Studies in Heritage Glazed Ceramics

The majolica azulejo heritage of *Quinta da Bacalhôa*

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PREFACE

Studies in Heritage Glazed Ceramics was forcefully interrupted for almost two years due to the COVID-19 crisis, but returns with its third number, the first of a special series of four volumes dedicated to the renaissance majolica azulejo heritage of *Palácio e Quinta da Bacalhôa* in Azeitão, Portugal.

The azulejos of Bacalhôa have a legendary status in the studies of renaissance majolica in the Iberian Peninsula in general, because of their extraordinary variety and quality and the fact that its most mythical panel, representing the biblical episode of *Susanna and the Elders*, is dated "1565" – a chronology hardly compatible with the then-recent production of azulejos in Portugal. Several hypotheses were advanced over the years to cope with this seemingly impossibility, almost always involving Flemish potters immigrated to the Peninsula.

Another problem stems from the assortment of patterned tiles, often depicting variations in the design or the quality of the workmanship only explainable by the involvement of, not one, but several workshops… But what could those workshops be? Who were the potters and painters behind such artistic achievement? What is the approximate chronology of the different (non-dated) panels and linings with patterned tiles? And most of all: how does the unrivalled treasure of renaissance tiles of Bacalhôa fit within the history of the diffusion of the majolica technology and its firm establishment in Spain and Portugal, where azulejos developed to become a cultural trait still flourishing today?

Following the studies in the early production of majolica azulejos in Portugal, published in the first two numbers of this journal, a multidisciplinary research team was formed to try and reply (within the bounds of the possible) to those questions, as well as to shed light on a number of other perplexing details related to the surviving panels. The research lasted for two years and the results will be published in a dedicated special series. This first volume includes four articles which deal with the basic issues and establish the basis for the detailed study of the panels and patterned tiles that will follow. Four more articles will be published in the second volume, in January 2022, and the last eight articles will be published in the third and fourth volumes within the following 12 months.

The scientific production stands on several pillars, one of them the peer-reviewers of the authors' papers, whose names are often unknown but whose importance in the final output is singular. The editors wish to heartily thank the reviewers for this number: Professor Nuno Senos of *Instituto de História da Arte* of *Universidade Nova de Lisboa*, Doctor Alexandre Nobre Pais, Director of *Museu Nacional do Azulejo* and Doctor António dos Santos Silva of *Laboratório Nacional de Engenharia Civil* (LNEC) who have graciously accepted the hardship of the revisions.

LNEC thus presents this third number of its journal dedicated to azulejos and other glazed ceramics with a set of articles resulting from the cooperation of the tools of Humanities and Natural Sciences aiming to support in solid foundations the study and understanding of one of today's most prized cultural heritages of Portugal.

The Editors

EDITORS

SCOPE

Studies in Heritage Glazed Ceramics is dedicated to the results of scientific studies in the field with a particular emphasis on analytical results, conservation issues and historical studies and very specially to multidisciplinary research in the domain.

The contents will include:

- Archaeometry studies, namely the application of analytic methods to the identification of materials and the establishment of technologies, provenance or the setting of chronologies;
- The artistic and historical context of productions, materials and evolving technologies, as well as the origin, preparation and trade routes of pigments and other raw materials;
- Decay of glazed ceramics, techniques and materials for conservation;
- Other innovative research results in the field.

The 16th century majolica azulejo heritage of *Palácio e Quinta da Bacalhôa*: imported panels and tiles

João Manuel Mimoso, Alfonso Pleguezuelo, Maria Augusta Antunes, Ángel Sanchez-Cabezudo, Sílvia Pereira, Dória Costa, Álvaro Silva

ABSTRACT

Although the chronology of the tiling of the Pleasure House of Bacalhôa with majolica azulejos was always known to be around 1565, given the date inscribed in the panel representing the biblical episode of Susanna and the Elders, their provenance as well as the authorship of the figurative panels, remained clouded and open to personal opinion.

A previous analytical study of the main panels and linings with patterned tiles of Bacalhôa concluded that some of them could not be ascribed to the workshops of Lisbon at that chronology, differing in terms of glaze and biscuit compositions and micro-morphology, suggesting that they may have been imported.

The present paper presents a detailed study of those presumably imported panels and patterned tiles, firstly setting a reference based on the micro-morphological and analytical characteristics of the two panels depicting coats of arms, and then comparing the remaining items with them to verify whether they may be clustered together. Finally, their possible provenance is discussed.

RESUMO

Embora a data "1565", inscrita no painel que representa o episódio bíblico de Susana e os Velhos, tenha sido sempre aceite como referência aproximada para a cronologia dos revestimentos da Casa de Prazer da Bacalhôa com azulejos de faiança, a sua proveniência, bem como a autoria dos painéis figurativos, permaneceu obscura e aberta a opiniões pessoais.

Anteriormente foi realizado um estudo analítico dos principais painéis e azulejos de padronagem existentes na Bacalhôa, tendo-se concluído que alguns deles não podiam ser atribuídos às oficinas de Lisboa nesta época, diferindo das produções locais, tanto na composição e micro-morfologia do vidrado, como na argila utilizada para a fabricação das chacotas. Assim, deduziu-se que teriam provavelmente sido importados.

O presente trabalho apresenta um estudo detalhado desses painéis e azulejos de padrão que terão sido importados, começando por estabelecer um quadro referencial com base em dois dos painéis que representam brasões, com os quais os restantes casos são depois comparados para determinar se todos podem ser agregados num único grupo. Finalmente discute-se a sua possível proveniência.

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KEYWORDS: Renaissance majolica; Palace of Bacalhôa; Portuguese azulejos; Jan Floris; Juan Flores

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Our sincere thanks to Reverend Father Nicolás Rivero Porras of Garrovillas de Alconétar (Cáceres) and to Reverend Father Roberto Rubio Domínguez of Cañaveral (Cáceres) for receiving us and allowing the sampling of tiles at, respectively, the Church of Saint Peter and the Church of Saint Marina.

We thank *Museu Nacional do Azulejo* in Lisbon for authorization to use samples from their collections (identified as Az032, Az040, Az306, Az338 and Az345) as well as *Igreja da Graça* in Lisbon (Az013).

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1. INTRODUCTION

The palace and gardens presently known as *Bacalhôa*, in Vila Fresca de Azeitão (35 km SE of Lisbon), were acquired by Brás [Afonso] de Albuquerque in 1528 (all historical references to Bacalhôa or Albuquerque stem from [1]). The new owner modernized the extant palace and added a number of annexes. The date "1554", inscribed over the entrance gate, dates the completion of the work at the palace, while the Pleasure House by the lake and the other annexes were probably built shortly afterwards.

Brás [Afonso] de Albuquerque died in 1581 after which judicial disputes for the property ensued, finally settled in 1609. The dates "1554" and "1581" thus set chronological limits to the 16th century majolica azulejo linings of the palace and the fully tiled Pleasure House which is decorated with an unrivalled profusion of renaissance majolica azulejos, both patterned linings of often unique designs skirted by friezes of *grotteschi*, and figurative panels representing the Albuquerque coat of arms and scenes of biblical or mythological inspiration.

The third and central room of the Pleasure House is decorated with three different panels, one of which - *Susanna and the Elders* - has the date "1565" inscribed (Figure 1). This date probably refers to the completion of the panel but most of the majolica linings, particularly of this pavilion, are presumed to have been made around that time.

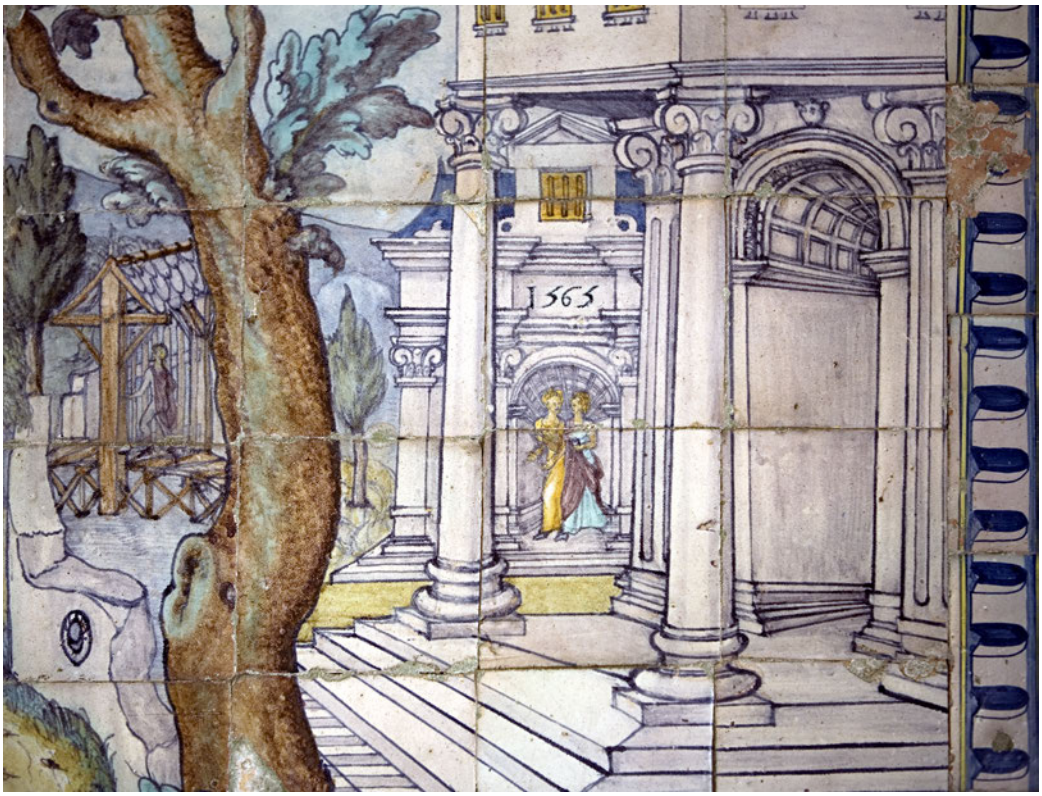

Figure 1. The date "1565" over a portal in *Susanna and the Elders* (image © Associação de Colecções | The Berardo Collection).

From a previous study [2], we know what to expect, in terms of composition and glaze morphology, from the known productions of the workshops of Lisbon from the 1560s until after 1580. Guided by the well-grounded hypothesis on the date of the main majolica panels and patterned linings of Bacalhôa, we did a first analytical study [3] and concluded that they could be systematized in groups, one of which could not be ascribed to what is known from the workshops of Lisbon at this time, differing in terms of glaze and biscuit morphologies and compositions. Accordingly, we concluded that these panels and patterned tiles had likely been imported into Portugal. This paper presents the results of a research on them.

The second and fourth rooms of the Pleasure House are decorated with Hispano-Moresque tiles of an exclusive design (known as *Bacalhôa pattern*), in the midst of which were once applied two equally-sized panels, of which only one, an attractive scroll cartouche with the Albuquerque coat of arms, survives today (Figure 2). This was the main panel which our preliminary study of Bacalhôa concluded to be likely of non-Portuguese origin. The dated *Susanna and the Elders* does not belong to this group [3] and will be dealt with in a separate article.

Since we do not have an "anchor", a panel of known provenance and chronology to serve as a comparison reference, we shall firstly study the Albuquerque coat of arms together with its lost twin-panel, of which enough fragments are preserved at the Palácio da Bacalhôa Museum to show that it depicted also a coat of arms, that of Albuquerque's wife Maria de Noronha [1] (Figures 3 and 4). The results obtained were used as a reference against which all panels presumably imported were compared.

The substantial part of this paper is divided into three parts. In the first (Section 3) we study the Albuquerque and the Noronha coats of arms; in the second (Sections 4 and 5) we compare the other panels and patterned tiles with the coats of arms, to verify whether they may all be attributed to the same provenance; finally, in the third part (Section 6) we try to reply to the question: "what is the provenance of those imports?".

2. METHODS, INSTRUMENTAL MEANS AND SOFTWARE

Small samples were carefully removed from tiles with a scalpel, stabilized in chlorine-free epoxy resin, lapped and polished to obtain a flat cross-section for observation and analysis by scanning-electron microscopy coupled with an X-ray energy-dispersive spectrometer (SEM-EDS).

SEM observations and EDS analyses were made at LNEC using a TESCAN MIRA 3 field emission microscope combined with a BRUKER XFlash 6|30 EDS system. The samples were uncoated and the observations were made in backscattered electrons mode (BSE), with a chamber pressure of typically 10 Pa, at an accelerating voltage of 20 kV with the sample sections at a distance of 14 ± 1 mm from the detector. SEM images were typically acquired at magnifications of 350x and 700x for the glazes and ca. 3000x for the biscuits.

The selection of areas for EDS quantification avoided large inclusions in the glaze or biscuit representing more than ca. 5% of the full selected area. From our previous experience, the adequate minimum measurement areas are 200 x 200 μm for glazes and 500 x 500 μm for biscuits. In general, multiple measurements were made and in such case the results are averages. Whenever possible, the analyses were performed on white glazes to avoid interference from elements diffused from the blue, green or violet pigments which, when

present, were neglected. The yellow pigments remain at the surface and therefore do not present the same problem. Still, in the case of zinc-bearing yellow pigments, the analyses must be performed at a safe distance from the colour layer.

Having in view comparisons through log-based Principal Component Analysis (PCA), ancillary elements often representing less than 1% of the compositions, such as magnesium (Mg), titanium (Ti) and iron (Fe) in the glazes, as well as phosphorus (P), chlorine (Cl) and Ti in the biscuits were not included in the tables of results.

The presence of lead (Pb) is usually detected in the biscuits due to penetration of glaze. Its content was determined but not considered because it is not part of the natural composition of the biscuit and depends on the proximity to the interface. The presence of lead renders the quantification of sulphur (S) doubtful because of a superposition of spectral peaks and therefore it too was not considered. The quantification of tin (Sn) in the glazes may be problematic because the aggregation of crystals often results in a large variance. That problem was dealt with by using larger areas whenever aggregation was visually detected in the SEM images or, when that was not possible, averaging the results of multiple analyses on different areas.

The amount of oxygen (O) was calculated through the remaining elements stoichiometry of their most commonly considered oxides (Na_2O, MgO, Al_2O_3, SiO_2, K_2O, CaO, Fe_2O_3, SnO_2, PbO) and the result was normalized to 100 %.

PCAs of EDS results were made using the SPSS® software platform by IBM Analytics.

3. THE ALBUQUERQUE COAT OF ARMS AND RELATED ITEMS

3.1. Introduction

Because of their connection with the owners of the property, the most remarkable figurative panels of presumed foreign origin are the two coats of arms that decorated rooms 2 and 4 of the Pleasure House [1]. The preserved panel (Figure 2) has 5 x 9 tiles and depicts the Albuquerque coat of arms set in its center.

The cartouche is made up of scrolls and, as was customary in Flanders, it is designed in two different planes. The background plane is painted in blue from which protrude towards the viewer scrolled elements holding a flat yellow plate, making up the fore plane. This plate, from which twelve flower-shaped rivets and two faun masks stand out, contains the arms. The illusion of depth is accentuated by the shadows projected by an imaginary light source beyond the left side of the panel. This rigorous representation of shadows is one of the most significant features telling us that its author was an expert in perspective, a discipline that was studied to gain access to master status within the painters' guilds.

Unfortunately, the second coat of arms has been removed, broken and discarded and only an empty hollow remains today where it once stood (Figure 3). Of this second heraldic panel, only a few reasonably complete tiles and a number of fragments are preserved (Figure 4). These were fortuitously recovered during an excavation nearby, suggesting that the tiles were not removed whole for possible future re-assembly but rather broken

Figure 2. The Albuquerque Coat of Arms panel in room 2 of the Pleasure House, with its marginal frame (image © Associação de Colecções | The Berardo Collection).

Figure 3. The hollow of the lost Noronha Coat of Arms panel with part of its marginal frame still in place stands against a background of Bacalhôa pattern Hispano-Moresque tiles (image © Associação de Colecções | The Berardo Collection).

and discarded. From one of the fragments, depicting part of a crest, it was possible to determine that the Noronha coat of arms was originally represented [1]. Albeit few, the tiles and fragments still show that the cartouche was different from that of the preserved panel, although the design would be very similar in its Flemish style.

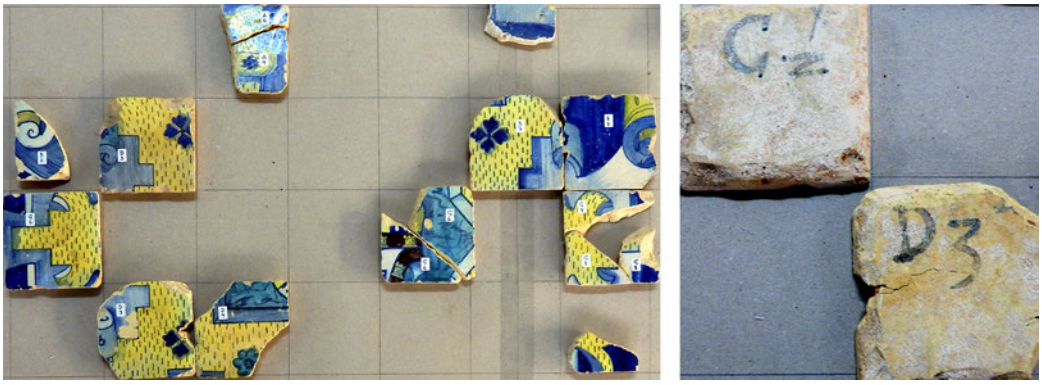

Figure 4. Fragments of the second coat of arms and backside markings (images © Associação de Colecções | The Berardo Collection).

The composition is difficult to retrieve due to the small area recovered. It would be somewhat different from the Albuquerque Coat of Arms panel since one of the tiles depicts the head of an eagle that does not appear in the preserved panel and, furthermore, the yellow background on which the four-leafed rivets are repeated, is not smooth, but striped with discontinuous lines, a graphic resource that imitates the etching that frequently nuances the shine of metals and, therefore, was reproduced in some fittings that simulated that material.

It is unknown when and why the panel was destroyed. Maybe it was removed when Brás [Afonso] de Albuquerque, widowed, re-married with Catharina de Menezes or it may also have been broken by order of his second wife after her husband passed away in 1581.

Figure 5. Pattern of the tiles that framed the Albuquerque and the Noronha Coats of Arms panels. On the left side, the pattern with strings of pearls (coded 301-P34 by the system of the *Museu do Palácio da Bacalhôa*) and on the right side the simpler pattern with straight lines (301-P33) whose chemical composition is in line with that of the panels themselves.

The tiles that framed the coats of arms should also be considered together with the panels. They are formed by glyph motifs- a continuous succession of arches with strings

of pearls around the Albuquerque Coat of Arms (Figure 2 and left side of Figure 5), and a simpler motif in which the pearls are substituted by straight lines in the lost Noronha Coat of Arms (Figure 3 and right side of Figure 5) of which the original frame tiles only subsist on top and on the lower corners. The two vertical sides of the frame are composed with the variant with strings of pearls as in the still extant Albuquerque panel. Curiously, analyses have shown that only the simpler pattern as in the right side of Figure 5 is in line with the panels themselves, in terms of glaze and biscuit compositions, while the composition of the tiles with pearls is only compatible with a manufacture by the workshops of Lisbon and will not be addressed by this paper.

3.2. Sampling

Figure 6 exemplifies the sampling done on the still extant coat of arms panel (designated by the coding system of the *Museu do Palácio da Bacalhôa* "301-11"), one of the fragments of the second coat of arms (301-96) and one of its remaining frame tiles (301-P33). In this last case, as noted before, two slightly different frame patterns are present, but the original, subsisting at the top side and at the lower corners, is discernible by the superior quality of the painting and by its gloss. Table 1 includes all the samples that were taken, identified by their technical references, and the total number of analyses made.

Figure 6. Examples of sampling spots on the Albuquerque Coat of Arms panel (301-11), the fragmented Noronha Coat of Arms panel (301-96) and one of the original frame tiles (301-P33).

Table 1. Samples taken from the coats of arms and frame tiles: references, number and analyses made

Panel/tile code and description	Sample references	Nr. of samples	Total nr. of analyses
301-11 Albuquerque Coat of Arms	Bac018	2	4 (glaze); 2 (biscuit)
301-96 Noronha Coat of Arms	Bac007; -009; -104	6	8 (glaze); 3 (biscuit)
301-P33 Frame tiles	Bac062; -132	2	2 (glaze); 2 (biscuit)

3.3. Morphology and composition of the glazes

Figure 7 depicts sectional SEM images of the glaze and interface of samples from the two panels and one of the frame tiles at the same magnifications (350x and 700x). The light grey area on top is the glaze, while the dark grey area corresponds to the biscuit. Because of its colour, the inclusions in the glaze are conspicuous: gas bubbles retained in

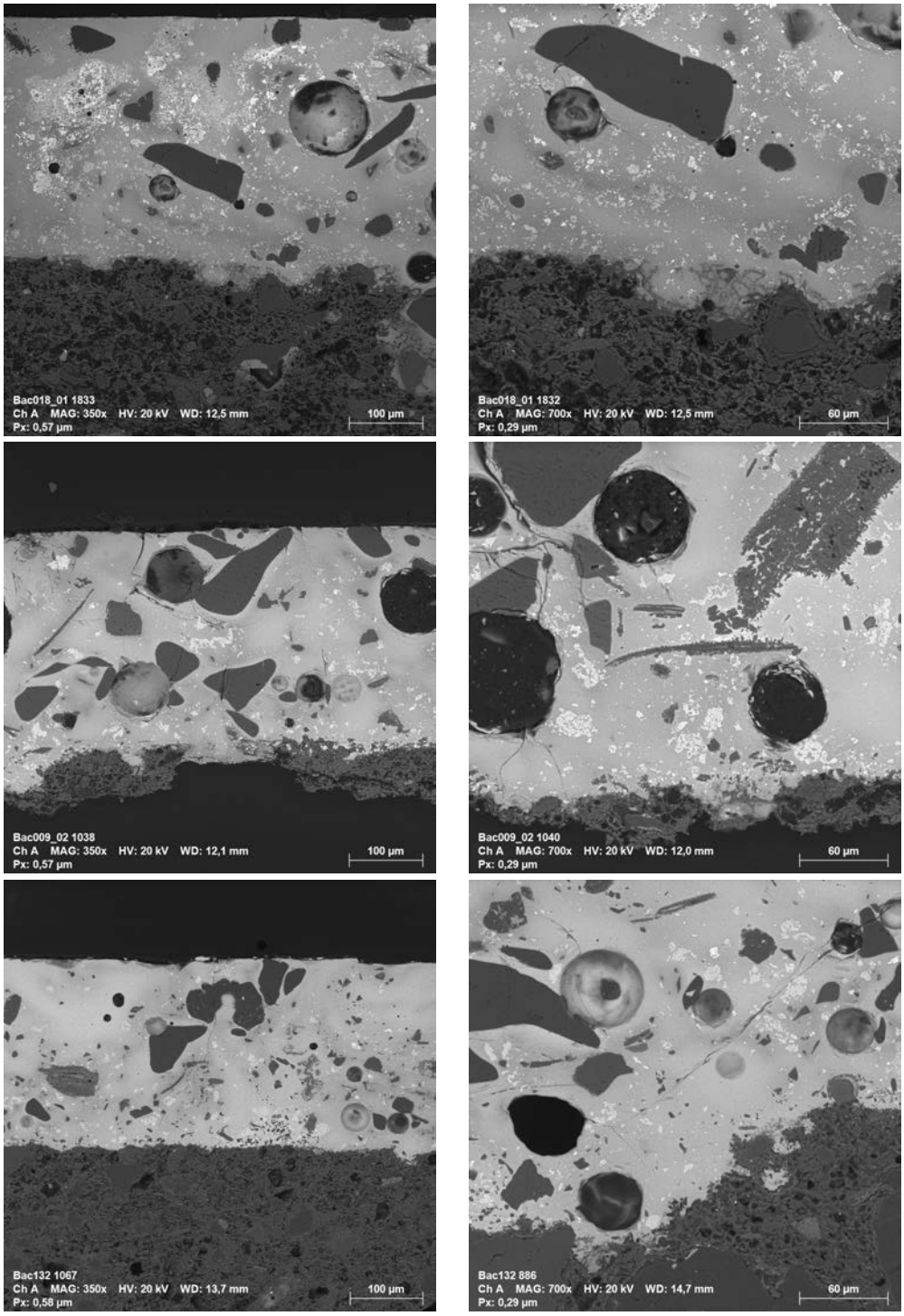

Figure 7. Morphology of the glazes and interface of (top to bottom): 301-11 (sample Bac018/01); 301-96 (Bac009/02) and 301-P33 (Bac132) (images: LNEC).

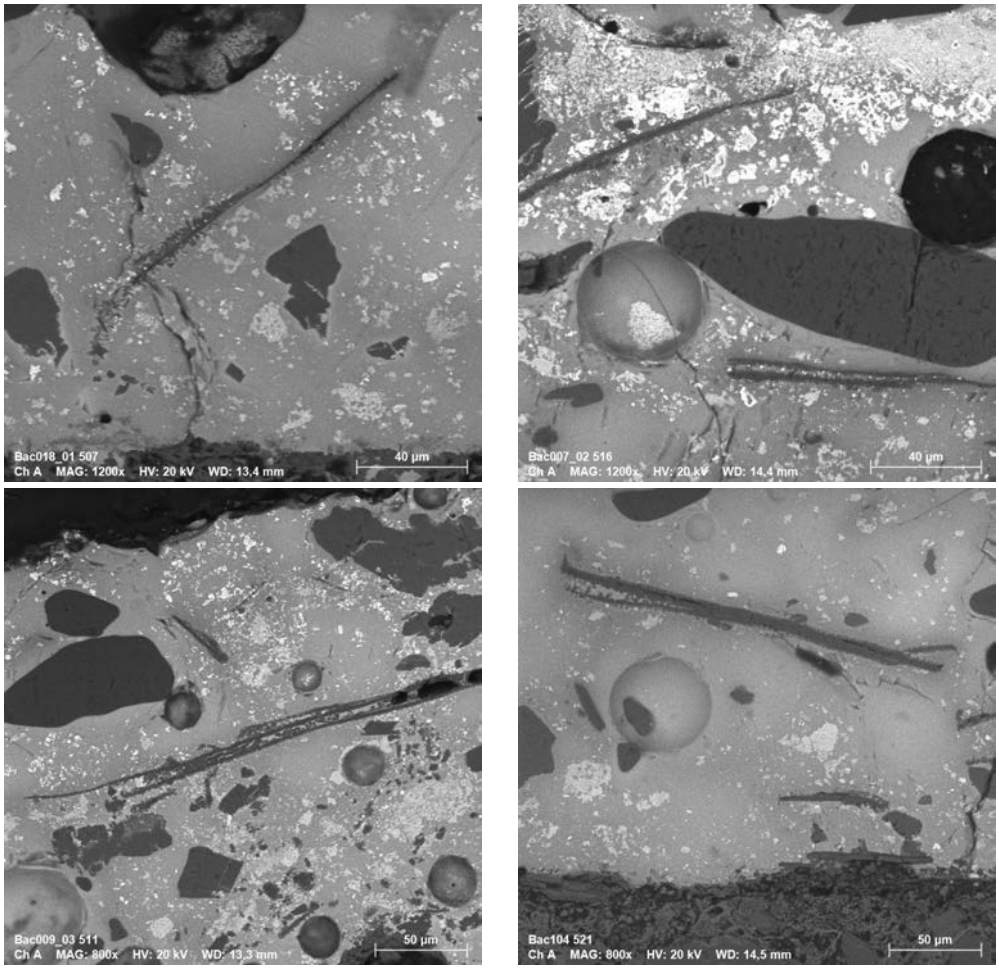

Figure 8. Micaceous inclusions in the glazes (left to right and top to bottom: 301-11 (sample Bac 018/01); 301-96 (sample Bac007/02); 301-96 (sample Bac009/03); 301-P33 (sample Bac104) (images: LNEC).

the glass, grains of sand (larger compact dark inclusions, usually with rounded edges) and bits of feldspars, often in disaggregation. The white spots in the midst of the glaze are crystals of the opacifier (tin oxide), while a continuity of similar white spots near the surface may correspond to the lead-rich yellow pigments.

The study of tiles when there is no reference of known provenance and chronology for comparison purposes must rely on characteristics, preferably uncommon, that may be used to group together similar cases. Close observation of the glaze morphology revealed an unusual characteristic for all the samples studied: the presence of long shaped sheet minerals (often ca. 100-150 µm long) with very small outgrowths caused by crystallizations during the cooling stage (Figure 8). Similar inclusions are known from Portuguese glazes but they are rarer and almost always much shorter. Besides their length, these inclusions depict another readily recognizable characteristic: they are often split on one of the sides in two or more thinner sheets. The EDS analysis determined the main elements present to be aluminium, silicon and potassium, pointing to a phyllosilicate. The shape,

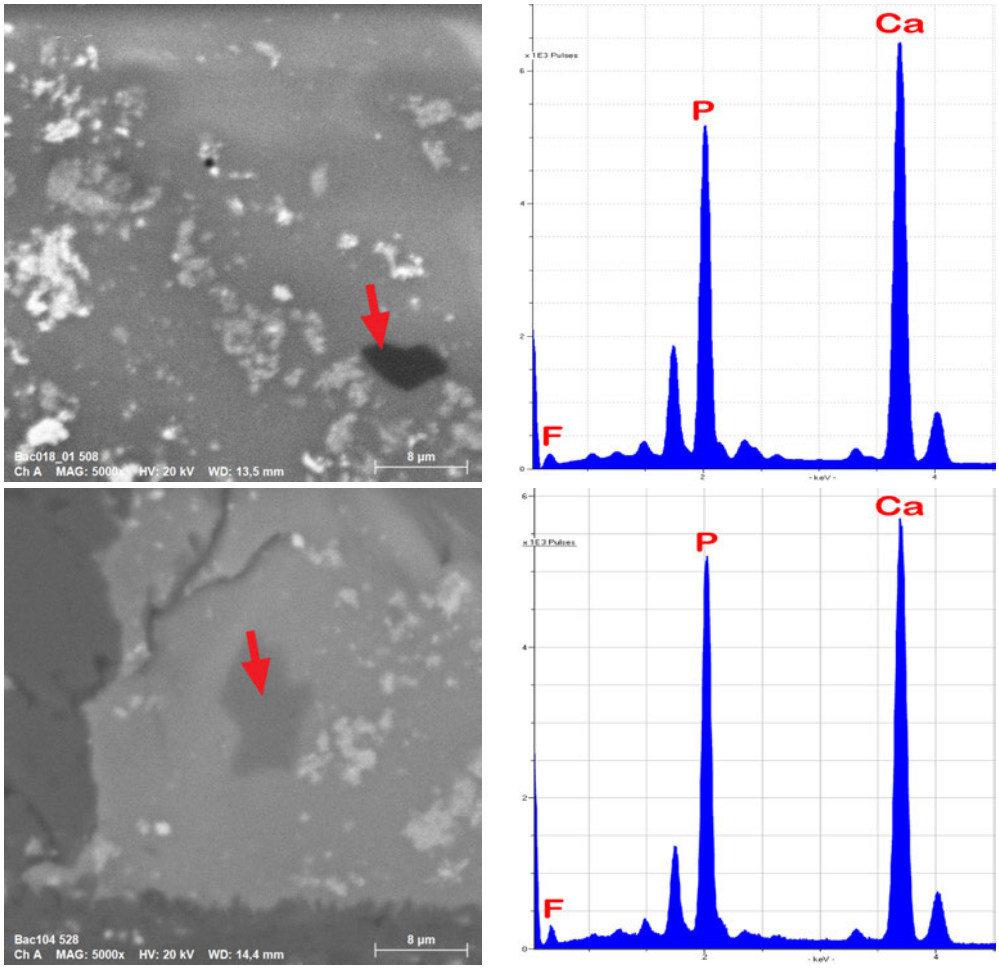

Figure 9. Particles of a substance rich in phosphorus (P) and calcium (Ca), with fluorine (F), presumably resulting from the addition of bone ash to the glazes of both coats of arms panels (top: 301-11, sample Bac018/01; bottom: 301-96, sample Bac104) (images: LNEC).

dimensions and composition (the contents in magnesium and iron do not exceed what could be expected from the influence of the matrix) suggest the inclusions are likely of the mica *muscovite*. Similar micaceous sheets were found in Antwerp majolica with morphologies of dispersion in the glaze that strongly suggest they were used to add glitter to the surfaces.[1] That was probably also the purpose in this case.

Another peculiar aspect is the presence of small inclusions in the glazes (ca. 5 µm across) that are frequently perceived with a characteristic diffuse aspect in BSE (Figure 9). An EDS analysis shows them to be composed of calcium (Ca) and phosphorus (P), sometimes with fluorine (F). They likely result from the addition of bone (presumably bone ash) to the glaze. The presence of these inclusions points directly to the technology used by at least one of the workshops of Antwerp - that which manufactured the azulejos acquired

1 Personal communication by Bauvois, Stefanie of the ARCHES Research Group, University of Antwerpen.

by Duke D. Teodósio II of Bragança to decorate his palace in Vila Viçosa (200 km SE of Lisbon) and it was when studying these Flemish tiles that we identified bone ash for the first time [4]. Bone, sometimes in fragments of up to 500μm, was used as an opacifier of glass since at least the 5th century [5].

Bone was not added in such quantity that bone particles could be identified in every small sample area, still we found them in both coat of arms panels (Figure 9) but not in the frame tiles, maybe because the sections of our particular test items, collected from two different tiles, did not have any such particle conspicuously visible.

Table 2 includes the semi-quantitative results of analyses of the glazes by EDS in weight %. Each result is the average of all determinations of the element in the respective panel or frame tiles, given with the standard deviation. The silicon/lead (Si/Pb) ratios have been determined and are also included in the table. This ratio is a technological trait set by the glaze recipe and gives important information about the firing conditions in the kiln because the lower the ratio, the lower the temperature at which the glaze could be properly fired.

Since the samples from the Noronha Coat of Arms stem from fragments that have been buried for several centuries, presumably subject to water infiltrations causing lixiviation and deposition of chemical species, the contents should be considered with care. In this sense, the semi-quantitative results of the panel 301-11 and the frame tile 301-P33, still applied on to the walls, should be considered more reliable than those pertaining to 301-96.

Table 2. Semi-quantitative composition of the glazes of the samples taken from the Bacalhôa coats of arms and frame tile determined by EDS (values in wt. % with oxygen obtained by stoichiometry and sum of all elements normalized to 100%) with Si/Pb ratios included

Panel / Pattern *		O	Na	Al	Si	K	Ca	Sn	Pb	Si/Pb
Albuquerque Coat of Arms (301-11)	**average**	**37.11**	**2.77**	**3.11**	**24.30**	**5.46**	**1.70**	**5.48**	**20.07**	**1.2**
	st. deviation	-	0.70	0.23	2.05	0.51	0.34	0.83	4.01	
Noronha Coat of Arms (301-96)	**average**	**38.06**	**2.44**	**2.87**	**25.59**	**6.65**	**1.22**	**5.98**	**17.19**	**1.5**
	st. deviation	-	0.44	0.49	0.91	0.44	0.26	1.20	2.40	
Frame tiles (301-P33)	**average**	**35.90**	**1.29**	**2.32**	**24.53**	**6.87**	**1.15**	**4.28**	**23.65**	**1.0**
	st. deviation	-	0.23	0.49	1.91	0.04	0.20	2.86	7.48	

A further remarkable aspect has to do with the use of *coperta* - a sprinkled layer of transparent glass applied at least over the yellow pigment, where it gives gloss to an otherwise possibly dull colour and which is more readily perceivable on the yellow because the colour does not diffuse into the glaze. Figure 10 shows images of optical microscopy (OM) and SEM of the yellow colour in a sample of the Albuquerque Coat of Arms. In this case the drops of *coperta* were rather thick and, when seen in a sectional cut as in Figure 10, they impart a wavy aspect to the colour because the yellow "sank"

deeper into the glaze at the spots where a drop of glass fell on it. Analyses of this overlay of glass show that the composition is virtually the same as that of the glaze but without any tin - the opacifier that renders it white. The *coperta* is usually devoid of inclusions but in this case, curiously, it has small grains of sand.

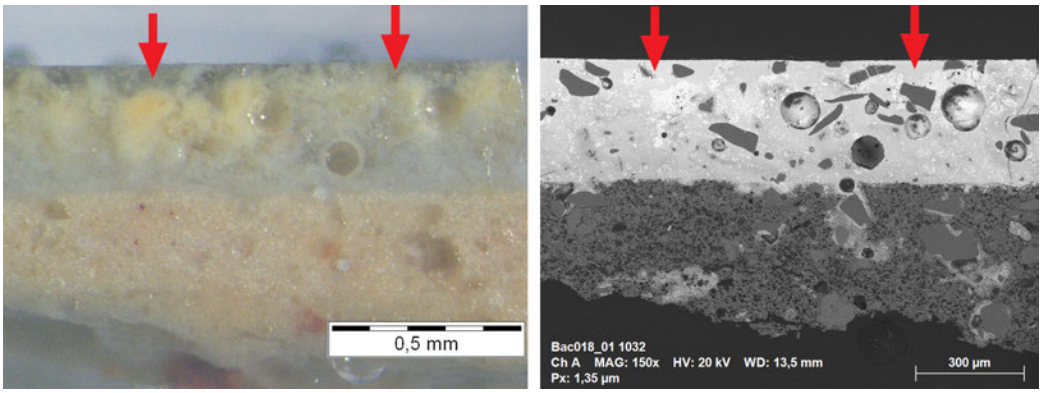

Figure 10. OM and SEM images of the same area of sample Bac018/01 (panel 301-11) showing the *coperta* over the yellow colour (in the SEM image, the yellow pigment is perceived as white specks on a darker background) (images: LNEC).

3.4. Composition of the biscuits

Table 3 includes the semi-quantitative results of analyses of the biscuits by EDS in weight %. Each result given is the average of all determinations of the element in the respective panel with their standard deviations.

Table 3. Semi-quantitative composition of the biscuits of the samples taken from the Bacalhôa coats of arms and frame tiles determined by EDS (values in wt. % with oxygen obtained by stoichiometry and sum of all elements normalized to 100%)

Panel / Pattern		O	Na	Mg	Al	Si	K	Ca	Fe
Albuquerque Coat of Arms (301-11)	**average**	**43.69**	**0.86**	**4.44**	**7.69**	**22.23**	**1.22**	**15.91**	**3.95**
	st. deviation	-	0.10	0.03	0.03	0.70	0.63	0.40	0.11
Noronha Coat of Arms (301-96)	**average**	**43.16**	**1.12**	**3.75**	**7.28**	**22.00**	**2.10**	**16.91**	**3.69**
	st. deviation	-	0.10	0.03	0.03	0.70	0.63	0.40	0.11
Frame tiles (301-P33)	**average**	**42.26**	**0.97**	**4.37**	**7.04**	**20.01**	**1.24**	**20.64**	**3.48**
	st. deviation	-	0.03	0.70	0.10	2.79	0.06	5.42	0.16

4. THE FLOWERBED PANELS WITH FAUNS

4.1. Introduction

The access to the first room of the Pleasure House goes through a space (the *Secret Garden*) that has two entrances, a main one from a path directly from the palace, probably used by the owners and their guests, and a secondary one from the terrain outside the garden, which would be used by the service personnel [1]. The tile panels used to line the fronts of the four flowerbeds of this small garden were decorated with fauns and other fanciful designs.

Of the twenty-one original panels, the remains of nineteen have been preserved, of which only six are reasonably complete. The two panels whose analyses have suggested an import from abroad are numbers 8 and 12 of the set (shown in Figure 11 after their recent restoration), while the analytical results on samples taken from other panels led to the conclusion that all but two, for which a definite conclusion could not be reached, were very likely made in Portugal (see [3] for the analytical results of one of those panels, coded 301-27). The two doubtful cases, that seemingly bridge the foreign with the local productions, are included in a comparative study done of all the nineteen preserved panels lining the Secret Garden to be published later.

Figure 11. Flowerbed panels with fauns and birds. Top, nr. 8 (301-19); bottom, nr. 12 (301-23) after restoration (images © Associação de Colecções | The Berardo Collection).

The largest square tiles that we see still applied at Bacalhôa (18 x 18 x 2.5 cm) were used in these and in the other panels of the same set. It is possible that the decision to use this format was conditioned by the height of the surfaces that had to be covered and also to avoid that the joints between the tiles coincided with parts of the figuration that could alter

their aesthetic appreciation. However, this fact allows indirectly to deduce that whoever manufactured them had to have drawings and elevations with the measurements of their future emplacement. This was foreseeable having in mind that also to make the two coats of arms it was recommendable that the artist knew the proportions of the walls on which they were to be placed. For this, the potter may have had to make a preliminary visit to the site, or else he received plans with the measurements. It is also significant that to the length of these two panels, presumably made abroad for this garden, does not correspond a round number of tiles but rather six plus a part of a seventh tile to complete the measure of the flowerbed each should cover. The same happens for other panels used in this small garden, showing that the panels were manufactured when the flowerbeds were already built and only needed the tile linings to be finished.

The markings on the backs of all the panels in this garden pose complex problems of interpretation as they do not all correspond to a single criterion, probably in line with different origins and deliveries (to be published). Among all the markings examined, those used on these two panels are unique since the backs are marked following a rule that is not strictly repeated in any other of those that were conserved. The author of the markings in panel 301-19 identified the tiles by writing uppercase letters from *A* to *F*, from left to right, repeating these letters in both the upper and lower rows without adding a second mark that in panels of greater height indicates which of the rows corresponds to each tile. But in this case the simplicity of these panels did not need a more elaborate system. Presumably the two smaller tile fragments that are missing would correspond to the letter "*G*". The markings on the second panel follow the sequence but are more interesting because they are made of lowercase cursive letters. The small tile fragments located at the extreme left of the composition were seemingly left unmarked but would otherwise have corresponded to "g" and the other tiles are designated *h*, *y (i?)*, *k*, *l*, *m* and *n* (Figure 12). The sequence suggests both panels were manufactured at the same time while the use of upper and lowercase letters may indicate they were meant to be applied separated.

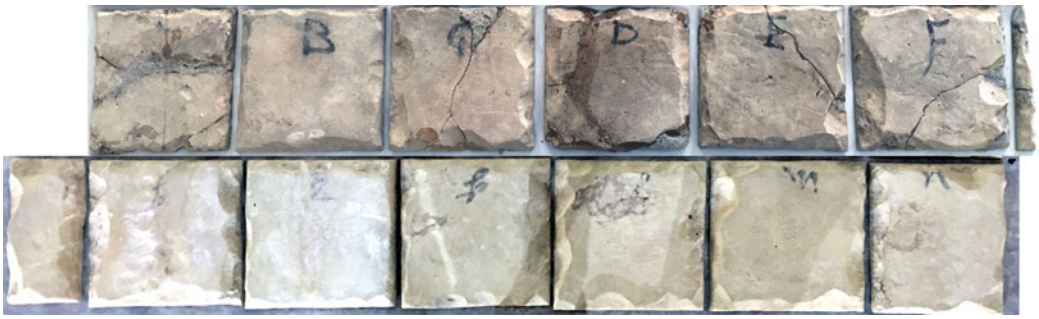

Figure 12. Backside markings on the lower rows of panels 301-19 (top) and 301-23 of the Secret Garden (images © Associação de Colecções | The Berardo Collection).

Like all the panels in this space, the composition has a horizontal development and is framed by a golden yellow ribbon that adopts the silhouette of ironwork, an ornamental element better known by its French name *ferronnerie*. These fittings embrace a faun, on the right side, and a she-faun on the left, at the belly level, so that they are thus symbolically imprisoned and immobilized. They both hold the end of the cartouche that occupies the middle of the panel with one hand and, with the other, a fine purple cloth festoon, from which hang a golden pearl, a crown of black pearls and a large green fleur-de-lis. The

ironwork cartouche that they hold between them serves as a frame for a jasper stone with blue and green veins. On the lateral and pointed ends of the cartouche two birds are perched (Figure 11). The cartouche has a silhouette of straight, curved and counter-curved lines and is made up of two planes. The closest to the viewer is a flat, yellow design, of the same colour as the outer panel trim. The *ferronnerie* in the rear plane is painted in blue and represented as a deep structure of forward-curved plates that receive light from the left and cast shadows to the right, creating an illusion of volume and connecting these panels with the design and Flemish style of the Albuquerque Coat of Arms.

4.2. Sampling

Figure 13 shows the sampling spots on both panels. A single small sample was taken of each, to which were assigned the references Bac147 for 301-19 and Bac107 for 301-23.

Figure 13. Sampling points of panels 301-19 (Bac147) and 301-23 (Bac107) (images © Associação de Colecções | The Berardo Collection).

4.3. Morphology and composition of the glaze

SEM images of the glaze and interface of the samples are depicted in Figure 14. The odd features visible in the glaze of panel 301-23 (bottom images) are a consequence of decay: EDS analyses confirmed that lead lixiviated from the glaze, leaving dark Si-rich areas around fissures (left side of the figure), and subsequently deposited inside bubbles (seen, in section, on the right side of the figure, as white rings coating the inner surfaces of the bubbles).

Both panels have micaceous inclusions and depict the use of coperta over the yellow, but in smaller droplets than in the coats of arms (Figure 15). Bone ash was not identified in the glazes of these panels, either because it was not used, or else the samples small areas and the inconspicuous nature of the inclusions did not allow their detection.

Table 4 includes the semi-quantitative results of analyses of the glazes by EDS in weight %, including the Si/Pb ratios. Although these panels have not been excavated, as the fragments of the Noronha Coat of Arms, the humidity of their environment and

particularly the fact that they were applied on a watered flowerbed took a heavy toll, perceived e.g. through the crazing of the glaze and in the frayed aspect of some surfaces. Decay may impair locally the original proportions of the elements and therefore the semi-quantitative results should be considered with care.

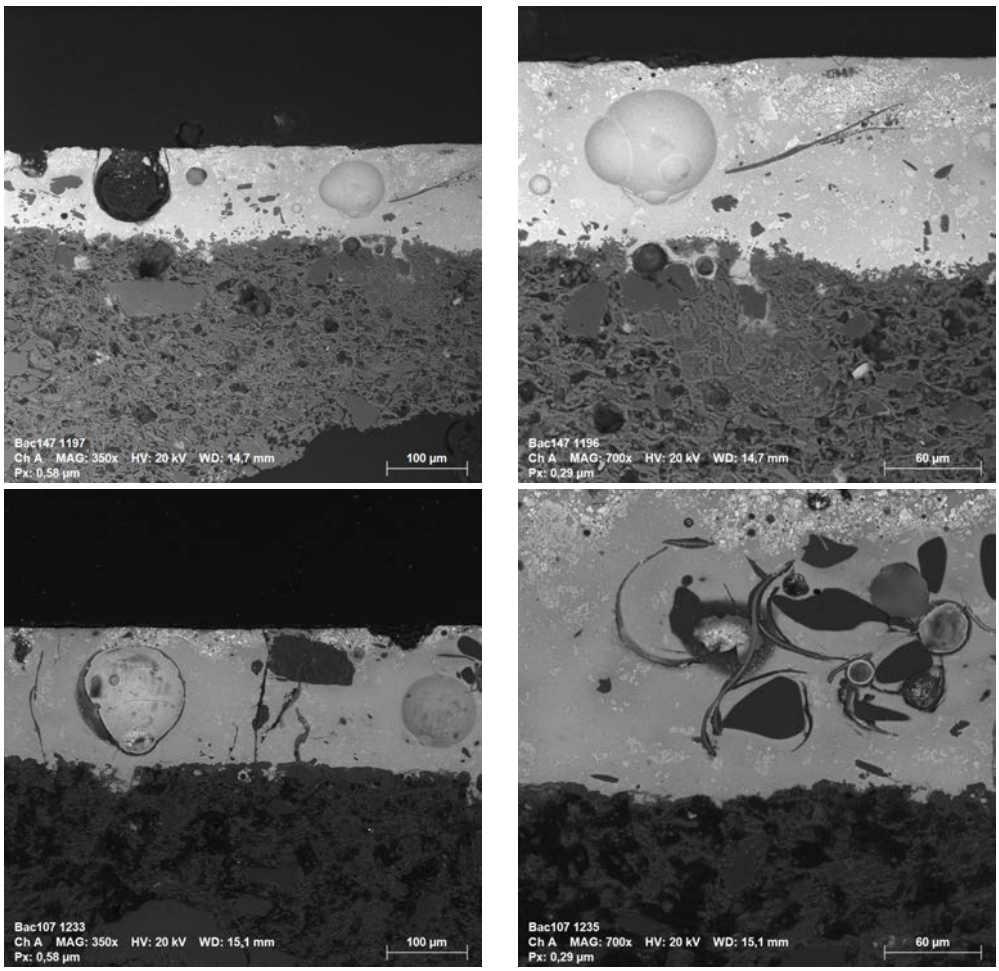

Figure 14. SEM images showing the morphology of the glazes and interface of panels 301-19 (top) and 301-23 (bottom) (images: LNEC).

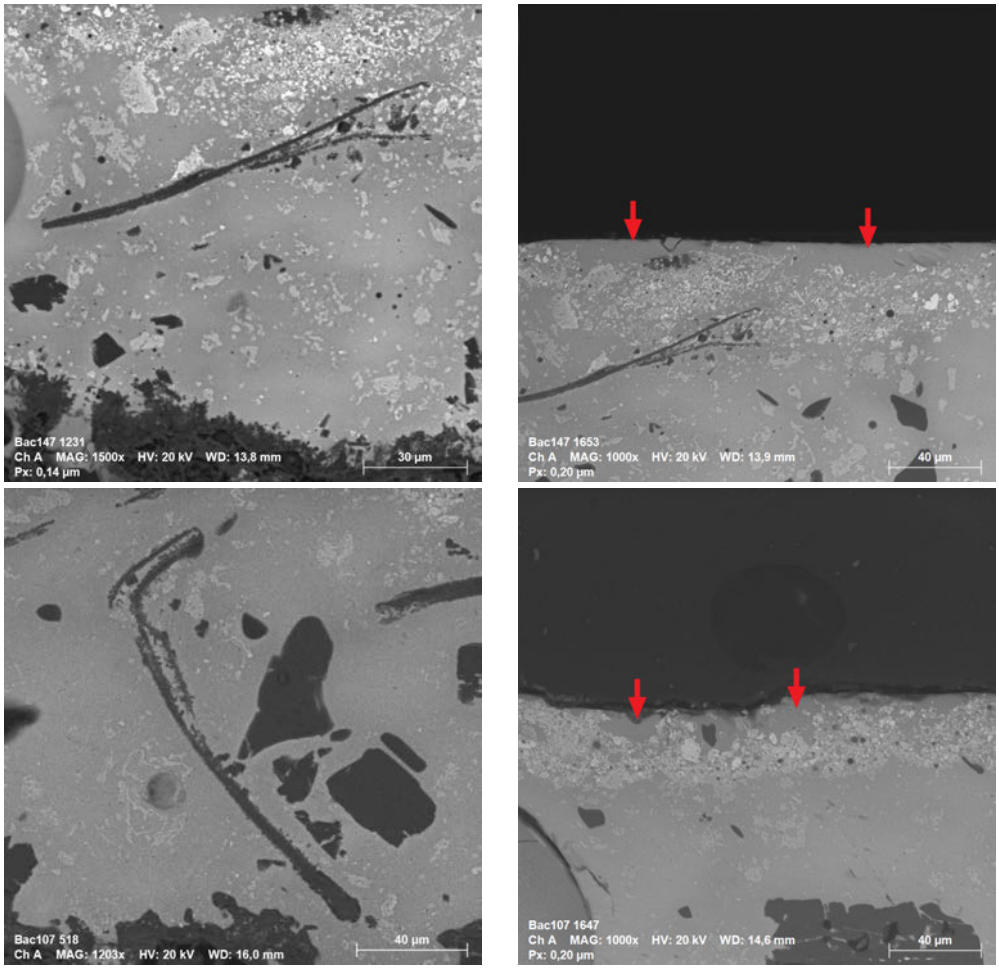

Figure 15. Micaceous sheets and *coperta* (indicated by arrows) in panels 301-19 (top) and 301-23 (bottom) (images: LNEC).

Table 4. Semi-quantitative composition of the glaze of the two faun panels 301-19 and 301-23 determined by EDS (values in wt. % with oxygen obtained by stoichiometry and sum of all elements normalized to 100%) with Si/Pb ratios included

Panel / Sample		O	Na	Al	Si	K	Ca	Sn	Pb	Si/Pb
301-19	**average**	**32.41**	**1.55**	**2.08**	**20.61**	**5.08**	**2.29**	**7.14**	**28.84**	**0.7**
Bac147	st. deviation	-	0.10	0.22	0.55	0.20	0.36	0.14	1.19	
301-23	**average**	**34.65**	**1.83**	**2.19**	**23.19**	**5.03**	**1.79**	**5.62**	**25.69**	**0.9**
Bac107	st. deviation	-	0.14	0.46	1.53	0.21	0.34	1.61	4.38	

4.4. Composition of the biscuit

Table 5 includes the semi-quantitative results of the analysis of the biscuits by EDS in weight %.

Table 5. Semi-quantitative composition of the biscuit of the two faun panels 301-19 and 301-23 determined by EDS (values in wt. % with oxygen obtained by stoichiometry and elements normalized to 100%)

Panel / Sample		O	Na	Mg	Al	Si	K	Ca	Fe
301-19	**average**	**43.18**	**0.68**	**4.03**	**7.68**	**21.54**	**1.81**	**16.70**	**4.38**
Bac 147	st. deviation	-	0.04	0.18	0.11	0.39	0.34	0.58	0.19
301-23	**average**	**44.20**	**0.70**	**4.85**	**9.33**	**22.08**	**1.74**	**13.26**	**3.85**
Bac107	st. deviation	-	0.17	0.05	0.81	0.62	0.20	1.64	0.42

5. THE PATTERNED TILES

5.1. Introduction

The Bacalhôa patterned tiles used as wall linings are, so far, the first majolica of that type known to have been used in Portugal, because all those confirmedly older are Hispano-Moresque *cuerda seca* or *arista*. In Vila Viçosa there are no patterned tiles in the known imports from Antwerp dated "1558" and the works of around this time attributed to João de Góis and his possible collaborators are essentially figurative [6].

In addition to the demonstration of artistry that were the two coats of arms and the flowerbed panels with fauns, the potter or potters who produced them also delivered to Bacalhôa tiles of repetitive patterns to clad large areas of walls. When the decision was made that e.g. three chambers of the Pleasure House should be lined with majolica tiles from the level of the pavements to that of the now lost stucco ceilings, a large number of these tiles would obviously be needed. And several patterns would also be necessary since, observing the setting, the decision that a majolica pattern should not be repeated in different chambers is clear.

The tiles designed and seemingly brought from abroad for use in Bacalhôa [3] correspond to three patterns (Figure 16). The tally of copies of each pattern imported was probably insufficient for the full areas to be lined, so that of at least two of them we find tiles whose glaze composition does not match that of the imported tiles. Also, these are not quite as perfect and seem to have been decorated by other painters, Flemish, Spanish or Portuguese, on the glazes known to be used in Portugal, although following the same decorative design as the imported ones. Perhaps the painting of repetitive patterns would be mostly carried out by collaborators, while the master used his time on the execution of figurative panels requiring a special pictorial acumen that only he possessed.

Of the three patterns that, according to the studies carried out, were used in tiles not of local manufacture, pattern 301-P41 (left side of Figure 16) has a special relevance since

it was also used in Spain (see Figure 22). In Bacalhôa, tiles of this pattern line the first room of the Pleasure House, the first chamber accessed after entering through the Secret Garden. From the visual examination of the tiles in that chamber, not all those that line the walls of this space are part of the group that was imported: some of them have glazes of a different recipe, known from the workshops of Lisbon, and were painted by someone other than the painter of the imported tiles, with thicker and less precise outlines and slightly different colours.

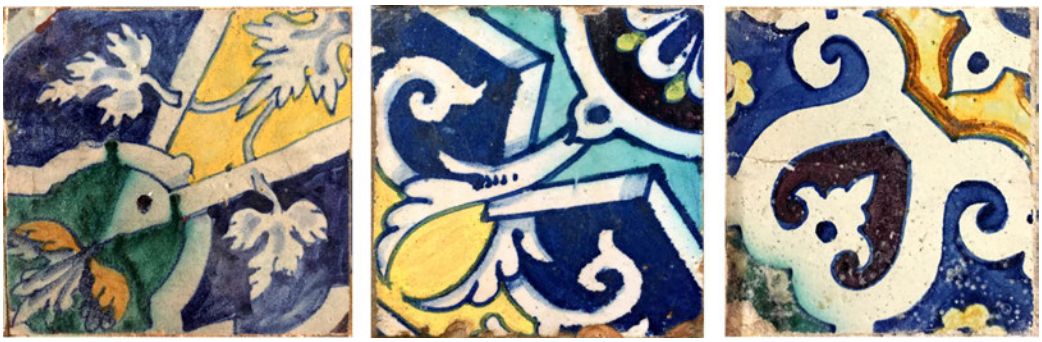

Figure 16. The three patterns identified that were presumably imported and applied to line walls at Bacalhôa (from left to right): 301-P41; 301-P11 and 301-P1 (image © Associação de Colecções | The Berardo Collection).

Another pattern brought from abroad is illustrated at the mid of Figure 16 and is coded "301-P11". The locations where it was applied are unknown today and we only see some of them integrated into various parts of the garden. This is the case of the fronts of some of the water troughs in the entrance courtyard or the benches and flowerbeds of the palace paths to the orchards, although we cannot be sure whether these applications are original, or else the tiles were re-applied there at some later time. Many fragments of this same pattern are presently kept in the reserves of the local *Museu do Palácio da Bacalhôa*.

Even though the main original purpose of the tiles of this pattern is unknown, we may hypothesize that they were intended for an important space because of their fine design and time-consuming execution, very close in conception to the previous pattern and to other patterns of similar design used in Spain (see e.g. Figure 23, Sp06 "Cañaveral"). In this, as in the previous pattern, the work of at least two painters is clearly perceived, revealing very different qualities. These differences will be detailed in a future paper.

The third motif (Pattern 301-P1 on the right side of Figure 16) is somewhat simpler, although with the same Flemish flavour. It was used to line the walls of the noblest area of the ground floor of the Palace, the Coats of Arms Room [1], where it subsists today in wainscot panels four tiles high with a frame (Figure 17) maybe the last remains of a decorative solution once widespread throughout the premises.

Figure 17. Wainscot panel with pattern 301-P1 in the Arms Room (image © Associação de Colecções | The Berardo Collection).

5.2. Sampling

Table 6 includes information on all the samples taken from the patterned tiles addressed in this section, their technical references and the total number of analytical results.

Table 6. Samples taken from the patterned tiles and total number of analyses

Patterned Tile / Location	Samples references	Nr. of samples	Total nr. of results
301-P41- Pleasure House, Room1	Bac100; -125; -138; -143	4	7 (glaze); 6 (biscuit)
301-P11- Several locations	Bac082; -113; -123	4	11 (glaze); 6 (biscuit)
301-P1- Coat of Arms Room	Bac109; -120	3	3 (glaze); 3 (biscuit)

5.3. Morphology and composition of the glazes

Figure 18 depicts SEM images of the glaze and interface of samples of tiles with the three patterns.

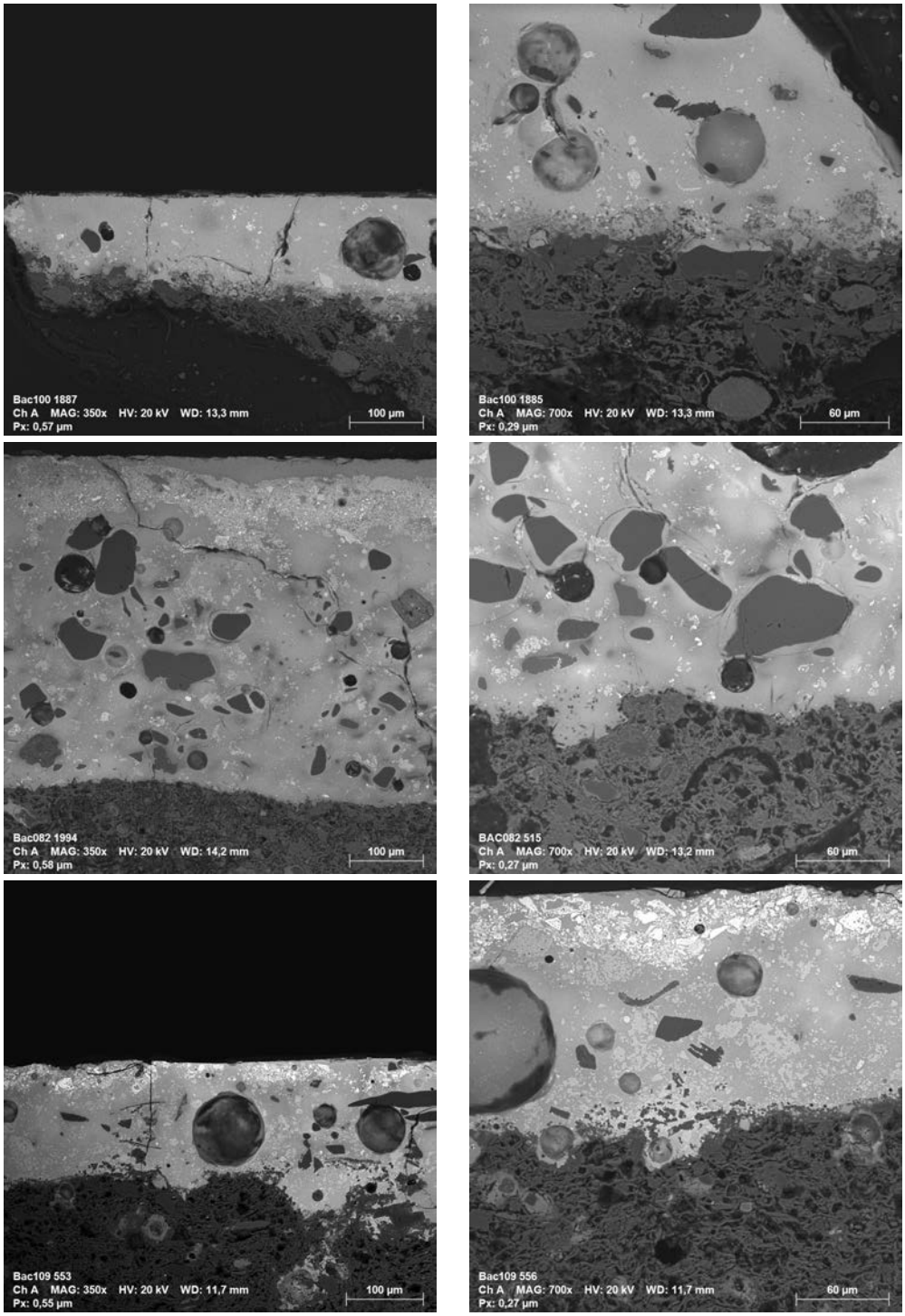

Figure 18. SEM images showing the morphology of the glazes and interface of (top to bottom): 301-P41 (Bac100); 301-P11 (Bac082) and 301-P1 (Bac109) (images: LNEC).

Table 7 includes the semi-quantitative results of analyses of the glazes by EDS in weight %. Each result given is the average of all determinations of the element in samples taken from similar tiles of the same pattern. The standard deviations have been determined and are included. As in the previous cases, the ratios Si/Pb have been determined and are also included.

Table 7. Semi-quantitative composition of the glazes of the sampled Bacalhôa patterned tiles determined by EDS (values in wt. % with oxygen obtained by stoichiometry and sum of all elements normalized to 100%) with Si/Pb ratios included

Pattern		O	Na	Al	Si	K	Ca	Sn	Pb	Si/Pb
301-P41	**average**	**35.42**	**2.48**	**1.32**	**24.44**	**3.64**	**2.37**	**4.61**	**25.72**	**1.0**
	st. deviation	-	0.53	0.13	1.71	0.73	0.47	0.59	4.2	
301-P11	**average**	**35.83**	**0.91**	**2.60**	**24.22**	**6.26**	**1.23**	**5.66**	**23.29**	**1.0**
	st. deviation	-	0.1	0.28	1.48	0.68	0.36	1.9	4.02	
301-P1	**average**	**35.25**	**1.88**	**2.49**	**22.71**	**5.62**	**1.17**	**8.80**	**22.09**	**1.0**
	st. deviation	-	0.31	0.73	1.10	1.08	0.11	1.09	2.79	

Mica-like inclusions, similar to those depicted in Figures 8 and 15, were found in samples of 301-P11 and 301-P1 (Figure 19) but not on 301-P41, notwithstanding the number of tiles sampled and observed.

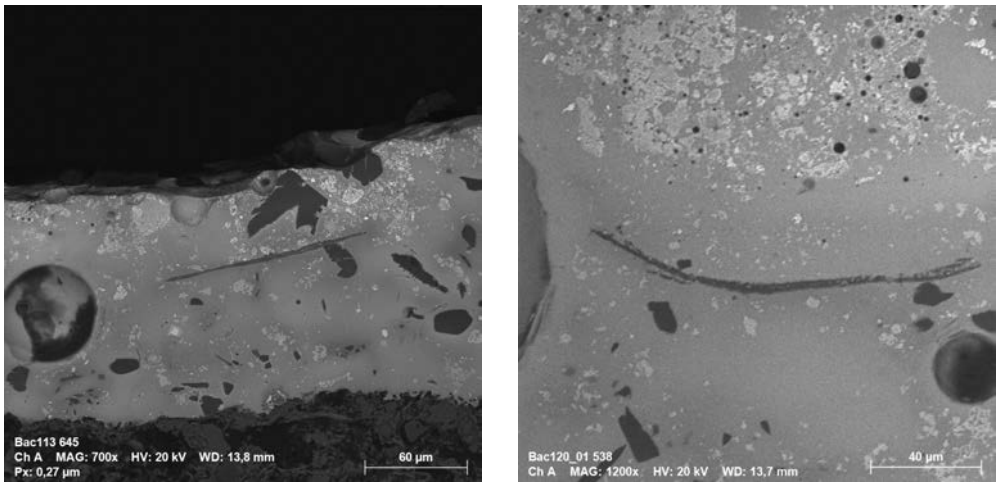

Figure 19. Micaceous inclusions in the glazes of: 301-P11 (left side image, sample Bac113) and 301-P1 (right side image, sample Bac120/01) (images: LNEC).

Bone ash inclusions were found in 301-P41 and in 301-P1 (Figure 20). The analysis of one of the inclusions in 301-P41 also detected a considerable content in chlorine (Cl), suggesting that the bone had been bleached with a chlorine compound. Given the difficulty in spotting the small bone particles amidst the other inclusions, it is likely that bone was also present in the glazes of 301-P11, but went undetected.

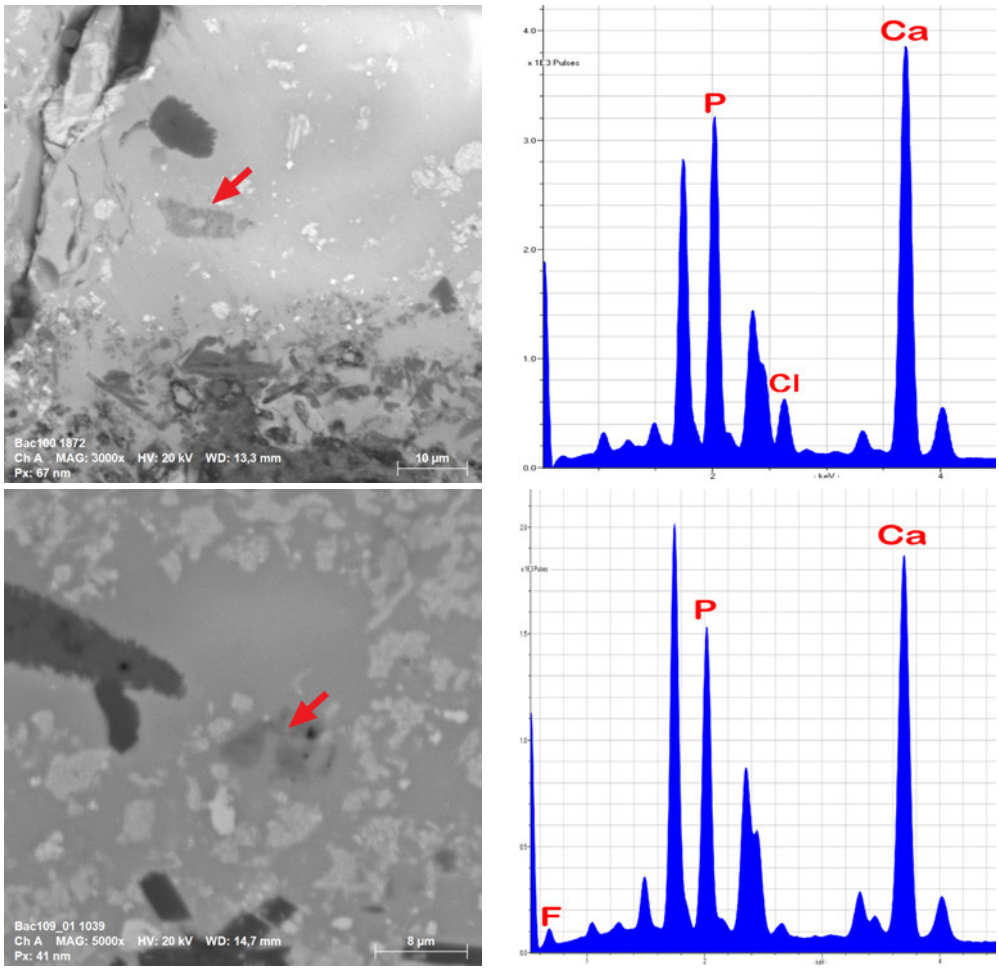

Figure 20. Particles of a substance with phosphorus and calcium, presumably bone ash, in the glazes of: 301-P41 (Bac100) on top; and 301-P1 (Bac109/01) at the bottom (images: LNEC).

All patterned tiles referred to in this section used *coperta* applied in rather large drops, as indicated by the morphology of the yellow pigment (Figure 21) and analyses of the upper layer of glass returning a practically nil content in tin.

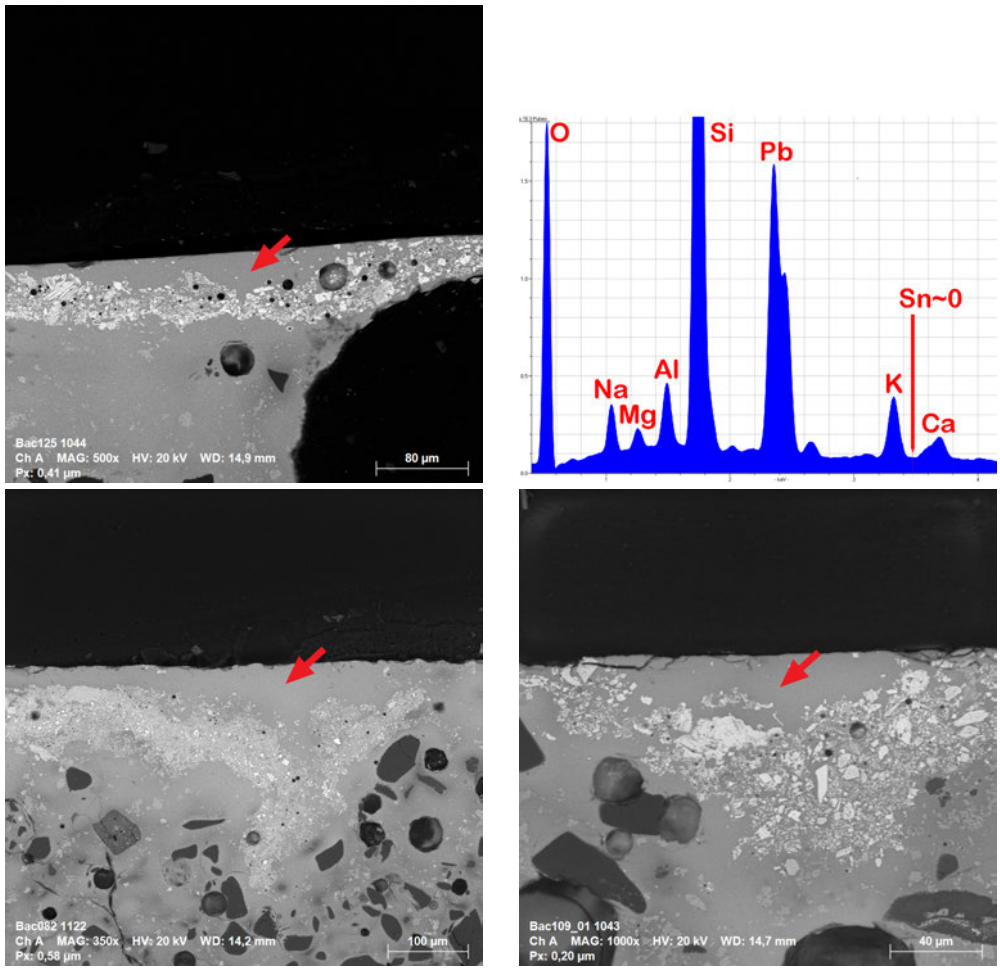

Figure 21. Top to bottom and left to right: SEM images depicting *coperta* over the yellow pigment in 301-P41 (sample Bac125 side by side with the analytical spectrum); 301-P11 (sample Bac082) and 301-P1 (Bac109/01) (images: LNEC).

5.4. Composition of the biscuits

Table 8 includes the semi-quantitative results of analyses of the biscuits by EDS in weight %.

Table 8. Semi-quantitative composition of the biscuits of the sampled Bacalhôa patterned tiles determined by EDS (values in wt. % with oxygen obtained by stoichiometry and sum of all elements normalized to 100%) with averages and standard deviations included

Pattern		O	Na	Mg	Al	Si	K	Ca	Fe
301-P41	**average**	**43.27**	**1.29**	**2.83**	**8.02**	**21.89**	**1.57**	**17.06**	**4.05**
	st. deviation	-	0.16	1.13	0.03	2.17	0.43	3.48	0.22
301-P11	**average**	**41.66**	**0.98**	**4.12**	**6.96**	**19.02**	**1.24**	**22.43**	**3.61**
	st. deviation	-	0.27	0.60	0.58	0.73	0.28	2.17	0.23
301-P1	**average**	**42.13**	**1.03**	**3.64**	**7.54**	**19.74**	**1.58**	**19.86**	**4.48**
	st. deviation	-	0.12	0.29	0.60	1.33	0.24	2.41	0.12

6. DISCUSSION

6.1. Do all these panels and tiles have the same provenance?

In a previous paper we grouped together most panels and patterned tiles studied here and advocated a likely non-Portuguese provenance [3]. In the same paper, we ruled out the possibility of multiple geographical provenances based on the fact that the biscuits could be considered to cluster together and all depicted the same widespread occurrence of lozenge hollows left by the consumption of euhedral dolomite crystals over firing. This is a rather striking morphology that we had encountered only twice before and never with the present profusion.

However, the glazes were not considered in detail. Are all the tiles exactly matched? Table 9 summarizes the results and findings already presented, including all elemental contents in the glazes that derive from weighted raw materials, the use of *coperta* and the occurrence of the long mica-like inclusions as well as of additions of, presumably, bone ash. The table entries were sorted by decreasing Si/Pb ratios.

A case that might be individualized corresponds to the faun panels 301-19 and 301-23 (highlighted in blue in Table 9) whose Si/Pb ratio may be slightly lower than the rest and in whose glaze no bone ash was found. Another interesting note is that, although *coperta* was used on all tiles with yellow painting that were appraised, whoever applied it on these two faun panels used a slightly different technique that resulted in a deposition of very small droplets (seen in Figure 15) needing an analysis for confirmation, compared to the drops of transparent glass deposited on the other tiles (Figures 10 and 21) that left no doubt about their nature. On the other side, the composition in its whole and the long micaceous inclusions in the glaze relate these faun panels with the remaining panels and tiles, except for pattern 301-P41.

Pattern 301-P41 (highlighted in purple in Table 9) comes to attention because, even though relatively large samples, obtained from several different tiles, were observed, no mica-like inclusions were found in the glazes. This is the same pattern that a PCA set off the aggregation of its potential peers (see [3]) and, indeed, it has a uniquely low content in potassium. Table 7 also shows that it has a substantially lower content in aluminium than the rest. On the other side, the fact that bone was found in the glaze, immediately relates this pattern with the two coats of arms and with pattern 301-P1.

Table 9. Comparison of the glazes of the tiles addressed by this paper (?N.F.= maybe present, but not found)

Panel/Tile		Si/Pb	Na	K	Sn	mica	bone	*coperta*
Coats of arms	**301-96**	1.5	2.41±0.44	6.56±0.44	5.90±1.20	YES	YES	YES
	301-11	1.2	2.73±0.70	5.37±0.51	5.39±0.83	YES	YES	YES
	301-P33	1.0	1.28±0.23	6.80±0.04	4.24±2.86	YES	? N.F.	YES
Patterns	**301-P11**	1.0	0.90±0.52	6.20±0.68	5.61±1.90	YES	? N.F.	YES
	301-P1	1.0	1.85±0.31	5.52±1.08	8.65±1.09	YES	YES	YES
	301-P41	1.0	2.45±0.53	3.60±0.73	4.56±0.59	NO	YES	YES
Fauns	**301-23**	0.9	1.82±0.14	4.99±0.21	5.58±1.61	YES	? N.F.	YES
	301-19	0.7	1.54±0.10	5.04±0.20	7.08±0.14	YES	? N.F.	YES

Therefore, there is no strong reason solely based on the morphology and composition of the glazes to rebut the grouping together of all the panels and patterned tiles that were addressed by this paper as representing the same basic technology and sharing a single regional provenance. However, of all the tiles studied, at least those painted with pattern 301-P41 may have been made by a different workshop that used the same or a very similar clay for the biscuits, but whose glaze recipe was somewhat distinct.

6.2. What is the provenance of these panels and tiles?

Finally, it may be asked what the provenance of these panels and patterned tiles is. In a previous paper we excluded the possibility of a manufacture by the workshops of Lisbon based on the fact that both the clay and the glaze recipe were unknown to us from the local workshops at this early chronology [3]. In the present paper we strengthened the argument by showing that there was a technical detail, namely the use of bone ash in the glazes, pointing to Flemish technology until now unreported from Portugal. Knowing that Flemish masters of majolica were active in the Peninsula at this time [7, pp 51-52]. the likely provenance possibilities would then be: i) the workshops of Antwerp; ii) the Spanish workshops of Seville where Frans Andries worked [7] and are known to be the source of majolica imports to Portugal later in the century [8]; iii) else workshops from some other until now unreported location, probably in Spain.

Alfonso Pleguezuelo, one of the authors of this paper, connected the person of Juan Flores, a Flemish potter working in Spain[2] at this time, to the tiling of Bacalhôa based,

2 Jan Floris, renowned master potter and painter of the Guild of St. Luke of Antwerp, is known from Flemish sources to be working in Spain for king Philip II at this time [7, p 51]. Juan Flores,

partly, on circumstantial documental evidence related to his possible absence from Talavera (Spain), where he lived since 1562, for a period from 1564 to the Summer of 1565 [9; 10] coinciding with the date inscribed in *Susanna and the Elders* (Figure 1). But, on the other side, he offered substantial proof of a connection with Portugal by pointing that in a frontal made for *Iglesia de San Pedro* in Garrovillas (province of Mérida in Spain), including figures of St. Andrew and St. Paul which the author signed "I.F." and dated "1559", was used a pattern practically identical to the pattern 301-P41 that was supplied to Bacalhôa (Figure 22). In fact, if from the larger tiles used in Garrovillas a peripheral strip is cut off, the exact pattern 301-P41 will be obtained. Also, other unique patterns used in Bacalhôa [1; 3] bear an undeniable family resemblance with another pattern used by Flores in Spain, seen in Figure 23 where it is identified as "Sp06- Cañaveral". But… are there any objective confirmations on the analytical side?

Figure 22. Left side: San Pedro de Garrovillas, Spain; right side: Pleasure House of Bacalhôa - note the longitudinal application of the tiles in Spain vs. the characteristic diagonal application in Portugal.

Juan Flores resided for several years in Plasencia (Province of Cáceres, Spain) until he moved to Talavera (now *Talavera de la Reina*, in the Province of Toledo) in 1562 [9]. Figure 23 illustrates Spanish works attributed to Flores [10], all presumed to date from his Plasencia period, used here for comparison purposes.

A study of the panels that were attributed to Flores in Spain revealed a considerable variation of the morphologies and compositions of the glazes, as if he painted on tiles made by other potters [10]. Still, Figure 24 compares SEM images of the glazes and interfaces of some tiles of the Spanish works illustrated in Figure 23 with similar images of samples from Bacalhôa, showing that the same general morphologies occur in both cases. Also, whenever yellow-painted tiles could be examined (samples from Garrovillas and Cañaveral) the use of *coperta* over the colour was confirmed, as in the imported tiles of Bacalhôa. Particles of a compound rich in phosphorous and calcium were also found in the glaze of tiles from Garrovillas, Cañaveral and Garganta la Olla [10]. Since the use of what we presume is bone ash in the glazes is a distinctive technological trait, its use connects at least three of the works attributed to Flores in Spain with the imported tiles of Bacalhôa. The long micaceous sheets that were a readily noticeable characteristic of all but one of the imported panels and tiles are, however, absent from the Spanish samples.

who is vastly documented in Spain to have been under contract with the king [9], is certainly the same person.

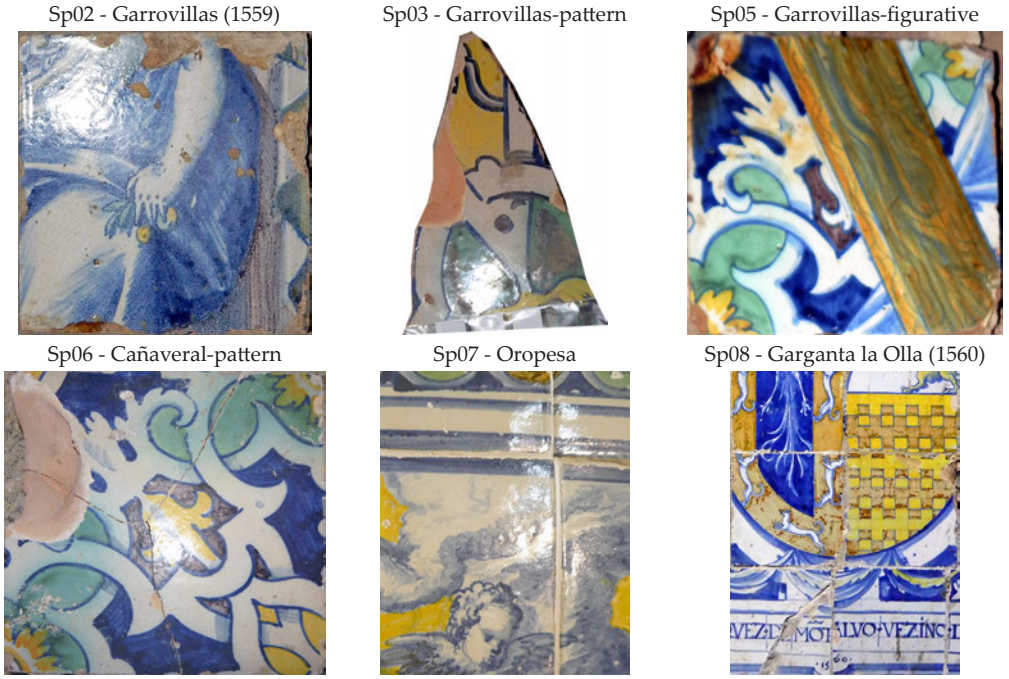

Figure 23. Reference, location and date (when known) of the Spanish panels and tiles referred in this section (from [10]).

In a paper published in 2019 we successfully used PCA to ascribe a single excavated fragment to a Portuguese production by comparing it with the analytical results of Portuguese samples from *Igreja da Graça* (identified by the code Az013) and the panel *Nossa Senhora da Vida* (identified by the code Az032), as well as samples from Antwerp (Az031 and Az311), Seville 16th to early 17th centuries (Az040, Az192, Az306, Az338 and Az345) plus Portuguese 17th century samples [11]. We shall now replicate the same procedure but, in this case, omitting the Portuguese 17th century samples because the panels and tiles we are studying are not suspected to be their possible peers. And instead of the fragment that was the item of interest in the 2019 paper, we shall now include in the PCA both the Bacalhôa samples and the samples from the Spanish productions ascribed to Juan Flores (using the analytical results from [10]).

The result of the PCA analysis of the glazes is presented in Figure 25 through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 58 % of the variance and is controlled in the positive sense by the contents in sodium (Na), silicon (Si), potassium (K) and calcium (Ca), and in the opposite sense mostly by the contents in tin (Sn) and lead (Pb). PC2 explains 17 % of the variation and is controlled in the positive sense mostly by the contents in aluminium (Al) and tin, and in the opposite sense mostly by the content in lead, as seen in Figure 26, where the loadings plot is represented as a vector graph.

Four clusters have been proposed in the PCA of Figure 25: the green cluster includes all Portuguese samples and occupies the 2nd and 3rd quadrants of the plot; the yellow cluster, occupying the 4th quadrant, includes all the Sevillian samples (Hispano-Moresque together with majolica tiles) and the Antwerp samples; the blue and red clusters occupy the 1st quadrant and include respectively all the presumably imported Bacalhôa panels

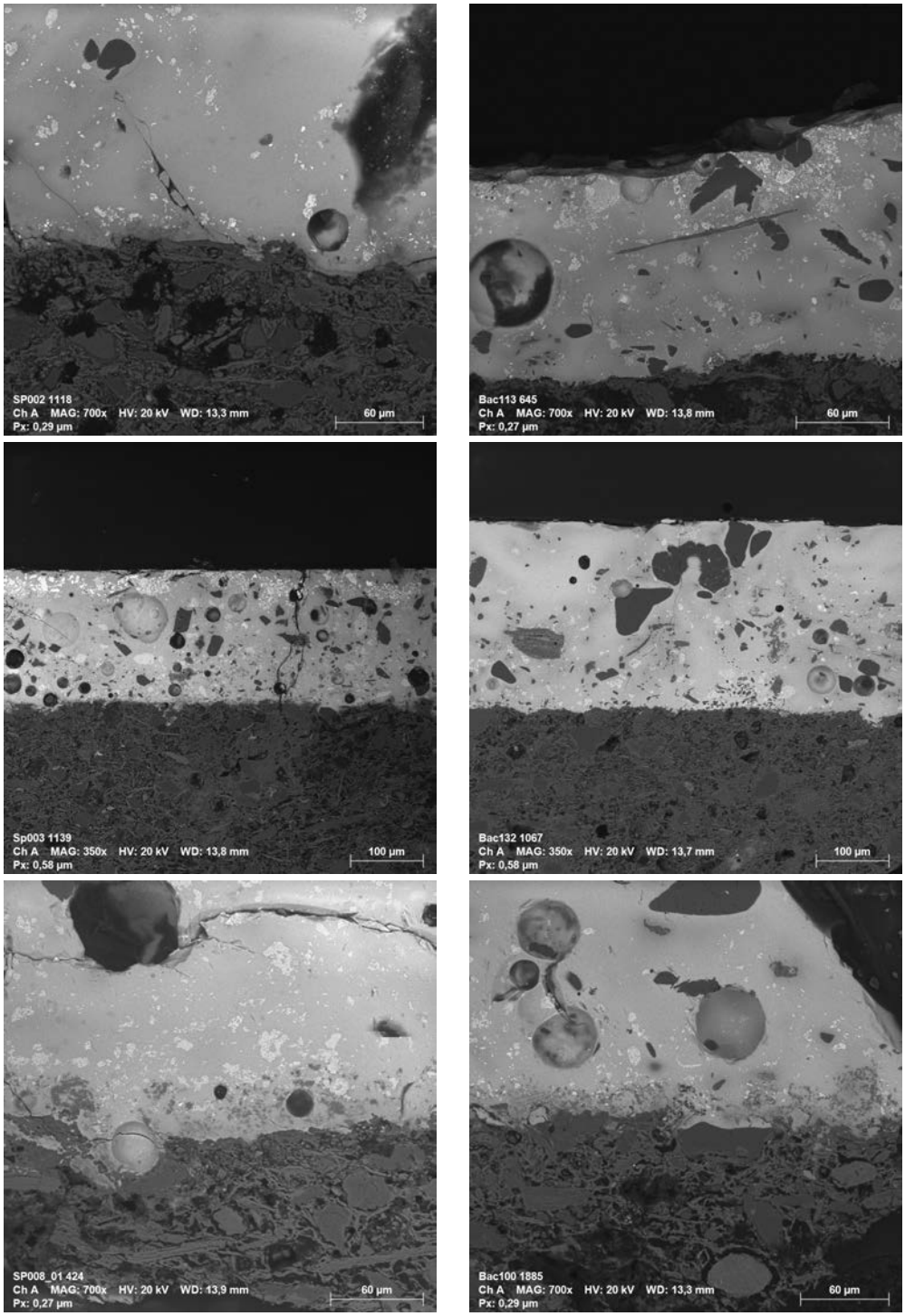

Figure 24. From top to bottom, the left side image is from a Spanish sample and the right side image from a Bacalhôa sample: Sp02 vs. 301-P11 (sample Bac113); Sp03 vs 301-P33 (sample Bac132); Sp08 vs. 301-P41 (Bac100) (images: LNEC).

and tiles, and the Spanish panels and tiles attributed to Juan Flores. These two clusters are not exclusive and, in fact, they intermix in a way that may suggest consolidating both in a single cluster, indicating that the glaze compositions of the presumed Bacalhôa imports are much more similar to the Spanish panels and tiles attributed to Juan Flores, than to any of the other groups. It should also be noticed that the pattern 301-P11 (P41) is again set aside from the rest mostly because of its lower aluminium content.

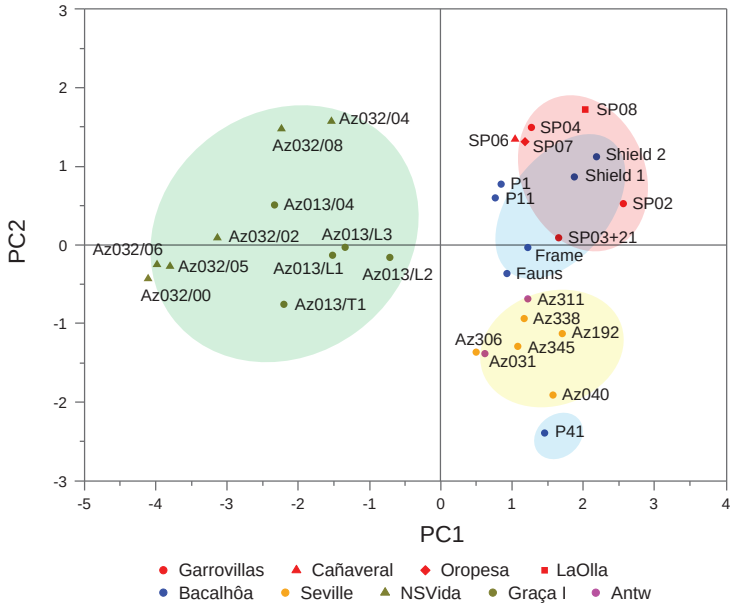

Figure 25. Score plot of the PCA of the glazes of the Bacalhôa panels and patterns studied in this paper (blue cluster), together with representative 16th century samples from Portugal (green cluster), Seville and Antwerp (yellow cluster) and Talavera (red cluster).

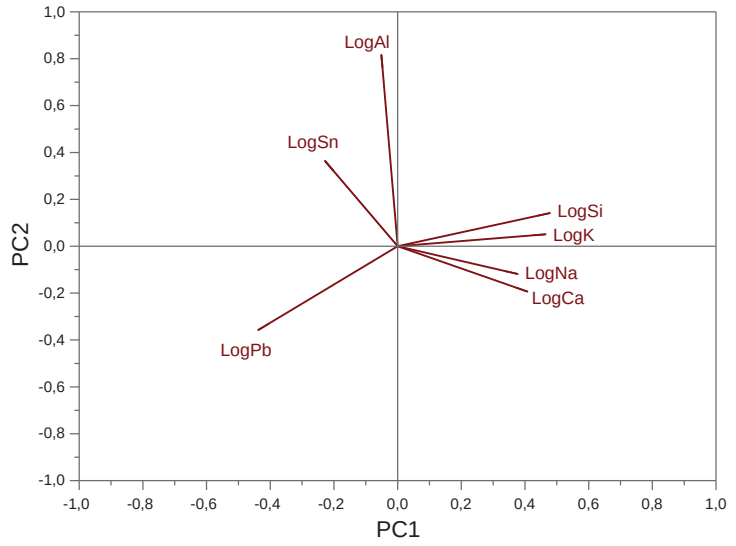

Figure 26. Loadings plot of the PCA of the glazes represented in Figure 25.

Considering now the biscuits, Figure 27 depicts the results of the log-based PCA as before. Since some of the tiles attributed to Flores lacked a sufficiently representative area of biscuit, two large biscuit samples from the panels in Cañaveral and Oropesa were included and are identified "SpCan" and "SpOrop".

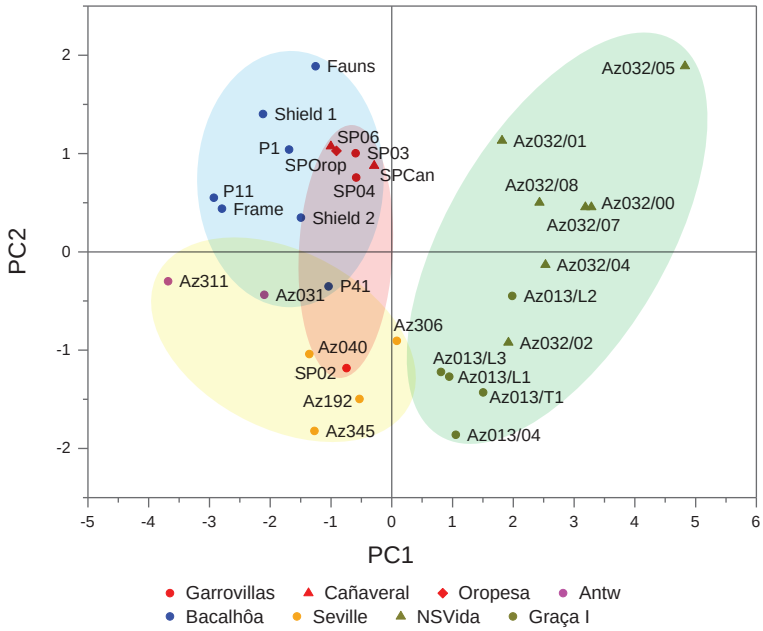

Figure 27. Score plot of the PCA of the biscuits of the Bacalhôa panels and patterns studied in this paper (blue cluster), together with representative 16th century samples from Portugal (green cluster), Seville and Antwerp (yellow cluster) and Talavera (red cluster).

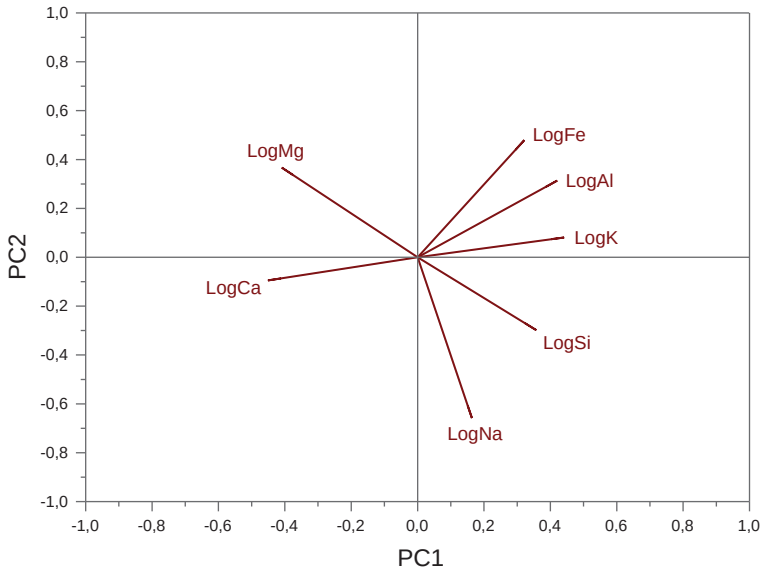

Figure 28. Loadings plot of the PCA of the biscuits represented in Figure 27.

The result of the PCA analysis is depicted through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 60% of the variance and is controlled in the positive sense mostly by the contents in aluminium (Al), silicon (Si), potassium (K) and iron (Fe), and in the opposite sense by the contents in magnesium (Mg) and calcium (Ca). PC2 explains 17 % of the variation and is controlled in the positive sense mostly by the contents in magnesium, aluminium and iron and in the opposite sense mostly by the contents in sodium (Na) and silicon, as seen in Figure 28, where the loadings plot is represented as a vector graph.

The same clusters as proposed for the glazes in Figure 25 also fit the biscuit results in the score plot of Figure 27: the green cluster includes all Portuguese samples and occupies the 1st and 4th quadrants; the yellow cluster, occupying the 3rd quadrant, includes all the Sevillian samples (Hispano-Moresque and majolica) and the two samples from the productions of Antwerp; and the blue and red clusters, occupying the 2nd quadrant, include respectively all the Bacalhôa imported panels and tiles, and the Spanish panels and tiles attributed to Juan Flores. The pattern 301-P41 (P41 in the plot) is again set aside from the blue cluster, but this time the distance is relatively short and one of the samples from Garrovillas (Sp02) is also set aside but in this case, given the position of the other samples from the same panel, the result may stem from an occasional concentration of sodium in the small sample. The blue and the red clusters are very close and, again, they could be merged into a single cluster. Therefore, there is a great proximity of their chemical compositions.

Clays are inhomogeneous materials whose composition is naturally variable, even in the same pit, as exploration proceeds. Are there any other clues pointing to a common origin? In a previous paper, in which we systematized the tile productions present at Bacalhôa, we identified an unusual morphological characteristic of the biscuits stemming from the occurrence in the clay of euhedral dolomite crystals that were partly consumed over firing leaving lozenge hollows [3, figure 10]. That characteristic is also present in the clays of the Spanish productions of Juan Flores- it has been found in most of the samples but the hollows are never congregated, with many present in a small area as in the Bacalhôa clays. In the Spanish samples only the hollows left by isolated large crystals were seen (Figure 29). There are, however, other points in common, both as refers to the occurrence of the same inclusions of rare minerals [12; 3 p 136] and of silica frustules of, presumably, centric diatoms with similar morphologies (Figure 30), adding to the plausibility that the compositional proximity of the biscuits is not fortuitous.

Even if an identity of the clays could not be proved beyond a reasonable doubt, all results in this section converge on the conclusion that the Bacalhôa imports are indeed closely related with the productions of Juan Flores in Castille.

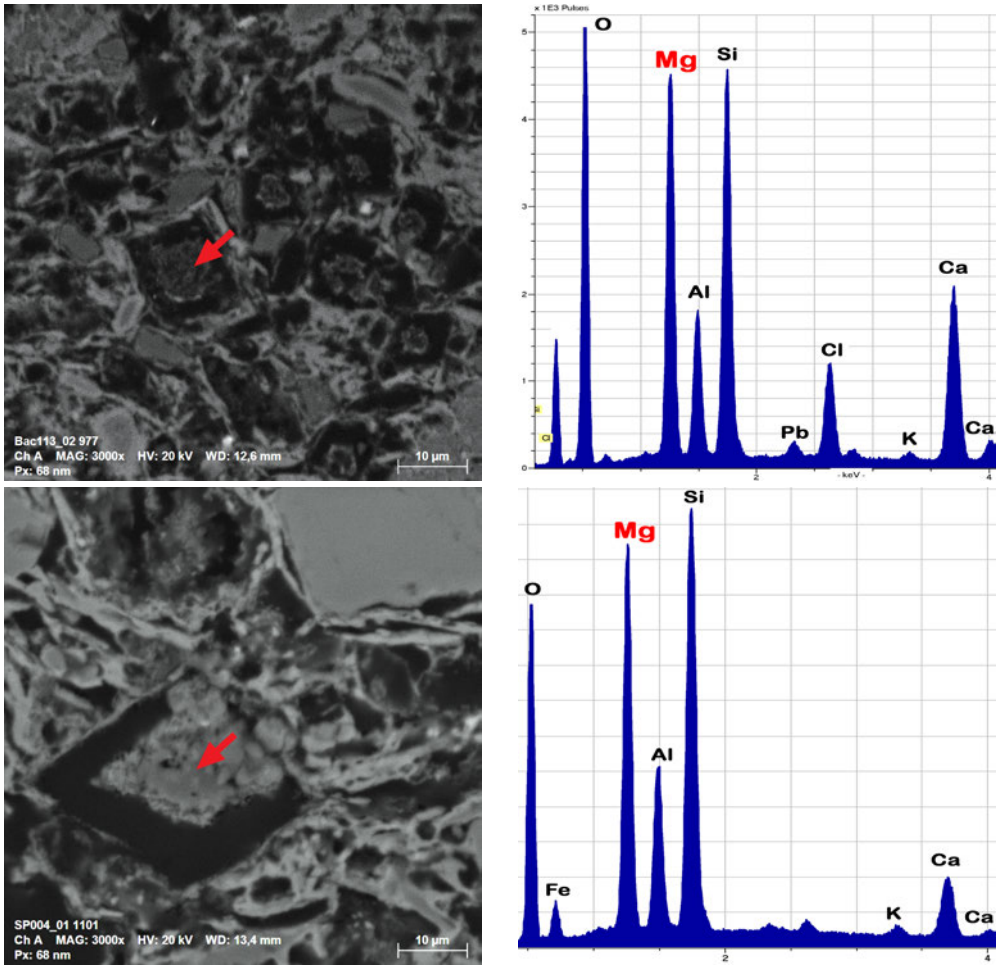

Figure 29. Rhomboid hollows left by euhedral dolomite crystals and spectra resulting from the analyses of the residues inside, showing the characteristic high contents in magnesium (Mg): pattern 301-P11 - sample Bac113 (top); Garrovillas – sample Sp04 (bottom) (images: LNEC).

Figure 30. Silica frustules of, presumably, centric diatoms in an imported Bacalhôa biscuit (sample Bac017/03) on the left side, and a biscuit from a Garrovillas panel (sample Sp04/01) on the right side (images: LNEC).

7. A REASONED SUM UP

There are strong reasons to believe that the panels and patterned tiles in Bacalhôa that were studied in this paper have been imported: the biscuits and glaze compositions are unknown from Portugal at the time when they may be assumed to have been manufactured, during the 1560s; and the interface morphologies suggest that the firing schedule was also different from what was then current in the workshop or workshops of Lisbon that manufactured majolica azulejos [3].

The style of the coats of arms is typically Flemish which, together with the adroitness of their painter, point to a remarkable artist, maybe a master of the Guild of St. Luke of Antwerp [7]. The recurrent use of an addition rich in phosphorus and calcium to the glaze, probably bone ash to improve the whiteness without adding more tin, connects the tiles studied with at least one of the workshops of Antwerp [4].

Alfonso Pleguezuelo, one of the authors of this paper, hypothesized in 1999 that Juan Flores (a Castilian name under which Jan Floris De Vriendt worked in Spain) was connected with the tiling of Bacalhôa, both as a potter and as a painter [9]. He also pointed to the use of the same pattern in one of his signed and dated productions in Spain, as well as in Bacalhôa (Figure 22), and to the stylistic proximity between his known pattern designs and some of the unique patterns used in Bacalhôa. Finally, he showed that for a period, including part of 1565, the date inscribed in Susanna and the Elders, Flores was seemingly absent from Talavera (Spain) where he lived since 1562 [9; 10]. None of these facts is sufficient proof in itself, but all together give compelling evidence that Jan Floris was the skilful Flemish potter and painter behind at least a part of the superb technical and artistic achievements of the majolica linings of Bacalhôa, and in particular of the panels and patterned tiles studied in this paper.

A comparison with azulejo panels in Spain presently attributed to Flores contributed further analytical evidence: i) the compositions of the glazes of the Bacalhôa imported panels and tiles are compatible with the composition of the glazes used in Spain by

Flores or his associates, as demonstrated by a PCA including glazes of various alternative provenances; ii) the composition of the clay used in Spain is very similar to the composition of the clay used for the Bacalhôa tiles; iii) coperta, a top layer of transparent glaze, was used both in the Spanish productions and in all of the Bacalhôa imported tiles; iv) the presence of inclusions of a substance rich in calcium and phosphorus, likely bone ash, was confirmed both in the glazes of the Spanish works and in the Bacalhôa tiles studied in this paper – all converging on a common attribution.

There may be a good reason for the fact that a total analytical and morphological match was not found: the two dated Spanish panels are from 1559 and 1560 while Flores lived in Plasencia [10], and the other works presently known in Spain may also be from before Flores moved to Talavera in 1562, under a contract with king Philip II of Spain [9]. The clay used around 1565 may have been different from that used in 1560, either because it was extracted from a different location, or because of the compositional variability of the material as new layers are reached. The occurrence of the mica sheets in most glazes of Bacalhôa, unknown in the Spanish panels, probably deliberate to achieve a glittering effect, could be explained likewise as a characteristic associated to a period after Floris moved to Talavera. The differences found in the glazes of the tiles decorated with the pattern 301-P41, precisely the same also used in Garrovillas, suggest that its glaze may have been prepared at a different time or with some raw materials of a different provenance, but the sharing of the same clay with the other Bacalhôa imported tiles and panels leads to the conclusion that the chronology should not, in fact, be very different.

Finally, it may be noted that throughout this paper we often referred to the panels and tiles as *presumably imported*. Besides the caution that characterizes the scientific attitude, this approach also derives from recognizing a less likely but not remote possibility: that the potter or potters who went to Portugal could have taken with them, besides a sizable number of biscuits, the raw glaze to make majolica tiles there, in which case they might be indistinguishable from a Spanish manufacture. Although in such case the local of production would not be particularly relevant, it is interesting to note that evidence obtained from other tiles extant in Bacalhôa indeed points to a limited import of raw glaze and, possibly, clay (to be published). However, those cases are identifiable by the interface morphology derived from the firing in the local kiln or kilns, which is not recognizable in the tiles and panels addressed by the present article.

The technical review of types previously done [3] systematized the majolica tiles of Bacalhôa in four groups, one of which was studied in this paper and likely represents the earliest major acquisition of such tiles to the palace and gardens. However, since the second half of the 1550s there were other Flemish potters of glazed ceramics and majolica working in Lisbon, particularly the brothers João and Filipe de Góis about whom important information was obtained from the registers of the Holy Inquisition [13]. Given his fondness of azulejos, Brás [Afonso] de Albuquerque certainly would know well the workshops of Lisbon and the fact that he arranged for one or more potters from abroad to work for him should mean that, at the time, he considered the local productions inferior to what he could obtain from another not too distant source. The research done suggests that there may have indeed been previous acquisitions from the workshops of Lisbon, but any such purchases made locally before ca. 1565 were probably of single-colour tiles (to be published). Still, the Góis brothers must have been involved in work with Flores at Bacalhôa resulting in a technological input that may have had an important impact on the quality of their own future productions.

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