Studies of the southern Gaul *sigillata* ceramics: the workshops of La Graufesenque and Montans

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ABSTRACT The *Terra Sigillata* ceramics from two very big workshops in southern Gaul are studied by X-ray diffraction, Microprobe and SEM. In both cases, different clays were used for body and slip preparation. The slip was obtained from a non-calcareous clay. Our investigations show the greater homogeneity of the production of La Graufesenque. That is in agreement with the excavations, which showed that La Graufesenque had an industrial organisation whereas Montans was a small-scale production.

1. Introduction

Among the Gaulish workshops, the centre of La Graufesenque (Aveyron, France) was a very important workshop of *terra sigillata* ceramics. During the first century AD, this centre produced vast quantities of *sigillata* table-wares, which were sold all over the Roman Empire, mainly in Gaul, Great Britain, Germany and Spain. The excavations showed that the centre had an organisation, which can be qualified as industrial with collective firing in very big kilns. The biggest kiln to fire this type of wares was found at La Graufesenque (Vernhet, 1981). Its capacity was estimated between 10 000 and 40 000 vessels. This centre has also given the greatest number of *graffitis* (or potters' logbooks). Up to now, as many as 400 *graffitis* have been found at La Graufesenque, whereas less than 10 have been found in other main workshops as Arezzo (Italy) or Lezoux (central Gaul). The number of pieces and the name of all the potters, who participated in the firing, are mentioned. The total number is between 20 000 and 35 000 pieces on each *graffito*. This is in good agreement with the estimated capacity of the big kiln.

The excavations carried out at Montans correspond to a smaller scale production. The kilns were smaller and, up to now, only two *graffitis* have been found. This workshop also started the production of high quality *sigillata*, during the Tiberian period (AD 15-38), following a test period where Italian models were copied. The main diffusion was along the Atlantic coasts.

2. Archaeological samples and experimental methods

Forty and fifteen sherds from La Graufesenque and Montans respectively have been selected for investigation. All the samples were found during the excavations of the workshops and are dated between AD 15 and 150. The sherds with slip of bad quality or overfiring have been removed.

The diffraction patterns of bodies and slips of all the samples were recorded using a Seifert 3000T diffractometer equipped with a post-sample graphite-monochromater (λ=CuK$\alpha_{1,2}$). The microprobe analysis was performed on a probe microanalyser SX50 (Cameca)[4]. Morphological examinations using a SEM Jeol 820 were carried out on fresh fracture sections.

3. Investigation of the body

A review of the main archaeometric studies of western Mediterranean *terra sigillata* can be found in the paper of Madrid Fernández and Buxeda i Garrigós (2002). The chemical composition of the bodies has been analysed in many studies, in particular by M. Picon and Schneider using XRF (Picon et al., 1975, Schneider, 1978). The chemical composition is different enough between the productions of the two workshops to distinguish them. The variation of composition is greater for Montans. In previous papers we have analysed the mineral composition of some sherds of La Graufesenque by X-ray diffraction and found small variations from one sample to another. From the works of Maggetti (1982) about the clay firing and from our test firings of the local clay, we managed to determine more precisely the firing temperatures (Sciau and Vezian, 2002). The firing temperatures were very homogeneous and can be estimated between 1020°C and 1080°C. The accuracy is better if the temperature dwell time can be specified: for a short temperature dwelling time (1h), the temperature range is reduced to [1050-1080]°C. On the other hand, for a long dwelling time (10h), the temperature is around [1020-1060]°C.

3.1 La Graufesenque

The present study on a greater number of analysed samples confirms our previous results (Sciau and Vezian, 2002). The main mineral phases are plagioclase, quartz, hematite and pyroxene. The ten most different diffraction patterns were refined using the Rietveld method. When the crystal structures of the constituent phases are known, this method is a good way for analysing the diffraction patterns from powder samples. Here, the structures of quartz and hematite are well known but which structure should we choose for the plagioclase and the pyroxene? The plagioclase is a solid solution of anorthite and albite. The diffraction pattern is closer to the anorthite's and as the bodies contain much more Ca (around 8% in atomic weight) than Na (0,2%) we have chosen the anorthite structure. The chemical composition of pyroxene is more complex since there can be many different atoms in the same crystallographic sites. However the diffraction patterns of pyroxenes of different types are very similar and in our case the proportion of pyroxene is too small and thus the different types cannot be identified. Therefore, we have chosen the diopside structure of the pyroxene phase. For each phase, we have refined the proportion, the lattice cell and the peak profile parameters.

The results confirm the great homogeneity of the mineral composition (Table 1). The larger variations concern the pyroxene and in a smaller extent the hematite. The proportion of plagioclase is quite similar from one sample to another and mainly depends on the firing temperatures. The samples with the highest amounts of plagioclase are also the samples for which the plagioclase reflections are the thinnest. In the study of the local clay v.s temperature, we have shown that the width of the plagioclase reflections decreases when the temperature increases. The weak variation of the plagioclase proportion confirms the great homogeneity of the firing temperatures.

TABLE 1
Mineral composition (diffraction contribution in percentages).

Sample	Provenance	datation	Plagioclase	Quartz	Hematite	Pyroxene
TSGFRD17A	Graufesenque	15-30	73 (2)	11 (1)	11 (2)	5 (2)
TSGFRD24B	Graufesenque	15-30	79 (3)	10 (1)	6 (1)	5 (2)
TSG35A	Graufesenque	20-50	74 (2)	10 (1)	6 (1)	10 (2)
TSG50AA	Graufesenque	40-60	71 (3)	10 (1)	5 (1)	14 (3)
TSG50GL1	Graufesenque	40-60	75 (2)	10 (1)	9 (1)	5 (2)
TSG60C	Graufesenque	50-70	78 (3)	6 (1)	8 (1)	8 (2)
TSG70H9A	Graufesenque	60-90	76 (2)	10 (1)	6 (1)	8 (2)
TSG100A	Graufesenque	90-110	80 (3)	11 (1)	7 (1)	1 (4)
TSG125A	Graufesenque	100-150	73 (2)	9 (1)	8 (1)	10 (2)
TSG125C	Graufesenque	100-150	75 (2)	14 (2)	8 (1)	3 (3)
Mean			75	10	7.4	6.5
TSMTH1	Montans	80-110	56 (2)	17 (1)	9 (1)	18 (2)
TSMTH3	Montans	15-40	44 (2)	19 (2)	3 (1)	33(2)
TSMIB	Montans	30-60	33 (2)	23 (2)	2 (2)	42 (2)
TSMIF	Montans	30-60	50 (2)	15 (1)	4 (1)	30 (2)
TSMIG	Montans	50-100	57 (2)	5 (1)	2 (2)	36 (2)
TSMIH	Montans	50-100	43 (2)	19 (2)	3 (2)	35 (2)
Mean			47	16.3	3.8	32

3.2 Montans

The diffraction patterns show more differences. The same approach was used and the most different patterns were refined using the Rietveld method. The mineral composition is more heterogeneous than at La Graufesenque. The variations concern all the phases (Table 1). The proportion of pyroxene is larger and there is no difficulty in distinguishing the Montans products from the ones of La Graufesenque. The local clay used by the potters has not been studied yet. However from Maggetti, the firing temperatures can be estimated between 1000 and 1100°C. The plagioclase profile shows more variation. In some samples of Montans, like TSMIG, the reflections are thinner and correspond to a well crystallized plagioclase phase. For La Graufesenque, we have found this degree of crystallisation in the overfired samples only. Nevertheless these Montans *sigillata* of this type do not seem to have been overfired. Their pastes are rich in calcium (Ca(TSMIG) = 10,1%) and can be fired at higher temperature. On the other hand, the samples like TSMTH1 (Ca = 7,4%) present a broader plagioclase profile similar to the diffraction profiles measured for the clay of La Graufesenque. This is some evidence for a lower firing temperature. For such samples of Montans, we assume the firing temperaure was lowered and kept below the glass transition.

The difference in the mineral composition is due to both the variation of the clay composition, which is also observed in the chemical composition, and the firing temperatures.

4. Investigation of the slip

Few papers present archaeometric studies about the slips of these two workshops. The first chemical analysis of the slips from La Graufesenque was made by Willgallis and

Heyer (1976). More recently Picon (1997) has presented a study of a few sherds from La Graufesenque by microprobe. From the difference of chemical compositions in the body and the slip, in particular the value of the K/Al ratio, he has concluded that two different clays were used.

4.1 La Graufesenque

The mineral compositions of the slip were examined by X-ray diffraction in the reflection mode. In a previous paper we have shown that the slips from La Graufesenque are quite thick (around 30 µm) and the signal of the paste is strongly attenuated on a laboratory diffractometer with Cukα radiation (Vendier et al., 2002). Typical diffraction patterns recorded in this condition are shown in Fig. 1. The main mineral phases are quartz, hematite and a corundum type phase. In a study of glossy clay layers, Michel et al. (1987) reported the presence of corundum in some slips after firing at high temperature (above 1100°C). In the *sigillata* of La Graufesenque, the firing temperature of the slips is a little lower (around 1050°C), and for now we do not know if corundum appears during the firing or if it was initially present in the raw clay.

The patterns of the 40 studied samples are very similar. Three of these samples were analysed by microprobe (Table 2). The results are in good agreement with the published results (Picon, 1997). From the mineral and chemical compositions, the slip comes from a non-calcareous clay of illitic type. Michel et al. noticed that it is the type of clay, which gives the best surface aspect.

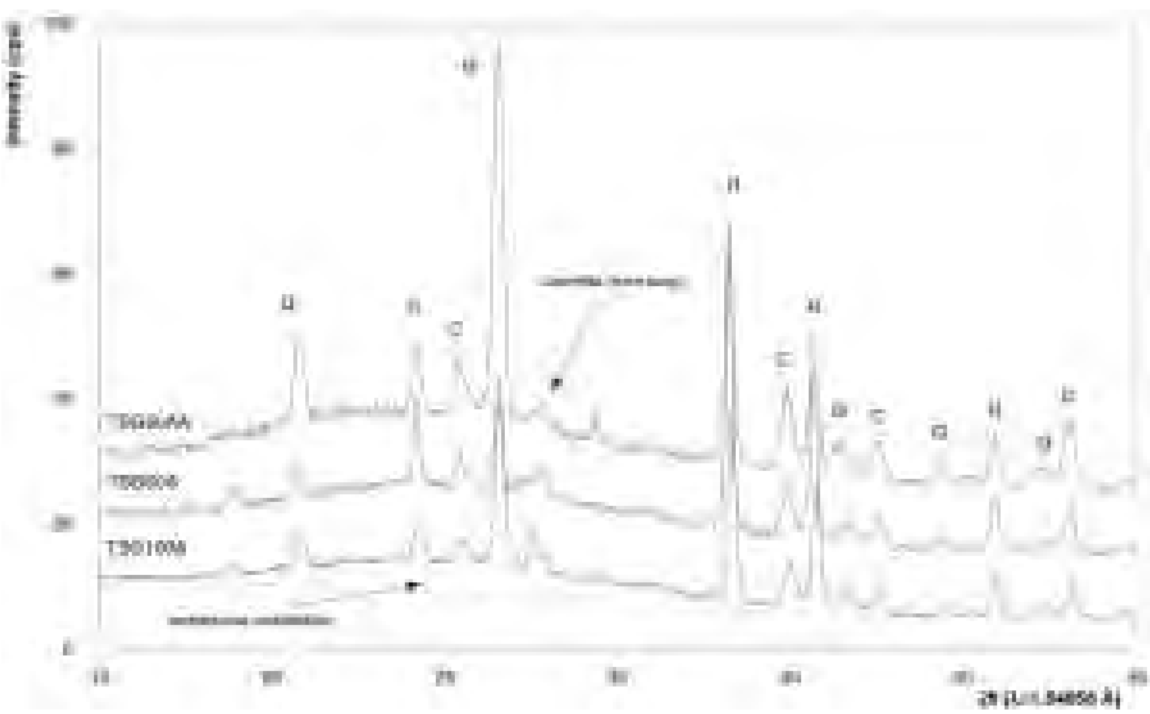

FIG. 1 – Diffraction patterns of the 3 most different slips from La Graufesenque (No 40). Q quartz, H hematite and C corundum.

TABLE 2
Microprobe analytical data (weight percentages).

Sample	O	Fe	Ca	K	Al	Si	Ti	Mg	Na	Mn	Ba	P	Cr	total	K/Al
TSG50AA	46,1	7,4	1,0	6,15	12,44	25,7	0,48	0,83	0,05	0,03	0,1	0,07	0,03	100,3	0,49
TSG60C	46,1	6,5	0,7	6,0	12,7	26,0	0,4	0,7	0,05	0,04	0,1	0,1	0,02	99,4	0,47
TSG100A	45,3	7,4	1,3	6,3	12,9	25,2	0,45	0,8	0,09	0,05	0,07	0,0	0,02	100,0	0,49
TSMTH3	44,9	8,1	1,7	7,5	12,9	23,8	0,83	0,6	0,15	0,03	0,07	0,09	0,03	100,3	0,58
TSMIF	44,0	7,5	1,2	8,6	16,3	20,3	0,44	0,76	0,34	0,03	0,06		0,02	99,6	0,53

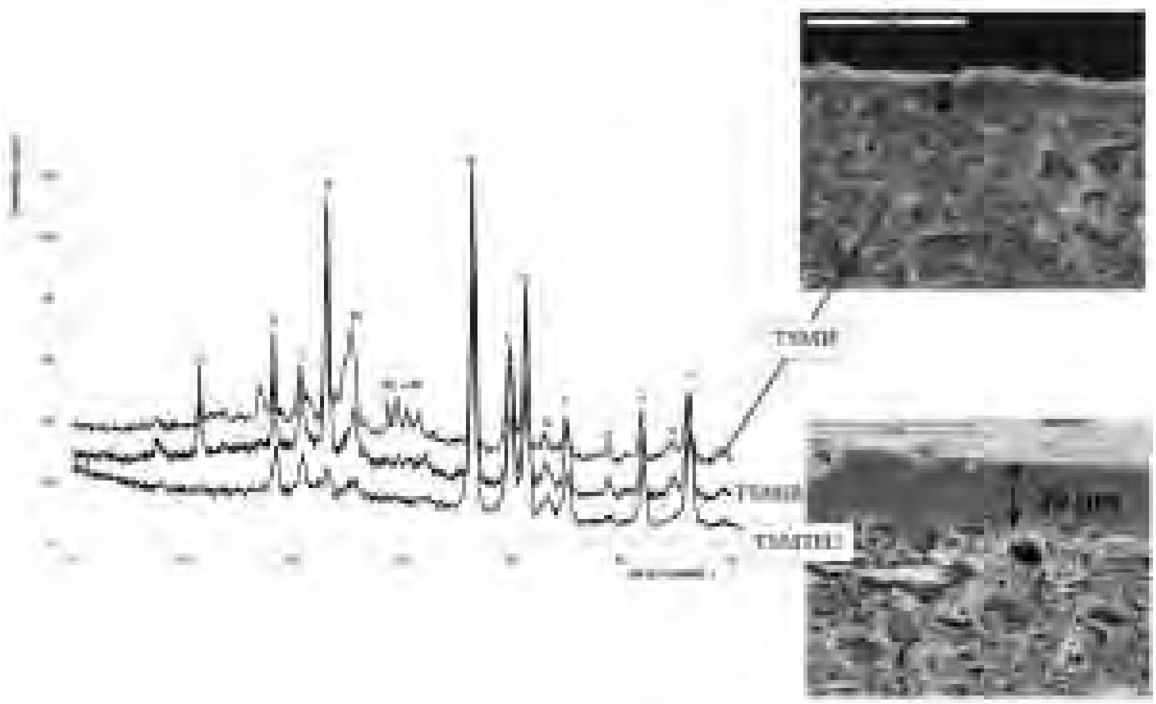

FIG. 2 – Diffraction patterns of the slips from Montans and the corresponding SEM cross-section. The thickness of the intermediate slip (TSMIB) is around 15 µm.

4.2 Montans

The diffraction patterns show some variations between samples (Fig. 2). The main phases are the same as for La Graufesenque but in some samples (TSMIF type) the reflections of plagioclase and pyroxene are observed. The thickness of the slips was observed by scattering electron microscope and we have noticed that all samples of TSMIF type have a very thin slip compared to the samples (TSMTH3 type). Samples of TSMSTH3 type do not exhibit strong plagioclase or pyroxene reflections (Fig. 2). One sample of each type was analysed by microprobe and no significant difference was found (Table 2). The percentage of all the elements is very close. The slip of TSMIF type does not contain more calcium. Slips of both types have the same composition. The difference in their respective diffraction signatures comes from the probability to observe or not the diffraction from the plagioclase and the pyroxene in the body, depending on the thickness of the slip. These slips have the same composition as for La Graufesenque. However the proportion of corundum, in the analysed samples, is slightly superior as the ratio K/Al is: 0.483 and 0.555 respectively at Montans and La Graufesenque.

5. Conclusion

The mineral compositions of the bodies are different enough to distinguish between the productions either from Montans or from La Graufesenque. X-ray diffraction, as well as XRF, is a suitable technique for the problem of provenance. For both La Graufesenque and Montans, different clays were used for preparing the body and the slip respectively. The ceramic body was prepared from the calcareous local clay close to the workshops. On the other hand, the slip was obtained from a non-calcareous clay of illitic type. For La Graufesenque this clay probably originates from a site of the Trias era, situated 20 km farther. There is no such source of calcareous clay nearby Montans. The research on the origin of the clay present in the slips of the Montans pottery still is in progress.

The chemical and mineral compositions are much more homogeneous at La Graufesenque. It seems that it is due to the more industrial organisation with collective clay preparations and collective firings. The weak variations of the mineral composition confirm the great mastery of the firing under oxidising atmosphere.

NOTES

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