



LATE ROMAN AND EARLY ISLAMIC GLASS IN SPAIN: PRODUCTION AND CONSUMPTION

Jorge de Juan Ares, Nadine Schibille

► To cite this version:

Jorge de Juan Ares, Nadine Schibille. LATE ROMAN AND EARLY ISLAMIC GLASS IN SPAIN: PRODUCTION AND CONSUMPTION. ANNALES du 21e CONGRÈS de l'ASSOCIATION INTERNATIONALE pour l'HISTOIRE du VERRE (İstanbul, 03-07 Septembre 2018), 21, pp.471-484, 2021, 978-605-7880-10-9. hal-03474013

HAL Id: hal-03474013

<https://hal.science/hal-03474013>

Submitted on 10 Dec 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ANNALES

du 21^e CONGRÈS de l'ASSOCIATION
INTERNATIONALE pour l'HISTOIRE du VERRE

3-7 Septembre 2018, Istanbul



ANNALES

du 21^e CONGRÈS de l'ASSOCIATION INTERNATIONALE
pour l'HISTOIRE du VERRE

İstanbul 2018

Editor

Orhan Sevindik

Editorial Committee

Erdoğan Köse

Üzlifat Özgümüş

Ergün Laflı

Ömür Bakırer

Ömür Dünya Çakmaklı

İSTANBUL 2021

ANNALES

du 21^e CONGRÈS de l'ASSOCIATION INTERNATIONALE
pour l'HISTOIRE du VERRE

Istanbul, 03-07 Septembre 2018

Editor: Orhan Sevindik

Editorial Committee: Erdoğan Köse, Üzlifat Özgümüş, Ergün Laflı, Ömür Bakırer,
Ömür Dünya Çakmaklı

Scientific Committee: Ali Akın Akyol, Anastassios Antonaras, Şeniz Atik, Ömür Bakırer,
Janet Duncan Jones, Emel Erten, Semavi Eyice, Sylvia Fünfschilling, Sid Goldstein, Yael
Gorin Rosen, Binnur Gürler, Julian Henderson, Despina Ignatiadou, Ergün Laflı, Chris
Lightfoot, Teresa Medici, M.Dominique Nenna, Jennifer Price †, Ann De Pury-Gysel,
Rabia Özakin, Eva Marianne Stern, Sophie Wolf

Special thanks:

Ergün Laflı prepared the First, Second and Third Circulars.

E.Marianne Stern corrected the English version of Preface and Brigitte Demierre

Prihodkine translated the English version into French.

Nuri Aydın (*Rector, Istanbul University-Cerrahpasa*)

Mahmut Ak (*Rector, Istanbul University*)

Hami Eyilik- Efeglass (*sponsor*)

Serra Kanyak

Computer layout: Orhan Sevindik

Cover Design: Emir Bostancı

Printed by: Vadi Grafik Tasarım ve Reklamcılık Ltd. Şti.
İvedik Organize San. 1420. Cad. No: 58/1-2-3-4-5
Ostim - Y. Mahalle / ANKARA - Tel: 0312 395 85 71-72
Certificate Number: 47479

No. of copies: 250

Publisher: AIHV

Association Internationale pour l'Histoire du Verre

International Association for the History of Glass

<http://www.aihv.org>

Secretariat: Via A. Alciato 2 I-27100 Pavia, Italy

© AIHV and authors - 2021

ISBN: 978-605-7880-10-9

*Cover image: Roman handle applique found in the Marmaray-Metro
Excavations - Istanbul. 4th Century*

in memoriam
YOKO SHINDO

CONTENTS

PREFACE- Sylvia FÜNFSCHILLING	11
PRÉFACE- Sylvia FÜNFSCHILLING	13
VORWORT- Sylvia FÜNFSCHILLING	15
 2nd - 1st Millenium BC/Bronze Age/Iron Age/ Archaic/Late Classical Glass	
<i>HENDERSON Julian, CHENERY Simon, MATSUMURAKI Kimiyoshi, EVANS Jane, OMURA Sachihiro</i>	
DID THE HITTITES MAKE GLASS?	17
 <i>ENGİN Atilla, ATİK Şeniz, ÖZER Ali</i>	
MIDDLE BRONZE AGE VITREOUS MATERIAL OF OYLUM HÖYÜK AND NEW FINDINGS.....	35
 <i>BROCHAT Katja</i>	
GLAS AUS DEM GRAB DES TUTANCHAMUN	49
 <i>ŞENYURT Yücel, ERTEN Emel</i>	
A GLASS HORSE RHYTON FROM AŞAĞI SALAT MOUND IN DİYARBAKIR, TURKEY	61
 <i>JONES Janet, MARSH Ben</i>	
A GLASS-BASED HISTORY OF GORDION	69
 <i>KOLESNYCHENKO Anzhelika, KIOSAK Dmytro</i>	
THE ANCIENT GLASS-WORKSHOP OF YAHORLYK SETTLEMENT IN THE NORTHERN PONTIC REGION	81
 <i>IGNATIADOU Despina</i>	
THE FACES ON THE PENDANTS	95

Roman Glass

LIGHTFOOT Christopher

ANCIENT GLASS IN ROMAN ITALY BEFORE THE INVENTION OF BLOWING: CAST MOSAIC GLASS..... 109

ŠTEFANAC Berislav

ROMAN NON-BLOWN GLASS FROM ZADAR (CROATIA)..... 119

NENNA Marie-Dominique

THE GLASS FROM HEGRA (MADÂ'IN SÂLIH, SAUDI ARABIA)..... 133

DIANI Maria Grazia, REBAJOLI Francesca

CONTRIBUTION TO THE MAP OF DISTRIBUTION OF HEAD-SHAPED VESSELS IN ITALY: AN UNCONVENTIONAL BEAKER FROM VERCELLI (PIEDMONT)..... 141

LAZAR Irena

NEW FINDS OF ROMAN HIGH QUALITY GLASS FROM ROMULA (PANNONIA) 149

ERTEN Emel

GLASS FROM OLBA IN ROUGH CILICIA..... 161

STERRET-KRAUSE Allison

RECONSTRUCTING LIFE FROM THE LITTER IN POMPEII'S SOUTHWEST CORNER: GLASS FROM THE EXCAVATIONS OF THE POMPEII ARCHAEOLOGICAL RESEARCH PROJECT: PORTA STABIA..... 171

HANAR Elif

MOLD-BLOWN GLASS VESSELS IN DİYARBAKIR MUSEUM 183

ZACHARIAS Nikolaos, OIKONOMOU Artemios, ARAPOGIANNI Xeni

TECHNOLOGY AND USE OF GLASS DURING THE CLASSICAL - HELLENISTIC TIMES:A CASE STUDY OF GLASS KNUCKLEBONES 195

IVANOV Mario, CHOLAKOVA Anastasia, GRATUZE Bernard

GLASS FURNACES FROM SERDICA - AN EXAMPLE OF ROMAN PRACTICE OF GLASS MIXING 207

ÇELİKBAŞ Ersin, KELEŞ Vedat

GLASS FINDS FROM LATE ROMAN HOUSE IN PAPHLAGONIAN HADRIANOPOLIS 221

BULJEVIĆ Zrinka

MOULD-BLOWN GLASS VESSELS FROM SALONA 233

AKKUŞ KOÇAK Emine

GLASS WORKSHOPS AND GLASS PRODUCTION IN METROPOLIS (IONIA) 245

*TRAVIGLIA Arianna, PANIGHELLO Serena, MORETTO Ligia, ORSEGA Emilio Francesco,
BERNARDONI Anna, FLOREANI Stefi, MORO Giulia, MANDRUZZATO Luciana*

**PICKING UP THE HINT: RAW GLASS CHUNKS AND GLASS WASTES FROM
PLOUGHSOIL COLLECTION IN AQUILEIA (ITALY) 255**

GRÜNEWALD Martin

**GLÄSERNE GRABFUNDE SPÄTANTIKER ZEIT AUS DEM RHEINISCHEN
BRAUNKOHLEREVIER (DEUTSCHLAND) 265**

Late Roman/Byzantine /Early Islamic/Medieval Glass

ŽIVANOVIĆ Miloš

GLASS WORKING ACTIVITIES IN LATE ROMAN DOCLEA (MONTENEGRO) 283

COSYNS Peter, CEGLIA Andrea, THIENPONT Hugo, von WARTBURG Marie-Louise

**A LATE ANTIQUE GLASS WORKSHOP AT THE APHRODITE SANCTUARY OF
PALAEPAPHOS, KOUKLIA (CYPRUS) 291**

SCHINTLMEISTER Luise

**GLASS OF A LATE ANTIQUE-MEDIEVAL URBAN QUARTER IN EPHESES/TURKEY
(4TH/5TH–12TH CENTURIES CE) - PRELIMINARY REPORT 307**

GORIN ROSEN Yael

**SECONDARY GLASS PRODUCTION IN ISRAEL - BRIEF SUMMARY
OF THE FINDS AND NEW DISCOVERIES 319**

RUMYANTSEVA Olga, YUBITCHEV Mikhail, PETRAUSKAS Oleg,

CHERVYAKOVSKAYA Maria, KHANIN Dmitry, TRIFONOV Alexander
**‘BARBARIAN’ BEAKERS WITH FACET CUT DECORATION: COMPOSITION,
ORIGIN, SOCIAL AND CULTURAL CONTEXT 333**

BAYBO Selda

**EIN ÜBERBLICK ÜBER DIE GLASFUNDE VON LIMYRA (1969-2012)
UND DIE BEFUNDE ZUR GLASPRODUKTION AUS DEN OSTTORGRABUNGEN 349**

STERN E. Marianne Stern

GLASS FROM THREE BYZANTINE CHURCHES AT ANCIENT ANEMURIUM (TR) . 363

GENÇ Deniz, AKYOL Ali Akın

**ARCHAEOLOGICAL INVESTIGATIONS OF THE EARLY BYZANTINE
SITE SIDE GLASS FINDS 375**

<i>CHINNI Tania, FERRERI Debora, CIRELLI Enrico</i> GLASSWORKING IN CLASSE: WORKING DEBRIS FROM THE SOUTHERN DISTRICT	389
<i>COUTSINAS Nadia</i> NEW LIGHT ON THE EARLY BYZANTINE GLASS FROM ELEUTHERNA PYRGI (CRETE)	399
<i>TAŞTEMUR Emre, DİNÇ Münteha</i> GLASS OBJECTS FOUND IN AKMONIA CITY SURFACE RESEARCH	417
<i>STORCHAN Benyamin, GANOR Adrienne</i> GLASS, POTTERY, PLASTER AND IRON: PRELIMINARY TECHNOLOGICAL INSIGHTS FROM THE WINDOWS AT THE CHURCH OF THE GLORIOUS MARTYR IN THE HOLY LAND	433
<i>NOBACK Andreas, GROBE Lars O, LANG Franziska</i> MODELLING THE EFFECTS OF DAYLIGHT SCATTERING BY WINDOW GLASS: THE CASE OF SIXTH CENTURY HAGIA SOPHIA IN ISTANBUL.....	443
<i>BAKIRER Ömür, ERCİYAS D. Burcu</i> MEDIEVAL GLASS FINDS FROM THE KOMANA EXCAVATIONS NEAR TOKAT, TURKEY	457
<i>DE JUAN ARES Jorge, SCHIBILLE Nadine</i> LATE ROMAN AND EARLY ISLAMIC GLASS IN SPAIN: PRODUCTION AND CONSUMPTION	471
<i>WINTER Tamar</i> OPULENCE ON THE DESERT FRINGES? GLASS ASSEMBLAGES OF THE EARLY ISLAMIC PERIOD FROM THE NORTHEASTERN NEGEV, ISRAEL.....	485
<i>KÜRTÖSI Brigitta Maria</i> A DIVERSE PRODUCTION METHOD OF GOLD GLASS MOSAIC TESSERAE FROM MEDIEVAL HUNGARY, ROYAL BASILICA OF ALBA REGIA/SZÉKESFEHÉRVÁR	497
<i>STOLYAROVA Ekaterina</i> MEDIAEVAL GLASS BRACELETS IN RUS' (ACCORDING TO THE FINDS IN THE TOWNS OF THE NORTH-EAST OF RUS').....	507
Islamic Glass	
<i>VALIULINA Svetlana</i> ISLAMIC GLASS OF BILYAR: IMPORT AND PRODUCTION	521

ARVEILLER-DULONG Véronique

LES VERRES ISLAMIQUES D'ANTINOÉ (MOYENNE-ÉGYPTE) CONSERVÉS AU LOUVRE: UN APERÇU	529
--	------------

GEYİK Gül

ISLAMIC GLASS IN SOME ANATOLIAN MUSEUMS	539
--	------------

ÖZAKIN Rabia, CANAV-ÖZGÜMÜŞ Üzlifat, KANYAK Serra, ÇELİK İzzet Umut

DECORATIVE WINDOW GLASS FROM SOME OTTOMAN TOMBS IN ISTANBUL ..	549
---	------------

European Glass

TOPIC Nikolina

LATE MEDIEVAL GLASS LAMPS FROM DUBROVNIK	559
---	------------

MEDICI Teresa

A NOTE ON LATE MEDIEVAL AND EARLY MODERN OPAQUE RED GLASS VESSELS	569
--	------------

JARGSTORF Sibylle

FICHTELGEBIRGSGLAS	579
---------------------------------	------------

FONTAINE-HODIAMONT Chantal, WOUTERS Helena, LEFRANCQ Janette

LE VERRE VÉNITIEN SOUFFLÉ-MOULÉ AUX ARMES D'ANVERS, DEUXIÈME MOITIÉ DU XVI^e SIÈCLE. APPROCHE TYPOLOGIQUE, ANALYTIQUE ET HISTORIQUE	587
--	------------

LIKHTER Ju. A.

GLASS FAÇON DE VENISE FROM THE EXCAVATIONS IN MOSCOW AND OTHER CITIES (VYAZMA, MANGAZEYA)	597
--	------------

JOVIĆ GAZIĆ Vedrana

MAPPING OF THE 17TH CENTURY GLASS LAMPS ON THE EASTERN ADRIATIC COAST - CESENDELLO TYPE (HANGING LAMP)	609
---	------------

ANTONARAS Anastassios

OTTOMAN-ERA (17TH AND 19TH-CENTURY), GLASS LAMPS FROM CHURCH A' IN PLATAMONAS CASTLE	621
---	------------

KOS Mateja

GEORG FRANZ KREYBICH AND HIS TRAVEL TO LJUBLJANA (LAIBACH IN KRAIN) IN 1681	629
--	------------

<i>COSYNS Peter, DE VOS Annemie, CEGLIA Andrea, WARMENBOL Eugène</i> THE ALEXANDER MEDALLION OF THE MAS, ANTWERP (BELGIUM) RECONSIDERED	637
---	------------

General Themes

<i>ŠTEFANAC Marko, ŠTEFANAC Berislav</i> EXPERIMENTAL APPROACH TO MAKING EARLY ROMAN FREE-BLOWN GLASS FORMS.....	649
--	------------

<i>LARSON Katherine A.</i> BUILDING A COLLECTION: RAY WINFIELD SMITH AND THE CORNING MUSEUM OF GLASS.....	657
---	------------

INDEX OF AUTHORS.....	669
------------------------------	------------

PHOTOGRAPHS	671
--------------------------	------------

DE JUAN ARES, Jorge, SCHIBILLE Nadine

LATE ROMAN AND EARLY ISLAMIC GLASS IN SPAIN: PRODUCTION AND CONSUMPTION

INTRODUCTION

Roman glass typologies in Spain are relatively well established¹, while later periods have not been studied in any detail. The lack of research is even more pronounced with regard to chemical compositions, despite the fact that some of the earliest analyses of Roman glass were carried out in Spain². Our knowledge of glass compositions in medieval Spain has increased over the last few years thanks to new research initiatives³. In this paper, we synthesize the current state-of-the-art and future perspectives of the study of glass in late Roman and early medieval Spain, drawing particularly on the results from our on-going research project and published data. Within the scope of our current project *GlassRoutes*, we have care-

fully selected glass finds from well-dated archaeological contexts spanning the fourth to twelfth century CE and from different geographical and cultural environments in order to capture the totality of glass finds encountered in the Iberian Peninsula during this period. This is work in progress, but we can already identify some major patterns in the consumption of glass across time and what appears to be the first primary production of genuinely Iberian glass.

THE NATRON GLASS

Up to now, we have analysed the typology and composition of more than one thousand samples of natron-type glass objects. They include a large number of late Roman and early medieval vessels and tesserae from various sites dating from the fourth to ninth century CE. A substantial number stems from Alicante on the eastern coast of Spain like the

1 SÁNCHEZ 2018, 377–390.

2 RUA 1864, 45–54.

3 CARMONA et al. 2009, DUCKWORTH 2017, SÁNCHEZ 2018, and our own project *GlassRoutes*.

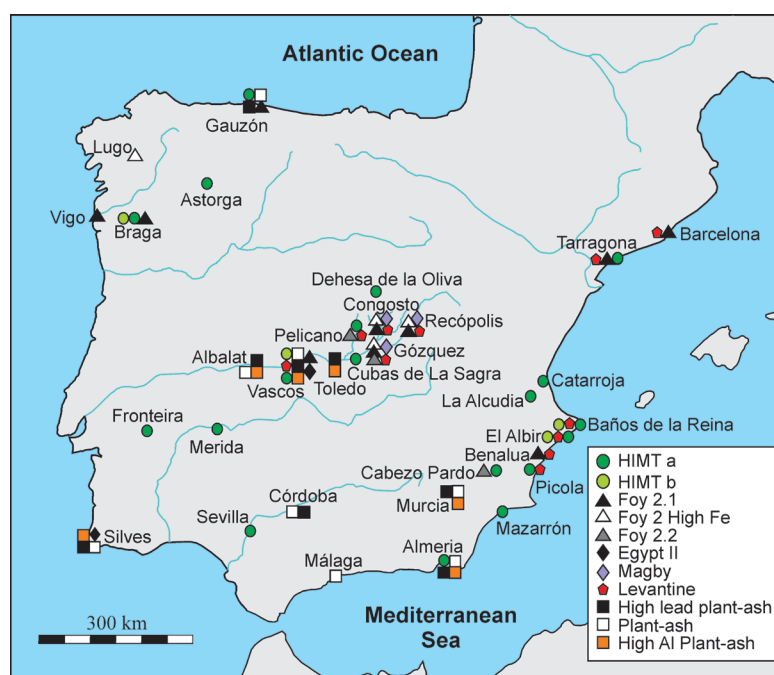


Fig. 1: Map of glass groups identified in the Iberian Peninsula. References to data analyzed prior to 2017 in DE JUAN and SCHIBILLE 2017b. Other analyses in: DE JUAN and SCHIBILLE 2017a, DE JUAN et al. 2018a, 2018b, DE JUAN, SCHIBILLE, and XIMENEZ 2018, DE JUAN et al. 2019.

Roman villas of Baños de la Reina and El Albir, the late Roman fish factory of Picola and the Islamic settlement of Cabezo Pardo⁴. We also investigated glass finds from the central Peninsula, for example, from the Roman villa of Noheda SCHIBILLE et al. 2020 and different Visigothic and early Islamic settlements around Madrid and Toledo such as Góñez, El Pelicano, Congosto⁵ and Recópolis (publication in preparation). Another set of samples without a clear archaeological context comes from later medieval sites at Ciudad de Vascos and Gauzón⁶. Their typological features and clear affiliation with well-established compositional groups allows their attribution to the late Roman or early medieval period (Fig. 1).

4 DE JUAN et al. 2018b, DE JUAN, SCHIBILLE, and XIMENEZ 2018, 271–279.

5 DE JUAN et al., 2019.

6 DE JUAN and SCHIBILLE 2017a, 5–7, DE JUAN et al. 2018a, 258–259.

On the basis of the available data, early Roman glass compositions in Hispania fit the general trends observed for other areas of the Roman Empire. As elsewhere, glass assemblages are characterised by the presence of Levantine and Egyptian natron-type glass with variable contents of antimony or/and manganese⁷. During the fourth and fifth centuries, the eastern imports reflect significant changes in the compositional characteristics of the glass finds. While our analytical data are still incomplete for the first half of the fourth century, a clear picture is already emerging for the second half of the fourth and early fifth century CE. Sim-

ilar to other western Mediterranean regions at this time, glass assemblages are almost exclusively composed of the Egyptian high iron, manganese and titanium (HIMT) glass group first defined by Freestone⁸. Of the two sub-groups, HIMTa and HIMTb⁹, HIMTa is the main category in fourth- and fifth-century Spain and Portugal. HIMTb dating probably to the beginning of the fifth century has been only detected very sporadically in the Iberian Peninsula, for example, in Braga, Vascos¹⁰, Baños de la Reina and El Albir (see Fig. 1).

Major transformations of the political and economic systems of the Mediterranean world following the collapse of the Western Roman Empire and the settlement

7 DE JUAN and SCHIBILLE 2017b, 6.

8 FREESTONE 1994, 290.

9 CEGLIA et al. 2015, 2017, FREESTONE et al. 2018, 164.

10 DE JUAN et al. 2018b, Table 1.

	wt %												ppm	
	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	Cl	K ₂ O	CaO	TiO ₂	MnO	Fe ₂ O ₃	PbO	Sr	Zr
HIMT a (n=51)	18.4	1.03	2.86	65.4	0.04	1.02	0.40	5.95	0.50	2.03	1.96	0.00	449	246
SD	1.0	0.15	0.22	1.7	0.01	0.10	0.07	0.50	0.11	0.22	0.66	0.00	32	62
HIMT b (n=4)	17.5	1.21	3.06	64.6	0.14	1.03	0.48	5.84	0.54	1.81	3.48	0.00	471	212
SD	1.2	0.24	0.28	1.3	0.04	0.20	0.14	0.70	0.12	0.37	0.47	0.00	42	37
Levantine (n=55)	15.1	0.65	3.09	69.6	0.10	0.83	0.65	9.18	0.08	0.02	0.51	0.00	439	41
SD	0.9	0.10	0.15	1.6	0.05	0.10	0.21	1.15	0.01	0.00	0.09	0.00	65	5
Foy 2.1 (n=43)	17.1	1.13	2.47	66.3	0.15	0.82	0.77	8.58	0.14	1.31	0.94	0.01	639	73
SD	1.0	0.12	0.16	1.0	0.05	0.06	0.17	0.69	0.01	0.48	0.14	0.02	86	9
Foy 2.1 high Fe (n=19)	17.9	1.29	2.76	64.6	0.23	0.81	0.90	7.66	0.18	1.12	2.27	0.01	618	94
SD	0.9	0.11	0.20	0.8	0.03	0.07	0.13	0.56	0.02	0.34	0.54	0.00	62	12
Foy 2.2 (n=5)	16.1	0.79	2.74	68.4	0.14	0.76	0.94	7.79	0.13	0.65	0.96	0.10	483	69
SD	1.0	0.20	0.35	1.5	0.07	0.13	0.19	0.68	0.04	0.77	0.50	0.05	14	12
Magby (n=25)	16.1	1.90	2.03	64.8	0.38	0.66	1.48	9.29	0.16	1.53	1.37	0.00	795	85
SD	1.0	0.20	0.35	1.5	0.07	0.13	0.19	0.68	0.04	0.77	0.50	0.00	96	21
Egypt II (n=2)	14.0	0.48	2.40	69.3	0.07	1.06	0.34	10.8	0.24	0.38	0.85	0.00	166	162
Plant-ash (n=34)	14.3	3.22	1.82	66.4	0.44	0.96	2.21	8.50	0.09	0.90	0.66	0.29	528	53
SD	2.7	1.03	0.30	2.8	0.14	0.15	0.45	1.59	0.02	0.57	0.18	0.84	192	36
Plant-ash high Al (n=32)	19.0	4.45	4.91	58.7	0.63	1.09	2.33	6.73	0.27	0.50	0.98	0.18	345	146
SD	1.1	0.65	0.98	2.0	0.20	0.12	0.30	0.90	0.04	0.25	0.21	0.25	92	28
Plant-ash high lead (n=6)	5.52	1.11	1.16	40.1	0.37	2.01	0.66	1.96	0.06	0.50	0.58	45.13	69	18
SD	0.74	0.23	0.39	1.5	0.11	0.31	0.23	0.63	0.02	0.34	0.16	2.94	14	4

Table 1: Average compositions and standard deviations (SD) of the identified glass groups. Major and minor elements in wt% oxides, strontium and zirconium [ppm]. Data: HIMT a (DE JUAN *et al.* 2018b); HIMT b, Egypt II, Plant-ash, Plant-ash High Al and high lead plant-ash (DE JUAN and SCHIBILLE, 2017a); Levantine, Foy 2.1, Foy high Fe and Magby (DE JUAN *et al.*, 2019).

of the Germanic tribes on the Iberian Peninsula resulted in considerable technological changes in the primary production of glass in the second half of the fifth century. The analytical data indicate that at this time HIMT glass ceased to reach the Iberian Peninsula. It was replaced by the so-called Foy 2.1 compositional group likewise of Egyptian origin. This group differs from HIMT in its lower titanium and higher calcium oxides. It has been documented in western Europe in France, Italy and the United Kingdom, where it is dated to the sixth century¹¹. Spanish data along with other recent analyses supports a slightly earlier occurrence¹². Foy 2.1 (high Fe)¹³, which has higher iron and associated trace element concentrations, turns up in the

archaeological records in the last quarter of the fifth century. A recently recognised high magnesium Byzantine glass type (defined by Schibille as Magby)¹⁴ is yet another related compositional group that has been identified among Iberian glass assemblages dating to the second half of the sixth to about the middle of the seventh century CE. It differs from Foy 2.1 by lower alumina and elevated magnesium and potassium oxide levels that suggest the addition of a plant-ash component to the glass melt (Table 1). Its presence in the Iberian Peninsula as well as in the UK, Italy, Serbia and among Byzantine glass weights¹⁵ confirms that it was more widespread than has previously been assumed and not a local phenomenon.

11 FOY *et al.* 2003, 55–58, CONTE *et al.* 2014, 6–20.

12 GLIOZZO *et al.* 2017, DE JUAN *et al.*, 2019.

13 CEGLIA *et al.* 2015, 2017.

14 SCHIBILLE *et al.* 2016, 12.

15 DRAUSCHKE and GREIFF 2010, FREESTONE *et al.* 2008, SCHIBILLE *et al.* 2016.

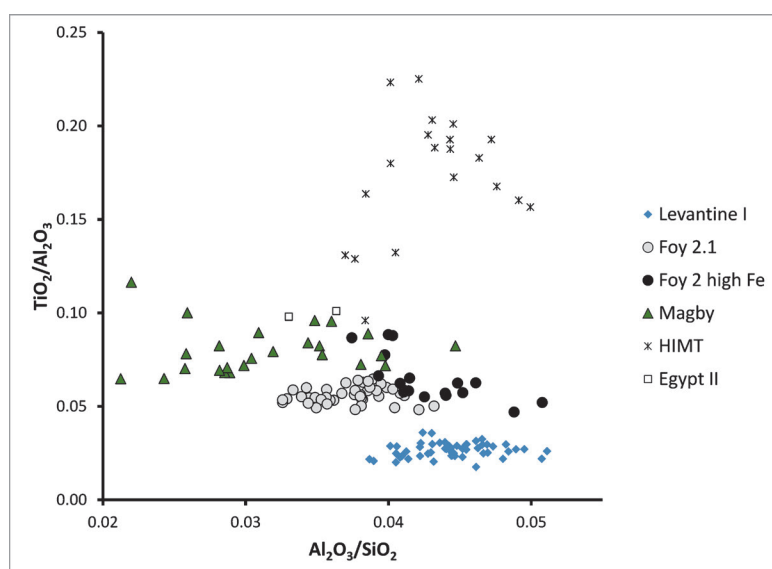


Fig. 2: Natron-type glass groups identified among Iberian assemblages in terms of titanium, aluminium and silicon oxides. Data: HIMT (Picola), DE JUAN et al. 2018b; Levantine, Foy 2.1, Foy high Fe and Magby (Gómez and Congosto), DE JUAN et al., 2019; Egypt II (Ciudad de Vascos), DE JUAN, Jorge and SCHIBILLE, Nadine, 2017a.

Only few glass fragments attributable to a Levantine Provenance have been identified in Iberia that date to the fourth and fifth centuries. The glass tends to be similar in composition to the vitreous finds from the fourth-century glass factories at Jalame in Israel. Until about the middle of the sixth century, glass finds with a Levantine compositional signature remain limited in the Iberian Peninsula. The situation changes completely in the second half of the century, coinciding with the Byzantine expansion into the western Mediterranean. Levantine I glass related to the sixth- to seventh-century glass from Apollonia (Israel) becomes the most abundant compositional group among Iberian glass finds. Glasses produced on the Levantine coast tend to have lower silica-related heavy metal contaminations than Egyptian glasses¹⁶ (Fig 2). Levantine I constitutes the main proportion of the glass assemblages

from the sixth-century Visigothic settlements around Toledo and Recopolis, the city founded by the Visigothic king Leovigild in 578 CE.

Throughout the seventh and early eighth century Levantine imports to the Iberian Peninsula continue. However, glass compositions become increasingly variable and show more and more signs of recycling practices¹⁷. A notable example of recycled glass is the presence of Foy série 2.2 recorded in the eighth-century glass assemblages from Narbonne and Rome¹⁸. In the Iberian Peninsula only very few fragments from rural settlements around Madrid and Alicante can be attributed to this group¹⁹. All of them date to the last decade of the seventh or the first half of the eighth century CE. In the late eighth century or early ninth century, Islamic glass of the Egypt II primary production group appears to reach the Iberian Peninsula, albeit in small numbers²⁰. Egypt II is easily recognisable due to its low alumina, high lime and low strontium levels together with elevated heavy element concentrations (Table 1). It is the last natron-type glass that was produced in Egypt and production appears to have ceased sometime in the second half of the ninth century²¹.

17 DE JUAN et al., 2019.

18 FOY et al. 2003, 60–61.

19 DE JUAN, SCHIBILLE and XIMENEZ 2018, 275, DE JUAN et al., 2019.

20 DE JUAN and SCHIBILLE 2017a, 7; SCHIBILLE et al. 2020b.

21 SCHIBILLE et al. 2019.

16 SCHIBILLE et al. 2016, 8.

From a typological perspective, fourth- and fifth-century glass exhibits a greater homogeneity than during the early Roman period. Tableware was restricted mainly to beakers, bowls and dishes. Fourth-century vessels usually have cracked off rims. Starting in the fifth century, thickened-rounded edges become more abundant. Occasionally they are decorated with applied threads, incised lines or semi-opaque blue cobalt coloured glass drops. These typological patterns are very similar to other contemporary western glass assemblages from Italy, southern France and Tunisia suggesting a shared aesthetic in the manufacture of objects, transmission of skills and the existence of inter-regional trade of finished products²². During the sixth and seventh centuries, the trend towards further simplification continues. Cups become more abundant and beakers with blue drop decorations virtually disappear. In contrast, opaque white thread decorations now appear on some vessels mostly dated to the sixth century. Other decorations are few and generally limited to simple incised lines or colourless applied threads.

A drop in vitreous materials appears to occur around the time of the Islamic conquest. Compared to previous centuries, the absolute numbers of glass finds in the archaeological record of the eighth and ninth century is drastically diminished. Typological information is practically inexistent for the eighth century and only minor differences can be recognised with respect to late Visigothic glass finds. Some patterns can be discerned from the ninth-century evidence in that the known typologies are reminiscent of contemporary oriental Islamic types. To what extent these represent imports from the

eastern Mediterranean, however, cannot be clearly determined at the moment due to a lack of analytical data.

Little is known about the compositional characteristics of mosaic tesserae in Roman and medieval Spain²³. The most comprehensive analytical study was conducted on the fourth-century floor mosaics found at the Roman villa of Noheda (Cuenca)²⁴. In contrast to the prevalence of HIMT glass among utilitarian tableware, only a handful of HIMT glasses were identified among the over 400 tesserae that were analysed. Most of the fourth-century mosaic tesserae from Noheda appear to have been produced from mixed Roman antimony and manganese base glass. As attested elsewhere, some colours (red, green, orange) were produced with a plant ash component. The base glass features as well as the exclusive presence of antimony compounds as opacifying agents reflect a certain archaism in the specialized traditions of making mosaic tesserae.

ISLAMIC PLANT ASH GLASS

Our knowledge about the integration of the Iberian Peninsula into the production and trade systems of Islamic glass from the eastern Mediterranean is very limited. As regards the period under investigation, a small number of samples (69) from Murcia²⁵, Cordoba, and Málaga²⁶ have been analysed in recent years, to which we can now add nearly half a thousand samples resulting from our research on the glass finds from Vascos, Albalat, Silves, Alicante, Cordoba and Asturias. It is quite likely that Islamic soda-ash glasses first arrived in the Peninsula in the

²² SÁNCHEZ 2018, 281, DE JUAN et al. 2018b.

²³ DE JUAN and SCHIBILLE, 2017b, 6.

²⁴ SCHIBILLE et al., 2020.

²⁵ CARMONA et al. 2009

²⁶ DUCKWORTH et al. 2015, DUCKWORTH 2017.

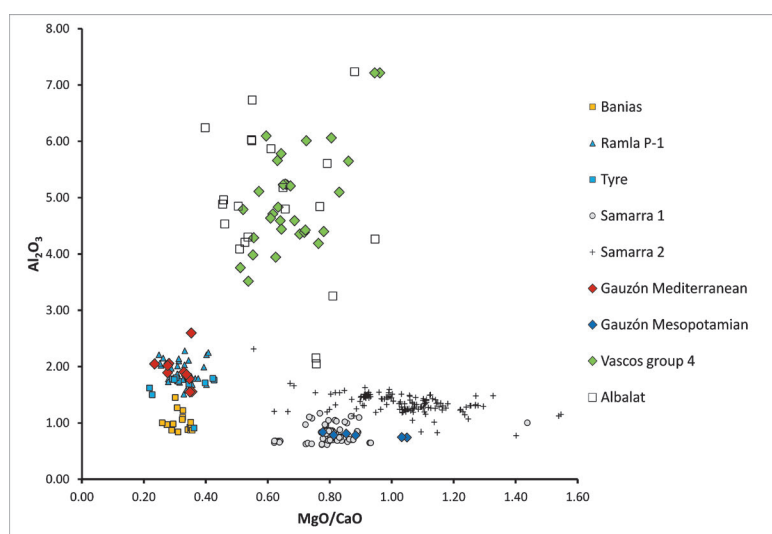


Fig. 3: Aluminium oxide compared with magnesium to calcium ratios of plant ash glass groups from Spain (Albalat, Vascos and Gauzón) in comparison with glasses from Mesopotamia (Samarra) and the Levant (Banias, Ramla and Tyre). Data source: Banias (FREESTONE, GORIN-ROSEN and HUGHES, 2000), Group P-1 of Ramla (Phelps, 2018), Tyre (FREESTONE 2002), Groups 1 and 2 of Samarra (SCHIBILLE et al., 2018), Gauzón (DE JUAN et al., 2018a), Group 4 of Vascos (DE JUAN and SCHIBILLE, 2017) and Albalat (publicacion in preparation).

ninth century but more research is needed to establish exact dates.

The analytical data indicates that by the tenth century, soda-ash glass had completely replaced natron-type glass and made up the vast majority of the Iberian glass assemblages. At least some of this glass can be clearly attributed to a Mesopotamian or eastern Mediterranean origin. Imports of high quality decorated vessels from Mesopotamia and the Levant arrived not only in al-Andalus, but they are also found in the Christian parts of the peninsula. This is evident from the analytical results of the vitreous material from the castle of Gauzón²⁷ owned by the Castilian-Leonese monarchs where some relief-cut decorated glass vessels present compositional features akin to those of the glass furnaces at

Tyre and Ramla (Fig. 3). The fragments with high magnesium to calcium ratios and low quantities of silica-related impurities can instead be linked with the plant-ash glass produced in Mesopotamian and more accurately to Samarra group 1²⁸.

The analytical study of eleventh- and twelfth-century glass assemblages from the Iberian Peninsula revealed a distinct plant ash glass group that appears to identify a regional production and supply of glass. The earliest occurrence of this glass group cannot yet be determined with precision. It was defined as “group 4” in context of the glass assemblage from Ciudad de Vascos in Toledo²⁹. It has distinctively high alumina (> 3.5%), heavy elements and REE contents which clearly distinguish it from contemporary plant ash glasses typically encountered in the Islamic east. This type of plant ash glass has so far only been found on the Iberian Peninsula and its immediate surroundings and its compositional characteristics are similar to some Iberian glasses from the late medieval period³⁰. Given its geographical range, it is likely to have been the output of a local production and it may thus be considered as the first entirely locally produced soda ash glass from the Iberian Peninsula. It appears to have been manufactured throughout the eleventh century becoming probably the prevalent glass

It has distinctively high alumina (> 3.5%), heavy elements and REE contents which clearly distinguish it from contemporary plant ash glasses typically encountered in the Islamic east. This type of plant ash glass has so far only been found on the Iberian Peninsula and its immediate surroundings and its compositional characteristics are similar to some Iberian glasses from the late medieval period³⁰. Given its geographical range, it is likely to have been the output of a local production and it may thus be considered as the first entirely locally produced soda ash glass from the Iberian Peninsula. It appears to have been manufactured throughout the eleventh century becoming probably the prevalent glass

27 DE JUAN et al. 2018a, 260–261.

28 SCHIBILLE et al. 2018, 7–8.

29 DE JUAN and SCHIBILLE 2017a, 8–9, 13–14.

30 COUTINHO et al. 2016, 15–16.

composition in the Iberian Peninsula by the second half of the century.

In the tenth to twelve centuries an unusual soda-ash lead glass appears in the archaeological record of the Iberian Peninsula. High lead glass is known from diverse Islamic contexts³¹ from Mesopotamia to Morocco, but soda-ash lead glass with high lead (usually 40–50%) and moderate sodium and potassium contents is practically exclusive to al-Andalus. This type of soda-ash lead glass is particularly abundant in Cordoba³², but has also been recovered from numerous other Iberian places such as Vascos, Murcia, Toledo, Almeria, Albalat, Silves or Gauzon³³ (see Fig. 1). The very distinctive compositional characteristics combined with its relative abundance in the Iberian Peninsula and lead isotope data have shown that these glasses were made from a mixture of silica (maybe glass cullet), soda-rich plant ash and a waste product perhaps from the flourishing lead-silver mining industry around Cordoba³⁴.

Although there are not many studies on glassware of the tenth and eleventh centuries in the western Mediterranean³⁵ it is possible to recognize that typologies in the Iberian Peninsula were at that time strongly ‘orientalized’ and closer to the Islamic east than to European traditions as reflected, for example, in the characteristic mould- and relief-cut decorations³⁶. The formal preferences change as well: stemmed goblets

disappear and are replaced by beakers with straight walls, and hemispheric bowls and jars with pinched rims increase rapidly in number. These preferences apply to Islamic contexts and Christian kingdoms in the north and east of Iberian Peninsula alike³⁷.

In Islamic Spain glass was valued as a prestige commodity. It was used in architectural decoration in some of the most prestigious constructions at the time as confirmed by written sources describing its use in the tenth-century caliphal city of Madīnat al-Zahrā’ and the eleventh-century palace of the sultan of Toledo³⁸, or the import of glass tesserae from Byzantium to be used in the Mosque of Cordoba. That these textual sources have a basis in reality is evidenced by the mosaics in the Mosque of Cordoba³⁹, the remains of glass tesserae recovered during archaeological excavations at Madīnat al-Zahrā’⁴⁰ and the recent discovery of horse-shoe arches decorated with painted plaster figures and coloured glass from the eleventh century of Toledo⁴¹. Architectural glass decorations have also been archaeologically attested in the twelfth and thirteenth century in Cieza, Yecla and Murcia⁴². Glass tableware is well represented in elite environments such as palaces or in the principal houses of the main cities, while being rarely present in rural or modest domestic contexts. Nonetheless, it seems that medical purposes were one of most common uses of glass in al-Andalus and it is often quoted in Andalusian medical treatises. Moreover, small unguentaria destined to preserve ointments represent the most common vessel type recovered from

31 SAYRE and SMITH 1961, 1826.

32 DUCKWORTH et al. 2015.

33 DE JUAN and SCHIBILLE 2017b, *Tabla 1*.

34 DE JUAN and SCHIBILLE 2017a, DUCKWORTH et al. 2015, 36, DUCKWORTH 2017, 388–389, SCHIBILLE et al. 2020b.

35 FOY, 2017, 19–29.

36 JIMENEZ 2006, 55–66, DE JUAN and SCHIBILLE, 2020.

37 DE JUAN et al. 2018a.

38 DE JUAN and SCHIBILLE 2018, 476–477.

39 GÓMEZ-MORÓN et al. 2021

40 VALLEJO 2010, Fig. 307.

41 MONZÓN, 2004, 53–54.

42 GONZALEZ, 2014, 213.

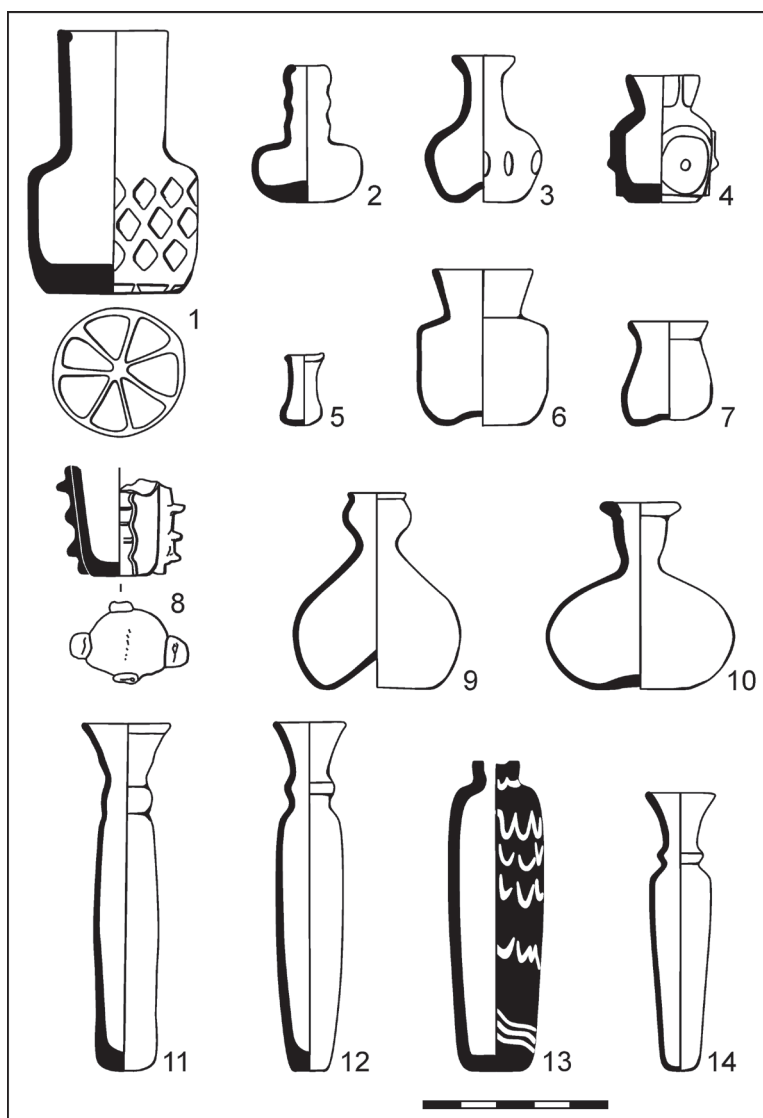


Fig. 4: Drawings of unguentaries from al-Andalus dating to the tenth to early thirteen centuries. Adopted from: (1–4,13) Puig des Molins, CAPELLÀ and RIERA 2015, Figs. 1, 2-3, 5, 7 and Fig. 4.3, (5–8) Ciudad de Vascos, DE JUAN and CÁCERES 2016, Fig. 2, 1,4-5 and 3, 5; 11, (11) Castillo del Río, PUCHE 2000, Fig. 1.4, (9-10) Murcia and Lietor, JIMÉNEZ 2000, Figs. 9.1–2 and Silves (14) GOMES 2015, Fig. 6.

archaeological excavations⁴³ (Fig. 4). When analysed, their contents appear to correspond to the ingredients described in the written sources. The archaeological and textual evidence thus confirms that in al-Andalus there was an active trade of medicinal and cosmetics products⁴⁴.

43 DE JUAN and CÁCERES 2016, 9–12.

44 DE JUAN and SCHIBILLE, 2018, 478–480.

From the twelfth century onwards glass finds become again more numerous and shapes more diverse. This seems to be related to the expansion of local raw glass production to the detriment of eastern imports. The existence of glass workshops in al-Andalus is documented by reliable written sources from the eleventh century, even though the earliest remains published to date are attributed to the twelfth century⁴⁵. Archaeological evidence of primary glass workshops exists from twelfth-century Seville, Murcia or Almería. The first reference to a thriving glass industry in the Christian kingdoms is also documented during this period⁴⁶. Written mention of workshops dating to the mid-eighth century has to be assessed with caution as the earliest Arab source that transmits this information dates to the end of eleventh century, three centuries after the events it relates⁴⁷.

CONCLUSION

The research into the development of glass consumption, trade and production in the Iberian Peninsula between the fourth and the twelfth century is still ongoing and we

45 JIMÉNEZ, MUÑOZ and THIRIOT 2000, 433–452.

46 DE JUAN and SCHIBILLE, 2017b, 199, GUDIOL, 1936, 15–20.

47 DE JUAN and SCHIBILLE, 2018, 475–476.

hope to be able to provide further details on some of the issues raised in the near future. For the time being, we can say that during the late antique and early medieval periods there are close similarities between the glass groups found in the Iberian Peninsula and those from other regions of the western Mediterranean. With this new information, we can start mapping some of the chronological and geographical patterns in more detail. It is clear that the glass trade from the east continued well into the sixth and seventh centuries, and even during the Islamic period we see evidence of imports from the eastern Mediterranean, although to a lesser extent. After the Umayyad conquest in 711 CE, early Islamic Spain evidently maintained close commercial links with the rest of the Islamic world. Not only was soda-ash glass imported from the east, but evidence

also appears to indicate the transfer of technological skills. In contrast, the production of distinct types of high lead glass was a regional development, possibly to compensate the lack of imports of eastern raw glass. The compositions of the plant-ash glasses in Iberia began to change also at the end of the first-millennium CE, pointing to the gradual establishment of a new, specifically Iberian glass industry.

ACKNOWLEDGMENTS

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 647315 to NS). The funding organization had no influence in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

REFERENCES

- CAPELLÀ, Miguel Á. and RIERA, María M., 2015: 'El vidrio de época andalusí: problemática y bases para su estudio en las Baleares'. In: MARTÍNEZ, Antonia and GRAZIANI, Glenda (eds.), *VI Jornades d'Arqueologia de les Illes Balears*. Formentera, 313–321.
- CARMONA, Noemí, VILLEGAS, María A., JIMÉNEZ, Pedro, NAVARRO, Julio and GARCÍA-HERAS, Manuel, 2009. 'Islamic Glasses from Al-Andalus. Characterisation of Materials from a Murcian Workshop (12th Century AD, Spain)'. *Journal of Cultural Heritage* 10, 439–445.
- CEGLIA, Andrea, COSYNS, Peter, NYS, Karin, TERRY, Herman, THIENPONT, Hugo and MEULEBROECK, Wendy, 2015. 'Late antique glass distribution and consumption in Cyprus: a chemical study', *Journal of Archaeological Science*, 61, 213–22.
- CEGLIA, Andrea, COSYNS, Peter, SCHIBILLE, Nadine and MEULEBROECK, Wendy, 2017. 'Unravelling provenance and recycling of late antique glass from Cyprus with trace elements', *Archaeological and Anthropological Sciences*, 11, 1, 279–291.
- CONTE, Sonia, CHINNI, Tania, ARLETTI, Rossella and VANDINI, Mariangela, 2014. 'Butrint (Albania) between Eastern and Western Mediterranean Glass Production: EMPA and LA-ICP-MS of Late Antique and Early Medieval Finds'. *Journal of Archaeological Science*, 49, 6–20.
- COUTINHO, Inês, MEDICI, Teresa, COENTRO, Susana, ALVES, Luís C. and VILARIGUES, Márcia, 2016. 'First archaeometric study on medieval glass found in Beja (Southern Portugal)'. *Journal of Medieval Iberian Studies*, 8, 148–175.
- DE JUAN, Jorge and CÁCERES, Yasmina, 2016, 'Los vidrios de ciudad de Vascos (Toledo) (ss. X-XI)', *Arqueología y Territorio Medieval*, 23, 7–22.
- DE JUAN, Jorge and SCHIBILLE, Nadine, 2017a. 'Glass import and production in Hispania during the early medieval period: The glass from Ciudad de Vascos (Toledo)', *PLoS One*, 12, e0182129.
- DE JUAN, Jorge and SCHIBILLE, Nadine, 2017b. 'La Hispania antigua y medieval a través del vidrio: La aportación de la arqueometría', *Boletín de la Sociedad Española de Cerámica y vidrio*, 56, 195–204.
- DE JUAN, Jorge and SCHIBILLE, Nadine, 2018. 'El vidrio en la taifa de Toledo: reflexiones a partir de Ciudad de Vascos y el convento de Santa Fe'. In: B. SARR, Bilal (ed.), *Ṭawā'if. Historia y Arqueología de los reinos taifas*, Granada, 473–487.
- DE JUAN, Jorge, FERNÁNDEZ, Noelia, MUÑIZ, Iván, GARCÍA, Alejandro and SCHIBILLE, Nadine, 2018a. 'Islamic soda-ash glasses in the Christian kingdoms of Asturias and León (Spain)', *Journal of Archaeological Science: Reports*, 22, 257–263.

- DE JUAN, Jorge, SCHIBILLE, Nadine, N. and XIMENEZ, 2018a. 'Los primeros vidrios de al-Andalus: análisis arqueométricos en el yacimiento emiral de Cabezo Pardo (Alicante)', *Lucentum*, 37, 271–279.
- DE JUAN, Jorge, SCHIBILLE, Nadine, VIDAL, Jaime and SÁNCHEZ, María D. 2018b. 'The Supply of Glass at Portus Ilicitanus (Alicante, Spain): A Meta-Analysis of HIMT Glasses', *Archaeometry*, 61, 3, 647–662., <https://doi.org/10.1111/arcm.12446>
- DE JUAN, Jorge, VIGIL-ESCALERA, Alfonso, CÁCERES, Yasmina and SCHIBILLE, Nadine, 2019. 'Changes in the supply of eastern Mediterranean glasses to Visigothic Spain' *Journal of Archaeological Science*, 107, 3–31. <https://doi.org/10.1016/j.jas.2019.04.006>.
- DE JUAN, Jorge, SCHIBILLE, Nadine, 2020. "El vidrio en al-Andalus: Una historia fragmentada", in: GÓMEZ, Susana (Ed), *Las Artes del Islam II. Vidrios, marfiles, metales, cerámica y tejidos*. Universidad de Sevilla, Col. de Estudios Árabo-islámicos de Almonaster La Real, nº 19, pp. 45-70 & 232-240.
- DRAUSCHKE, Jörg and GREIFF, Susanne, 2010. 'Chemical aspects of Byzantine glass from Caricin Grad/Iustiniana Prima (Serbia)'. In: DRAUSCHKE, Jörg and KELLER, Daniel (eds.), *Glass in Byzantium - Production, Usage, Analyses*. RGZM - Tagungen 8, Römisch-Germanisches Zentralmuseum. Mainz, 25–46.
- DUCKWORTH, Chloe N., CÓRDOBA, Ricardo, FABER, Edward W, GOVANTES, David J. and HENDERSON, Julian, 2015. 'Electron Microprobe Analysis of 9th-12th Century Islamic Glass from Córdoba, Spain', *Archaeometry*, 57 (1), 27–50.
- DUCKWORTH, Chloe N., 2017. 'Glass production in medieval Spain: a long-term perspective on knowledge transfer'. In: WOLF, Sophie, PURY-GYSEL Anne (eds.), *Annales du 20^e congrès de l'Association Internationale pour l'Histoire du verre*, Fribourg, septembre. 2015. Romont, 385–390.
- FOY, Danièle, 2017. 'Entre orient et occident, le verre Islamique (VIIIe-XIIIe): apports récentes et réflexions sur les échanges et les influences'. In: WOLF, Sophie, PURY-GYSEL Anne (eds.), *Annales du 20^e congrès de l'Association Internationale pour l'Histoire du verre*, Fribourg, septembre. 2015. Romont, 10–34.
- FOY, Danièle, PICON, Maurice, VICHY, Michèle, and THIRION-MERLE, Valérie, 2003, 'Caractérisation des verres de la fin de l'Antiquité en Méditerranée Occidentale: l'émergence de nouveaux courants commerciaux'. In: FOY, Danièle and NENNA, Marie-Dominique (eds.), *Échanges et commerce du verre dans le monde antique, Actes du colloque de l'Association française pour l'archéologie du verre*, Aix-en-Provence, juin. Montagnac, 41–85.

- FREESTONE, I. C., 1994. 'Appendix: chemical analysis of 'raw' glass fragments'. In: Hurst, H. R. (ed.), *Excavations at Carthage: the British mission. The circular harbour, north side. The site and finds other than pottery*, Vol. 2: 1, British Academy Monographs in Archaeology 4, Oxford, 290.
- FREESTONE, Ian C., 2002. 'Composition and affinities of glass from the furnaces on the Island Site, Tyre'. *Journal of Glass Studies*, 44, 67–77.
- FREESTONE, Ian C., GORIN-ROSEN, Yael, HUGHES, Michael J., 2000. 'Primary glass from Israel and the production of glass in late antiquity and the early Islamic period'. In: *La Route du verre. Ateliers primaires et secondaires du second millénaire av. J.-C. au Moyen Âge*, Maison del'Orient et de la Méditerranée, 83, 65–83.
- FREESTONE, Ian C., HUGHES, Michael J. and STAPLETON, Collen P., 2008. 'The composition and production of Anglo- Saxon glass'. In: EVISON, Vera I. (ed.), *Catalogue of Anglo-Saxon Glass in the British Museum*, British Museum, London, 29–46.
- FREESTONE, Ian C., DEGRYSE, Patrick, LANKTON, James, GRATUZE, Bernard and SCHNEIDER, Jens, 2018., 'HIMT, glass composition and commodity branding in the primary glass industry'. In: ROSENOW, Daniela, PHELPS, Matt, MEEK, Andrew, and FREESTONE, Ian C. (eds.), *Things that travelled: Mediterranean glass in the first millennium CE*. London, 159–190.
- GLIOZZO, Elisabetta, BRASCHI, Eleonora, GIANNETTI, F., LANGONE, Antonio and TURCHIANO, Maria, 2017. 'New geochemical and 613 isotopic insights into the Late Antique Apulian glass and the HIMT1 and HIMT2 glass 614 productions—the glass vessels from San Giusto (Foggia, Italy) and the diagrams for 615 provenance studies', *Archaeological and Anthropological Sciences*, 11 (2019) 141–170.
- GOMES, Rosa. 'Islamic glass from Silves' castle (Portugal)'. *Annales du 19e congrès de l'Association Internationale pour l'Histoire du Verre*, Piran, 17–21 September 2012. Thessaloniki, Koper, 438–445.
- GÓMEZ-MORÓN, María Auxiliadora, PALOMAR, Teresa, CERQUEIRA, Luis, ORTIZ, Pilar, VILARIGUES, Marcia, SCHIBILLE, Nadine. 2021. "Christian-Muslim contacts across the Mediterranean: Byzantine glass mosaics in the Great Umayyad Mosque of Córdoba (Spain)", *Journal of Archaeological Science*, 129, <https://doi.org/10.1016/j.jas.2021.105370>
- GONZÁLEZ, Margarita, 2014. 'La puesta en valor de un conjunto de fragmentos de arco decorados con yaserías islámicas hallados en el antiguo convento de Santa Fe de Toledo', *Informes y Trabajos*, 10, 195–226.
- GUDIOL, José, 1936. *Els vidres catalans*, Barcelona.

- JIMÉNEZ, Pedro, 2000. 'El vidrio andalusí en Murcia', *El vidrio en al-Andalus*. Cressier Patrice (ed.). Palermo, 117–148.
- JIMÉNEZ, Pedro, MUÑOZ, Francisco and THIRIOT, Jacques, 2000. 'Les ateliers urbains de verriers de Murcia au XIIe siècle (C. Puxmarina et Pl. Belluga)'. In: Pierre Pétrequin, Fluzin, Philippe, Thiriot, Jacques et al. (eds.), *Arts du feu et productions artisanales, XXe rencontres internationales d'archéologie et d'histoire d'Antibes*. Antibes, 433–452.
- JIMÉNEZ, Pedro, 2006. 'Talleres, técnicas y producciones de vidrio en al-Andalus'. In: RONTOMÉ, Enrique, PASTOR, Paloma (eds.), *El vidrio islámico en al-Andalus*. La Granja. 51–70.
- MONZÓN, Fabiola, 2004. 'Las estancias palaciegas de época islámica registradas en el ex convento de Santa Fe de Toledo', *Bolskan*, 21, 45–55.
- PHELPS, Matt, 2018. Glass supply and trade in Early Islamic Ramla: an investigation of the plant ash glass. In: ROSENOW, Daniela, PHELPS, Matt, MEEK, Andrew, and FREESTONE, Ian C. (eds.), *Things that travelled: Mediterranean glass in the first millennium CE*. London, 236–282.
- PUCHE, Catalina, 2000. 'Los vidrios islámicos de Alicante'. In: CRESSIER, Patrice (ed.). *El vidrio en al-Andalus*. Palermo, 149–164.
- RUA, Ramón, 1864. 'Composición de un vidrio de la época romana', *Revista Minera*. 15, 45–54.
- SÁNCHEZ, María D., DA CRUZ, Mario, 2014. 'La producción de vidrio en Hispania. Una versión actualizada'. In: ÁLVAREZ, J.M., NOGALES, T. and RODÀ I. (eds.), *Proceedings XVIIIth International Congress of Classical Archaeology*, Mérida, 2014, 1393–1397.
- SÁNCHEZ, María D., 2018. *La vajilla de vidrio en el ámbito suroriental de la Hispania Romana. Comercio y Producción entre los siglos I-VII d.C.* Alicante.
- SAYRE, Edward V. and SMITH, Ray W., 1961. 'Compositional categories of ancient glass', *Science*, 133 (3467), 1824–1826.
- SCHIBILLE, Nadine, MEEK, Andrew, BENDEGUZ, Tobias, ENTWISTLE, Chris, AVIS-SEAU-BROUSTET, Mathilde, DA MOTA, Henrique and GRATUZE, Bernard, 2016. 'Comprehensive chemical characterisation of Byzantine glass weights', *PLoS One*, 11(12), e0168289.
- SCHIBILLE, Nadine, MEEK, Andrew, WYPYSKI, Mark T., KRÖGER, Jens, ROSSER-OWEN, Mariam, WADE, Rosalind, 2018. 'The glass walls of Samarra (Iraq): ninth-century Abbasid glass production and imports', *PLoS ONE*, 13 (8), e0201749.
- SCHIBILLE, Nadine, GRATUZE, Bernard, OLLIVIER, Eric and BLONDEAU, Étienne, 2019. 'Chronology of early Islamic glass compositions from Egypt', *Journal of Archaeological Science*. 107, 3–31. <https://doi.org/10.1016/j.jas.2019.04.006>.

SCHIBILLE, Nadine; BOSCHETTI, Cristina; VALERO, Miguel Ángel, VERON, Emmanuel, DE JUAN, Jorge. 2020a. “The Color Palette of the Mosaics in the Roman Villa of Noheda (Spain)” *Minerals* 10, no. 3: 272. <https://doi.org/10.3390/min10030272>.

SCHIBILLE, N.; DE JUAN, Jorge; CASAL, María Teresa; GUERRO, Catherine. 2020b. “Ex novo development of lead glassmaking in early Umayyad Spain, *Proceedings of the National Academy of Sciences of the United States*, 117 (28), 16243-16249. <https://doi.org/10.1073/pnas.2003440117>

SCHIBILLE, Nadine, 2020. ‘The palette of the mosaicist: base glass and colours in the fourth-century Roman Villa of Noheda (Spain)’.

VALLEJO, Antonio, 2010. *La ciudad califal de Medīnat al-Zahrā*. Almuzara.

JORGE DE JUAN ARES

Université d’Orléans
IRAMAT-CEB, UMR 5060, CNRS
3D, rue de la Férollerie, 45071
Orléans cedex 2, France.
jares@letras.ulisboa.pt

NADINE SCHIBILLE

Université d’Orléans
IRAMAT-CEB, UMR5060, CNRS
3D, rue de la Férollerie, 45071
Orléans cedex 2, France.
nadine.schibille@cnrs-orleans.fr