser la provenance, leur composition élémentaire a été déterminée par spectrométrie de fluorescence X. Cet article présente les résultats des mesures et propose certaines interprétations possibles pour le passage du contexte domestique au contexte funéraire de ces vases.*

Keywords: dilatometry, elemental composition, Early Roman Empire, firing temperature, *Lugdunum* ossuary ceramic ware, X-Ray fluorescence spectrometry

Mots clés : *composition élémentaire, dilatométrie, Haut Empire Romain, spectrométrie de fluorescence X, température de cuisson, vase ossuaire de* Lugdunum

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1. Introduction

This study concerns a particular type of ceramic ware of the Early Roman Empire that we shall qualify as "*ossuary vases*". Ossuary vases are recipients intended to receive a variable quantity of burnt bone of a cremated deceased collected on a funeral pyre. These bones may have been washed before being placed in the vases. The recipient, most often ceramic, is then deposited in a permanent structure located in the same place as the pyre itself or in a pit specially dug for that purpose (Blaizot dir., 2009).

According to recent studies, in *Lugdunum* during the Augusto-Tiberian Period, the ossuary ceramic ware consists of exactly the same recipients as those found in domestic contexts and used in the kitchen as cooking pots intended to go on the fire. Most often, they are cooking pots of egg- or globular shape with a wide but narrowed opening and covered with an adapted lid (Fig.1).

However, it was noticed that the surface finish of some of these pots used to collect burnt bone, of this precise period—that is to say from the end of the 1st century BC to the beginning of the 1st century AD— is very different from that of domestic ones. The pots have a damaged surface which does not correspond to that usually observed on pots in domestic or workshop contexts. Nor is this damaged appearance identified by archaeologists on pots from later periods. The peeled nature of the surface of some of the ossuary vases and other characteristics detailed below are particularly suggestive of under-firing (Bonnet *et al.,* 2016).

The hypothesis put forward is that ceramic ware unsuitable for cooking use was selected for another use, that of collecting the burnt bones of the deceased.

To try to understand these differences and to verify if some of the pots were really underfired, we have measured *apparent* firing temperature with a dilatometer on ceramics found in three of *Lugdunum*'s funerary areas. We have also tried to determine whether there were several workshops involved or a specialized one and if the ossuary ware came from already known *Lugdunum* workshops.

The study was made possible thanks to the extensive archaeological knowledge of the ceramic assemblages dating from the Early Roman Empire in Lyon, due to the great number of excavations of domestic and workshop contexts in the city.

2. Sample

The sample consists of 28 sherds of ossuary vases or lids found in three of *Lugdunum's* funerary areas, two of the Augusto-Tiberian period and one more recent. The first site is *62 Rue du Commandant Charcot*, and the second *19 Rue des Granges*. These two sites are located in the 5th arrondissement of Lyon (France) on the Fourvière hill (Fig. 2).

Fifteen globular pots and four lids came from the *Rue du Commandant Charcot* site (OSL 1 to OSL 19), seven globular pots and one lid from the *Rue des Granges* site (OSL 20 to OSL 27) (Fig.1). Some of these sherds have a damaged appearance which does not correspond to that observed on pots found in domestic contexts or in workshops (Bonnet *et al.*, 2016). In the *Rue du Commandant Charcot* ensemble, the surfaces of the pots are mostly missing or they have a peeled appearance (Table 1). We observe sand grains on the surfaces and slits or cracks. Some pots seem to be underfired since they are rather soft and do not produce the sound of well fired ceramics. In the *Rue des Granges* ensemble, the vases are less damaged, but the surfaces seem to be worn and also look peeled. The walls or bottoms of some pots, sometimes cracked, are abnormally thin to the point that a domestic use seems excluded.

One globular pot coming from a more recent funerary site, *Rues Chevrier-Rochette* (OSL 28), was also included in this study. This last site, dated from the end of the 2nd century AD to the 3rd century AD, is located in the 7th arrondissement of Lyon. This object has a usual appearance with the same thickness, the same colour, and the same surfaces as a domestic pot. It is probably well fired. It was selected to compare a normal sherd with the damaged ones.

It is possible that the observed damages could be linked to burial conditions, but it seemed important to us to try to correlate these macroscopic observations with the technical characteristics of the vases such as the firing temperatures.

3. Experimental observations

To determine their composition and try to identify their provenance, the ceramics were analysed by Wavelength Dispersive X-Ray Fluorescence Spectrometry (WD-XRF), according to the standard procedures of the Archaeology and Archaeometry Laboratory at CNRS–University of Lyon in France, using a Bruker S8 Tiger spectrometer with a Rh excitation source. This procedure gives the bulk chemical composition of the ceramic (matrix and sandy fraction) and consequently of the material used for its manufacture (Thirion-Merle, 2014; Waksman, 2014). Measurement

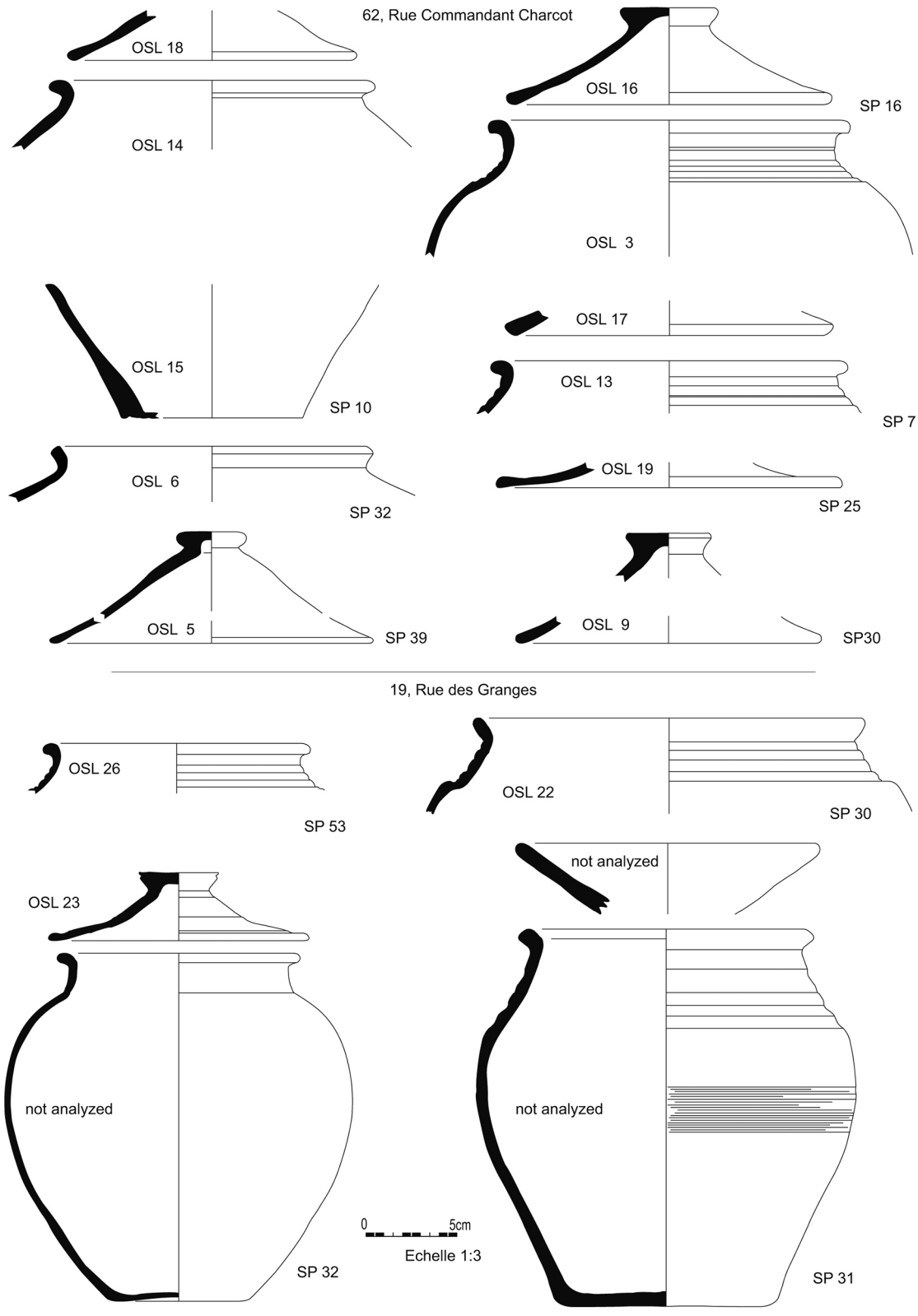


Figure 1: Selected ossuary vases from the two Augusto-Tiberian funerary ensembles (Bonnet *et al.*, 2016).
Figure 1 : Vases ossuaires sélectionnés des deux ensembles funéraires Augusto-tibériens (Bonnet et al.*, 2016).*

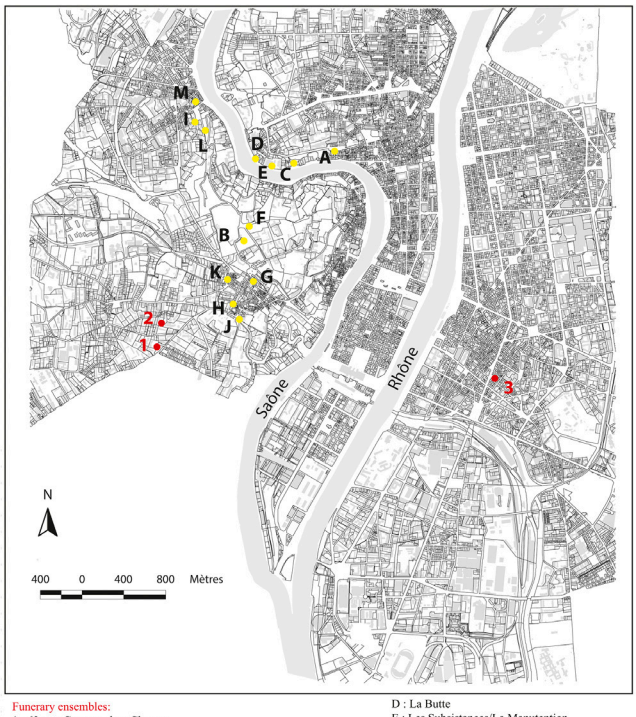


Figure 2: (See colour plate XVI) Map of the funerary ensembles selected for this study and of Lyon's ceramic workshops (Data from the French National Archaeological Map. IGN BD TOPO ® IGN – 2014; Direction régionale des affaires culturelles Auvergne-Rhône-Alpes, Service régional de l'Archéologie).
Figure 2 : (Voir planche couleur XVI) Carte des ensembles funéraires sélectionnés pour l'étude et des ateliers de potiers de Lyon (Données issues de la carte archéologique nationale. IGN BD TOPO ® IGN – 2014 ; Direction régionale des affaires culturelles Auvergne-Rhône-Alpes, Service régional de l'Archéologie).

is carried out on glass discs of homogenous composition containing only 800 mg of powdered sample. For each sample, twenty-four components are determined, ten majors or minors and fourteen traces. The calibration curves were established with forty international geo-standards.

The estimation of the firing temperature of the vases was done using a dilatometer measuring the thermal expansion of ceramics. This method is based on the thermal expansion properties of the ceramics and on the assumption that when clays are fired, shrinkage occurs as a result of various sintering processes (Tite, 1969). Consequently, when a fired clay ceramic is reheated from room temperature, it exhibits normal reversible thermal expansion, characteristic of its mineralogical composition. At a temperature close to the one at which the ceramic was initially fired, the physical and chemical changes occurring during its initial firing start again. Consequently, the ceramic begins to contract. The temperature at which we note this change is called "apparent firing temperature" (Fig.3a). The relationship between the apparent firing temperature and the original firing temperature depends on the mineralogical composition of the clay, the clay minerals and the impurities present in the clay as well as the time during which the highest temperature was maintained in the kiln. In general, the apparent firing temperature is not very different from that of the initial firing temperature, which is the range at which firing ended before cooling began (Cuomo di Caprio and Picon, 1999). For these measurements a Netzsch dilatometer, model 402 EP, was employed. Each sample was reheated from room temperature to 1020°C with a heating rate of 3 K/min. This temperature was maintained during one hour, and then the sample was cooled to room temperature at the same rate. For the acquisition of the dL-signal, a measuring range of 4000 µm was selected, and consequently a resolution of 1 µm.

4. Results

The compositions of the 28 sherds are given in table 1. They reveal that all the ceramics have non calcareous fabric, and that the sample is not chemically homogeneous. Special attention was given to phosphorus oxide (P_2O_5), a chemical component that can be trapped by ceramics in contact with bone during burial, especially in locally acidic conditions. This phenomenon depends on the nature of the ceramic (calcareous or non-calcareous) and the porosity, and could be more important for low-fired ceramics (Collomb and Maggetti, 1996; Maritan and Mazzoli, 2004; Maritan *et al.*,

Table 1: Summary table giving the normalized chemical compositions of *Lugdunum* ossuary pots, obtained by WD-XRF, in the same order as the Figure 4 dendrogram (majors and minors are given in percentage of oxide, trace elements in parts per million of metal), the apparent firing temperatures and the damage observed on the wares (RNP = Ribbed neck pot; ASP = Angular shouldered pot; L = rounded lip lid).
Tableau 1 : Tableau récapitulatif donnant les compositions chimiques normalisées des vases ossuaires obtenus par WD-XRF dans l'ordre du dendrogramme de la figure 4 (Les concentrations des majeurs et mineurs sont exprimées en pourcentage d'oxyde, les éléments traces en parties par million), les températures apparentes de cuisson et les dommages observés sur les vases (RNP = pot à col côtelé; ASP = pot à épaule carénée; L = couvercle à lèvre arrondie).

Sample Nr.	Archeological form	Funerary site	CaO	Fe_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	Na_2O	P_2O_5	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu	Apparent firing temp.	Damage observed on sherds
			weight oxide %										ppm														°C	
OSL 8	ASP	Charcot	1.17	6.83	0.995	3.49	62.28	21.13	1.39	0.0456	1.72	0.75	316	158	190	105	122	47	75	674	95	142	56	27	45	33	809	original grey colour of the surfaces is almost gone exposing the tan colour inside the sherd, surfaces are peeled
OSL 9	L	Charcot	1.12	6.93	1.020	3.46	61.76	21.64	1.42	0.0409	1.74	0.67	330	156	175	108	125	47	60	656	103	139	57	28	47	37	877	sandy grey-tan surfaces and red brownish colour inside the sherd
OSL 12	ind. pot	Charcot	1.14	7.06	1.029	3.94	60.73	21.86	1.67	0.0474	1.82	0.49	331	165	228	110	127	56	65	693	86	150	57	30	47	46	780	sandy dark grey surfaces, surfaces are peeled
OSL 22	RNP	Granges	1.28	8.10	1.020	3.02	63.35	19.15	1.78	0.0751	1.18	0.84	293	129	182	128	116	51	63	657	122	114	49	18	41	34	849	sandy grey-tan surfaces and same inside the sherd
OSL 2	ind. pot	Charcot	1.50	7.66	1.090	3.20	60.25	22.16	1.63	0.0736	1.58	0.63	299	163	191	110	150	75	71	781	113	135	62	28	63	44	640	surfaces are dark black, sherd is dark brownish inside, walls are cracked
OSL 6	ASP	Charcot	1.53	6.26	0.823	3.54	63.57	19.75	1.56	0.0597	2.12	0.58	238	201	190	90	126	70	57	787	80	120	40	24	48	36	684	surfaces are dark black, sherd is red brownish inside, walls are granular
OSL 7	ind. pot	Charcot	1.54	6.01	0.831	3.52	63.47	20.02	1.59	0.0460	2.20	0.57	246	206	196	94	128	81	68	784	77	119	46	28	50	37	728	surfaces are dark black, sherd is red brownish inside, walls are granular
OSL 14	ASP	Charcot	1.08	6.27	0.877	1.53	70.72	18.07	0.50	0.0457	0.32	0.43	326	108	80	73	102	46	37	599	95	85	31	19	29	37	not det.	outer surface is grey, inner surface is tan-grey and the sherd is red brownish, surfaces are peeled, cracks
OSL 24	ind. pot	Granges	1.24	6.18	0.854	1.22	71.76	17.62	0.51	0.0598	0.20	0.19	332	77	69	75	105	51	43	543	94	72	27	16	37	45	624	surfaces are dark black, sherd is red brownish inside, walls are split
OSL 15	ind. pot	Charcot	0.93	6.55	0.900	1.56	69.88	18.73	0.46	0.0745	0.31	0.44	348	102	81	80	106	53	43	590	97	94	31	20	33	40	628	surfaces are dark black, sherd is red brownish inside, walls are cracked
OSL 18	L	Charcot	1.23	6.70	0.885	1.17	69.94	18.50	0.52	0.0869	0.22	0.57	347	99	68	82	111	59	29	495	114	77	28	17	32	35	not det.	original black colour of the surfaces is almost gone and shows the red brownish colour inside the sherd
OSL 17	L	Charcot	1.00	6.13	0.861	1.09	72.95	16.44	0.40	0.0505	0.19	0.73	364	75	63	97	99	46	41	455	104	79	27	21	34	77	not det.	surfaces are dark black, sherd is red brownish inside. No visible damage
OSL 1	L	Charcot	0.87	6.50	0.886	1.65	70.30	17.92	0.48	0.0254	0.43	0.76	384	77	83	69	112	45	52	388	116	107	36	18	45	211	626	original black colour of the surfaces is almost gone and shows the tan colour inside the sherd
OSL 16	L	Charcot	0.82	6.78	0.929	1.44	69.62	18.76	0.52	0.0316	0.18	0.76	395	68	61	88	120	50	56	336	127	111	37	18	37	54	620	original black colour of the surfaces is almost gone and shows the tan colour inside the sherd
OSL 26	RNP	Granges	0.79	6.52	0.951	0.95	70.09	18.93	0.59	0.0438	0.12	0.87	360	58	54	69	102	43	45	355	92	107	32	21	38	30	not det.	grey sandy surfaces, tan brownish inside the sherd
OSL 4	ind. pot	Charcot	0.88	7.29	0.847	1.99	69.31	17.99	0.74	0.0407	0.20	0.53	327	79	102	94	124	61	41	652	125	83	33	19	35	42	674	original black colour of the surfaces is almost gone and shows the tan-grey colours inside, walls are cracked
OSL 5	L	Charcot	0.82	7.06	0.875	1.80	70.72	17.15	0.59	0.0195	0.23	0.56	365	74	94	92	120	57	45	530	121	88	38	21	30	54	662	original black colour of the surfaces is almost gone and shows the tan colour inside the sherd
OSL 13	ind. pot	Charcot	0.64	7.60	0.864	1.47	69.03	18.78	0.72	0.0256	0.15	0.57	361	58	79	95	129	46	51	358	122	88	31	22	30	42	623	original black colour of the surfaces is completely gone and shows the tan-grey colour inside, with sand appearing
OSL 10	ind. pot	Charcot	0.77	6.82	0.847	1.56	70.75	17.52	0.63	0.0296	0.24	0.67	343	73	94	75	110	40	46	414	103	82	32	16	31	38	803	original surfaces are gone and show a tan-grey colour on the outer surface, and a orange colour on the inner surface, surface is peeled, walls are cracked
OSL 11	ind. pot	Charcot	0.76	6.51	0.797	1.94	71.26	16.80	0.93	0.0397	0.18	0.61	343	78	113	94	117	50	38	446	99	87	29	20	35	48	843	sandy grey-tan surfaces and red brownish colour inside the sherd
OSL 21	ind. pot	Granges	0.69	6.38	0.924	0.95	69.11	20.52	0.63	0.0828	0.08	0.48	344	51	57	106	97	48	55	289	67	113	40	20	40	133	804	homogenous orange colour
OSL 27	RNP	Granges	0.65	4.99	0.820	0.90	75.96	15.56	0.59	0.0551	0.23	0.11	347	57	61	37	81	58	79	242	90	142	48	18	36	33	948	homogenous grey sandy surfaces
OSL 25	ind. pot	Granges	0.62	5.57	0.846	0.99	73.89	16.86	0.67	0.0465	0.21	0.16	330	61	62	40	86	56	75	269	99	122	47	19	30	25	919	homogenous grey sandy surfaces
OSL 23	L	Granges	0.75	5.70	0.843	1.10	74.64	15.70	0.57	0.0190	0.25	0.29	338	81	73	50	94	45	43	287	98	96	29	19	39	30	796	tan-grey outer surfaces are peeled, the grey colour inside the sherd seems homogenous
OSL 20	ind. pot	Granges	0.53	6.16	0.835	1.18	74.70	15.52	0.62	0.0270	0.11	0.19	369	39	74	62	87	35	44	258	96	91	30	16	35	32	not det.	sandy grey-tan surfaces and same inside, very thin walls
OSL 3	RNP	Charcot	0.79	8.07	0.920	1.67	66.92	19.39	0.85	0.0216	0.15	1.04	368	76	81	117	148	68	50	464	127	97	34	22	44	144	675	original black colour of the surfaces is almost gone and shows the tan-grey colour inside the sherd
OSL 28	pot	Rochette	0.80	8.01	0.891	1.61	65.74	21.99	0.67	0.0531	0.00	0.09	237	43	87	48	113	37	54	430	139	87	28	20	41	25	882	homogenous black colour on the surfaces and grey colour inside the sherd
OSL 19	L	Charcot	1.13	6.22	0.770	1.63	71.81	16.80	0.87	0.1971	0.22	0.15	315	105	107	77	105	75	36	777	105	84	21	24	44	40	684	surfaces are dark black, sherd is red brownish inside

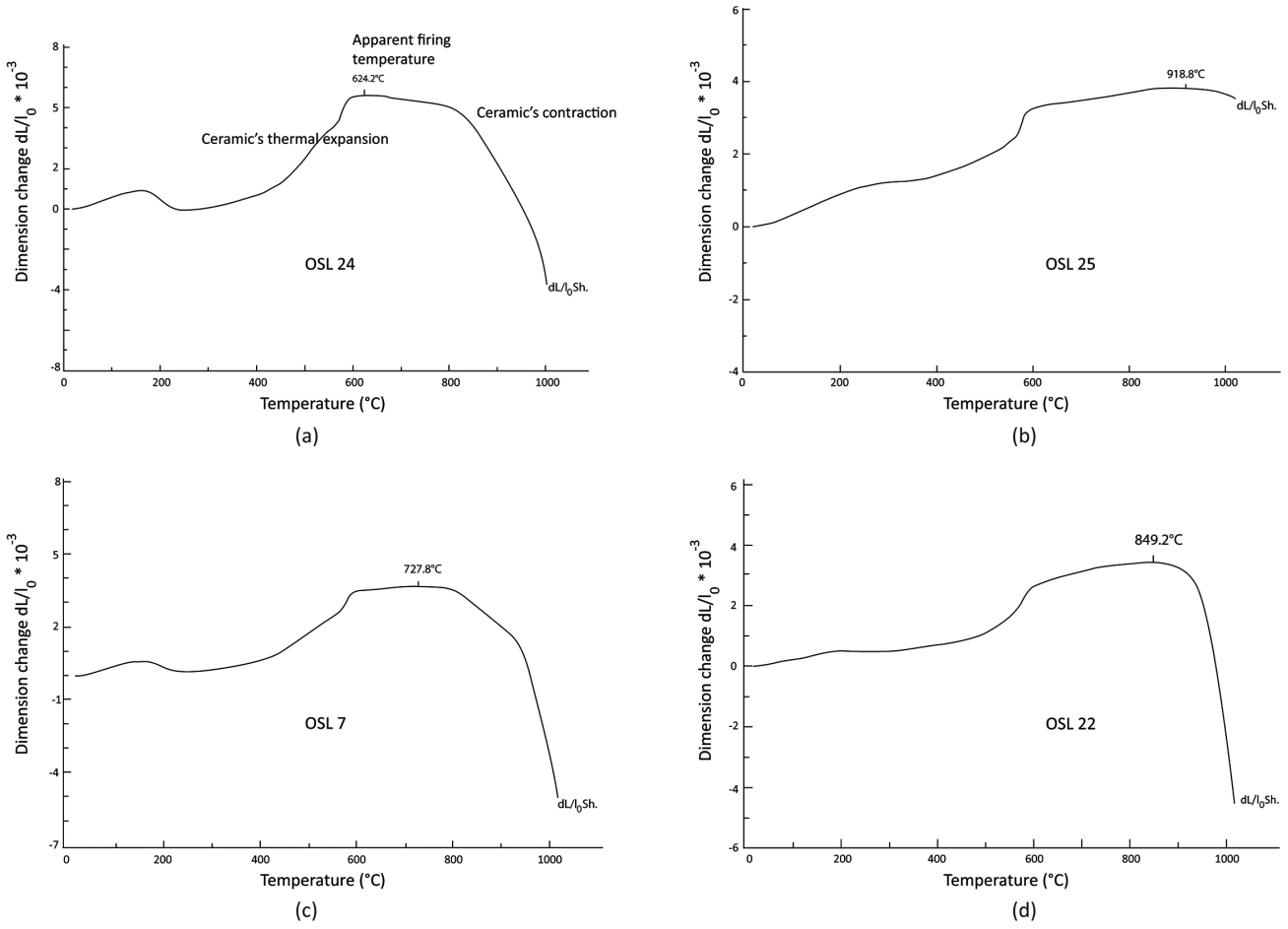


Figure 3: Thermal expansion curves recorded for four ossuary pots.
Figure 3 : Courbes de dilatation enregistrées pour 4 vases ossuaires.

2009). It is generally correlated with higher barium content and the leaching of other elements (Schneider, 2017). This could consequently affect the bulk ceramic composition and induce problems in determining the origin. However, in some cases, the occurrence of phosphates in the samples does not significantly influence their bulk chemical composition (Maritan and Mazzoli, 2004). In our case, the P_2O_5 contents vary between 0.2 and 0.8 wt. %. Only one sherd has a content of about 1wt % (OSL 3) and may therefore have been altered. For the others, phosphorus contamination is not obvious, especially since barium levels are not particularly high. These values are lower than might have been expected from ceramics in contact with bones, even if a threshold for contamination is often difficult to fix. In clay, the phosphorus content varies generally from 0.2% to 0.5 wt.%, whereas in the ceramics produced from it, the content is slightly higher due to the simple loss on ignition from the firing (Collomb and Maggetti, 1996). Only a few vases could have been affected by phosphorus contamination. Nevertheless, attention will be paid to this point later when using the data.

In order to classify the analyses and to test resemblances, multivariate statistical data treatment was processed. The method used is a hierarchical clustering analysis, applied to reduced centred data, using Euclidian distance and average linkage (Picon, 1984; Baxter, 1994). In our case, the calculations were carried out on 17 of the 24 determined chemical components: 8 major and minor elements in ceramics (MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, MnO, Fe_2O_3) and 9 trace elements of various geochemical behaviour (V, Cr, Ni, Zn, Rb, Sr, Zr, Ba, and Ce). Phosphorus oxide (P_2O_5), lead (Pb) and copper (Cu) were not considered for classification since they are indicative of possible pollution problems; sodium oxide (Na_2O), lanthanum (La), yttrium (Y), thorium (Th) lack relevance for the comparisons. The cluster

analysis of these 28 sherds shows at least four compositional groups and many isolated samples (Fig. 4).

The first two groups (named A1 and A2), as well as the two isolated samples situated between them, present similar chemical characteristics, and can be distinguished from the B groups by higher contents of alumina, potassium oxide, magnesium oxide and sodium oxide as well as higher contents of strontium, rubidium, chromium and cerium (Table 1).

The two other groups (B1 and B2) comprising 18 samples, as well as the isolated sample between them, have also similar chemical characteristics, particularly high content of silica and lower content of titanium oxide (Table 1). With the exception of group B2, exclusively composed of samples found in the *Rue des Granges* site, the groups are composed of samples found at both sites. The marginal position of the OSL 3 sample could possibly be explained by an altered composition linked to the burial conditions insofar as the contents of elements such as phosphorus, zinc, copper and also chromium are relatively high.

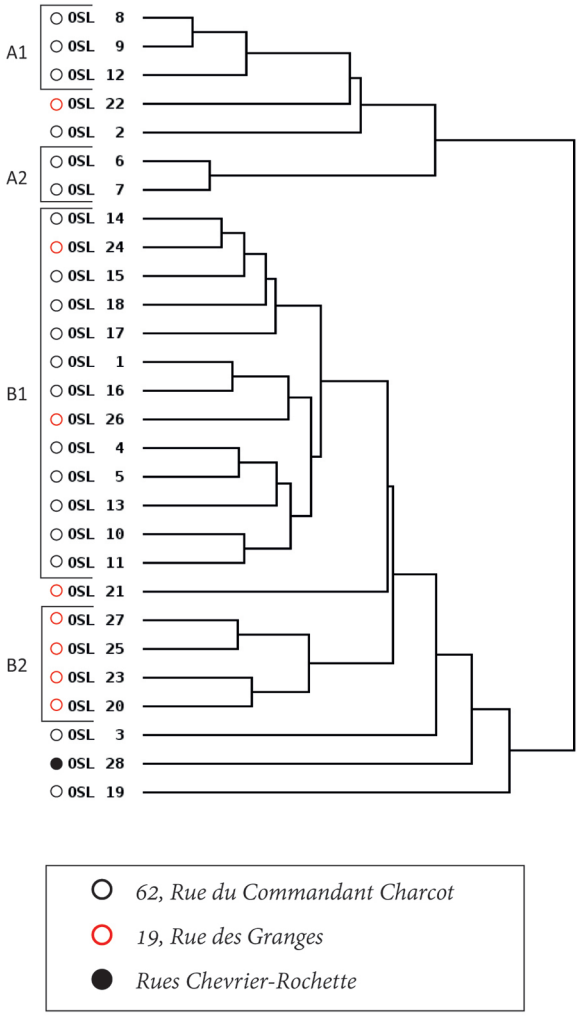


Figure 4: (See colour plate XVI) Dendrogram of cluster analysis of the 28 ossuary vases studied – calculations based on 17 chemical components.
Figure 4 : (Voir planche couleur XVI) Classification ascendante hiérarchique des 28 vases ossuaires étudiés ; calculs réalisés sur 17 composants chimiques.

The more recent sample discovered at the *Rues Chevrier-Rochette* site (OSL 28) is isolated at the end of the dendrogram and presents a completely different composition, suggesting another clay material and another provenance.

Consequently, there are more than four different clay materials used to produce these ossuary pots.

A final remark concerning the composition of these vases: for three of them, we note abnormally high content in copper (more than 130 ppm) which is higher than the natural content in clay. It might be due to the presence in the pots of metallic parts which could have contaminated the ceramic. However, no information about metallic objects was mentioned in the excavation reports.

The apparent firing temperature was determined for only 23 of the 28 samples (Table 1) due to practical reasons: some sherds were too small to be sampled for the dilatometer measurement. Thus, the apparent firing temperature of three sherds of the *Rue du Commandant Charcot* site (OSL 14, OSL 17 and OSL 18) and two of the *Rue des Granges* site (OSL 20, OSL 26) was not determined. We recorded the thermal expansion curves of the different samples and determined their apparent firing temperatures. We observed different profiles of the thermal expansion curves, suggesting that the sintering processes do not occur at the same temperature range. We got a curve profile for samples having low apparent firing temperature (below 650°C, Fig.3a). Samples whose apparent firing temperatures are above 900°C present a totally different curve profile (Fig.3b). Samples with intermediate apparent firing temperatures present two similar curve profiles (Fig.3c and 3d).

We also made a histogram of the apparent firing temperatures of these ceramic samples from a funerary context (Fig5a) in which we indicate the chemical group to which each sample belongs. These apparent temperatures are spread between 620°C and 950°C. They cover a wide range and are highly variable. Some samples are not very well fired and indeed markedly less fired than others. In particular, we notice that most samples of chemical group B1 are much underfired, while those of group B2 are highly fired. As for the samples belonging to groups A, they present a large variety of firing temperatures, from 640°C to 880°C. We can conclude that, for these two funerary contexts, the apparent firing temperatures are not homogeneous, varying from low to high.

In a previous study, apparent firing temperatures were measured on cooking wares found in domestic contexts in *Lugdunum*, also situated in the 5th arrondissement and dating between *La Tène finale* and the 3rd century AD. The selected samples were all produced in local workshops (Batigne Vallet, 1999). The author favoured measurements on samples from consumption contexts rather than workshop contexts, because wares found in workshops might have been rejected by the potters due to firing problems. Remarkably, in domestic ensembles, very few samples present apparent firing temperatures below 700°C. We can deduce that traditionally in *Lugdunum* at this period the pots used for cooking were fired at temperatures ranging from 750 and 950°C (Fig 5b).

5. Discussion

From the chemical compositions, we can deduce that the ossuary pots of our sample were made with many different clay materials suggesting various workshops and consequently various supplies.

We then tried to determine the origin of these vases and to compare them, first of all, with those of local workshops.

In *Lugdunum*, 13 ceramic workshops dating from the middle of the 1st century B.C. to the 4th century A.D., are known (Desbat, 2010). They are distributed in three areas: on the right bank of the Saône in the Vaise district, on the left bank of the Saône and on Fourvière hill (Fig.2). Numerous studies have been carried out on these workshops and their productions, and several reference groups created based on chemical composition to characterize the different productions (Desbat *et al.,* 1996; Desbat *et al.*, 1997, Batigne Vallet dir.).

Our ossuary samples were compared to the references established for five of these workshops: those which produced non-calcareous common ware and in particular the type of cooking pots corresponding to the ossuary vases which have been chemically characterized (workshops F, G, K, L and M of fig.2). Chronologically, the workshops named La Sarra

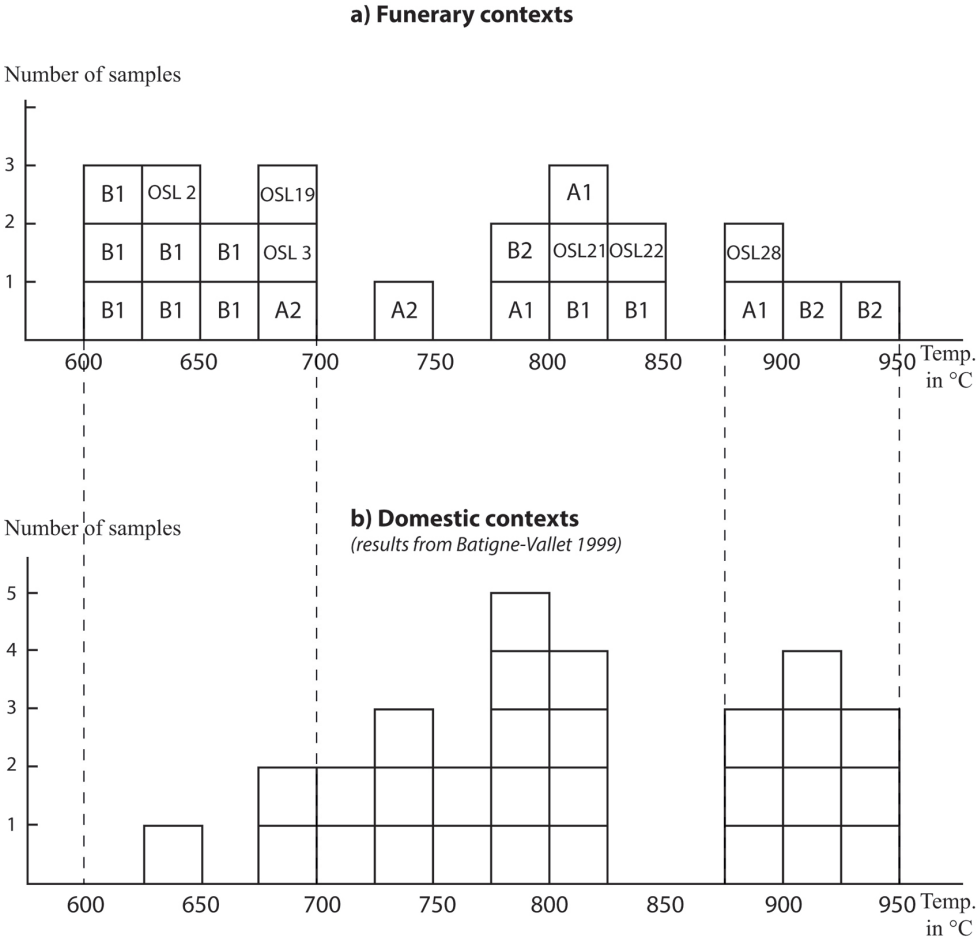


Figure 5: Histograms of apparent firing temperatures (For each sample either the compositional group to which it belongs or its analysis number is given).
Figure 5 : Histogrammes des températures de cuisson apparentes (Pour chaque échantillon est indiqué soit le groupe de composition auquel il appartient soit son numéro d'analyse).

(F) and Cardinal-Gerlier (G) correspond to the two funerary areas studied.

The dendrogram of the new classification is given in figure 6. The A groups' samples form a separate group at the end of the dendrogram, suggesting completely different compositions. Examination of the compositional data of the *Lugdunum* workshops' references and those of the A groups' samples shows that the latter were not produced by one of the 5 selected workshops. Comparisons made with all analysed common ware coming from domestic contexts in *Lugdunum* (Batigne Vallet, 1999) and other regional workshops (Batigne Vallet dir.) show that, in terms of chemical composition, there exists a group of common ware including our ossuary vases of the A groups that could have been produced by a yet-to-be-identified workshop located in Lyon or to the south, along the Rhône near Saint-Romain-en-Gal.

The ceramics belonging to group B2 fit into the Lyon references. Their chemical compositions are very similar to some Lyon references, especially those corresponding to the workshop "La Sarra" which is, as already mentioned, contemporary.

The ossuary vases of group B1 form a distinct group among the Lyon references. Their compositions show differences in elements such as chromium or zirconium. We can ask if their compositions might have been subject to variations due to their burial conditions, or if they represent a very limited production run of one of the *Lugdunum* workshops. They might also correspond to an as-yet-unidentified and analysed *Lugdunum* workshop. Indeed, as for the vases of the A groups, they correspond to the compositions of another group of common ware from *Lugdunum's* domestic contexts which have also been attributed to a Lyon production on archaeological grounds (Batigne Vallet, 1999). Moreover, they are totally different from the compositions of all the identified and analysed regional workshops, as are the vases of group B2 (Batigne Vallet dir.). Consequently, the most likely hypothesis is that all these different ossuary vases from groups B1 and B2 were produced in *Lugdunum* workshops.

Thus, the ossuary vases used in *Lugdunum* during the Augusto-Tiberian period do not come from a single specialised workshop. The supply is varied, with the pots coming from different local workshops as well as from more distant ones.

From the study of the apparent firing temperatures, we noted that the ossuary vases of group B2 are fired at a higher temperature than the others. They were probably diverted from their first function, namely the cooking of food, for a reason other than poor quality due to bad firing. On the other hand, most of the B1 samples are underfired and present very bad surface finishes, and are hence unsuitable for cooking. However, the potters did not want to lose their production and therefore sold it for some other purpose, such as funerary use, as a second choice. Concerning the vases of groups A1 and A2 (probably imported ceramics), they were made of several clay materials and fired at various

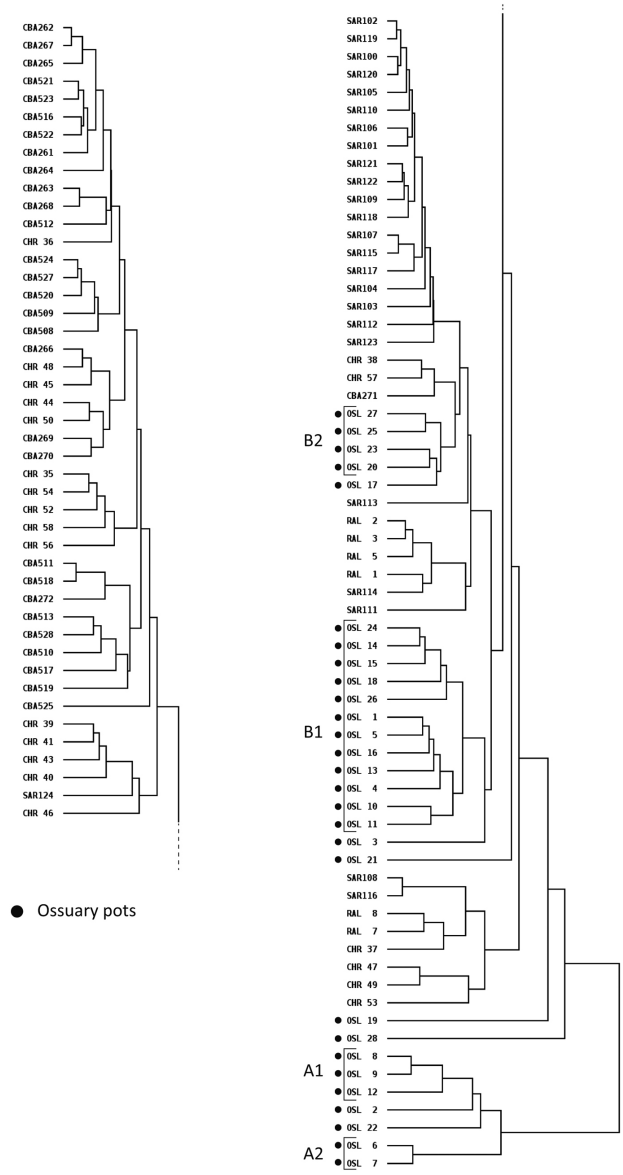


Figure 6: Dendrogram of cluster analysis of the 28 ossuary vases studied and the *Lugdunum* references, calculated on 14 chemical components (Zn, Ba and Ce have not been used due to pollution problems with the reference samples).
Figure 6 : Classification ascendante hiérarchique des 28 vases ossuaires et des références des ateliers lyonnais ; calculs réalisés sur 14 composants chimiques (Zn, Ba et Ce n'ont pas été retenus du fait de problèmes de pollution des échantillons références).

temperatures. The production of these vases is not standardised, so they might either come from several workshops or from a single workshop following several protocols of production concerning clay materials and firing.

6. Conclusion

Thus, it seems from the chemical characterization that most of the ossuary vases of our study come from several *Lugdunum* workshops of cooking wares. They do not come from a specific workshop that specialised in the production of ossuary vases. The macroscopic observations made with the naked eye were supported by the apparent firing temperatures measured with the dilatometer: the ceramics which presented particularly damaged surfaces with characteristics of underfired ceramics were truly underfired as they were fired at temperatures below 700°C. These underfired vases used as funerary pots are not found in later period funerary ensembles.

It is therefore possible to think that there was an opportunistic selection of vases for use in funerary contexts: sometimes taken directly from the kitchen dresser, sometimes bought expressly for funerary usage either in an undamaged state, or as producers' seconds.

It must be emphasised that this study was possible because in Lyon, both domestic and production contexts are very well known, allowing macroscopic and analytical comparisons with the finds of funerary sites. It is also clear that this is a preliminary case study that should be extended to other funerary sites in Lyon and then those of other regions.

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