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FENESTRA. 800 Years of FENESTRAtion History: Flat Glass and Windows in Federal Scientific Institutes

ABSTRACT

This paper presents the rationale of the FENESTRA project, which focuses on the flat-glass collection conserved at the Royal Museums of Art and History, one of the most comprehensive collections of flat glass in the Low Countries. Running through 2021, FENESTRA is funded by the Belgian Science Policy Office. Today, cultural heritage professionals agree that only through collaboration with colleagues of different disciplines can appropriate decisions on management, conservation, and stewardship be made. Hence, the methodological approach to study this exceptional glass collection is interdisciplinary, merging history, art history, technical art examination, applied sciences, and conservation. The authors seek a continuing dialogue among specialists of different fields, maximising the information that can be obtained from this study. This paper highlights the preliminary results obtained in the different domains.

KEYWORDS

Stained glass · Conservation · Archaeometry · Low Countries · Belgium · Royal Museums of Art and History

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INTRODUCTION

FENESTRA is a multidisciplinary project funded by the Belgian Science Policy Office (BELSPO) with more than 500,000 Euro. The project involves four institutions: Vrije Universiteit Brussel (VUB), the Royal Museums of Art and History (RMAH), the Royal Institute of Cultural Heritage (KIK-IRPA), and the University College London (UCL). The main objectives are research, dissemination, preservation, and access of one of the most important Belgian flat-glass collections. The glass collection offers an unparalleled opportunity to study the technical and stylistic evolutions of stained-glass art and glaziers' craft in the Low Countries and Belgium. The collection consists of more than 400 pieces from religious and secular buildings dated between the 13th and 20th centuries. Most of the material originates from the southern Low Countries and Belgium, with additional pieces from France (13th century), Germany (14th century), and Switzerland (16th and 17th centuries). However, referring to 'a piece' belies the

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Figure 1. *Four examples of art pieces belonging to the flat-glass collection of the RMAH:*
a) stained-glass window of the Park Abbey, Jan de Caumont, 1643 CE, H 180 cm × L 140 cm. Royal Museums of Art and History I.A.9029 · Copyright Isabelle Lecocq;
b) stained-glass panel, angel from the waist up with an amulet, ca. 1230-1250 CE, H 61.5 cm × L 54.5 cm. I.A.974;
c) roundel, hunter with falcon and dogs, ca. 1470-1530 CE, Diam. 18.6 cm. V.2756; and
d) stained fragment of a head from Brussels Cathedral, Bernard Van Orley, 1540-1547 CE, H 28 cm × L 27 cm. I.A.3095A · Copyright Royal Institute of Cultural Heritage, Brussels

complex nature of these objects, as each can comprise various types of flat glass, including complete stained-glass windows, individual stained-glass panels, leaded light windows, unipartite panels, and an important collection of roundels. Figure 1 shows four examples of object types in this collection.

Although this collection is one of the most comprehensive flat-glass collections in Belgium, recent studies on stained-glass windows have paid little detailed attention to it and, to date, a well-researched collection catalogue is lacking. A general information booklet for visitors was written by Marlene Van Cauwelaert (1990) but does not detail all the collections and their history.

The objectives targeted within this project can be classified in seven main categories leading to specific research proposals:

Past results

Over the last 50 years, small-scale research projects were undertaken to study individual pieces or execute conservation of some stained-glass windows. The results of these actions were not always communicated to the RMAH. As such, it is a priority and primary goal of this project to collect all data, research results, and publications pertaining to the collection. A critical interdisciplinary examination and synthesis of these researches will be realised.

Historical objectives

Research on the ownership history, or provenance, of the flat-glass collection sheds light on the historical, social, and economic context in which fenestration was created, dismantled, and collected. The goal is to collect provenance and contextual data that have become separated from the collections, contributing to the understanding and interpretation of the sub-collections to be studied. This research will also elucidate the history of the formation of these collections.

Art historical and technical art historical objectives

The catalogue of the flat-glass collection has not been updated in 30 years. A detailed inventory of all material studied will be used to create an open access database available to the public. Historical, art historical, and technical art historical research on the collection will detail technological and stylistic assessments, which will permit comparative statistical analysis of attributes and the frequencies with which those attributes are encountered. This research will be the foundation for all future applied scientific research.

Applied sciences

The goal is to improve the methodology of dating flat glass based on chemical and optical characteristics. Subsequently, fingerprinting potash, high-lime low-alkali (HLLA), and industrial material related to technical

characteristics is of major importance in order to create a scientific dating tool. A second objective is to further investigate the relationships between composition, fabrication technology, material thickness, and optical transparency. A third focus will be the research on flashed and silver stained-glass, coloured glass, and vitreous paint layers by optical means. Finally, applied sciences will be at the centre of conservation issues in order to safeguard the collection and achieve prudent collections management.

Collections management and conservation

The main goal in reviewing this collection is to understand the scope, state of preservation, and art historical value of the different sub-collections. This goal merges the twin demands of collection access and maintenance. This research will focus on the material aspects of the sub-collections concerning the state of preservation of the glass, the vitreous paint, and the lead came. Results will inform conservation decisions and define questions for applied scientific research. Furthermore, it will be an indispensable aid for preventive conservation and long-term storage of the full collection.

Interdisciplinary evaluation

The main goal is to fully integrate all involved research domains and disciplines related to the different sub-collections. These interdisciplinary evaluations are fundamental for any applied scientific research, destructive or non-destructive. However, results of applied scientific research may lead to the re-evaluation of the art historical findings.

Access

Through partnership among different disciplines, the research results will be published in a wide range of peer reviewed journals, as well as a Corpus Vitrearum (CVMA) publication. The project also aims to bridge the gap between academicians and the public by organising an exhibition, by publishing communications via different websites, and by targeting press releases to engage the print and audio-visual media. Due to the importance of the Low Countries as a glass trade centre, these results will certainly initiate new international collaborations.

METHODOLOGY

A multidisciplinary approach is of major importance to foster successful communication between researchers in the humanities and the natural sciences. The interdisciplinary team will collaborate closely throughout the project, interpreting all data together, rather than meeting for only a few days to obtain samples. The broadest techniques of problem solving and the most comprehensive methodologies and research procedures will be used to allow cross-discipline comparison in examining technological and stylistic properties of this collection related to historical research, optical and chemical examination, and conservation issues, in order to unveil the collection's histories. This close collaboration will enhance the intelligibility of the applied scientific research for the general public. The goal is to research, publish, preserve, and increase access to the flat-glass collection of the RMAH. This multidisciplinary approach can easily be applied to other collections in Belgium, and the massive amount of unstudied material abroad.

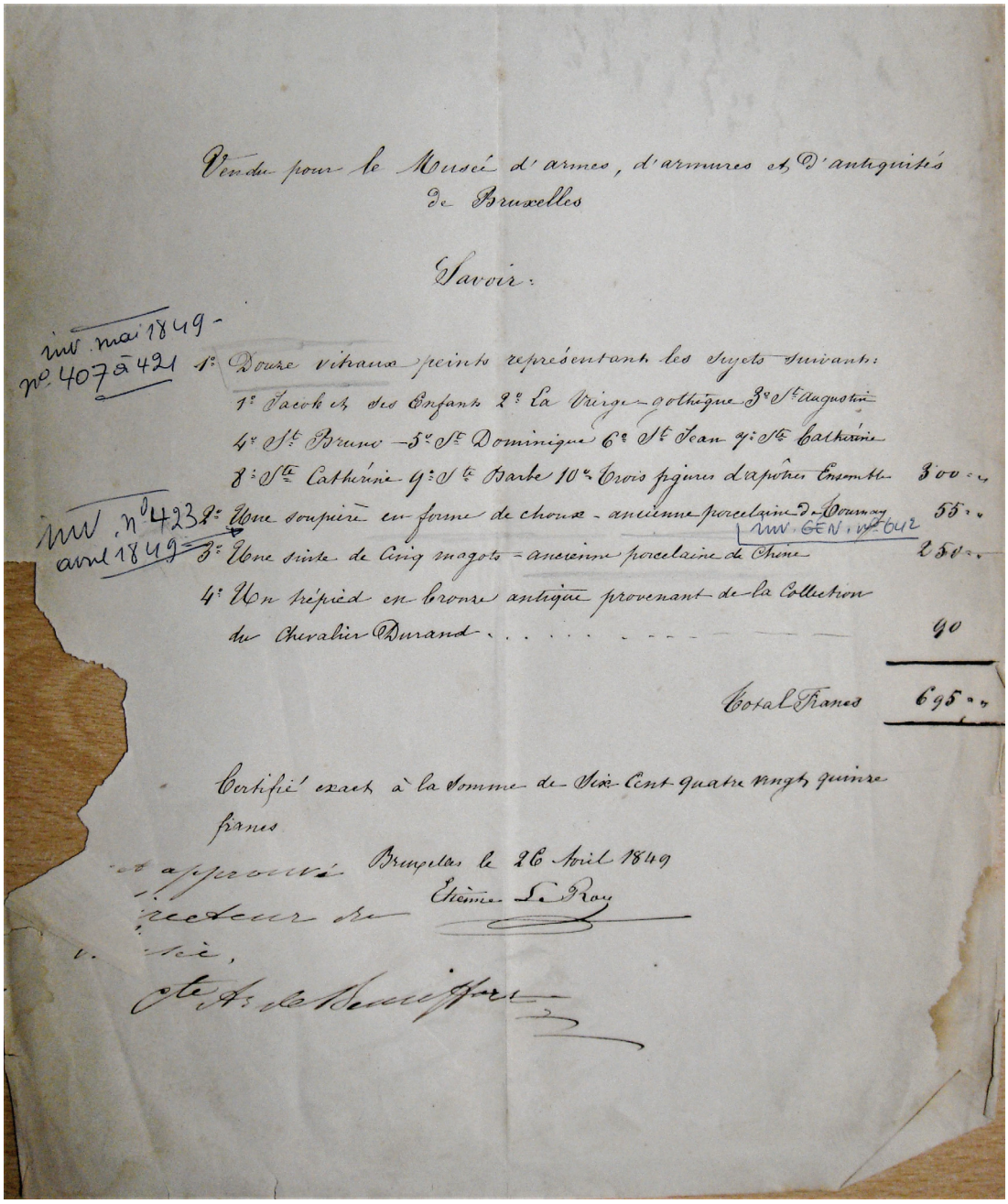
PRELIMINARY RESULTS

The initial task of the research team was to gather previous publications concerning any of the pieces belonging to the collection. A small selection of the large numbers of books and papers available is reported here (Helbig 1943; Helbig 1961; Helbig and Vanden Bemden 1974; Vanden Bemden 1976; Vanden Bemden 1977; Vanden Bemden 1979; Husband 1995; Lecocq 2005; Lecocq 2012; Berserik and Caen 2007; Berserik and Caen 2011; Berserik and Caen 2014; Berserik and Caen 2018; Caen et al. 2013; Wouters et al. 2013).

Following the collection of past research, several actions have been undertaken in each of the domains involved in the project. The following sections provide an overview of the current status of research for each of the main topics. The reader is invited to follow future publications in order to get a more in-depth view of the results.

CONSERVATION AND COLLECTIONS MANAGEMENT

At the beginning of the project, there was a profound lack of knowledge about several aspects of the glass collection of the RMAH: an accurate


Vendu pour le Musée d'armes, d'armures et d'antiquités
de Bruxelles

Savoir:

inv. mai 1849 -
nº 407 à 421 1º Douze vitraux peints représentant les sujets suivants:
1º Jacob et ses Enfants 2º La Vierge - gothique 3º St Augustin
4º St Bruno - 5º Ste Dominique 6º St Jean 7º Ste Catherine
8º Ste Catherine 9º Ste Barbe 10º Trois figures d'apôtres Ensemble 300 -
inv. nº 4232 2º Une soupière en forme de choux - ancienne porcelaine de Tournay 55 -
ann 1849 - 3º Une suite de cinq magots - ancienne porcelaine de Chine 250 -
inv. GEN. nº 642
4º Un trépied en bronze antique provenant de la Collection
du Chevalier Durand 90

Total Francs 695 -

Certifié exact à la somme de Six-Cent-quatre vingts quinze
francs

Bruxelles le 26 Avril 1849
Etienne Le Roy

Figure 2. *Document dated April 26th, 1849 found in the archives, certifying the acquisition of 12 painted glass objects from merchant Etienne Le Roy*

inventory of the collection was missing, previous conservation treatments were not always reported, we lacked a modern database containing information on the conservation history of each object, and the pieces were stored in inappropriate conditions.

The first urgent measure was undertaken during the summer of 2018, when a new storage room was set up. A combination of vertical and horizontal storage systems has been installed, and the room temperature and relative humidity are now monitored at regular intervals. While the temperature was rather stable, the humidity varied, reaching peaks higher than 50 percent. Therefore, a humidification control system is currently being installed.

The museum's archival records were researched. In addition to the accession books and inventory

Figure 3. *The curator (left) working on the state report drawing (right) of Nativity, ca. 1600-1700 CE, I.A.691 (center)*

paper files listing all acquired objects, different types of documents were investigated (Figure 2). Deeds of sale and written communications between museum personnel give interesting information about the formation of the collection, for example, how some of the stained-glass windows entered the collection and why some objects were purchased and others were not. Within the archives of the section 'Stained glass windows', curatorial correspondence elucidates details about the management of the collection, the way it was presented to the public, and the difficulties that were faced by the museum. These written sources include reports of past restorations, which are of particular interest for the conservator. Elucidated by this research, the growth of the collection is a consequence of three main factors: the sale of major private collections during the 19th century (Van Huerne 1844, Huyvetter 1851, Van Parijs 1853, de Fré 1866), gifts (Cavens 1892), and bequests (Gustave Hagemans † Liège 1908, Gustace Vermersch † Bruxelles 1911) and, most significantly, the concern of the curators not only to preserve the Belgian cultural heritage, but also to form a representative stained-glass collection of material from the Low Countries.

Most pieces in the collection have been professionally photographed, and images are available online via the RMAH and KIK-IRPA databases: 'Carmentis' and 'Belgian Art Links and Tools' (BALaT).

Concerning the conservation of the collection, the first step was to develop condition report files, or *constat d'état*, where general information about the artwork and detailed information on the conservation state of the glass and painting layers are reported. In addition, the condition report files contain information about past restoration and recommendations regarding object handling and storage, as well as proposals for future conservation treatments. While examining the objects, the conservator carries out a dry cleaning with a soft brush and a vacuum cleaner with a high-efficiency particulate air (HEPA) filter to remove dust. The condition report files are augmented with current documentation including drawings that indicate areas of previous restorations and weathering by use of a colour-coded system (Figure 3). In addition, the conservator has been gathering all broken fragments for future reconstruction.

ICONOGRAPHIC AND TECHNICAL ART RESEARCH

Iconographic research has been carried out for all objects in the collection, which has enabled the interpretation of the objects. For example, the theme of a series of four roundels, inv. 569 A and B, 571, and 681, has just been identified as the Story of Griselda, after Boccacio's tale from *The Decameron*. In this story, Griselda has to overcome a series of tests to prove her total loyalty to her

husband, the Marquis of Saluzzo. The story of Griselda has been popular since the Middle Ages, but there are not many depictions of the theme during the *Ancien Régime*, the period in European history between the end of the medieval period and the end of the French revolution, ca. 1450-1800 CE. Most of the roundels and unipartite panels have religious iconographies developed into series; examples include, the Story of Joseph, the Story of Toby, the Four Evangelists, and the Catholic Virtues. With a few exceptions, all iconographic information is already available to the public through KIK-IRPA's online search tool BALaT, which includes high resolution pictures, bibliographic references, and dating.

A technical visual examination under front and back lighting conditions using simple magnifying instruments of each individual piece is performed. This includes a detailed account of glass production and manufacturing information, paint layers, and stylistic details. This research includes the selection of sample locations for the applied research, ensuring that the bare glass, framework glass, and different paint layers are all included. The identification of technical features of the painting layers might lead to recognition of artists' hands or workshops. We focus on material properties, occurring colours, and painting style. Another topic tackled by the technical study is the contribution to the definition of the quality of the glass. Here we investigate the visual appearance of fabrication left-overs, the number of occurring inclusions, and the relationship between the quality of the paint layers and the number of inclusions.

APPLIED SCIENCES

So far, our work has focused on the 15th- and 16th-century roundels, which make up a considerable part of the glass collection at approximately 275 objects. Research questions concern the provenance, dating, and authentication of the objects, as well as changes in chemical composition and the technology of silver staining.

Most of the roundels have been studied using visible absorption spectroscopy employing a spectral broadband light source at the illumination side, a DHS-BAL deuterium lamp combined with the Avalight-HAL halogen source from Avantes, and an Avaspec-3648 optical spectrum analyzer as detector, also from Avantes. This method has been largely used by our group in previous work (Meulebroeck et al. 2010a; Ceglia et al. 2012; Meulebroeck et al. 2010b; Meulebroeck et al. 2012; Wouters et al. 2012; Meulebroeck et al. 2016). Optical transmission spectra were recorded in the spectral region between 300 nm and 1600 nm, with a typical spectral resolution of approximately 1.5 nm. The light emitted by the light source is focused to a spot size of 1.5 mm at the position of the artifact. All the transmitted light is captured by an integrating sphere, which is connected to the optical spectrum analyzer. As a non-destructive technique, visible absorption spectroscopy can be applied to all glass in the collection. However, this type of optical spectroscopy is limited to the study of translucent colours, hence it cannot be applied to characterise the vitreous paints. Nevertheless, useful information can be gleaned regarding the colouring agents, whether intentionally or unintentionally added, such as iron present as a contaminant in the sand used to make the glass. Visible absorption spectroscopy can also yield information elucidating the silver stain technology and the identification of different glass types.

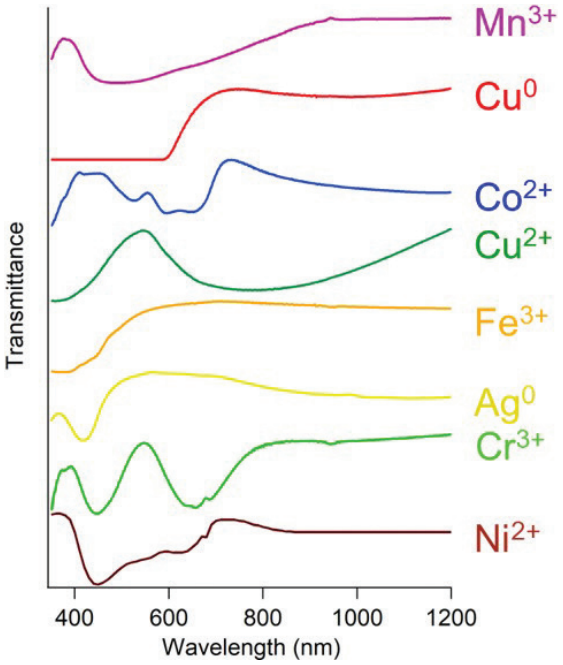


Figure 4. *Typical transmission spectra of some transition metal ions responsible for colour in glass*

As a general illustration, Figure 4 shows visible and near infrared absorption spectra of colouring

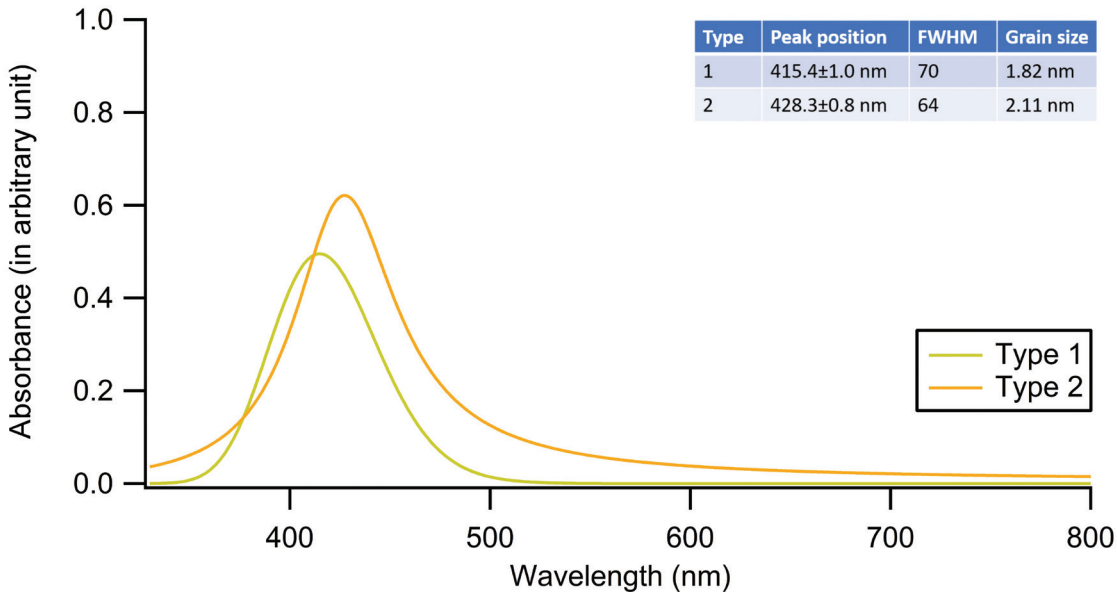


Figure 5. *Absorption peaks for silver visibly shifted because of the different sizes of the nanoparticles*

agents that can be identified in glass using optical spectroscopy. Transition metal ions, including manganese III (Mn^{3+}), cobalt II (Co^{2+}), and copper II (Cu^{2+}), absorb light at characteristic wavelengths and give rise to different hues. Within a glassy matrix, the position of the cations' absorption bands can be influenced by the chemical composition of the glass or by the technological process used to produce the colour. The influence of the chemical composition on the absorption of cobalt is known. The first peak in the visible region occurs at 525 nm for HLLA glass (Ceglia et al. 2012; Fornacelli et al. 2018), at 535 nm for soda-rich glass (Ceglia et al. 2012; Fornacelli et al. 2018), and at 540 nm for potassium-rich glass (Bacci and Picollo 1996). Manufacturing technology, as in the case of silver stain (Delgado et al. 2011; Molina et al. 2014), can also influence the positions of absorption bands. Metallic silver nanoparticles on the surface layers of glass impart a variety of hues from yellow to orange to red as a function of the size of the nanoparticles. The firing time and temperature affect particle size, which is also influenced by the silver salt and the supporting clay used to apply the colour to the glass. For example, Figure 5 shows two absorption spectra from silver nanoparticles on 16th-17th-century roundels. The peak shifts in position and changes in shape based on the average nanoparticle size of either 1.8 nm or 2.1 nm. The two types of spectra are linked to different types of silver stain and have been recognised on several roundels analysed thus far. This work is still ongoing but suggests increasing nanoparticle size over time, implying changes in the technological process of silver staining.

Currently, portable X-ray fluorescence spectroscopy (p-XRF) using a Bruker Tracer instrument is being carried out on all pieces in the collection. Although p-XRF has poor detection for light elements important for glass, such as sodium (Na), magnesium (Mg), aluminum (Al), and silicon (Si), studies have shown that p-XRF data can be used to cluster glass into different chemical groups by using heavy elements as proxies for lighter ones (Adlington and Freestone 2017). Additionally, p-XRF enables a qualitative study of the paint layers, aimed in this research at linking certain recipes to specific glass workshops. Of course, this goal can only be achieved by integrating the results of chemical analysis with information gleaned through technical art examination.

CONCLUSIONS AND PROSPECTIVE WORK

The aim of the FENESTRA project is to set a milestone in modern collections management. Today, it is essential to integrate different disciplines and approaches to extract the most information from each object and the collection as a whole. Applied sciences and art historical research support each other and, combined, unveil the histories of glass objects. Archival research is paramount to determining the best conservation strategy, which should be predicated on knowledge of previous conservation treatments.

After completion of the condition report files, the conservation team will start restoration interventions. At this stage, a thorough discussion between the art historians, the conservator, and the scientific team will be necessary to design the best sampling strategy to answer research questions posed in each discipline.

A close examination of each object in the collection will allow for the detailed description of the paintwork and systematic characterisation of decorative materials, distinguishing materials such as overpaint, or *sanguine*, from other vitreous paints. The study of the iconography through comparisons with other stained-glass and contemporary works in other media will deepen the knowledge of Renaissance art and culture.

The scientific team will continue non-destructive analyses of the collection and select, together with the conservator, the sample sites with the greatest potential to answer research questions on topics such as provenance of the glass, technology of vitreous paints, and silver stain colouring technology. Planned analyses include a variety of non-destructive and semi-destructive lab-based physico-chemical methods such as scanning electron microscopy-energy dispersive spectroscopy, laser ablation-inductively coupled plasma-mass spectrometry, Raman spectroscopy, synchrotron X-ray methods, and others.

An important aim of the FENESTRA project is dissemination of findings. Publications and outreach activities provide the most important means of spreading the information obtained through the project on this precious glass collection. So far, we have presented the project in three posters at the International Symposium of Archaeometry in May 2018, Mexico, and the 29th International Colloquium of the Corpus Vitrearum in July 2018, Antwerp. Moreover, some objects belonging to the collection have received considerable attention via the RMAH Facebook account, which will give regular updates about the project.

In collaboration with the Corpus Vitrearum Organisation, a checklist publication focussing on the RMAH collection will be prepared in the course of the next two years. Two scientific papers, one on the technological evolution of silver staining and another on the chemical-optical analysis of the roundels, are being prepared. An exhibition of the glass collection is planned for 2020.

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