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Assessment of the amphora spectrum in a rural Late La Tène settlement at Reinach-Nord, Basel region, Switzerland

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ABSTRACT

The relatively high quantity of amphorae among the ceramic material discovered in Late La Tène structures at Reinach-Nord appears quite unusual at a rural settlement of this period in NE Switzerland and warranted further investigation. How does the amphora spectrum compare to the one of earlier or later sites in the region? On earlier settlements in the area between Lyon, the Upper Rhine Valley and NE Switzerland, we find Italic wine amphorae from mainly the same few provenances in Etruria (Albinia, Cosa), Northern Campania (Falerne/ Mondragone) and Pompeii. On later sites in the same region (especially the Roman colonial towns of Lyon, Augst and Avenches), wine is only one of many commodities imported in amphorae and those of Italic provenance become rare. Macroscopic classification of the amphora fabrics, petrographic and chemical analyses by XRF-WDS of 35 samples representative of fabric groups and the comparison with a large database (> 500 analyses from kiln sites, > 500 analyses from consumer sites) reveal basically the typical spectrum known for the region with slight differences to earlier as well as to later sites. These are, in comparison to earlier sites: - a smaller proportion originating from important production sites in Etruria and Northern Campania, no representation of the Pompeii region; - some ascertained imports from Southern Latium; - presence of a non-Italic fabric indicative of Spanish origin (Tarraconnensis). In contrast to later sites, Reinach still shows almost exclusively wine amphorae mainly of Italic origin and a smaller number of different provenances, comparable to the diversity met on the earlier sites (10–15 groups).

1. Introduction

The amphora is the trade packaging of the antiquity, which – contrary to many other kinds of containers – has survived among the archaeological remains. Amphorae thus allow us to trace ancient trading routes for different commodities and the evolution of trading patterns over several centuries. The archaeometric study of the amphorae from several Iron Age settlements (2nd century and 1st century BCE, Fig. 1) in the region between Lyon, France and Basel, Switzerland, has revealed a common pattern answering several questions: a trading route Lyon (Rhône)-Saône-Doubs to NE Switzerland and the Upper Rhine Valley is confirmed for the wine; the provenance areas of the amphorae and thus the wine are few and stay unchanged over the whole period with some variations as to the relative quantity; 95% of the amphorae could be linked to the Tyrrhenian coast of Italy (Thierrin-Michael, 2007; Martin-Kilcher et al., 2013). Furthermore, the homogeneity of subgroups suggests the consumption of large quantities of wine in short time laps. Important changes took place around the middle of the 1st cent. BCE, leading to completely different consumer habits during the Roman era as seen in the Roman colonial town Augusta Rauricorum: Italian wine constitutes only a very small part of the goods imported from afar (Spanish oil and fish sauce; wine from Southern France, Spain and the Eastern Mediterranean…); the provenance areas of the few Italic amphorae, however, are largely the same as before (Martin-Kilcher et al., 2013).The studied sites were mostly larger settlements and none of the Iron Age sites reached into the time after the foundation of the Roman town Augusta Rauricorum. The present study is a start towards filling this gap.

1.1. The site

The excavation site Reinach-Nord lies in the valley of the river Birse running north to the Rhine in Basel (Fig. 1). The Late Iron Age rural settlement (1st cent. BCE) discovered there consisted of at least six houses and a granary pertaining to two different phases. This Iron Age farmstead was situated at the foot of a steep slope of loess subject to mudslides, adjacent to a road. It was abandoned around 30 BCE, only a few years before the foundation of the colonial town Augusta

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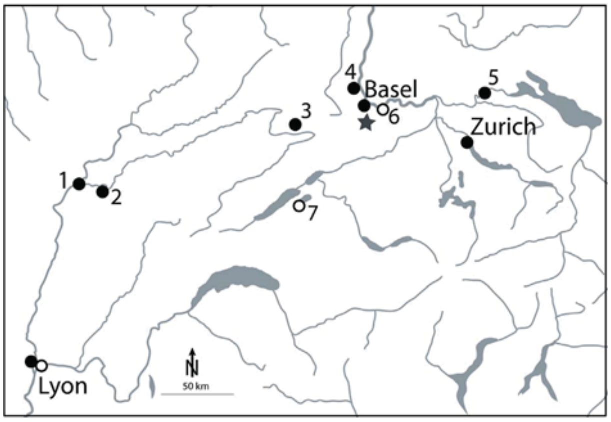

Fig. 1. Geographical situation of Reinach-Nord (dark gray star) and consumer sites with formerly studied amphora assemblages. Rivers, lakes: medium gray.
Iron Age sites (black points) in Lyon, Verdun s/Doubs (1), Authumes (2), Chevenez (3), Sierentz (4), Basel, Rheinau (5) and Zurich. Roman towns (white points) Lugdunum/Lyon, Augusta Rauricorum/Augst (6) and Aventicum/Avenches (7).

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Rauricorum about 15 BCE (Tretola Martinez, 2014, 2016). The subsequent Roman occupation at the site moved slightly further North, also along the road at the foot of the hill but to a location where the slope decreased (Ammann, 2003). The remains of at least 77 amphorae were found in the Iron Age structures.

1.2. Questions

The amphorae in Reinach-Nord belong almost exclusively to forms used for wine transport, mostly type Dressel 1B, but also one Dressel 2–4, at least three Lamboglia 2/Dressel 6A and three Tarraconense1/Pascual1; furthermore one typologically undetermined and hence from the analyses excluded Baetican amphora for fish sauce is present. The first question is: Where did the wine come from? In order to answer this, the origin of the amphorae is to be determined.

The large quantity of amphorae at Reinach-Nord is remarkable, especially in consideration of the small number of amphorae recovered at the rural settlements at Sierentz and Sausheim located in Alsace, both dating to the Late Iron Age as well (Martin-Kilcher et al., 2013). We wonder why and how so much wine was consumed at this site showing no particular activity besides farming and metalworking. Was wine offered on a few occasions of large gatherings? Did the villagers drink wine frequently and share approximately an amphora per year among them (an amphora Dressel 1B holds around 20 to 30 l of wine according to Laubenheimer and Humbert, 2006)? Or were the amphorae lost, broken or left as payment there on a regular transport route from the Rhine to other, larger settlements? The analyses were expected to contribute solving this enigma by:

– comparing the amphora spectrum from Reinach-Nord to those of other Iron Age settlements, as well as to later, Roman sites in the region. As the drinking pattern reflected in the amphorae material changes between Iron Age and Roman sites (from much wine at few occasions drunk by the Celtic inhabitants before the Roman conquest to regular wine consumption by the Roman newcomers and Romanised Celts), resemblance to earlier or later sites may suggest one or the other practice.
– checking for the presence of tight compositional groups, which could mean amphorae produced, filled and shipped at the same time, thus suggesting large wine consumption in a short time.

1.3. Analytical methods and database

The following analytical methods were applied:

– Petrographic analysis on thin sections by optical microscopy. The thin sections were obtained by cutting a thin slice (about 5 mm) across the sherd along the profile. This slice was then hardened and glued with epoxy resin on a glass plate and finally ground down to a thickness of 0.03 mm. Photomicrographs were taken using a Zeiss Axiophot microscope.
– Chemical analysis by XRF-WDS. Sample preparation: sherd sections of 5 to 10 g were cleaned by removing the surfaces with a diamond blade saw. They were then ground in a tungsten carbide mill to a fine powder. Two grams of this were fired at 900 °C for 1 h and the loss on ignition measured. A mixture of 0.700 g of fired sample, 6.650 g of MERCK Spectromelt A10 ($Li_2B_4O_7$) and 0.350 g of MERCK LiF was melted in a Platinum crucible at 1150 °C for 10 min (Philips Perl X-2) in order to obtain the glass tablets on which the XRF measurements were carried out. Major, minor and trace elements were measured using a Philips PW 2400 wavelength dispersive spectrometer (Rhodium tube, 60 kV and 30 mA). The analyses were calibrated with 40 international standards (BCR, DTS, PCC, BHVO, QLO, RGM, SCO, BIR, DNC, W-2, SY-2, GA, GH, Mica-Mg, UB-N, DT-N, GS-N, FK-N, AN-G, BE-N, JG-1, JG-1a, JG-2, JG-3, JB1, JB-1a, JB-2, JB-3, JR-1, JR-2, JA-2, JA-3, JF-1, JF-2, JP-1, JGb-1, NIM-G, NIM-L, NIM-N, NIM-S). Oxides were calculated relative to the standards. Accuracy and precision were checked on the laboratory sample RT. Error has been evaluated by repetitive measurements of this internal standard to be < 5% for all measured elements. This standard procedure is in use at the laboratory of the Department of Geosciences, University of Fribourg, for several decades and has also been applied for the constitution of the database used, which facilitates comparison.

The available database for amphora production sites consists of over 500 analyses from reference groups of kiln sites on the Tyrrhenian coast of Italy, as well as reference samples from kiln sites in Spain and France (Hesnard et al., 1989; Thierrin-Michael, 1990; Thierrin-Michael and Galetti, 1996; Thierrin-Michael et al., 2004).

Chemical data for the most important Italic groups are available online (http://www.unifr.ch/geoscience/geology/en/research/archaeometry/ceramics/reference-groups). The petrographic determination key elaborated through the study of these reference groups and based on characteristic proportions of inclusions in these amphora productions (Thierrin-Michael, 1990), is used for the petrographic description and differentiation of the sherds in the present study.

The database for consumer sites comprises over 500 analyses of amphorae from several sites on the Rhône-Saône-Doubs-Upper Rhine Valley route dating to the 2nd to 1st cent. BCE and from the Roman colonial towns Augusta Rauricorum and Aventicum, studied and discussed in earlier projects (Fig. 1, Hesnard et al., 1989, Martin-Kilcher et al., 2013, Thierrin-Michael, 1994, 2007, 2009, Thierrin-Michael and Maza, 2002, Thierrin-Michael et al., 2005).

1.4. Sampling

All the amphorae sherds recovered from the Iron Age structures were classified macroscopically into fabric groups according to the classification method detailed in Thierrin-Michael (2003). Differentiation was problematical for part of the material because of poor preservation. Visually this seemed to affect mainly the surface which was often powdery, but some sherds developed fissures throughout the body and crumbled into smaller pieces after drying out. This problem led us to choose 35 samples for analysis selected from the rim or base of 35 separate amphorae (a very large number in respect of the total of 77 separate amphorae recovered) in order to assure that members of all types were sampled (Table 1). Included, in particular, were samples from a fabric group attributable to Albinia, a kiln site in Etruria. The production of Albinia, first described by Peacock (1977), displays a macroscopically and microscopically very distinctive fabric. It has been

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Table 1
Chemical compositions of 35 amphorae from Reinach (AMR1-AMR35) presented according to fabric groups with means and standard deviations per group. Abbreviations type: Dr. = Dressel, Lamb = Lamboglia, Tar = Tarraconense, Pasc = Pascual,? = uncertain typological determination.
Tyrrhenian coast of Italy: groups a to f. No attribution: AMR19, AMR32. Spanish (Tarraconnensis): AMR34.

No	Type	Fabric	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	SUM	Ba	Cr	Nb	Ni	Rb	Sr	Y	Zn	Zr
			%	%	%	%	%	%	%	%	%	%		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
AMR1	Dr1B	a	61.59	0.93	19.32	8.64	0.25	2.68	3.23	0.66	1.42	0.41	99.27	275	221	17	93	43	118	35	142	172
AMR2	Dr1B	a	58.69	0.94	20.09	8.40	0.23	2.66	4.39	0.87	2.03	0.36	98.82	298	152	18	94	81	177	35	141	164
AMR3	Dr1B	a	56.94	0.98	20.76	8.69	0.23	2.76	5.02	0.78	1.73	0.59	98.61	258	156	19	96	62	160	37	149	174
AMR4	Dr1B	a	55.11	1.09	22.76	9.59	0.24	3.00	3.96	0.60	1.81	0.34	98.66	285	195	20	102	60	147	40	161	193
AMR5	Dr1B	a	58.64	0.90	19.58	7.99	0.19	2.64	3.91	1.15	3.02	0.63	98.82	325	142	19	88	148	177	34	137	155
AMR6	Dr2-4	a	58.02	0.92	19.81	8.10	0.20	2.69	4.04	1.17	2.93	0.69	98.73	343	151	18	91	139	176	33	135	156
Mean a			58.17	0.96	20.39	8.57	0.22	2.74	4.09	0.87	2.16	0.50	98.82	297	170	19	94	89	159	36	144	169
stdev a			2.15	0.07	1.26	0.57	0.02	0.13	0.59	0.24	0.66	0.15	0.24	32	31	1	5	44	24	3	10	14
AMR7	Dr1B	a sim	60.09	0.98	21.14	8.51	0.20	2.54	2.46	0.56	1.59	0.42	98.61	243	168	18	94	48	87	35	143	162
AMR29	Dr1B	a sim	58.73	1.03	21.83	9.26	0.23	2.63	1.99	0.49	1.62	0.98	98.93	306	156	19	105	47	76	38	151	175
AMR8	Dr1B	b	59.20	0.79	20.50	6.13	0.15	1.79	3.10	1.93	4.34	0.44	98.56	519	69	48	38	218	235	42	106	388
AMR9	Dr1B	b	61.01	0.75	18.22	5.94	0.13	2.03	5.64	1.36	3.11	0.48	98.81	459	90	28	45	156	229	32	99	244
AMR15	Dr1B	b	61.07	0.87	20.21	6.92	0.15	2.08	2.40	1.09	2.83	0.79	98.58	455	112	33	57	134	180	36	115	295
AMR16	Dr1B	b	59.13	0.91	20.84	7.34	0.16	2.52	3.23	0.87	2.76	0.55	98.47	396	112	29	65	144	154	43	115	290
AMR17	Dr1B	b	63.78	0.78	17.78	5.60	0.17	1.93	2.86	1.63	3.30	0.32	98.32	475	88	30	43	172	211	35	92	293
AMR31	Dr1B	b	65.42	0.82	17.18	6.18	0.13	1.54	3.67	1.09	2.32	0.18	98.70	461	93	26	50	131	207	39	94	309
Mean b			61.60	0.82	19.12	6.35	0.15	1.98	3.48	1.33	3.11	0.46	98.57	461	94	32	50	159	203	38	104	303
stdev b			2.52	0.06	1.58	0.65	0.02	0.33	1.14	0.39	0.69	0.21	0.17	40	16	8	10	33	31	4	10	47
AMR10	Dr1B	c	63.82	0.80	15.85	6.66	0.14	1.85	5.78	0.91	2.59	0.25	98.82	399	172	16	65	109	250	33	111	226
AMR11	Dr1B	c	60.27	0.79	17.06	5.94	0.12	1.57	8.38	0.69	2.40	1.29	98.70	540	122	16	54	109	327	32	101	270
AMR12	Dr1B	c	66.95	0.75	16.28	4.84	0.08	1.41	4.27	0.67	2.56	0.46	98.44	486	120	16	50	114	248	30	83	287
AMR13	Dr1B	c	63.81	0.88	16.79	7.24	0.12	1.76	3.51	0.79	2.94	0.46	98.48	489	176	17	67	131	307	33	118	301
AMR18	Dr1B	c	67.75	0.80	17.37	5.49	0.09	1.05	2.53	0.64	2.45	0.36	98.70	502	114	17	47	115	222	30	85	265
Mean c			64.52	0.80	16.67	6.03	0.11	1.53	4.89	0.74	2.59	0.56	98.63	483	141	16	57	116	271	32	100	270
stdev c			2.97	0.05	0.61	0.95	0.02	0.32	2.28	0.11	0.21	0.42	0.16	52	30	1	9	9	44	2	15	28
AMR14	Dr1B	c 2	57.24	0.72	17.08	5.96	0.11	2.28	11.40	1.06	2.29	0.18	98.46	419	87	21	49	104	246	30	94	234
AMR33	? Dr1B Lamb2	c 2	63.44	0.91	18.69	6.85	0.16	1.34	2.93	1.03	2.40	0.47	98.39	491	119	26	56	115	161	41	104	348
AMR20	? Dr1B	c 3	66.62	0.72	16.98	5.52	0.11	1.49	3.14	1.39	2.63	0.19	98.96	522	59	26	39	136	202	32	85	255
AMR35	Dr1B	c 3	56.91	0.94	20.80	7.83	0.14	3.12	4.08	0.81	2.45	0.81	98.03	373	141	20	70	73	142	36	133	217
AMR21	Dr1B	d	55.57	1.03	18.03	8.95	0.22	3.61	7.44	0.77	2.26	0.59	98.64	370	161	26	69	105	157	42	127	253
AMR22	Dr1	d	54.58	1.17	16.92	10.76	0.24	3.43	7.66	0.87	2.13	0.59	98.51	368	133	25	67	92	166	44	148	292
AMR23	Dr1	d	54.28	0.94	16.94	8.09	0.21	3.48	9.96	0.96	2.22	1.07	98.32	414	134	23	66	107	197	40	128	230
AMR24	Dr1	d	54.68	1.09	19.05	9.22	0.18	3.65	6.36	0.86	2.23	0.73	98.21	415	160	26	72	94	183	41	139	250
Mean d			54.78	1.06	17.74	9.26	0.21	3.54	7.86	0.87	2.21	0.75	98.42	392	147	25	69	100	176	42	136	256
stdev d			0.56	0.10	1.02	1.11	0.03	0.10	1.51	0.08	0.06	0.23	0.19	26	16	1	3	8	18	2	10	26
AMR26	Dr1	e	51.64	1.00	16.96	9.40	0.23	4.88	10.75	0.81	2.21	1.09	99.15	428	173	26	70	114	217	40	124	231
AMR27	Dr1B	e	50.03	1.27	15.95	12.47	0.24	5.57	10.32	0.84	1.93	0.53	99.33	288	198	29	70	107	176	46	149	305
AMR28	Dr1B	e	49.08	1.19	16.72	11.56	0.26	5.42	10.88	0.77	1.89	0.78	98.74	328	260	27	71	90	202	42	145	271
Mean e			50.25	1.15	16.54	11.14	0.24	5.29	10.65	0.81	2.01	0.80	99.07	348	210	27	70	104	198	43	139	269
stdev e			1.29	0.14	0.53	1.58	0.02	0.36	0.29	0.04	0.17	0.28	0.30	72	45	2	1	12	21	3	13	37
AMR30	Dr1	f 1	61.28	0.97	18.34	7.48	0.13	2.23	5.14	0.50	2.39	0.40	99.02	478	171	17	71	88	261	33	128	222
AMR25	Dr1B	f 2	56.09	0.83	19.14	6.91	0.14	2.41	8.32	0.94	2.79	0.83	98.56	478	110	21	54	92	230	33	109	196
AMR19	Dr1B	isol	68.84	0.60	15.55	4.67	0.12	1.51	3.78	1.47	2.69	0.27	99.66	461	64	25	29	165	251	27	68	231
AMR32	Lamb2	isol	63.34	0.89	18.02	7.57	0.17	1.65	0.99	1.23	2.58	1.69	98.32	598	245	18	163	124	112	34	121	233
AMR34	? Tar1 Pasc1	isol	56.72	1.09	21.71	9.22	0.11	2.22	1.90	1.40	2.88	0.56	97.95	462	55	19	29	102	106	51	108	283

recognized on many consumer sites and the macroscopically determined origin has been confirmed beyond doubt by analyses in every instance (Martin-Kilcher et al., 2013; Thierrin-Michael, 1994, 1999, 2007, 2009; Thierrin-Michael et al., 2005). The attribution is therefore deemed certain and the analysis should show if, and in what manner, the burial conditions affected the chemical composition. Former studies on Italic amphorae, or on ceramics in general, rarely revealed alterations important enough to impede comparison with reference material (Béarat, 1990). As overfired sherds have proved more vulnerable to alteration (Picon, 1991; Buxeda i Garrigòs et al., 2002), no overfired sherds were analysed in the present study in order to avoid potential alteration problems linked to that parameter.

2. Results

2.1. Classification and comparison to reference database

As a first step, groups are formed according to fabric characteristics identified under the polarisation microscope. These are then compared to reference groups and groups from consumer sites. Usually, classification according to the chemical composition is carried out in parallel to the petrographic analysis and the results combined afterwards. Due to the alteration problem discussed in Section 2.1.2, however, the chemical composition is used in the present case study only to check the provenance attributions and parallels found according to the petrographic characteristics.

2.1.1. Petrographic analysis

Specific criteria for the petrographic classification of Italic amphorae were developed on the basis of the differentiation of reference groups from the Tyrrhenian coast of Italy (Thierrin-Michael, 1990). Amphorae produced in the area between central Etruria and the bay of Naples contain different proportions of inclusions derived from the ultrapotassic mafic volcanic rocks occurring in that region. In particular, these amphorae are characterised by the combined presence of the inclusions of clinopyroxene and fresh, unaltered sanidine which indicates this region of provenance to the exclusion of others. While ultrapotassic volcanic rocks also occur on some Greek islands, sanidine

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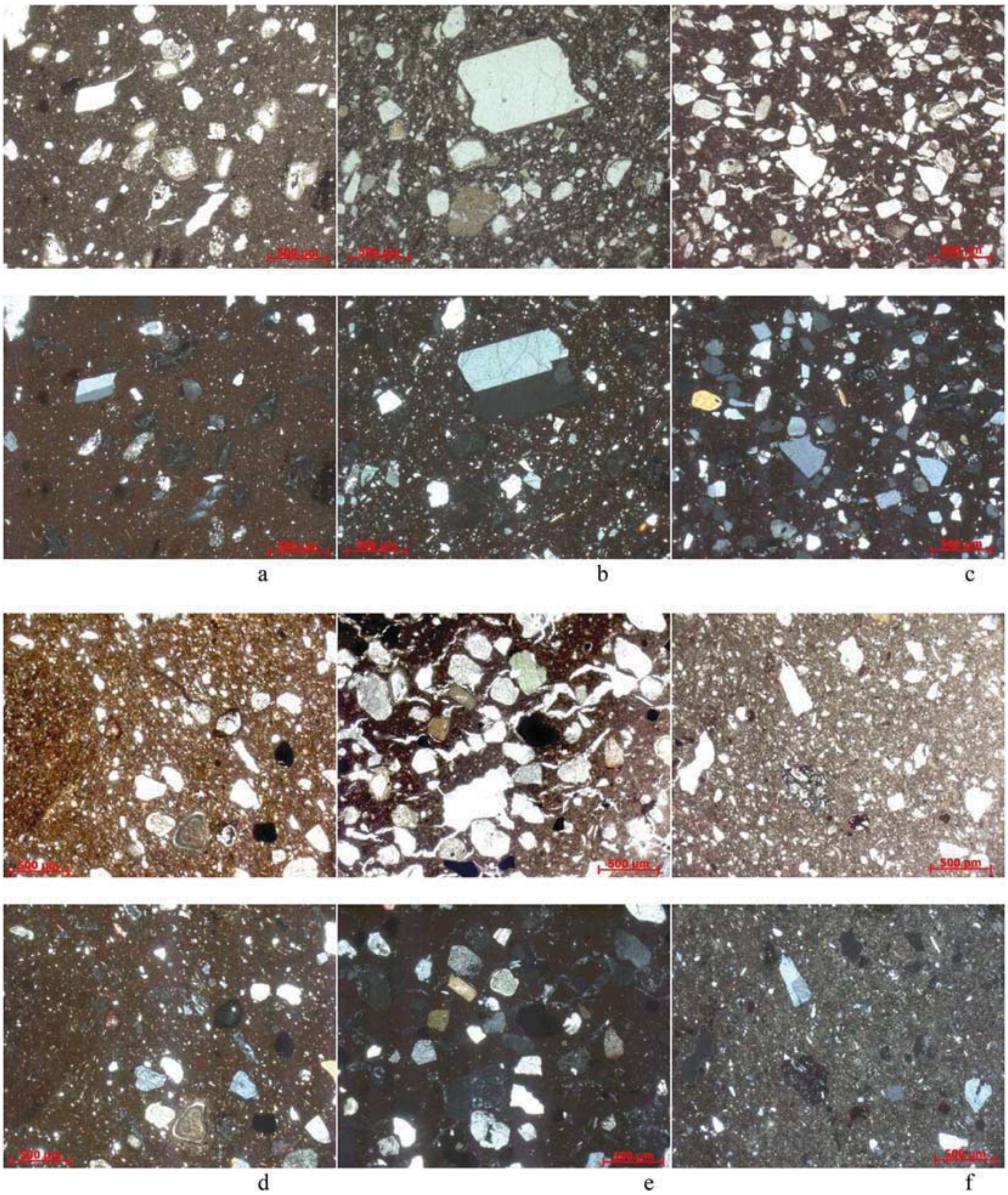

Fig. 2. Italic fabric groups a-e and isolated sherd f. Representative details under the microscope, plane-polarised light above, cross-polarised light below; a: Albinia (AMR6), b: Mondragone coarse/Falerne (AMR17), c: inclusion-rich light Tyrrhenian fabric (AMR18), d: Black Sand Minturno (AMR22), e: Black Sand B (AMR27), f: Black Sand undetermined (AMR25).

there appears generally slightly altered.

With the exception of samples AMR19, AMR32 and AMR34, the analysed sherds contain clinopyroxene and sanidine among the inclusions and are therefore considered to come from the tyrrhenian coast of Italy.

The 32 sherds containing volcanic inclusions split into six groups a-f and some isolated samples (Fig. 2). The significant characteristics of each group are the following:

Group a (AMR1, AMR2, AMR3, AMR4, AMR5, AMR6): around 20% of relatively well sorted inclusions of mono-, poly-, and microcrystalline quartz, some carbonate and ferruginous nodules as well as minor amounts of sanidine and clinopyroxene in a matrix with rounded voids and few fine inclusions. Four sherds show these characteristics with an optically inactive matrix, two sherds (AMR4, AMR5) are very similar but with an optically slightly active matrix containing some mica.

This fabric is typical of amphorae produced in Albinia, Central Etruria (Capelli et al., 2007; Peacock, 1977; Thierrin-Michael, 1990, 1994, 1999). It is present at all studied sites between Lyon and Augusta Rauricorum, attested from the 2nd cent. BCE to the beginning of the 1st cent. CE, mostly in the well fired variety with optically inactive matrix.

Group b (AMR8, AMR9, AMR15, AMR16, AMR17, AMR31): around 25% very poorly sorted inclusions of volcanic origin (predominantly sanidine, volcanic rock fragments and volcanic glass, some clinopyroxene and other isolated volcanic minerals) as well as carbonate and mono-, poly-, and microcrystalline quartz. Three samples (AMR8, AMR17, AMR31) are of a coarser variety with inclusions up to 3 mm in length.

Amphorae of the coarse as well as the finer variety are produced in kiln sites at Mondragone and its hinterland (Falerne region) in Northern Campania. They are present at all studied sites between Lyon and Augusta Rauricorum, attested from the 2nd cent. BCE to the beginning of the 1st cent. CE (Thierrin-Michael and Maza, 2002).

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Group c (AMR10 - AMR 14, AMR18, AMR20, AMR33, AMR35): around 25 to 35% rather well sorted inclusions of mono-, poly-, and microcrystalline quartz, volcanic inclusions mostly of sanidine, some clinopyroxene and almost no rock fragments, some carbonate and/or microfossils. The sherds AMR 14 and AMR33, AMR20, AMR35 differ slightly from the main group (AMR10, AMR11, AMR12, AMR13, AMR18) concerning the roundness of grains as well as the amount of carbonate grains and microfossil content. AMR35 exhibits a mica-bearing matrix not observed in the other sherds of the group.

Sherds similar to those of group c are found on most of the studied consumer sites. The fabric, however, appears not very distinctive, and a difference indicative of the production at different sites would be difficult to recognize. While the best parallel among the known kiln sites comes from Fondi, similar sherds exist also in the reference groups from Cosa and Mondragone.

Group d (AMR21-AMR24): a so-called Black Sand fabric (Peacock, 1971), characterised by 15 to 20% of sub-rounded inclusions mostly of isolated dark volcanic minerals including clinopyroxene, opaque minerals, brown amphibole, melanitic garnet, olivine and biotite as well as some sanidine; little carbonate and quartz; matrix with few fine inclusions. The relatively high amount of opaque minerals is particularly noteworthy.

This fabric is identical to the one of amphorae from Minturno (limit Southern Latium/Northern Campania). Very few examples of this group were found at Iron Age sites of the 1st cent. BCE, while it is well represented among the Italic amphorae from the Roman towns Augusta Rauricorum and Aventicum.

Group e (AMR26-AMR28): another Black Sand fabric, characterised by around 35% well sorted sub-rounded inclusions almost exclusively of volcanic origin (mostly isolated dark volcanic minerals - clinopyroxene, opaque minerals, brown amphibole, melanitic garnet, olivine and biotite – plus some sanidine and calcic feldspar) and only few carbonate grains, in a matrix exempt of fine inclusions, with many elongated pores.

There exists no parallel among the known kiln sites. This group, however, called Black Sand B, is attested in small numbers both at the Iron Age and at the Roman sites of the region considered.

Group f (AMR30, AMR25): Two more Black Sand fabrics; the first (AMR30) with around 25% rounded volcanic inclusions plus quartz and carbonate sand, corresponds to amphorae from Cosa, Central Etruria, and is present at the Iron Age sites. The second (AMR25) is characterised by around 20% inclusions composed of volcanic rock fragments (including leucitite, Fig. 2f), clinopyroxene and sanidine in a fossiliferous matrix. For this fabric, no parallel at kiln or considered consumer sites was identified. None of the Black Sand fabrics coincides with the Pompeii/Eumachi group.

Isolated sherds AMR7, AMR29: these two remaining sherds contain only very little volcanic inclusions; they are close to fabric group a, but contain more non-volcanic rock fragments.

The three sherds without volcanic inclusions do not form a group. Sample AMR34 shows a distinctive fabric with large inclusions of granitic rock fragments in a silty micaceous matrix (Fig. 3a). It is identical to some reference samples from kiln sites in the Tarraconnensis, Spain (Fig. 3b). The second sample, AMR32, contains many large argillaceous rock fragments plus finer silicate inclusions in an optically very active matrix showing intermeshed clay mineral packets (Fig. 3c). No parallel is known either from the database or from literature. The last one (AMR19) does not show very distinctive features, containing mostly mono-, poly- and microcrystalline quartz, some small grains of clinopyroxene but no identifiable sanidine.

2.1.2. *Chemical analysis*

2.1.2.1. Evaluation of the data set and alteration problem. The chemical compositions are represented in Table 1. The sum of major and minor elements (calculated to oxides) is slightly low, but test analyses show the shift from 100 $\pm$ 1 to 98.9 $\pm$ 1, probably due to the weakening of the X-ray tube, to be proportional over all the constituents and therefore not problematic.

In checking the data set for signs of a possible alteration due to the burial of the sherds in the earth, one considers primarily the values for P_2O_5. Natural sediments contain up to 0.5 wt% P_2O_5 (Koritnig, 1978). For amphorae, being made of natural sediments, values above 0.5 wt% indicate therefore an enrichment. In the present data set, P_2O_5 contents are below 0.5 wt% in more than half of the samples and exceed 1 wt% in only 4 cases. This minor enrichment is not considered as a severe alteration that could impede the comparison to reference data (Béarat, 1990).

The CaO-values, however, appear low overall. This is quite unusual for Italic amphorae, as the mean CaO-contents in amphorae productions from the known kiln sites in Italy as well as those from groups present on formerly studied consumer sites oscillate between 7 and 17 wt% in most cases (Table 2). Comparing the samples from Reinach-Nord only to the reference groups, which we expect to be represented among the Reinach-Nord assemblage according to the petrographic attributions, we find a considerable discrepancy in the CaO contents (Fig. 4). One could conclude, of course, that only very few of the amphorae from Reinach-Nord correspond to these reference groups. Yet, the shift to lower CaO contents also concerns the four sherds which are attributable without doubt to Albinia on the basis of the macroscopic and petrographic fabric analysis and which have been included in the sample for control. Leaching of CaO clearly affected these sherds. The hydrogeological situation of the site, where water coming down the adjacent hill regularly percolated through the archaeological layer consisting of loess (Tauber, 2006), partly explains the leaching. The percolating water may also have been acidified while transiting the forest soil of the slope, intensifying the weathering process affecting the sherds. Consequently, we may assume that many of the other samples also have lost more or less CaO during burial and now show CaO values not reflecting the original CaO content. It is difficult, however, to estimate the amount of CaO lost, because on the one hand, the leaching is unlikely to have been uniform over the entire site and on the other hand, the sherds were more or less susceptible to the leaching depending on their

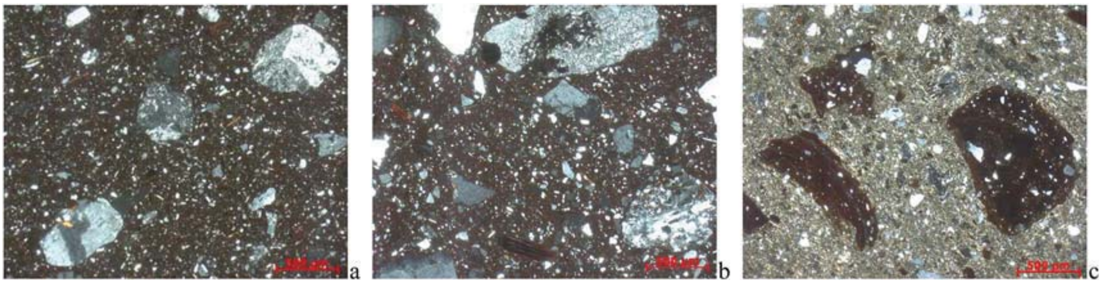

Fig. 3. Fabrics without volcanic inclusions from Central Italian volcanic contexts. Microphotographs taken with cross-polarised light.
a,b: sample AMR34 from Reinach and sample from kiln site in Tarraconnensis;
c: sherd AMR32 of undetermined origin.

Table 2
Mean chemical compositions of studied amphorae productions between Central Etruria and the bay of Naples (from N to S, Albinia to Pompeii) and two groups of Black Sand fabrics (BS A and BS B) from consumer sites (Hesnard et al., 1989; Thierrin-Michael, 1990, 1992; Thierrin-Michael and Galetti, 1996). Highlighted are groups represented in the sample from Reinach-Nord.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ba	Cr	Ni	Rb	Sr	V	Zn	Zr
	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Albinia	n = 25																	
Mean	59.56	0.83	17.54	7.38	0.20	2.77	7.63	1.29	2.64	0.18	391	137	82	129	268	142	121	140
stdev	2.11	0.05	0.89	0.45	0.04	0.33	1.24	0.28	0.22	0.03	93	40	9	16	34	16	11	9
Cosa	n = 23																	
Mean	60.93	0.77	15.24	6.19	0.11	2.52	10.47	0.71	2.86	0.16	458	127	63	128	359	133	102	179
stdev	1.62	0.06	0.79	0.44	0.01	0.31	1.40	0.26	0.21	0.04	76	26	7	10	54	15	17	16
Fondi	n = 50																	
Mean	62.45	0.74	17.54	6.19	0.07	2.29	6.77	1.12	2.44	0.19	443	112	57	103	274	115	92	236
stdev	2.39	0.05	0.99	0.50	0.01	0.42	2.51	0.20	0.12	0.08	81	11	6	16	41	16	10	33
Minturno	n = 43																	
Mean	54.60	0.99	15.94	8.66	0.17	3.58	12.29	0.81	2.31	0.32	483	126	59	141	285	164	110	267
stdev	2.00	0.08	0.96	0.77	0.02	0.55	2.17	0.21	0.25	0.15	104	15	4	24	32	23	10	42
Garigliano	n = 10																	
Mean	52.85	0.72	15.07	6.28	0.12	3.42	17.39	0.73	2.62	0.27	470	93	49	158	449	128	99	191
stdev	2.29	0.04	1.42	0.52	0.01	0.45	1.78	0.25	0.26	0.12	53	15	9	17	48	20	17	20
Mondragone	n = 51																	
Mean	61.83	0.71	16.89	5.60	0.12	2.16	7.77	1.40	3.14	0.16	508	89	46	165	309	97	97	283
stdev	2.61	0.06	1.41	0.48	0.03	0.37	3.28	0.29	0.38	0.04	112	11	7	23	180	11	12	38
Falerne	n = 19																	
Mean	60.16	0.73	17.68	6.21	0.11	2.06	8.06	1.08	3.39	0.29	559	111	66	198	302	114	115	199
stdev	2.90	0.08	1.71	0.44	0.02	0.36	3.98	0.11	0.36	0.09	200	10	6	45	74	12	18	34
Cales	n = 14																	
Mean	58.48	0.73	17.05	6.27	0.12	2.18	11.20	0.79	2.83	0.21	435	102	58	168	290	117	101	198
stdev	2.03	0.02	0.91	0.12	0.02	0.29	2.90	0.35	0.20	0.02	58	9	10	17	40	10	7	30
Dugenta	n = 15																	
Mean	57.86	0.78	16.30	6.84	0.13	2.61	10.90	1.16	3.07	0.25	451	99	50	179	369	135	102	201
stdev	2.36	6.00	0.64	0.77	0.01	0.22	3.17	0.10	0.13	0.03	60	12	9	18	39	17	12	34
Pompeii	n = 8																	
Mean	53.43	0.86	18.56	7.62	0.15	3.71	9.81	1.71	3.18	0.45	810	127	60	152	471	162	112	214
stdev	0.66	0.02	0.42	0.21	0.01	0.38	0.89	0.25	0.27	0.11	36	19	8	21	23	10	4	5
BS A	n = 12																	
Mean	52.05	1.12	16.86	11.26	0.23	4.58	10.93	0.39	1.87	0.49	447	189	81	97	215	214	145	241
stdev	1.35	0.06	0.62	1.05	0.01	0.38	0.81	0.22	0.16	0.16	96	16	5	11	31	20	10	20
BS B	n = 15																	
Mean	52.31	1.01	15.84	9.85	0.22	5.09	11.96	0.96	2.19	0.32	414	188	79	128	262	198	128	229
stdev	0.92	0.05	0.46	0.62	0.02	0.54	0.66	0.16	0.22	0.05	85	9	6	11	49	13	11	12

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(original) mineral composition and texture. Well-fired amphorae, in which the CaO is mainly bound in the firing phases gehlenite and diopside, should be less vulnerable to CaO-loss, as only the portion of CaO contained in calcite is easily mobilizable (Thierrin-Michael, 1999). This portion has been judged negligible in well-fired ceramics, but in the light of the present findings, the original calcite content of the amphorae must have been underestimated. In the case of the Albinia production, secondary calcite lines the typical rounded pores (former calcite grains); it represents the CaO not integrated into calcium-silicates during firing which reformed to calcite after cooling. In the Reinach examples, pore linings exist sometimes (Fig. 2a), but they consist of submicroscopic material rather than microcrystalline or larger-grained, sparitic, recrystallized calcite like in most other studied samples from the kiln site or other consumer sites. Based on the shift seen in Fig. 4, the secondary calcite ordinarily present in these amphorae and now missing appears to have accounted for around 2–4 wt%. Fig. 4a shows furthermore, that at least in the amphorae occupying the field of the lowest MgO and CaO values, some MgO may have been lost in addition to CaO. This concerns again sherds where MgO was mainly concentrated in the matrix or in carbonate grains (Mg-rich calcite and/or dolomite), but not those where MgO is mainly due to the presence of mafic minerals (olivine, clinopyroxene, amphibole). The pieces with high concentrations of mafic minerals will therefore retain high contents of MgO, as long as the ceramic matrix remains strong enough to hold the inclusions. Also Sr, geochemically linked to CaO, is affected by the alteration (Fig. 4b). While no other alteration may be detected with any certainty, it cannot be excluded that other elements are also affected.

In consequence of the alteration, the chemical analysis can only be used for some selected particular parameters or in semi-quantitative comparisons and not for regular multivariate statistical analysis. Bearing these restrictions in mind, and therefore accounting for higher CaO, MgO and Sr values and proportionally lower values for the other major and minor elements (albeit without the means for correct estimation), the comparisons of the chemical compositions of the samples with those of the reference groups and data from other consumer sites allow, nevertheless, the following statements to be made (Tables 1 and 2):

Group a: The overall compositions correspond quite well with the reference group Albinia. In particular, the differentiating parameters for the Albinia production (relatively high Cr and Ni, high MnO and low Zr contents) stand out also in the amphorae from Reinach-Nord, including the two sherds which, petrographically, show less typical fabrics (AMR4, AMR5).

Group b: Three samples contain particularly high amounts of K_2O and Rb (AMR8, AMR9, AMR17). The petrographic attribution to the Mondragone-Falerne region can be confirmed without doubt for these, as high values in K_2O and Rb, combined with medium Fe_2O_3 and MgO values, differentiate part of the Mondragone/Falerne production from all other reference groups. The other three samples

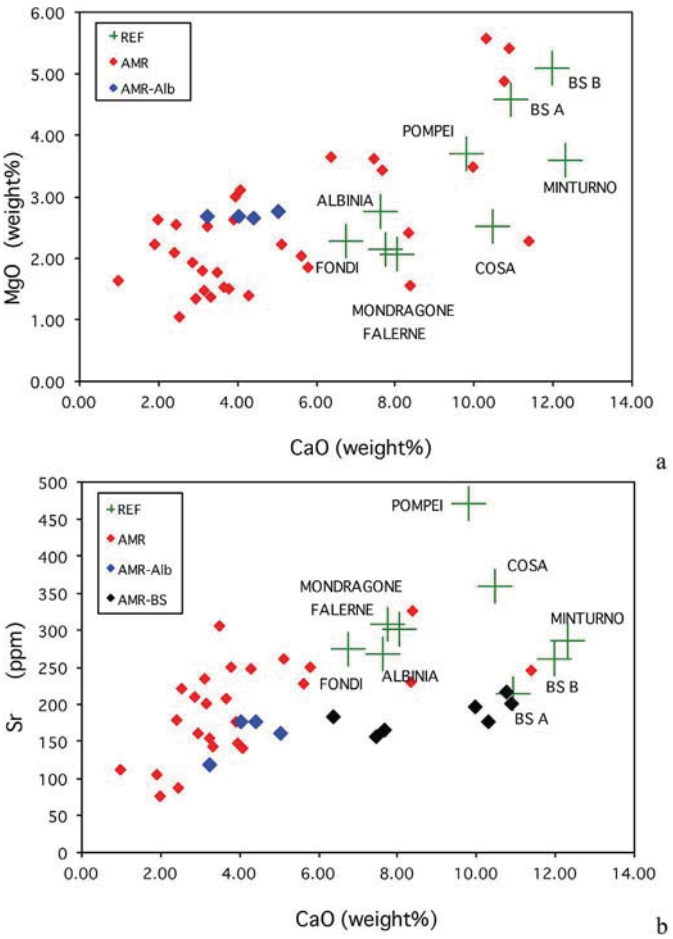

Fig. 4. Bi-plots MgO/CaO and Sr/CaO. Abbreviations in legend: REF: representation of the mean values for different Italic reference groups, as well as groups Black Sand A and B (BS A, BS B). AMR: the samples from Reinach-Nord. AMR-Alb: Samples from Reinach attribuably to Albinia with certainty according to their fabric (macrocopic and petrographic analysis). AMR-BS: Samples from Reinach showing many dark volcanic inclusions ("Black Sand fabric").

of group b (AMR15, AMR16, AMR31) fit with the part of that production which overlaps with other reference groups thus not allowing a definite attribution on the basis of the chemical composition.

Group c: While the group appears relatively homogenous concerning the overall chemical composition and no clear subdivisions are revealed, there are no particular characteristics which would allow drawing parallels to other reference groups or data from other consumer sites without multivariate statistical analysis.

Group d: Characteristically high TiO_2 and Fe_2O_3 contents corroborate the petrographic attribution of this group to Minturno (Table 2). In Fig. 5, in which different Black Sand productions are differentiated, the samples from Reinach-Nord lie in the centre of the variation field for Minturno, close to the only other amphora attributable to Minturno from a Late Iron Age site of the region (Basel Münsterhügel).

Group e: The particularities of the three samples AMR26, AMR27, AMR28 seen in Table 1 - high values in TiO_2, Fe_3O_5 and MgO combined with moderate amount of K_2O; Cr and Ni content - coincide with those of the group Black Sand B (Table 2), found at many Late Iron Age sites, in particular in Lyon and Basel (Hesnard et al., 1989; Thierrin-Michael, 2007). Noteworthy is a high Cr/Ni ratio as well as particularly high MgO-contents, characteristic of that group. In addition, the samples fall into the variation field of Black Sand B in Fig. 5, outside the overlap with other groups. The distinction from

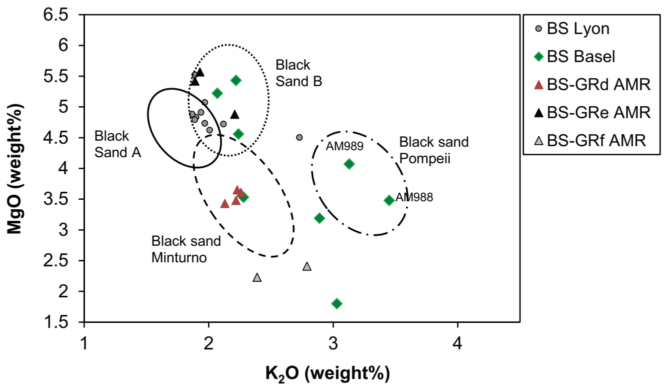

Fig. 5. Bi-plot MgO/K_2O. Represented are the variation fields of four Black Sand fabric reference groups, samples of Black Sand fabric from Iron Age sites in Lyon (BS Lyon), Basel (BS Basel, Gasfabrik and Münsterhügel) and the Black Sand samples from Reinach groups d, e and the f (BS-GRd AMR, BS-GRe AMR and BS-GRf AMR). Variation fields are drawn in a way to include all reference samples.

the Pompeii group is confirmed.

Group f (AMR30, AMR25): AMR30, with petrographic similarities to amphorae from Cosa, shows also a chemical composition close to that group. Without multivariate statistical analysis, however, which cannot be meaningfully applied in the light of the alteration problem, no convincing attribution is achievable. The second isolated Black Sand sherd AMR25 does not stand out by any particular values.

Isolated sherds: The isolated sherds AMR7 and AR29, petrographically similar to group a resemble that group chemically as well.

Among the sherds without volcanic inclusions, two are clearly distinguished from the groups discussed previously by their chemical compositions. The sherd AMR34 (Tarraconense 1 or Pascual 1) of Spanish fabric is characterised by low Cr and Ni values and high Fe_2O_3-content. The overall composition fits with some references from Spanish kiln sites (two unpublished analyses by the authors, unpublished analyses by the laboratoire de céramologie Lyon and personal communication Veronica Martinez Ferreras, University of Barcelona). AMR19, without striking petrographic characteristics, exhibits low TiO_2, Fe_2O_3, MgO and low Cr and Ni. None of the known references show these characteristics. On closer inspection, the third sample, AMR32, showing the highest P_2O_5 content, also proves quite different from the Italic groups due to its higher Cr and Ni values and a significantly lower Cr/Ni ratio. Although no precise reference was found, this could point to an origin in the Eastern Mediterranean where the combination of ophiolitic environment (high Cr, Ni) with argillaceous rocks (see Section 2.1.1.) is common (Whitbread, 1995). But as the sherd in question belongs to a Lamboglia 2 amphora, this origin is excluded for archaeological reasons. The Italian Adriatic coast may be excluded for geological reasons because of the high Cr and Ni values. However, comparable Cr and Ni contents have been reported from Hellenistic amphorae and terra rossa from Croatian islands (Mise and Serneels, in prep.). Istria therefore appears the most probable origin for this amphora at the present state of research.

2.2. *Interpretation and discussion*

Although the chemical analyses were affected by some alterations during burial, the combination with the petrographic fabric analysis allows a coherent classification of the sherds from Reinach. While the attribution of fabric group a to Albinia did not warrant chemical analyses for validation, the provenances of samples attributed to Mondragone and Minturno, as well as the correspondence to one or the other of the Black Sand groups, had to be verified by checking the chemical compositions of the Reinach-Nord sherds for the typical

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characteristics. The evaluation of the alteration effect discussed in Section 2.1.2 revealed no direct influence on elements other than CaO, MgO, Sr and P_2O_5, and it is argued that even MgO, if derived from volcanic inclusions, would remain stable. In the face of the very distinctive features of the Black Sand groups (Minturno included), the semi-quantitative accordance with the reference groups is deemed sufficient confirmation. In the case of Mondragone, only the samples showing K_2O values higher than the maxima of other productions, are validated beyond doubt by the chemical analyses. However, sample AMR31, exhibiting the most typical coarse fabric and possessing a composition well in the range of the Mondragone reference group, although in the overlap zone with other groups, is also counted as certain attribution. Fabric group c presents a problem for more precise attribution, as neither the fabric nor the chemical composition offer distinguishing features beyond the volcanic inclusions placing their origin on the tyrrhenian coast of Italy. Without recourse to multivariate statistical analyses, no precise information on this group may be gained.

The alteration problem mainly reduces the interpretational possibilities concerning the detailed comparison with other consumer sites. Under these circumstances, it is not possible to evaluate the degree of similarity inside groups and to identify particularly homogenous lots of amphorae, which might eventually lead to a better understanding of the distribution patterns or of the drinking habits. But even without this very detailed information, the assessment of the amphora spectrum of Reinach-Nord in comparison to those of other, mostly older, Iron Age sites and to those of the nearby Roman colonial town Augusta Rauricorum allows several conclusions to be drawn, mainly concerning changes over time in the proportion of wares reaching the region.

As on the other Late Iron Age sites, over 90% of the amphorae from Reinach-Nord come from Italy. Reinach-Nord is, however, the earliest site with confirmed examples of Spanish amphorae (one sample, AMR34, analysed for three different objects of the same fabric). In Augusta Rauricorum wine amphorae from the Tarraconnensis are present, but copies of these amphorae made in Lyon are more common. No exact parallels to the extra-Italic samples from Reinach-Nord (AMR19, AMR32, AMR34) were identified at the other considered sites; this includes the rare sherds belonging to amphorae Lamboglia 2 present for example in Basel-Gasfabrik which do not resemble AMR32 petrographically or chemically.

Amphorae from Albinia and from the Mondragone - Falerne region are present on all studied sites regardless of age or socio-economic importance. On Iron Age sites, Cosa, another production site from Etruria, is generally well represented, but of uncertain presence or missing in Reinach-Nord and in Augusta Rauricorum. The Black Sand fabric groups, while present everywhere, constitute only a small proportion of amphora assemblages in the Late Iron Age sites north of Lyon, and come usually from several, albeit mostly unknown, production sites, but generally not including Minturno, like in Reinach-Nord. Amphorae from Minturno do, on the contrary, form a large proportion of the Italic amphora assemblage at Augusta Rauricorum. Fabric group d in Reinach-Nord appears to represent the beginning of the import from this particular site. The Black Sand fabric from Pompeii is not represented in Reinach-Nord. While not identified among the studied sherds from Basel-Münsterhügel (early 1st cent. BCE), amphorae from Pompeii are found in the earlier site Basel-Gasfabrik (2nd cent. BCE) and in Augusta Rauricorum (Thierrin-Michael, 1990; Martin-Kilcher, 1994; Martin-Kilcher et al., 2013). However, in regard of the small proportions of amphorae from Pompeii in any of the considered sites, combined with the small number of amphorae from Reinach-Nord, the absence of material from Pompeii is not statistically significant and has to be used with caution in the archaeological discussion. The number of groups representing amphorae of different provenances in Reinach-Nord lies between 10 and 12 depending on group c, where the question of one or several provenances cannot be answered. This small number of sources for amphorae corresponds to the situation generally observed on the other Late Iron Age sites considered. This comparison shows that the amphora spectrum in Reinach-Nord combines aspects from those of earlier and of later sites and that no significant feature in the amphora assemblage at Reinach-Nord differs from those of contemporaneous urban settlements. The problem of the chemical alteration of the samples prevented the very detailed statistical comparisons necessary to provide clues regarding the high wine consumption at this farmstead.

3. Conclusions

The results of the present study may be summarised as follows:

- The petrographic and chemical analyses allow the classification and provenance determination of the amphorae from Reinach-Nord and a comparison to the amphora spectra from other sites of the region, in spite of somewhat altered chemical compositions (leaching of CaO).
- With three exceptions, the analysed samples are of Italic origin.
- The wine amphorae come from a maximum of 12 different production sites.
- Amphorae from the production centres of Albinia (Etruria), Minturno (limit Southern Latium/Northern Campania), Mondragone - Falerne (Northern Campania) in Italy and from the Tarraconnensis (Spain) were determined precisely.
- Three more so-called Black Sand fabrics and another fabric with few dark inclusions, of undetermined production sites on the Tyrrhenian coast of Italy are distinguished.
- Groups Albinia, Mondragone and the Black Sand fabrics are found also on other Late Iron Age sites, as well as among the amphorae from the Roman town of Augusta Rauricorum.
- Amphorae from Minturno are very rare or absent on Late Iron Age sites of the region between Lyon and the Upper Rhine valley, but form an important group among the Italic amphorae in Augusta Rauricorum; Tarraconnensis is not represented at the other Iron Age sites.
- The amphora spectrum in Reinach-Nord thus appears to combine some aspects present in both earlier and later sites, and shows no significant difference to spectra from larger settlements.

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