GREYWARE POTTERY FROM SANT MIQUEL DE LA VALL: SOME THOUGHTS ABOUT THE DISTRIBUTION AND EXCHANGE OF UTILITARIAN COOKING POTS IN MEDIEVAL CATALONIA

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Abstract

Medieval greyware pottery from Sant Miquel de la Vall presents a specific case for the study of this type of production in Catalonia. The archaeometric characterization of a group of 10 samples, consisting of their petrographic analysis based on the microscopical examination of thin sections and their chemical and mineral characterization through the analysis of X Ray Fluorescence (XRF) and X Ray Diffraction (XRD), has allowed to identify up to four different productions, some of which have also been retrieved in distant sites located on the areas of Anoia and Gironès. The aim of this paper is to present some thoughts about the possible routes of distribution and exchange of pottery in the Middle Age and on the role played by the rivers Segre, Llobregat and Ter in connecting different sites throughout the Catalan landscape between 11th and 12th centuries.[1]

Keywords

Middle Age, Greyware Pottery, Petrography, X Ray Fluorescence, and X Ray Diffraction.

Capitalia Verba

Medium Aevum, Ceramica cinerea, Petrographia, Radiorum X fluorescentia et Radiorum X diffractio.

1. Introduction

Utilitarian cooking wares fired under reducing atmosphere, usually known as 'greyware', constitute one of the most common archaeological remains in Medieval sites in Catalonia, the North of the Iberian Peninsula, the South of France and Italy. Commonly regarded as local products, their process of manufacture has often been interpreted either as a seasonal activity, complementing agricultural and herding activities in order to satisfy domestic needs, or as a trade product in narrow circles, like small local markets. The highly utilitarian quality of these products, often lacking ornamentation or just including simple carved motives, and the continuance of their simple shape for very long periods of time make it very difficult to interpret their origin only through a morphologic and macroscopic approach.

For the last few years, a multidisciplinary research project has been carried out focusing on the analysis of a large group of greywares from all over Catalonia, aiming to define with precision the existence of production areas with singular features and their interrelation at the territorial level. The result of this project has revealed the general scenario of production and distribution of this type of product, showing a distinction between major and minor production centres scattered throughout the territory, and causing different impact on the land according to their productive capacity.[2] In general, this type of cooking-ware corresponds in fact to a narrow regional production, strongly influenced by the local production and distribution networks. However, the word 'local' turns out to be an imprecise denomination when defining this type of production.

In fact, the word 'local' has been triggering extensive reflection and discussion for so long. Since the first analytic approaches carried out in the late 1970s aiming to determine the provenance of pottery products, it is generally accepted that the sources of raw materials determining the original location of a group of items can be distinguished through their chemical, mineral and petrographic composition.[3] From this perspective based on the analysis of pastes, the identification of the production area is complex in absence of direct evidence. A key element for the identification of provenance is the knowledge of the local and regional geology and the comparison with materials of known origin.[4] Nevertheless, it is necessary to take into account

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2. Travé, Esther; López, María Dolores; Álvaro, Karen. "Circuitos de distribución de cerámica culinaria en el noreste peninsular: una aproximación territorial a partir del estudio analítico de vajilla utilitaria". *Arqueología y Territorio Medieval*, 21 (2014): 125-153.

3. Tite, Michael S. "Ceramic production, provenance and use – a review". *Archaeometry*, 50/2 (2008): 216-231.

4. Arnold, Dean E.; Neff, Hector; Bishop, Ronald L. "Compositional analysis and 'sources' of pottery: an ethnoarchaeological approach". *American anthropologist*, 93 (1991): 70-90; Bishop, Ronald L.; Rands,

other factors that may influence provenance, such as the variability of sources of raw materials and the techniques used for paste preparation.

If we consider as 'local' those vessels produced exclusively by the community that will use it, this phenomenon is not so frequent as it might seem. In Catalonia, the large dimensions and productive capacity of the medieval workshops of Cabrera d'Anoia and Casampons have revealed the necessity of a much wider production, circulating across a much more extensive area. On the other hand, the tradition of pottery manufacture in towns like Verdú, Piera, Quart and La Bisbal, widely known as common pottery production centres, most of them still working, also constitutes an element for reflection about the extent of this type of production in Medieval times. In any case, the scenery in Catalonia seems to be that of a diversity of regional circles with unequal levels of impact on the territory. As a matter of fact, they should be described as a group of reduced networks where one or several isolated or nucleated[5] workshops supply the villages around them, at a shorter or longer distance depending on their productive capacity.

However, supposing that a significant nuance in the word 'local' allowed for the inclusion of this more extensive regional area, the analysis of the greyware pots found in Castelló Sobirà de Sant Miquel de la Vall (Illustration 1) provides evidence that goes beyond these reduced networks. Within the above mentioned project fremework, the study of a small batch of 10 samples from this site in the Pyrenees[6] has revealed the existence of clearly different productions, and their comparison with other known reference groups suggests regular circulation of products between the Pyrenees and the plains within a considerable distance. This paper presents the results of the archaeometric characterization of this sample as a significant starting point for a much wider reflection on the reach of this type of product and their potential in a multidisciplinary study aiming to determine the processes of organization of the territory in the Middle Age.

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5. Peacock, David P. S. *Pottery in the roman world: An ethnoarchaeological approach*. London: Longman, 1982: 9.

6. Riu, Manuel. "Castelló Sobirà de Sant Miquel de la Vall", *Catalunya romànica*, Antoni Pladevall, ed. Barcelona: Enciclopèdia Catalana, 1993: XV, 333-339.

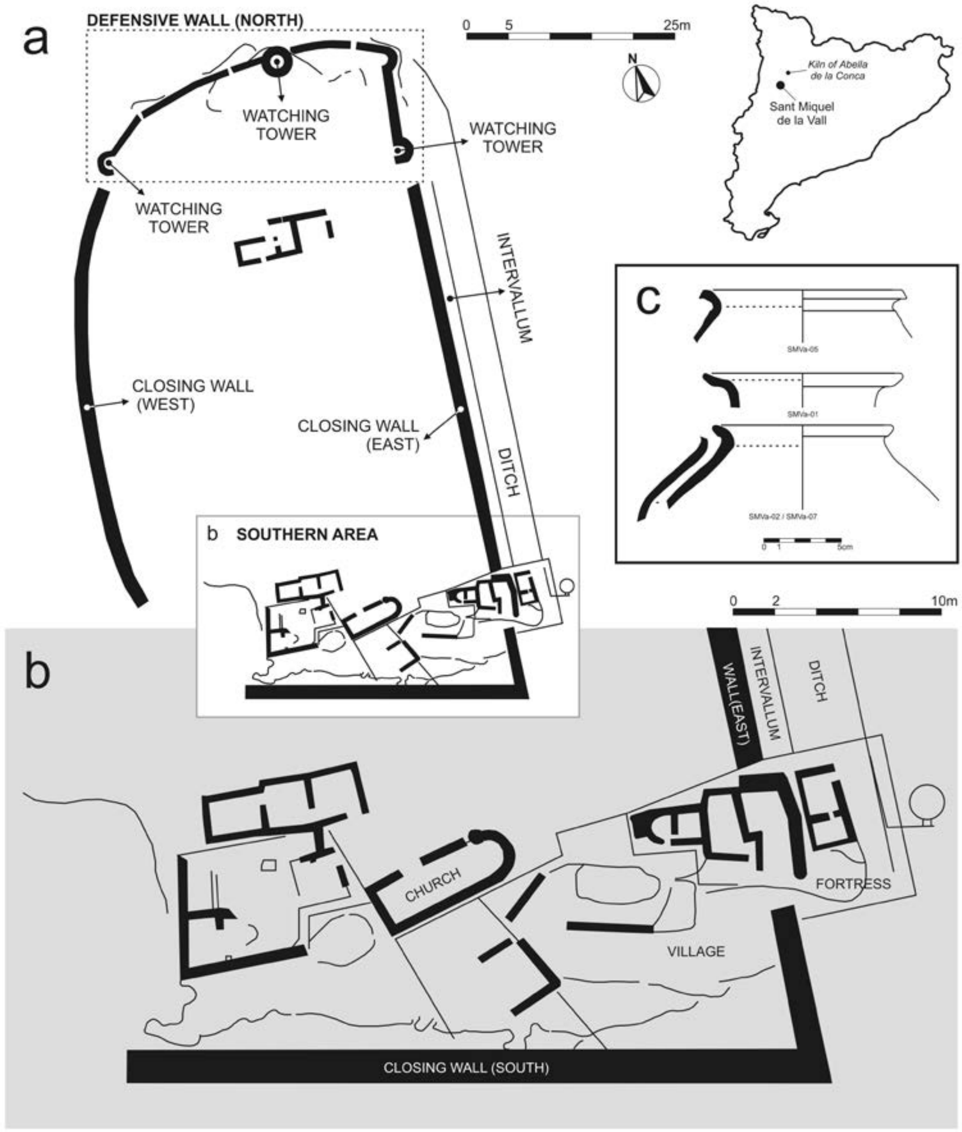

Illustration 1. General layout of the village of Sant Miquel de la Vall (a), detail of the southern area (b) and representation of the fragments with shaped analysed in this article (c).

In that sense, the site of Sant Miquel de la Vall becomes a paradigmatic case of study, as far as its population features are concerned. This site offers a small-sized representation of the main traits found in a society in process of feudalization, and it is a clear example of 11th and 12th century fortified villages.[7] This model of land occupation, including a fortification and a concentration of rural habitat within the same space, was widely spread in County territories during the 11th century, in correspondence with the transformations in social and political structures. The distribution of dwelling structures inside a walled village (Illustration 1a), surrounding houses with a defensive structure and often presenting reinforced back walls, is not always in order to defend them from dangers outside, but also to organize the territory and existing population strategically. This phenomenon reflects the consequences on territory organization generated by the implantation of the feudal order.[8] Similar examples of this type of village can be found in the area of the Pallars itself, in the castle of Mur,[9] and all over Catalonia in villages abandoned from the 14th century onwards, such as Roc de Palomera,[10] in the area of Berguedà; the village of Caulers,[11] in Caldes de Malavella; or the medieval village of l'Esquerda,[12] in Osona; all of them inhabited during 11th and 12th centuries.

The inner distribution of the site is not very different from the usual structure of Medieval villages and hamlets, whether fortified or not. The small castle and the whole village are located to the south of the walled structure, where the houses are placed along a NE-SW axis that follows the slope of the terrain, upwards until the eastern corner along three successive terraces (Illustration 1). At the highest point, the castle stands over the village, protected by the southern wall. The village spreads downwards to the south, until the lowest area where the church devoted to St. Michael is placed. Probably of late-Roman origin, the building presents a single nave and basilical shape.[13]

2. Methods and analytical routine

The 10 greyware samples analysed were taken from wall fragments of the boiling-pot shape, with the exception of three fragments of rim (Illustration 1c), each of them belonging to different individuals. They were characterized through a combination of techniques including the petrographic analysis through optical microscopy (OM)

7. Riu, Manuel. "Creació i desaparició d'alguns vilatges fortificats a la Catalunya Medieval". *Cota Zero: Revista d'Arqueologia i Ciència*, 6 (1990): 57-66.

8. Padilla, José I. "Últimas intervenciones en el despoblado de Sant Miquel de la Vall (Pallars Jussà)". *Tribuna d'Arqueologia*, (1985-1986): 75-82.

9. Adell, Joan Albert; Benito, Pere. "Castell de Mur", *Catalunya romànica*, Antoni Pladevall, ed. Barcelona: Enciclopèdia Catalana, 1993: XV, 347-352.

10. Riu, Manuel. "Creació i desaparició d'alguns vilatges...": 57-66.

11. Riu, Manuel. *Excavaciones en el poblado medieval de Caulers (mun. Caldes de Malavella, prov. Gerona)*. Madrid: Servicio de Publicaciones del Ministerio de Educacion y Ciencia, 1976.

12. Ollich, Imma. "Roda ciutat (L'Esquerda) i la defensa de la línia del Ter al comtat d'Osona", *Actes del Congrés Els Castells Medievals a la Mediterrània Nord-Occidental (Arbúcies, Girona, 5-7 març 2003)*. Arbucies: Museu Etnològic del Montseny, 2004: 179-194.

13. Padilla, José I. "Últimas intervenciones en el despoblado...": 78.

of thin sections and the examination of chemical composition through X Ray Fluorescence (XRF). Both procedures have been carried out independently, and then the results both results have been compared to each other, as well as to the macroscopic and contextual information from the fragments themselves and other samples of greyware coming from sites all over Catalonia, which have been used as reference material.

In order to carry out the petrographic study (OM), a 3µm-thick standard thin-section was prepared out of a vertical cut of each of the samples. These sections were then observed under a polarising light microscope *LEICA DM EP*, provided with a *Q-imaging Go-3* photo camera. Studying them allowed for their grouping in petrographic fabrics according to their inclusions, matrix and voids.[14] This technique makes it possible to identify particular aspects about the provenance of the samples, the raw material used to make them and the technology of their process of production. The study of their provenance was carried out comparing the obtained results to other greyware samples and to the geological map of Catalonia, using the geological cartography base provided by the Institut Cartogràfic de Catalunya. This base was compared to the topographic base through the online application http://www.icc.cat/vissir3/.

The chemical analysis of pressed pellets was carried out with a *Spectro X-Lab 2000 ED-XRF* equipment. Pellets were made out of a sample of c. 5g, with the exception of sample SMVa03, which was too small to undergo all the tests. For that reason, the preparation of the thin section was prioritized in this case. As to the rest of individuals, the pressed pellets were obtained from a mixture of 4g of sample previously grinded, milled and dried for 12 hours at 100ºC, with 0.9g of *Hoescht* powder wax pressed for 2.5 minutes under 15 Tm of pressure. 8 major (Na_2O, MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, Fe_2O_3) and 2 minor elements (P_2O_5, MnO) were analysed and expressed as %wt. Also 20 trace elements (S, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Hf, Ta, Pb, Th) were included in statistical data exploitation expressed as ppm. All the elements with concentrations inferior to 10 ppm were discarded because they were below the limit of detection of the instruments.

The data table obtained, once values had been normalized to 100%, is a special case of the d+1-dimensional vector space giving a d-dimensional projective geometry, in which projective points from the origin are projected within the *Sd* simplex following logarithmic intervals.[15] Therefore, the dataset has been centred log-transformed (CLR) according to

14. Travé, Esther. *Producció i distribució d'una terrisseria medieval: Cabrera d'Anoia*. Barcelona: Universitat de Barcelona (PhD Dissertation), 2009: 260-275; Travé, Esther. "Producció i distribució d'una terrisseria medieval: Cabrera d'Anoia". *Tesis doctorales en Red*. 12 January 2010, Universitat de Barcelona. 14 January 2015 <http://www.tesisenred.net/handle/10803/2072>; Quinn, Patrick S. *Ceramic Petrography. The Interpretation of Archeological Pottery & Related Artefacts in Thin Section*. Oxford: Archaeopress, 2013: 73-79.

15. Barceló Vidal, Carles; Martín Fernández, José A., Pawlowsky Glahn, Vera. "Mathematical foundations of compositional data analysis", *Proceedings of IAMG'01. The Annual meeting of the International Association for Mathematical Geology (Cancun 6-12 September)*, Gina Ross, ed. Lawrence: Kansas Geological Survey, 2001: 1-20 (CD-ROM). Online version: Barceló Vidal, Carles; Martín Fernández, José A., Pawlowsky Glahn, Vera. "Mathematical foundations of compositional data analysis". *Universitat de Girona*. 12 January

$$\mathbf{x} \in \mathrm{S}^d \rightarrow \mathbf{y} = log\left(\frac{\mathbf{x}}{g(\mathbf{x})}\right) \in \mathrm{R}^{d+1}$$

where S^d is the d-dimensional simplex and g($\mathbf{x}$) is the geometric mean of all the $\mathbf{x}$ d+1 components. Data obtained from this transformation have been statistically exploited through several Principal Component Analyses (PCA) and Hierarchical Cluster Analyses (HCA), by using the software IBM SPSS (19.0). There is still no unanimous agreement about the use of log-transformation because, even though it contributes to minimize internal variability of datasets due to the perturbation problem, raw data exploitation maximizes group difference in homogenous assemblages.[16] Despite this, it seems to be obvious that such a small batch as the one introduced in this paper requires the minimization of effects occurring from internal variability.

In addition, total variance (vt) of the dataset has been calculated through the equation

$$\mathrm{vt} = \frac{\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{d}_{\mathrm{a}}^{2}(\mathrm{x}_{\mathrm{i}}, \mathrm{g}(\mathbf{x}))}{\mathrm{n}}$$

and the origin of this variability has been analysed by a compositional variation matrix (CVM) defined as

$$\mathrm{T} = [\tau_{\mathrm{ij}}] = var[log(\mathrm{x}_{\mathrm{i}}/\mathrm{x}_{\mathrm{j}})]$$

where $i = 1, \dots, D-1$ and $j = i+1, \dots, D$. It is a symetric matrix with '0' values in its diagonal simplified considering $v_{ij} = \exp\left(-\sqrt{\tau_{ij}}\right)$ for each value in the final version in order to obtain values included within the interval [0,1], where 0_{ij} implies lack of proportionality and 1_{ij} implies perfect proportionality.

Once the main compositional groups had been determined, the mineral characterization of samples SMVa02, SMVa05 and SMVa09 were analysed through X Ray Diffraction (XRD), using 0.5g of previously prepared powder from the specimen. This powder was placed on a sample carrier prepared for that use and compacted by hand against a glass slide until a flat and even surface was obtained. Measuring was performed with a benchtop *RIGAKU MiniFlex 600* X-ray diffractometre operating with Cu (λ= 1,54060 Å) Kα radiation at 0,6 kW (40kV, 15mA) in a scan range between 3 and 90º2θ with a step with of 0,02º2θ and a scan speed of 10º/min. Crystalline phases have been determined by using the X'Pert High Score Plus® software with a PDF2 2005 ICSD (Inorganic Crystal Structure Database). This multidisciplinary approach offers interesting insights for archaeological interpretation of these pieces of greyware, their circulation

2015 <http://ima.udg.edu/~barcelo/index_archivos/Cancun.pdf>; Aitchison, John. "A concise guide to compositional data analysis". *Department of Statistics University of Glasgow*. 2005. 14 January 2015 <http://www.leg.ufpr.br/lib/exe/fetch.php/pessoais:abtmartins:a_concise_guide_to_compositional_data_analysis.pdf>; Buxeda, Jaume. "Revisiting the compositional data. Some fundamental questions and new prospects in Archaeometry and Archaeology", *Proceedings of CO-DAWORK'08, The 3rd compositional Data Analysis Workshop, May 27-30, Girona*, Josep Daunis, Josep Antoni Martín, eds. Girona: Universitat de Girona, 2008, 1-18.

16. Baxter, Mike J., Freestone, Ian C. "Log-ratio compositional data analysis in archaeometry". *Archaeometry*, 48 (2006): 511-531.

across the territory and the production techniques used to make them, adding new insights as to the greyware production and distribution strategies in the rural areas of Medieval Catalonia.

3. Characterization of the greyware from Sant Miquel de la Vall

The greyware from Sant Miquel de la Vall presents pale or slightly lead grey pastes, homogeneous and properly mixed, relatively fine, with some little inclusions usually less than 1mm thick. From a macroscopic perspective, it is only possible to distinguish between one fabric, formed by samples SMVa01 and SMVa09, presenting a large number of small inclusions of diverse nature, usually whitish, and other darker ones; and another fabric including the rest of samples, with slightly coarser inclusions and generally identifiable as quartz, with exception of some reddish and yellowish inclusions of indeterminate nature.

The petrographic analysis of the thin sections allowed for the identification of four clearly differentiated fabrics, according to the nature of the inclusions. The first one is a (1) fine quartz and micrite fabric; the second one is a (2) fine quartz, calcite and opaques fabric; the third one is a (3) sandy marl fabric and, finally, a fourth outlier sample with sedimentary and metamorphic rock fragments (table 1).

Table 1. General classification of the samples analysed

Sample	Number	Petrographic fabric	Chemical group
SMVa01	SMVa.0262.004	Fine quartz, micrite and opaques	2
SMVa02	SMVa.0262.011	Fine quartz and micrite	1
SMVa03	SMVa.0262.012	Sandy Marl	Discarded (<5g)
SMVa04	SMVa.0263.002	Rock Fragments	Non-classified
SMVa05	SMVa.0263.003	Fine quartz and micrite	1
SMVa06	SMVa.0263.008	Sandy Marl	3
SMVa07	SMVa.0263.018	Fine quartz and micrite	1
SMVa08	SMVa.0263.019	Fine quartz and micrite	1
SMVa09	SMVa.0263.021	Fine quartz, micrite and opaques	2
SMVa10	SMVa.0264.003	Sandy Marl	3

The fine quartz and micrite fabric (Illustration 2a) includes the highest number of samples. It is characterized by the presence of 35-40% inclusions forming a predominant fine or very fine monocrystalline quartz sand, their dimensions ranging from 0.03 to 0.5mm (exceptionally up to 1mm in samples SMVa02 and SMVa07). It also includes a small part of microcrystalline calcite or micrite, ranging from common to very scarce, which does not seem to have been added intentionally. The pastes of SMVa02, 05 and 07 present some very scarce inclusions of chert and some tiny fragments of rock fragments (≤0.25), likely to be sedimentary. Only sample SMVa08 contains some very infrequent inclusions of feldspar, biotite and opaque minerals. All of them show a proportion of brown or greyish clay matrix, around 55%, generally dark and not birefringent, and 5% voids formed by meso- and macrovaughs.

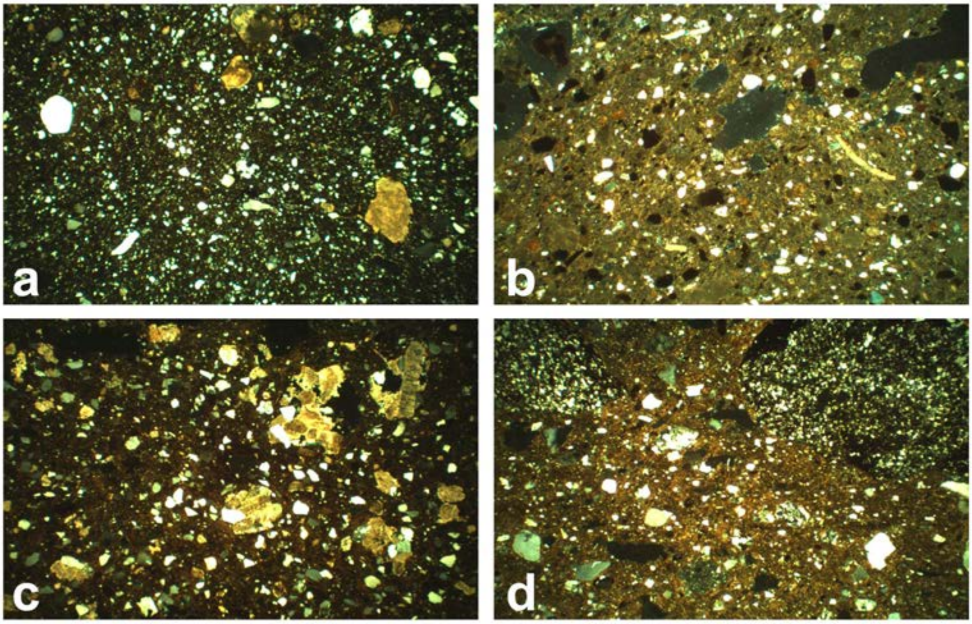

Illustration 2. Representation of the documented petrographic fabrics: fine quartz and micrite fabric (a), fine quartz, calcite and opaques fabric (b), sandy marl fabric (c) and outlier sample with sedimentary and metamorphic rock fragments (d). Microphotographs taken at 25x in crossed polars. Field of vision: 6mm wide.

The fine quartz, calcite and opaques fabric (Illustration 2b) is formed by two samples which are clearly distinguishable at naked eye. It presents 60% light brown yellowish matrix of slightly calcareous appearance, not birefringent and slightly vitrified in SMVa01, and 30% inclusions formed by predominant monocrystalline quartz (0.1-0.5mm) and very frequent opaque inclusions (0.1-1mm), occasionally looking like reddish clay. It also presents common calcareous inclusions, some of them coming from bivalve mollusc shells. The final 10% presents porosity, generally marked by the presence of quite round meso- and macrovaughs. All the inclusions seem relatable to some type of biomicritic or coralline carbonate rock, which in some cases seems to cause small micrite inclusions and in other cases presents the texture of clay rock, likely to cause the opaque inclusions.

The sandy marl fabric (Illustration 2c) is made out of relatively coarse paste, in comparison to the other ones, with 35-45% inclusions. The predominant inclusions are fragments related to sandy marl, formed by aggregations of monocrystalline quartz and calcite, generally micrite and sparite. The breaking of these inclusions seems to originate a calcareous sand formed by monocrystalline quartz and 50% micrite and 50% sparite, constituting the majority of inclusions. However, some whole fragments of sandy marl are also perceptible, especially in SMVa03. Sample SMVa10 also presents some scarce fragments of chert. The samples of this fabric present 50-55% matrix and 5-10% porosity. Exceptionally, SMVa06 and SMVa10 are the coarsest and most porous samples respectively.

Finally, sample SMVa04 (Illustration 2d) cannot be included in any of the groups above mentioned. It is characterized by the presence of 25% poorly sorted inclusions formed by quartz (0.25-0.5mm), which is the predominant element, common fragments of sedimentary rock, probably limestone (2.5-4mm), and some scarce fragments of metamorphic rock. Some clay pellets, chert, and some very scarce calcareous inclusion can also be found. 65% of the paste is composed by non-calcareous homogeneous matrix, and its colour is light brown or reddish brown with moderated optical activity. The last 10% corresponds to porosity, which is similar to the fabrics previously described, although this case presents a macrovaugh (1mm) with slightly burnt and darkened edges.

Regarding chemical traits, obtained through FRX, the group presents very high total variation (tv = 2.2979), revealing polygenetic origin, although the sample is quite small. Observing the chart of compositional uniformity (Illustration 3a), it can be perceived how the elements MnO, P_2O_5, TiO_2 and MgO impose very little variation on the whole group, since $tv/\tau_i > 0.75$, whereas the origin of the variation can be found in the multiplicity of components where $tv/\tau_i < 0.55$. It is important to remark that the variability imposed by these components grows evenly. Due to this fact, it is possible to conclude that variability depends on many sources. Another significant fact is that the major elements SiO_2, Al_2O_3 and Fe_2O_3, generally constituting c. 90% of pottery, are included in this group of components, so that they explain a very high degree of variability, which reinforces the idea of polygenetic origin for the entire group.

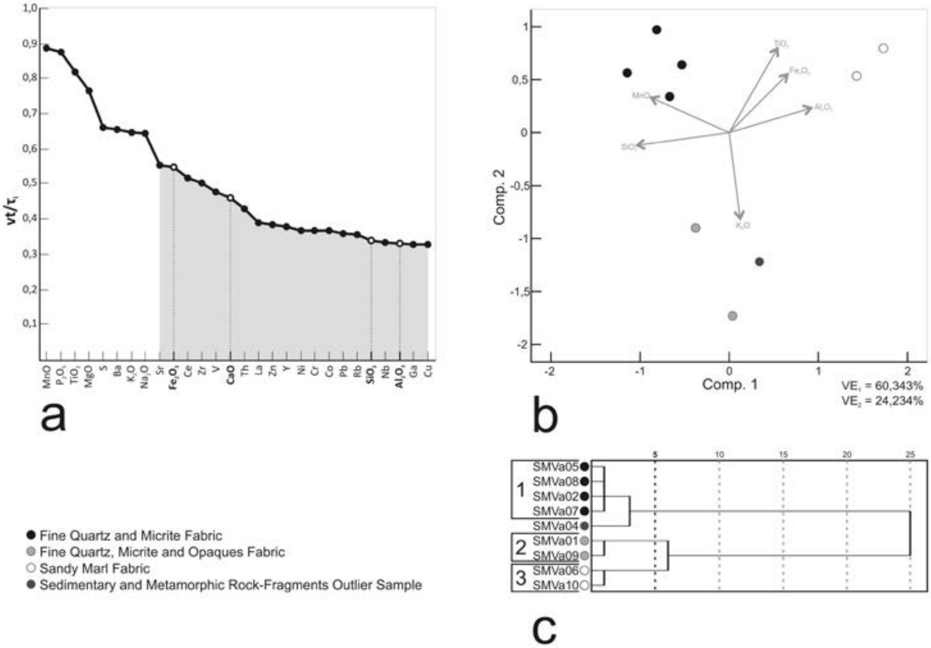

Illustration 3. Charts representing the characterization of the materials from Sant Miquel de la Vall: Chart of uniformity of compositional variability with the determined elements (x-axis) in decreasing order according to the tv/τ_{I} value (y-axis) (a); scatter plot according to components 1 and 2 in the PCA realised for sub-composition Al_2O_3, SiO_2, K_2O, TiO_2, Fe_2O_3 and MnO with logarithmic transformation (b); and dendrogram resulting from the hierarchical cluster analysis for the same sub-composition using Ward's linkage (c).

It is possible to define clearly the chemical singularities of each detected fabric (Illustration 3b) through a principal component analysis (PCA) taking into consideration the major elements, with the exception of Na_2O, MgO, CaO and P_2O_5. These elements have been excluded from the analysis because the values they present in some samples seem to indicate that either they are affected by postdepositional alteration, or they variability depends on the texture of the paste. In the case of P, its concentration in sample SMVa06, 0.46%, which creates a significant contrast with the usual values in the rest of samples (c. 0.1%) suggests that the origin of this element in the sample might be due to some contamination through organic material, although the origin is unknown[17] (table 2).

17. Collomb, Phillippe; Maggetti, Marino. "Dissolution des phosphates présentes dans des céramiques contaminées". *Revue d'Archéometrie*, 2 (1996): 69-75; Duma, György. "Phosphate content of ancient pots as indication of use". *Current Anthropology*, 13 (1972): 127-130.

Table 2. Concentration of major elements in each of the samples analysed, expressed in %wt.

	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Fe_2O_3	P_2O_5	MnO
SMVa01	0,04	1,31	24,06	58,66	1,95	3,36	0,95	9,31	0,10	0,03
SMVa02	0,04	1,14	14,77	68,93	2,03	5,85	0,82	5,97	0,10	0,13
SMVa04	0,19	1,36	18,39	66,73	3,05	2,05	0,72	7,09	0,13	0,08
SMVa05	1,26	1,47	15,74	68,56	1,96	2,78	0,82	7,00	0,08	0,14
SMVa06	0,29	1,34	14,34	65,83	2,62	9,09	0,66	5,12	0,46	0,04
SMVa07	0,26	1,18	13,75	74,74	1,75	1,13	0,75	6,06	0,08	0,12
SMVa08	0,04	1,18	15,16	71,23	1,83	2,82	0,88	6,40	0,10	0,15
SMVa09	0,04	1,36	28,24	55,25	1,87	3,58	1,08	8,22	0,11	0,03
SMVa10	0,04	1,85	17,15	70,99	1,95	2,37	0,65	4,69	0,10	0,04

On the other hand, the variation of the proportion of calcium in the majority of samples depends on the number of calcareous inclusions detected through the petrographic analysis. Sample SMVa06 presents a high level in comparison to the rest of samples (9.09%), directly related to the higher number of calcareous inclusions of sandy marl. Likewise, sample SMVa02 presents 5.85% CaO concentration, also related to a higher proportion of micrite inclusions than in the rest of samples of its fabric. The presence of calcareous inclusions decisively characterizing the petrographic fabrics in slightly variable proportions also seems to affect the concentrations of Na_2O and MgO, and that is why it was decided to exclude these elements as well from the PCA.

Moreover, taking into account these elements causes a decrease in the total variation explained by the two first components in the PCA, so that, excluding them, the total variation becomes 84.577% (Illustration 3b). In the scatter plots resulting from the comparison between the first two components in the PCA for major elements, it is possible to detect the presence of 3 definite groups corresponding to the petrographic fabrics described above. In this chart, the outlier sample SMVa04 appears close to the fine quartz, calcite and opaques fabric samples. This fact seems to be due to a major attraction towards the element K_2O. Nevertheless, the nature of the paste and the main inclusions in this sample makes it difficult to consider it beforehand as belonging to this fabric.

In order to clarify this relationship and to prove the validity of the identified groups, a hierarchical cluster analysis (HCA) has been carried out for the same composition, and the resulting dendrogram makes it possible to prove the division of the group into three chemical groups (Illustration 3c). Therefore, it is possible to identify the existence of a chemical group '1' including the samples corresponding to the fine quartz and micrite fabric, basically characterized by a very high concentration of SiO_2 (70.87%), due to the abundance of small quartz inclusions, moderate values of Al_2O_3 (14.86%) and a remarkable concentration of Zr (275 ppm) in comparison to the other groups (table 3).

Table 3. Average values of chemical composition and values of standard deviation (*italics*) for each of the groups identified in Sant Miquel de la Vall (SMVa), and chemical data from the reference groups, from the sites in Sant Feliu de Girona (SFG) and Sant Miquel de Veciana (SMV).

	Fine Quartz and Micrite Fabric		**Fine quartz, Micrite and Opaques Fabric**				**Sandy Marl Fabric**				**RF Fabric**
	(1)		**(2)**				**(3)**				
	SMVa		**SMVa**		**SFG**		**SMVa**		**SMV**		**SMVa04**
	(N=4)		**(N=2)**		**(N=4)**		**(N=2)**		**(N=8)**		
	(μ)	(σ)	(μ)	(σ)	(μ)	(σ)	(μ)	(σ)	(μ)	(σ)	-
Na_2O	0,40	0,50	0,04	0,00	0,17	0,16	0,17	0,12	0,60	0,33	0,19
MgO	1,24	0,13	1,33	0,03	1,51	0,05	1,60	0,25	2,43	0,25	1,36
Al_2O_3	14,86	0,72	26,15	2,09	22,23	0,54	15,74	1,41	17,69	0,69	18,39
SiO_2	70,87	2,46	56,95	1,71	61,52	0,60	68,41	2,58	66,02	0,75	66,73
K_2O	1,89	0,11	1,91	0,04	3,39	0,56	2,29	0,34	3,42	0,18	3,05
CaO	3,14	1,70	3,47	0,11	2,32	1,23	5,73	3,36	1,94	1,00	2,05
TiO_2	0,82	0,05	1,02	0,06	0,98	0,08	0,65	0,00	0,72	0,02	0,72
Fe_2O_3	6,36	0,40	8,76	0,54	7,00	0,68	4,90	0,21	6,75	0,17	7,09
P_2O_5	0,09	0,01	0,10	0,00	0,33	0,19	0,28	0,18	0,11	0,01	0,13
MnO	0,14	0,01	0,03	0,00	0,06	0,03	0,04	0,00	0,07	0,01	0,08
S	354	60,64	417	77,22	1012	655,28	535	179,68	518	64,88	347
V	154	24,82	153	37,97	122	14,53	121	8,41	123	5,77	106

Cr	130	13,15	139	0,05	95	12,87	114	1,38	96	11,79	98
Co	47	13,74	27	6,82	39	14,92	31	14,41	28	12,63	55
Ni	43	4,24	53	4,92	42	10,05	33	6,43	42	1,84	52
Cu	28	3,37	28	1,66	25	5,41	20	3,14	42	3,60	36
Zn	87	6,83	47	1,96	97	41,55	58	5,34	88	3,33	85
Ga	19	1,02	32	0,33	29	2,54	18	2,53	22	1,05	23
Rb	113	5,44	111	5,95	177	44,57	112	5,40	122	8,48	128
Sr	159	30,35	215	95,37	154	53,18	152	49,47	131	13,47	100
Y	34	3,26	48	10,71	60	5,62	31	5,96	41	2,25	54
Zr	275	12,21	191	6,79	196	28,82	172	7,90	284	13,41	225
Nb	20	2,04	24	4,42	31	8,10	13	2,81	19	1,52	19
Ba	309	29,32	501	110,65	572	123,02	348	62,32	725	144,13	598
La	36	7,57	74	15,01	67	10,75	36	10,70	37	4,67	48
Ce	67	23,22	141	78,48	146	19,42	45	12,77	71	14,72	58
Pb	30	1,72	36	4,07	38	7,32	27	2,91	31	3,46	31
Th	13	0,57	19	0,04	24	6,10	11	0,65	16	0,82	14

Chemical group ‘2’ includes the samples belonging to the fine quartz, calcite and opaques fabric. It is a singular group as regards the majority of elements. Firstly, the most remarkable traits are the unusually high proportion, in comparison to the rest, of Al_2O_3 and Fe_2O_3 (26.15% and 8.76% respectively), along with a rather low proportion of SiO_2 (56.95%). These traits seem to be closely related to the nature of the inclusions, with a low proportion of quartz, which gives an explanation for the silica values and a great number of opaque inclusions, of clay type, very rich in iron and aluminium. However, the trace elements explain a great part of the singularity in this group, which presents particularly high concentrations of Cr, Ni, Zn, Ga, Sr, Ce and Th (table 3). It must be remarked that in this group the unusually high concentration of barium is due to an anomalous concentration in sample SMVa01 (612 ppm), probably caused by postdepositional contamination.[18]

Chemical group ‘3’ corresponds to the *sandy marl fabric*. Although the high proportion of CaO (5.73%) in this group is affected by the high concentration in sample SMVa06 and that makes standard deviation (σ) not entirely reliable, the concentration of Na_2O and MgO (0.17% and 1.6% respectively) seems to confirm the relationship between these concentrations and the calcarian inclusions identified as sandy marl. The group outstands because of its low concentrations in trace elements in comparison to the rest, the values of V, Cr, Ni, Cu, Ga Y, Zr, Nb, Ce, Pb and Th being especially remarkable (table 3).

Finally, sample SMVa04 was definitely considered as an outlier sample, although according to composition it presents a higher similarity with group 1 than with groups 2 and 3, particularly as far as the elements Fe_2O_3, S, Zr, Ce, Pb and Th are concerned. This similarity is clearly perceptible in the dendrogram (Illustration 3c), where sample SMVa04 appears as related to group 1, whereas groups 2 and 3 appear related (to each other / to it) farther from the base of the dendrogram. Taking into account that, in this chart, the farther from the base the relationship is placed the higher the compositional difference of the groups is, then it is significant that groups 2 and 3 are highly dissimilar from group 1 and sample SMVa04. Thus, it is possible to presume a distinction between local and imported products beforehand.

From the technical point of view, all pastes have been prepared with relatively coarse clay, and in no case do they seem to present added temper. On the contrary, both the inclusions present in the past and their variability seem to result from the natural presence of these non-plastic components in residual clay originated out of the erosion of preferably sedimentary rocks. Even when they are basically characterized by the higher or lower presence of calcareous inclusions, the pastes are technologically defined as non-calcareous, since the presence of CaO < 5-6%. This fact is not surprising when dealing with cooking greyware.[19]

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18. Picon, Maurice. “Un exemple de pollution aux dimensions kilométriques: la fixation du baryum par les céramiques”. *Revue d’Archéometrie*, 9 (1985): 27-29; Picon, Maurice. “La fixation du baryum et du strontium par les céramiques”. *Revue d’Archéometrie*, 11 (1987): 41-47.

19. Picon, Maurice. “Grises et grises: quelques réflexions sur les céramiques cuites en mode B”, *Actas das 1ª Jornadas de Cerâmica Medieval e Pós-Medieval, métodos e resultados para o seu estudo (1992)*. Tondela: Edições Municipais, 1995: 283-287.

Taking a close look at the situation both of the analysed samples and the groups identified in the so-called greyware triangle, a ternary chart indicating the percentages of SiO_2, Al_2O_3 and CaO-MgO-Fe_2O_3, normalized at 100% in its endpoints (Illustration 4a), it can be perceived how the greyware from Sant Miquel de la Vall is located at the edge between the quartz-anortite-wollastonite and quartz-anortite-mullite termodynamic balance triangles. These triangles correspond to calcarian greyware and non-calcareous greyware respectively. This situation is basically due to the high presence of Fe_2O_3 in some samples, likely to act as a flow, and also to the relatively high presence of CaO in some cases, which strongly points at the pastes of SMV1a02 and SMVa06 being calcarian.

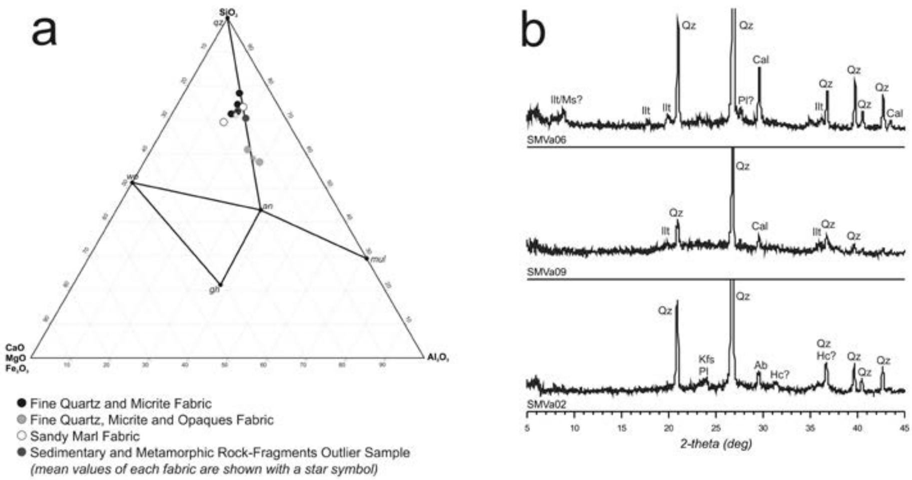

Illustration 4. Charts representing main technological traits in the analysed sample: ternary chart of the greyware triangle ($CaO + MgO + Fe_2O_3$) – Al_2O_3 – SiO_2, an: anortite ($Ca[Al_2Si_2O_8]$), gh: gehlenite ($Ca_2Al[Si,Al]_2O_7$), mu: mullite ($Al_6[Si_2O_{13}]$), qz: quartz (SiO_2) and wo: wollastonite ($CaSiO_3$) (a) and diffractograms of the three samples analysed through XRD (b).

The results obtained from the XRD for samples SMVa02 SMVa09 and SMVa06 belonging to groups 1, 2 and 3 respectively make it possible to determine a low firing temperature for groups 2 and 3, whereas the greyware belonging to the fine quartz and micrite fabric would have probably experienced higher firing temperatures (Illustration 4b). Samples SMVa06 and SMVa09 certainly present the mineral phase of calcite in primary form, as can be clearly perceived from microscopic observation. Thus, it is possible to estimate a firing temperature that could have not been higher than 750-800ºC. Nevertheless, sample SMVa02 does not present this mineral phase and seems to present some hercinite peaks. Hercinite is a mineral steadily developed in reducing atmospheres higher than 900ºC.

4. Discussion of results: local and imported products

The comparison of the materials from Sant Miquel de la Vall to the geologic map of the area (Illustration 5) does not suggest the non-local origin of the analysed greyware. However, the lack of clay samples and reference materials from some kiln-sites known in the area, such as the greyware pottery kiln in Abella de la Conca[20] makes it difficult to determine beyond doubt the origin of the described groups. Indeed, the site of Sant Miquel de la Vall is placed on a conglomerate, clay and sandstone outcrop north of the Serra de Montsec (Illustration 5). North of this sandstone zone, there are a series of calcareous outcrops east of the Lake Sant Antoni, spreading to Organyà, Coll de Nargó, and the surroundings of Port del Comte. The presence of the kiln in Abella on these formations might suggest a relation with some of the identified fabrics –probably the first one.

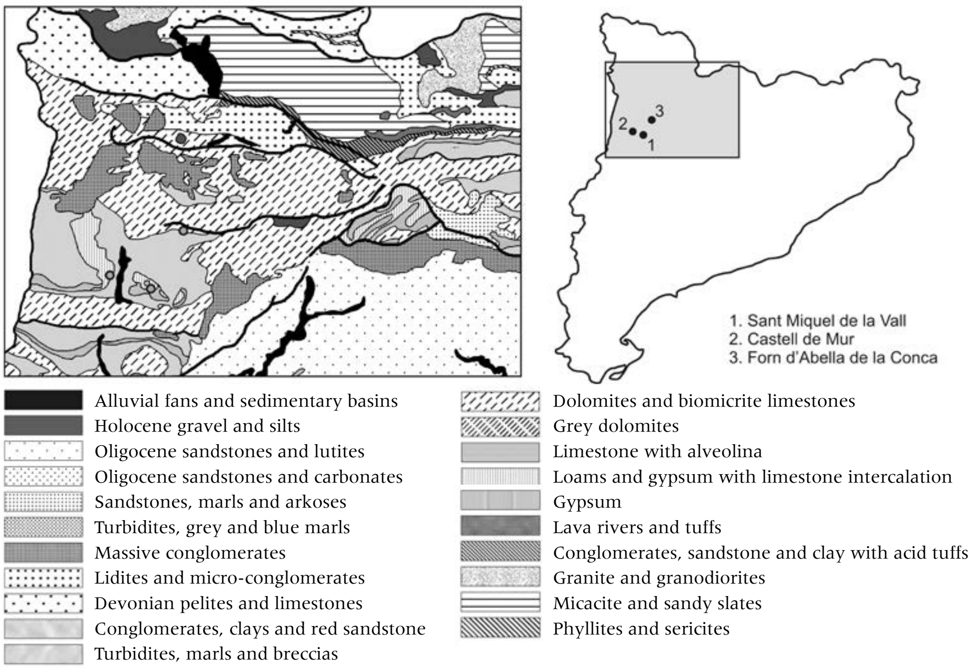

Illustration 5. Geological map of the area of Sant Miquel de la Vall.

20. Riu, Manuel. "Talleres y hornos alfareros de cerámica gris en Cataluña", *Fours de Poitiers et testares Médiévaux en Méditerranée Occidentale*. Madrid: Publicaciones de la Casa de Velázquez, 1990: 105-115.

In order to throw light on this question as far as possible, and to determine the local or external origin of the fabrics of Sant Miquel de la Vall, the obtained results were compared to the data of archaeometrical characterization, from a wide collection of coetaneous greyware samples from all over Catalonia.[21] In this new group, we were able to check that fabric 1 presents significant similarities with the greyware from other areas of Catalonia, whereas fabrics 2 and 3 find parallels in two groups of greyware retrieved in the churches of Sant Feliu de Girona (Gironès) and Sant Miquel de Veciana (Anoia) respectively. The similarity between the fine quartz, calcite and opaques fabric (Illustration 6a-d) and sandy marl fabric (Illustration 6e-f) and the fabrics of the same name in distant areas is evident from the petrographic point of view, particularly in the first case, and also reasonable from the compositional point of view (Illustration 7).

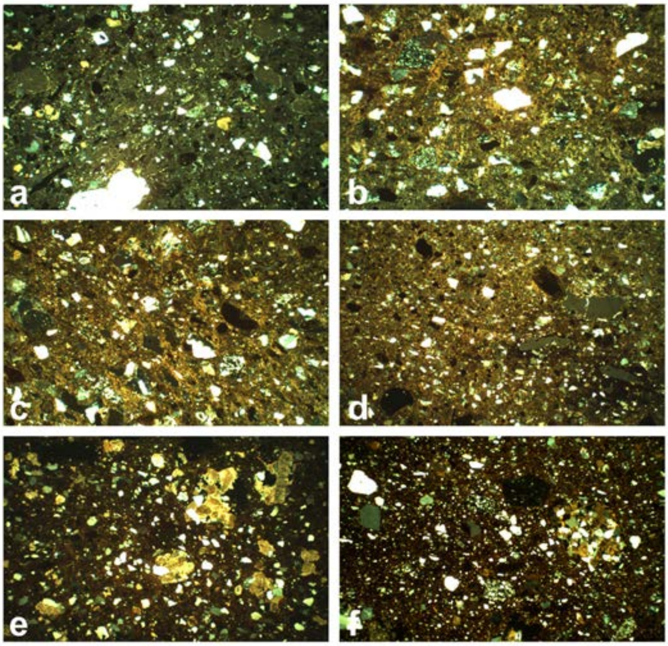

Illustration 6. Microphotographs from samples SMVa01 (a), SFG09 (b), SFG10 (c), SFG05 (d), SMVa03 (e) and SMVa08 (f), where the similarity between the samples from Sant Miquel de la Vall and the reference sites can be perceived for the fine quartz, calcite and opaques fabric (a-d) and the sandy marl fabric (e-f). Microphotographs taken at 25x in crossed polars. Field of vision: 6mm wide.

21. Travé, Esther; López, María Dolores; Álvaro, Karen. "Estrategias de producción y distribución de cerámicas grises medievales en el Nordeste Peninsular: caracterización arqueométrica de los materiales de Caulers y Sant Feliu de Girona". *Munibe. Antropologia-Arkeologia*, 64 (2013): 199-217; Travé, Esther; Ollich, Imma; Rocafiguera, Montserrat de. "Les terrisseries i la producció d'atuells de cuina a Osona en època medieval: Caracterització química i petrogràfica d'un conjunt de ceràmica grisa de l'Esquerda". *Ausa*, 172 (2013): 259-285; Travé, Esther; López, María Dolores; Álvaro, Karen. "Circuitos de distribución de cerámica culinaria...": 125-153.

In order to establish a much more detailed comparison, samples from these fabrics found in Girona and Veciana were selected and analysed along with those from Sant Miquel de la Vall. In this case, the total variation presents a lower value (tv = 1.3314), which is explained by the incorporation to the dataset of a series of samples very similar in theory to some of the samples from Sant Miquel de la Vall, so that it is easy to suggest a relation between them.

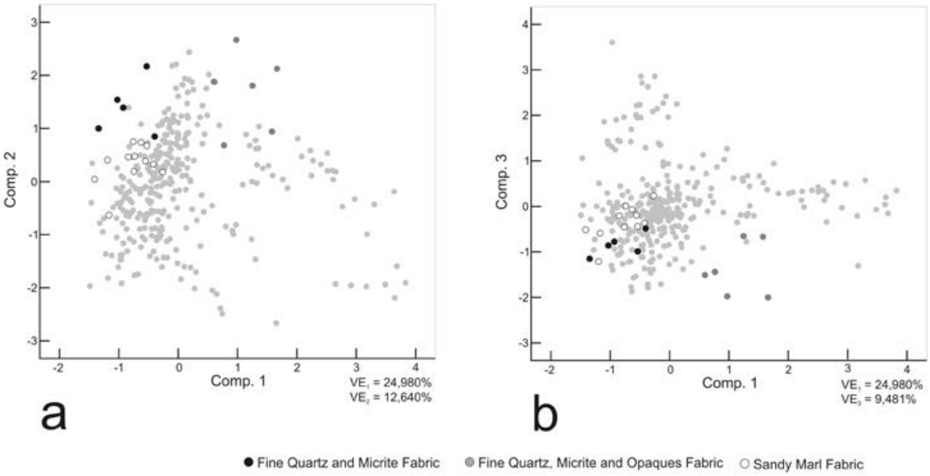

Illustration 7. Identification of the fine quartz and micrite fabric; fine quartz, calcite and opaques fabric and the sandy marl fabric retrieved from Sant Miquel de la Vall, Sant Feliu de Girona and Sant Miquel de Veciana on the charts corresponding to a general PCA including all the samples in the project taken as reference according to components 1 and 2 (a), and 1 and 3 (b).

Both the new PCA and HCA (Illustration 8) carried out on this group as a comparison regarding the concentrations of certain elements in the shape of a dispersion matrix allow as to perceive how the samples in fabric 2 present a higher similarity with each other independently of the origin site, whereas the sandy marl fabric presents some discrepancies between the group from Sant Miquel de la Vall and the samples from Veciana. The detailed analysis of the fine quartz, opaques and micrite fabric in relation to the greyware retrieved in Girona corroborates the relationship between the samples. For this reason, it seems accurate to regard them as belonging to the same fabric, whose place of production is still unknown, although it could be hypothetically located in some area in the Pyrenees, rich in biomicritic limestone, and quite far from the city of Girona.

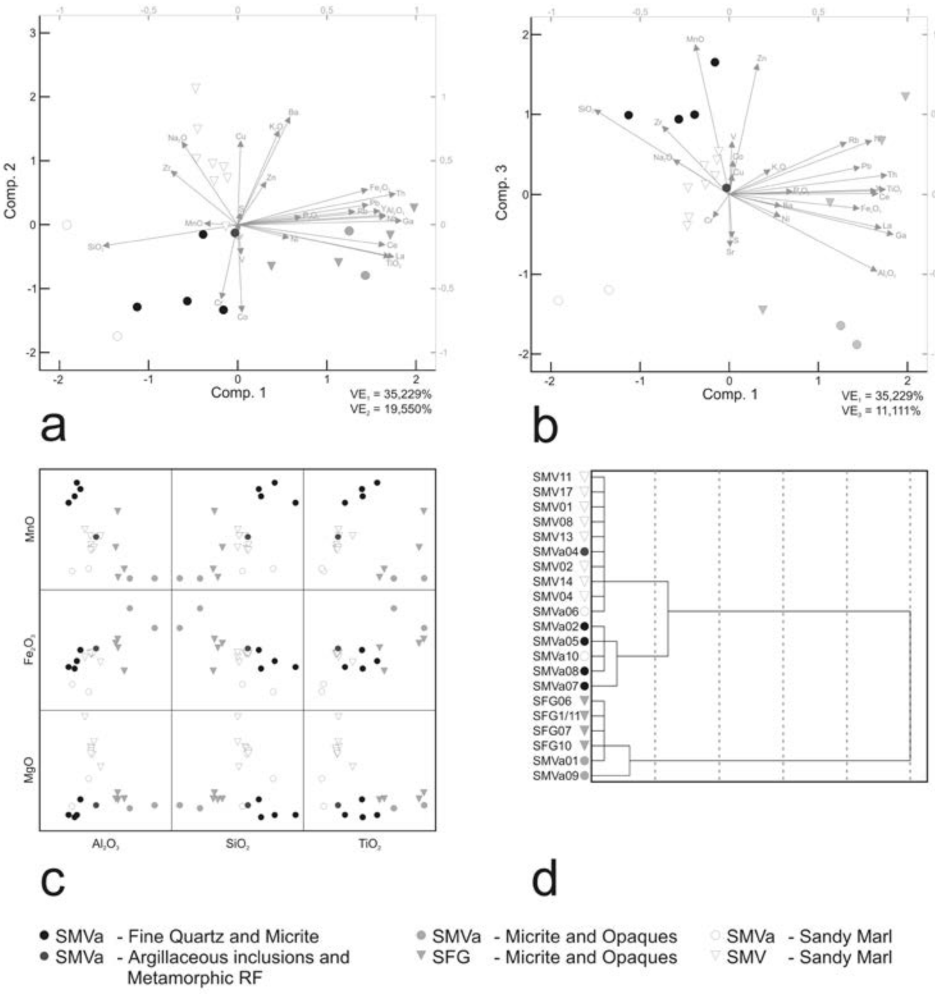

Illustration 8. Charts of exploitation of the samples from Sant Miquel de la Vall along with the equivalent fabrics retrieved from other sites and used as reference: scatter plot according to components 1 and 2 of the PCA carried out for sub-composition Na_2O, Al_2O_3, SiO_2, K_2O, TiO_2, Fe_2O_3, P_2O_5, MnO, S, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Pb and Th with logarithmic transformation (a); scatter plot according to components 1 and 3 of the same PCA (b); dispersion matrix according to elements Al_2O_3, TiO_2 and SiO_2 on the x-axis and MgO, Fe_2O_3 and MnO on the y-axis; and dendrogram resulting from the hierarchical cluster analysis for the same sub-composition using Ward's linkage (d).

The particular nature of the sandy marl inclusions characteristically found in group 3 and their petrographic similarity with the greyware from Anoia make us cautiously think of a possible relation between these samples and the limestone-rich area within the triangle delimited by the towns of Veciana, Tàrrega and Cervera, including the town of Verdú. The relation between the fabrics detected in Sant Miquel de la Vall and the samples retrieved in other far more distant areas could point to the theory above mentioned, according to which the productions might be external in relation to the immediate local area surrounding Sant Miquel de la Vall. In any case, the clearly differentiate nature of the identified productions in this site in the area of Pallars must necessarily start a reflection about the traditionally considered 'local' productions, as far as the study of utilitarian cooking wares fired under reducing atmosphere in medieval times is concerned.

In fact, it is necessary to apply diverse criteria in the definition of local and external. The abundance or scarcity of different groups in a given territory, the stylistic factor and the possibility of documenting production centres in the surrounding area must be necessarily taken into account along with the compositional traits in the pastes. Indeed, the idea of a large site that might have been receiving products from several productive centres instead of producing them itself is not new in the field of utilitarian wares. Recent research on ceramic vessels from the Andes, for example, reveal this paradigm[22]. In our case, the products from Sant Miquel de la Vall, seemingly related to greyware located more than 100km away, open a new perspective to interpret the dynamics of production and distribution of this type of pottery products in Catalonia, and reinforce the idea of an intra- and supra-regional range of distribution of pottery products, which had been suggested in previous works.[23]

In that sense, it seems accurate to claim that the basins of rivers Llobregat, Segre and Ter played a remarkable role in the circulation and exchange of products, goods and ideas along these supra-regional distribution circuits, as proved by the circulation of products along the rivers Ter and Onyar in the area of Girona, or the distribution of the products of Casampons and Cabrera d'Anoia along the Llobregat. Indeed, in the case examined here, it is relevant to remark the role of the river Segre as an axis of circulation of products. The route along the Pyrenees traced by the flows of the rivers Segre and Ter could have been a remarkable connection of these Pyrenean circuits, making it possible to distribute pottery whose exact origin is unknown but seems genuine from the north of Catalonia, supplying both the area of Pallars and the area of Girona. On the other hand, the Segre, in its flow southwards, links the Pyrenean area with the plains of Lleida and central Catalonia, so that it could have been a usual distribution space for the products in this area.

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22. Druc, Isabelle. "What is local? Looking at ceramic production in the Peruvian Highlands and Beyond". *Journal of Anthropological Research*, 69 (2013): 485-513.

23. See also: Esther; López, María Dolores; Álvaro, Karen. "Estrategias de producción y distribución de cerámicas grises...": 199-217; Travé, Esther; López, María Dolores; Álvaro, Karen. "Circuitos de distribución de cerámica culinaria...": 125-153.

5. Conclusions

It is difficult to determine the place of production of utilitarian pottery with precision, due to the lack of characterization of the production centres of reference in great part of Catalonia. However, the multiplicity of factors intervening in provenance determination and the creation of a new wide inventory of greyware offer significant elements of comparison between the different detected productions in quite a vast territory –within a period comprised between 11th and 12th century, and make it possible to detect interrelations. Moreover, the highly diverse geology found in Catalonia is advantageous to this kind of approach.

The petrographic, chemical and mineral characterization of the samples from Sant Miquel de la Vall which has been presented in this paper provides significant insights as to the distribution of greyware in Catalonia. Moreover, it makes it possible to doubt, or at least to add significant nuances, to the generally accepted belief according to which the production of utilitarian cooking wares fired under reducing atmosphere is restricted to local centres with a limited regional impact.

The apparent relation between two of the three provenance groups detected at Sant Miquel de la Vall and some other products which, although not in vast majority, have been found significantly in the areas of Anoia and Girona respectively point to the strong possibility of the external provenance of these groups from the area of the Western Pyrennes. The evidence of petrographic traits which do not seem intrinsically relatable to the geology of Pallars reinforces this idea. Therefore, the analysis brings to the foreground the existence of an exchange circuit beyond the traditionally considered regional circles, and describes a scenario of relationships between different places in the Pyrenees and between the Pyrenees and the plains. Watercourses, particularly the rivers Segre, Ter and Llobregat, would have played a remarkable role in these circuits.

The sample characterized in Sant Miquel de la Vall is highly heterogeneous in spite of being formed by a small number of items. The comparison of this sample with the materials used as reference makes it possible to detect tendencies reinforcing the idea of wide exchange circles. However, as regards production technology, the materials in Sant Miquel de la Vall are similar to the usual appearance of medieval greyware pottery in general, and they answer to production processes widely spread across a vast territory, consisting of a simple preparation of pastes out of originally coarse clays which do not undergo systematic specific treatment. Consequently, it seems that the existence of widely shared manufacturing techniques and local and regional production circles, exercising more or less impact on the territory according to the dimensions and production capacity of the different workshops, does not prevent the existence of communication and exchange between remoter areas, beyond the immediate regional circles.