Instrumental study of the 16th century azulejo panel decorating a public fountain in Alcácer do Sal - Portugal

João Manuel Mimoso, Alexandre Pais, Marisol Ferreira, Maria de Lurdes Esteves, Sílvia R. M. Pereira, Maria Augusta Antunes, Rita Valona, Ana Margarida Cardoso, António Candeias

ABSTRACT

The public fountain at *Largo Prof. Dr. Francisco Gentil* in the town of Alcácer do Sal (65 km SE of Lisbon) is decorated with a square panel of 81 azulejos with a heraldic symbol of the Municipality. The panel is particularly important in the Portuguese context for bearing an inscribed date (1592), being the only Portuguese dated panel yet known from that decade. Another interesting feature is the text it bears: "SALATIA UBRS IMPERATORIA" referring to the Latin designation of the town in Roman times.

The panel has been generally considered of Portuguese manufacture by art historians and in this paper we report the results of an analytical study confirming that, indeed, it is a product of the workshops of Lisbon. Therefore, its micro-morphologic and compositional characteristics offer a chronologic anchor that may help to assign an approximate date to other azulejo panels or related archaeologic findings.

RESUMO

O fontanário no antigo Largo Prof. Dr. Francisco Gentil em Alcácer do Sal (65 km a sudeste de Lisboa) é decorado com um painel quadrado de 81 azulejos com um símbolo heráldico do Município. O painel é particularmente importante no contexto português por ter a data inscrita (1592), sendo o único até agora conhecido desta década. Outra característica interessante é o texto nele inscrito: "SALATIA UBRS IMPERATORIA" referindo-se à designação latina da cidade na época romana.

O painel tem sido geralmente considerado de fabricação portuguesa pelos historiadores de arte e neste trabalho relatamos os resultados de um estudo analítico do qual se conclui que, de facto, é um produto das oficinas de Lisboa. Assim, as suas características micro-morfológicas e composicionais oferecem uma âncora cronológica que pode ajudar a atribuir uma data aproximada a outros painéis azulejares ou a achados arqueológicos.

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KEYWORDS: Renaissance majolica / Alcácer do Sal azulejo heritage / João de Góis / Early Portuguese azulejos

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1. INTRODUCTION

The public fountain at *Largo Prof. Dr. Francisco Gentil* in the town of Alcácer do Sal (65 km SE of Lisbon) is decorated with a square panel of 81 azulejos with a heraldic symbol of the Municipality (Figure 1). Given the fact that its frame is not closed below, the panel may have been set over a pre-existing architectural structure, or else may be missing at least one lower azulejo row.

Generally considered of Portuguese manufacture [1; 2], the panel must have been originally better protected from the elements, as testifies the progression of its decay suffered over the last sixty years perceived by comparing the present condition with its condition ca. 1956 (Figure 1).

Figure 1. The panel in 2018 (top) and ca.1956 (colourised photo reproduced from [1])

The panel is particularly important in the Portuguese context for bearing an inscribed date: "1592", eight years after the signed and dated panel at *Capela de São Roque* in Lisbon [3]. It also bears the text "SALATIA UBRS IMPERATORIA" tentatively following the Latin designation "SALACIA IMPERATORIA URBS", the name of Alcácer do Sal in Roman times [4].

The date inscribed in the panel is separated in two parts by one of the symbolic castles and may also be transcribed as "IS / 92" instead of "15 / 92" because the graphic representation of the numerals changes, suggesting that the first two characters could also represent the letters "IS". The use of a dot over the numeral "1" is known in the field – at *Capela do Espírito Santo* in Évora, the panels of the Main Chapel are dated "1631" with both "1" numerals in the date superimposed by a dot [5, plate LVI]. However, here, there is a difference: the characters are purposely positioned to be separated in two groups of different calligraphy by the castle, suggesting a double entendre proposition on the observer representing, for instance, the initials of the workshop master or the person who commissioned the panel, while the date "92" may relate to an event of importance to the community of Alcácer or to whoever ordered the azulejos. In such case the panel may actually have been manufactured later than the date inscribed.

There is a general absence of references to this panel in terms of bibliography before the 20th century. However, reading an important collection of books published in 1873 about the history, chorography, heraldry, (etc.) of all the towns and villages of Portugal [6], there is a striking information regarding this particular municipality: "water is abundant in the whole region of Alcácer do Sal – however, inside the town proper there is no fountain!" (*É o termo da villa abundantíssimo de águas – mas dentro da villa não há fonte nenhuma!*). From this information we conclude that this fountain and its panel were not in place at their present site before circa 1873, the date when the book was published. This seems to be confirmed by the fact that the author makes a point of mentioning heraldic aspects and, although azulejos were so common that they were not considered worth mentioning in themselves, he would expectedly not go without noting a panel bearing the coat of arms of the town if it was publicly visible at its center. The first reference we found to the panel is in the second edition of Vergilio Correia's work on dated azulejos [7]. He does not mention any source, giving the impression that the panel was only recently identified. The notion of novelty is strengthened by the fact that he used a line drawing (dated "1921") of the panel for the cover. His list of dated azulejo panels was originally published in 1915, in a journal [8], but the panel was not mentioned at that time, even though the journal of the Archaeologist's Society, of which the author was a member, published frequent articles on Alcácer do Sal and its antiquities, the earliest and most complete of which in its first year of publication [9], and it is not likely that a panel of epigraphic interest would go unmentioned. Seemingly, the panel was applied at its present location between 1915 and 1921 but, unfortunately, none of the references yet found mentions its provenance.

Another interesting aspect that the author of the books published in 1873 mentions when describing the most important figures and events of the region is a reference to one Rui Salema (act.1537-1578). This nobleman built the Salema Manor that still stands not far from the fountain and, with his wife Catarina Sotomaior, is connected with the foundation of both the hospital in Alcácer do Sal and the Clarissa Convent of *Nossa Senhora de Aracoeli* [10, pp. 157-159]. Rui Salema had several brothers, one of which was Cristóvão Salema. Cristóvão Salema fathered Diogo Salema who in 1586 founded the second most important chapel in the Church of *Santa Maria da Graça* in Setúbal, the *Capela*

do Santíssimo [10, pp. 161-164]. The set of dispersed azulejos recently found in that church and tentatively dated to the late 1580s or 1590s may have been related with *Capela do Santíssimo* [11] and, if so, the Salema family could be involved in the purchase of both the Setúbal and the Alcácer do Sal panels. Rui Salema had died childless in 1578 but other members of the same family, whose name is connected with Alcácer do Sal since an early time, were active, including a cousin, João Salema, who returned from Ceuta precisely in 1592 [10, pp. 141-151].

On the other hand, the coincidence of family relations and the presence of early contemporaneous azulejo panels, maybe even from the same workshop, in both Setúbal and Alcácer do Sal, may well be fortuitous, but at least offers a starting point for a future investigation.

In this paper, we report the results of an analytical study of the Alcácer do Sal panel relating it with other 16th century azulejo panels by the workshops of Lisbon.

2. EXPERIMENTAL

2.1. Samples

The azulejo panel was given the reference Az334. Seven samples were carefully collected from the panel by removing small fractions, preferably of the glaze with biscuit attached, from areas already with previous damage. Each sample was identified with an alphanumerical code added to the panel reference (e.g. Az334/01). The sampling locations are shown in figure 2 and were intended to be representative of the whole panel.

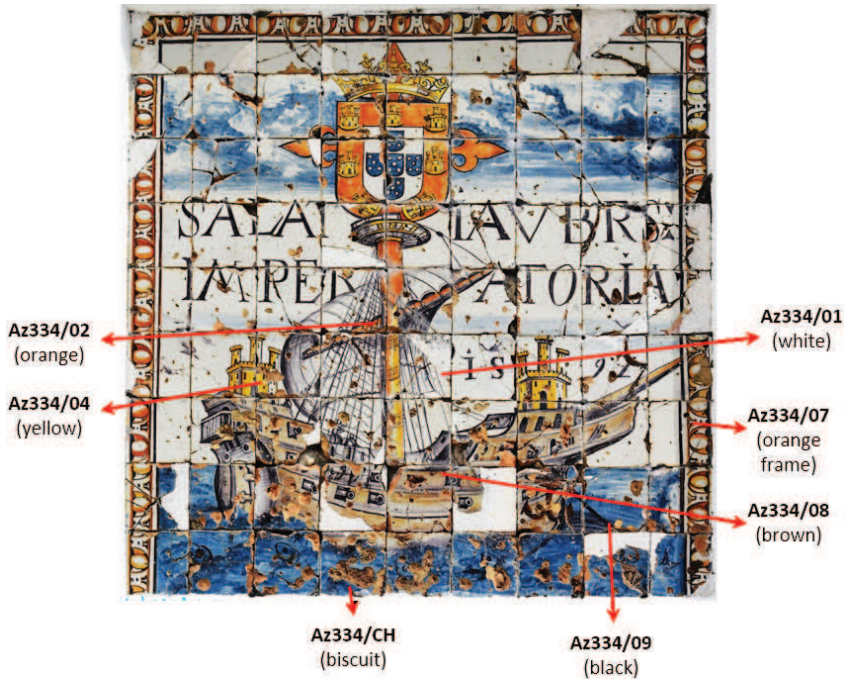

Figure 2. Sampling locations and sample references

2.2. Analytical methodology

The azulejo samples were stabilized in resin, lapped and polished to obtain a cross-section for observation and analysis by scanning-electron microscopy coupled with an X-ray energy-dispersive spectrometer (SEM-EDS).

The optical acquisition of images of the sections was obtained with a Leica DFC295 digital camera coupled to a M205C stereomicroscope of the same brand.

SEM-EDS observations and analyses were made at the HERCULES Laboratory in Évora using a Hitachi S3700N SEM with a coupled Bruker XFlash 5010 EDS. The specimens were uncoated and the observations were made in backscattered electrons mode (BSE) in variable pressure mode at 40 Pa and at an accelerating voltage of 20.0 kV. The acquisition of X-ray spectra was done with the detector at ca. 10 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. Whenever possible area sizes of ca. 200 x 200 μm for glazes and 500 x 500 μm for biscuits, or larger, were used but acceptable repeatability was verified in areas four times smaller. For comparison purposes, only the elements usually representing the major components were considered, excluding tin (Sn) in the glazes and lead (Pb) in the biscuits due to their variability with the area chosen (in the case of Sn in the glaze because of crystal aggregations and in the case of Pb in the biscuit because the content increases with proximity to the interface). The results of the EDS analyses were given in weight % of each element considered.

Principal Component Analysis (PCA) of EDS results was made using the SPSS© software platform by IBM Analytics.

2.3. Results

2.3.1. Morphological characteristics

Figure 3 illustrates microscopic images of two of the sample sections prepared. All biscuits are of a buff colour. No *coperta* (a transparent glaze layer sprinkled on top of the painted glaze) was used over the painting.

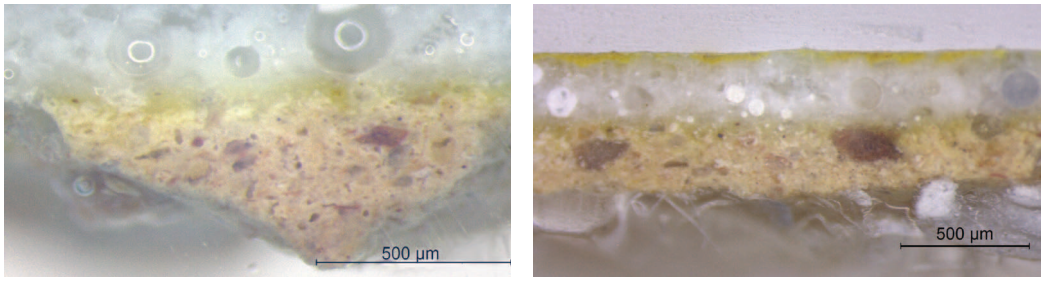

Figure 3. Prepared sections in optical microscopy – from left to right: Az334/01 and Az334/04

Figure 4 illustrates SEM images of samples Az334/01, Az334/07 and Az334/09 that exemplify the main micro-morphological characteristics generally associated with the glazes of this panel: relatively few inclusions, mostly large-sized grains of sand and rarer feldspars, and interface glaze-biscuit with many crystals of neoformation.

Both are distinguishing characteristics and the interfacial outgrowth is a particularly striking one that associates this panel with the productions of the circle of João de Góis [12].

All the sections bearing both glaze and biscuit are morphologically similar, although the density of the inclusions and of the interfacial crystals may vary.

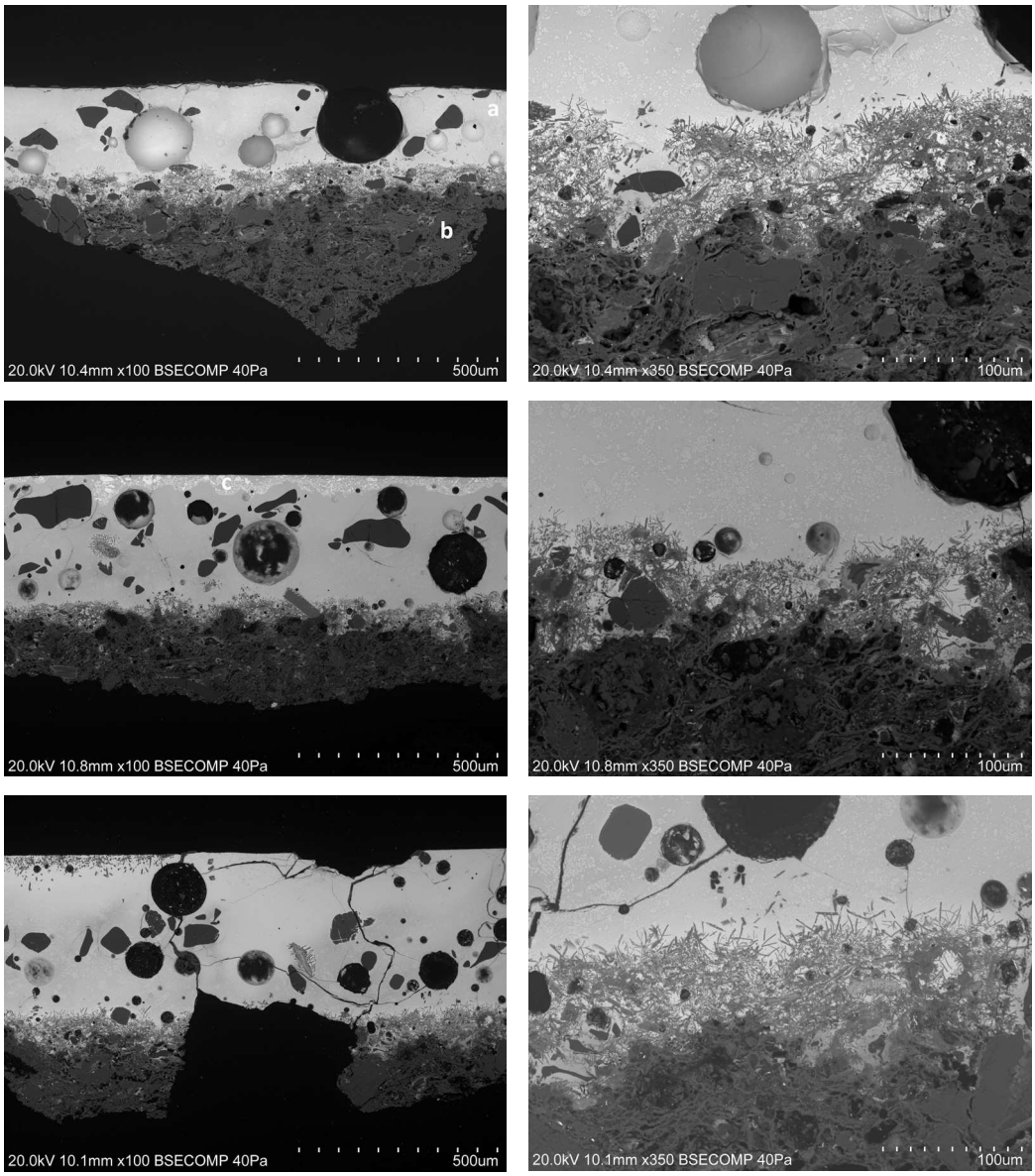

Figure 4. SEM images of samples Az334/01 (top), Az334/07 (middle) and Az334/09 (bottom) exemplifying the main micro-morphologic characteristics generally associated with the glazes and the interface glaze-biscuit of this panel (a – glaze; b – biscuit; c – orange pigment)

2.3.2. Glaze composition

Table 1 includes the semi-quantitative results of individual 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 and the results were normalized to 100%. The ratio between Si and Pb (the main components of the glaze) was determined and is also included in the table.

Table 1. Semi-quantitative composition of the glazes determined by SEM-EDS (wt.% of oxygen and main elements, excluding Sn, for comparative purposes, corrected to 100%)

Samples	Na	Mg	Al	Si	K	Fe	Pb	O	Si/Pb
Az334/01	1.13	0.66	3.30	17.18	1.61	0.55	47.98	27.60	0.36
Az334/02	0.81	0.51	3.27	16.24	1.34	0.94	50.29	26.59	0.32
Az334/04	1.01	0.53	3.12	17.60	1.33	0.62	48.03	27.77	0.37
Az334/07	1.17	0.66	3.75	17.36	1.37	1.06	46.37	28.27	0.37

2.3.3. Biscuit composition

Table 2 includes the semi-quantitative results of individual analyses of the biscuits by EDS in weight %. The results refer to oxygen and eight other elements of higher content and particular interest for comparison purposes. Pb was detected in all cases but excluded for the reasons pointed in 2.2. The amount of oxygen was calculated through the remaining elements stoichiometry of their most commonly considered oxides and the results were normalized to 100%. The table also includes the ratios between the main components of the biscuit – Ca and Si.

Table 2. Semi-quantitative composition of the biscuits determined by SEM-EDS (wt.% of the main elements corrected to 100%)

Samples	Na	Mg	Al	Si	K	Ca	Ti	Fe	O	Ca/Si
Az334/01	1.08	2.26	7.98	19.11	1.83	21.13	0.60	4.25	41.77	1.11
Az334/02	1.06	2.45	7.15	15.66	1.46	28.80	0.47	3.25	39.69	1.84
Az334/04	1.50	1.93	7.86	20.53	1.86	20.23	0.52	3.21	42.36	0.99
Az334/07	1.40	4.33	8.62	19.94	2.64	15.34	0.82	4.17	42.73	0.77
Az334/09	1.52	3.98	8.65	20.96	4.57	13.62	0.57	3.27	42.87	0.65
Az334/CH	1.31	2.53	7.46	20.81	1.57	19.08	0.51	4.18	42.55	0.92

2.3.4. Yellow, orange, brown and black colours

A grain of yellow pigment from Az334/04 was analysed and the pigment found to be, not Naples yellow, but rather tin-antimony-lead yellow [12, pp. 129] as shown by the high contents in Sn, Sb and Pb observed in the EDS spectrum (Figure 5). The approximate proportion between Sn and Sb was found to be 1:2 in weight.

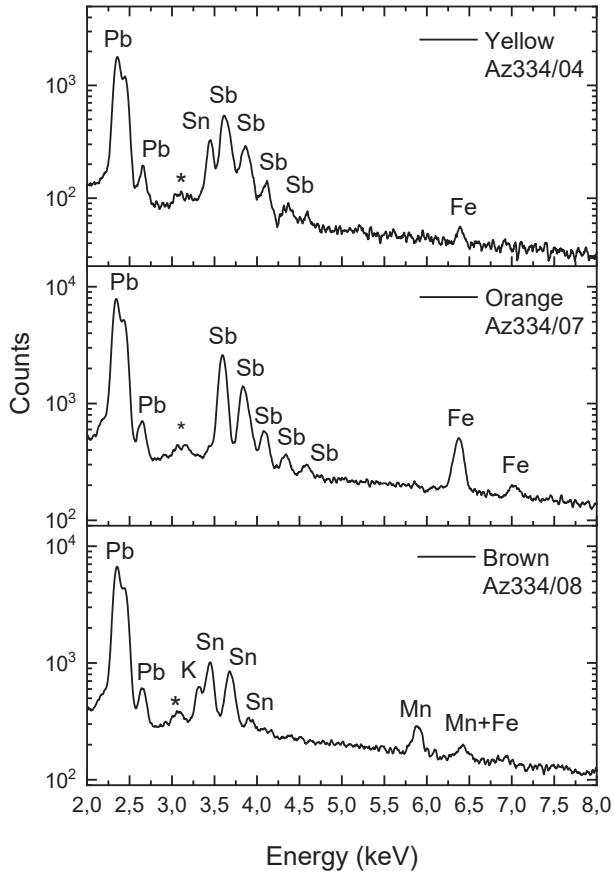

Figure 5. Partial SEM-EDS spectra of the pigments. From top to bottom: yellow (Az334/04), orange (Az334/07) and brown (Az334/08) – the peak marked "*" is an instrumental artefact

A grain of orange colour in Az334/07 was mapped by EDS (Figure 6) on the basis that it could either be a mixture of yellow pigment with iron oxide, or else an orange pigment, such as the one described by Piccolpasso [13]. The EDS colour-maps clearly show a coincidence of the occurrence of Fe and Sb in the grain areas, therefore indicating that an orange pigment was very likely used. The EDS spectrum of a single grain of the orange pigment is presented in figure 5 (approximate proportions Fe:Sb = 1:6).

The EDS analysis of the brown colour (Az334/08) showed that a manganese-based pigment was used (Figure 5).

A black colour sample (Az334/09) that includes a drawing outline was probed (Figure 7). The inclusions of grains of sand are limited to the lower part of the section, showing that

the colour was painted as a finely ground smalt, seen as a lighter whitish area in the SEM image of figure 7. The darker part of the optical image seemingly corresponds to the outline and in the SEM image small inclusions are clearly visible in it.

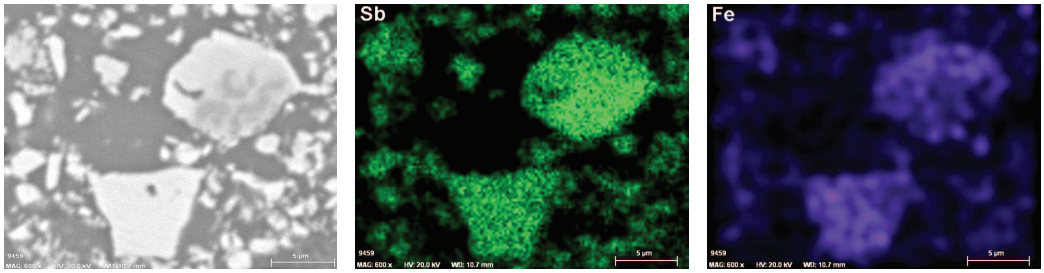

Figure 6. Selection of an area of orange colour (left side image) and elemental maps of Sb (centre image) and Fe (right side image) showing that areas of high content in both elements coincide with the grains of pigment

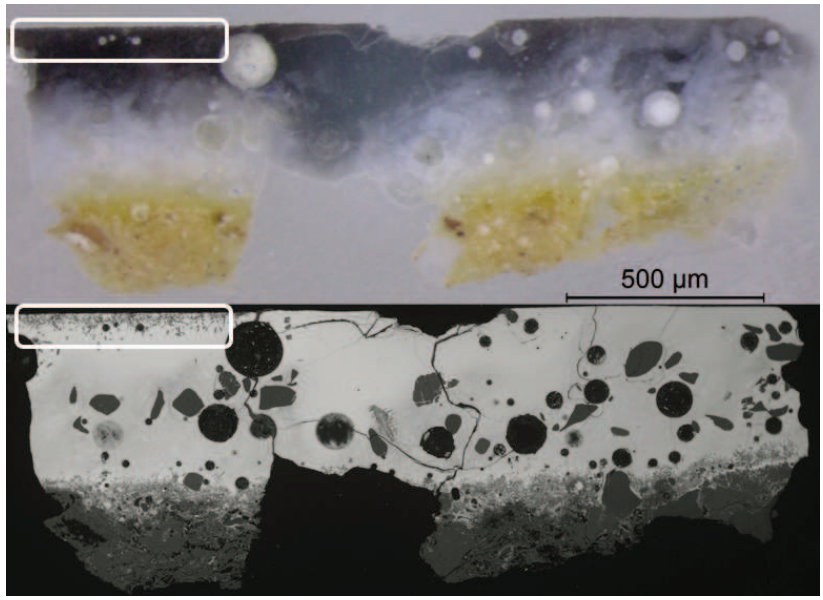

Figure 7. Sample Az334/09 in optical and scanning electron microscopy. The colour was painted as smalt and its darker part, seemingly an outline, is highlighted by the white rectangle

Figure 8 shows a detail of the area with the dark inclusions pointed out in figure 7 seen to be constituted by roundish particles and angular crystals. Figure 9 depicts a smaller area with elemental mapping by EDS (top images) and the EDS spectrum of the analysis of one of the dark crystal-like inclusions (bottom image), whose semi-quantitative composition is presented in table 3. Besides the elements present in the smalt, including the blue cobalt pigment and its associated elements (Ni and As), the simultaneous high contents in Si and Ca besides Mn, suggest, either the use of an unusual Ca-rich Mn mineral, or else, more likely, these inclusions are not purely pigmentary but derive from the addition of a particulate rich in Si and Ca to thicken the paint used on the outlines.

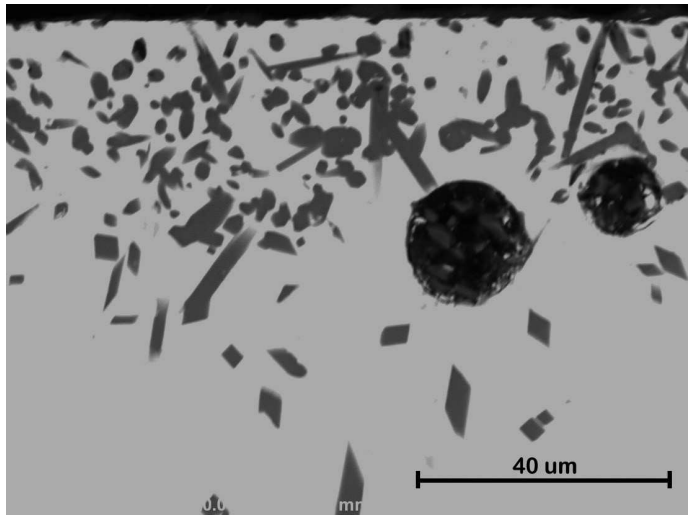

Figure 8. SEM image of a darker area of the colour in Az334/09 showing the geometry of the inclusions

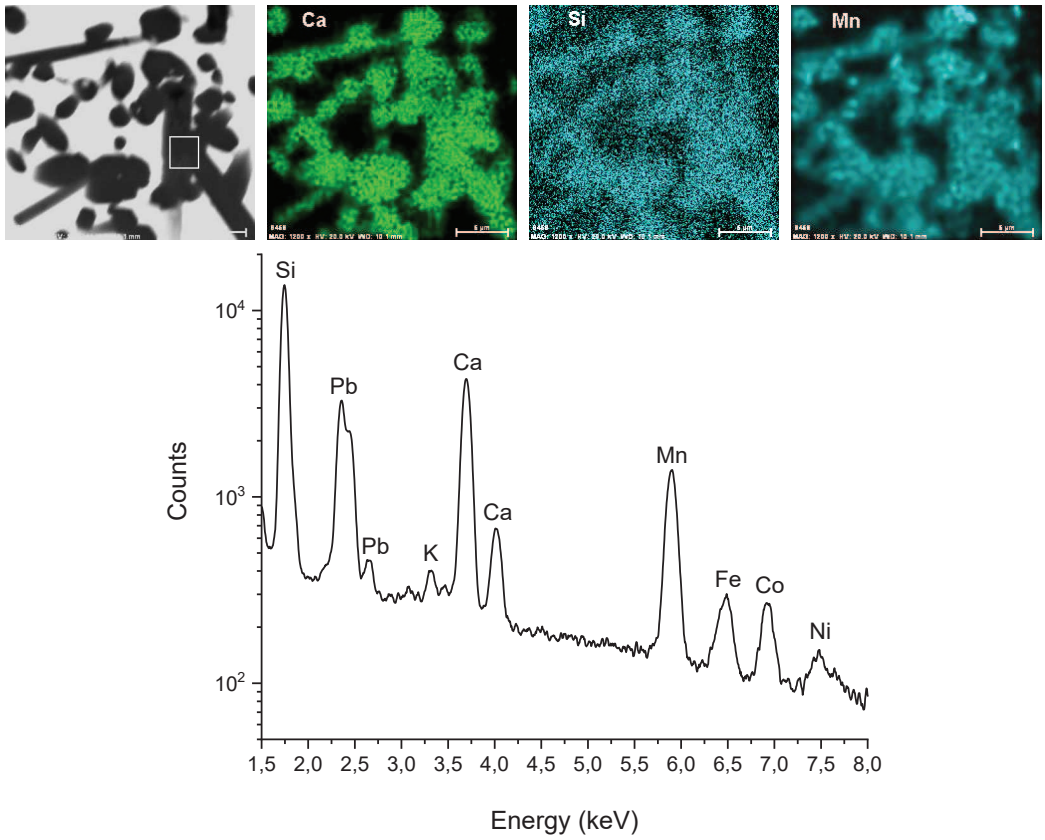

Figure 9. Selection of an area with inclusions (top - left) and elemental EDS maps of Ca, Si and Mn (top - from left to right) showing that the dark inclusions are rich in all those elements. Partial EDS spectrum (bottom) obtained in the analysis of a dark crystal-like inclusion (the area of analysis is highlighted in the top left image)

Table 3. Semi-quantitative composition of a dark inclusion in Az334/09 (wt.% of the main elements corrected to 100%).

Az334/09	Na	Mg	Al	Si	K	Ca	Mn	Fe	Co	Ni	As	Pb	O
Inclusion	0.52	0.38	1.12	18.62	0.67	14.59	9.02	0.45	1.71	0.69	1.13	17.30	33.78

2.4. Principal Component Analysis (PCA)

A log-based PCA was performed for the glazes and biscuits of all samples analysed, considering the results in tables 1 and 2, respectively, together with samples from works already known to be by the circle of João de Góis: *Igreja da Graça* (identified by the designations Graça I and Graça II), the panel *Nossa Senhora da Vida*, *Capela de São Roque* [12] to which were added the panels recently found in the Cathedral of Setúbal [11].

2.4.1. Glazes

Figure 10 shows the PCA results of the glazes, through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 45% of the total variance in the data set and is controlled in the positive sense by the contents in Al, Si, K and Fe and in the opposite sense by the content in Pb. PC2 explains 25% of the variance and is controlled mostly by the contents in Na and Mg in the positive sense.

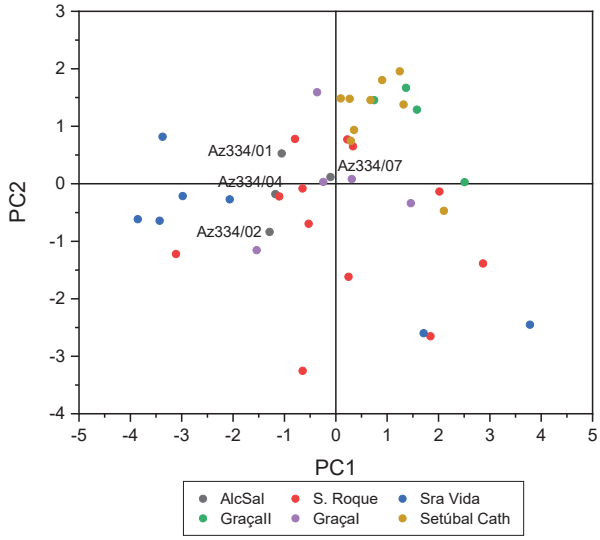

Figure 10. Score plot of the PCA of the glazes of Az334 (Alcácer do Sal) and other four 16th century panels

2.4.2. Biscuits

Figure 11 shows the PCA results of the biscuits, through a plot in the plane of the two first principal components (PC1 and PC2). PC1 explains 41% of the total variation and is controlled by Al, Si, and K in the positive sense and Mg and Ca in the opposite sense. PC2 explains 26% of the variation and is controlled in the positive sense by the contents in Na,

Mg, Al, Ti and Fe and in the negative sense by Si (as seen through figure 12 in which the loadings plot is represented as a vector graph).

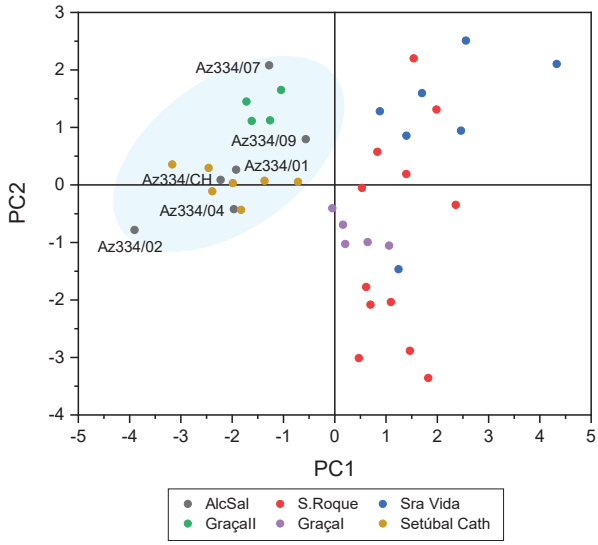

Figure 11. Score plot of the PCA of the biscuits of Az334 and other four 16th century panels

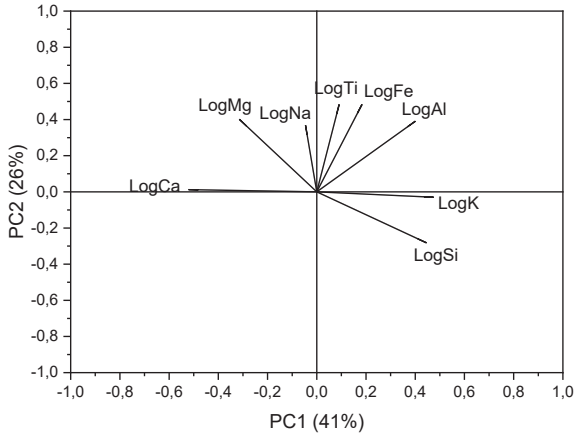

Figure 12. Loadings plot of the PCA of the biscuits

3. DISCUSSION

3.1. Technology

The SEM images of the glaze sections and their interfaces with the biscuits (Figure 4) depict morphologies compatible with the very distinctive configuration that characterizes the panels attributed to João de Góis or his circle [12] as well as with the panel recently identified at the Cathedral of Setúbal [11]. This similarity can be attributed to a comparable preparation of the raw materials and an analogous firing cycle, as was experimentally observed through the study of replicates [14]. In fact, such a close similarity points to a

possible firing of all these panels in the same kiln [12, p. 130], the same associated to João de Góis and his brother Filipe which was situated at the bottom of the Santa Catarina Hill [15, p. 19].

The use of a Sn+Sb+Pb yellow pigment and of a Fe+Sb+Pb orange pigment suggests purchases from abroad, possibly from Antwerp, where, seemingly, the light-yellow pigment was commonly used [16]. Such pigment was also used by João de Góis, e.g. in the *Nossa Senhora da Vida* panel [12, p. 129].

Inclusions rich in Mn, Si and Ca were found near the surface at the dark outlines, suggesting they may derive from the incorporation to the pigment of a mineral addition, following a technology akin to one already seen in other panels stemming from the circle of João de Góis [12, pps. 128-129].

3.2. Clustering

The PCA of the glazes (Figure 10) does not allow a clear clustering: samples from the Alcácer do Sal panel are intermixed with samples from *Capela de São Roque* which, on their side, are intermixed with others. Although the distribution is not random (the Alcácer do Sal samples are concentrated near the centre of the plot) no clear clustering can be proposed and, at least until more results become available, all the glazes should be considered similar.

However, the PCA of the biscuits (Figure 11) offers a completely different vision of the possible relations between the panels. Two clusters may be separated resourcing only to PC1. One group, set on the positive side of PC1, includes the *Nossa Senhora da Vida* panel, the lining of *Capela de São Roque* and what we believe is the earliest phase of *Igreja da Graça* – identified here by "Graça I" [see also 12, p. 127], corresponding to biscuits with a lower Ca/Si ratio and higher contents in Al and K. Most interestingly, the second cluster, nearly corresponding to the top-left quadrant of the plot (highlighted in blue in figure 11), includes the Alcácer do Sal panel, the panel from the Cathedral of Setúbal [11], but also the second phase of *Igreja da Graça* – identified here by "Graça II" – [see also 12, p. 127], whose biscuit compositions are akin mainly by their higher content in Ca, suggesting a chronologic separation from panels whose biscuits are plotted on the positive side of PC1.

4. CONCLUSION

We consider very relevant the fact that the glaze of this panel, dated "1592", has a micro-morphology and a composition similar to other panels attributable to the circle of João de Góis. The morphological characteristics indicate the panel was fired using a cycle very similar to the unusual cycle used by João de Góis presumably since at least the 1560s, even though the biscuits were now, in 1592, much richer in calcium than before. The fact that the painting of the Alcácer do Sal panel made use of rather uncommon yellow and orange pigments such as those also used by João de Góis and his circle, also strongly suggests a technical connection between them all.

The different biscuit compositions when compared with presumably older panels such as *Igreja da Graça* I, *Nossa Senhora da Vida* and *Capela de São Roque* [12] suggests that, either a different clay source was now used, or a depth of the clay pits was attained at which the composition was much richer in calcium. In any case, the compositional similarity within

a biscuit cluster suggests an approximate chronology of the productions included in it. The fact that Alcácer do Sal is dated "1592" and its biscuit clusters closely with Cathedral of Setúbal and then, less closely, with *Igreja da Graça* II suggests that the chronology of both those two other works, particularly the chronology of the panels recently unveiled at the Cathedral of Setúbal, should be not too distant from 1592.

It is interesting to mention in this respect that Pais et al. [15, pp. 19] have tentatively identified the kiln used by João de Góis, his brother Filipe, and probably several other workshop masters firing glazed pottery, as the edification with chimneys seen in an old map at the bottom of the Santa Catarina hill in Lisbon (Figure 13). On July 21, 1597 there was a catastrophic collapse of part of the Santa Catarina and Chagas hills towards the river destroying three whole streets and the *Cais das Negras* (Black Womens' Wharf) on the river, which were entirely buried with earth and debris [17]. The location of *Cais das Negras* is unknown but archaeologist Alexandra Gomes, who researched the ancient wharfs in that section of the river [18], suggests that it may be a structure dimly seen in Georg Braun's map [19] exactly in front of the edification that may have been the kiln - figure 13. If that was the case, the kiln was destroyed in 1597 and, in fact, we have not yet seen any azulejos firmly assigned to the 17th century that were fired using a cycle resulting in the same interfacial morphology…

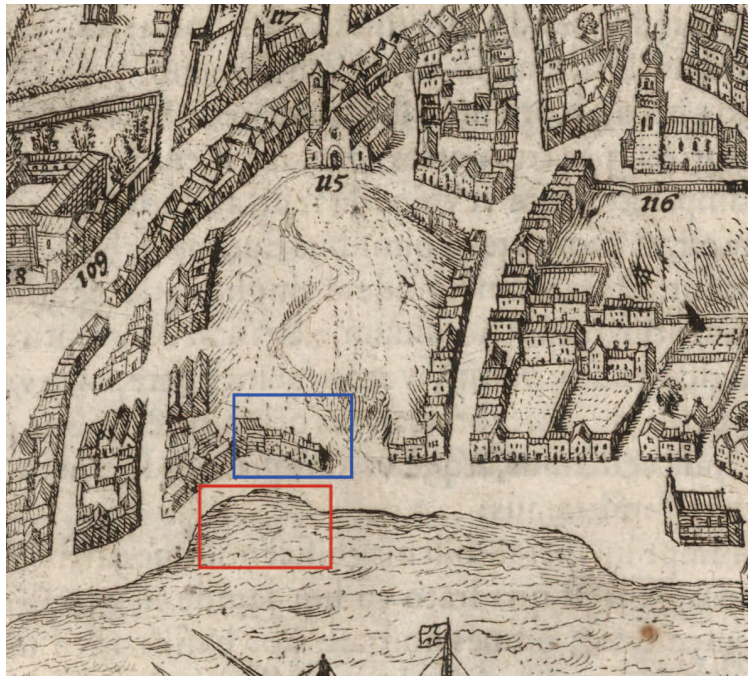

Figure 13. The Santa Catarina and the Chagas hills (115 & 116 in the image above) that collapsed on the night of July 21, 1597 forming the rift where today runs the *Elevador da Bica* tramway. The edification presumed to house the kiln used by the De Góis brothers is indicated by the blue rectangle, while the area of the wharf buried by the collapse is indicated by the red rectangle

This work exemplifies the sort of information that may derive from the study of a chronologic anchor, a dated azulejo panel, and its comparison with other panels to which, previously, no date could be assigned on documentary evidence with some degree of

certainty. Much is still expectable from comparative studies based on glazed ceramics for which date, authorship or any other useful historical information is known.

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