The GEMMAE Project: A multidisciplinary study of Roman glass-gems

M. Musa([1])([3]), E. Gagetti([2]), M.P. Riccardi([3]), G. Marcucci([1]) and D. Di Martino([1])

([1]) *Department of Physics "G. Occhialini", University of Milano-Bicocca, Milan, Italy. E-mail: maya.musa@unimib.it; giulia.marcucci@unimib.it; daniela.dimartino@unimib.it*
([2]) *University of Milano "La Statale", Milan, Italy. E-mail: elisabetta.gagetti@unimi.it*
([3]) *Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy. E-mail: mariapia.riccardi@unipv.it*

Summary. — Aquileia, in northeastern Italy, is one of the most important ancient Roman archaeological sites worldwide. Its museum, among the other cultural heritage materials, holds one of the most important and rich collections of gemstones, counting more than 6000 gems, dated between the 2nd century BC and 2nd century AD and mainly discovered both in the ancient city and in its cemeteries. In other words, the collection principally counts stones with a known archaeological origin. Unfortunately, it is not valid for all the gems. Due to this peculiarity, the chance to study this amazing collection represents a scientific privilege. In the present paper, the characterization project focused on the Roman glass-gems study, and a case study of the expected results will be preliminarily reported.

1. – Introduction

What do we intend with the term Archaeometry? In the first meaning, we can describe an archaeometric application as the science at the service of archaeology. Indeed, an archaeologist, founding an ancient artefact, has to properly identify not only the material constituting the object but also when or who made it. Thus, on the basis of all these pieces of information, he/she may answer to the last important archaeological question: for what? The second important characteristic of this type of study is multidisciplinarity: archaeometry is intrinsically interdisciplinary on two levels, not only because it concerns the interaction between different expertise belonging to several disciplines, but also in consequence to the different analytical techniques which must be complementarily applied to solve the identification and characterization issues of the samples [1]. An important consideration regarding the peculiarities of the samples has to be made: except for very few cases, cultural heritage materials, as well as archaeological samples, have to be analyzed without any preparation and by only non-destructive techniques.

Sometimes this implies for material identification the impossibility of applying several standard gemological tests. For example, due to museums' or artefact owners' policies, the refractometer index cannot be collected due to the use of contact liquid [2]. In other situations, the nature of the samples can affect the result of the tests, making the analysis completely useless. An example of this may be the specific gravity, carried out by the hydrostatic method [3] where, in addition to the temperature of the water, the dimensions and roughness of the samples can strongly compromise the results. Thus, it is a good strategy for cultural heritage identification and characterization project scheduling to combine standard tests with high-tech analytical techniques. Moreover, in several cases scheduling on-site the analysis campaign is mandatory due to the impossibility of moving the samples outside the museum, as per the present project.

2. – GEMMAE: the Aquileia's glass-gems characterization project

The Roman city of Aquileia, founded in 181 BC—and reinforced in 169 BC as a colony made up of more than 3000 families from Central Italy—had a long life-time, until the 5th century AD. After its almost complete destruction by Attila in 452, the city was rebuilt southeast of the ancient Roman settlement, which remained, even if ruined, under a land that had become of agricultural use. Aquileia played an important role not only under the military point of view, but also with regard to an economic perspective, owing to its location in the northern recess of the Adriatic Sea and at the very centre of a road network linking the northern and eastern regions of the expanding Roman empire. Already in 2nd century BC, the earliest glyptic workshops were set up. They could take an advantage of being located at a pivot point both of the trades of hardstones from the Alps and the East; and of the routes of specialised craftsmen. On the whole, the glyptic production at Aquileia can be dated from the 2nd century BC to, at least, the 3rd century AD. The main productions were carved gemstones [4]. The first records of Roman gems from Aquileia appear during the Renaissance, but a study of such artefacts started in the 18th century. An extensive work of reordering and cataloguing the collection of the National Archaeological Museum of Aquileia started in 2016 and made it possible to reconstruct a catalogue of over 6000 specimens: 1300 are glass-gems. Even if the vast majority of gems were found by chance on the occasion of agricultural work, so that we know only, and not for all, just the area of the ancient town or its cemeteries from where they were recovered, in progress of time some of them came to light in the frame of controlled, stratigraphic excavations. Moreover, there is a third type of provenance: from donations of private owners to the museum. In this group, there are ancient glyptic artefacts of unknown findspot, and even modern intaglios, cameos, and glass-gems, these last better defined as glass-pastes [5]. Due to the importance of this collection, we developed the GEMMAE project (Glass-gems Exploration by Multidisciplinary Methods, Analyses and Experiments). Aims of the project, involving completely non-invasive investigations, are: (i) digitalization, focused on Reflectance Transformation Imaging (RTI) and profilometer imaging acquisitions on the samples, and promotion of digitalised heritage, combining all the information acquired on the collection, both for remote use, for comparison studies on archetypes, and for dissemination purposes too; (ii) elemental characterization aimed at deepening the knowledge on manufacturing techniques and recipes of specific artefacts, in order to highlight similarities so close as to point to the same workshops, possibly located in Aquileia itself. So, we will extend the analysis of gems composition by a point and micro-mapping X-ray Fluorescence (XRF) analysis; (iii) the use of Raman spectroscopy on a subset of gems, which can disclose unexplored sources of valuable information from

the detailed investigation of the aggregation structure and homogeneity of glasses. The highly complementary nature of the information provided by XRF, Raman spectroscopy and profilometer imaging techniques makes their combination especially intriguing. The key aspect of GEMMAE project is gathering powerful non-destructive techniques following an unconventional approach for the study of glass gemstones, for assessing new protocols based on a combination of gemological-XRF-Raman investigations and complementary RTI/profilometer techniques. After a preliminary typological and glyptic study, in collaboration with the Museum, the GEMMAE team has selected about 100 significant glass-gems. The specimens were first characterized by Particle-Induced X-ray Emission/Particle-Induced Gamma-ray Emission (PIXE/PIGE) during a recent AGLAE facility (Accélérateur Grand Louvre d'analyse élémentaire) access [6]. Moreover, a MOLAB (MObile LABoratory) access has been recently granted, and we will show in the following a particular result.

3. – The case study

In the present paper, the identification performed by Raman spectroscopy of a gem has been reported as an example of the type of materials analysed and results collected. The glyptic artefact Inv. No. 26271 (fig. 1a) has an oval tablet shape, and its dimensions are 14×12×4 mm. The provenance is unknown. On the upper face the device, in negative, is a Chrismon, i.e. the superimposed first two Greek letters (X and P) of the name of Christ. This monogram appears in Roman glyptics (both on gemstones and glass-gems) in the late 2nd and 3rd centuries AD [7]. From a gemological point of view, the sample is a semitranslucent (STL) brownish Red (brR) gem, showing an aventurescence optical effect. In order to identify the material, the sample has been analysed by a portable-Raman Spectrometer, BWTEC i-Raman Plus model with 532 and 785 nm sources coupled with optical microscopy by an optical fibre system, and the relative spectrum is shown in Fig. 1b. It is interesting to note that the spectrum is characterized by very broad bands. Only by its visual aspect, 26271 could be wrongly identified as a sunstone, one of the phenomenal gemstones variety of the feldspar group [8], but thanks to the Raman technique, it is easy to classify the material as a glass [9] (sunstone imitation or aventurine glass); therefore, completely unusual material in Roman glyptics. Further investigation will be performed on this sample in order to hypothesize a dating.

4. – Conclusion

GEMMAE project has been presented, and a preliminary result has been shown, within a comprehensive study of glass-gems from the wide collection of the National Archeological Museum of Aquileia, starting from a selection of about 100 specimens and including all main typologies. An in-depth characterization of glass-gem specimens is being obtained, extending the results of a previous experiment, and following a multidisciplinary protocol: glass-gems are compared by composition, glass structure, glass opacifiers, iconography and style. Archaeologists and glass experts will learn more about ancient trade routes and the policies of raw materials, as well as ancient manufacturing techniques. Measurements and data analysis are still running and further publications are foreseen. The case study here reported has been used to highlight how important is to combine high-tech analyses with basic observation in a multidisciplinary approach. In fact, thanks to the Raman spectroscopy combined with the gemological observation, the

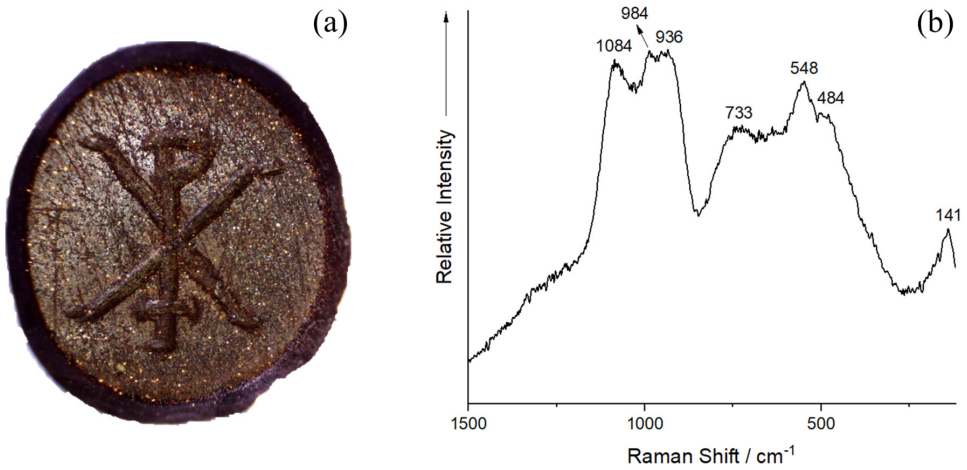

Fig. 1. – Identification of the study case: (a) sample Inv. No. 26271; (b) the relative Raman spectrum. Acquisition parameters: 532 nm source, 20 cycles/30 seconds each, Optical Microscopy object 80x corresponding to 20 µm spot. © Direzione Regionale Musei del Friuli Venezia Giulia - Museo Archeologico Nazionale di Aquileia

case study has been properly identified as aventurine-glass. Further investigations will be performed in order to better dating the object.

* * *

The authors acknowledge the director, Dr. Marta Novello, and all the staff of Museo Archeologico Nazionale di Aquileia, not only for the access to the collection but also for their kind willingness during the research. We also thank colleagues of CNR ISPC and CNR SCITEC for their efforts and participation to the MOLAB on-site analyses campaign, within E-RIHS (European Research Infrastructure for Heritage Science), with the financial support of Ministero dell'Università e della Ricerca (MUR).

REFERENCES

[1] Musa M., *Appl. Sci.*, **12** (2022) 7168.
[2] Sturman D.K., *J. Gemmol.*, **32** (2010) 74.
[3] Sinkankas J., *Gems Gemol.*, **157** (1986) 156.
[4] Gagetti E. and Novello M., In *Proceedings of the International Conference 'Iconografia 2022', Padua-Venice, Italy, 12th-14th December 2022*, edited by Ghedini F., Salvadori M. and Baggio M. forthcoming.
[5] Zwierlein-Diehl E., *Glaspasten im Martin-von-Wagner-Museum der Universität Würzburg*, Prestel Verlag, München 1986.
[6] Spier J., *Late Antique and Early Christian Gems*, Reichert Verlag, Wiesbaden, 2007.
[7] Di Martino D., Gagetti E., Marcucci G., Lemasson Q. and Riccardi M.P., "Glass-gems from the National Archaeological Museum in Aquileia: A PIXE/PIGE compositional Study", In *Journal of Physics: Conference Series, 2204(1), 012074*. 2022
[8] Aitkens I., *Feldspar Gems (Amazon Stone, Moonstone, Sunstone, etc.)*, in *Information Circular 6533*, edited by Department of Commerce, United States Bureau of Mines, 1931.
[9] Janssens K., *Modern Methods for Analysing Archaeological and Historical Glass*, edited by John Wiley. and sons, Vol.1, 2013.