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# Assessing petrographic variability and regional connections in Medieval and Modern Catalonian Greyware Pottery: Insights from geochemical analysis

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ABSTRACT

Greyware pottery, commonly found in most archaeological contexts in medieval Catalonia (northwestern Spain), reflects a long-standing tradition of ceramic production that has continually adapted to social and economic transformations. Originating in the late Roman period, this tradition has persisted into the present day, surviving in the form of artisanal and traditional wares. This study explores regional connections in medieval and modern greyware pottery production and distribution areas in Catalonia through petrographic examination and geochemical analysis. A dataset of 74 samples was selected for wavelength dispersive X-ray fluorescence (WD-XRF) analysis from an extensive assemblage previously examined via thin-section petrography. The primary objectives were to determine the geochemical composition of the samples, test de validity of the petrographic groups, and ultimately to examine how these two sources of information (petrography and chemistry) converge to reinforce the group definitions or diverge to reveal new dimensions of variability. At the same time, regional connections were explored, particularly regarding fabrics found in the area of Les Gavarres. Significant correlations between geochemical compositions and petrographic classifications further reinforces the validity of the previously defined petrographic groups. The findings reveal regional patterns, suggesting connections between the eastern region and other consumption centres in coastal and central Catalonia, providing new insights for studying technological practices and cultural transfer, and enhancing our understanding of utilitarian greyware pottery production and distribution dynamics over the centuries.

## 1. Introduction

Cooking pots fired under a reducing atmosphere are among the most common vessels found in archaeological contexts in medieval Catalonia (northwestern Spain). This so-called greyware pottery (Brogiolo and Gelichi, 1986, Padilla, 1984) reflects a longstanding tradition of production that adapted to social and economic transformations, enduring from Late Antiquity (Riutort et al., 2018, Buxeda and Cau, 2005, Riutort et al., 2020, 2022, Travé et al., 2024a) until today in the form of artisanal and traditional products. These vessels, characterized by very coarse fabrics and rough surfaces, became the most prevalent class of pottery in medieval Catalonia and other regions of the northern Iberian Peninsula and the northwestern Mediterranean coast (Bohigas and Gutiérrez, 1989, Bonhoure and Marchesi, 1993, Milanese, 2007). This continuity persisted beyond the Middle Ages, even as the widespread adoption of lead-glazed vessels for cooking purposes in the late 14th century marked a significant transformation in the shapes and functions of greyware pottery. By the Modern Era, greyware vessels were rarely used for cooking, and boiling pots and pans progressively disappeared from the archaeological record. However, a considerable variety of new forms emerged for specialized purposes, allowing greyware pottery to reemerge in a deeply transformed state, achieving wide distribution between the 17th and 19th centuries (Travé et al., 2023). While the term 'greyware' is used here as a broad classificatory label, it encompasses a

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range of technological and morphological changes over time. Its application reflects both historical continuity in certain firing practices and surface treatments, and the evolving character of production traditions, which we further explore in the analysis below.

As part of an ongoing research project, we sought to investigate the changes in provenance and technology that occurred during these transitional periods. These include the evolution of late antique coarse wares into the medieval common forms and fabrics, as well as the late medieval transformations driven by the widespread use of glazes in common wares that prompted greyware to adapt. This shift addressed a crisis in use and demand, leading to the creation of new shapes and functions to ensure its survival. In the early modern period, societal and economic changes not only transformed vessels but also reshaped the entire production system. Many large and specialized medieval production centres disappeared, replaced by smaller workshops that initially had limited impact but later became key nodes in greyware production networks. This transition is evident in eastern Catalonia, where the sites of Quart and La Bisbal d'Empordà (Fig. 1a) emerged as significant production villages during the Modern Era, as confirmed by both written and material evidence, while most medieval and late medieval workshops throughout Catalonia ceased their activity.

Our study combines petrographic examination of samples with chemical characterization via wavelength dispersive X-ray fluorescence (WD-XRF) to investigate the phenomena of endurance and transformation, particularly during periods traditionally regarded as transitional. To explore these trends, we sampled contexts dating from the 7th to 9th centuries and the 16th century onwards. Given the coarse or very coarse nature of most pastes used in greyware manufacture, ceramic petrography is a cost-effective and widely used technique for studying such materials. Over the past five years, we have analysed more than 400 thin sections of early medieval, late medieval, and modern greyware pottery from Catalonia. The distinctive nature of inclusions and the general aspects of the fabric observed in many samples enabled us to identify more than fifty distinct compositional groups that correspond to the products of different workshops. Catalonia's rich geological diversity allowed us to confidently attribute many of these fabrics to specific production centres, and in cases where precise attribution was not possible, we could at least estimate broader production areas.

Nevertheless, the homogeneity of fabrics and the generally widespread potting traditions made chemical characterization a critical tool for further validating the distinction criteria of less-defined fabrics and for more confidently assessing the provenance of groups found far from their presumed places of origin. In this paper, we present the results of this combined approach and discuss them considering the regional patterns and connections identified. Furthermore, we propose the validity of a research strategy that combines the study of large assemblages via thin-section petrography with complimentary analytical techniques, to refine sampling and enhance the accuracy of provenance studies.

## 2. Materials and methods

Out of a larger assemblage (Travé et al., 2021) previously examined using thin-section petrography (n = 291), 74 samples were selected for chemical characterisation by wavelength dispersive X-ray fluorescence (WD-XRF) analysis. Samples included in this study were found in archaeological contexts at the rural sites of L'Esquerda (Roda de Ter) (n = 10) and Santa Margarida (Martorell) (n = 10), the medieval monasteries of Sant Pere de Grau d'Escales (Navès) (n = 10) and Sant Genís de Rocafort (Martorell) (n = 10), the urban settlement of La Foneria (Barcelona) (n = 10), and the fortified Tower of Campelles (Campelles) (n = 5). Additionally, a single sample from a traditional washbasin from a private collection in Torelló (n = 1) was included (Fig. 1a). Finally, some ceramic materials from casual finds and/or private collections stored at the former Pottery Museum of Quart (n = 18) provided the samples for the study of the northeastern area of Catalonia, in the mountains of Les Gavarres (Fig. 1b).

The chronology of the samples spans from the 7th to the 20th centuries (Table 1), allowing the exploration of diachronic changes and continuities in regional distribution patterns of greyware products in Catalonia. Contextual information and detailed descriptions of the ceramic assemblages from where the samples were collected are available in previously published literature for each case, with references provided in Table 1. Most of the samples of the earlier periods (7th-12th centuries) consist of slow-wheel-made cooking wares, typically produced using a combination of coil-building and wheel-throwing techniques. The wheel served as a support for coiling, with slow rotation

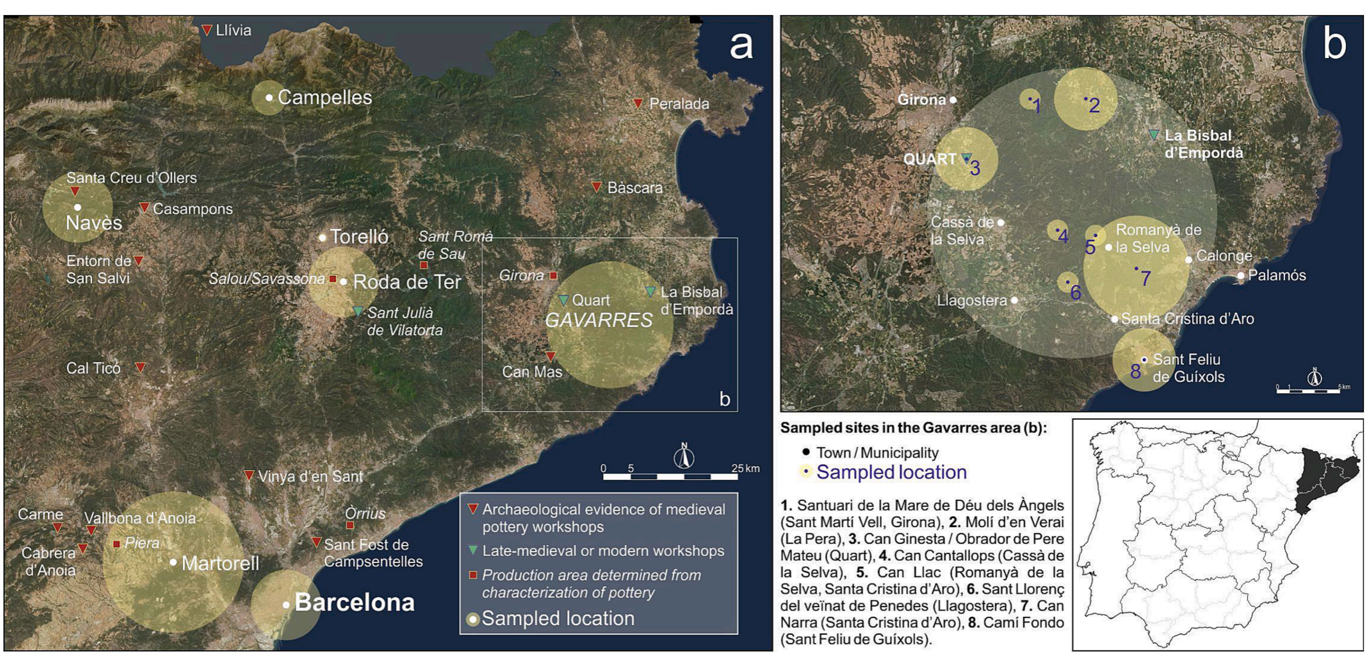


**Fig. 1.** Location map of sampled sites (a) and detail of the Les Gavarres area (b). The diameter of yellow circles is proportional to the number of samples collected at each location. Background aerial view of Catalonia retrieved from the Catalonian Cartographic and Geological Institute (ICGC. Institut Cartogràfic i Geològic de Catalunya). Scale: 1:25.000 (2.5 m/px).

**Table 1**
Summary table of the analysed samples in this study including their main archaeological information and previous published references.

| Sample | Archaeological label | Context | Site / Location | Town / Area | Vessel Type | Chronology | Pottery class | Published Reference(s) |
|---|---|---|---|---|---|---|---|---|
| GR004 | MTQ-D.01–011 | Surface material | Quart | GAVARRES | water jug | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR006 | MTQ-D.03–001 | Surface material | Quart | GAVARRES | basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR051 | PG-A4-0330 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR062 | PG-A5-0440 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR064 | PG-A5-0434 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR075 | PG-A6-0510 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR078 | E98-09003-sn1 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | boiling pot | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR081 | E02-09074-sn | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR089 | E02-09096–2859 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR091 | E02-09084–3157 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 9th century | Frankish Pottery | Travé et al., 2024a |
| GR105 | E08-08072–2087 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR106 | E08-08072–2091 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 9th century | Frankish Pottery | Travé et al., 2024a |
| GR109 | E08-08054–2218 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR113 | E08-08048–2634 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR117 | E08-08046-sn | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR133 | E09-08104–1570 | Archaeological excavation | L'Esquerda | Roda de Ter (Osona) | non-diagnostic | 7th-8th centuries | Early Medieval Greyware | Travé et al., 2024a |
| GR140 | CF-D.05–001 | Surface material | Sant Feliu de Guíxols | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR144 | CBat-D.04–001 | Private collection | Sant Feliu de Guíxols | GAVARRES | gardening plate | 20th century | Contemporary Greyware | Travé et al., 2023 |
| GR145 | CC15-2007-m2 | Archaeological excavation | Torre de Campelles | Campelles (Ripollès) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Pratdesaba & Travé, 2024 |
| GR146 | CC16-3001-m1 | Archaeological excavation | Torre de Campelles | Campelles (Ripollès) | wash basin | 14th-16th centuries | Late Medieval Greyware | Pratdesaba & Travé, 2024 |
| GR152 | CC17-3066-m2 | Archaeological excavation | Torre de Campelles | Campelles (Ripollès) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Pratdesaba & Travé, 2024 |
| GR157 | CC19-3112-m3 | Archaeological excavation | Torre de Campelles | Campelles (Ripollès) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Pratdesaba & Travé, 2024 |
| GR162 | CC19-3116-m1 | Archaeological excavation | Torre de Campelles | Campelles (Ripollès) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Pratdesaba & Travé, 2024 |
| GR169 | 69–99-0000–007 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR171 | 69–99-0364–002 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR176 | 69–99-0460–060 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR181 | 69–99-0465–020 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 15th-16th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR187 | 69–99-0503–565 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR188 | 69–99-0503–566 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR190 | 69–99-0503–569 | Archaeological excavation | La Foneria | Barcelona | water jug | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR195 | 69–99-0503–580 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR196 | 69–99-0503–582 | Archaeological excavation | La Foneria | Barcelona | non-diagnostic | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR203 | 69–99-1199–011 | Archaeological excavation | La Foneria | Barcelona | boiling pot | 16th-18th centuries | Modern Greyware | Travé & Álvaro, 2025 |
| GR272 | SGR.0228-m3 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR273 | SGR.0228-m3 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR280 | SM-XII.0550-m01 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |

(*continued on next page*)

**Table 1** (*continued*)

| Sample | Archaeological label | Context | Site / Location | Town / Area | Vessel Type | Chronology | Pottery class | Published Reference(s) |
|---|---|---|---|---|---|---|---|---|
| GR283 | SM-XII.0550-m04 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR284 | SM-XII.0550-m05 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR285 | SM-XII.0550-m06 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR287 | SM-XII.0550-m07 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR293 | SM-XII.0550-m13 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR294 | SM-XII.0550-m14 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR295 | SM-XII.0550-m15 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR298 | SM-XII.0550-m17 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR301 | SM-XII.0550-m19 | Archaeological excavation | Santa Margarida | Martorell (Baix Llobregat) | non-diagnostic | 9th-10th centuries | Early Medieval Greyware | Travé et al., 2024b |
| GR370 | MSF-D.07–001 | Surface material | Sant Feliu de Guíxols | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR374 | A-D.08–001 | Surface material | Sant Martí Vell | GAVARRES | lid | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR375 | MV-D.09–001 | Surface material | La Pera | GAVARRES | water jug | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR403 | MV-D.09–002 | Surface material | La Pera | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR404 | MV-D.09–002 | Surface material | La Pera | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR406 | T-D.14–001 | Private collection | Torelló (Osona) | Torelló (Osona) | wash basin | 20th century | Contemporary Greyware | unpublished |
| GR433 | CLl-D.17–001 | Surface material | Romanyà de la Selva | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR434 | CLP- 0D.18–001 | Surface material | Cassà de la Selva | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR435 | CN-D.16–001 | Surface material | Santa Cristina d'Aro | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR436 | CN-D.16–002 | Surface material | Santa Cristina d'Aro | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR438 | CN-D.16–005 | Surface material | Santa Cristina d'Aro | GAVARRES | wash basin | 20th century | Contemporary Greyware | Travé et al., 2023 |
| GR439 | CN-D.16–006 | Surface material | Santa Cristina d'Aro | GAVARRES | wash basin | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR445 | CN-D.16–011 | Surface material | Santa Cristina d'Aro | GAVARRES | non-diagnostic | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR446 | MTQ-D.19–001 | Surface material | Quart | GAVARRES | bunghole jar | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR450 | LP- 0D.21–001 | Surface material | Sant Llorenç de Penedes | GAVARRES | bee smoker | 17th-19th centuries | Modern Greyware | Travé et al., 2023 |
| GR901 | PG-A2-0257 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR902 | PG-A5-0430 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | non-diagnostic | 12th century | Medieval Greyware | Padilla, 1978 |
| GR903 | PG-A7-0480 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | boiling pot | 12th century | Medieval Greyware | Padilla, 1978 |
| GR904 | PG-A7-0483 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | boiling pot | 12th century | Medieval Greyware | Padilla, 1978 |
| GR905 | PG-A7-0539 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | boiling pot | 12th century | Medieval Greyware | Padilla, 1978 |
| GR906 | PG-A7-0554 | Archaeological excavation | Sant Pere de Graudescales | Navès (Berguedà) | boiling pot | 12th century | Medieval Greyware | Padilla, 1978 |
| GR907 | SGR.0223-m3 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR908 | SGR.0225-m2 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR909 | SGR.0225-m3 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR910 | SGR.0225-m4 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al. 2025 |
| GR911 | SGR.0225-m5 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR912 | SGR.0225-m7 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR913 | SGR.0225-m7 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |
| GR914 | SGR.0228-m1 | Archaeological excavation | Sant Genís de Rocafort | Martorell (Baix Llobregat) | non-diagnostic | 14th-16th centuries | Late Medieval Greyware | Travé et al., 2025 |

used at the final stages to achieve even vessel walls and surfaces. While most selected sherds from this period are non-diagnostic in typological terms, they were recovered from contexts where boiling pots were the predominant shape. In many cases, the curvature and thickness of the fragments allow us to identify vessel walls vessel walls with a globular tendency, which are characteristic of boiling pots, even in the absence of rims or bases. Indeed, boiling pots vessels are the only identifiable shape among these earlier samples.

From the 14th century onwards, the formal repertoire expands significantly. In addition to non-diagnostic sherds, wash basins or *cossis* —as they are called in Catalan— are the most prevalent forms found in the Les Gavarres area, along with water jars or *càntirs* and other less frequent vessels including basins, bee smokers, jars and lids. Exceptionally, a boiling pot from Barcelona is included within the repertoire of this later phase. Fast wheel-throwing is the predominant technique for vessel production in this period, except for wash basins, which had to be coil-built due to their size (Travé et al., 2023: 330). Boiling pots and non-diagnostic fragments are mostly undecorated, though a few exceptions exist. Decorated vessels from the earlier periods feature very simple linear incised designs, while later examples include more intricate combed or incised patterns, occasionally adorned with finger-pinched decorative coils attached to the wash basin walls (Fig. 2).

OM analysis was conducted using an Olympus BX51 polarizing microscope, equipped with an Olympus SC-50 digital camera, operating at magnifications between 20x and 100x. Visual grouping of thin sections, along with detailed descriptions of inclusions, clay matrix, and voids,

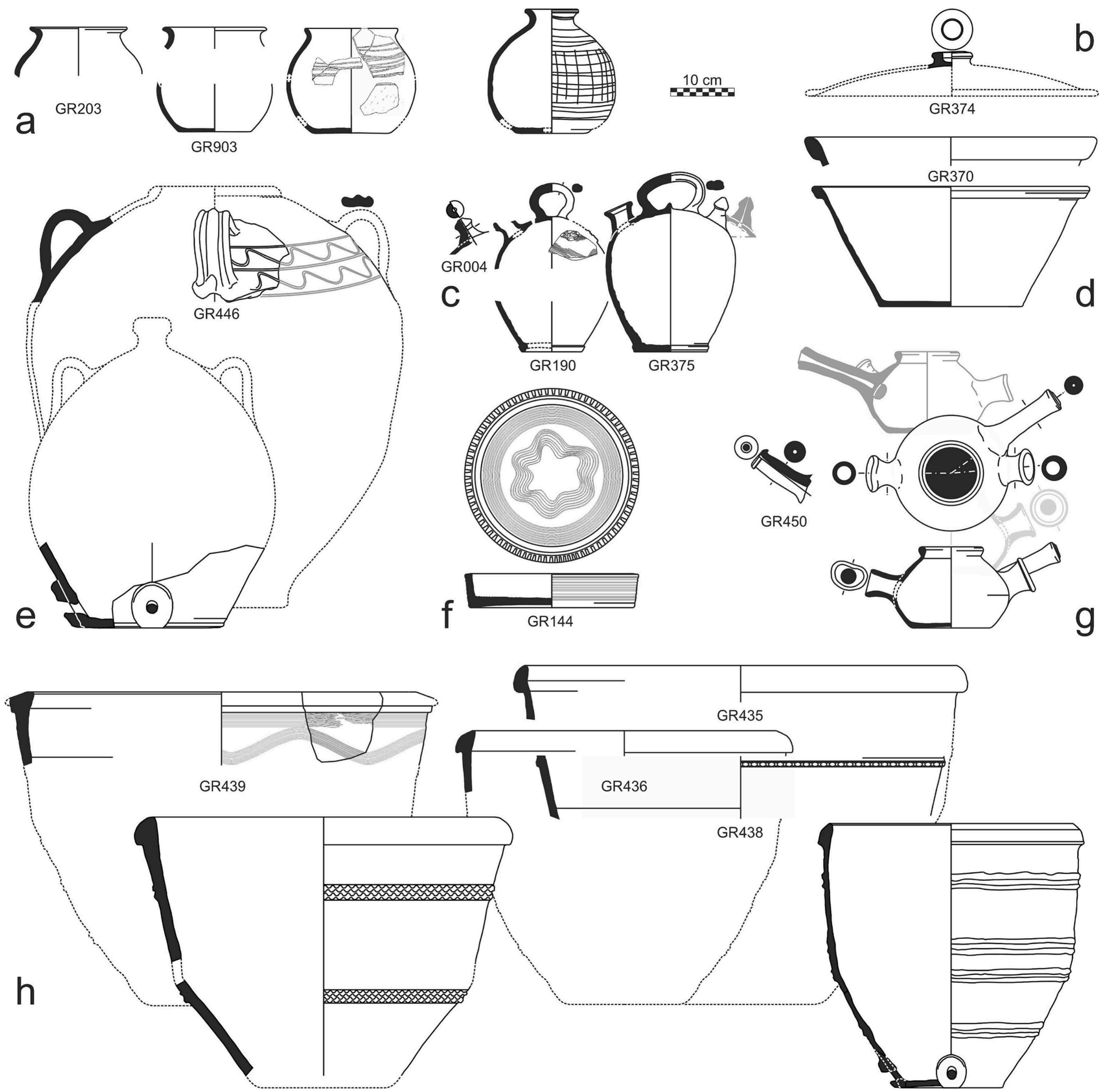


**Fig. 2.** Illustrations of the main repertoire of greyware pottery vessels from the sampled sites. Boiling pots (a) were the most common shapes in the Middle Age. Modern shapes from the 16th century include lids (b), water jugs (c), basins (d), jars (e), plant soucers (f), bee smokers (g) and large wash basins (h).

**Table 2**
Summary of the results of thin section petrographic analysis including for each OM Fabric, the total number of samples ($n_1$), the number of samples selected for WD-XRF ($n_2$), a brief description and the location where samples were found.

| OM Fabric | $n_1$ | $n_2$ | Main distinctive features | Location |
|---|---|---|---|---|
| **FINE CALCAREOUS FABRICS** | | | | |
| 54a Fine Calcareous Fabric | 3 | 2 | <5% inclusions, c. 90 % matrix, <5% voids Very few < 0.25-mm monocrystalline quartz inclusions within a pale brown calcareous matrix with moderate birefringence and patchy texture. | Barcelona |
| 54b Fine Calcareous Fabric with Quartz and Sandy Marl | 9 | 3 | <10 % inclusions, >85 % matrix, c. 5 % voids Predominant < 0.25-mm monocrystalline quartz inclusions, few clay pellets and sandy marl, occasionally with some microfossils (genus *textularia*) within a brown calcareous matrix with low birefringence and patchy texture. | Martorell |
| 54b Fine Calcareous Fabric with Quartz and Rare Calcite | 1 | 1 | 30 % inclusions, 65 % matrix, 5 % voidsCoarser outlier sample with fine (<0.25 mm) inclusions of dominant quartz, and few to rare metamorphic rock fragments, mica (biotite and muscovite), marl, chert and very rare amphibole. | Les Gavarres |
| **COARSE GRANITIC FABRICS** | | | | |
| 39 Very coarse granite and biotite | 7 | 1 | 30 % inclusions, 65 % matrix, 5 % voidsModerately to poorly sorted (0.03–3 mm) inclusions of dominant quartz and feldspar (orthoclase, plagioclase) aggregates of granitic origin, along with common coarse biotite, and very few to rare microcline, amphibole and pyroxene within a dark brown matrix with low birefringence. | Roda de Ter |
| 48 Coarse Quartz and Biotite | 5 | 1 | 40 % inclusions, 55 % matrix, 5 % voidsModerately sorted small inclusions (0.03–0.5 mm). Predominant assemblage of quartz, feldspars and aggregates of both minerals in frequent proportion with few biotite inclusions. Brownish matrices and slightly elongated voids occasionally aligned with the margins. | Roda de Ter |
| 49 Slightly Calcareous Fabric with Granite | 3 | 2 | 40 % inclusions, 50 % matrix, 10 % voidsPoorly sorted inclusions (0.03–2 mm) of common quartz, granite and marl fragments together with few metamorphic inclusions and very rare microcrystalline quartz (chert or rhyolite). Yellowish pale brown slightly calcareous matrix with darker margins and planar voids. | Roda de Ter |
| 55 Coarse Granite (1) | 4 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsPoorly sorted coarse angular inclusions (0.03–2 mm) derived from granite within a non-calcareous clay matrix. These include common quartz, few plagioclase and alkali feldspar, biotite and some aggregates of these minerals. Rare inclusions of amphibole (hornblende) and microcline may occur. | Barcelona |
| 55 Very Coarse (Feldspar-rich) Granite | 7 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsVery similar to the previous fabric, these fabric is richer in feldspars both within the matrix and forming aggregates with quartz of granitic origin. Weathered orthoclase is common, along with plagioclase and microcline. Again, some amphibole inclusions may occur. | Barcelona |
| 63 Coarse Granite (2) | 8 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsPoorly sorted coarse angular inclusions (0.01–2 mm) derived from granite within a non-calcareous clay matrix. These include common quartz, polycrystalline quartz, weathered plagioclase and alkali feldspar, biotite and small intact rock fragments composed of two or more of these minerals. Small amounts of few other inclusions such as phyllite, calcite and sandstone might occur in some samples. | Martorell |
| **COARSE METAMORPHIC FABRICS** | | | | |
| 20b Coarse Mica-Schist and Quartz | 5 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsVery poorly sorted inclusions (0.03–4 mm) of a predominant assemblage of quartz and coarse-sized (2–3 mm) inclusions of metamorphic origin containing quartz, biotite, muscovite, rare sericite and very rare chlorite, often combining to form aggregates identified as mica-schist. Dark brown homogeneous matrices with slightly darker margins with null birefringence and slight vitrification occasionally. | Martorell |
| 20c Coarse Metamorphic | 33 | 10 | 30 % inclusions, 60 % matrix, 10 % voidsVery poorly sorted inclusions (0.03–2.5 mm) of dominant quartz, common metamorphic inclusions (phyllite and slate), mica (biotite, muscovite and sericite) and aggregates of these minerals, within reddish-brown to brown matrices slightly heterogeneous in texture and birefringence. | Martorell |
| 20c Coarse Metamorphic (Biotite-rich) | 13 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsVariant of the previous fabric, with frequent and relatively coarse (0.5–0.75 mm) inclusions of biotite. | Martorell |
| 20c Coarse Metamorphic (Quartz-tempered) | 14 | 4 | 40 % inclusions, 55 % matrix, 5 % voidsAnother variant of the previous fabric, with a distinctive silty texture due to the amount of non-very coarse moderately to well-sorted (0.25–1 mm, rarely larger than 2 mm) angular inclusions of predominantly monocrystalline quartz that might be added as temper. | Martorell |
| **QUARTZ AND FELDSPAR FABRICS** | | | | |
| 24a Coarse Quartz, Feldspar and Rock Fragments | 11 | 1 | 35 % inclusions, 60 % matrix, 5 % voidsPoorly sorted inclusions (0.03–1.5 mm) of dominant quartz and feldspar, common to few phyllite and sandstone fragments, and few to rare biotite inclusions, chert and clay pellets within a dark brown matrix with very low to null birefringence. | Navès |
| 24c Coarse Quartz, Feldspar and Sandy Marl | 10 | 4 | 35 % inclusions, 60 % matrix, 5 % voidsVery similar to the previous fabric, with distinctive and common sandy marl inclusions usually formed of micrite aggregates that may include some monocrystalline quartz inclusions or sparite, within more reddish matrices. | Navès |
| 24e Fine Quartz and Feldspar (Clay Lumps) | 4 | 2 | 25 % inclusions, 65 % matrix, 10 % voidsModerately sorted inclusions (0.01–0.5 mm) of dominant quartz and feldspar with common bitotite and coarse (c. 1–2 mm) clay lumps very concordant with the matrix with neutral density almost non distinguishable in xp, but very dark and with well-defined edges in ppl. Occasionally, with rare metamorphic inclusions. Dark grey almost anisotropic matrices and elongated vughs. | Navès |
| 24e Fine Quartz and Feldspar (Clay Mixing) | 6 | 3 | 30 % inclusions, 65 % matrix, 5 % voidsPoorly sorted inclusions (0.03–1 mm) of dominant quartz and feldspar, common to few phyllite, sandstone fragments and | Navès |

(*continued on next page*)

**Table 2** (*continued*)

| OM Fabric | $n_1$ | $n_2$ | Main distinctive features | Location |
|---|---|---|---|---|
| | | | pellets, similar to the previous fabrics, within a reddish heterogeneous matrix with swirls and bands with different degrees of birefringence. | |
| 28b Coarse sand with quartz, pellets and rock fragments | 29 | 11 | 20 % inclusions, 70 % matrix, 10 % voidsWell sorted angular inclusions (0.25–1.5 mm) of quartz-rich coarse sand that includes feldspar, granite, metamorphic or argillaceous inclusions in fewer amounts, added as temper to a fine clay matrix. Reddish to dark brown matrices with very low birefringence. | Les Gavarres, Campelles & Barcelona |
| 28c Coarse sand with dominant quartz (Highly reducing) | 18 | 4 | 20 % inclusions, 70 % matrix, 10 % voidsWell sorted angular inclusions (0.5–2 mm) of coarse sand of predominant quartz, along with fewer inclusions of feldspar (orthoclase) and very few metamorphic inclusions, added as temper to an extremely fine clay matrix. Dark grey to black matrices with none optical activity. | Les Gavarres & Barcelona |
| 32 Quartz and Feldspar Rock Fragments and Pellets | 30 | 1 | <30 % inclusions, >60 % matrix, 10 % voidsPoorly sorted inclusions (<2 mm) of dominant quartz and feldspar rock fragments of undetermined origin together with less frequent inclusions of limolite or arenite naturally occurring within the clay. Highly heterogeneous brown and greyish dark matrices with common pellets, bands and swirls, slightly vitrified texture and cracky appearance. | Roda de Ter |
| 34 Pollycrystalline Quartz and Acidic Igneous Rock Fragments | 13 | 1 | <30 % inclusions, >60 % matrix, <10 % voidsModerately sorted (0.2–2 mm) inclusions of predominant quartz and feldspar aggregates. Arkosic microconglomerate very rare in most of analysed samples within a slightly heterogeneous grey or brown matrices. | Roda de Ter |
| 36 Arkose and Sandy Marl | 11 | 1 | <25 % inclusions, >60 % matrix, <15 % voidsPoorly sorted (<1 mm) inclusions of frequent inclusions of sandy marl including some fine-silt-sized inclusions of monocrystalline quartz within a calcareous matrix of micrite and sparite, along with a quartz-and-feldspar-rich assemblage. Variable matrices (orange to dark grey) and irregular mesovoids. | Roda de Ter |
| 38 Quartz Sand | 11 | 3 | 40 % inclusions, 50 % matrix, 10 % voidsAngular to very angular well sorted inclusions of dominant quartz and frequent orthoclase (< 1.5 mm), interpreted as medium-to-coarse sand added as temper. Dark brown to grey pastes, with slight birefringence and planar voids of microcracking appearance. | Roda de Ter |
| 46 Very Fine Quartz (non-calcareous) | 18 | 6 | 20 % inclusions, 75 % matrix, 5 % voidsPoorly sorted angular inclusions (<1 mm) of frequent quartz and feldspar inclusions, along with fewer pellets and rare metamorphic rock fragments. Dark brown or grey matrices with very low to null birefringence. Argillaceous lumps are common within the matrix, with sharp edges. | Les Gavarres, Campelles & Barcelona |
| 47 Fine Quartz, Mica and Clay pellets | 6 | 3 | 30 % inclusions, 65 % matrix, 5 % voidsVery poorly sorted inclusions; slightly bimodal microstructure, with very few coarse (c. 0.75 mm) inclusions and an abundant fine fraction (c. 0.05 mm) of dominant quartz and mica inclusions. Among the coarser inclusions, metamorphic rock fragments, clay pellets and feldspars are common. Reddish brown to dark grey matrices with very low birefringence. | Les Gavarres |
| 52 Fine Fabric with Rare Marl and Organic Matter | 3 | 2 | 15 % inclusions, 80 % matrix, 5 % voids Slightly bimodal. 20 % coarse fraction (0.5–2 mm) of common quartz-and-feldspar rich inclusions, sandy marl and pellets; and 80 % fine fraction (<0.10 mm) of predominant quartz and mica (muscovite and biotite) Homogeneous dark brown or grey matrices with low birefringence. Distinctive vughs with darkened edges probably resulting of burnt organic matter. | Campelles |
| 53 Metamorphic with pellets and lumps (clay mixing) | 5 | 2 | 20 % inclusions, 70 % matrix, 10 % voidsVery poorly sorted inclusions (0.10 to > 1.5 mm) of common quartz and common to few metamorphic inclusions (phyllite and slate), and feldspars (microcline and plagioclase). Heterogeneous orange to reddish brown matrices with swirls and different degrees of birefringence (high to low optical activity). | Campelles |
| 56 Coarse Feldspar-rich Fabric with Organic Matter | 4 | 1 | 30 % inclusions, 60 % matrix, 10 % voidsSimilar to the granitic fabrics from Barcelona (see description for fabric 55 above), a dominant assemblage of quartz and feldspar (0.03–2 mm) inclusions occur within a non-calcareous dark brownish or grey matrix. Samples include few to rare metamorphic inclusions and a considerable amount of vughs with very dark edges probably resulting of burnt organic matter. | Barcelona |

$n_1$ = number of total individuals included in the OM Fabric according to the GREYWARE database (n = 291).
$n_2$ = number of individuals per fabric sampled for WD-XRF analysis and included in the current dataset under study (n = 74).

followed the methodology proposed by Whitbread (1989, 1995) and Quinn (2013, 2022). This approach enabled the identification of distinct fabrics, which were subsequently interpreted in terms of their raw materials and manufacturing technologies. Geological maps of the area were used to identify potential sources of raw materials compatible with the composition of the ceramics assigned to specific petrographic fabrics. The aim of selecting this batch was to obtain, through elemental analysis, a more nuanced understanding of the groups established by optical microscopy (OM) and their potential provenance implications.

WD-XRF chemical analysis was performed using a Panalytical-Axios PW 4400/40 spectrometer. Major and minor elements were determined by preparing fused beads, using 0.3 g of powdered specimens in an alkaline fusion with lithium tetraborate at a 1/20 dilution. Trace elements were determined using pressed pellets made from 5 g of a specimen mixed with an Elvacite agglutinating agent, placed over boric acid in an aluminum capsule, and pressed for 60 s at 200 kN. Sixty International Geological Standards were used for calibration (Cau, 2003; see also Hein et al., 2002). A total of 25 elements were quantified: $Fe_2O_3$ (as total Fe), $Al_2O_3$, MnO, $P_2O_5$, $TiO_2$, MgO, CaO, $Na_2O$, $K_2O$, $SiO_2$, Ba, Rb, Th, Nb, Pb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni, and Cr. The loss on ignition (LOI) was determined by heating 0.3 g of dried specimen at 950 °C for 3 h. Elemental data were subjected to statistical treatment using the software Splus2000 (Baxter, 2015, Baxter & Cool, 2016, Venables & Ripley, 1999); for multivariate statistical procedures, chemical concentrations were transformed into additive log-ratios (Aitchinson, 1986, Baxter, 1994, Buxeda, 1999).

## 3. Results

### 3.1. *Petrographic analysis of greyware pottery*

Given that most of these samples exhibit coarse or very coarse non-plastic inclusions, petrographic analysis is a highly effective technique for building a significant corpus of data. Such data can be discussed in terms of provenance and technological choices, shedding light on the potting practices of past societies in producing common wares for cooking and other daily uses. The 74 selected samples belong to 28 different OM Fabrics, which include a total of 291 thin sections. A

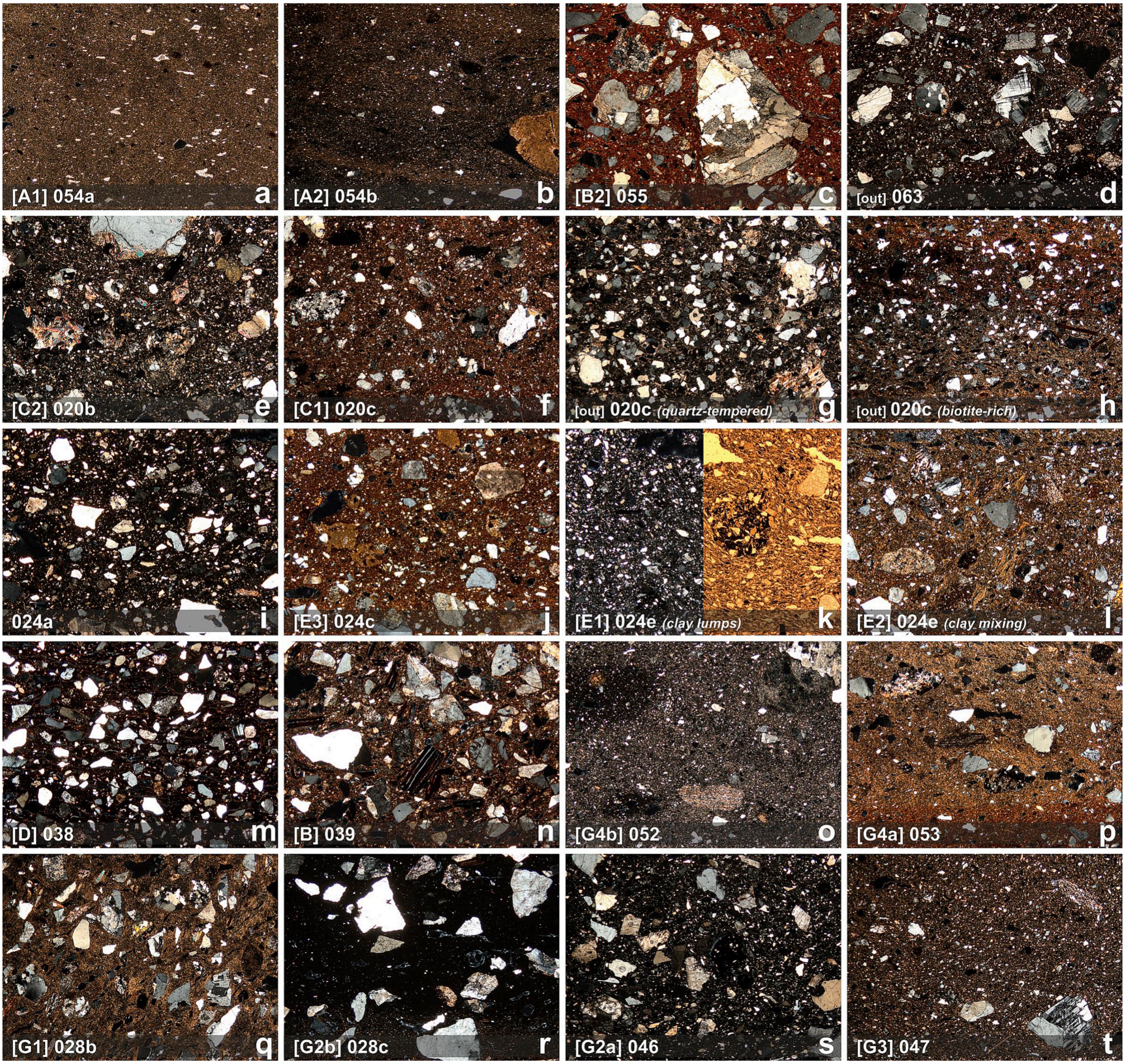


**Fig. 3.** Summary chart of the main petrographic fabrics mentioned in this study and described in Table 2 including calcareous fabrics (a-b), granitic fabrics found in Barcelona (c) and Martorell (d), metamorphic fabrics from Martorell (e-h), quartz-and-feldspar-rich fabrics found in Navès (i-l) and Roda de Ter (m-n), specific fabrics with metamorphic inclusions from Campelles (o-p), and sand-tempered fabrics (q-r) and fine fabrics (s-t) from les Gavarres. Labels for chemical groups and petrogroups are provided. All micrographs are in crossed pollars at 20x magnification (Field of view: 6 mm wide). For enhancing visibility of the clay lumps in sample MO-024e, picture (k) is given in both crossed polars and plane polarized light.

detailed description of each fabric exceeds the scope of this paper; the primary features of this pottery can be found in recent publications (Travé et al., 2024a, Pratdesaba & Travé, 2024) as well as specific site-focused studies on medieval and modern pottery (Travé et al., 2023, 2024b, 2025, Travé & Álvaro, 2025). Table 2 summarizes the main characteristics of these fabrics, the total number of samples in each fabric ($n_1$), the number selected for WD-XRF analysis ($n_2$), and the sites where they were found.

The general assemblage comprises four major greyware fabric groups distributed across different areas of Catalonia: Fine Calcareous, Coarse Granitic, Coarse Metamorphic, and Quartz and Feldspar Fabrics (Table 2 and Fig. 3). The Fine Calcareous Fabric is the least common, representing 4 % of the entire assemblage and 8 % of the samples selected for WD-XRF analysis. Fabrics in this group are characterized by a low proportion of small inclusions (<0.25 mm) of monocrystalline quartz within a calcareous matrix (Fig. 3a-b). These fine calcareous matrices, which are rare among greyware pottery, are their most distinctive feature. Variations between fabrics in this group primarily relate to the presence or absence of coarser non-plastic inclusions, such as sandy marl.

The Coarse Granitic fabrics are characterized by coarse inclusions of granitic origin, which cover 30–40 % of the total thin-section surface. These fabrics are common in the general assemblage of greyware pottery, accounting for approximately 10 % of the studied samples. The coarse inclusions, often measuring 2–3 mm in size, enable the identification of granite rock fragments amidst a general assemblage of quartz,

**Table 3**
Elemental composition of the 74 ceramic samples analysed through WD-XRF. Concentrations of major and minor elements are expressed as percentages of weight, while trace elements are in parts per million. Lost on ignition (L.O.I) values are expressed as percentage of weight. Samples are ordered according to the dendrogram in Fig. 4 for easier comparison of raw data values.

| Chem. group | OM Fabric | Sample | $Fe_2O_3$ | MnO | $TiO_2$ | CaO | $K_2O$ | $P_2O_5$ | $SiO_2$ | $Al_2O_3$ | MgO | $Na_2O$ | Ba | Ce | Cr | Cu | Ga | Nb | Ni | Pb | Rb | Sr | Th | V | Y | Zn | Zr | Mn | L.O.I. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| outlier | 20c – Coarse Metamorphic (Biotite-rich) | **GR273** | 5,95 | 0,04 | 0,67 | 0,61 | 2,95 | 0,08 | 70,07 | 17,72 | 1,20 | 0,22 | 760 | 105 | 36 | 60 | 24 | 19 | 30 | 3 | 130 | 58 | 14 | 100 | 31 | 33 | 200 | 324 | 0,66 |
| outlier | 20c – Coarse Metamorphic (Quartz-tempered) | **GR272** | 4,97 | 0,05 | 0,72 | 0,93 | 2,81 | 0,06 | 71,79 | 17,03 | 1,42 | 0,17 | 530 | 82 | 64 | 62 | 22 | 19 | 35 | 6 | 111 | 38 | 12 | 94 | 35 | 40 | 195 | 410 | 0,42 |
| outlier | 20c – Coarse Metamorphic (Quartz-tempered) | **GR285** | 3,17 | 0,02 | 0,68 | 0,49 | 3,46 | 0,12 | 70,25 | 19,51 | 0,84 | 0,23 | 682 | 131 | 15 | 106 | 26 | 20 | 13 | 17 | 115 | 55 | 13 | 86 | 30 | 78 | 193 | 140 | 1,01 |
| outlier | 63 – Coarse Granite (2) | **GR909** | 5,15 | 0,02 | 0,63 | 1,16 | 2,26 | 0,17 | 66,00 | 18,74 | 1,14 | 0,24 | 1363 | 202 | 28 | 100 | 24 | 18 | 38 | 15 | 111 | 99 | 15 | 100 | 22 | 32 | 146 | 135 | 4,00 |
| outlier | 20c – Coarse Metamorphic (Quartz-tempered) | **GR287** | 4,84 | 0,03 | 0,67 | 0,92 | 3,35 | 0,11 | 67,07 | 19,61 | 1,30 | 0,28 | 1022 | 108 | 30 | 304 | 26 | 21 | 39 | 16 | 130 | 59 | 16 | 94 | 36 | 73 | 198 | 276 | 0,73 |
| outlier | 38 – Quartz Sand | **GR089** | 5,19 | 0,04 | 0,43 | 1,23 | 3,57 | 0,26 | 71,13 | 14,90 | 0,86 | 1,26 | 600 | 53 | 63 | 20 | 18 | 16 | 27 | 39 | 127 | 94 | 14 | 94 | 26 | 69 | 147 | 323 | 1,80 |
| A (outlier) | 54b – Fine Calcareous Fabric with Quartz and Sandy Marl | **GR908** | 5,70 | 0,06 | 0,73 | 10,92 | 3,20 | 0,21 | 50,01 | 15,59 | 3,17 | 0,48 | 1276 | 59 | 56 | 23 | 18 | 20 | 30 | 27 | 125 | 232 | 19 | 98 | 27 | 95 | 149 | 441 | 1,30 |
| A (outlier) | 54b – Fine Calcareous Fabric with Quartz and Rare Calcite | **GR375** | 6,15 | 0,07 | 0,89 | 8,18 | 3,20 | 0,14 | 58,85 | 17,32 | 1,36 | 0,55 | 580 | 95 | 67 | 38 | 19 | 24 | 27 | 39 | 132 | 139 | 18 | 99 | 31 | 94 | 233 | 521 | 2,96 |
| A1 | 54a – Fine Calcareous Fabric | **GR190** | 6,30 | 0,08 | 0,75 | 10,64 | 3,82 | 0,20 | 50,40 | 18,21 | 3,45 | 0,52 | 674 | 73 | 75 | 36 | 18 | 21 | 38 | 37 | 156 | 254 | 19 | 123 | 28 | 115 | 141 | 663 | 5,95 |
| A1 | 54a – Fine Calcareous Fabric | **GR195** | 5,86 | 0,07 | 0,70 | 9,07 | 3,80 | 0,18 | 47,18 | 17,01 | 4,53 | 0,51 | 625 | 69 | 67 | 36 | 21 | 20 | 35 | 39 | 139 | 190 | 18 | 117 | 25 | 109 | 132 | 595 | 10,63 |
| A2 | 54b – Fine Calcareous Fabric with Quartz and Sandy Marl | **GR914** | 5,80 | 0,07 | 0,76 | 10,98 | 3,27 | 0,36 | 51,97 | 16,29 | 2,87 | 0,56 | 1290 | 72 | 60 | 18 | 17 | 20 | 31 | 28 | 133 | 264 | 20 | 97 | 28 | 98 | 154 | 524 | 7,49 |
| A2 | 54b – Fine Calcareous Fabric with Quartz and Sandy Marl | **GR280** | 5,90 | 0,08 | 0,76 | 9,25 | 3,37 | 0,51 | 53,33 | 16,68 | 3,08 | 0,64 | 1369 | 75 | 64 | 28 | 18 | 20 | 32 | 24 | 140 | 452 | 21 | 107 | 28 | 105 | 163 | 673 | 6,37 |
| outlier | 20c – Coarse Metamorphic (Quartz-tempered) | **GR294** | 6,25 | 0,04 | 0,62 | 1,27 | 2,32 | 0,61 | 64,36 | 16,23 | 1,06 | 0,38 | 1868 | 118 | 71 | 30 | 20 | 20 | 41 | 28 | 111 | 174 | 21 | 117 | 33 | 47 | 234 | 320 | 5,02 |
| outlier | 36 – Arkose and Sandy Marl | **GR109** | 4,76 | 0,04 | 0,61 | 2,08 | 2,84 | 0,19 | 64,16 | 14,59 | 1,19 | 0,90 | 690 | 71 | 66 | 20 | 19 | 20 | 27 | 40 | 135 | 115 | 17 | 95 | 28 | 79 | 188 | 393 | 8,09 |
| outlier | 28b – Coarse sand with quartz, pellets and rock fragments | **GR450** | 7,40 | 0,07 | 0,91 | 0,58 | 3,15 | 0,13 | 57,54 | 20,08 | 1,43 | 0,60 | 649 | 141 | 66 | 23 | 27 | 26 | 34 | 36 | 169 | 74 | 25 | 127 | 39 | 112 | 137 | 586 | 4,69 |
| outlier | 24e – Fine Quartz and Feldspar (Clay Mixing) | **GR901** | 6,54 | 0,08 | 0,65 | 2,00 | 3,35 | 0,10 | 63,58 | 18,97 | 1,83 | 0,63 | 492 | 94 | 70 | 20 | 24 | 20 | 36 | 23 | 151 | 84 | 20 | 117 | 31 | 82 | 159 | 644 | 2,03 |
| outlier | 28c – Coarse sand with dominant quartz (Highly reducing) | **GR434** | 6,96 | 0,10 | 0,91 | 1,20 | 3,92 | 0,15 | 62,92 | 21,00 | 1,59 | 0,86 | 665 | 102 | 73 | 12 | 29 | 31 | 25 | 25 | 187 | 79 | 22 | 86 | 42 | 96 | 173 | 706 | 0,70 |
| F | 46 – Very Fine Quartz (non-calcareous) | **GR438** | 5,99 | 0,06 | 0,87 | 0,68 | 3,58 | 0,15 | 67,04 | 18,80 | 1,07 | 0,62 | 600 | 119 | 68 | 3 | 26 | 26 | 31 | 28 | 190 | 78 | 22 | 99 | 44 | 88 | 216 | 455 | 0,34 |
| F | 46 – Very Fine Quartz (non-calcareous) | **GR406** | 5,47 | 0,08 | 0,81 | 0,73 | 3,32 | 0,05 | 67,82 | 18,80 | 1,02 | 1,35 | 582 | 105 | 43 | 3 | 23 | 23 | 12 | 26 | 136 | 104 | 22 | 90 | 38 | 60 | 265 | 652 | 0,93 |
| B | 39 – Very coarse granite and biotite | **GR133** | 3,64 | 0,02 | 0,41 | 1,56 | 3,61 | 0,29 | 65,93 | 16,41 | 0,88 | 2,53 | 886 | 78 | 18 | 12 | 21 | 17 | 3 | 18 | 118 | 168 | 22 | 56 | 30 | 58 | 141 | 197 | 3,72 |
| B | 55 – Coarse Granite (1) | **GR181** | 5,82 | 0,06 | 0,69 | 1,57 | 3,09 | 0,52 | 61,33 | 16,77 | 1,44 | 1,73 | 680 | 86 | 32 | 30 | 20 | 20 | 14 | 30 | 113 | 172 | 19 | 102 | 28 | 107 | 196 | 496 | 6,37 |
| B | 48 – Coarse Quartz and Biotite | **GR106** | 5,42 | 0,07 | 0,64 | 1,93 | 2,72 | 0,18 | 64,17 | 16,28 | 1,28 | 2,20 | 821 | 108 | 31 | 12 | 20 | 18 | 11 | 29 | 106 | 181 | 20 | 80 | 30 | 77 | 194 | 551 | 4,84 |
| B | 55 – Very Coarse (Feldspar-rich) Granite | **GR169** | 5,17 | 0,07 | 0,62 | 1,84 | 3,41 | 0,36 | 66,24 | 16,52 | 1,29 | 1,92 | 698 | 82 | 30 | 14 | 20 | 18 | 6 | 20 | 112 | 149 | 17 | 72 | 23 | 60 | 164 | 543 | 3,01 |
| B | 49 – Slightly Calcareous Fabric with Granite | **GR113** | 5,51 | 0,07 | 0,60 | 1,79 | 2,89 | 0,33 | 62,50 | 16,92 | 1,25 | 2,58 | 909 | 107 | 25 | 9 | 22 | 18 | 5 | 25 | 100 | 185 | 20 | 83 | 31 | 79 | 178 | 594 | 5,65 |
| outlier | 49 – Slightly Calcareous Fabric with Granite | **GR105** | 5,60 | 0,06 | 0,67 | 2,16 | 2,63 | 0,46 | 63,73 | 16,41 | 1,33 | 1,98 | 854 | 101 | 37 | 15 | 21 | 19 | 12 | 28 | 101 | 213 | 20 | 95 | 30 | 77 | 199 | 541 | 5,09 |
| D | 32 – Quartz and Feldspar Rock Fragments and Pellets | **GR078** | 4,73 | 0,04 | 0,45 | 2,24 | 3,20 | 0,38 | 63,91 | 15,04 | 0,94 | 1,20 | 1117 | 61 | 60 | 18 | 18 | 17 | 26 | 45 | 133 | 206 | 17 | 102 | 27 | 66 | 156 | 333 | 8,07 |
| D | 38 – Quartz Sand | **GR117** | 5,23 | 0,04 | 0,33 | 1,59 | 3,69 | 0,19 | 63,49 | 16,69 | 1,03 | 1,31 | 767 | 50 | 61 | 19 | 21 | 15 | 29 | 134 | 150 | 139 | 15 | 93 | 25 | 80 | 107 | 361 | 6,88 |
| D | 38 – Quartz Sand | **GR091** | 5,17 | 0,04 | 0,24 | 2,03 | 3,87 | 0,51 | 60,35 | 17,58 | 0,81 | 1,65 | 867 | 50 | 62 | 23 | 20 | 13 | 29 | 35 | 134 | 148 | 14 | 88 | 29 | 78 | 80 | 322 | 7,84 |
| E1 | 24e – Fine Quartz and Feldspar (Clay Lumps) | **GR062** | 6,10 | 0,13 | 0,69 | 1,11 | 3,23 | 0,11 | 67,62 | 17,66 | 1,81 | 0,39 | 404 | 107 | 84 | 17 | 24 | 21 | 39 | 21 | 141 | 71 | 19 | 110 | 36 | 80 | 201 | 990 | 0,31 |
| E1 | 24e – Fine Quartz and Feldspar (Clay Lumps) | **GR904** | 5,59 | 0,09 | 0,69 | 1,13 | 2,55 | 0,70 | 69,15 | 14,84 | 0,98 | 0,40 | 434 | 84 | 73 | 15 | 18 | 19 | 32 | 27 | 106 | 85 | 16 | 97 | 32 | 58 | 210 | 692 | 3,65 |
| E2 | 24e – Fine Quartz and Feldspar (Clay Mixing) | **GR051** | 6,07 | 0,09 | 0,75 | 2,07 | 3,15 | 0,14 | 66,68 | 16,67 | 1,33 | 0,59 | 574 | 91 | 68 | 18 | 23 | 21 | 34 | 23 | 138 | 81 | 17 | 115 | 29 | 85 | 197 | 658 | 2,50 |
| E2 | 24e – Fine Quartz and Feldspar (Clay Mixing) | **GR902** | 5,83 | 0,09 | 0,67 | 2,13 | 3,03 | 0,25 | 63,98 | 16,92 | 1,10 | 0,58 | 525 | 89 | 65 | 20 | 20 | 20 | 36 | 30 | 130 | 93 | 17 | 112 | 32 | 78 | 186 | 761 | 3,18 |
| E3 | 24c – Coarse Quartz, Feldspar and Sandy Marl | **GR903** | 5,09 | 0,10 | 0,61 | 2,70 | 2,58 | 0,92 | 66,50 | 14,11 | 0,88 | 0,44 | 449 | 83 | 69 | 25 | 17 | 18 | 35 | 20 | 110 | 106 | 16 | 95 | 34 | 66 | 182 | 790 | 5,36 |
| E3 | 24c – Coarse Quartz, Feldspar and Sandy Marl | **GR906** | 5,70 | 0,11 | 0,70 | 2,31 | 2,54 | 0,41 | 68,53 | 14,57 | 1,34 | 0,36 | 421 | 81 | 76 | 19 | 18 | 20 | 34 | 22 | 114 | 83 | 17 | 109 | 32 | 65 | 211 | 897 | 3,09 |
| E3 | 24c – Coarse Quartz, Feldspar and Sandy Marl | **GR075** | 5,85 | 0,10 | 0,62 | 2,75 | 2,70 | 0,29 | 68,30 | 15,04 | 1,25 | 0,47 | 377 | 86 | 68 | 18 | 18 | 18 | 33 | 24 | 115 | 86 | 16 | 94 | 36 | 65 | 185 | 765 | 3,33 |
| E3 | 24c – Coarse Quartz, Feldspar and Sandy Marl | **GR905** | 5,87 | 0,10 | 0,64 | 2,41 | 2,57 | 0,26 | 68,54 | 15,15 | 1,38 | 0,43 | 406 | 96 | 68 | 17 | 17 | 19 | 36 | 23 | 113 | 80 | 17 | 105 | 37 | 65 | 197 | 843 | 3,05 |
| G1 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR374** | 6,08 | 0,09 | 0,78 | 2,49 | 3,83 | 0,10 | 61,19 | 20,11 | 1,52 | 0,97 | 633 | 103 | 68 | 15 | 28 | 24 | 26 | 33 | 186 | 101 | 21 | 108 | 32 | 112 | 133 | 686 | 2,39 |
| G1 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR146** | 5,92 | 0,12 | 0,75 | 2,06 | 3,42 | 0,10 | 62,01 | 19,53 | 1,54 | 0,66 | 709 | 100 | 74 | 21 | 28 | 27 | 29 | 34 | 197 | 105 | 23 | 111 | 35 | 110 | 124 | 961 | 1,31 |
| G1 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR435** | 6,34 | 0,09 | 0,75 | 4,75 | 3,70 | 0,12 | 59,21 | 20,65 | 1,66 | 0,69 | 693 | 95 | 93 | 17 | 27 | 24 | 32 | 23 | 182 | 121 | 21 | 111 | 32 | 123 | 112 | 665 | 2,24 |
| G1 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR436** | 6,26 | 0,07 | 0,77 | 3,37 | 3,61 | 0,11 | 61,06 | 20,67 | 1,49 | 0,70 | 661 | 98 | 66 | 13 | 27 | 26 | 29 | 30 | 188 | 127 | 21 | 107 | 33 | 111 | 121 | 561 | 2,10 |
| G (outlier) | 28b – Coarse sand with quartz, pellets and rock fragments | **GR004** | 6,90 | 0,17 | 0,93 | 1,27 | 3,72 | 0,12 | 59,87 | 21,80 | 1,44 | 0,58 | 724 | 109 | 62 | 22 | 28 | 28 | 27 | 32 | 192 | 74 | 24 | 105 | 37 | 115 | 162 | 1198 | 3,03 |
| G (outlier) | 47 – Fine Quartz, Mica and Clay pellets | **GR144** | 4,99 | 0,06 | 0,84 | 1,80 | 3,31 | 0,66 | 67,85 | 16,79 | 0,70 | 0,75 | 630 | 84 | 59 | 16 | 24 | 23 | 20 | 32 | 171 | 78 | 19 | 77 | 39 | 83 | 245 | 491 | 1,08 |
| G2a | 24a – Coarse Quartz, Feldspar and Rock Fragments | **GR064** | 4,88 | 0,08 | 0,61 | 1,08 | 3,17 | 0,17 | 67,36 | 16,52 | 0,91 | 1,09 | 449 | 82 | 64 | 13 | 22 | 19 | 21 | 26 | 113 | 74 | 17 | 83 | 26 | 61 | 175 | 597 | 4,38 |
| G2a | 34 – Pollycr. Quartz and Acidic Igneous Rock Fragments | **GR081** | 5,70 | 0,08 | 0,73 | 1,75 | 3,21 | 0,16 | 67,27 | 17,47 | 1,52 | 1,50 | 638 | 92 | 48 | 11 | 24 | 21 | 23 | 24 | 128 | 112 | 20 | 101 | 36 | 74 | 220 | 692 | 1,06 |
| G2a | 46 – Very Fine Quartz (non-calcareous) | **GR404** | 6,20 | 0,08 | 0,98 | 1,54 | 3,34 | 0,14 | 62,63 | 18,90 | 1,19 | 1,25 | 726 | 118 | 75 | 11 | 25 | 32 | 23 | 27 | 176 | 95 | 25 | 84 | 43 | 86 | 238 | 604 | 2,48 |
| G2a | 46 – Very Fine Quartz (non-calcareous) | **GR187** | 5,81 | 0,07 | 0,87 | 1,13 | 3,00 | 0,20 | 67,64 | 18,19 | 1,21 | 1,63 | 611 | 120 | 48 | 16 | 24 | 25 | 20 | 84 | 140 | 102 | 25 | 104 | 42 | 62 | 205 | 545 | 0,87 |
| G2a | 46 – Very Fine Quartz (non-calcareous) | **GR188** | 5,53 | 0,06 | 0,86 | 1,01 | 2,93 | 0,16 | 68,17 | 17,98 | 1,15 | 1,63 | 612 | 126 | 52 | 10 | 21 | 26 | 20 | 273 | 141 | 109 | 24 | 101 | 46 | 55 | 244 | 532 | 0,41 |
| G2b | 28c – Coarse sand with dominant quartz (Highly reducing) | **GR171** | 6,86 | 0,07 | 0,87 | 0,98 | 3,62 | 0,22 | 63,38 | 21,39 | 1,50 | 1,30 | 692 | 117 | 64 | 22 | 27 | 26 | 27 | 46 | 171 | 115 | 26 | 122 | 38 | 152 | 131 | 588 | 3,01 |
| G2b | 28b – Coarse sand with quartz, pellets and rock fragments | **GR439** | 6,53 | 0,07 | 0,80 | 1,02 | 3,72 | 0,24 | 64,47 | 19,27 | 1,34 | 0,97 | 675 | 126 | 60 | 17 | 25 | 25 | 26 | 31 | 177 | 101 | 22 | 105 | 38 | 103 | 126 | 577 | 1,40 |
| G2b | 28b – Coarse sand with quartz, pellets and rock fragments | **GR446** | 6,75 | 0,06 | 0,87 | 0,90 | 3,68 | 0,17 | 60,23 | 19,90 | 1,48 | 0,77 | 636 | 144 | 64 | 18 | 26 | 27 | 27 | 47 | 185 | 94 | 25 | 117 | 38 | 117 | 126 | 480 | 4,50 |
| G2b | 28c – Coarse sand with dominant quartz (Highly reducing) | **GR433** | 5,64 | 0,09 | 0,90 | 0,91 | 3,59 | 0,10 | 67,04 | 19,34 | 1,12 | 1,12 | 679 | 145 | 74 | 14 | 29 | 29 | 30 | 36 | 206 | 97 | 26 | 115 | 41 | 121 | 131 | 846 | 0,71 |
| G2b | 46 – Very Fine Quartz (non-calcareous) | **GR196** | 6,21 | 0,09 | 0,94 | 1,24 | 3,17 | 0,08 | 58,96 | 19,35 | 1,38 | 1,20 | 639 | 123 | 63 | 14 | 27 | 29 | 25 | 43 | 168 | 102 | 28 | 123 | 44 | 92 | 185 | 778 | 6,97 |
| G2b | 28c – Coarse sand with dominant quartz (Highly reducing) | **GR176** | 6,55 | 0,10 | 0,85 | 1,10 | 3,64 | 0,11 | 61,66 | 20,83 | 1,57 | 1,29 | 706 | 126 | 61 | 18 | 28 | 26 | 24 | 42 | 169 | 101 | 26 | 119 | 41 | 108 | 139 | 804 | 0,61 |
| G2b | 28b – Coarse sand with quartz, pellets and rock fragments | **GR006** | 7,42 | 0,12 | 1,07 | 1,23 | 3,58 | 0,14 | 61,17 | 21,45 | 1,46 | 1,35 | 624 | 151 | 55 | 15 | 30 | 33 | 25 | 33 | 201 | 95 | 30 | 112 | 49 | 118 | 153 | 907 | 2,16 |

(*continued on next page*)

**Table 3** (*continued*)

| Chem. group | OM Fabric | Sample | $Fe_2O_3$ | MnO | $TiO_2$ | CaO | $K_2O$ | $P_2O_5$ | $SiO_2$ | $Al_2O_3$ | MgO | $Na_2O$ | Ba | Ce | Cr | Cu | Ga | Nb | Ni | Pb | Rb | Sr | Th | V | Y | Zn | Zr | Mn | L.O.I. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G3 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR403** | 6,29 | 0,10 | 0,95 | 0,97 | 3,74 | 0,20 | 61,73 | 21,54 | 1,09 | 0,80 | 719 | 108 | 65 | 11 | 29 | 31 | 27 | 45 | 204 | 82 | 21 | 98 | 42 | 114 | 151 | 738 | 1,89 |
| G3 | 47 – Fine Quartz, Mica and Clay pellets | **GR140** | 6,53 | 0,05 | 0,97 | 0,59 | 3,44 | 0,12 | 67,08 | 19,02 | 1,05 | 0,43 | 565 | 124 | 63 | 9 | 25 | 26 | 27 | 32 | 191 | 68 | 22 | 106 | 42 | 101 | 238 | 417 | 0,09 |
| G3 | 28b – Coarse sand with quartz, pellets and rock fragments | **GR445** | 6,58 | 0,06 | 0,88 | 0,75 | 3,54 | 0,15 | 64,72 | 19,34 | 1,17 | 0,55 | 640 | 108 | 64 | 14 | 26 | 24 | 28 | 32 | 183 | 80 | 21 | 107 | 37 | 92 | 183 | 455 | 1,80 |
| G3 | 47 – Fine Quartz, Mica and Clay pellets | **GR370** | 6,97 | 0,08 | 1,00 | 0,85 | 3,61 | 0,14 | 65,06 | 20,40 | 1,17 | 0,58 | 599 | 126 | 67 | 13 | 27 | 28 | 29 | 26 | 192 | 75 | 24 | 107 | 43 | 97 | 231 | 640 | 0,86 |
| G4a | 53 – Metamorphic with pellets and lumps (clay mixing) | **GR145** | 7,50 | 0,07 | 0,90 | 1,35 | 3,01 | 0,10 | 60,02 | 21,12 | 1,83 | 0,85 | 893 | 95 | 68 | 37 | 26 | 22 | 35 | 51 | 140 | 132 | 20 | 121 | 32 | 85 | 178 | 600 | 3,17 |
| G4a | 53 – Metamorphic with pellets and lumps (clay mixing) | **GR152** | 7,43 | 0,07 | 0,83 | 1,30 | 3,16 | 0,35 | 60,55 | 20,42 | 1,80 | 0,91 | 950 | 106 | 75 | 37 | 25 | 21 | 51 | 27 | 144 | 109 | 19 | 127 | 36 | 88 | 175 | 571 | 3,05 |
| G4 (outlier) | 56 – Coarse Feldspar-rich Fabric with Organic Matter | **GR203** | 5,11 | 0,03 | 0,63 | 1,17 | 3,31 | 0,62 | 67,13 | 16,86 | 0,89 | 1,03 | 570 | 53 | 58 | 22 | 21 | 20 | 19 | 41 | 126 | 108 | 18 | 91 | 26 | 65 | 189 | 203 | 3,69 |
| G4b | 52 – Fine Fabric with Rare Marl and Organic Matter | **GR157** | 4,62 | 0,04 | 0,81 | 1,11 | 4,18 | 0,07 | 65,65 | 20,18 | 1,19 | 0,65 | 858 | 87 | 68 | 24 | 27 | 24 | 32 | 53 | 194 | 105 | 20 | 105 | 35 | 129 | 194 | 348 | 1,05 |
| G4b | 52 – Fine Fabric with Rare Marl and Organic Matter | **GR162** | 4,64 | 0,04 | 0,81 | 0,84 | 4,18 | 0,08 | 64,62 | 20,09 | 1,14 | 0,66 | 850 | 87 | 67 | 25 | 27 | 25 | 31 | 55 | 197 | 105 | 20 | 107 | 35 | 127 | 194 | 322 | 3,01 |
| C2 | 20c – Coarse Metamorphic | **GR298** | 5,63 | 0,08 | 0,74 | 1,66 | 3,34 | 0,20 | 67,93 | 16,79 | 1,15 | 0,49 | 937 | 105 | 47 | 80 | 21 | 21 | 30 | 22 | 124 | 95 | 18 | 98 | 30 | 50 | 263 | 648 | 2,78 |
| C2 | 20b – Coarse Mica-Schist and Quartz | **GR293** | 6,21 | 0,03 | 0,76 | 0,87 | 3,41 | 0,19 | 66,48 | 18,84 | 1,47 | 0,29 | 637 | 97 | 60 | 84 | 25 | 21 | 27 | 17 | 150 | 57 | 17 | 116 | 26 | 78 | 222 | 270 | 0,82 |
| C1 | 20c – Coarse Metamorphic | **GR907** | 5,36 | 0,01 | 0,56 | 1,48 | 2,31 | 0,12 | 67,73 | 15,92 | 1,15 | 0,36 | 1026 | 56 | 35 | 23 | 20 | 18 | 19 | 10 | 92 | 70 | 15 | 80 | 22 | 27 | 177 | 119 | 2,66 |
| C1 | 20c – Coarse Metamorphic | **GR911** | 5,30 | 0,01 | 0,52 | 0,98 | 2,40 | 0,10 | 69,76 | 15,44 | 1,05 | 0,26 | 1118 | 46 | 32 | 36 | 20 | 17 | 13 | 13 | 97 | 60 | 15 | 81 | 23 | 39 | 162 | 129 | 3,82 |
| C1 | 20c – Coarse Metamorphic | **GR913** | 5,35 | 0,03 | 0,66 | 1,09 | 2,70 | 0,17 | 68,62 | 15,45 | 1,19 | 0,41 | 1530 | 77 | 41 | 17 | 18 | 20 | 23 | 21 | 103 | 81 | 17 | 88 | 27 | 29 | 249 | 269 | 3,43 |
| C1 | 20c – Coarse Metamorphic | **GR301** | 6,11 | 0,05 | 0,72 | 1,07 | 2,86 | 0,18 | 66,54 | 16,08 | 1,24 | 0,59 | 1568 | 83 | 70 | 29 | 23 | 21 | 35 | 27 | 120 | 118 | 20 | 112 | 30 | 49 | 272 | 435 | 3,97 |
| C1 | 20c – Coarse Metamorphic | **GR284** | 5,84 | 0,04 | 0,75 | 0,87 | 3,12 | 0,10 | 70,49 | 16,12 | 1,26 | 0,53 | 666 | 113 | 70 | 21 | 22 | 23 | 34 | 22 | 136 | 83 | 20 | 107 | 34 | 40 | 302 | 355 | 0,60 |
| C1 | 20c – Coarse Metamorphic | **GR283** | 5,71 | 0,02 | 0,54 | 0,82 | 2,36 | 0,09 | 72,36 | 15,68 | 1,04 | 0,23 | 791 | 76 | 58 | 22 | 20 | 19 | 25 | 19 | 121 | 64 | 16 | 98 | 23 | 25 | 218 | 149 | 0,18 |
| C1 | 20c – Coarse Metamorphic | **GR295** | 5,74 | 0,03 | 0,61 | 0,92 | 2,07 | 0,41 | 71,31 | 14,16 | 0,93 | 0,28 | 857 | 74 | 57 | 26 | 17 | 20 | 28 | 10 | 100 | 98 | 16 | 94 | 22 | 19 | 242 | 223 | 2,24 |
| C1 | 20c – Coarse Metamorphic | **GR910** | 5,71 | 0,03 | 0,76 | 0,84 | 2,63 | 0,09 | 69,47 | 17,96 | 1,24 | 0,40 | 856 | 98 | 54 | 46 | 25 | 22 | 33 | 22 | 118 | 92 | 18 | 116 | 32 | 39 | 264 | 273 | 1,11 |
| C1 | 20c – Coarse Metamorphic | **GR912** | 5,75 | 0,03 | 0,77 | 0,88 | 2,63 | 0,09 | 69,46 | 18,07 | 1,24 | 0,40 | 836 | 99 | 59 | 44 | 23 | 21 | 33 | 21 | 116 | 94 | 18 | 112 | 30 | 40 | 259 | 274 | 0,82 |

feldspar, and mica inclusions in similar proportions (Fig. 3c-d). The presence or absence of less common minerals, such as amphibole and pyroxene, within the acidic igneous assemblage, along with the type and weathering state of feldspar inclusions, helps distinguish different fabrics.

A distinctive group of Coarse Metamorphic fabrics is primarily associated with the town of Martorell and its surrounding area. These fabrics are characterized by the presence of very coarse inclusions of metamorphic origin, typically mica-schist or phyllite (Fig. 3e-h), and account for 22 % of the studied samples. While the group is relatively homogeneous, subtle differences between fabrics emerge, often linked to the disproportionate presence of specific minerals, such as biotite in some samples, or to technological variations such as the presence of fabrics prepared with the same clay base but with or without quartz temper. These aspects will be further explored in the discussion.

Quartz and Feldspar Fabrics constitute a significant portion of the assemblage, accounting for approximately 60 % of the total. These fabrics are characterized by dominant quartz and frequent feldspar inclusions, but the inclusions alone are insufficient to link them to specific geological outcrops. Detailed petrographic examination, however, reveals meaningful differences between fabrics in terms of textural features and the nature of less frequent inclusions. The presence or absence of specific rock fragments —such as sandy marl, arkose, metamorphic inclusions, or weathered feldspars— combined with variations in matrix heterogeneity, argillaceous inclusions, and voids, supports a more nuanced classification of fabrics. Technological variations are evident in the quartz and feldspar fabrics from Navès (Fig. 3i-l), while textural differences are pronounced among the fabrics found at Roda de Ter (Fig. 3m-n) and Campelles (Fig. 3o-p) (Table 2).

Most of the samples examined contain poorly sorted inclusions of natural origin, with bimodal or polymodal distributions indicative of temper being uncommon. However, there are a few exceptions. One notable exception is a clearly tempered fabric with some variants —the 28 Coarse Sand Fabric (Fig. 3q-r)— identified in the Les Gavarres area. This fabric stands out due to its relatively abundant (20 %) very coarse fraction (>0.5 mm) of inclusions within a very fine clay matrix, where the usual fine quartz inclusions found in other fabrics are almost entirely absent. Found in several locations across Catalonia, alongside other widely distributed fabrics (Fig. 3s-t), this fabric represents approximately 15 % of the total assemblage analysed via OM. Determining whether this distribution reflects regional trade connections or merely a technological coincidence between different local workshops was essential for interpreting pottery production and distribution patterns. To this end, a higher proportion of samples from this fabric (20 %) were selected for WD-XRF analysis.

### 3.2. *Chemical characterization and clustering*

The chemical analysis of the 74 ceramic samples conducted using WD-XRF reveals that the assemblage is relatively homogeneous in elemental composition, with minor variations observed primarily in trace elements (Table 3). Most samples exhibit low calcareous content (CaO < 5 %, typically below 3 %), a characteristic feature of greyware pottery (Picon, 1995). Exceptions to this trend include samples GR190, GR195, GR280, GR375, GR908, and GR914, which display a calcareous composition (CaO 8–12 %). Within the non-calcareous group, $SiO_2$ levels are notably high (approximately 60–70 %), while MgO content generally remains below 1.5 %, with only a few exceptions (GR145 and GR152). $K_2O$ concentrations range between 3–4 %, and $Fe_2O_3$ levels fall between 5–8 %.

A more nuanced understanding of the chemical variability within the dataset can be achieved by calculating the compositional variation matrix (CVM) (Buxeda and Kilikoglou, 2003). The total variation (vt) value is notably high (3.49), indicating a polygenic sample. The CVM further reveals that most of this variability is driven by fluctuations in CaO ($\tau.i$ = 16.16), $Na_2O$ ($\tau.i$ = 20.10), and Cu ($\tau.i$ = 15.55). This

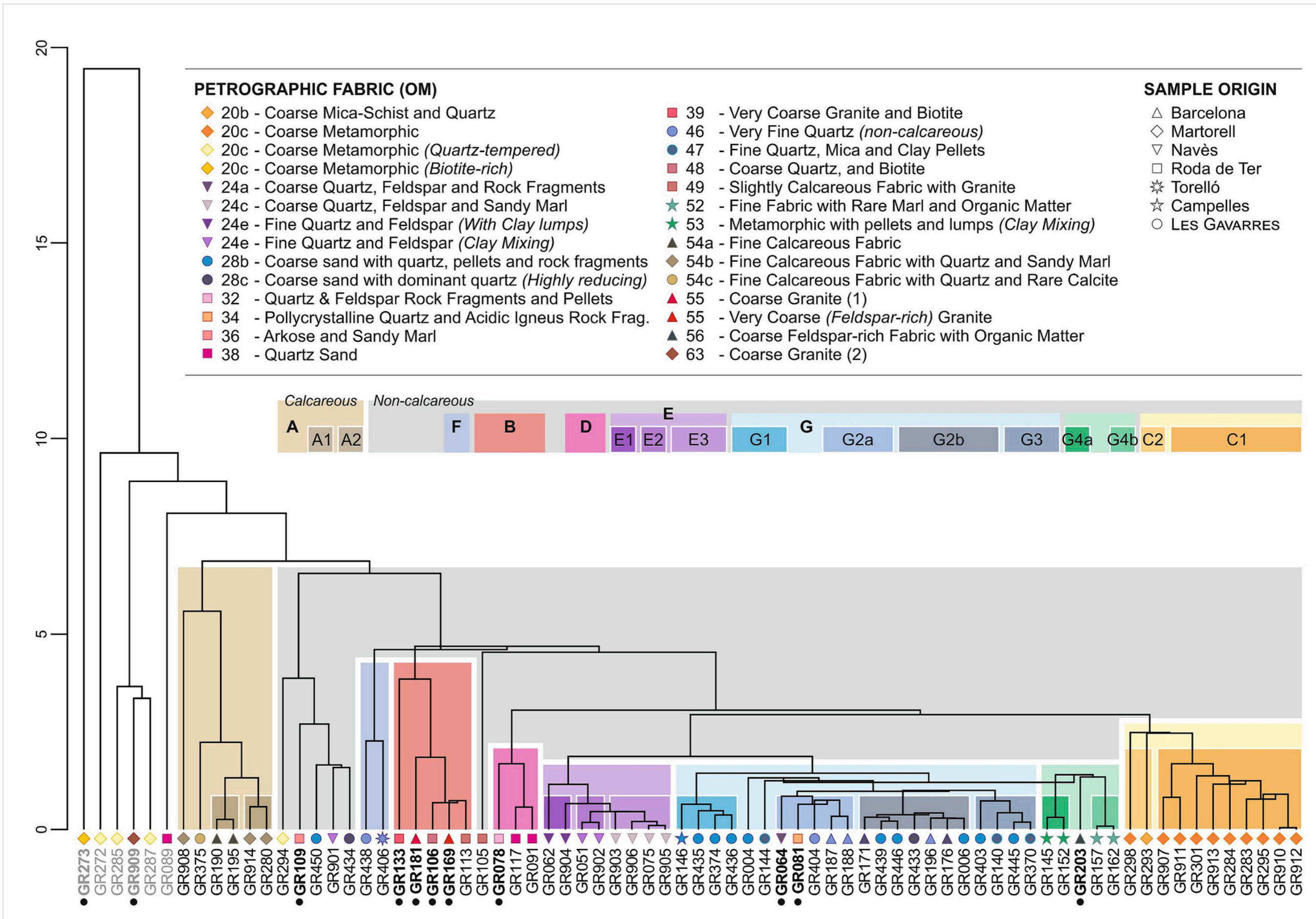


**Fig. 4.** Dendrogram resulting from a hierarchical cluster analysis (using the centroid agglomerative method and the squared Euclidean distance) on the entire assemblage studied based on the alr-transformed concentrations of $Fe_2O_3$, MnO, $TiO_2$, CaO, $K_2O$, $SiO_2$, MgO, $Na_2O$, Ba, Ce, Cr, Cu, Ga, Nb, Ni, Pb, Rb, Sr, Th, V, Y, Zn, Zr Rb, Th, Nb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni, and Cr, using $Al_2O_3$ as divisor in the log-ratio transformation of the data. Main clusters and chemical groups are indicated. Petrographic group for each sample is provided according to the legend. Those samples being the only representative of the petrographic group they belong included in this study are indicated with a black dot next to the label.

variability is particularly explained —especially in the case of calcium— by the presence of six calcareous samples. As will be discussed further below, the variation in $Na_2O$, ranging from 0.1 to 2.8 %, emerges as a key factor in identifying some regional differences within the dataset, mostly due to the plagioclase content in granitic fabrics (Table 3).

A cluster analysis (CA) of the chemical data (Fig. 4) provided an initial graphical overview of the compositional similarities between samples. For the statistical treatment, concentrations were transformed into additive log-ratios (alr) (Aitchinson, 1986, Buxeda, 1999) using $Al_2O_3$ as the divisor, as it was the element with the lowest variance ($\tau$.i = 3.79) according to the CVM. Co and W were excluded from the analysis for possible contaminations during sample preparation, while $P_2O_5$ and Pb were excluded as well, due to potential post-depositional contaminations. The cluster tree generated by the CA revealed the presence of two main groups —calcareous (A) and non-calcareous— as well as six outlier samples that fell outside these groups. To refine the classification, we compared the clustering results with the petrographic characteristics of the samples and conducted a principal component analysis (PCA) (Fig. 5) based on the same subcomposition used in the CA, which corroborated this classification.

The calcareous group (A) includes all samples classified within the OM Fine Calcareous Fabrics. While groups A1 and A2 share similar compositions for major elements, they differ significantly in their trace element content, with notable variations in Ba, Ni, Sr, Zn, and Zr concentrations (Table 4). The difference in $SiO_2$ content—lower in A1 and higher in A2—can be attributed to petrographic differences, as the samples in group A2 contain quartz and sandy marl inclusions. GR908 and GR375 are part of the calcareous cluster but are considered outliers in relation to groups A1 and A2. GR375 presents much lower Ba, Ni concentrations than both A1 and A2 and its slightly less calcareous, while GR908 is slightly more calcareous than the rest.

Within the non-calcareous group, a detailed examination of the data and a comparison between OM Fabrics and the CA is crucial for an accurate classification. Samples GR294, GR109, GR450, GR901, and GR434, for instance, apparently form a group but they are considered outliers. Indeed, the standard deviation in the content of several major elements, combined with the petrographic features of these fabrics (see Table 2 and descriptions in the previous section), and the total variation of this association (vt = 1.58) indicates that they cannot be classified as a cohesive—but random or spurious—chemical group. Sample GR105 is also categorized as an outlier due to minor differences in certain trace elements (Cr, Sr, and Zr). The remaining samples are confidently assigned to six groups (labelled B to G), with differences linked to provenance and technological choices, as will be discussed in the following section.

Group B (n = 5) includes most of the granitic fabrics in this dataset, despite the petrographic differences among them (Table 3). The content of major elements does not significantly differ from the general assemblage; however, certain trace elements reveal relevant distinctions that help explain the singularities of this group. Specifically, values for Cr,

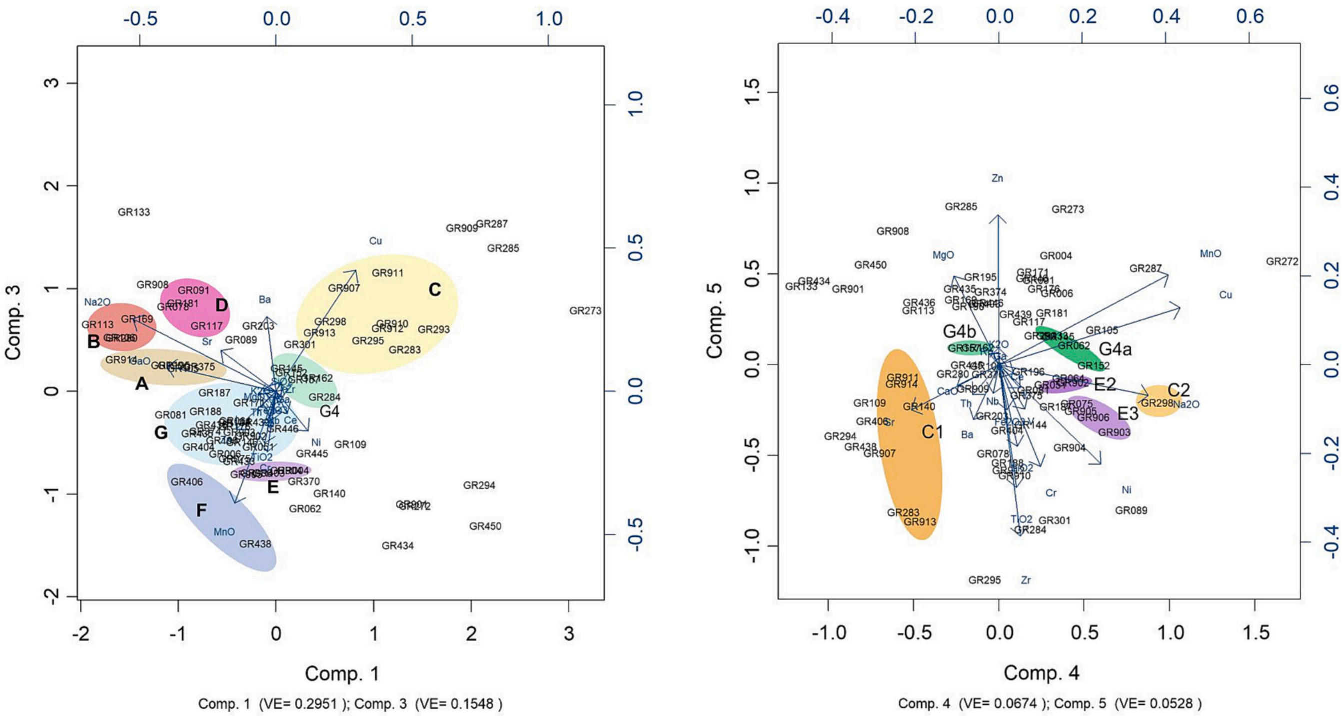


**Fig. 5.** Principal component analysis of the multivariate geochemical data using the same alr-transformed concentrations than per the HCA. Scatterplots of principal component 1 versus principal component 2 (a) and principal component 4 versus principal component 5.

**Table 4**
Mean chemical composition (WD-XRF) of the main groups defined from multivariate statistical analysis of the data. Standard deviation (σ) values are given in brackets for each element. Concentrations of major and minor oxides are expressed as percentages and trace elements are in parts per million.

| Chemical group | OM Fabric | Fe2O3 | MnO | TiO2 | CaO | K2O | P2O5 | SiO2 | Al2O3 | MgO | Na2O |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** (n = 2) | 54a - Fine Calcareous Fabric | **6.63** *(0.06)* | **0.08** *(0.00)* | **0.80** *(0.01)* | **10.72** *(0.75)* | **4.15** *(0.16)* | **0.21** *(0.01)* | **53.14** *(0.25)* | **19.18** *(0.11)* | **4.37** *(1.02)* | **0.56** *(0.01)* |
| **A2** (n = 2) | 54b - Fine Calcareous Fabric with Quartz and Sandy Marl | **6.26** *(0.04)* | **0.08** *(0.01)* | **0.81** *(0.00)* | **10.82** *(1.37)* | **3.55** *(0.06)* | **0.47** *(0.12)* | **56.31** *(0.73)* | **17.63** *(0.21)* | **3.18** *(0.14)* | **0.64** *(0.06)* |
| **F** (n = 2) | 46 - Very Fine Quartz (non-calcareous) | **5.77** *(0.40)* | **0.07** *(0.01)* | **0.85** *(0.04)* | **0.71** *(0.04)* | **3.48** *(0.21)* | **0.10** *(0.07)* | **67.90** *(0.26)* | **18.94** *(0.08)* | **1.06** *(0.04)* | **0.99** *(0.51)* |
| **B** (n = 5) | *Mixed OM Granitic Fabrics* | **5.37** *(0.94)* | **0.06** *(0.02)* | **0.62** *(0.12)* | **1.82** *(0.16)* | **3.31** *(0.36)* | **0.36** *(0.13)* | **67.26** *(1.36)* | **17.42** *(0.48)* | **1.29** *(0.23)* | **2.31** *(0.39)* |
| **D** (n = 3) | *Mixed OM fabrics (from l'Esquerda site)* | **5.43** *(0.27)* | **0.05** *(0.01)* | **0.37** *(0.12)* | **2.11** *(0.37)* | **3.86** *(0.36)* | **0.39** *(0.18)* | **67.41** *(1.97)* | **17.70** *(1.37)* | **0.99** *(0.11)* | **1.49** *(0.26)* |
| **E1** (n = 2) | 24e - Fine Quartz and Feldspar (Clay Lumps) | **5.99** *(0.26)* | **0.11** *(0.03)* | **0.71** *(0.01)* | **1.15** *(0.04)* | **2.96** *(0.43)* | **0.42** *(0.44)* | **70.09** *(2.50)* | **16.63** *(1.71)* | **1.42** *(0.57)* | **0.41** *(0.01)* |
| **E2** (n = 2) | 24e - Fine Quartz and Feldspar (Clay Mixing) | **6.19** *(0.04)* | **0.10** *(0.01)* | **0.74** *(0.04)* | **2.19** *(0.09)* | **3.21** *(0.01)* | **0.20** *(0.08)* | **67.91** *(0.50)* | **17.47** *(0.56)* | **1.26** *(0.14)* | **0.56** *(0.08)* |
| **E3** (n = 4) | 24c - Coarse Quartz, Feldspar and Sandy Marl | **5.83** *(0.29)* | **0.11** *(0.01)* | **0.67** *(0.04)* | **2.64** *(0.24)* | **2.70** *(0.07)* | **0.49** *(0.33)* | **70.49** *(0.37)* | **15.26** *(0.26)* | **1.25** *(0.22)* | **0.44** *(0.05)* |
| **G1** (n = 4) | 28b - Coarse sand with quartz, pellets and rock fragments | **6.31** *(0.14)* | **0.09** *(0.02)* | **0.78** *(0.01)* | **3.24** *(1.19)* | **3.73** *(0.16)* | **0.11** *(0.01)* | **62.44** *(1.69)* | **20.76** *(0.36)* | **1.60** *(0.08)* | **0.77** *(0.15)* |
| **G2a** (n = 3) | 46 - Very Fine Quartz (non-calcareous) | **5.93** *(0.45)* | **0.07** *(0.01)* | **0.92** *(0.09)* | **1.25** *(0.31)* | **3.13** *(0.28)* | **0.17** *(0.03)* | **67.02** *(1.82)* | **18.58** *(0.80)* | **1.20** *(0.05)* | **1.52** *(0.19)* |
| **G2b** (n = 7) | *Mixed OM fabrics (from Les Gavarres and Barcelona)* | **6.73** *(0.57)* | **0.09** *(0.02)* | **0.92** *(0.09)* | **1.08** *(0.16)* | **3.65** *(0.15)* | **0.15** *(0.06)* | **63.89** *(1.76)* | **20.70** *(0.90)* | **1.44** *(0.16)* | **1.17** *(0.20)* |
| **G3** (n = 4) | *Mixed OM fabrics (from Les Gavarres and Barcelona)* | **6.67** *(0.23)* | **0.07** *(0.02)* | **0.96** *(0.05)* | **0.80** *(0.17)* | **3.63** *(0.15)* | **0.16** *(0.04)* | **65.47** *(1.77)* | **20.34** *(1.27)* | **1.14** *(0.06)* | **0.60** *(0.16)* |
| **G4a** (n = 2) | 53 - Metamorphic with pellets and lumps (clay mixing) | **7.70** *(0.05)* | **0.08** *(0.01)* | **0.89** *(0.06)* | **1.37** *(0.04)* | **3.18** *(0.10)* | **0.23** *(0.18)* | **62.16** *(0.35)* | **21.42** *(0.52)* | **1.88** *(0.02)* | **0.91** *(0.04)* |
| **G4b** (n = 2) | 52 - Fine Fabric with Rare Marl and Organic Matter | **4.73** *(0.06)* | **0.04** *(0.00)* | **0.83** *(0.01)* | **1.00** *(0.18)* | **4.27** *(0.05)* | **0.08** *(0.01)* | **66.47** *(0.09)* | **20.55** *(0.14)* | **1.19** *(0.01)* | **0.67** *(0.02)* |
| **C1** (n = 9) | 20c - Coarse Metamorphic | **5.80** *(0.25)* | **0.03** *(0.01)* | **0.67** *(0.10)* | **1.02** *(0.23)* | **2.63** *(0.31)* | **0.16** *(0.11)* | **71.39** *(1.52)* | **16.52** *(1.10)* | **1.18** *(0.12)* | **0.39** *(0.12)* |

| | Ba | Ce | Cr | Cu | Ga | Nb | Ni | Pb | Rb | Sr | Th | V | Y | Zn | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** | **708** *(7.78)* | **77** *(0.00)* | **77** *(2.83)* | **39** *(1.41)* | **22** *(3.54)* | **23** *(0.71)* | **40** *(0.71)* | **42** *(3.54)* | **161** *(6.36)* | **241** *(39.60)* | **21** *(0.71)* | **131** *(0.71)* | **29** *(1.41)* | **122** *(0.00)* | **149** *(1.41)* |
| **A2** | **1422** *(51.62)* | **79** *(2.12)* | **67** *(3.54)* | **25** *(7.78)* | **19** *(0.71)* | **22** *(0.00)* | **34** *(0.71)* | **28** *(2.83)* | **146** *(4.95)* | **383** *(140.01)* | **23** *(0.71)* | **110** *(6.36)* | **30** *(0.71)* | **109** *(4.24)* | **169** *(5.66)* |
| **F** | **595** *(15.56)* | **113** *(11.31)* | **57** *(17.68)* | **3** *(0.00)* | **25** *(2.12)* | **25** *(2.12)* | **22** *(13.44)* | **27** *(1.41)* | **165** *(38.89)* | **92** *(19.09)* | **22** *(0.00)* | **95** *(7.07)* | **42** *(4.95)* | **74** *(19.80)* | **242** *(33.94)* |
| **B** | **839** *(112.30)* | **97** *(15.52)* | **29** *(6.10)* | **16** *(9.23)* | **22** *(1.22)* | **19** *(1.10)* | **8** *(4.93)* | **26** *(6.06)* | **115** *(7.01)* | **180** *(17.33)* | **21** *(1.82)* | **83** *(18.37)* | **30** *(3.35)* | **80** *(21.90)* | **184** *(25.71)* |
| **D** | **989** *(200.85)* | **54** *(1.53)* | **66** *(1.73)* | **22** *(3.06)* | **21** *(1.53)* | **16** *(2.00)* | **30** *(1.15)* | **76** *(57.95)* | **150** *(8.96)* | **177** *(40.29)* | **16** *(1.53)* | **102** *(7.37)* | **29** *(2.52)* | **80** *(7.81)* | **121** *(38.97)* |
| **E1** | **430** *(28.99)* | **99** *(14.85)* | **81** *(6.36)* | **17** *(0.71)* | **22** *(3.54)* | **21** *(0.71)* | **37** *(4.95)* | **25** *(4.95)* | **126** *(22.63)* | **81** *(12.02)* | **18** *(1.41)* | **106** *(7.78)* | **35** *(2.83)* | **71** *(14.14)* | **211** *(9.90)* |
| **E2** | **572** *(23.33)* | **94** *(0.71)* | **69** *(1.41)* | **20** *(1.41)* | **22** *(1.41)* | **21** *(0.00)* | **36** *(2.83)* | **27** *(5.66)* | **140** *(3.54)* | **91** *(10.61)* | **18** *(0.71)* | **118** *(0.71)* | **32** *(2.83)* | **85** *(3.54)* | **199** *(4.24)* |
| **E3** | **429** *(38.17)* | **90** *(6.76)* | **71** *(1.50)* | **20** *(4.03)* | **18** *(0.50)* | **20** *(0.82)* | **36** *(1.50)* | **23** *(1.15)* | **117** *(0.96)* | **92** *(14.21)* | **17** *(0.50)* | **105** *(7.51)* | **36** *(2.16)* | **68** *(1.73)* | **201** *(12.84)* |
| **G1** | **692** *(37.30)* | **102** *(3.70)* | **77** *(12.57)* | **17** *(3.56)* | **29** *(0.58)* | **26** *(1.83)* | **30** *(2.45)* | **31** *(5.44)* | **193** *(8.42)* | **117** *(11.90)* | **22** *(1.41)* | **112** *(3.37)* | **34** *(1.71)* | **117** *(5.56)* | **126** *(9.71)* |
| **G2a** | **659** *(81.13)* | **123** *(3.00)* | **59** *(16.29)* | **12** *(3.21)* | **24** *(2.52)* | **28** *(4.36)* | **21** *(2.31)* | **129** *(128.94)* | **154** *(23.97)* | **103** *(5.57)* | **25** *(1.00)* | **98** *(9.29)* | **44** *(2.00)* | **69** *(17.95)* | **232** *(23.69)* |
| **G2b** | **680** *(27.21)* | **136** *(13.52)* | **65** *(5.71)* | **17** *(2.64)* | **28** *(1.68)* | **28** *(2.98)* | **27** *(1.73)* | **41** *(7.14)* | **187** *(14.51)* | **103** *(6.73)* | **27** *(2.48)* | **119** *(8.36)* | **42** *(4.57)* | **118** *(16.92)* | **145** *(25.26)* |
| **G3** | **639** *(73.65)* | **118** *(8.42)* | **66** *(1.00)* | **12** *(2.16)* | **27** *(2.06)* | **28** *(3.10)* | **28** *(0.96)* | **34** *(8.42)* | **195** *(9.63)* | **78** *(6.86)* | **23** *(1.00)* | **106** *(3.87)* | **42** *(2.50)* | **102** *(10.24)* | **203** *(39.63)* |
| **G4a** | **950** *(41.01)* | **104** *(8.49)* | **74** *(5.66)* | **38** *(0.00)* | **27** *(0.71)* | **23** *(0.71)* | **44** *(11.31)* | **41** *(17.68)* | **147** *(2.12)* | **124** *(16.97)* | **21** *(0.71)* | **128** *(4.24)* | **35** *(2.83)* | **90** *(2.12)* | **182** *(2.12)* |
| **G4b** | **872** *(2.83)* | **89** *(0.71)* | **69** *(0.00)* | **25** *(1.41)* | **28** *(0.00)* | **25** *(0.71)* | **32** *(0.00)* | **55** *(1.41)* | **200** *(4.95)* | **108** *(0.71)* | **21** *(0.71)* | **108** *(2.83)* | **36** *(0.71)* | **131** *(0.71)* | **198** *(2.12)* |
| **C1** | **1059** *(348.20)* | **82** *(20.55)* | **54** *(14.11)* | **30** *(10.46)* | **22** *(2.55)* | **21** *(1.88)* | **28** *(7.43)* | **19** *(6.04)* | **114** *(13.17)* | **87** *(18.75)* | **18** *(1.99)* | **101** *(13.24)* | **28** *(4.58)* | **35** *(9.53)* | **242** *(43.77)* |

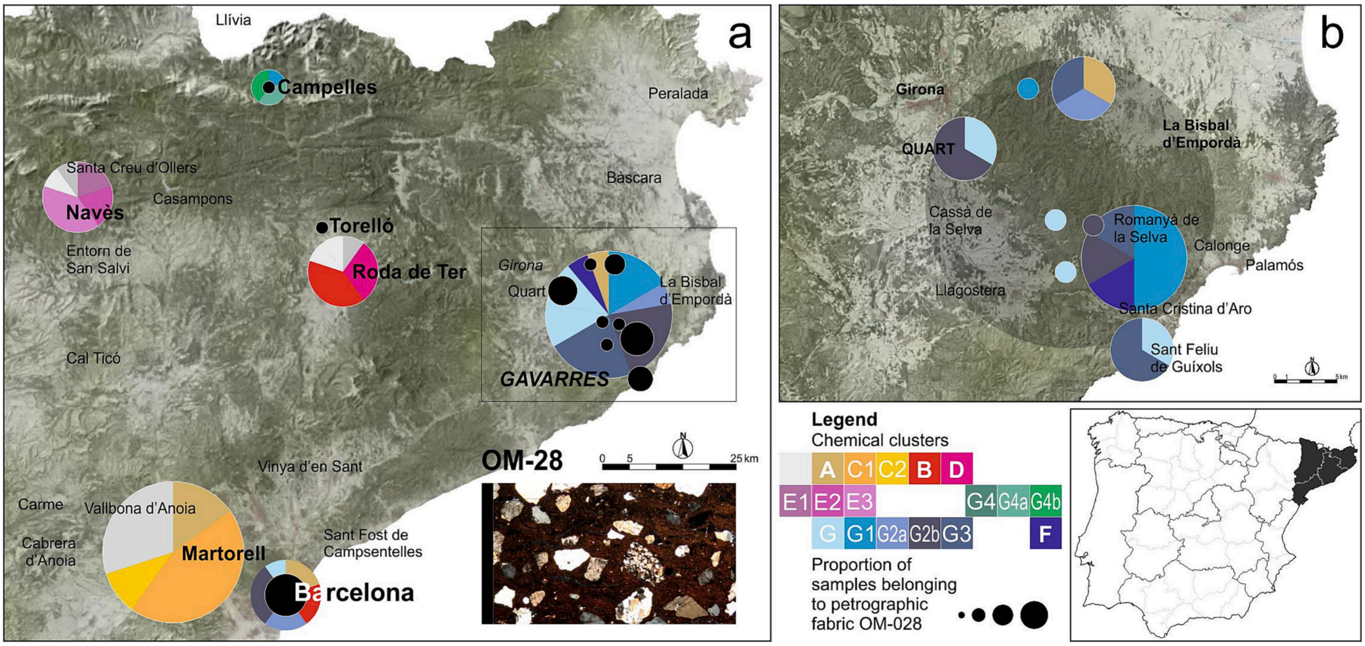


**Fig. 6.** Distribution map of identified groups (a) and detail of the Gavarres area (b). The proportion of samples attributed to the different fabrics at each location is represented as pie charts. The diameter of these is proportional to the number of samples at each site. The distribution of fabric MO-028 (regardless of the variants) is represented with black dots sized according to the proportion of samples as well.

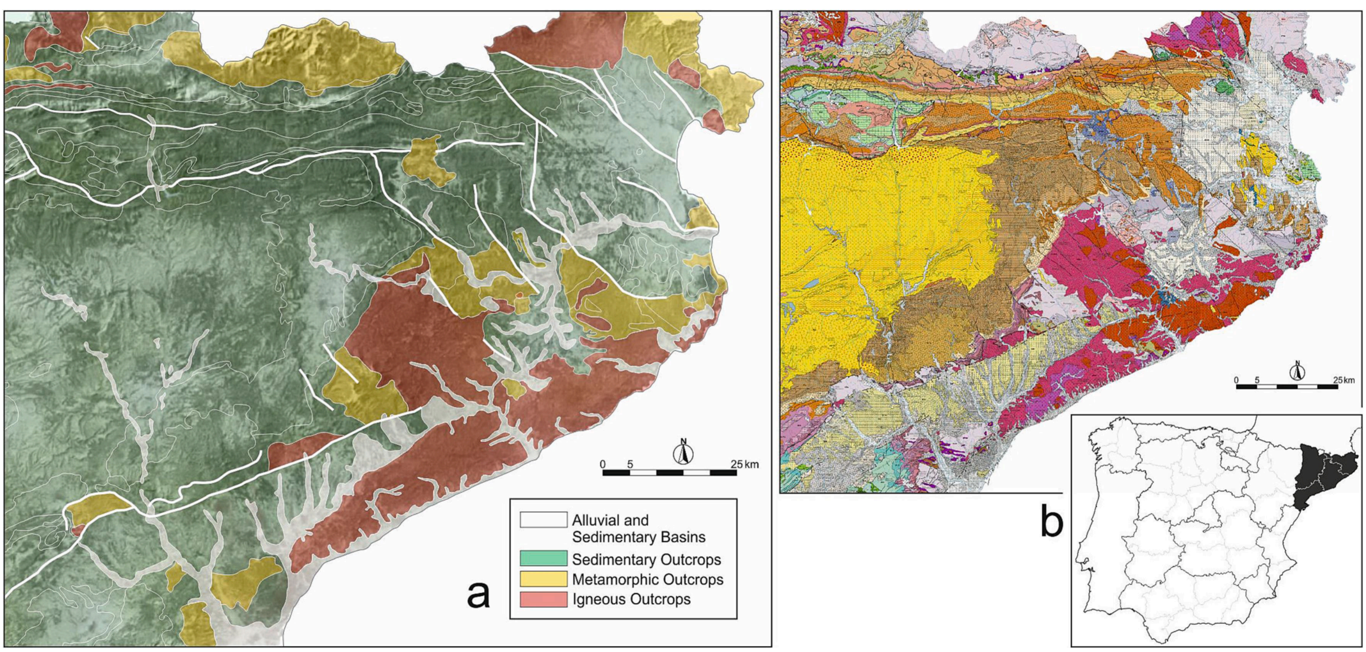


**Fig. 7.** Geological map of the studied area. Synthetic lithological map indicating the extension of the sedimentary, igneous and metamorphic outcrops (a), and detailed geology as provided by the Institut Cartogràfic de Catalunya in its 1:250000 geological map (b). Detailed map and legend are available online (access date: 07/02/2025).

Ni, Rb, and V are considerably lower compared to most other groups. As shown in Fig. 3, samples GR133, GR181, GR106, and GR169 are the only ones selected from their respective petrographic fabrics (Table 2). Petrographic evidence suggests that this group warrants further discussion. Additionally, note the relatively high standard deviation for some of the mean percentage values of major elements ($Fe_2O_3$: $\sigma = 0.94$, $SiO_2$: $\sigma = 1.36$), compared to other groups within the dataset. The mean $Na_2O$ percentage is also notably high (2.31 %), despite the substantial standard deviation ($\sigma = 2.31$), which is mostly due to the petrographic differences between fabrics, including granite or granodiorite inclusions, more or less acidic and with considerable variation among the plagioclase content.

Except for a few outliers (GR272, GR273, GR285, and GR287), most of the samples from the Coarse Metamorphic Fabric found at the town of Martorell are included within chemical group C. The core of this group (C1) is characterized by distinctive singularities in the major element values. The samples display the lowest percentages of MnO, $TiO_2$, $K_2O$, and $Na_2O$, while the $SiO_2$ percentage is the highest. Despite the large number of samples included (n = 9), which is the highest in the dataset, the standard deviation for most elements means remains relatively low (Table 4). Ba content is notably high, or very high, in most of the samples (Picon, 1987), a common feature for a subgroup from this location, which might be due to the particular geology of the site, rich in barite cements covering the underlying sediments (Gimeno et al., 1988, Tritlla & Cardellach, 1988, Calvet et al., 2000: 26).

Groups D and E include samples from two different sites —L'Esquerda (Roda de Ter) (n = 3) and Sant Pere de Graudescales (Navès) (n = 6)— despite some differences in their petrographic features. Samples in group D exhibit the lowest value for MgO, as well as very low values for some trace elements (Ce, Nb, and Th), while Cu content is the highest in the dataset. Group E, on the other hand, includes samples with the highest content of MnO (0.10–0.11 %) and the lowest values of $Al_2O_3$ (15–16 %) among the major elements. In terms of trace elements, barium content is relatively low (430–570 ppm), as well as Rb, Sr, and Y. According to the CA (Fig. 4), subtle differences in the chemical composition of the samples, correlated with their petrographic features, allowed us to divide the group into subgroups E1, E2, and E3 (Table 4), the significance of which will be discussed in the following section. While the major elements are quite similar across the subgroups, except for CaO (where E1 = 1.15 % is the lowest value), a detailed examination of the trace elements supports the decision to consider these as separate subgroups. The content of Cu, Ga, Nb, Ni, Sr, and Th accounts for the differences, with low values for the standard deviation in all three subgroups.

Group F includes two samples (GR438 and GR406) found at different sites but sharing almost identical chemical compositions, shapes, and OM fabrics, which highlights the significance of this cluster. The most relevant chemical features of this group are their very low values of CaO (0.68–0.73 %) and MgO (0.06–0.08 %), as well as the low or very low values of some trace elements (Ba, Cu, and V).

Group G includes a considerable number of samples (n = 27) classified within the Quartz and Feldspar OM Fabrics. This cluster comprises most samples from Les Gavarres and Campelles, along with some samples from Barcelona. A detailed examination of their composition, the correlation between potential subgroups and petrographic fabrics, and the degree of similarity between samples, allowed us to subdivide group G into four subgroups, each showing some variation. While subgroups G1, G2, and G3 include samples from Les Gavarres and Barcelona, most samples from Campelles are grouped in G4. The latter exhibits the greatest differences in $Fe_2O_3$ and several trace elements (especially Ba, Ce, Cu, Nb, Ni, and Rb), while subgroups G1, G2, and G3 show greater internal homogeneity in terms of elemental composition, particularly regarding trace elements.

Subgroup G1 includes samples GR146, GR435, GR374, and GR436, found in the Les Gavarres area and Campelles (sample GR146). All these samples belong to fabric *28b – Coarse sand with quartz, pellets, and rock fragments*. Compared to other samples in group G, these have the highest percentages of CaO, $K_2O$, and MgO, with no significant differences in trace elements, except for Cr, which has the highest value within the cluster (Cr = 77 ppm), and Y, which has the lowest value (Y = 34 ppm). Subgroups G2 and G3 form the core of the cluster. The chemical signatures of all samples in these subgroups are very similar, but the correlation between some of the minor variants (G2a, G2b, and G3) with different OM fabrics, paste textures, and sites of origin suggests the existence of distinct workshops, as will be discussed in the next section. Additionally, splitting these subgroups revealed chemical differences in major elements such as $SiO_2$, $Al_2O_3$, and $Fe_2O_3$, particularly between variants G2a and G2b. The same holds true for group G4, where variants G4a and G4b show differences in both major and trace elements when considered separately (Fig. 4). As observed in the previous subgroups, $Na_2O$ values contribute significantly to explaining the differences between variants within the cluster in relation to feldspar content.

## 4. Discussion

The results of the 74 samples analyzed confirm a significant correlation between petrographic classification and the geochemical composition of the defined groups. To establish the archaeological significance of these groups a further step requires evaluating them using the available archaeological information and the typological characteristics of the samples within the broader framework of greyware pottery production in Catalonia. This section will discuss the findings in terms of provenance, technological practices, and a diachronic perspective on the evolution of greyware pottery production, emphasizing elements of continuity and change.

We analysed the distribution of samples across groups based on the sites where they were found (Fig. 6) and compared these findings with geological maps of the region to interpret their provenance. Catalonia's diverse geology includes outcrops of varied origins and characteristics. While sedimentary basins dominate the landscape, igneous formations are found along the coastal area between Barcelona and the Les Gavarres region. Additionally, many metamorphic outcrops are located within a corridor along the pre-coastal mountain range, where slight contact metamorphism has occurred (Fig. 7).

Samples classified within the calcareous chemical group A were recovered from Martorell, Barcelona, and a single site —El Molí d'en Verai (La Pera)— in the Les Gavarres area. However, sufficient chemical differences exist among these samples to warrant their division into separate groups: A1 in Barcelona, A2 in Martorell, and GR375 as an outlier in correlation with their petrography.

While all the Granitic OM Fabrics cluster within chemical group B, a detailed examination of their features suggests treating them as distinct groups. Most granitic samples were found in Roda de Ter and Barcelona, the closest locations to the igneous formations of the northern coastal region of Catalonia. Relevant parallels for these granitic fabrics are found in the literature on late antique greyware vessels from the Barcelona hinterland (Buxeda and Cau, 2005, Riutort et al., 2018), which interpret them as local products —a plausible explanation for our granitic samples as well. Sample GR909 stands out as an outlier of the granitic fabric found in Martorell. Previous studies (Travé et al., 2016) linked the arrival of pottery displaying granitic fabrics in Martorell to supplies from the nearby kiln site of Cabrera d'Anoia, located a few kilometres to the west.

Geochemical groups C, D, and E show a strong correlation with the place where the ceramics were found. Metamorphic fabrics from group C are exclusively found in Martorell, while samples in groups D and E were recovered from Roda de Ter and Navès, respectively. Chronological differences also characterize these assemblages: samples from Roda de Ter are the earliest, dating to the 7th–9th centuries, whereas those from Navès belong to a later period (12th century). Notably, the samples investigated in Martorell originate from two different sites and contexts of varying chronology (Table 1). Despite this, their petrographic features and elemental compositions exhibit no significant differences, suggesting the enduring nature of a local production tradition over time.

As highlighted in the results section, samples in groups D and E explain regional circuits based on the local character of the products. Despite having very few samples from the monastery of Sant Pere de Graudescales, in Navès (group D) and from the site of l'Esquerda (Roda de Ter) (Group E), a detailed petrographic examination suggests the presence of distinct workshops producing locally, as evidenced by the technological variations that justify distinctions (Travé et al., 2024a) such as those between groups E1, E2, and E3. In this regard, ceramic petrography proves invaluable as a cost-effective initial approach to studying these coarse ceramics. Additionally, the petrographic resolution achieved for the broader assemblage (n = 291) is notably high, underscoring the method's effectiveness.

The classification within chemical cluster G presents a more complex overview that requires careful interpretation. While group G4 shares geochemical similarities with the rest of the cluster, it stands out due to its samples from the northern site of Campelles, where the main characteristics of local products (G4a and G4b) have been investigated via OM and published elsewhere (Pratdesaba & Travé, 2024). These local fabrics are related to the use of nearby raw materials, processed in different ways —occasionally incorporating organic matter or preparing specific paste recipes by mixing clays— likely reflecting the presence of different workshops in the area. In contrast, the remaining groups (G1, G2, and G3) include four OM fabrics, that are primarily finer or coarser and that are variations of pastes with similar compositions found at various sites, including the town of Quart. While the main assemblage comes from Les Gavarres, samples from Barcelona and Campelles are also present. Group G3 consists exclusively of samples from Les Gavarres with mostly coarser pastes, while samples in subgroup G2 have been found at different sites. Despite the chemical signature of samples from G2 being very similar, petrographic differences between the fine and coarse pastes allowed us to distinguish variants G2a and G2b. All the samples included in chemical group G belong to modern greyware pottery dating from the 17th century onwards. During this period, Quart and La Bisbal (see their locations in Figs. 1 and 6) were the primary centres of production in the Les Gavarres region. Quart has had a strong tradition of greyware pottery production since at least the 14th century, when it was already a well-established craft and first mentioned in archival sources. Greyware pottery was not produced in La Bisbal until around CE 1800, when a potter from Quart relocated there and established a workshop, continuing the tradition of his family's craft. The study of greyware production in La Bisbal is still ongoing, but when compared to pottery from Quart, the main macroscopic difference lies in the texture: Quart greyware is rougher and coarser, while La Bisbal greyware is made from a notably finer paste. Whether the fine calcareous sample (GR375) found near La Bisbal was produced there remains uncertain in the current context.

Nevertheless, the coarse sand-tempered fabrics (OM-28, described in Table 2) are widespread in the region and can confidently be attributed to the workshops of Quart. The petrographic and chemical variation among these samples can be explained by the presence of nearly thirty workshops operating from the 16th to the 19th centuries in the town. These workshops exploited the same raw material sources but developed their own distinct paste recipes, which accounts for the slight differences observed between groups G1, G2 (with finer and coarser variants G2a and G2b, respectively), and G3 —likely corresponding to different workshops within Quart. The chemistry of the samples GR064 and GR081 aligns closely with subgroup G2a, though they differ in petrography, belonging to well-defined petrographic groups found at other locations. While we lack a plausible explanation for these anomalies, the fact that they are the only samples selected from their respective petrographic fabrics may reduce their impact on the general assemblage.

Despite this discrepancy, the strong correlation between the coarse and fine petrographic fabrics from Les Gavarres and the chemical composition of the other samples in these geochemical groups supports the interpretation of groups G1, G2, and G3 as local products from Quart. Moreover, most of these samples are wash basins, which remain a signature vessel type produced in the town to this day. The most significant finding of this study is that these products were not confined to a small regional area but reached broader distances across Catalonia, explaining their presence in places like Campelles and Barcelona (Fig. 6). The high quality of Quart's vessels, along with the effective guild organization in the town, made its potters highly competitive during the modern era. This interpretation also applies to chemical group F, which includes only two samples (GR406 and GR438), found in Torelló and Les Gavarres, respectively. The distinction between these two wash basin sherds in group F and those in group G lies in their chronology. Both are contemporary products from the 20th century, while the samples in group G date to the modern era. Therefore, the enduring popularity of these products aligns with an evolution of techniques —specifically, the refinement of pastes over the centuries— and minor adjustments in raw material procurement areas within the same regions.

## 5. Concluding remarks

This study provides a comprehensive assessment of greyware pottery production in Catalonia over a broad timespan, integrating petrographic and geochemical analyses. The results reveal the existence of well-established regional products and distribution routes that persisted throughout the medieval and modern periods. While these products were predominantly local, the data indicate an internal circulation of goods—especially in the modern era—that extends beyond the idea of strictly localized, seasonal, or complementary agricultural activities. Within this regional framework, a network of workshops supplying everyday vessels to nearby populations can be observed, alongside a smaller yet significant movement of products from long-standing production centres reaching greater distances. One of the most notable findings is the first archaeometric evidence confirming that greyware pottery produced in the Les Gavarres area—particularly from Quart—was already reaching the city of Barcelona as early as the 15th century.

The study highlights the strong correlation between petrographic classification and geochemical clustering, further validating the accuracy of petrographic groupings and confirming the presence of technological variations that likely correspond to different workshops. The variety observed within granitic fabrics—common among Catalonian medieval coarse wares—demonstrates the need to consider both petrographic and geochemical nuances when interpreting variations within seemingly homogeneous groups. Similarly, the analysis of quartz and feldspar fabrics in clusters G and F reveals not only chemical differences but also textural and compositional variability, suggesting the presence of multiple workshops within production centres like Quart. These differences illustrate how specific workshops developed their own recipes and techniques, reflecting both deeply rooted traditions and broader distribution networks. The evolution observed in group F, representing 20th-century wash basins, further demonstrates the refinement of pottery-making techniques over time, while maintaining the enduring appeal of these products.

While the combined petrographic and geochemical data provide strong support for identifying production centres and possible workshop signatures, we acknowledge that the absence of direct archaeological evidence—such as kilns or workshop debris—limits full confirmation of these attributions. Alternative explanations, such as shared technological practices among neighbouring workshops or parallel developments in similar geological settings, remain plausible. Nonetheless, several interpretations are reinforced by contextual data: for example, the presence of Quart products in 15th-century Barcelona aligns with historical records of guild activity and expanding regional trade networks, while the consistent fabric signatures in Martorell across different contexts suggest a long-lived local production tradition.

This study underscores the strong regional continuity in greyware pottery production and distribution, but the results also offer valuable potential for identifying patterns of mobility and exchange. The presence of Les Gavarres products in 15th-century Barcelona, for example, reflects not only established regional trade circuits but also the movement of goods over considerable distances, indicating dynamic interaction spheres beyond local boundaries starting at the end of the Middle Ages. Recognizing these aspects enhances our understanding of the social and economic networks underpinning pottery production and circulation, illustrating a more nuanced picture of medieval and modern Catalonian communities that encompasses both stability and mobility.

The strategic selection of samples based on petrographic classification has proven to be a valuable method for optimizing analytical resources and ensuring a meaningful representation of the assemblage. Given the high degree of homogeneity in greyware pottery, as well as its local character and frequent occurrence in excavations, random or non-systematic sampling methods as was traditionally the case often struggle to provide representative datasets. Our approach—combining macroscopic observations with a detailed petrographic characterization of a large number of samples—has proven highly effective for selecting relevant samples for further analyses, such as XRF. Future research should aim to integrate this methodological feedback into fieldwork and macroscopic classification during inventory phases. This would allow for more precise sample selection in future studies, maximizing the efficiency of analytical work and optimizing the allocation of research budgets dedicated to ceramic characterization.

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**CRediT authorship contribution statement**

**Esther Travé Allepuz:** Writing – original draft, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Evanthia Tsantini:** Writing – review & editing, Visualization, Investigation, Formal analysis. **Leandro Fantuzzi:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Karen Álvaro:** Writing – review & editing, Investigation, Data curation. **Miguel Ángel Cau Ontiveros:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

**Data availability**

All data included in this research are provided through text and tables

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