

Analytical study of the 16th century azulejo panel “Nossa Senhora da Vida” and related archaeological findings

João Manuel Mimoso, Alexandre Pais, Victor Filipe, Maria de Lurdes Esteves, Sílvia R. M. Pereira, Maria Antónia Pinto de Matos, Ana Margarida Cardoso, António Candeias

ABSTRACT

One of the jewels in the collections of the Museu Nacional do Azulejo (National Museum of Azulejo) is a renaissance azulejo panel representing the Annunciation and the Adoration of the Shepherds, originally from Nossa Senhora da Vida (Our Lady of Life) chapel of the now demolished Santo André (Saint Andrew) church in Lisbon. Before the chapel was demolished, in 1845, the panel was removed and put in storage, while a second panel, considered of lesser value, was left in place and presumably destroyed. An archaeological excavation in 2018 on the site of the church unearthed fragments of figurative azulejos, thought to be part of the lost panel.

This paper includes the results of an analytical study of azulejos from both the Nossa Senhora da Vida panel and from the excavated shard, compares the results and discusses the possibility that the findings were indeed once part of the lost azulejo panel.

RESUMO

Uma das joias das coleções do Museu Nacional do Azulejo é um painel de azulejos renascentista, com representações da Anunciação e da Adoração dos Pastores, originário da Capela de Nossa Senhora da Vida na já demolida Igreja de Santo André em Lisboa. Antes da demolição da capela, em 1845, o painel foi removido e colocado em depósito, enquanto um segundo painel, considerado de menor valor, foi deixado no lugar e presumivelmente destruído. Uma escavação arqueológica realizada em 2018 no local da igreja recuperou uma série de fragmentos de azulejos de um ou mais painéis figurativos.

Este artigo inclui os resultados de um estudo instrumental dos azulejos do painel de Nossa Senhora da Vida e dos fragmentos encontrados no sítio da antiga Igreja de Santo André. Os resultados são comparados e discute-se a possibilidade de os fragmentos encontrados terem pertencido ao painel perdido.

João Manuel Mimoso

LNEC - Laboratório Nacional de Engenharia Civil, Lisbon, Portugal, jmimoso@lnec.pt

Alexandre Pais

Museu Nacional do Azulejo, Lisbon, Portugal

Victor Filipe

Uniarq - Centro de Arqueologia da Universidade de Lisboa, Portugal

Maria de Lurdes Esteves

Museu Nacional do Azulejo, Lisbon, Portugal

Sílvia R. M. Pereira

LNEC - Laboratório Nacional de Engenharia Civil, Lisbon, Portugal / Laboratório HERCULES - Universidade de Évora, Portugal

Maria Antónia Pinto de Matos

Museu Nacional do Azulejo, Lisbon, Portugal

Ana Margarida Cardoso

Laboratório HERCULES - Universidade de Évora, Portugal

António Candeias

Laboratório HERCULES - Universidade de Évora, Portugal

KEYWORDS: Renaissance majolica / Azulejo panel Nossa Senhora da Vida / João de Góis / / Early Portuguese azulejos / Museu Nacional do Azulejo

ACKNOWLEDGEMENTS

Paper produced as an output of Project FCT-AzuRe - Estudos no Azulejo Português para Candidatura a Património da Humanidade (PTDC/EPH-PAT/5096/2014) funded by FCT, the Portuguese Foundation for Science and Technology.

LNEC Research Project 0202/111/19747.

Aviso legal

As opiniões manifestadas no *Studies in Heritage Glazed Ceramics* são da exclusiva responsabilidade dos seus autores.

Legal notice

The views expressed in the *Studies in Heritage Glazed Ceramics* are the sole responsibility of the authors.

1. INTRODUCTION

The Santo André (Saint Andrew) church, near the old Graça convent and church in Lisbon, was founded in the 14th century. At the end of the 16th century it had a number of small side chapels among which, near the entrance, was the Nossa Senhora da Vida (Our Lady of Life) chapel. This had been instituted by Bartholomeu Vaz de Lemos (?- ca. 1582) and was lined on the back by a panel of azulejos known by the name of the chapel. Possibly the utmost work of art of this type produced anywhere in Europe in its time, the technical quality and enduring aesthetic appeal of Nossa Senhora da Vida (Figure 1) granted its preservation when the church was demolished and the panel is now on display at the Museu Nacional do Azulejo (National Museum of Azulejo).

The historical information concerning the church and the panel, as well as its sources can be found in [1].



Figure 1. The superlative Nossa Senhora da Vida azulejo panel

Nossa Senhora da Vida was saved through the efforts of a man named José Valentim, who called attention to it and then assisted with its removal in January 1845. He left a testimony of the joint efforts to save the panel and keep it in the country, mentioning that it was not dated but that *in the painting that was on the other side of the chapel and was of lesser quality one could read “1580”*. So, he believed that *it is likely they were from the same time although the others were not as valuable, being less well sketched and of inferior colour* [2].

From his comparison of the quality of the sketch and colours, we may conclude that there was indeed at least one other azulejo panel, to which was associated the date “1580”. The mention to inferior colours suggests that the panel or panels might be from a different workshop or chronology.

In 2018 an archaeological excavation in grounds that may be associated to the former Santo André church, found six fragments of faience azulejos some of which – part of the face of an elderly man and the locks of hair of, maybe, a child – are certainly from a figurative panel (Figure 2) and the reference to another early panel in the church at the time of its demolition came to mind: could these fragments be part of it?

In this paper we report the results of an analytical study of the Nossa Senhora da Vida panel and of the fragments found, comparing the results based on the assumption that they are coeval and were produced by the same workshop.

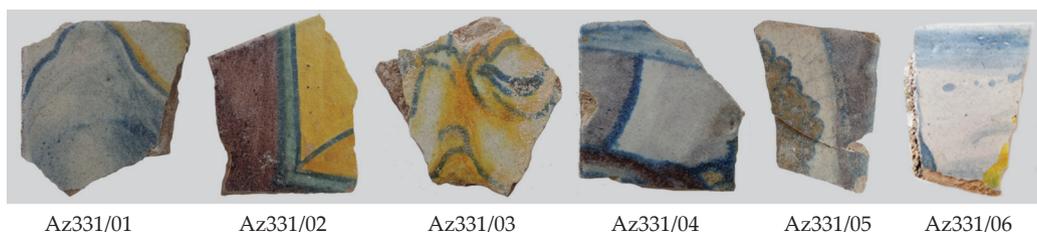


Figure 2. Azulejo fragments found during an archaeological excavation in the grounds of the demolished Santo André church and thought to have been part of one or more azulejo panels from the church

2. EXPERIMENTAL

2.1. Samples

Samples were carefully collected from various tiles of Nossa Senhora da Vida by removing small fractions of the glaze and biscuit with a scalpel from areas where it was already partially detached. The samples were identified with the reference Az032 (corresponding to this panel) plus an additional code to identify each sample. Some of the sampling locations are shown in Figure 3 but because the panel made up a single unit, at this phase the samples were chosen without any particular intention except that they should include a section of white glaze and a selection of colours, including the dark outline used to define many of the figures, to investigate the technique used. Table 1 includes a list of samples and their locations and colours.



Figure 3. Some areas from where samples were collected – from left to right: Az032/01 and Az032/02; Az032/05; Az032/08

The shard recovered during the excavation of the former Santo André church bear the reference Az331 and the samples collected from the six fragments were identified as indicated in Figure 2. The glaze of these fragments is in excellent condition when compared to other similar shards recently recovered [e.g. 3] suggesting that the soil from which they were excavated was dry throughout the year.

Table 1. Samples from Nossa Senhora da Vida

Sample	Panel / Location	Colour
Az032/00	Child Jesus elbow / arm	white
Az032/01	crib	fawn
Az032/02	crib	green
Az032/04	Mary's mantle	blue
Az032/05	crib straw	yellow
Az032/06	above Jesus' feet	purple
Az032/08	protruding vertical line of the frame	dark purple / black

2.2. Equipment and technical methodology

The fragments detached from the azulejos were stabilized in epoxy resin, lapped and polished to obtain a flat surface for observation and analysis by scanning electron microscopy coupled with an X-ray energy-dispersive spectrometer (SEM-EDS).

The optical acquisition of sample images was made with a Leica DFC295 digital camera attached to a Leica M205C stereomicroscope.

SEM-EDS observations and analyses were made at the HERCULES Laboratory in Évora using a HITACHI 3700N SEM coupled to a BRUKER XFlash 5010 EDS. The specimens were uncoated and the observations were made in backscattered electrons mode (BSE) with the chamber at a pressure of 40 Pa and at an accelerating voltage of 20 kV. The acquisition of X-ray spectra was done with the detector set at ca. 8 mm working distance.

The selection of areas for EDS analysis avoided inclusions in the glaze or biscuit representing more than ca. 5 % of the full area analysed. The area sizes were ca. 200 x 200 μm^2 for glazes and 500 x 500 μm^2 for biscuits but acceptable repeatability was

verified in areas four times smaller. For comparison purposes, only the elements usually representing the major contents were considered, excluding tin (Sn) in the glaze and lead (Pb) in the biscuit due to their variability with the area chosen (in the case of Sn because of local aggregations of SnO₂ crystals; in the case of Pb because its content in the biscuit increases with proximity to the interface with the glaze). The results of the EDS analyses are given in weight % of each element identified.

Principal component analysis (PCA) was made of EDS results using the SPSS® software platform by IBM Analytics.

3. RESULTS

3.1. Glaze morphology

Figure 4 illustrates microscopic images of three of the sections prepared from Nossa Senhora da Vida. No *coperta* (a transparent glaze layer sprinkled on top of the painted glaze) was used, as testified by the section of Az032/03 in Figure 4. All biscuits are of a dark red colour.

It is particularly remarkable that on sample Az032/08 (right side of Figure 4) the dark outline is very well defined in section: it remains coherent and protruding from the glaze with very little spread of the pigments present in the dark colour, down into the glaze under it. This sample corresponds to cases as in Figure 5 in which the outline stands clearly out of the face of the tiles.



Figure 4. Polished sections of the azulejo panel Nossa Senhora da Vida observed at the optical microscope – left to right: Az032/00; Az032/03; Az032/08



Figure 5. Part of the sketch of the azulejo panel Nossa Senhora da Vida showing how some dark outlines protrude from the face of the tiles

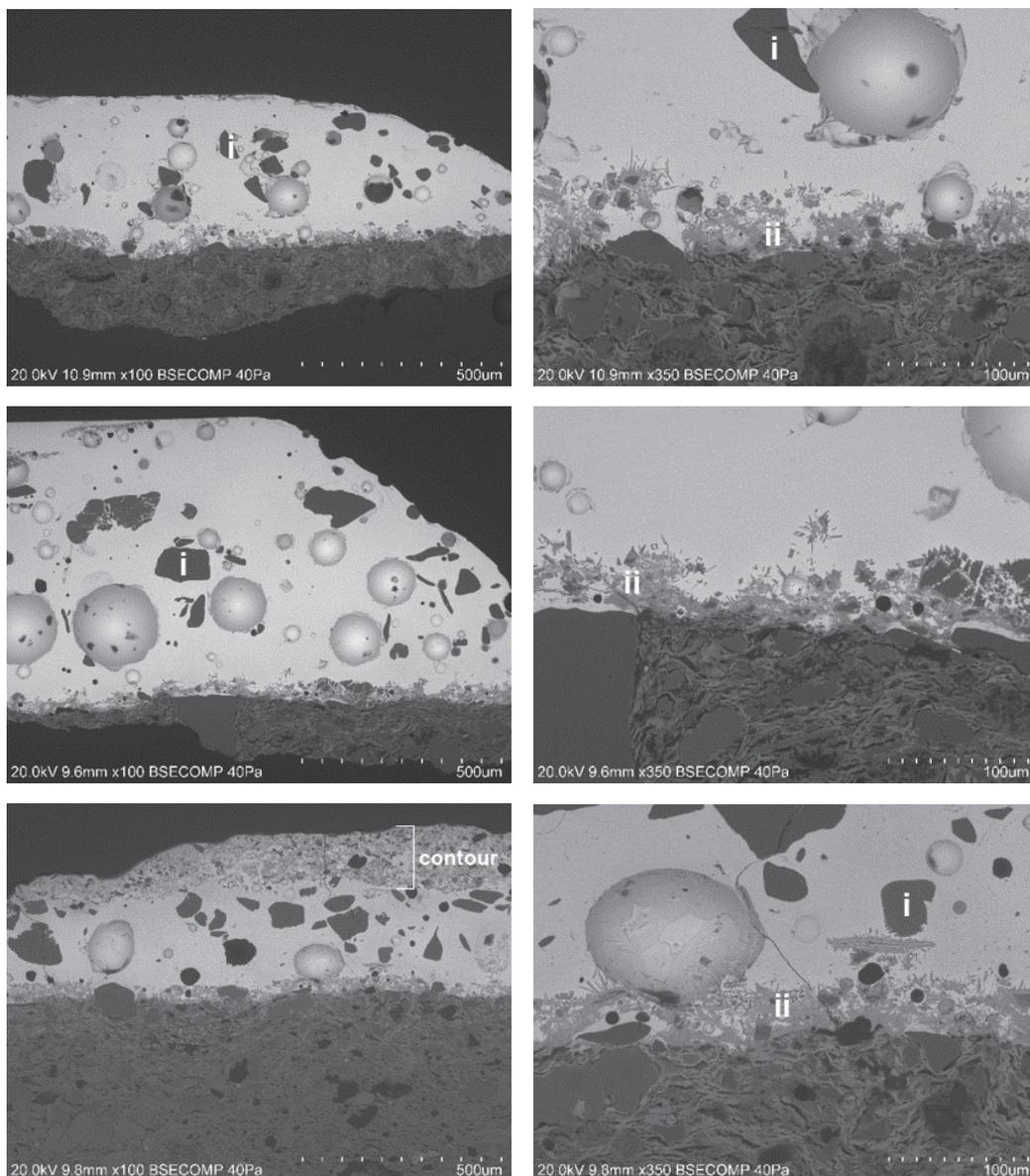


Figure 6. SEM images of samples of Nossa Senhora da Vida panel at lower and higher magnification – from top to bottom: Az032/01; Az032/02; and Az032/08, that exemplify the main micro-morphologic characteristics generally associated with the glazes of this panel. *i* - Sand grain; *ii* - neo-formation interfacial K-feldspar crystals; “contour” – protruding outline in section

Figure 6 depicts SEM images of samples Az032/01, Az032/02 and Az032/08 that exemplify the main micro-morphologic characteristics generally associated with the glazes of this panel: relatively few inclusions, mostly large-sized grains of sand; interface glaze-biscuit with abundant K-feldspar crystals formed during the second firing [4]. Both can be considered distinctive and the interfacial outgrowth is a particularly striking one that we had only previously seen with similar profusion in white glazes in some

Hispano-Moresque tiles [5]. This morphology likely results from the firing technology used, with long firing and cooling times [6; 7]. The glazes of all samples studied were morphologically similar with minor variations in the size and shape of the interfacial outgrowths.

In sample Az032/08 the section of the protruding outline depicts many small inclusions, probably added to the smalt to make a paste with which the contour lines were painted. EDS analyses of the inclusions were attempted and three sorts of particles were identified (Figure 7): *a* - particles that look light-coloured in BSE mode and were tentatively identified as lead arsenate whose crystals may also be seen inside the bubbles, prompted by the use of arsenic-rich blue cobalt pigment to make the colour; *b* - particles with sharp edges that look almost black in BSE mode and are small grains of sand; and *c* - particles that look grey in the image. A high content in Ca was found in these particles, together with a higher content in Si than can be explained by the glass matrix. Their mineralogy has not yet been identified but they may be a calcium silicate.

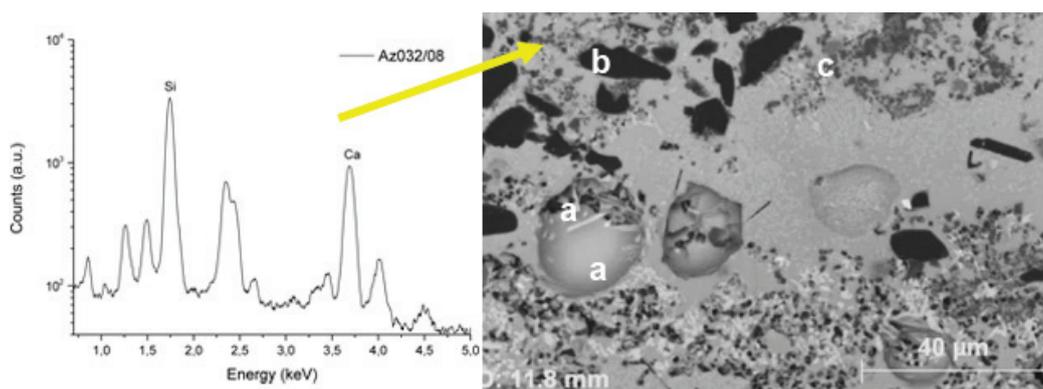


Figure 7. EDS spectrum of the grey inclusions in the protruding outlines. Besides the matrix and the gas bubbles, the sectional image depicts: *a* - “white” particles and crystals of lead arsenate; *b* - sand grains; *c* - grey particles of, maybe, a calcium silicate

Figure 8 illustrates microscopic images of three of the sections prepared from the excavated fragments from Santo André church. All biscuits are of a cream colour and again no coperta was used.



Figure 8. Polished sections of samples from the Santo André shard observed at the optical microscope. Left to right: Az331/03; Az331/05 and Az331/06

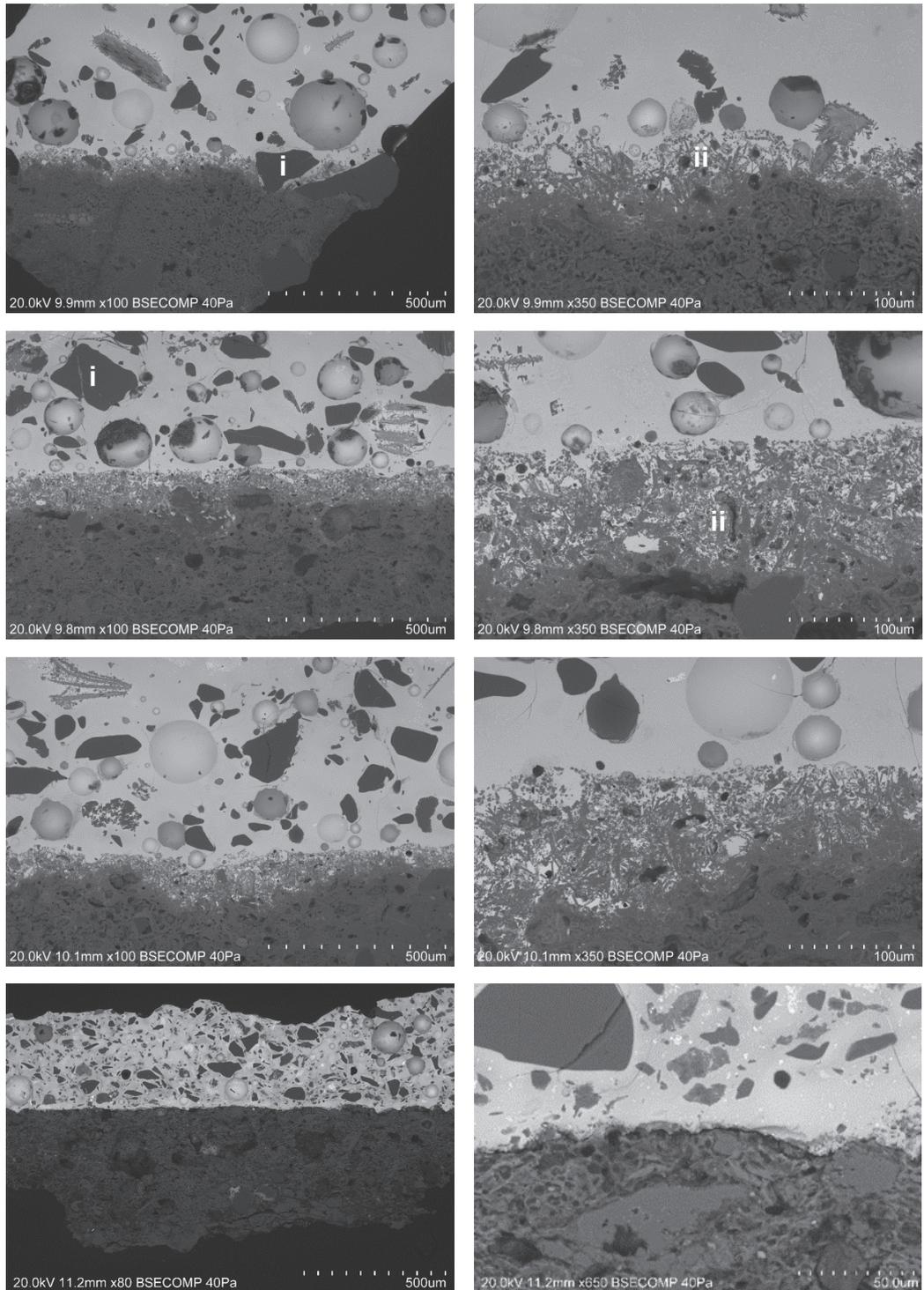


Figure 9. SEM images of the samples from the shard found at the site of Santo André church, exemplifying the main micro-morphologic characteristics generally associated with them. From top to bottom: Az331/02; Az331/03; Az331/05; and Az331/06. **i** - Sand grain, **ii** - neo-formation K-feldspar crystals

Figure 9 illustrates SEM images of samples Az331/02; Az331/03; Az331/05 and Az331/06 from the shard excavated at the grounds of Santo André church. They depict glaze-biscuit interfaces with, in general, abundant crystallizations comparable to the samples from the Nossa Senhora da Vida panel in Figure 6. However, although the glaze inclusions are also similar to those seen in Figure 6, they are often more numerous per unit sectional area. But there is a remarkable exception to this general similarity: sample Az331/06 depicts a completely different morphology of the inclusions and, at the stated scale, only minor outgrowths from the biscuit in its interface with the glaze.

3.2. Glaze composition

Table 2 includes the semi-quantitative results of analyses of the glazes by EDS in weight %. Sn was excluded for the reasons pointed out in section 2.2. The amount of oxygen was calculated through the remaining elements stoichiometry of their most commonly considered oxides (Na_2O , MgO , Al_2O_3 , SiO_2 , K_2O , Fe_2O_3 and PbO). The results were normalized to 100 % and the table also indicates the ratios Si/Pb.

Table 2. Semi-quantitative composition (% w/w) of the glazes determined by EDS (weight of the elements normalized to 100 %) and Si/Pb ratio for Nossa Senhora da Vida and the shard from Santo André church

Sample	Na	Mg	Al	Si	K	Fe	Pb	O	Si/Pb
Nossa Senhora da Vida									
Az032/00	0.9	0.5	2.4	14.5	0.9	0.6	56.1	24.1	0.26
Az032/01	1.4	0.7	2.6	15.3	0.8	0.6	53.3	25.3	0.29
Az032/02	0.8	0.7	2.9	16.5	1.2	0.6	50.6	26.6	0.33
Az032/04	0.7	0.2	3.7	23.8	2.6	1.1	33.6	34.4	0.71
Az032/05	0.9	0.5	2.7	15.0	0.7	0.8	54.5	24.9	0.28
Az032/06	1.1	0.5	2.3	15.6	1.0	0.7	53.5	25.2	0.29
Az032/08	0.7	0.2	4.2	20.5	1.5	1.0	40.5	31.4	0.51
Shard Santo André church									
Az331/01	1.0	0.4	2.6	16.7	1.6	0.6	50.7	26.4	0.33
Az331/02	1.3	0.6	3.0	17.4	1.5	1.3	47.0	27.9	0.37
Az331/03	1.0	0.5	2.8	14.6	0.9	0.7	54.8	24.6	0.27
Az331/04	1.3	0.5	2.8	18.4	2.9	0.8	44.6	28.7	0.41
Az331/05	1.3	0.6	2.3	16.5	1.2	0.8	51.1	26.2	0.32
Az331/06	3.4	0.8	3.6	21.9	3.6	1.3	31.8	33.6	0.69

Figure 10 shows the results of a log-based principal component analysis (PCA) of the glazes of all samples, considering the analytical results in Table 2, through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 61 % of the variation and is controlled in the positive sense mostly by the contents in Al, Si, K and Fe and in the opposite sense by the content in Pb, as can be seen from the loadings plot of

Figure 11 in which the projections of the vectors on an axis show the contribution of each element to the respective principal component. PC2 explains 26 % and is controlled in the positive sense mostly by the contents in Na and Mg and in the opposite sense mostly by the contents in Al and Pb (Figure 11).

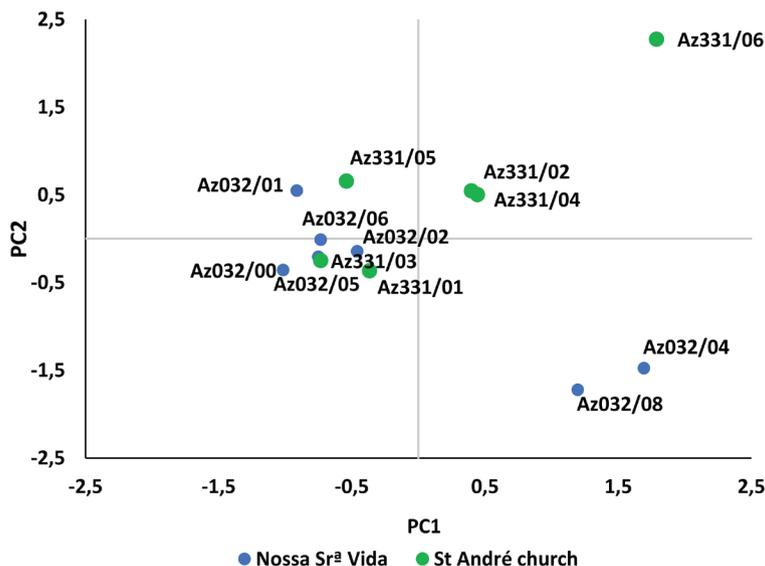


Figure 10. Score plot PC1 vs. PC2 of the PCA analysis of the glazes

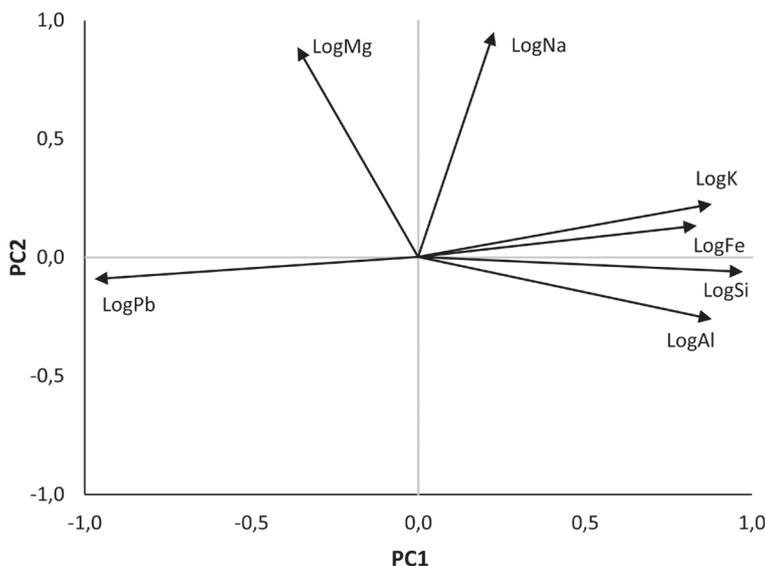


Figure 11. Loadings plot of the PCA analysis of the glazes

Considering the score plot of Figure 10, the samples are similar and those from the Nossa Senhora da Vida panel cannot be clustered together in a way that separates them squarely from the shard samples. However, sample Az331/06, with a higher content in Na and K and lower in Pb (Table 2), is clearly separated from all others. This is meaningful because

Az331/06 is the sample that was seen to be morphologically dissimilar from the rest (Figure 9 bottom). The glazes of samples Az032/04 and Az032/08 are also compositionally different from the remaining, mostly due to a higher Si/Pb ratio. The tiles from which those samples were collected were macroscopically examined and no peculiarity has been found in them that could point to a later incorporation or restauration. The difference may result from the natural compositional variability of the glazes, particularly at the small scale at which they are analysed.

3.3. Biscuit composition

Table 3 includes the semi-quantitative results of analyses of the biscuits by EDS in weight %. Pb was excluded for the reasons pointed out in section 2.2. The amount of oxygen was calculated through the remaining elements stoichiometry considering their most commonly used oxides (Na_2O , MgO , Al_2O_3 , SiO_2 , K_2O , CaO and Fe_2O_3). The results were normalized to 100 % and the table also indicates the ratios Ca/Si.

Table 3. Semi-quantitative composition (% w/w) of the biscuits determined by EDS (weight of the elements normalized to 100 %) and Ca/Si ratio for Nossa Senhora da Vida and the shard from Santo André church

Sample	Na	Mg	Al	Si	K	Ca	Fe	O	Ca/Si
Nossa Senhora da Vida									
Az032/00	1.5	1.7	10.5	25.3	3.8	6.4	5.3	45.4	0.25
Az032/01	1.2	2.2	9.1	24.6	2.7	9.5	5.9	44.9	0.39
Az032/02	1.1	1.5	8.7	28.8	2.7	6.9	3.5	46.7	0.24
Az032/04	1.8	1.4	9.7	23.2	4.0	10.8	5.2	44.0	0.47
Az032/05	1.2	1.7	12.7	25.4	4.2	2.6	6.0	46.2	0.10
Az032/07	1.3	1.5	10.3	25.9	3.8	6.5	5.1	45.7	0.25
Az032/08	1.4	1.8	10.7	23.6	3.6	9.3	4.8	44.7	0.39
Shard Santo André church									
Az331/01	0.8	1.7	7.0	15.6	0.7	31.2	3.6	39.5	2.00
Az331/02	1.1	1.9	7.0	15.9	1.0	30.5	3.1	39.6	1.92
Az331/03	0.6	1.6	6.9	16.0	0.8	30.4	4.0	39.6	1.90
Az331/04	0.7	1.9	7.0	15.1	0.4	31.9	3.7	39.3	2.11
Az331/05	1.0	1.9	7.6	18.0	0.9	25.7	3.9	41.0	1.43
Az331/06	2.0	2.1	8.2	13.5	1.1	29.9	4.4	38.8	2.21

Figure 12 shows the results of a log-based principal component analysis of the biscuits, considering the analytical results in Table 3, through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 68 % of the variation and is controlled in the positive sense mostly by the contents in Al, Si, K, Na and Fe and in the opposite sense mostly by the content in Ca, as can be seen from the loadings plot of Figure 13. PC2 explains 16 % of the variation and is controlled in the positive sense mostly by the content in Mg and the opposite sense by the content in Si (Figure 13).

In the score plot of Figure 12, it can be seen that the samples from Nossa Senhora da Vida and the Santo André shard are clearly separated and may be aggregated in two different clusters mostly due to their relative contents in Ca, the samples from the excavated fragments having a much higher Ca/Si ratio than the rest.

It is interesting to note that neither Az032/04 and Az032/08 singled by the score plot of Figure 10, are separated from their respective clusters when the biscuits are considered.

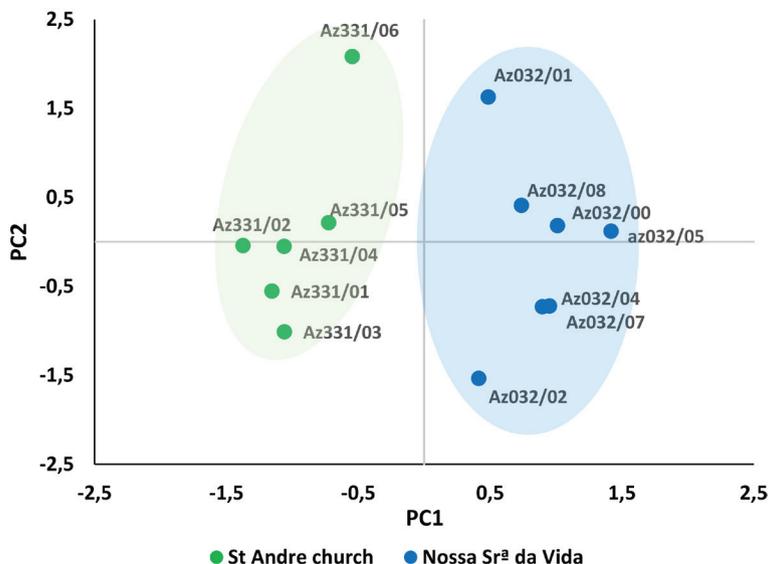


Figure 12. Score plot (PC1 vs. PC2) of the PCA analysis of the biscuits of Az032 and Az331 samples

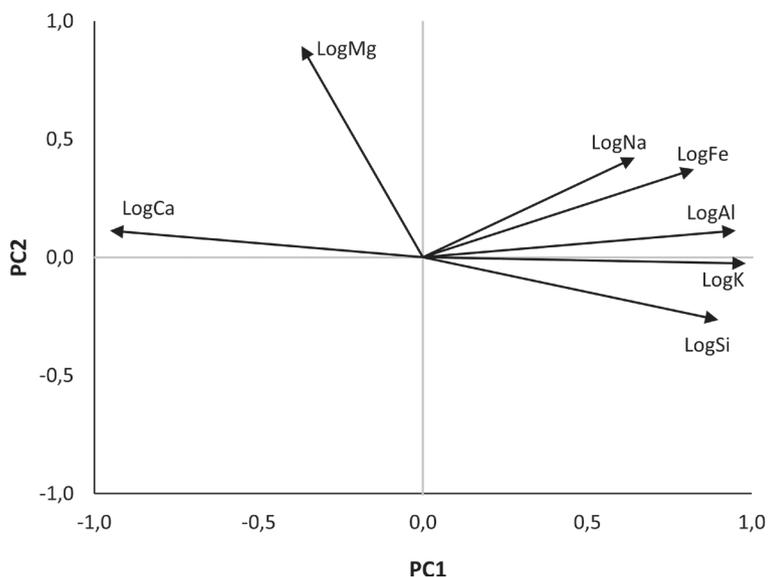


Figure 13. Loadings plot of the PCA analysis of the biscuits

4. DISCUSSION

All tiles except that represented by Az331/06 seem to have been fired in a cycle including a long cooling period, maybe using the same kiln that fired the tiles of other panels presenting similar morphologies [8]. Such a firing cycle results in a characteristically well-developed interface with extensive growth of K-feldspars already found by other authors and by us in reproduction studies [4; 6; 7].

Considering the morphological characteristics of the glazes (Figures 6; 9), their compositions (Table 2), and PCA results (Figure 10), the samples can be considered to form two groups: Senhora da Vida (minus eventual uncharacteristic outliers) and the fragments Az331/01 to Az331/05 from the site of Santo André church make up a first group, while Az331/06 is different. Albeit similar, the inclusions and interfacial growth of Senhora da Vida and of the five fragments mentioned are not an exact match. Such situation is what might be expected from the application of the same broad technology at two different and possibly distant chronologies. In the case of Az331/06, not only the nature and density of the inclusions are diverse but also the interface, largely devoid of outgrowths when considered at the same scale as the other samples, is completely different. Compositionally, Az331/06, in which the glaze contents in Na and K, as well as the ratio Si/Pb are much higher, is also distinct.

Table 3 and the PCA results in Figure 12 compare the composition of Nossa Senhora da Vida biscuits with the shard of Santo André and they are seen to be very different. Indeed, against a Ca/Si ratio under 0.4 for Senhora da Vida, all the samples from Santo André church present ratios five times higher. The excellent condition of the glazes shows no lixiviation of the lead in the presence of water [3] and therefore the fragments were probably buried in an essentially dry soil. Therefore, the possibility of substantial deposition of alien calcium carbonate in the excavated fragments can be refuted. Actually, the compositions of the biscuits of the Santo André shard are similar to those of 17th century Portuguese tiles [5]. It is also noteworthy that, in the case of the biscuits, Az331/06 is close to the other fragments from Santo André church, even though the glazes are very distinct. The separation derives only from the lesser PC2 component.

Referring to samples Az331/01 to Az331/05 we may put forward that the panel which they represent stems from the same technological circle as Senhora da Vida, using a similar glaze formulation and a similar firing cycle. All may even have been fired at the same kiln. The glaze, poor in alkalis and with a low Si/Pb ratio, fired in a long cycle that promoted the interfacial growth is a typical 16th century trait of the workshops of Lisbon that may have spanned to the early 17th century but was not enduring [5]. However, the biscuits tell a completely different story: Senhora da Vida used a ceramic paste low in Ca that fired to a reddish colour with the cycle used, while the panels (at least two) from Santo André chapel, represented by the six fragments studied, used a paste high in Ca that characterizes later productions in which the Ca/Si ratios are well above 1.0 [5]. This paste fired to cream biscuits, even when a firing cycle similar to that of Senhora da Vida was used.

A discussion of the chronology of the panel from Santo André church represented by the fragments from which samples Az331/01 to Az331/05 were taken should now be tried based on the analytical results. Advancing as a hypothesis that all extant Lisbon azulejo workshops (if more than one) were using a similar technology in the 1580s, then based on the present information about the productions of which a date is (at least approximately) known [8] we are induced to place the panel represented by those fragments after the lining of São Roque chapel, dated “1584” [9]. The assumption that they might be coeval

with Senhora da Vida is therefore remote. This conclusion stems from the composition of the biscuits, with high Ca/Si ratios, similar to 17th century productions. If we recall Mr. José Valentim’s documented testimony that he saw associated to another now lost panel the date “1580”, then it is unlikely that the fragments recovered may be from that exact panel.

The glaze of fragment Az331/06, with a higher Si/Pb ratio, can be associated to a different and very likely even later production, given the morphology of the glaze and the small crystalline development of the glaze-biscuit interface, characteristic of the 17th century [5].

The unusual addition of finely ground minerals to a smalt used to paint outlines (Az032/08 in Figures 6 and 7), presumably to give them body and avoid the running of the colour over firing, may characterize a single painter or workshop. The dark lines remain protruding from the glaze with very little spread of the blue or violet pigments down into the glaze under it (Figure 4). This suggests that the protruding outlines were painted over an already fired glaze which was subsequently re-fired at a lower temperature to avoid the spread of the colours. This technique would certainly add to the cost and is quite unexpected. It may have also been used in the 1558 tiles from Antwerp applied in the *Palácio de Vila Viçosa* in South Portugal, in which slightly protruding dark lines and outlines can also be seen, but in that case no similar mineral inclusions were observed in the smalt [10]. A final conclusion on the technology used for this purpose needs to be based on the making of reproductions.

5. CONCLUSION

Based on the results of this study, the fragments represented by Az331/01 to Az331/05 stem from the same technological circle as the panel Nossa Senhora da Vida and the panel or panels they represent may even have been produced at a later time by the same workshop that made Nossa Senhora da Vida. But the biscuits are different and their similarity to later types points to a date after 1584. Therefore, these should not be part of another panel in the same church said to be dated “1580”. Until more archaeological finds are made, we have to consider the search for the lost panel as an open case.

These fragments may, however, be highly important because they seemingly testify to a transition. Their glaze composition and firing cycle are “ancient” in the sense they represent the earliest faience azulejo technology known from Portugal, but their biscuits are “modern” in the sense their composition is what could be expected in a 17th century tile. They are a hybrid link that mark a time as yet undated when an important technological transition was taking shape, that would endure through the 17th and 18th centuries.

BIBLIOGRAPHIC REFERENCES:

1. PAIS, A. et al. – *The 16th century nativity azulejo panel called “de Nossa Senhora da Vida”* in *Studies in Heritage Glazed Ceramics*, No. 1, pp. 67-76 , LNEC, Lisbon, Portugal, February 2019.
2. GUIMARÃES, Ribeiro – *Summario de varia historia. Narrativas, lendas, biographias, descripções de templos e monumentos, estatísticas, costumes civis, políticos e religiosos de outras eras. Por...* vol. II, pp. 103-111, Rolland & Semiond, Lisbon, 1872.

3. PAIS, A. et al. – *16th century azulejos – what lies beneath the ground of Lisbon?* in Proc. Int. Conf. Glazed Ceramics in Cultural Heritage (GlazeArt 2018), LNEC, Lisbon Oct. 29-30, pp. 298-312, LNEC, Lisbon, 2018.
4. MOLERA, J. et al. – *The growth of sanidine crystals in the lead of the glazes of Hispano-Moresque pottery*, App. Clay Sc. 7/1993, pp. 483-491, 1993.
5. MIMOSO, J. et al. – *A comparison of the earliest faience tiles produced in Lisbon with earlier and later types* in Studies in Heritage Glazed Ceramics, No. 1, pp. 25-46, LNEC, Lisbon, February 2019.
6. MOLERA, J. et al. – *Interactions between Clay Bodies and Lead Glazes*, Journal of the American Ceramic Society, Vol. 84, No. 5, pp. 1120-1128, May 2001.
7. PEREIRA, S. et al. – *Influence of the production technology on the morphological characteristics of azulejos* in Proc. Int. Conf. Glazed Ceramics in Cultural Heritage (GlazeArt 2018), LNEC, Lisbon Oct. 29-30, pp. 140-149, LNEC, Lisbon, 2018.
8. MIMOSO, J. et al. – *A technical comparison of three renaissance azulejo panels from the workshops of Lisbon* in Studies in Heritage Glazed Ceramics, No. 1, pp. 113-132, LNEC, Lisbon, February 2019.
9. MIMOSO, J. et al. – *A research on the azulejo panels of the São Roque chapel in Lisbon* in Studies in Heritage Glazed Ceramics, No. 1, pp. 93-112, LNEC, Lisbon, February 2019.
10. MIMOSO, J. et al. – *Analytical study of tiles of presumed Flemish origin from the Palace of the Dukes of Braganza in Vila Viçosa*, in “From Flanders. The azulejos commissioned by D. Teodósio I, 5th Duke of Braganza, pp. 64-74, Museu Nacional do Azulejo & Fundação da Casa de Bragança, Lisbon, 2012.