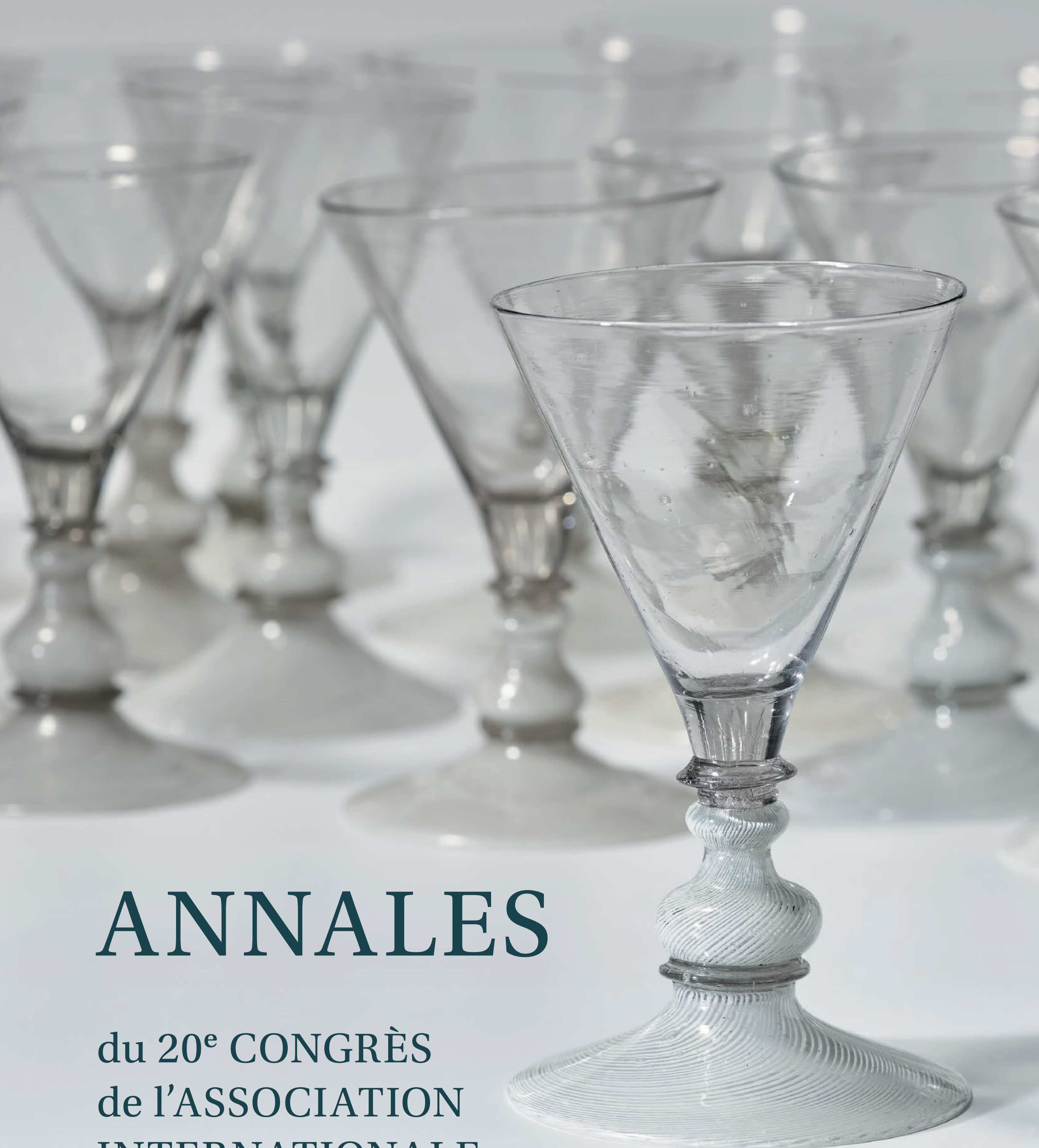
Looking through late medieval and early modern glass in Portugal

Teresa Medici, Inês Coutinho, Luís C. Alves, Bernard Gratuze, Márcia Vilarigues



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Cover illustration
Goblets with white filigree decoration, produced in Swiss glasshouses, late 17th to early 18th century. From different Swiss public and private collections. For a detailed discussion see: Erwin Baumgartner, Reflets de Venise, Bern 2015, p. 254–272, 322–328 and the contribution of Christophe Gerber in the present volume, page 564.

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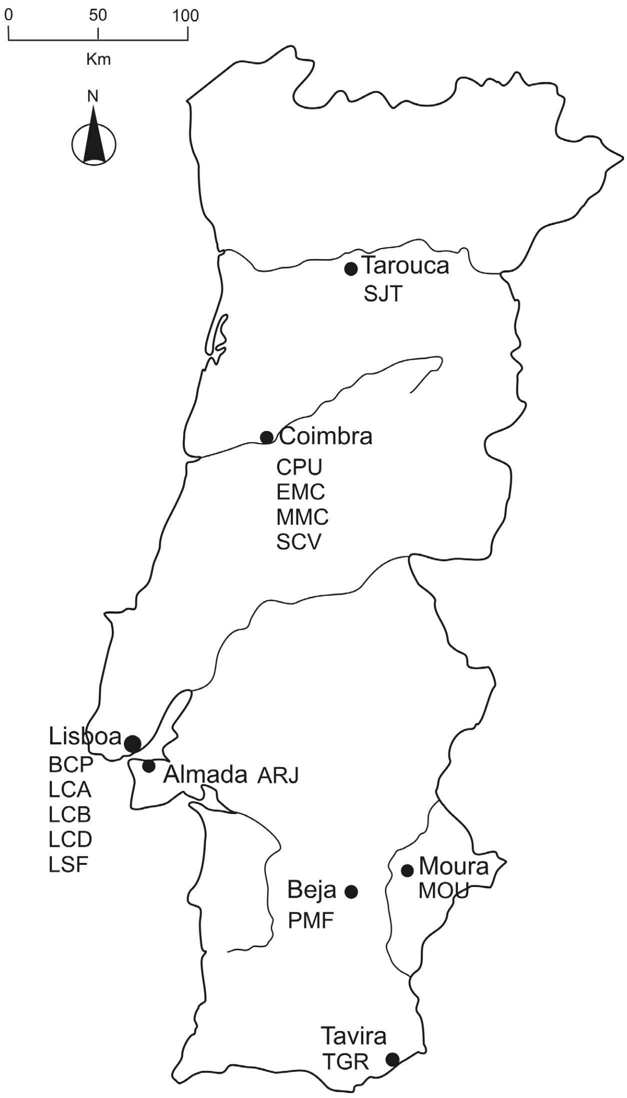

Fig. 1: Localisation of the archaeological sites included in the study.

Post-Roman glass in Portugal has recently become a subject of extensive investigations combining archaeological and archaeometric approaches. Within the research project 'Portuguese glass collections: study and preservation' carried out by VICARTE with C2TN/IST - University of Lisbon (Portugal), and IRAMAT - Centre Ernest-Babelon, CNRS Université d'Orléans (France), several glass collections and archaeological assemblages dating from the 14th through 19th century are being studied.

This study looks at fourteen glass assemblages dating to between the 14th and the 17th century, coming from different Portuguese archaeological sites from the North to the South of the country (figure 1). The examination of almost 2800 objects made it possible to propose, for the first time, a chrono-typological classification for late medieval and Early Modern glass in Portugal.[1]

The glass from the 14th to 15th century fits into the typical range of late medieval glassware in Europe; drinking glasses, bottles, and urinals in primarily yellowish or green glass make up the majority of the studied groups (figure 2a). The beakers are often decorated with mould-blown rib patterns and/or applied trails. A few colourless fragments have a blue trailing on the rim. One beaker with enamelled decoration ('Aldrevandin beaker') dates from the late 13th to the first half of the 14th century. Fragments of prunted beakers (*Krautstrunk*) were also identified. The goblets have hollow stems and mould-blown rib decoration and were probably made shaping one single parison of yellowish or green glass. Pedestal beakers are documented from the end of the 15th century.

The presence of bracelets is also worth noting. During the 14th and 15th century, bracelet diffusion in Western Europe seems to be restricted to the Iberian Peninsula, probably as a result of the Islamic presence. In Spain they appear frequently in burials worn by women, not only in Al-Andalus, but also in Mudejar, Christian, and Jewish cemeteries in the Meseta, Castella, and Aragon.[2] They were also worn by a young Christian woman found in the Portuguese town of Alcácer Ceguer, Morocco.[3]

During the 16th century, most medieval forms were gradually replaced by typical Renaissance footed glass types, such as goblets with stems made of one or more knops, pedestal beakers, and *tazzas* (figure 2b). So far, all of the footed specimens recorded were produced by blowing and shaping a single gather of glass. This is a different technique than Venetian stemmed glasses that were made by joining separate elements. Another common feature of this period are globular bottles with truncated-conical or long cylindrical necks, often decorated by a mould-blown ribbed pattern. Bracelets are still popular, made from black, blue, or yellow glass rods, either plain or decorated with a spiraling white trail.

1 Medici 2014a. Preliminary results have been published in Ferreira 2004; Ferreira and Medici 2010; Medici 2005; Medici 2008; Medici 2011; Medici 2014b; Medici et al. 2009.

2 Balado Pachón and Escribano Velasco 2001; Malalana Ureña and Lora Hernández 2014.

3 Redman 1986, 204.

During the 17th century, the functions of glass objects widened to include all the aspects of everyday life (figure 3). Table glass, jugs, utilitarian and decorative vases, lamps, urinals, devices for medical and hygienic care (like suction cups), inkwells, and so on seem to have large circulation. The variety of glass colours available broadened to include dark green, blue, and dark red.[4] Venetian glass is identified, as the opaque white cups with speckled decoration or a moulded vase with human faces and festoons.[5] Others types, belonging to the *façon de Venise* family, are also present. Some bowls and jars could have a Spanish origin. Rare items were also found, for example a globular bottle with gilded decoration: a fairly common Portuguese form from the 17th century glass, the decoration on this bottle makes this a very special piece.[6] *Millefiori* and opaque red glass also appeared in several places.

THE ORIGIN OF THE GLASS FOUND IN PORTUGAL

The lack of suitable archaeological records concerning furnaces strongly hinders the comprehension of the glass types produced and circulating in Portugal before the 18th century.

Written sources show that glass production in Portugal began as early as the 15th century. The locations of workshops and names of several glass masters are known.[7] The import of glass from Venice, Catalonia, and the Low Countries is mentioned and valuable objects identified as Venetian appear in inventories.[8] Documents rarely describe the objects in detail, so it is impossible to know what kind of glass was being produced or imported. A verdict dated February 22nd 1625, which puts an end to a dispute between the glasshouse of Côvo (Oliveira de Azeméis) and the counts da Feira, records that in order to liquidate the appropriate amount the guilty party should deliver 'seis peças de vidro bons como no prazo se dizia e aujam de ser guarrafas púcaros guomis',[9] that is 'six items of good glass ... and should be bottles, mugs and ewers', in addition to some money.

Both local production and imports from abroad reached some significance during the 16th century. A royal charter from King D. Sebastião, passed in 1563, prohibited the import of Venetian glass because the local production was of a comparable quality:

'Eu ElRey…sam informado que os vidros que trazem de Veneza a vender a estes Reinos não sam necessários nem proveituosos por aver em eles vidros da teRa que hos podem escusar …'.[10]

A report addressed to Ferdinand I de' Medici, *Granduca di Toscana*, dating to 1592, discusses the Murano glass trade. The document mentions that during that year a variety of glass was sent to Lisbon, including vessels in the shape of lions and boats:

'Per Lisbona vetraria fina e cristalli assai per duc. 10.000. Cristalli bolliti, grandi, di lire 40 fino a 50 cento, foggie di lione, nave, sporte, fontane, tal pezo lire 1,1 ½, lire 2, 2 ½,e lire 3 il pezo, e spechiere fornite.'[11]

In the 1704 inventory of the goods of D. Luís de Lencastre, Count of Vila Nova, the origin of the listed glass is not mentioned. However, a detailed description of some of the objects allows us to identify some items as Venetian or *façon de Venice*. The document lists, among other items, two crystal goblets with gilded stems, one in the shape of a serpent with two emerald eyes and the other in the shape of an owl, both recalling well known 17th century types:[12]

'Outra taça com seu pée forma de uma bicha tudo de cristal com sua cauda vizel em o pée e garganta de ouro tem duas esmeraldas em os olhos … Hum mocho de christal com pées e vizel em o pescoço tudo de prata dourada …'.[13]

Approaching the archaeological glass under study, a stylistic approach was the first analytical method to discern the difference between imported and locally produced glasses.

In some cases, well-known glass types such as some 17th century Venetian or *façon de Venise* glasses were easily identified. In other cases, the identification of features that are without parallels outside Portugal provided evidence to consider some objects as local products, at least as a working hypothesis, as for example the gourd-shaped bottles (figure 3: SCV0079-V022).

Chemical analysis was conducted on a selection of the glass vessels believed to be local products and on a selection of supposed Venetian and *façon de Venise* glasses with the aim of identifying some compositional features supporting our interpretation. All the late medieval and early modern fragments analysed so far were made of soda-lime-silica glass using coastal plant ashes as the flux, connecting the products with the Mediterranean glass-making tradition. Some samples have unusually high alumina contents, 3–6 wt. % Al_2O_2, which is rare for European glass from this period. Some pieces revealed an additional complexity such as the *millefiori* glasses. *Millefiori* is considered to be a typical Venetian decoration, but the analyses have highlighted that in some objects the body glass and the glass used for the decoration are different. The vessel bodies were produced with non-Venetian glass with a high alumina content while the decoration was made from multicoloured glass rods of genuine Venetian origin.[14]

4 Ferreira 2004; Medici et al. 2009.
5 Medici 2014b.
6 Coutinho et al. 2016b.
7 Mendes 2002, 39, fig. 28; Valente 1950.
8 Matos Sequeira [s.d.] III.
9 Cartório da Casa do Côvo, Sentença da Casa da Relação do Porto, de 18 de Junho de 1626, *apud* Costa 1955, 12.
10 I know that glasses arriving from Venice to be sold in these kingdoms are superfluous and not convenient, because glass from this country does exist that make them unnecessary': 'Alvará régio sobre a importação e venda de vidros de Veneza: 1563-VII-15', in: *Documentos* 1969, 70.
11 Corti 1971, 653.
12 See for example a serpent stem with blue eyes at the Corning Museum of Glass (inv. n.º 51.3.118, available at: http://www.cmog.org/ through the "Search collection" tool (27th January 2016) and an owl stem at the British Museum (inv. n.º S.461: Tait 1991[2012], 144, fig. 86).
13 de Andrade e Sousa 1956, 33–34.
14 For preliminary results concerning late medieval glass objects from Beja and 17th century glass from Coimbra, Sta. Clara-a-Velha, see: Lima et al. 2012; Coutinho et al. 2016a; Coutinho et al. 2016b; and Coutinho et al. 2016c.
15 Grime and Dawson 1995.

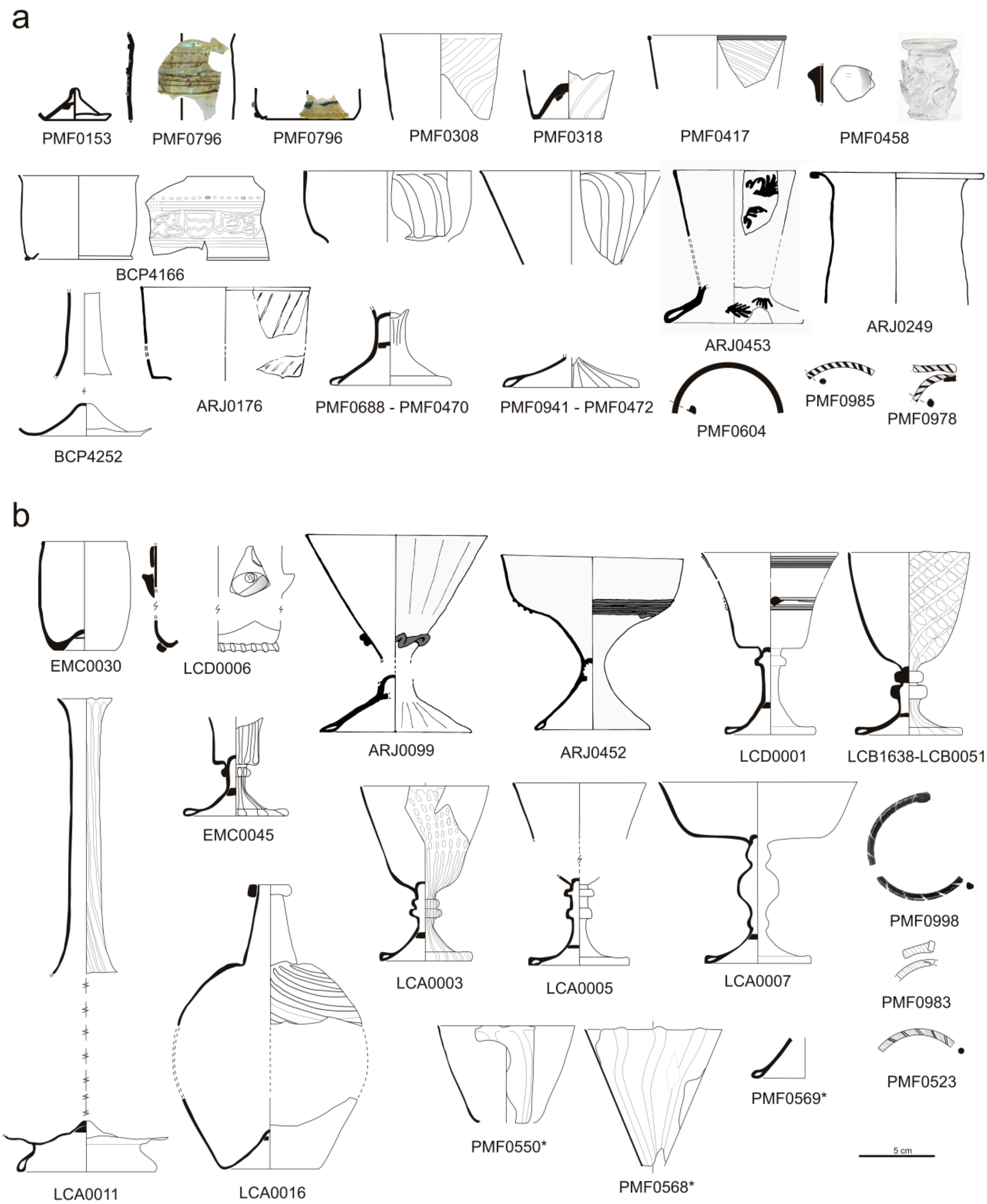

Fig. 2: a) 14th–15th century glass; b) 16th century glass. The asterisk (*) indicates the analysed objects (drawings: T.Medici; scale 1:4).

VENETIAN OR *FAÇON DE VENISE*?

A deeper investigation was done on a selection of 31 Venetian and/or *façon de Venise* objects belonging to the archaeological contexts of Santa Clara-a-Velha Monastery in Coimbra (SCV), São João de Tarouca Monastery (SJT), Miguel Fernandes square in Beja (PMF), and to the Coimbra University courtyard (CPU). The mostly colourless goblets and bottles, sometimes with a greyish or bluish hue, are decorated with filigree, diamond point engraving, or mould blown ribs (figures 2 and 3).

Experimental

The chemical composition was determined by particle induced X-ray emission (μ-PIXE) down to tens of μg/g level. The results allowed selecting some objects to further extend the trace elements analysis down to the ng/g level through the use of laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Glass colours and natural hues were studied by means of UV/VIS reflectance spectroscopy.

Fig. 3: 17th century glass. The asterisk (*) indicates the analysed objects (drawings: T. Medici, M. Ferreira, and N. Santos, scale 1:4; photographs by T. Medici and I. Coutinho, unless SCV0030-V034, SCV0002-V002, and SCV-V108 by Miguel Munhóz © DRCC / Mosteiro de Santa Clara-a-Velha).

The chosen methodology implied sampling of all selected objects in order to avoid erroneous results by analysing and quantifying corrosion layers instead of the uncorroded bulk glass. Small samples of 2–4 mm^2 were dry-cut from the fragments using a diamond wire. Samples were embedded in an epoxy resin and polished with SiC sandpapers down to 4000 mesh. This sampling procedure was performed only on broken objects and on individual fragments without possible connections.

Produced by the 2.5 MV Van de Graaff accelerator installed at Polo de Loures, Portugal, from IST, MeV proton beams were used to perform μ-PIXE sample analysis using an Oxford Microbeams OM150 type nuclear microprobe. The proton beam was focused down to 3 × 4 μm^2 and the produced X-rays detected by a 145 eV resolution Si(Li) or SDD detector. In order to avoid or detect possible local glass heterogeneities, imaging (2D elemental distribution) and X-ray spectra were obtained from an irradiated sample area of 750 x 750 μm^2. Operation and basic data manipulation were achieved through the OMDAQ software code[15] and quantitative analysis done with GUPIX program.[16] The results in oxides weight percentage (wt. %) form were normalized to 100 %. In order to validate the results, two glass reference standards were also analysed, Corning B and Corning C.

16 Campbell et al. 2010.
17 Gratuze 2013; Gratuze 2014.

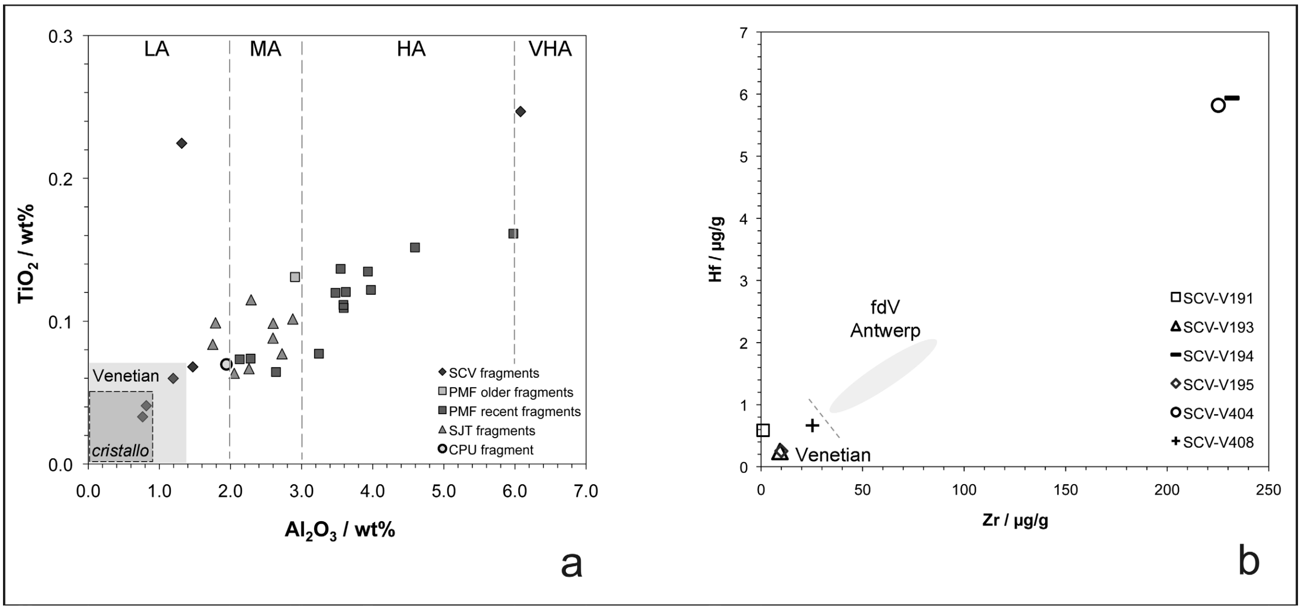

Fig. 4: Binary plots of a) Al_2O_3 *vs.* TiO_2, in weight percent of oxides and measured by µ-PIXE; and b) of Zr *vs.* Hf concentrations in µg/g determined by means of LA-ICP-MS for the SCV *façon-de-Venise* objects. The dashed lines are general Antwerp *façon-de-Venise* and general Venetian regions taken from the literature (De Raedt et al. 2001).

The SCV fragments were also analysed by LA-ICP-MS since the study of this assemblage is part of a larger research project. The LA-ICP-MS analysis was carried out on the resin embedded glass cross-sections. The ablation system used here is located at the National Centre of Scientific Research (CNRS) in Orleans, France. It consists of a Nd:YAG laser working at 266 nm (quadrupled frequency) operating at a maximum energy of 2 mJ and at a maximum pulse frequency of 15 Hz. The laser beam diameter can be adjusted from 20 µm to 100 µm. The glass analysis was performed at 8 Hz with a beam diameter of 80 µm. A pre-ablation time of 20 s was set in order to eliminate the transient part of the signal which was then acquired for 55 s corresponding to 20 mass scans from lithium to uranium (the signal in counts/second is measured in low resolution mode for 58 different isotopes). Calibration for glass was undertaken by employing NIST610 and Corning B, C, and D glass reference material.[17] The detection limits range from 0.1 % to 0.01 % for major elements and from 20 ng/g to 500 ng/g for others. The composition is calculated from the average of two ablations carried out in different areas of the sample. In order to validate the obtained concentration results, the glass reference standard Corning A was also analysed as an unknown sample.

Results and Discussion

Analysing the relation between aluminium and titanium oxides makes it possible to formulate some considerations on the employed silica sources. Regarding the division of alumina contents as defined by Lima et al.,[18] the objects can be divided in four groups with low, medium, high and very high alumina contents (figure 4 a).

Venetian and *façon de Venise* glass are characterised by their choice of pure raw materials with low contents of impurities.[19] The results (figure 4 a) show that some of these objects have a chemical composition that is unusual for *façon de Venise* glass. Many of these fragments have high alumina contents that do not match with any European *façon de Venise* production centres that are known.[20]

The alumina content is attributable to the siliceous materials chosen for the glass production, notably sand.[21] It is known that the choice of raw materials was a primary phase of glass manufacture, since these influenced the quality of the final result, particularly in terms of transparency and of the possibility of obtaining colourless glass. The most pure material was quartz and was used by the Venetian glassmakers who imported it from other Italian regions.[22] However, typically the most exploited raw material was sand and it came from places near the glass production locations.[23] For this reason we cannot exclude that the high alumina levels derive from the use of local sands rich in feldspar.

According to values published in literature, Venetian glass (both *cristallo* and *vitrum blanchum*) is characterised by low contents of TiO_2 [around 0.05 wt. %], as represented in figure 4a by the two marked regions.[24] Three SCV objects, with alumina contents below 2.0 wt. % and titanium dioxide content below 0.1 wt. %, are compatible with Venetian compositions; from these, two are within the *cristallo* boundaries.

18 Lima et al. 2012.
19 Verità and Zecchin 2009.
20 For typical Venetians compositions see Verità 2013; for values of glass in several *façon de Venise* production centres see Lima et al. 2012, p.1244, Table 4.
21 Moretti and Hreglich 2013.
22 Verità and Zecchin 2009.
23 Navarro 2003, 130.
24 Verità 2013.
25 Verità and Zecchin 2009.

Comparing the obtained results with coeval and genuine Venetian and *façon de Venise* glass[25] confirms that few fragments from SCV are probably genuine Venetian objects. To validate the Venetian provenance of selected SCV fragments, these were analysed by LA-ICP-MS. This allowed quantifying the trace and the rare earth elements that are considered the fingerprint of the employed raw materials. Looking at the contents of zirconium and hafnium (figure 4 b), both elements deriving from the silica source, four of the SCV fragments are within the Venetian boundaries;[26] this confirms that these objects are genuine imports from Venice.

The fragments from the remaining assemblages do not fall within the Venetian boundaries and are considered to originate from different production centres. The PMF fragments form one group and a majority of samples from SJT form another one.

Regarding the flux properties, studying the distinct fractions of sodium and potassium oxides will allow one to distinguish between the different fluxes used. In the chart presented in figure 5, the fractions of both oxides were normalised to the content of all alkaline and alkaline-earth oxides.[27]

A large group of fragments is arranged along the inverse correlation line of glass made by using purified ashes and is close to the *cristallo* boundaries. The objects from this group were probably manufactured using pure ash similar to the ones brought to Venice from the Levantine region. The lower normalised potassium oxide values imply higher contents of soda, which is compatible with the identification of Levantine ashes used in genuine Venetian glass production.[28] The three SCV objects (figure 3: SCV-V191, SCV-V193 and SCV-V195) previously identified as Venetian are within this region (the points appear overlapped) and for this reason they are considered imported Venetian *cristallo* glass.

The majority of PMF fragments fall between the purified and unpurified ashes tendency lines. The fluxes employed in their manufacture were chosen to approach and imitate *cristallo* glass. Recalling the alumina contents of these objects, this reinforces the idea that these objects were made in a *façon-de-Venise* production centre where glass was melted using sands rich in feldspar, a circumstance that so far seems to have never been recorded for European glass of the 17th century.

Some SJT and CPU fragments are also within or close to the *cristallo* boundaries. The CPU fragments always appear related to SJT and some PMF fragments, especially when analysing the flux but also the silica sources. This indicates that these objects were manufactured in the same production centre or using the same raw materials.

When looking closer at the SJT fragments, three objects (figure 3: SJT0014, SJT0112, and SJT0135) present lower amounts of Na_2O and higher amounts of K_2O and CaO when compared to the remaining SJT fragments. Two of these samples are close to the *vitrum blanchum II* area and sample SJT0135 is close to the European *Barilla* area.

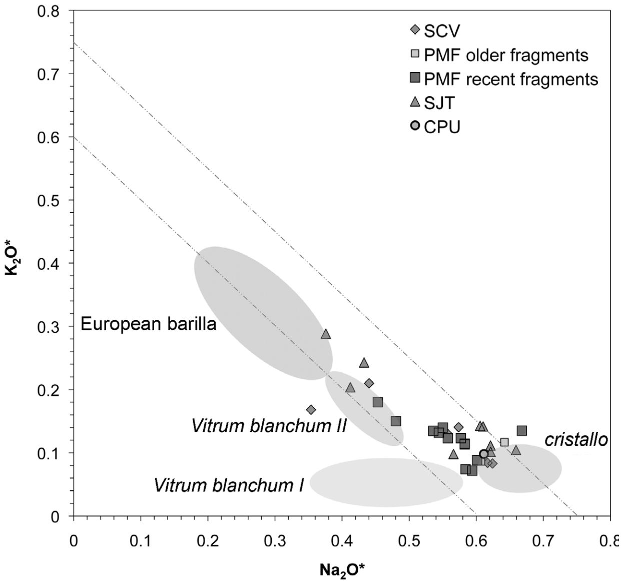

Fig. 5: Binary plot of Na_2O^* *vs*. K_2O^*. Na_2O^* and K_2O^* values are obtained through the division of the respective oxide by every components introduced by the ash (Na_2O, MgO, P_2O_5, K_2O and CaO). The two correlation lines represent the purified ash ($Na_2O^* + K_2O^* = 0.75$) and the unpurified ash ($Na_2O^* + K_2O^* = 0.6$). It is also possible to observe the Venetian *cristallo* boundaries, as well as the two *vitrum blanchum* known areas and the European Barilla area (Cagno et al. 2012; Šmit et al. 2009).

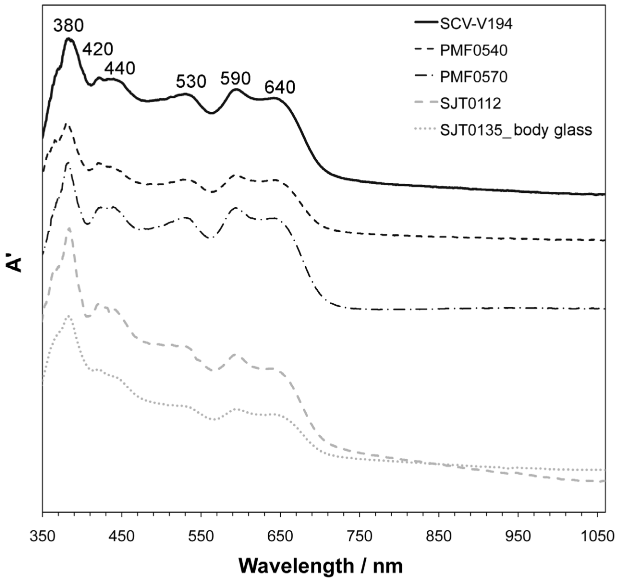

Fig. 6: UV-Vis reflectance spectrum of several *façon-de-Venise* objects from SCV, PMF and SJT assemblages.

Another particularity of the group was the natural hue of the glass featuring shades of grey and blue. Only the SCV fragments imported from Venice do not present such visible hues.

26 De Raedt et al. 2001.
27 Cagno et al. 2012, Šmit et al. 2009.
28 Cagno et al. 2012
29 Jackson 2006.

UV-Vis reflectance spectroscopy allows one to determine that this grey/blue hue is caused by the simultaneous presence of iron and cobalt oxides (Fe(III) – 380 nm, 420 nm and 440 nm; Co(II) – 530 nm, 590 nm and 640 nm) as shown in figure 6. As far as it is known, the presence of cobalt in colourless *façon-de-Venise* glass is not usual and has rarely been reported in the literature.[29]

In conclusion, a Venetian provenance is confirmed for some specimens from SCV. The objects made of *cristallo* glass are: a stem with a ribbed knop and an engraved pattern on the foot (SCV – V195), a lid with *vetro a fili* decoration (SCV – V191), and a wall fragment with an applied raspberry prunt and engraved decoration, possibly belonging to a cup (SCV – V193) (figure 3).

Among the remaining objects whose provenance could not be determined, some were made using ashes from carefully chosen plants capable of originating pure glass as raw material for the flux. This was done to imitate *cristallo* glass, but their composition is not compatible with glass originated in Venice or in any other *façon de Venise* production centre analysed so far because of the alumina content.

This is the case for most samples from Beja (PMF) that present high alumina levels. These objects are mainly bowls or bases of goblets in greyish glass either plain or decorated with mould blown ribs (see figure 2b: PMF0550, PMF0568, and PMF0569).[30] The glass used to blow this assemblage seems to be made with silica from the same sources, very rich in alumina and different from the silica used to produce the other sets. Closely related to the PMF samples is a previously analysed *millefiori* fragment from Coimbra (figure 3: SCV-V108).[31] This indicates that this glass was possibly made using raw materials coming from the same sources or having the same provenance.

A second sort of *façon-de-Venise* glass from the São João de Tarouca Monastery has been identified, which presents medium alumina levels. These samples are all closely related in terms of the silica source. The majority were also made using purified ashes. Two samples are close to the *vitrum blanchum II* area and one sample (figure 3, SJT0135, body glass) falls close to the border of the European Barilla area. This last object presents a decoration of white trails freely applied around the rim. The available fragments seem to be consistent with the shape of a *tazza* but the entire form cannot be reconstructed because the foot or stem is missing. It is worth noting that some of the specimens are decorated with a sort of 'rough' version of *vetro a fili* (SJT0012, SJT0123, SJT0135), while others are decorated with typical *façon de Venise* patterns and techniques such as SJT0121, with *filigrana a retortoli*; SJT0122, with broken threading; SJT0105, with gilding and engraving; and SJT0112, with ice glass effect (figure 3).

It is proposed that the analysed PMF and SJT fragments were produced in two unknown *façon de Venise* production centres whose location is yet to be discovered.

FINAL REMARKS

The results obtained during these first years of investigation are encouraging. Important goals were achieved, including the creation of a first typological classification of late medieval and early modern archaeological glass in Portugal and the first hypotheses on the production, diffusion, and use of glass in the country during the pre-industrial era. The main source of this information derives from the archaeological data.

The identification of the origin of the glass assumed to be imported confirms that trade imported glass from Venice and from other *façon de Venise* manufactures to Portugal. However, the influx of imported goods did not inhibit the development of a local glass production that took advantage of local raw materials and created vessels with recognizable shapes.

The identification of two kinds of *façon de Venise* glass, whose compositions demonstrate the attempt to employ pure raw materials, but present unique features, as the medium and high alumina levels, allows us to assume the existence of two yet unknown *façon de Venise* production centres.

The lack of comparable data concerning Portuguese glass furnaces earlier than the 18th century represents a limitation to our research and so far no final proof has been obtained concerning glasses of unquestionable Portuguese origin. The field archaeology will eventually provide these answers, and this is a necessary condition for the identification of shapes and types that we can surely consider as genuine Portuguese.

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30 More similar analysed fragments are: PMF0540, PMF0556, PMF0570, PMF0996, and PMF0527.

31 Lima et al. 2012.

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