Sampling strategies via statistical exploitation of morphometric data: Maximizing the assets of petrographic examination for a chronological review at the medieval town of Martorell (Barcelona, Spain)

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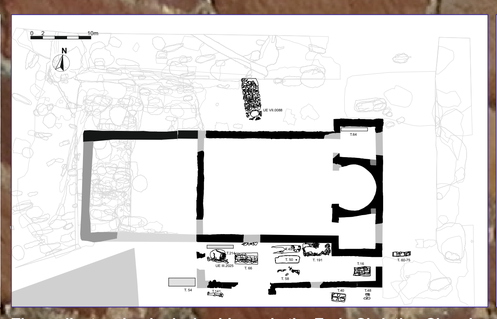
Introduction

The archaeological site of Santa Margarida (Martorell, Barcelona) is placed close to the ancient Via Augusta. The most ancient archaeological evidence is an Early Christian church with tripartite apse and its extensive necropolis. During the period between the 6th to the 12th Centuries this site experienced a great transformation in accordance to the surrounding landscape articulation, the origin of the medieval village of Martorell and the refurbishment of the church, transformed into a Romanesque building (Navarro & Mauri 1993, 1997, Travé *et al.* 2019). Medieval greyware is the most abundant finding at the site. A morphometric and petrographic study has been carried out recently. Greyware potsherds of four selected silos from different chronological horizons were sampled according to their morphometric characterization and examined via optical microscopy. Statistical exploitation of vessel shape compared to macroscopic paste examination led to a more precise sampling that has enabled us to interpret more accurately the chronological transformations of pottery at this site and the changing paste recipes. The success of this approach is related to the methodological improvements in terms of sampling strategies. The definition of paste macrogroups and stylistical or typological classification via morphometric shape analysis was key to stablish accurate reseach hypotheses. Database completion and exploitation has contributed significantly to easening and fastening sampling procedure. This piece of research aims at introducing this protocol and proving its validity.

Top view of trench 12 and silos selected for pottery analysis. (Picture made at 15 m high with drone assistance.)

Site and materials

Site location. Santa Margarida and Sant Genís de Rocafort are two close archaeological sites; Santa Margarida is at the Via Augusta and Sant Genís -founded in 1042 AD- is located on the top of a hill nearby.



The earliest archaeological evidence is the Early Christian Church, with a southern portico and probably a baptistery at the west. Early Christian necropolis occupied the south area and especially the portico.

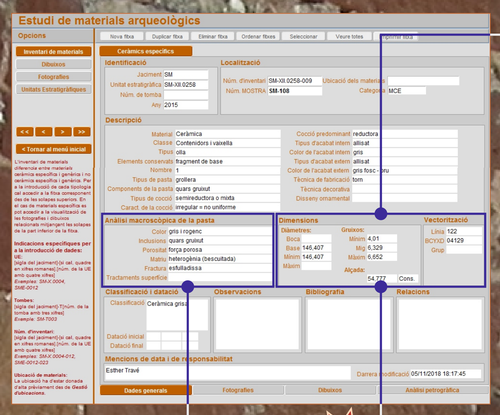
The ancient building was partially demolished and rebuilt as a Romanesque church *(see above)* after deep refurbishements during the early middle ages. A larger necropolis was formed during the medieval period and the surrounding area turned into a *sacraria*, where peasants found protection against feudal violence. A great number of silos from this period have been discovered, and four of them *(highlighted in red)* have been sampled in this study.

Research methods and sampling procedure

Individual pottery sherd register on database screen *(right)*. Gathered data for each sherd include information related to its context, storage location, description, general classification, and authorship.

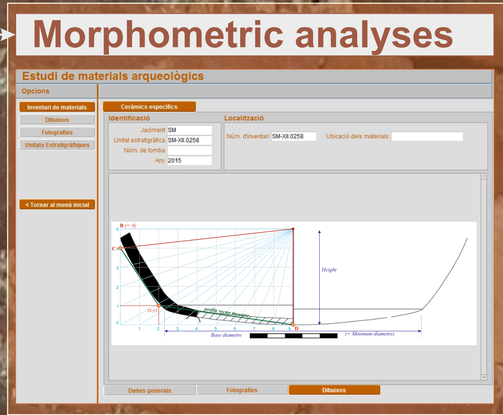
MACROSCOPIC PASTE ANALYSIS includes macroscopic examination of colour, inclusions, voids, matrix, fracture and surface treatment.

MORPHOMETRIC DATA are also considered. Amongst these, rim, base, maximum and minimum diametres, wall thickness, height, and profile vector are measured.



Individual petrographic sherd register on database screen *(top)*.

Morphometric analyses



Summary table of the main morphometric characteristics of 20 individuals selected for OM thin-section analysis *(below)*

Petro ID	Sample	Type	Sherd	Rim/Base D	Min/Max D	Min Thick	Med Thick	Max Thick	Height	Style
SM-107	SM-XII.0258-001	olla	base	123,288	123,288	7,300	7,300	7,300	40,190	122 4129
SM-108	SM-XII.0258-009	olla	base	146,407	146,407	4,010	6,329	6,652	54,777	122 4129
SM-116	SM-XII.0258-021	cover-lid	rim	191,391	198,010	6,313	8,346	10,378	18,203	122 1009
SM-117	SM-XII.0258-023	washbasin	rim	380,194	380,194	8,628	10,687	12,746	24,526	122 49323
SM-120	SM-XII.0258-029	olla	base	198,632	198,632	4,346	8,112	8,112	38,047	122 3119
SM-118	SM-XII.0258-031	olla	base	118,321	118,321	5,517	6,096	7,705	26,939	122 3129
SM-119	SM-XII.0258-032	olla	rim	115,789	102,019	7,231	7,914	8,597	25,886	125 433
SM-121	SM-XII.0258-033	washbasin	rim	325,980	325,980	6,729	7,122	13,693	73,048	122 19346
SM-122	SM-XII.0258-034	olla	base	92,427	92,427	3,517	5,461	7,673	18,872	122 2119
SM-131	SM-XII.0369-025	olla	rim	87,110	77,211	5,354	6,052	6,663	43,321	126 70790
SM-132	SM-XII.0369-025	olla	rim	87,110	77,210	5,354	6,051	6,663	43,321	126 70790
SM-133	SM-XII.0369-026	olla	base	163,726	163,726	4,800	5,657	7,689	35,091	122 3029
SM-134	SM-XII.0369-026	olla	base	163,726	163,726	4,800	5,657	7,689	35,091	122 3029
SM-135	SM-XII.0369-027	olla	base	149,410	149,410	4,957	5,291	5,624	21,880	122 2119
SM-164	SM-XII.0421-001	indetermined	base	105,138	150,771	4,539	6,393	8,849	143,413	121 36025
SM-165	SM-XII.0421-002	indetermined	rim	132,293	119,605	3,791	5,093	6,395	22,790	125 433
SM-138	SM-XII.0452-008	kitchen mortar	base	177,054	177,054	6,536	8,248	22,632	39,528	122 3029
SM-157	SM-XII.0452-015	kitchen mortar	base	110,450	159,201	5,200	4,475	9,260	94,477	122 19213
SM-148	SM-XII.0452-019	olla	rim	142,924	124,282	4,423	5,492	7,955	34,843	124 730
SM-152	SM-XII.0452-051	olla	base	112,476	157,301	4,912	4,997	9,146	116,163	121 35027

Drawing of sample SM-108 *(left)*, seen on the database screen. Scheme of main morphometric parametres analysed are indicated. Wall thickness is also considered.

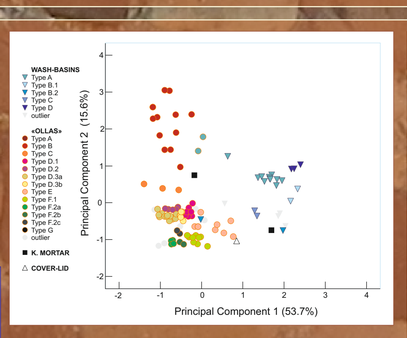
Morphometric approach considering rim or base and minimum or maximum diametres, wall thickness, height and profile (Travé 2009, Vicens & Travé 2018) allowed us to determine more precisely specific vessel shape.

Profile measurement turned into a five-digit number and determined by means of a template (Llanos & Vegas 1974, Travé 2009) is really useful to determine type and degree of breakage.

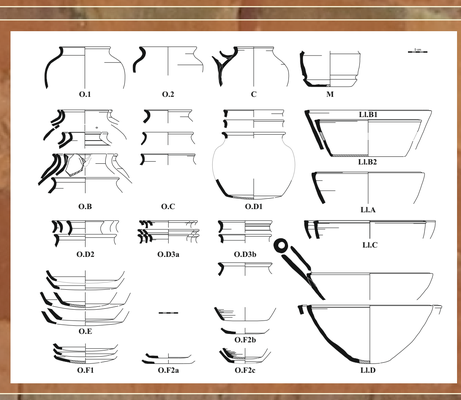
Typology and style

Pictures of boiling pots or «ollas» sampled at Santa Margarida *(left)*. They belong to paste macrogroups 1 *(left)* and 2 *(right)*.

PCA result of statistical exploitation of morphometric data *(right)*. Samples are coloured according to vessel type.



Pottery Classification of Santa Margarida's greyware *(right)*.



Morphometric examination through statistical data exploitation allowed us to identify several types of boiling-pots and wash-basins; amongst these, wash-basin type LI.D, which might be interpreted as an alembic receptacle (Armengol & Lerma 2012).

Combined sampling according to typological classification of vessel shape defined through statistical exploitation of morphometric data and paste macrogroups leads to a more precise selection and maximizes the assets of archaeometric approach.

This study includes 955 coarse greyware pottery sherds found at silos *222*, *453*, *404* and *272*. 120 samples were rims or bases from boiling pots *«ollae»* and wash-basins mainly. According to macroscopic and morphometric results described above, 60 samples representing the entire assemblage were thin-sectioned and grouped according to the nature of inclusions, matrix and voids (Quinn, 2013) and compared to reference material.

Paste Macrogroups

MG-B: Finer pastes, with abundant -but very fine- inclusions. There are some quartz inclusions, but they are difficult to identify. Firing atmosphere is variable: with greyish surfaces and grey or brownish matrix *(right)*.

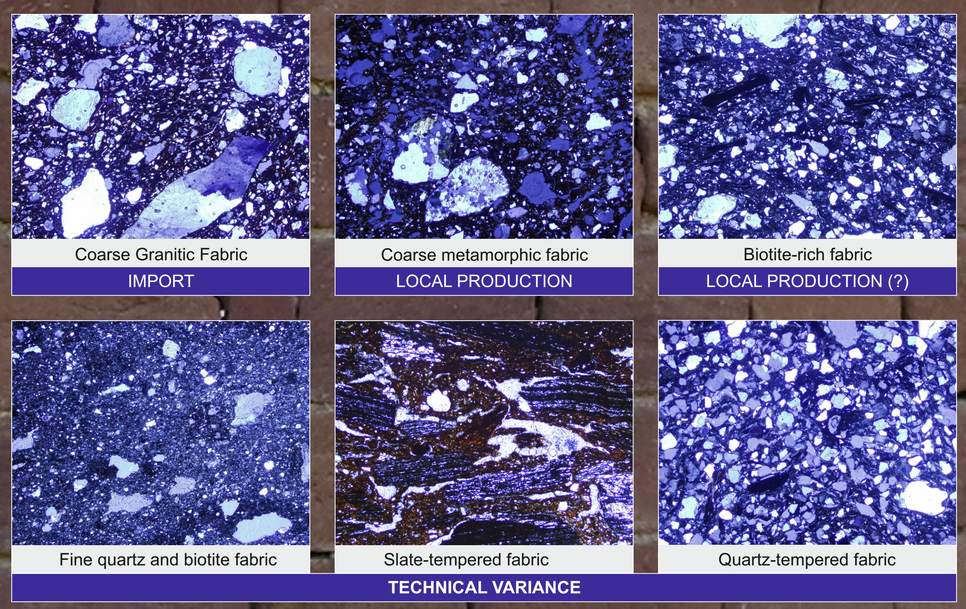
MG-A: Coarse or very coarse paste, with visible quartz inclusions (> 1 mm), rough surface and some pores *(left)*.
There are two different variants:

***MG-A1**: Grey or black surfaces and redder, more oxidized paste, brownish to reddish matrices* (left).
***MG-A2**: Grey or black surfaces and also grey, uniform matrices. Some mica inclusions can occur* (right).

MG-C: Very fine pastes, occasionally with rare inclusions; they were fired under reducing atmosphere, and exhibit pale whitish surfaces and matrices *(top)*.

MG-D: Very coarse slate-tempered pastes. Slate inclusions are 3-4 mm wide.
Both surfaces and matrix are greyish brown or dark brown *(top)*.

Results



Photomicrographs of selected fabrics detected within the 60 Santa Margarida's Medieval greyware pottery sherds analysed in this study. All images captured in crossed polars. Image width = 4 mm

According to reference materials and previous studies of pottery found at the medieval town of Martorell (Travé *et al.* 2017, Travé 2018), pottery was produced locally. Most samples (80%) were included within a Coarse Metamorphic Fabric with numerous mica-rich and Quarz-&-Feldspar inclusions probably related to a coarse schist.

Few samples (20%), were related to the close kiln site of Cabrera d'Anoia (Travé 2018). The present study confirms this provenance and distribution: 70% of them belong to the Coarse Granitic (7%) or Coarse Metamorphic (63%) fabrics. Metamorphic fabrics show coarser or finer versions of the same paste recipe.

Some new fabrics have been identified. Amongst these, the Biotite-Rich Fabric (12%) exhibits Inclusions of Quartz and Biotite (<1 mm), probably included naturally in the clay. While biotite is a common mineral found in Santa Margarida's environment, the features of this fabric, compared to the local products, suggest a non-local (though regional) provenance of these vessels.

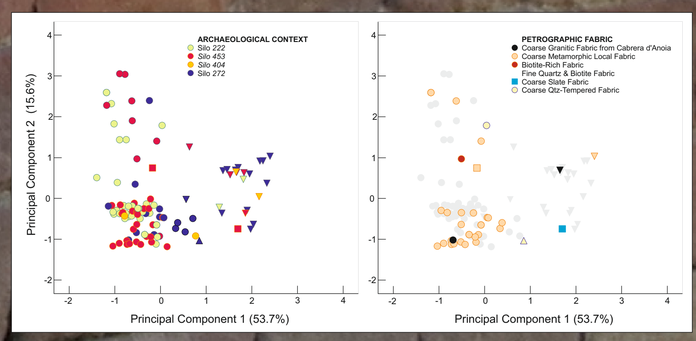
Other variants introduce technological variation within the local and non-local products. Fine Quartz & Biotite Fabric (3%) contains fewer and finer inclusions of quartz and biotite. It probably was a finer version of the previous fabric.

A Coarse Slate Fabric (5%) exhibits very coarse (4-5 mm) inclusions of slate, clearly added as temper. Similar products were found near the Monastery of Sant Genís. These show strong similarities with Late Bronze Age productions in the area, which suggests the existence of a settlement nearby and the accidental occurrence of such pots within the abandonment fillings of medieval silos. Finally, a Coarse Quartz-Tempered Fabric (10%) contains the same range of inclusions as the local metamorphic fabric, and it looks like a quartz tempered version of this.

Discussion

Silos 272 and 404 were filled with more recent deposits (c. 12th -13th Centuries) while 222 and 453 are from an earlier period (8th – 9th Centuries). The first impression arising from data comparison is that technological and typological changes have chronological and functional significance: ancient deposits contained mainly *ollae* while most of individuals in silo 272 are basins. Both local products and imported vessels from Cabrera d'Anoia lasted for most of the medieval period at the site, while biotite-rich samples, mainly in silo 222, suggests the existence of an ancient production abandoned at some point within the site's transformation. Further analysis of these changes will increase the knowledge about greywares transformation and endurance, as explored in some other areas nearby (Travé & Vicens 2018).

In our opinion, as explored and discussed in previous works (Travé 2009, Travé *et al.* 2018, 2019, Vicens & Travé 2018), profile measurement is a key element in order to classify vessels typologically, and sampling strategies should include these types, together with paste macrogroups in proportional selection of samples.



PCA result of statistical exploitation of morphometric data. Samples are coloured according to their archaeological context *(left)*, and petrographic fabric *(right)*.

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