

# CHEMICAL AND STATISTICAL ANALYSIS OF ROMAN GLASS FROM SEVERAL NORTHWEST-ERN IBERIAN ARCHAEOLOGICAL SITES

M. Dolores Petit-Domínguez<sup>\*1</sup>, Rosario García Giménez<sup>2</sup>, Isabel S. de Soto<sup>3</sup>, Isabel Rucandio<sup>4</sup>

<sup>1</sup>Departamento de Química Analítica y Análisis Instrumental. Facultad de Ciencias. Campus de Excelencia Internacional de la Universidad Autónoma de Madrid, 28049 Madrid, Spain.
<sup>2</sup>Departamento de Geología y Geoquímica. Facultad de Ciencias. Campus de Excelencia Internacional de la Universidad Autónoma de Madrid.28049 Madrid. Spain.
<sup>3</sup>Departamento de Ciencias del Medio Natural. Escuela Superior de Ingenieros Agrónomos. Universidad Pública de Navarra, 31006 Pamplona, Spain.
<sup>4</sup>Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), 28040

Madrid, Spain

Received: 12/01/2014Accepted: 05/05/2014Corresponding author: M. Dolores Petit-Domínguez (mdolores.petit@uam.es).

# ABSTRACT

A total 103 fragments of Roman glass tableware are studied, unearthed at 7 archaeological sites in the Northwest of the Iberian Peninsula, to establish both similarities and differences in their chemical composition. ICP Mass Spectrometry is used to characterize the chemical composition of: (i) major elements, so as to determine the type of glass; (ii) minor elements, added to improve the properties of the glass; and, (iii) trace elements, as indicators of the base raw material of the glass. Multivariate statistical studies are also used to establish links and significant differences between glass samples, shedding further light on knowledge of Roman glass manufacturing techniques in the Northwest of the Iberian Peninsula. Three main conclusions were achieved. (i) There are significant chemical differences between samples from Braga (*Bracara Augusta*, Portugal) and the other samples. (ii) These other samples may be sorted into three major groups according to their chemical constituents. (iii) Finally, the statistical analysis and the chemical composition of several glass fragments suggest they were found at some distance from their place of manufacture, requiring the reclassification of their archaeological site of provenance.

**KEYWORDS:** Roman Glass, Tableware fragments, Chemical analysis, Chemometric analysis, Iberian Peninsula.

# **1. INTRODUCTION**

The first ancient glassware is widely held to be glass beads, while the manufacture of hollow vessels had to wait until 1500 B.C. in Egypt, where glassware was introduced by skilled artisans from Southern Asia. In the 9<sup>th</sup> century B.C., the principal centres of glass production were in Syria and Mesopotamia from where the craft spread throughout the Mediterranean area. The technique of glassblowing developed in Phoenician coastal cities around the 1<sup>st</sup> century B.C. and glassmaking then extended throughout the Roman Empire (Fleming, 1999).

While the study of the origin and trade in stone and ceramics is now highly advanced, it may not say the same of ancient glass, as the nature of the minerals used as raw materials and the geographical location of their transformation into finished artefacts remain largely unclear. The vast majority of ancient glassware was made with silica fluxed with either soda or potash (Sayre and Smith, 1961; Henderson, 2002; Degryse and Scheneider, 2008). In terms of its chemical composition, sodabased glass (soda-silica-lime glass) falls into two categories: (i) one involves natron, a mineral source of alkali that is a mixture of evaporitic minerals. Silica may be found in sand and lime extracted from carbonatic sand fractions and/or shells. The mixture produces low Mg and K types of sodalime-glass. (ii) The second category uses plant ash as its main source of alkali. In the same way as natron-based glass, it introduces Na in the batch, together with quantities of K and Mg (Newton and Davison, 1996; Silvestri et al, 2005). Roman glass is a relatively homogeneous natron glass with little or no variation in the composition of its major elements (Freestone, 2006; Gliozzo et al, 2013).

However, elements such as Ca, Fe, Mg and Al may be related to concentrations of specific minerals (for example, feldspars or clays) in the glassmaking sand. Transition metal ions (Fe, Co and Cu among others) act as colouring agents, while Mn and Sb oxides are the principal decolorants used in ancient glass (Silvestri et al, 2005; La Delfa et al, 2008; Foster et al, 2009 and 2010). Rare earth element patterns are a promising tool for distinguishing between raw sandy materials that may have typical characteristics in certain geological environments, although these characterizations are largely unexplored (Freestone et al, 2002). Recent advances in the use of radiogenic isotopes (like Sr and Nd) have resulted in new approaches to determine the provenance of primary glass, even after its transformation or recycling in secondary workshops (Degryse and Schneider, 2008; Brems et al, 2013a and 2013b).

The expansion of our knowledge of Roman glasses has a serious limitation, insofar as glass fragments found at archaeological sites are the only source of original samples. Characterizations of Roman glasses in the Mediterranean area and in other archaeological settlements in Europe (mainly France, Great Britain and Italy) abound, while research in the Northwest of the Iberian Peninsula remains scarce. For example, most studies have been descriptive in nature: Sánchez de Prado (1984) and Fuentes et al (2001) for glasses from Spain or a description of glasses from Conimbriga (Portugal) by Alarcão and Alarcão (1967). However, over recent years some archaeometric studies in Roman Glass from the Iberian Peninsula have been conducted by Rincón (1984), Domínguez-Bella and Jurado-Fresnadillo (2004), Gómez-Tubío et al (2006), García Heras et al (2007), Carmona et al (2008), da Cruz (2009) and Petit-Domínguez et al (2013).

Our study concerns the chemical characterization of fragments of Roman glass tableware from the Northwest of the Iberian Peninsula produced throughout broad periods of Roman civilization. The primary purpose of the research is to determine the chemical composition of these glasses to contribute further knowledge of the types of glass produced by the Roman glassmakers over those time periods. A further objective is to classify samples as a function of the chemical composition of their major, minor and trace elements and to provide some insight into the technology developed to obtain the different colours and opacity of the glasses. Finally, the statistical analysis and the chemical composition of several glass fragments appear to suggest that they were discovered at some distance from their place of manufacture. These fragments were therefore reclassified as belonging to a different archaeological site.

# 2. EXPERIMENTAL

# 2.1 Sample description

Representative samples corresponding to 103 fragments of Roman glass tableware were selected on the basis of their morphology, colour, transparency and chronology (High and Low Roman Empire) (see Table 1).

Site	Sample	Form	Colour	Date
Lugo	LU01	quadrilateral carafe with signal	colourless	1 <sup>st</sup> -to-3 <sup>rd</sup> century
	LU02	bellical cup	bluish green	Reign of Augustus / Reign of Trajan
	LU03	glass in gross	yellowish green	Unknown
	LU04	bellical cup	yellowish green	Uncertain: mid-late 4th -to-5th centu-
				ry
	LU05	chalice	colourless	Mid-late 2 <sup>nd</sup> -to-early 3 <sup>rd</sup> century
	LU06	quadrilateral carafe	bluish green	1 <sup>st</sup> -to-3 <sup>rd</sup> century
	LU07	bellical cup-blown glass in mould	bluish green	Decade $40/60 \ 1^{st}$ century
	LU08	"modiolus"	bluish green	Decade 40/60 1 <sup>st</sup> century
Veranes	VR01	bracelet	opaque black	Late Roman
	VR02	undifferentiated edge	yellowish green	Unknown
	VR03	fragment	colourless	Uncertain: late 1 <sup>st</sup> -to- 3 <sup>rd</sup> century
	VR04	bellical cup	yellowish green	Uncertain: mid-late 4 <sup>th</sup> -to- 5 <sup>th</sup> centu-
				ry
	VR05	quadrilateral carafe	bluish green	1 <sup>st</sup> -to-3 <sup>rd</sup> century
	VR06	jug	dark green	Uncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> century
	VR07	silver cup reliefs	blue	Unknown
	VR08	plate	colourless	Uncertain: end 1 <sup>st</sup> -to-3 <sup>rd</sup> century
Astorga	AS01	cup	colourless	Uncertain: 3 <sup>rd</sup> -to- 4 <sup>th</sup> century
	AS02	glass in gross	bluish green	Unknown
	AS03	grooved cup	bluish green	Reign of Augustus/Reign of Trajan
	AS04	smooth arcuate-shaped cup	yellowish green	Uncertain mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century
	AS05	quadrilateral carafe	bluish green	1 <sup>st</sup> -to-3 <sup>rd</sup> century
	AS06	bellical cup	dark green	Uncertain: mid-late 4 <sup>th</sup> -to- 5 <sup>th</sup> centu-
				ry
	AS07	window	colourless green	Uncertain: 1 <sup>st</sup> -to-4 <sup>th</sup> century
	AS08	plate	colourless green	Uncertain: 1st -to- 3 <sup>rd</sup> century
	AS09	jug	colourless green	Unknown
	AS10	plate	colourless green	Uncertain: 1 <sup>st</sup> -to- 3 <sup>rd</sup> century
	ASII	fragment	colourless	Uncertain: mid 2 <sup>nd</sup> -to- 3 <sup>rd</sup> century
	ASI2	arched cup	colourless green	Uncertain: 4 <sup>th</sup> century
	ASI3	chalice	colourless green	Uncertain: 2 <sup>nd</sup> -to- 3 <sup>rd</sup> century
Castro de	VL01	corrugated cup	bluish green	Reign of Augustus/Reign of Irajan
Viladonga	VL02	quadrilateral carafe	bluish green	Ist -to - 2 <sup>nd</sup> century
	V L03	bellical cup	yellowish green	Uncertain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> centu-
	VI 04	halli ad ava		ry Uncertains wild late 4th to 5th control
	V L04	benncar cup	yenowishgreen	
	VI OF	arched cup	moonich weller.	1y Uncontain mid late 4th to 5th contra
	V L05	arched cup	greenisnyenow	
	VI 04	conical cup	colourloss	Ty End of 4th to 5th contury
	VL07	tubo cup odgo	vollowish gross	Line of 4 <sup>m</sup> -10-5 <sup>m</sup> century
	V LU7	tube cup euge	yenowisitgreen	
	VI 09	ing	wollowich mass	Iy Uncontain: 4th to 5th conterns
	V LUð	Jug	yenowish green	Uncertain: 4 <sup>th</sup> -10 - 3 <sup>th</sup> century

 Table 1. Samples studied: physical characteristics and dating

Vigo         VG01         glass in gross         yellowish green         Unknown           VG02         glass in gross         yellowish green         Unknown           VG04         bellical cup         yellowish green         Unknown           VG04         bellical cup         yellowish green         Uncertain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           Chaves         CH01         bellical cup         bluish green         Uncertain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           Chaves         CH01         bellical cup         pellowish green         Uncertain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           Braga         BR01         glass in gross         colourless         Unknown         Unknown           BR03         window         colourless         Unknown         Unknown         Unknown           BR05         glass in gross         colourless         Unknown         Unknown         Unknown           BR04         glass in gross         colourless         Unknown         Unknown         Unknown           BR05         gun pross         yellowish green         Unknown         Unknown         Unknown           BR05         diarteta - cage cup         colourless         Deligin of Magustus (1 <sup>th</sup> century B)         Deligin of Magustus (1 <sup>th</sup> century A)         D) <th>Site</th> <th>Sample</th> <th>Form</th> <th>Colour</th> <th>Date</th>	Site	Sample	Form	Colour	Date
VG02     glass in gross     opaque preen     Unknown       VG04     bellical cup     yellowish green     Unknown       VG05     bellical cup     yellowish green     Reign of Augustus / Reign of Trajan       Chaves     CH01     bellical cup     bluish green     Reign of Augustus / Reign of Trajan       Chaves     CH02     quadrilateral carafe     bluish green     I's century to 34 century       CH03     bluish green     Unknown     Uncertain: 18 -to -44 century       BR04     glass in gross     bluish green     Unknown       BR05     cup     yellowish green     Unknown       BR06     glass in gross     bluish green     Uncertain: 18 -to -44 century       BR05     cup     yellowish green     Uncertain: 18 -to -44 century       BR06     diatreta = cage cup     colourless     farly-mid 44" century       BR10     convex cup     yellow     Uncertain 14 -to -44" century       BR11     ceramic profile cup     dark green     Uncertain 14 -to -44" century       BR14     ceramic profile cup     yellow     Reign of Augustus (14" century B.C.)       BR16     quadrilateral carafe     bluish green     Reign of Augustus (14" century B.C.)       BR17     rensor fAugustus (14" century B.C.)     Reign of Augustus (14" century B.C.)       <	Vigo	VG01	glass in gross	yellowish green	Unknown
VG03     glass in gross     yellowish green     Uncertain: mid-late 4 <sup>h</sup> -to-6 <sup>h</sup> century       VG05     bellical cup     yellowish green     Trong the second sec	_	VG02	glass in gross	opaque green	Unknown
VG04         bellical cup         yellowish green         Uncertain: mid-late 5 <sup>th</sup> -to-6 <sup>th</sup> centur- Y           Chuves         CH01         bellical cup         bluish green         Reign of Augustus / Reign of Trajan           Chuves         CH02         quadrilateral carafe         bluish green         Net contrain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           CH03         bellical cup         yellowish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           CH04         quadrilateral carafe         bluish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           BR02         glass in gross         bluish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           BR05         cup         vellowish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           BR04         glass in gross         bluish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           BR05         cup         vellowish green         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century           BR05         cup optimisting cen         Uncertain: 1 <sup>th</sup> -to-4 <sup>th</sup> century         Alth optimisting cen           BR06         diatreta = cage cup         colourless         farly-mid 4 <sup>th</sup> century         Alth optimisting cen           BR10         convex cup         yellowish green         farly-mid 4 <sup>th</sup> century         Chiging farly		VG03	glass in gross	yellowish green	Unknown
VG05         bellical cup         yellowish green         Ty           Chaves         CH01         bellical cup         bluish green         Reign of Augustus / Reign of Trajan           CH02         quadrilateral carafe         bluish green         1* century to 3*4 century           Braga         BK01         glass in gross         colourless green         Unknown           BR03         glass in gross         colourless         Unknown           BR04         glass in gross         vellowish green         Unknown           BR05         cup         bornen         Two on the century to 3*4 century           BR06         glass in gross         buish green         Unknown         Unknown           BR07         hermispherical cup         brownish green         Luknown         Uncertain 1*4-to-4*0 century BC.)           BR09         Hiellensitic cup         yellow         Reign of Augustus (1* century BC.)         ////////////////////////////////////		VG04	bellical cup	yellowish green	Uncertain: mid-late 5th -to-6th centu-
VG05         bellical cup         yellowish green         Üncertain: mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           Chaves         CH01         pudarilateral carafe         bluish green         Reign of Augustus / Reign of Trajan           CH03         bellical cup         yellowish green         Def centry to 3 <sup>th</sup> century           Dias green         Uncertain: 1 <sup>th</sup> -to -4 <sup>th</sup> century         Uncertain: 1 <sup>th</sup> -to -4 <sup>th</sup> century           BR04         glass in gross         bluish green         Uncertain: 1 <sup>th</sup> -to -4 <sup>th</sup> century           BR05         cup         yellowish green         Uncertain: 1 <sup>th</sup> -to -4 <sup>th</sup> century           BR05         cup         yellowish green         Uncertain: 1 <sup>th</sup> -to -4 <sup>th</sup> century           BR06         glass in gross         bluish green         Uncertain 1 <sup>th</sup> -to -4 <sup>th</sup> century R.C.)           BR07         hemispherical cup         rownish green         Uncertain 1 <sup>th</sup> -to -4 <sup>th</sup> century R.C.)           BR16         convex cup         yellowish green         Uncertain 1 <sup>th</sup> -to -4 <sup>th</sup> century R.C.)           BR11         ceramic profile cup         yellowish green         Viegn of Augustus (1 <sup>th</sup> century R.C.)           BR12         ceramic profile cup         yellowish green         Reign of Augustus (1 <sup>th</sup> century R.C.)           BR12         ceramic profile cup         yellowish green         Reign o			•	, ,	ry
Chaves         CH01         bellical cup         bluish green         Reign of Augustus / Reign of Trajan           Braga         BR01         glass in gross         bluish green         Uncertain mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           BR03         glass in gross         bluish green         Uncertain mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century           BR04         glass in gross         brown in the second sec		VG05	bellical cup	yellowish green	Úncertain: mid-late 4 <sup>th</sup> -to- 5 <sup>th</sup> centu- ry
CH02quadrilateral carafebluish greenif eentury to 34 centuryBragaBR01glass in grosscolourless greenUncertain: 14 -to -54* centuryBR02glass in grosscolourlessUncertain: 14 -to -44* centuryBR04glass in grossbluish greenLat 34* -40 -44* centuryBR05cupbrownUncertain: 14 -to -44* centuryBR06glass in grossbluish greenLat 34* -40 -44* centuryBR07hemispherical cupbrownUncertain: 14 -to -44* centuryBR08diatreta = cage cupcolourlessEarly-mid 44* centuryBR09fielleristic cupblueReign of Augustus (14* century B.C.)BR11convext cupyellowReign of Augustus (14* century B.C.)BR12ceramic profile cupyellowReign of Augustus (14* century B.C.)BR13geop platecolourlessyellowish greenBR14grooved cupyellowish greenVincertain 14* -0-34* centuryBR15Hofneim cupyellowish greenUncertain: 44* -or a4* centuryBR18glass in grossyellowish greenUnknownBR25ballwhiteUnknownBR26bellical cupyellowish greenUncertain: 44* -or 54* centuryBR27pitcher edgeyellowish greenUncertain: 44* -or 55* centuryBR28bottleyellowish greenUncertain: 44* -or 55* centuryBR29bottleyellowish greenUncertain: 44* -or 55* centuryBR29bottleyellowish gree	Chaves	CH01	bellical cup	bluish green	Reign of Augustus / Reign of Trajan
CH03jellical cupyellowish greenUncertain mid-lafe 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBrogaBR01glass in grossbluish greenUnknownBR04glass in grossbluish greenUnknownBR05cupyellowish greenUnknownBR06glass in grossbluish greenUnknownBR07hemispherical cupbrownish greenLat 3 <sup>th</sup> -to-4 <sup>th</sup> centuryBR08diatreta = cage cupcolourlessReign of Augustus (1 <sup>st</sup> century A.D.)BR09Hellenistic cupblueReign of Augustus (1 <sup>st</sup> century B.C.)BR10convex cupyellowUncertain 1 <sup>st</sup> -to-3 <sup>th</sup> centuryBR11ceramic profile cupyellowUncertain 1 <sup>st</sup> -to-3 <sup>th</sup> century B.C.)BR13deep platecolourlessReign of Augustus (1 <sup>st</sup> century B.C.)BR14grooved cupyellowUncertain 1 <sup>st</sup> -to-3 <sup>th</sup> century B.C.)BR15Hofheim cupbluish greenReign of Augustus (1 <sup>st</sup> century B.C.)BR16guadrilateral carafeebluish greenUncertain 1 <sup>st</sup> -to-3 <sup>th</sup> century B.C.)BR17glass in grossbluish greenUnknownBR21cupcolourlessUnknownBR22pitcher edgevellowish greenUncertain 4 <sup>th</sup> centuryBR23pitcher edgevellowish greenUncertain 4 <sup>th</sup> centuryBR24bottlevellowish greenUncertain 4 <sup>th</sup> centuryBR25bottlevellowish greenUncertain 4 <sup>th</sup> centuryBR26bellical cupvellowish greenUncertai		CH02	quadrilateral carafe	bluish green	1 <sup>st</sup> century to 3 <sup>rd</sup> century
Braga         BR01         glass in gross window         colourless colourless         colourless brown clusis green         colourless Uncertain: 14-to-44° century Uncertain: 14-to-44° century           BR05         cup BR06         glass in gross brown bemispherical cup bemispherical cup BR09         brown brown signeen         Uncertain: 14-to-44° century Uncertain         Lat 3 <sup>3d</sup> -40-44° century Uncertain         Lat 4 <sup>3d</sup> -40-44° cen		CH03	bellical cup	yellowish green	Uncertain mid-late 4 <sup>th</sup> -to-5 <sup>th</sup> century
BR02     glass in gross     bluish green     Unknown       BR03     window     colourless     Unknown       BR04     glass in gross     brownish green     Lak own       BR05     cup     vellowish green     Lak own       BR06     glass in gross     bluish green     Lak own       BR08     diatreta - cage cup     colourless     Early wind 4/2 century       BR09     Hellemisticup     blue     Bigno in Are state 1/2 century A.D.)       BR10     ceramic profile cup     yellow     Reigno in Are state 1/2 century A.D.)       BR13     deep plate     colourless     Early wind 4/2 century       BR14     grooved cup     yellow     Reigno in Are state 1/2 century A.D.)       BR13     deep plate     colourless     Buish green       BR14     grooved cup     yellow     Reigno in Are -0.3 <sup>44</sup> century       BR15     Hofheim cup     bluish green     He -0.3 <sup>44</sup> century B.C.)       BR14     grooved cup     yellow     Unknown       BR15     Hofheim cup     bluish green     He -0.3 <sup>44</sup> century       BR14     grooved cup     yellow     Unknown       BR14     grooved cup     yellow     Unknown       BR15     Hofheim cup     colourless     Unknown	Braga	BR01	glass in gross	colourless green	Unknown
BR03       window       colurless       Uncertain: 14*-0-44* century         BR04       glass in gross       brown       Late 33*-16-44* century         BR05       cup       vellowish green       Late 33*-16-44* century         BR07       hemispherical cup       bluish green       Late 33*-16-44* century         BR08       diateta = cage cup       colourless       Early-mid 44* century       BC.)         BR09       diateta = cage cup       colourless       Early-mid 44* century       BC.)         BR09       corranic profile cup       velow       Biggin of Augustus (1* century B.C.)         BR13       deep plate       colourless       Uncertain: 14*-10-34* century       Chernhury B.C.)         BR14       prooved cup       yellowish green       H* contury       Late 33*-10*       Chernhury B.C.)         BR14       glass in gross       yellowish green       Late 14*-to-34* century       BC.)         BR15       Hoftein cup       vellowish green       Late 14*-to-34* century       BC.)         BR21       cup       colourless       Uncertain: 44*-co-34* century         BR22       pitcher edge       vellowish green       Late 14*-to-2** century         BR23       pitcher edge       vellowish green       Late 14*-to-2** cent		BR02	glass in gross	bluish green	Unknown
BN04     glass in gross     prown     Dikknown       BR05     cup     vellowish green     Liknown       BR06     glass in gross     bluish green     Liknown       BR08     diatreta = cage cup     colourless     Bryen A she century BC.)       BR09     Hellenistic cup     blue     Bryen A she century BC.)       BR10     ceramic profile cup     dark green     Bryen A she century BC.)       BR11     ceramic profile cup     dark green     Uncertain 14 + -0.5 <sup>40</sup> century       BR13     deep plate     colourless     Bryen A she curry BC.)       BR14     grooved cup     vellowish green     Breen A she curry BC.)       BR15     Hofheim cup     bluish green     Breen A she curry BC.)       BR14     grooved cup     vellowish green     Breen A she curry BC.)       BR12     plass in gross     bluish green     Breen A she curry BC.)       BR22     pitcher edge     vellowish green     Unknown       BR22     pitcher edge     vellowish green     Breentury       BR22     pitcher edge     vellowish green     Uncertain 4 <sup>10</sup> co-2 <sup>40</sup> century       BR22     bottle     colourless     Breentury       BR23     bottle     colourless     Breentury       BR24     contain et al co-4 <sup>10</sup> century </th <th></th> <th>BR03 BB04</th> <th>window</th> <th>colourless</th> <th>Uncertain: 1<sup>st</sup> -to- 4<sup>th</sup> century</th>		BR03 BB04	window	colourless	Uncertain: 1 <sup>st</sup> -to- 4 <sup>th</sup> century
BR06       cplassin gross       bitaish green       Unknown         BR07       hemispherical cup       brownish green       Unknown       Charles         BR08       diatreta = cage cup       colourless       Early - mid 4 <sup>th</sup> century BC.)         BR09       Hellenistic cup       blue       Reign of Augustus (1 <sup>a</sup> century BC.)         BR11       ceramic profile cup       yellow       Uncertain 1 <sup>a</sup> - 4-3 <sup>a</sup> century BC.)         BR13       deep plate       colourless       Uncertain 1 <sup>a</sup> - 4-3 <sup>a</sup> century BC.)         BR14       grooved cup       yellow       Reign of Augustus (1 <sup>a</sup> century BC.)         BR14       grooved cup       yellowish green       Unknown         BR15       Hofteim cup       bluish green       Unknown         BR16       quadrilateral carafe       bluish green       Unknown         BR20       ball       white       Unknown         BR21       container edge       yellowish green       Uncertain: 4 <sup>th</sup> century         BR22       pitcher edge       yellowish green       Uncertain: 4 <sup>th</sup> century         BR23       container edge       bluish green       Uncertain: 4 <sup>th</sup> century         BR24       container edge       blue       Steatury       Unknown         BR25		BR05	glass in gross	prown vellowish green	Unknown Late 3 <sup>rd</sup> -to- <sup>4th</sup> century
BR07hemispferical cupbrownish greenReign of Augustus (1* century A.D.) (Reign of Neo (1* century A.D.) (Reign of Augustus (1* century A.D.) (Reign of Augustus (1* century B.C.) (Reign of Neo (1* century A.D.))BR10convex cupyellowUncertain 1* -to-3* century (Reign of Neo (1* century A.D.))BR11ceramic profile cupyellowUncertain 1* -to-3* century (Reign of Neo (1* century A.D.))BR13deep platecolourlessUncertain 1* -to-3* century (Reign of Neo (1* century A.D.))BR14grooved cupyellowis green (Neo (1* century A.D.))BR15Hofheim cupbluish green (Neo (1* century A.D.))BR16quadrilateral carafe (Plus)bluish green (Neh own (Neh o		BR06	glass in gross	bluishgreen	Unknown
RR08diatreta = cage cupcolourless/ Reign of Augustus (1 <sup>d</sup> century A.D.)BR09Hellenistic cupblueReign of Augustus (1 <sup>d</sup> century B.C.)BR10corvex cupvellowReign of Augustus (1 <sup>d</sup> century B.C.)BR11ceramic profile cupdark greenUncertain 1 <sup>d</sup> - to-3 <sup>d</sup> centuryBR12ceramic profile cupvellowReign of Augustus (1 <sup>d</sup> century B.C.)BR13deep platecolourlessUncertain 1 <sup>d</sup> - to-3 <sup>d</sup> centuryBR14grooved cupvellowish green1 <sup>d</sup> - entury and entury A.D.)BR15Hofheim cupbluish green1 <sup>d</sup> - enturyBR16quadrilateral carafebluish green1 <sup>d</sup> - enturyBR17glass in grossvellowish green1 <sup>d</sup> - enturyBR20ballvellowUnknownBR21cupcolourlessUnknownBR22pitcher edgevellowish greenUncertain: 4 <sup>th</sup> enturyBR23pitcher edgevellowish greenUncertain: 4 <sup>th</sup> enturyBR24container edgebluish greenUncertain: 4 <sup>th</sup> enturyBR25bellical cupprobatis greenUncertain: 4 <sup>th</sup> - enturyBR26bottlevellowish greent- o-5 <sup>th</sup> centuryBR31quadrilateral carafebluish greent- at- 3 <sup>d</sup> centuryBR32jugvellowish greent- at- 3 <sup>d</sup> centuryBR34rim of jugblueUnknownBR35glass in grossblackUncertain: 1at 1 <sup>-1</sup> - 0-4 <sup>d</sup> centuryBR36glass in gross </th <th></th> <th>BR07</th> <th>hemispherical cup</th> <th>brownish green</th> <th>Reign of Augustus (1<sup>st</sup> century B.C.)</th>		BR07	hemispherical cup	brownish green	Reign of Augustus (1 <sup>st</sup> century B.C.)
BR08diatreta = cage cup colourlesscolourlessEarly-mid * enturyBR10convex cupblueReign of Augustus (1 <sup>d</sup> century B.C.)BR11ceramic profile cupyellowUncertain 1 <sup>d</sup> - to -3 <sup>h</sup> centuryBR13deep platecolourlessUncertain 1 <sup>d</sup> - to -3 <sup>h</sup> century B.C.)BR14grooved cupyellowish greenI* act -3 <sup>h</sup> centuryBR15Hofheim cupbluish greenReign of Augustus (1 <sup>d</sup> century B.C.)BR16quadrilateral carafebluish greenNe (1 <sup>d</sup> + century C.)BR17glass in grossbluish greenNe (1 <sup>d</sup> + century C.)BR18glass in grossvellowish brownUnknownBR20ballvellowUnknownBR21cupcolourlessMid-late 1 <sup>d</sup> to -2 <sup>ad</sup> centuryBR22cupcolourlessMid-late 1 <sup>d</sup> to -2 <sup>ad</sup> centuryBR22pitcher edgeyellowish greenUncertain 4 <sup>be</sup> centuryBR22pitcher edgeyellowish greenUncertain 4 <sup>be</sup> centuryBR23bellical cupbrownish greenUncertain 4 <sup>be</sup> centuryBR24hoopyellowish greenUncertain 4 <sup>be</sup> centuryBR25bottlecolourlessUncertain 4 <sup>be</sup> centuryBR34quadrilateral carafebluish greenUncertain 4 <sup>be</sup> centuryBR25hoopyellowish greenUncertain 4 <sup>be</sup> centuryBR34quadrilateral carafeblueNe colourlessBR34pass in grossblueVellowish greenBR34gas in gross<					/ Reign of Nero (1 <sup>st</sup> century A.D.)
bR09relienstic cupblueReign of Augustus (1 <sup>a</sup> century 0.C.)BR10convex cupvellowUncertain 1 <sup>a</sup> . 4.0 - 4 <sup>b</sup> centuryBR11ceramic profile cupvellowUncertain 1 <sup>a</sup> . 4.0 - 4 <sup>b</sup> century B.C.)BR13deep platecolourlessUncertain 1 <sup>a</sup> . 4.0 - 5 <sup>b</sup> century B.C.)BR14grooved cupvellowish green1 <sup>a</sup> . to-5 <sup>b</sup> century B.C.)BR15Hofheim cupbluish green1 <sup>a</sup> . to-5 <sup>ab</sup> centuryBR16quadrilateral carafebluish green1 <sup>a</sup> . to-5 <sup>ab</sup> centuryBR17glass in grossvellowish greenUncertain: 1 <sup>a</sup> . to-2 <sup>ab</sup> centuryBR21cupcolourlessUncertain: 4 <sup>b</sup> . conturyBR22pitcher edgevellowish greenUncertain: 4 <sup>b</sup> . centuryBR23pitcher edgevellowish greenUncertain: 4 <sup>b</sup> . centuryBR24container edgebluish greenUncertain: 4 <sup>b</sup> . centuryBR25bellical cupvellowish greenUncertain: 4 <sup>b</sup> . centuryBR26bellical cupvellowish greenUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR27hoopvellowish greenUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR33pudrilateral carafebluish greenUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR34rim of jugvellowish greenUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR35bottlevellowish greenUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR34rim of jugblueUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centuryBR35glass in grossblueUncertain: 4 <sup>b</sup> . to-5 <sup>b</sup> . centu		BR08	diatreta = cage cup	colourless	Early-mid 4 <sup>th</sup> century
BR11ConvextupyellowDirectian 14 -to-4h CenturyBR12ceramic profile cupyellowReign of Nero 14 century A.D.)BR13deep platecolourlessUncertain 14 -to-4h Century A.D.)BR14grooved cupyellowish green14 century A.D.)BR15Hofheim cupbluish green14 century B.C.)BR16quadrilateral carafebluish green14 centuryBR17glass in grossyellowish brownBR18glass in grossyellowish brownBR21cupcolourlessMid-later 14 -to -2 <sup>ad</sup> centuryBR22pitcher edgeyellowish greenUncertain: 4 <sup>a</sup> centuryBR23pitcher edgeyellowish greenUncertain: 4 <sup>b</sup> conturyBR24container edgebluish greenUncertain: 4 <sup>b</sup> - co-5 <sup>b</sup> centuryBR25bellical cupyellowish greenUncertain: 4 <sup>b</sup> - to-5 <sup>b</sup> centuryBR26bellical cupyellowish greenUncertain: 4 <sup>b</sup> - to-5 <sup>b</sup> centuryBR37quadrilateral carafebluish greenUncertain: 4 <sup>b</sup> - to-5 <sup>b</sup> centuryBR38glass in grossbluish green14 -to-5 <sup>b</sup> centuryBR31quadrilateral carafebluish green14 -to-5 <sup>b</sup> centuryBR31quadrilateral carafebluish green14 -to-5 <sup>b</sup> centuryBR32jugyellowish green14 -to-5 <sup>b</sup> centuryBR33iugyellowish green14 -to-5 <sup>b</sup> centuryBR44folowish green14 -to-5 <sup>b</sup> centuryBR45glass in grossbluish green </th <th></th> <th>BR10</th> <th>Hellenistic cup</th> <th>blue</th> <th>Keign of Augustus (1<sup>st</sup> century B.C.)</th>		BR10	Hellenistic cup	blue	Keign of Augustus (1 <sup>st</sup> century B.C.)
BR12ceramic profile cupyellowReign of Augustus (1ª century B.C.) / Reign of Augustus (1ª century B.C.) / Reign of Augustus (1ª century B.C.) / Reign of Augustus (1ª century D.C.) /		BR11	ceramic profile cup	dark green	Uncertain $1^{st}$ -to- $4^{th}$ century
BritsImage: Colourless// Reign of Nero (1° century A.D.) / Uncertain: 1* 4-0-3*d centuryBR14grooved cupyellowish green1* enturyBR15Hoheim cupbluish green1* enturyBR17glass in grossyellowish brown1* do-3*d centuryBR29ballvellowish brownUnknownBR21cupcolourless10 uknownBR22pitcher edgeyellowish greenUncertain: 4* centuryBR23pitcher edgeyellowish greenUncertain: 4* centuryBR24container edgebluish greenUncertain: 4* centuryBR25bellical cupvellowish greenUncertain: 4* centuryBR26bellical cupvellowish greenUncertain: 4* -co 5* centuryBR27hoopvellowish greenUncertain: 4* -to 5* centuryBR28bottlecolourlessUncertain: 4* -to 5* centuryBR31quadrilateral carafebluish green1* -to -5* centuryBR32iugblue4* -to -5* centuryBR33iugblue1* -to -5* centuryBR34rim of jugblue1* -to -5* centuryBR35salve bottlebluish green1* -to -5* centuryBR33glass in grossblack1* -to -5* centuryBR34glass in grossblue1* -to -5* centuryBR35glass in grossblue1* -to -4* centuryBR36glass in grossplackUnknownBR37glass in grosscolourless1* -to -4* c		BR12	ceramic profile cup	vellow	Reign of Augustus (1 <sup>st</sup> century B.C.)
BR14 BR14 grooved cupcolourless yellowish greenUncertain: 1* 4-0-3*d centuryBR15 BR16 quadrilateral carafebluish green bluish green1* do-3*d centuryBR17 BR17 glass in grossbluish green yellowish brown white1* do-3*d centuryBR20 BR21 BR22 BR22 pitcher edgevellowish brown whiteUnknownBR22 BR22 bluich redgevellowish green yellowish greenUncertain: 4* centuryBR24 BR25 BR25 Belical cupbluish green yellowish greenUncertain: 4* centuryBR25 BR26 BR27 BR28 BR29 BR21 BR29bottleplowish green yellowish green Uncertain: 4* centuryUncertain: 4* centuryBR25 BR26 BR27 BR27 BR33 BR33 guadrilateral carafeplowish green yellowish green Uncertain: 4* -to-5* centuryUncertain: 4* -to-5* centuryBR34 BR33 glass in grossplowish green yellowish greenUncertain: 4* -to-5* centuryBR34 BR34 glass in grossplow blue1* -to-5* centuryBR35 BR36 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR36 BR37 glass in grossplack blueUnknownBR44 BR44plate colourless				5	/ Reign of Nero (1 <sup>st</sup> century A.D.)
BR15Hofheim cup quadrilateral carafeVeilowish greenIsteps of Augustus (1ª century B.C.)BR16quadrilateral carafebluish green14 -to-3 <sup>ad</sup> centuryBR17glass in grossveilowish brownUnknownBR20ballwhiteUnknownBR21cupcolourlessMid-late 14 -to-2 <sup>ad</sup> centuryBR22pitcher edgeveilowish greenUncertain: 4 <sup>th</sup> centuryBR23pitcher edgeveilowish greenUncertain: 4 <sup>th</sup> centuryBR24containe redgebluish greenUncertain: 4 <sup>th</sup> centuryBR25bellical cupvellowish greenUncertain: 4 <sup>th</sup> centuryBR26bellical cupvellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR27hoopvellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR28bottlecolourlessUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR30bottlevellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR31quadrilateral carafebluish green14 -to-5 <sup>th</sup> centuryBR33iugvellowish green14 -to-5 <sup>th</sup> centuryBR34rim of jugblue4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR35glass in grossblueUnknownBR36glass in grossblueUnknownBR37glass in grossblueUnknownBR34glass in grossblueUnknownBR35glass in grossblueUnknownBR34glass in grossblueUnknownBR34glass i		BR13	deep plate	colourless	Uncertain: 1 <sup>st</sup> -to- 3 <sup>rd</sup> century
BR16 BR16 quadrilateral carafe plusish greenDruss green is to -3d century UnknownBR17 BR17 glass in grossplusish green vellowish brown UnknownInknownBR19 BR20 BR21 Cupballvellowish brown unknownUnknownBR21 BR22 BR22 pitcher edgevellowish green vellowish greenUncertain: 4b century Uncertain: 4b centuryBR22 BR24 Container edgevellowish green vellowish greenUncertain: 4b century Uncertain: 4b centuryBR25 BR26 bellical cupvellowish green vellowish greenUncertain: 4b century Uncertain: 4b centuryBR25 BR26 bellical cupvellowish green vellowish greenUncertain: 4b century Uncertain: 4b co- 5th centuryBR28 BR29 BR31 quadrilateral carafe BR33 glass in grossvellowish green vellowish greenUncertain: 4b -to- 5th century theo-5th centuryBR33 BR34 R33 BR35 BR34 R334 R345 R345 R345 R345 R345 R345 R345Vellowish green P1000000000000000000000000000000000000		BR14 PD15	grooved cup	yellowish green	1 <sup>st</sup> century Boign of Augustus (1 <sup>st</sup> contury B.C.)
BR17glass in grossbluish greenUnknownBR18glass in grossyellowish brownUnknownBR20ballwhiteUnknownBR21cupcolourlessMid-late 1* -to -2*d centuryBR22pitcher edgeyellowish greenUncertain: 4* centuryBR23pitcher edgeyellowish greenUncertain: 4* centuryBR24container edgebluish greenUncertain: 4* centuryBR25bellical cupvellowish greenUncertain: 4* centuryBR26bellical cupvellowish greenUncertain: 4* -to -5*h centuryBR27hoopvellowish greenUncertain: 4* -to -5*h centuryBR28bottlevellowish greenUncertain: 4* -to -5*h centuryBR30bottleyellowish greenUncertain: 4* -to -5*h centuryBR31quadrilateral carafebluish green1* -to -5*h centuryBR33jugyellowish green1* -to -5*h centuryBR34rim of jugblue4* -to -5*h centuryBR35salve bottlebluish green1* -to -2*d centuryBR36glass in grossblackUnknownBR39glass in grossblueUnknownBR44tesseragreenRoman / MedievalBR44fine walled glasscolourlessUncertain: 4* -to -5*h centuryBR44fine walled glasscolourlessUncertain: 4* -to -5*h centuryBR45fine walled glasscolourlessUnknownBR46fine walled glass<		DR15 BR16	nomenn cup quadrilateral carafe	bluish green	1 <sup>st</sup> -to- 3 <sup>rd</sup> century
BR18 BR19 BR19 BR19glass in gross pallyellow'fsh brown whiteUnknown UnknownBR20 BR21 Cupcupcolourless colourlessUnknown UnknownBR21 BR22 BR22 		BR17	glass in gross	bluishgreen	Unknown
BR19ballwhiteUnknownBR20ballvellowUnknownBR21cupcolourlessMid-late 1* to- 2 <sup>nd</sup> centuryBR22pitcher edgevellowish greenUncertain: 4 <sup>th</sup> centuryBR24container edgebluish greenUncertain: 4 <sup>th</sup> centuryBR25bellical cupvellowish greenUncertain: 5 <sup>th</sup> centuryBR26bellical cupvellowish greenUncertain: 4 <sup>th</sup> centuryBR27hoopvellowish greenUncertain: 4 <sup>th</sup> centuryBR28bottlecolurlessUncertain: 4 <sup>th</sup> - co-5 <sup>th</sup> centuryBR30bottlevellowish greenUncertain: 4 <sup>th</sup> - to-5 <sup>th</sup> centuryBR31quadrilateral carafebluish green1* -to-3 <sup>th</sup> centuryBR33jugvellowish green1* -to-5 <sup>th</sup> centuryBR34qasrin grossblackUnknownBR35salve bottlebluish green1* -to-2 <sup>nd</sup> centuryBR36glass in grossblueUnknownBR37glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossblueUnknownBR42grooved cupbluish green1* -to-4 <sup>th</sup> centuryBR44blown glasscolourless1* -to-4 <sup>th</sup> centuryBR45fine walled glass and massivecolourless1* -to-4 <sup>th</sup> centuryBR46fine walled glasscolourless1* -to-4 <sup>th</sup> centuryBR47contal trunk cupvellowish green1* -to-4 <sup>th</sup>		BR18	glass in gross	yellowish brown	Unknown
BR20ballvellowUnknownBR21cupcolourlessMid-late 1*-to-2*d centuryBR22pitcher edgevellowish greenUncertain: 4th centuryBR23pitcher edgebluish greenUncertain: 4th centuryBR24container edgebluish greenUncertain: 5th centuryBR25bellical cupprownish greenUncertain: 4th centuryBR26bellical cupvellowish greenUncertain: 4th centuryBR27hoopvellowish greenUncertain: 4th -to-5th centuryBR28bottlevellowish greenUncertain: 4th -to-5th centuryBR30bottlevellowish greenUncertain: 4th -to-5th centuryBR31quadrilateral carafebluish green1* -to-3th centuryBR32jugvellowish green4th -to-5th centuryBR33glass in grossblue4th -to-5th centuryBR34rim of jugblueblue4th -to-5th centuryBR35glass in grossblueUnknownBR39glass in grossblueUnknownBR41glass in grossblueUnknownBR42grooved cupvellowish greenIntertain -to-4th centuryBR43platecolourlessUncertain: late 1* -to-4th centuryBR44blown glasscolourlessUncertain: late 1* -to-4th centuryBR45fine walled glasscolourlessUncertain: late 1* -to-4th centuryBR44blown glasscolourlessIntertain 4th -to-5th century <t< th=""><th></th><th>BR19</th><th>ball</th><th>white</th><th>Unknown</th></t<>		BR19	ball	white	Unknown
bR21cupcolourlessMid-late 1* -10- 2 <sup>m</sup> centuryBR22pitcher edgeyellowish greenUncertain: 4 <sup>th</sup> centuryBR23pitcher edgebluish greenUncertain: 4 <sup>th</sup> centuryBR24bellical cupyellowish greenUncertain: 4 <sup>th</sup> centuryBR25bellical cupyellowish greenUncertain: 4 <sup>th</sup> centuryBR26bellical cupyellowish greenUncertain: 4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR27hoopyellowish greenUncertain: 4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR30bottleyellowish greenUncertain: 4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR31quadrilateral carafebluish green1 <sup>th</sup> -to -5 <sup>th</sup> centuryBR33jugyellowish green4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR33jugyellowish green4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR34rim of jugblue4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR35salve bottlebluish green1 <sup>st</sup> -to -2 <sup>th</sup> centuryBR36glass in grossblackUnknownBR38glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossyellowish greenLate 3 <sup>ad</sup> -to -4 <sup>th</sup> centuryBR44blown glasscabuchon cup, base of corpblueUnknownBR45fine walled glasscolourless1 <sup>st</sup> -to -4 <sup>th</sup> centuryBR46fine walled glasscolourless1 <sup>st</sup> -to -5 <sup>th</sup> centuryBR44blown glasscabuchon cup, base of corpblue1 <sup>th</sup> -to -5 <sup>th</sup> century </th <th></th> <th>BR20</th> <th>ball</th> <th>yellow</th> <th>Unknown</th>		BR20	ball	yellow	Unknown
BR22pitcher edgevellowish greenUncertain: 4 <sup>h</sup> centuryBR24container edgebuilsh greenUncertain: 4 <sup>h</sup> centuryBR25bellical cupvellowish greenUncertain: 4 <sup>h</sup> centuryBR26bellical cupvellowish greenUncertain: 4 <sup>h</sup> centuryBR27hoopvellowish greenUncertain: 4 <sup>h</sup> -to -5 <sup>h</sup> centuryBR28bottlecolourlessUncertain: 4 <sup>h</sup> -to -5 <sup>h</sup> centuryBR29bottlevellowish greenUncertain: 4 <sup>h</sup> -to -5 <sup>h</sup> centuryBR31quadrilateral carafebluish green1 <sup>a</sup> -to -5 <sup>h</sup> centuryBR33iugvellowish green1 <sup>a</sup> -to -5 <sup>h</sup> centuryBR34rim of jugblue4 <sup>h</sup> -to -5 <sup>h</sup> centuryBR35glass in grossblackUnknownBR36glass in grossblueUnknownBR41glass in grossblueUnknownBR42grooted cupbluis greenLot -4 <sup>h</sup> centuryBR43platecolourlessUncertain: 1ate 1 <sup>a</sup> -to -4 <sup>th</sup> centuryBR44blown glasscolourless1 <sup>a</sup> -to -4 <sup>th</sup> centuryBR45fine walled glasscolourless1 <sup>a</sup> -to -4 <sup>th</sup> centuryBR46cabuchon cup, base of corpblue1 <sup>a</sup> -to -4 <sup>th</sup> centuryBR55cylindrical cupvellowish green1 <sup>a</sup> -to -4 <sup>th</sup> centuryBR54arched cupvellowish green1 <sup>a</sup> -to -5 <sup>th</sup> centuryBR55cylindrical cupvellowish green1 <sup>a</sup> -to -5 <sup>th</sup> centuryBR55bluecolourless1 <sup></sup>		BR21 BR22	cup pitcher edge	colourless	Mid-late 1 <sup>st</sup> -to- 2 <sup>nd</sup> century
BR24container edgebluish greenUncertain: 4 <sup>th</sup> centuryBR25bellical cupbrownish greenSh-co-6 <sup>th</sup> centuryBR26bellical cupvellowish greenUncertain: 5 <sup>th</sup> centuryBR27hoopvellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR28bottlevellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR30bottlevellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR31quadrilateral carafebluish green4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR32jugvellowish green4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR33iugvellowish green4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR34rim of jugblue4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR35salve bottlebluish green1 <sup>st</sup> -to-3 <sup>cd</sup> centuryBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR40tesseragreenNothonownBR41glass in grossblueUnknownBR42grooved cupbluish green1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR46fine walled glass of corpblue1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR51cabuchon cup, corpcolourless green1 <sup>st</sup> -to-5 <sup>th</sup> centuryBR52hexagonal basecolourless green1 <sup>st</sup> -to-5 <sup>th</sup> centuryBR54arched cupcolourless1 <sup>st</sup> -to-5 <sup>th</sup> c		BR23	pitcher edge	vellowishgreen	Uncertain: 4 <sup>th</sup> century
BR25bellical cupbrownish green5th -to- 6th centuryBR26bellical cupvellowish greenUncertain: 5th centuryBR27hoopvellowish greenUncertain: 4th -to-5th centuryBR28bottlecolourlessUncertain: 4th -to-5th centuryBR30bottlevellowish greenUncertain: 4th -to-5th centuryBR31quadrilateral carafebluish green1st -to-3th centuryBR33jugvellowish green1st -to-5th centuryBR33iugvellowish green1st -to-5th centuryBR34rim of jugblue4th -to-5th centuryBR35glass in grossblackUnknownBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossvellowish greenLate 3td -to-4th centuryBR42grooved cupbluish greenLate 3td -to-4th centuryBR44blown glasscolourless1st -to-4th centuryBR45fine walled glasscolourless1st -to-4th centuryBR46fine walled glasscolourless1st -to-5th centuryBR50cabuchon cup, corpvellowish green1st -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR53hemispherical cupvellowish green1st -to-5th centuryBR54arched cupvellowish green1st -to-5th centuryBR55he		BR24	container edge	bluish green	Uncertain: 4 <sup>th</sup> century
BR26bellical cupvellowish greenUncertain: 5 <sup>th</sup> centuryBR27hoopvellowish greenUnknownBR28bottlecolourlessUncertain: 4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR29bottlevellowish greenUncertain: 4 <sup>th</sup> -to -5 <sup>th</sup> centuryBR31quadrilateral carafebluish green1st -to -5 <sup>th</sup> centuryBR32jugvellowish green1st -to -5 <sup>th</sup> centuryBR33iugvellowish green1st -to -5 <sup>th</sup> centuryBR34rim of jugblue4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR35salve bottlebluish green1st -to -5 <sup>th</sup> centuryBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR38glass in grossblueUnknownBR41glass in grossvellowish greenUnknownBR42grooved cupbluish greenLate 3 <sup>rd</sup> -to -4 <sup>th</sup> centuryBR43platecolourlessUncertain: late 1st -to -4 <sup>th</sup> centuryBR44blown glasscolourless1st -to -5 <sup>th</sup> centuryBR44concurrentcolourless1st -to -5 <sup>th</sup> centuryBR45rine walled glass and massive to colourless1st -to -5 <sup>th</sup> centuryBR46fine walled glasscolourless1st -to -5 <sup>th</sup> centuryBR47cabuchon cup, corpvellowish green1st -to -5 <sup>th</sup> centuryBR48cabuchon cup, corpvellowish green1st -to -5 <sup>th</sup> centuryBR49cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to -		BR25	bellical cup	brownish green	5 <sup>th</sup> -to- 6 <sup>th</sup> century
bR22hoopveltowish greenUnknownBR29bottleveltowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR30bottleveltowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR31quadrilateral carafebluish green1s -to-3 <sup>th</sup> centuryBR32jugvellowish green4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR33iugvellowish green4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR34rim of jugblue4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR35salve bottlebluish green1s + to-3 <sup>th</sup> centuryBR36glass in grossblackUnknownBR37glass in grossdlack blueUnknownBR38glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossblueUnknownBR42grooved cupbluish greenLate 3 <sup>th</sup> -to - 4 <sup>th</sup> centuryBR44blown glasscolourlessUncertain: late 1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR44blown glasscolourlessIs -to - 4 <sup>th</sup> centuryBR45fine walled glass and massive basecolourless1s + to - 5 <sup>th</sup> centuryBR46fine walled glasscolourless1s + to - 5 <sup>th</sup> centuryBR47conical trunk cupvellowish greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR46fine walled glasscolourless1s + to - 5 <sup>th</sup> centuryBR47cabuchon cup, corpvellowish greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR50cabuchon cup, base of corpblue <td< th=""><th></th><th>BR26</th><th>bellical cup</th><th>yellowish green</th><th>Uncertain: 5<sup>th</sup> century</th></td<>		BR26	bellical cup	yellowish green	Uncertain: 5 <sup>th</sup> century
BR29bottlecontrol low is symmetryBR20bottleyellowish greenUncertain: 4th -to-5th centuryBR31quadrilateral carafebluish greenUncertain: 4th -to-5th centuryBR32jugyellowish green4th -to-5th centuryBR33jugyellowish green4th -to-5th centuryBR34rim of jugblue4th -to-5th centuryBR35salve bottlebluish green1st -to-2nd centuryBR36glass in grossdark blueUnknownBR37glass in grossblueUnknownBR38glass in grossblueUnknownBR41glass in grossyellowish greenIate 3rd -to-4th centuryBR42grooved cupbluish greenIate 3rd -to-4th centuryBR43platecolourlessUncertain: 1ate 1st -to-4th centuryBR44blown glasscolourlessIst -to-4th centuryBR46fine walled glasscolourless1st -to-4th centuryBR48cabuchon cup, corpvellowish greenLate 4th -to-5th centuryBR49cabuchon cup, corpvellowish greenLate 4th -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR53hemispherical cupvellowish greenIst -to-3th centuryBR54arched cupyellowish greenIst -to-5th centuryBR55bellical cupvellowish greenIst -to-5th centuryBR56arched cupvellowish greenIst -to-5th century		BR27 BR28	hoop	vellowish green	Unknown Uncortain: 4th to 5th contury
BR30bottlevellowish greenUncertain: 4th -to -5th centuryBR31quadrilateral carafebluish green1st -to -3th centuryBR32jugvellowish green4th -to - 5th centuryBR33jugvellowish green4th -to - 5th centuryBR34rim of jugblue4th -to - 5th centuryBR35salve bottlebluish green1st -to - 2th centuryBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR39glass in grossblueUnknownBR41glass in grossvellowish greenUnknownBR42grooved cupbluish greenLate 3td -to - 4th centuryBR43platecolourless1st -to -4th centuryBR44blown glassdark blueUnknownBR45fine walled glasscolourless1st -to -4th centuryBR46fine walled glasscolourless1st -to -4th centuryBR47conical trunk cupvellowish greenLate 4th -to -5th centuryBR48cabuchon cup, base of corpblueLate 4th -to -5th centuryBR51cabuchon cup, base of corpblueLate 4th -to -5th centuryBR52hexagonal basecolourless greenUncertain: 4th -to -5th centuryBR54arched cupvellowish greenUncertain: 4th -to -5th centuryBR55cylindrical cupvellowish greenUncertain: 4th -to -5th centuryBR56arched cupvellowish greenUncertain: 4th -to -5		BR29	bottle	vellowish green	Uncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> century
BR31quadrilateral carafebluish green1st -to - 3rd centuryBR32jugyellowish green4th -to - 5th centuryBR33rim of jugblue4th -to - 5th centuryBR34rim of jugblue4th -to - 5th centuryBR35salve bottlebluish green1st -to -2rd centuryBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR38glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossyellowish greenUnknownBR42grooved cupbluish greenLate 3rd -to - 4th centuryBR43platecolourlessUncertain: late 1st -to - 4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1st -to - 4th centuryBR46fine walled glasscolourless1st -to - 4th centuryBR47conical trunk cupyellowish greenLate 4th -to - 5th centuryBR48cabuchon cup, corpyellowish greenLate 4th -to - 5th centuryBR50cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR51hemispherical cupyellowish green1st -to -3th centuryBR52hexagonal basecolourless greenIst -to -3th centuryBR55cylindrical cupyellowish green1st -to -3th centuryBR56arched cupyellowish greenIst -to -3th century <th></th> <th>BR30</th> <th>bottle</th> <th>vellowish green</th> <th>Uncertain: 4<sup>th</sup> -to-5<sup>th</sup> century</th>		BR30	bottle	vellowish green	Uncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> century
BR32jugvellowish green4th -to-5th centuryBR33jugvellowish green4th -to-5th centuryBR34rim of jugblue4th -to-5th centuryBR35salve bottlebluish green1st -to-2nd centuryBR36glass in grossblackUnknownBR37glass in grossblueUnknownBR38glass in grossblueUnknownBR39glass in grossblueUnknownBR41glass in grossblueUnknownBR42grooved cupbluish greenLate 3td -to -4th centuryBR41glass and massivecolourlessUncertain: late 1st -to -4th centuryBR43platecolourlessIst -to -4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massivecolourless1st -to -4th centurybasebluevellowish greenUncertain 4th -co -5th centuryBR46fine walled glasscolourless1st -to -4th centuryBR47conical trunk cupvellowish greenUncertain 4th -to -5th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to -5th centuryBR50cabuchon cup, base of corpblueLate 4th -to -5th centuryBR51nemispherical cupvellowish greenIst -to -5th centuryBR52hexagonal basecolourless greenIst -to -5th centuryBR51hemispherical cupvellowish greenIst -to -5th centuryBR52hexag		BR31	quadrilateral carafe	bluish green	1 <sup>st</sup> -to-3 <sup>rd</sup> century
BR33jugvellowish green4th -to - 5th centuryBR34rim of jugblue4th -to - 5th centuryBR35salve bottlebluish green1st -to - 2nd centuryBR36glass in grossblackUnknownBR37glass in grossbrownUnknownBR38glass in grossblueUnknownBR39glass in grossblueUnknownBR41glass in grossyellowish greenLate 3rd -to - 4th centuryBR42grooved cupbluish greenLate 3rd -to - 4th centuryBR43platecolourlessUnknownBR44blown glassdark blueUnknownBR45fine walled glass and massivecolourless1st -to - 4th centurybasebasecolourless1st -to - 4th centuryBR46fine walled glasscolourless1st -to - 4th centuryBR47conical trunk cupyellowish greenLate 4th -to - 5th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to - 5th centuryBR49cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR52hexagonal basecolourless greenIst -to -3th centuryBR53hemispherical cupcolourless greenUncertain: 4th -to -5th centuryBR54arched cupyellowish greenLate 4th -to -5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to -5th centu		BR32	jug	yellowish green	4 <sup>th</sup> -to- 5 <sup>th</sup> century
BR35salve bottleblue4 <sup>m-10-5<sup>m</sup></sup> centuryBR36glass in grossblackUnknownBR37glass in grossdark blueUnknownBR38glass in grossbrownUnknownBR39glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossvellowish greenUnknownBR42grooved cupbluish greenLate 3 <sup>rd</sup> -to-4 <sup>th</sup> centuryBR43platecolourlessUncertain: late 1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR46fine walled glasscolourless1 <sup>st</sup> -to-4 <sup>th</sup> centuryBR47conical trunk cupvellowish greenLate 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR48cabuchon cup, corpcolourless1 <sup>st</sup> -to-5 <sup>th</sup> centuryBR49cabuchon cup, corpvellowish greenLate 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupvellowish greenUnknownBR54arched cupvellowish greenUnknownBR55cylindrical cupvellowish greenUncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> centuryBR56arched cupcolourless1 <sup>st</sup> -to-6 <sup>th</sup> centuryBR56bellical cupbrownish green5 <sup>th</sup> -to-6 <sup>th</sup> century <t< th=""><th></th><th>BR33 BP24</th><th>jug rim of jug</th><th>yellowish green</th><th>4<sup>th</sup> -to - 5<sup>th</sup> century</th></t<>		BR33 BP24	jug rim of jug	yellowish green	4 <sup>th</sup> -to - 5 <sup>th</sup> century
BR36glass in grossblackUnknownBR37glass in grossblackUnknownBR37glass in grossblackUnknownBR38glass in grossblueUnknownBR39glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossyellowish greenUnknownBR42grooved cupbluish greenLate 3rd -to-4th centuryBR43platecolourlessUncertain: late 1st -to-4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1st -to-4th centuryBR46fine walled glasscolourless1st -to-4th centuryBR47conical trunk cupyellowish greenLate 4th -to-5th centuryBR48cabuchon cup, base of corpblueLate 4th -to-5th centuryBR50cabuchon cup, base of corpblueLate 4th -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to-3th centuryBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR55bellical cupbrownish greenUncertain: 4th -to-5th century		BR35	salve bottle	bluish green	$4^{\text{st}}$ -10- $5^{\text{st}}$ century 1st -to- $2^{\text{nd}}$ century
BR37glass in grossdark blueUnknownBR38glass in grossbrownUnknownBR39glass in grossblueUnknownBR40tesseragreenRoma / MedievalBR41glass in grossyellowish greenUnknownBR42grooved cupbluish greenLate 3rd -to - 4th centuryBR43platecolourlessUncertain: late 1st -to - 4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massivecolourless1st -to - 4th centurybasebaselast -to - 4th centurybaseBR46fine walled glasscolourless1st -to - 4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR50cabuchon cup, corpyellowish greenLate 4th -to - 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to - 5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourlessIst -to -3rd centuryBR54arched cupyellowish greenUncertain: 4th -to -5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to -5th centuryBR56arched cupyellowish green <t< th=""><th></th><th>BR36</th><th>glass in gross</th><th>black</th><th>Unknown</th></t<>		BR36	glass in gross	black	Unknown
BR38glass in grossbrownUnknownBR39glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossyellowish greenUnknownBR42grooved cupbluish greenLate 3 <sup>rd</sup> -to - 4 <sup>th</sup> centuryBR43platecolourlessUncertain: late 1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR46fine walled glasscolourless1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR47conical trunk cupyellowish greenUncertain 4 <sup>th</sup> centuryBR48cabuchon cup, corpcolourless greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR49cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR50cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR52hexagonal basecolourless greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR53hemispherical cupcolourless1 <sup>st</sup> -to - 5 <sup>th</sup> centuryBR54arched cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR55cylindrical cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR56arched cupcolourless1 <sup>st</sup> -to - 6 <sup>th</sup> centuryBR58bellical cupbrownish green5 <sup>th</sup> -to - 6 <sup>th</sup> century		BR37	glass in gross	dark blue	Unknown
BR39glass in grossblueUnknownBR40tesseragreenRoman / MedievalBR41glass in grossyellowish greenUnknownBR42grooved cupbluish greenLate 3 <sup>rd</sup> -to - 4 <sup>th</sup> centuryBR43platecolourlessUncertain: late 1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR44blown glassdark blueUnknownBR45fine walled glass and massivecolourless1 <sup>st</sup> -to - 4 <sup>th</sup> centurybasebaseseeseeBR46fine walled glasscolourless1 <sup>st</sup> -to - 4 <sup>th</sup> centuryBR47conical trunk cupyellowish greenUncertain 4 <sup>th</sup> centuryBR48cabuchon cup, corpcolourless greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR49cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR52hexagonal basecolourless greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR53hemispherical cupcolourless1 <sup>st</sup> -to - 3 <sup>rd</sup> centuryBR54arched cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR55cylindrical cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR56arched cupcolourlessUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR56arched cupcolourl		BR38	glass in gross	brown	Unknown
BR40letestragreenKontar/ MeduevalBR41glass in grossyellowish greenUnkonvmBR42grooved cupbluish greenLate 3rd -to- 4th centuryBR43platecolourlessUncertain: late 1st -to- 4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massivecolourless1st -to- 4th centurybasebase1st -to- 4th centuryBR46fine walled glasscolourless1st -to- 4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to- 5th centuryBR49cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR50cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to-3th centuryBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupcolourlessUncertain: 4th -to-5th centuryBR56arched cupbrownish greenSth -to-6th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical		BR39 BR40	glass in gross	blue	Unknown Roman / Modiaval
BR42grooved cupbluish greenLate 3rd -to- 4th centuryBR43platecolourlessUncertain: late 1st -to- 4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1st -to- 4th centuryBR46fine walled glasscolourless1st -to- 4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to- 5th centuryBR49cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR50cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to- 3rd centuryBR54arched cupyellowish greenUncertain: 4th -to- 5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to- 5th centuryBR56arched cupyellowish greenUncertain: 4th -to- 5th centuryBR56arched cupcolourlessUncertain: 4th -to- 5th centuryBR57bellical cupbrownish greenUncertain: 4th -to- 5th centuryBR58bellical cupbrownish green5th -to- 6th century		BR40 BR41	alassin gross	yellowish green	Unknown
BR43platecolourlessUncertain: late 1st -to-4th centuryBR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1st -to-4th centuryBR46fine walled glasscolourless1st -to-4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to-5th centuryBR49cabuchon cup, base of corpblueLate 4th -to-5th centuryBR50cabuchon cup, corpyellowish greenLate 4th -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless greenUnknownBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical cupbrownish green5th -to-6th century		BR42	grooved cup	bluishgreen	Late 3 <sup>rd</sup> -to- 4 <sup>th</sup> century
BR44blown glassdark blueUnknownBR45fine walled glass and massive basecolourless1st -to-4th centuryBR46fine walled glasscolourless1st -to-4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to-5th centuryBR49cabuchon cup, base of corpblueLate 4th -to-5th centuryBR50cabuchon cup, corpyellowish greenLate 4th -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless greenUnknownBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical cupbrownish green5th -to-6th century		BR43	plate	colourless	Uncertain: late 1 <sup>st</sup> -to- 4 <sup>th</sup> century
BR45fine walled glass and massive basecolourless1st -to-4th centuryBR46fine walled glasscolourless1st -to-4th centuryBR47conical trunk cupyellowish greenUncertain 4th centuryBR48cabuchon cup, corpcolourless greenLate 4th -to-5th centuryBR49cabuchon cup, base of corpblueLate 4th -to-5th centuryBR50cabuchon cup, corpyellowish greenLate 4th -to-5th centuryBR51cabuchon cup, base of corpblueLate 4th -to-5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless greenUncertain: 4th -to-5th centuryBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupcolourlessUncertain: 4th -to-5th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical cupbrownish green5th -to-6th century		BR44	blown glass	dark blue	Unknown
BR46fine walled glasscolourless $1^{st}$ -to- $4^{th}$ centuryBR47conical trunk cupyellowish greenUncertain $4^{th}$ centuryBR48cabuchon cup, corpcolourless greenLate $4^{th}$ -to- $5^{th}$ centuryBR49cabuchon cup, base of corpblueLate $4^{th}$ -to- $5^{th}$ centuryBR50cabuchon cup, corpyellowish greenLate $4^{th}$ -to- $5^{th}$ centuryBR51cabuchon cup, base of corpblueLate $4^{th}$ -to- $5^{th}$ centuryBR51cabuchon cup, base of corpblueLate $4^{th}$ -to- $5^{th}$ centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless $1^{st}$ -to- $3^{rd}$ centuryBR54arched cupyellowish greenUncertain: $4^{th}$ -to- $5^{th}$ centuryBR55cylindrical cupyellowish greenUncertain: $4^{th}$ -to- $5^{th}$ centuryBR56arched cupcolourlessUncertain: $4^{th}$ -to- $5^{th}$ centuryBR57bellical cupbrownish green $5^{th}$ -to- $6^{th}$ centuryBR58bellical cupbrownish green $5^{th}$ -to- $6^{th}$ century		BR45	fine walled glass and massive base	colourless	1 <sup>st</sup> -to-4 <sup>th</sup> century
bK4/contrait trunk cupyenowish greenUncertain 4 <sup>th</sup> centuryBR48cabuchon cup, corpcolourless greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR49cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR50cabuchon cup, corpyellowish greenLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR51cabuchon cup, base of corpblueLate 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1 <sup>st</sup> -to - 3 <sup>th</sup> centuryBR54arched cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR55cylindrical cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR56arched cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR57bellical cupbrownish green5 <sup>th</sup> -to - 6 <sup>th</sup> centuryBR58bellical cupbrownish green5 <sup>th</sup> -to - 6 <sup>th</sup> century		BR46 PD 47	tine walled glass	colourless	1 <sup>st</sup> -to- 4 <sup>th</sup> century
BR49cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR50cabuchon cup, corpyellowish greenLate 4th -to- 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR51cabuchon cup, base of corpblueLate 4th -to- 5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to- 3th centuryBR54arched cupyellowish greenUncertain: 4th -to- 5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to- 5th centuryBR56arched cupcolourlessUncertain: 4th -to- 5th centuryBR57bellical cupbrownish green5th -to- 6th centuryBR58bellical cupbrownish green5th -to- 6th century		DK4/ BR48	conical trunk cup	yellowish green	Uncertain 4 <sup>th</sup> century
BR50cabactor cup, base of corpyellowish greenLate 4th -to-5th centuryBR51cabachon cup, base of corpblueLate 4th -to-5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to-5th centuryBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupyellowish greenUncertain: 4th -to-5th centuryBR57bellical cupbrownish greenUncertain: 4th -to-5th centuryBR58bellical cupbrownish green5th -to-6th century		BR40 BR49	cabuchon cup, torp	blue	Late 4 <sup>th</sup> -to- 5 <sup>th</sup> century
BR51cabuchon cup, base of corp base of corpblueLate 4th -to - 5th centuryBR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to - 3rd centuryBR54arched cupyellowish greenUncertain: 4th -to - 5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to - 5th centuryBR56arched cupcolourlessUncertain: 4th -to - 5th centuryBR57bellical cupbrownish green5th -to - 6th centuryBR58bellical cupbrownish green5th -to - 6th century		BR50	cabuchon cup, corp	yellowish green	Late 4 <sup>th</sup> -to- 5 <sup>th</sup> century
BR52hexagonal basecolourless greenUnknownBR53hemispherical cupcolourless1st -to-3rd centuryBR54arched cupyellowish greenUncertain: 4th -to-5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to-5th centuryBR56arched cupcolourlessUncertain: 4th -to-5th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical cupbrownish green5th -to-6th century		BR51	cabuchon cup, base of corp	blue	Late 4 <sup>th</sup> -to- 5 <sup>th</sup> century
BK53hemispherical cupcolourless1st -to- 3rd centuryBR54arched cupyellowish greenUncertain: 4th -to- 5th centuryBR55cylindrical cupyellowish greenUncertain: 4th -to- 5th centuryBR56arched cupcolourlessUncertain: 4th -to- 5th centuryBR57bellical cupbrownish green5th -to- 6th centuryBR58bellical cupbrownish green5th -to- 6th century		BR52	hexagonal base	colourless green	Unknown
BR54arched cupyenowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR55cylindrical cupyellowish greenUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR56arched cupcolourlessUncertain: 4 <sup>th</sup> -to - 5 <sup>th</sup> centuryBR57bellical cupbrownish green5 <sup>th</sup> -to - 6 <sup>th</sup> centuryBR58bellical cupbrownish green5 <sup>th</sup> -to - 6 <sup>th</sup> century		BR53 BR54	hemispherical cup	colourless	1 <sup>st</sup> -to- 3 <sup>rd</sup> century
BR56arched cupcolourlessUncertain: 4th -to-5th centuryBR57bellical cupbrownish green5th -to-6th centuryBR58bellical cupbrownish green5th -to-6th century		BR55	cylindrical cup	vellowish green	Uncertain: 4 <sup>th</sup> -to-5 <sup>th</sup> century
BR57bellical cupbrownish green5th -to - 6th centuryBR58bellical cupbrownish green5th -to - 6th century		BR56	arched cup	colourless	Uncertain: $4^{\text{th}}$ -to- $5^{\text{th}}$ century
BR58 bellical cup brownish green 5 <sup>th</sup> -to - 6 <sup>th</sup> century		BR57	bellical cup	brownish green	5 <sup>th</sup> -to- 6 <sup>th</sup> century
		BR58	bellical cup	brownish green	5 <sup>th</sup> -to- 6 <sup>th</sup> century

They were found at seven different archaeological sites in the Northwest of the Iberian Peninsula (Spain: 8 samples from Lugo (LU); 8 from Veranes (VR), Asturias; 13 from Astorga (AS), León; 8 from Castro de Viladonga (VL), Orense; 5 from Vigo (VG), Pontevedra and Portugal: 3 from Chaves (CH) and 58 from Braga (BR) (Fig. 1).

In all cases, minimal samples were taken to reduce any damage to archaeological objects. After cleaning in an ultrasonic bath with twice-distilled water and drying at 120°C, external layers were cleaned off the fragments with a diamond-coated wheel and the samples were then cut from each fragment with a diamond-coated saw. Prior to analysis, each sample was ground with a pestle in an agate mortar, to ensure homogeneity and to reduce particle size. Due to the very small samples in most cases (sometimes less than 100 mg), not all analyses could always be replicated.

### 2.2. Optical microscopic analyses

Samples were observed with a Minolta optical microscope to visualize possible physical defects. Several photographs were registered in digital format using two resolutions: x32 and x64 magnification.

#### 2.3. Chemical Analyses

Samples were dissolved as follows (García Giménez *et al,* 2005): a minimum amount of sample was treated with hydrofluoric acid in an open vessel, heating it on a hot plate until dry. This treatment was followed by the addition of aqua regia, followed once again by heating until dry. The residue was dissolved with 1ml of concentrated hydrochloric acid and diluted with water to the mark in Teflon volumetric flasks. Care was taken to keep any possible contamination to a minimum. Ultrapure water was used at all times and all reagents were of analytical grade. Chemical analyses of major and minor elements were performed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) in a Sciex Elan 6000 Perkin-Elmer spectrometer equipped with an AS91 autosampler. A total of 45 elements were de-

termined: Al<sub>2</sub>O<sub>3</sub>, CaO, K<sub>2</sub>O, Fe<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, MgO, MnO<sub>2</sub>, and TiO<sub>2</sub> as major elements; Ag, B, Ba, Be, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Ga, Gd, Ho, La, Li, Mo, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Sm, Sn, Sr, Tb, Th, U, V, W, Y, Zn and Zr as minor and trace elements. SiO<sub>2</sub> content was estimated by difference. Blank samples and standard samples were simultaneously taken for quality control purposes. Several certified reference glass materials (soda-lime flat glass NIST SRM 620, soda-lime float glass NIST SRM 1830 and soft borosilicate glass NIST SRM 1411) were used to evaluate the accuracy of the analysis, with an error of up to 5% in all cases for the certified elements.



Figure 1 Location of Archaeological Sites

#### 2.4. Statistical analysis

Statistical processing of the data was performed with the following programs: SPSS 18 Programme, STATGRAPHICS Plus 5.0 for Windows<sup>®</sup>, and Origin v. 75E. The first step was to obtain the main descriptive statistics for chemical concentrations (major and minor constituents) in the archaeological samples. The second step was to draw a ternary diagram as a function of their major elements (Marengo et al, 2005). The Box & Whisker plot, a histogram-like method, assisted interpretation of the data distribution and classification of the samples by archaeological sites. In this plot, each box encloses the middle 50% and the median is represented as a horizontal line inside the box. Vertical lines extending from each end of the box (called whiskers) enclose data

within the 1.5 interquartile ranges. Values falling beyond the whiskers, but within three interquartile ranges, are plotted as individual points (suspect outliers) as well as points that are further away (outliers). Finally, in a third step, owing to the large matrix of chemical results (103 samples x 45 variables), several multivariate statistical studies were also performed to establish relations between glass samples with similar chemical compositions and to discern significant differences between them, so as to shed further light on existing knowledge of Roman glass manufacture in the Northwest of the Iberian Peninsula. This procedure is useful for classifying the dataset into groups. It generates a small number of functions of quantitative measurements, which are linear combinations of the standardized pattern variables with weighted

coefficients. An assumption of this procedure is that the variables are drawn from populations with multivariate normal distributions and have equal variances.

#### 3. RESULTS AND DISCUSSION

#### 3.1 Chemical analysis

The content of such major elements as  $Al_2O_3$ , CaO,  $K_2O$ ,  $Fe_2O_3$ ,  $Na_2O$ , MgO,  $MnO_2$ ,  $TiO_2$  and  $SiO_2$  were analyzed to characterize the type of glass (Table 2).

Fig. 2 shows a ternary diagram with alkaline (Na<sub>2</sub>O + K<sub>2</sub>O), structural (SiO<sub>2</sub> + TiO<sub>2</sub>) and alkaline earth and other major constituents (MgO + CaO + Al<sub>2</sub>O<sub>3</sub> + MnO<sub>2</sub> + Fe<sub>2</sub>O<sub>3</sub>). Most of the glass fragments are located in the right vertex of the triangle with five samples from Braga and one from Vigo outside this group.



Figure 2. Ternary diagram of (MgO+CaO+Al<sub>2</sub>O<sub>3</sub>+MnO<sub>2</sub>+Fe<sub>2</sub>O<sub>3</sub>) – (Na<sub>2</sub>O+K<sub>2</sub>O) – (SiO<sub>2</sub>+TiO<sub>2</sub>) for the glass samples.

The results indicated that the samples are typical silica-soda-lime glasses (García Heras *et al*, 2005; da Cruz, 2009; Mirti *et al*, 2009), with low concentrations of MgO, CaO, Al<sub>2</sub>O<sub>3</sub>, MnO<sub>2</sub> and Fe<sub>2</sub>O<sub>3</sub>. The main component of the samples was SiO<sub>2</sub> with values of between 43 and 93% (with exception of three samples with lower contents) and with a concentration range of 0.2-30%

for Na<sub>2</sub>O and of 0.3-9% for CaO. Although this representation appears to indicate some similarity between the samples, a detailed Box & Whisker plot, classified by archaeological sites, revealed important differences (Fig. 3). Accordingly, glass from Lugo and Veranes glasses showed the lowest content of Na<sub>2</sub>O, while glass from Astorga, Braga and Vigo showed the highest content. Important amounts of CaO and MgO were found in the Vigo samples, while dispersed and elevated K<sub>2</sub>O concentrations were found in the Braga samples.

According to Liritzis *et al* (1997) the ratio (Na<sub>2</sub>O+K<sub>2</sub>O):(CaO+MgO) can be used to evaluate the recipe used by the several *glassmaking Schools*. In this way, ratio value

ranges for most samples from Lugo (3.1-3.6), Chaves (2.9-3.2), Castro de Villadonga and Vigo (2.8-3.2) indicate that they can be assigned to the *Metropolitan Roman School*; while most samples from Astorga (2.0-2.5) could be assigned to the *Provincial Roman School*.

Table 2.	Concentrations	of major elements	(expressed as	percentages of their 1	espective oxides)
		,	<b>`</b>		

Sample	Na <sub>2</sub> O	MgO	$Al_2O_3$	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>
LU01	17.1	0.35	1.63	0.41	3.35	0.05	0.25	0.45	76.5
LU02	5.95	0.15	0.80	0.20	1.60	0.02	0.11	0.19	91.0
LU03	22.4	0.77	3.39	0.67	5.64	0.13	0.61	1.37	65.0
LU04	6.81	0.54	1.33	0.22	1.60	0.13	0.52	0.79	88.0
LU05	16.8	0.39	1.61	0.38	3.16	0.05	0.23	0.42	77.0
LU06	9.23	0.32	1.55	0.26	2.72	0.03	0.13	0.43	85.3
LU07	13.1	0.32	2.02	0.52	3.72	0.04	0.12	0.50	79.7
LU08	6.22	0.13	0.73	0.19	1.46	0.02	0.11	0.19	91.0
VR01	5.34	0.37	nd	0.21	2.09	nd	0.01	0.18	91.8
VR02	3.09	1.13	4.53	0.92	9.13	0.15	1.03	1.48	78.5
VR03	16.2	0.30	1.91	0.64	4.89	0.07	0.01	0.75	75.2
VR04	6.81	0.30	1.39	0.22	1.82	0.13	0.53	0.79	88.0
VR05	16.6	0.27	3.07	0.98	6.49	0.07	0.32	0.67	71.5
VR06	7.14	0.67	3.49	0.56	4.97	0.54	1.58	2.99	78.1
VR07	22.2	0.96	3.08	0.98	2.97	0.21	0.62	2.71	66.3
VR08	16.5	0.32	1.95	0.67	4.89	0.07	0.01	0.75	74.8
AS01	19.7	0.55	2.42	0.45	4.79	0.07	0.02	1.02	71.0
AS02	16.4	0.27	3.03	0.98	6.64	0.07	0.24	0.67	71.7
AS03	16.1	0.25	2.97	0.92	6.54	0.05	0.23	0.62	72.3
AS04	13.3	0.66	2.69	0.32	4.76	0.26	0.85	1.78	75.4
AS05	11.7	0.27	2.36	0.27	5.68	0.03	0.07	0.25	79.4
AS06	13.1	0.65	2.72	0.31	4.87	0.22	0.80	1.71	75.6
AS07	18.6	0.28	3.26	0.79	6.32	0.07	0.93	0.66	69.1
AS08	30.3	6.14	2.82	0.80	6.04	0.09	0.02	1.14	52.7
AS09	33.2	0.60	2.97	0.76	6.47	0.09	0.03	1.17	54.7
AS10	17.1	3.52	1.60	0.41	3.63	0.05	0.27	0.51	73.0
AS11	24.9	0.38	2.96	0.67	6.04	0.09	0.02	1.01	64.0
AS12	30.5	6.27	2.86	0.83	6.19	0.10	0.02	1.20	52.0
AS13	30.2	0.63	2.95	0.74	6.33	0.09	0.03	1.19	57.8
VL01	16.5	0.30	2.06	0.64	5.14	0.07	0.03	0.72	74.6
VL02	6.75	0.11	0.76	0.19	1.64	0.02	0.11	0.19	90.2
VL03	15.1	0.44	2.49	0.77	4.96	0.30	1.20	2.17	72.5
VL04	15.0	0.45	2.54	0.82	5.12	0.29	1.21	2.08	72.5
VL05	14.4	0.48	2.53	0.80	4.96	0.27	1.20	2.00	73.3
VL06	14.6	0.46	2.49	0.78	0.53	0.27	1.19	2.09	77.6
VL07	14.9	0.48	2.51	0.82	0.54	0.28	1.17	2.07	77.2
VL08	17.1	0.75	3.73	0.68	5.62	0.49	2.02	4.00	65.6
VG01	30.7	1.07	3.77	0.91	8.86	0.15	0.94	1.43	52.1
VG02	23.2	0.99	2.01	0.89	6.49	0.06	0.82	22.3	43.3
VG03	30.4	1.13	3.90	0.92	9.01	0.15	1.02	1.48	52.0
VG04	19.4	0.28	3.37	0.79	6.83	0.07	0.96	0.69	67.6
VG05	25.5	0.87	3.09	0.61	8.00	0.15	1.03	1.55	59.2
CH01	16.3	0.27	3.03	0.98	6.64	0.07	0.32	0.67	71.7
CHI02	16.2	0.30	1.95	0.64	5.01	0.07	0.03	0.75	75.0
CH03	15.3	0.45	2.60	0.88	5.12	0.32	1.21	2.11	72.0
BR01	22.7	0.67	6.85	2.64	4.81	0.34	0.33	2.64	59.0
BR02	19.2	0.63	8.12	1.98	5.16	0.19	0.48	1.76	62.5
BR03	25.3	0.30	4.00	0.51	4.28	nd	0.73	0.03	64.9

Sample	Na <sub>2</sub> O	ΜσΟ	Al <sub>2</sub> O <sub>2</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO <sub>2</sub>	Fe2O2	SiO <sub>2</sub>
BD04	211	072	766	209	509	024	053	152	624
DINU4	120	0.12	22.4	2.02	1/3	0.21	0.23	7.52	53.5
DKUS	20.4	0.10	763	2.54	1.4.0	0.57	0.20	1.30	63.2
BR06	20.4	0.25	2.00	2.10	4.17	0.14 nd	0.00	4.00	61.7
BR07	24.5	0.23	2.21	1.40	3.00	0.52	2.20	4.02	(2.0
BR08	24.4	0.71	3.8/	1.4/	3.77	0.52	0.05	1.00	65.0 70.7
BR09	20.2	0.23	2.88	0.83	3.98	na	0.19	1.00	/0./
BR10	22.4	0.25	2.41	1.41	3.3/	nd	0.01	0.29	69.9
BR11	3.72	0.0/	6.43	0.45	0.50	nd	0.05	0.14	88.6
BR12	2,12	0.01	3.56	0.42	0.70	nd	0.01	0.11	93.1
BR13	11.5	0.16	1.32	1.09	2.78	nd	0.03	0.24	82.9
BR14	6.39	1.05	2.33	0.28	0.78	nd	0.04	0.23	88.9
BR15	7.43	0.05	4.31	0.26	0.84	nd	0.21	0.10	86.8
BR16	7.72	0.04	5.77	0.19	0.91	nd	0.14	nd	85.2
BR17	5.36	2.22	0.17	0.22	0.25	nd	0.01	0.15	91.6
BR18	7.42	0.22	0.95	0.56	1.27	0.04	0.46	1.23	87.9
BR19	10.4	0.11	1.21	0.27	0.27	nd	0.01	0.18	87.6
BR20	3.44	0.09	1.64	1.95	0.97	nd	0.01	0.38	91.5
BR21	0.200	0.38	25.3	6.61	0.59	0.65	0.01	11.69	54.6
BR22	3.19	3.19	26.8	29.8	4.04	0.29	0.03	4.26	28.3
BR23	4.21	3.54	32.4	27.3	3.78	0.46	0.03	3.87	24.4
BR24	5.65	3.78	33.7	28.5	4.56	0.54	0.10	3.21	19.9
BR25	21.8	0.38	2.43	2.00	3.16	nd	2.53	3.48	64.2
BR26	27.6	0.12	3.52	0.90	3.21	nd	0.57	1.35	62.7
BR27	29.1	0.06	3.57	0.80	3.41	nd	0.55	1.38	61.1
BR28	25.3	0.24	307	0.64	584	nd	0.87	0.02	641
BR20	27.6	014	2.89	0.94	3.88	016	0.52	2.56	61.3
BD20	24.6	0.58	3.87	1.85	299	nd	2.87	501	582
DIX30 PD21	21.0	0.67	6.28	3.54	4.85	034	0.68	1.86	59.4
DIGI	26.0	0.54	3.08	0.01	317	0.54	0.00	312	615
BK32	20.9	0.21	2.00	0.91	4.52	0.52	0.50	0.1Z 0.27	60.2
DK33	20.0	0.51	2.94	0.01	4.52	0.21 nd	0.23	2.57	50.2
BK34	20.5 24 E	0.00	2.05	1.59	4.0/	0.27	0.97	240	09.5 E0.0
BK35	24.3 26.1	0.82	0.21	1.52	4.52	0.2/	0.64	2.51	09.2 60.6
BK36	20.1	0.40	2.04	0.01	4.00	110 1	0.64	2.55	02.0
BR37	20.4	0.30	3.11	0.80	4.00	na	0.62	2.51	60.4 (4 E
BR38	22,4	0.40	2.50	1.50	3.02	na	2.10	3.62	64.5 (2.4
BR39	20.1	0.71	7.26	2.09	5.08	0.24	0.53	1.52	62.4
BR40	23.4	0.52	3.15	3.26	2,99	0.12	2.64	5.77	58.1
BR41	21.5	0.6/	2.87	2.4/	3.59	nd	2.84	3.51	62.5
BR42	28.4	0.08	4.60	1.37	4.02	nd	0.65	0.05	60.8
BR43	27.2	0.22	2.15	0.70	5.36	nd	0.41	0.01	64.0
BR44	29.2	nd	2.89	0.51	8.03	nd	0.39	2.14	56.8
BR45	28.5	nd	2.70	0.37	4.27	nd	0.16	0.12	63.9
BR46	29.0	0.03	1.44	0.41	3.94	nd	0.01	nd	65.2
BR47	27.1	0.05	3.25	0.95	3.70	nd	0.53	0.20	64.2
BR48	28.3	nd	2.31	1.13	4.00	nd	0.03	0.09	64.2
BR49	26.3	0.09	1.70	1.70	3.82	nd	0.72	0.12	65.5
BR50	28.5	nd	2.86	1.21	5.27	0.17	0.51	0.08	61.5
BR51	27.2	nd	2.40	1.15	4.30	0.12	0.46	0.06	64.4
BR52	27.7	nd	2.51	0.25	3.41	nd	0.18	0.04	66.0
BR53	28.0	nd	1.28	0.53	3.20	nd	0.02	nd	66.9
BR54	27.9	0.09	3.60	0.80	3.46	nd	0.40	0.16	63.6
BR55	28.2	nd	3.32	0.42	3.14	nd	0.08	nd	64.8
BR56	27.5	0.31	2.30	0.63	4.80	nd	0.27	1.96	62.2
BR57	23.2	0.36	2.76	1.60	3.79	nd	2.48	4.16	61.7
BR58	28.0	0.09	3.31	0.82	3.56	nd	0.48	1.12	62.6

nd= no detected (under quantification limit)

Iron can produce many different colours (from green or blue when Fe(II) ions are present to brownish-yellow with Fe(III) ions), mainly depending on the kiln atmosphere (Silvestri et al., 2005). Besides, additions of minor elements that improve the properties of the glass were also found. Thus, some elements such as Cu, Se, Co, Pb, Mn, Sb and Cr may have been used as chromophoric agents in glasses (Costagliola et al., 2000; Garcia-Heras et al., 2005; Carmona et al., 2008 and 2009). Elements such as Mn, Sb or Pb were often added as decolouring agents in the preparation of the final glass product and the most common opacifier was SnO<sub>2</sub> (Costagliola et al., 2000). On the other hand, trace elements are usually good indicators of the base raw material. The results of the minor and trace elements (expressed as mean ± standard deviation) are summarized in Table 3, distributed by archaeological sites. Among the Spanish glass fragments, the samples from Lugo had remarkable concentrations of Mo and U, those from Veranes of Co, V and Zn. Samples from Astorga were characterized by high contents of Ce, Cr and Zn, those from Castro de Villadonga of Ba and Zr. Samples from Vigo had elevated concentrations of Sr, having one of the fragments (VG02) the highest content of an opacifier element such as Sn. Among the Portuguese glass fragments, the Chaves glass samples showed notable concentrations of Ba, La, Zn and Zr and those from Braga had high concentrations of Ce, Co, Cu, Li, Ni, Rb and Th and low concentrations of V.

The elements Pb and Sb were intentionally added to samples as decolouring agents: there are 2 samples from Veranes, 6 from Astorga, 1 from Chaves and 1 from Castro de Viladonga with very high concentrations of Sb (>1000 ppm) and Pb (between 100 and 300 ppm), the results for both elements being more disperse in the Braga samples.

Cu is used as a chromophore element in glass. It had been added to several samples from Braga (some samples with a Cu content of over 1000 ppm), Veranes, Castro de Viladonga and Chaves.



Figure 3. Box and Whiskers graph of the major elements in the glass samples as a function of sample origin.

	SPAIN PORTICAL								
	Lugo	Lugo Veranes Astorga C. Viladonga Vigo				Chaves	Braga		
Element	mean + σ	mean + σ	mean + σ	mean + α	$mean + \sigma$	mean $\pm \sigma$	mean + σ		
Element	$0.1 \pm 11$	$05 \pm 09$	$03 \pm 05$	$07 \pm 07$	nd	$10 \pm 10$	11 + 32		
Ag	$0.4 \pm 1.1$ $101 \pm 96$	$0.5 \pm 0.9$	$0.5 \pm 0.5$	$0.7 \pm 0.7$	10 125 ± 90	$1.0 \pm 1.0$ $276 \pm 51$	$1.4 \pm 0.2$		
В	$121 \pm 00$	$190 \pm 121$ $194 \pm 147$	209 ± 100	$200 \pm 17$	$100 \pm 00$ $175 \pm 101$	$2/0 \pm 51$	$74 \pm 112$		
Ba	94 I 00	104 I 14/	157 I 40 0FF + 0F1	500 ± 100	1/3 ± 101	204 I 04	202 I 109		
Ве	0.90 ± 0.60	$0.41 \pm 0.52$	0.55 ± 0.51	$0.93 \pm 0.32$	$0.20 \pm 0.42$	0.74 ± 0.62	0.62 ± 0.99		
Ce	$5.9 \pm 3.3$	9.0 ± 4.6	$15 \pm 13$	$11.6 \pm 4.7$	$11.6 \pm 2.0$	11.0 ± 3.5	14 ± 1/		
Со	$2.7 \pm 1.4$	$137 \pm 3/4$	$3.0 \pm 1.5$	7.0 ± 7.2	9.2 ± 6.2	$5.7 \pm 4.0$	78 ± 205		
Cr	19.2 ± 9.2	$50 \pm 26$	212 ± 29/	55 ± 15	45 ± 23	52 ± 29	31 ± 8/		
Cs	0.1 ±3.5	nd	nd	nd	nd	nd	1.7 ± 4.9		
Cu	55 ± 72	204 ± 412	32 ± 17	197 ± 106	78 ± 51	120 ± 138	601 ± 1613		
Dy	$0.51 \pm 0.50$	$0.54 \pm 0.52$	$1.1 \pm 0.3$	$0.92 \pm 0.62$	$1.2 \pm 0.7$	$1.0 \pm 0.3$	0.51 ± 0.93		
Er	0.10 ± 0.32	nd	0.44 ± 0.51	$0.62 \pm 0.54$	$0.83 \pm 0.42$	0.75 ± 0.64	0.31 ± 0.62		
Eu	nd	0.11 ± 0.34	nd	0.12 ± 0.35	nd	nd	$0.32 \pm 0.30$		
Ga	2.2 ± 1.2	4.2 ± 1.2	$2.7 \pm 1.0$	3.9 ± 1.6	3.6 ± 1.5	4.0 ± 1.0	$1.9 \pm 4.0$		
Gd	$0.4 \pm 0.5$	$1.0\ \pm\ 0.7$	$1.0 \pm 0.9$	$1.0 \pm 0.5$	$1.2 \pm 0.4$	$1.0 \pm 0.0$	$1.2 \pm 1.9$		
Ho	nd	nd	nd	nd	nd	nd	$0.10 \pm 0.10$		
La	2.6 ± 1.6	4.9 ± 2.5	5.3 ± 1.3	4.6 ± 2.4	6.0 ± 1.0	284 ± 54	7.1 ± 9.5		
Li	6.2 ± 7.9	2.5 ± 2.7	21 ± 1.5	5.9 ± 2.9	0.8 ± 1.3	6.7 ± 2.1	11 ± 25		
Мо	6.2 ± 7.5	1.7 ± 1.7	0.6 ± 1.2	25 ± 1.2	0.8 ± 1.8	2.0 ± 1.0	0.5 ± 1.3		
Nd	2.7 ± 1.6	4.2 ± 2.2	4.8 ± 0.9	4.2 ± 2.3	4.6 ± 1.1	4.3 ± 0.6	7.2 ± 8.1		
Ni	8.8 ± 9.5	16 ± 13	14.5 ± 5.2	13.2 ± 4.9	11.0 ± 1.9	16.0 ± 5.3	58 ± 148		
Pb	63 ± 119	67 ± 85	67 ± 59	115 ± 66	760 ± 1592	125 ± 99	871 ± 4950		
Pr	0.92 ± 0.64	1.1 ± 0.6	1.5 ± 0.5	2.0 ± 1.1	1.4 ± 0.5	1.3 ± 0.6	1.8 ± 2.1		
Rb	4.1 ± 3.7	4.7 ± 4.1	4.6 ± 1.5	4.4 ± 1.8	9.2 ± 4.0	5.0 ± 1.7	28 ± 71		
Sb	105 ± 100	750 ± 1289	1645 ± 1775	367 ± 575	92 ± 60	728 ± 947	298 ± 517		
Sc	7.4 ± 4.0	13.2 ± 5.6	14.5 ± 7.6	16.0 ± 5.6	12.2 ± 8.4	19.0 ± 7.2	3.3 ± 5.3		
Sm	0.62 ± 0.51	1.0 ± 0.5	1.0 ± 0.9	$1.0 \pm 0.5$	1.0 ± 0.8	1.0 ± 0.9	1.2 ± 1.5		
Sn	nd	nd	13 ± 26	nd	1167 ± 2609	nd	16 ± 48		
Sr	181 ± 80	344 ± 146	430 ± 104	348 ± 108	636 ± 171	385 ± 18	272 ± 111		
Tb	nd	nd	nd	nd	nd	nd	0.13 ± 0.20		
Th	1.0 ± 1.3	0.64 ± 0.53	0.72 ± 0.55	$1.0 \pm 0.5$	$0.2 \pm 0.4$	0.70 ± 0.62	3.9 ± 6.5		
IJ	89 ± 134	51 ± 29	47 ± 19	48 ± 22	47 ± 11	56 ± 12	2.0 ± 3.9		
V	147 ± 85	467 ± 349	269 ± 241	384 ± 144	353 ± 360	405 ± 282	47 ± 87		
W	$0.14 \pm 0.31$	nd	$0.15 \pm 0.32$	nd	nd	nd	0.33 ± 0.91		
Ŷ	$3.0 \pm 1.3$	47 ± 25	$5.3 \pm 0.9$	$5.5 \pm 2.3$	$6.8 \pm 0.8$	$5.7 \pm 0.6$	$4.6 \pm 6.6$		
7n	49 ± 24	96 ± 123	98 ± 104	84 ± 52	31 ± 59	91 ± 87	37 ± 104		
Zn Zr	26 ± 18	72 ± 70	49 ± 27	123 ± 80	$1.8 \pm 0.8$	72 ± 55	35 ± 46		

Table 3. Minor and trace element concentrations (expressed in ppm).

*nd*= *no* detected (under quantification limit)

## 3.2. Optical microscopic analysis

Different faults were observed by optical microscopy in the glass samples. These were mainly mass irregularities due to the fusion process, solid material and stone inclusions, bubbles and differences in coloration and fractures. A few of these imperfections were subsequently chosen and can be seen in Fig. 4: a yellowish green colour glass corresponding to sample CH03 (Fig. 4a) shows elongated bubbles in the direction of the mass of molten glass. Fig. 4b (VR01) corresponds to an opaque black glass that shows small and tiny bubbles and a conchoidal fracture. The photograph of a blue-coloured sample fragment with few bubbles is included in Fig. 4c (VR07), Sample 4d is a yellowish-green piece from a bellical cup (LU04) with many typical glass bubbles with a dark-black profile. Fig. 4e shows a colourless piece of a cup (AS01) with bubbles set around a fracture. Fig. 4f (BR40) shows a green glass fragment with bubbles and oxides on different planes, while Fig 4g (AS13) shows a fragment of a colourless green chalice with iron oxides around a fracture. Finally, a fragment of a colourless conical cup can be seen in Fig 4h (VL06) with fractures filled with oxides and some bubbles.



Figure 4. Photographs of glass samples with different faults observed under optical microscopy, a) CH03 b) VR01 c) VR07 d) LU04 e) AS01 f) BR40 g) AS13 h) VL06.

#### 3.3. Discriminant statistical analysis

Supervised Pattern Recognition involving discriminant analysis was applied to all of the chemical results (Fig. 5). The glass fragments are represented as a function of two most outstanding canonical discriminant functions, which explain 79% of the total variance (66% for F1 and 13% for F2), thereby establishing a classification of the samples by their seven archaeological sites and their minor and trace element chemical compositions. These functions with *P*values less than 0.05 are statistically significant at the 95% confidence level. Function 1 is a linear combination of the different variables and the elements with the most significant standardized coefficients are Cu, Ni, Rb, Ag and some rare earth elements in the positive axis and Sc in the negative one. In case of function 2, these are Sc, Ba and Nb in the positive axis and Cr and V in the negative one. The samples found in each group are framed within an enclosure and are characterized by a centroid, represented by a non-solid black square symbol of a bigger size. This symbol represents the average for each group (unique values in the classification factor field) that uses the discriminant functions. Linear Discriminant Analysis means that we can clearly differentiate the Braga samples from the other samples, due mainly to their higher Cu content, as well as their notable contents of Ni, Rb, Ag and some rare earth elements. Considering the rest of the samples, those from Veranes were also characterized by their content of V. On the other hand, samples from Castro de Viladonga (Spain) and Chaves (Portugal) presented similarities

and were characterized by their content of B, Ba and Sc. In the same way, samples from Vigo, Astorga and Lugo were similar, but Sc concentrations were higher in the first two. In conclusion, we may say that: (i) there were significant differences between samples from Braga (Bracara Augusta, Portugal) and all of the other samples; (ii) these other samples may be sorted into three major groups: one formed by glass from Veranes; a second that includes samples from Vigo, Astorga and Lugo; and, a third that includes samples from Chaves and Castro de Viladonga; (iii) the statistical study led to the reclassification of six samples which were assigned to new groups, probably due to trade between different peoples: 2 samples from Castro de Viladonga (VL01 reassigned to Chaves and VL02 to Lugo), 2 from Veranes (VR04 reassigned to Lugo and VR05 to Astorga), 1 from Chaves (CH01 reassigned to Astorga) and 1 from Astorga (AS10 reassigned to Lugo).



Figure 5. Graphical representation of the samples as a function of two canonical discriminant functions according to the sample origin.

In this step, the discriminant functions were examined to determine the importance of each independent variable (chemical composition) in the inter-group discrimination. Subsequently, the group averages were examined for each important variable, to highlight the differences between the groups. The criterion with which to assign each individual score is therefore determined by constructing the classification matrices and interpreting the discriminant functions, in order to establish their classification accuracy. Reclassification of cases based on the new canonical variables was highly successful: 92.2% of cases (95 glass fragments) were correctly reclassified into their original categories. The incorrectly classified samples were reclassified according to the probability of their belonging to one group or another. In statistical terms, samples VG02 and VG05 were well classified, in spite of their differences with the other samples from the Vigo group. One of them (VG02) was rich in Pb (about 3600 ppm) and Sn (5800 ppm). The other (VG05) had a higher content in B, Zn and Sr than the rest of the group samples; however, they were statistically similar and formed part of the same group.

#### 4. CONCLUSIONS

Chemical characterization of selected glass samples has been performed to shed further light on existing knowledge of the manufacture of Roman glass in the Northwest of the Iberian Peninsula. Certain significant differences in major and minor constituents were observed among the seven archaeological sites under consideration. Major elements that determined the type of glass (typical soda-silica-lime glasses) and relative low concentrations of Mg, Ca, Al, Mn and Fe oxides were found with the exception of six samples. It is important to notice that there is a high dispersion in the major constituent compositions as a consequence of the evolution of the manufacturing processes of samples during a broad chronological range even if they are made in the same place. Minor elements intentionally added to improve the properties of the glass were detected, such as Sn as opacifier, Sb and Pb as decolouring agents, and Cu, Cr and Ni as chromophores. Trace elements, such as rare earth elements and associated elements, are indicators of the base raw material used to make the glass. The samples from Chaves had high contents of La, some glasses from Astorga and Braga had high contents of Ce, and others from Lugo had high contents of U.

Statistical analyses helped us to distinguish important peculiarities of each archaeological site as a function of its chemical composition. In this sense, (i) there were significant differences between the samples from Braga (Bracara Augusta, Portugal) and the other samples; (ii) These other samples may be sorted into three major groups: one formed by glass from Veranes; a second that includes samples from Vigo, Astorga and Lugo; and, a third that includes samples from Chaves and Castro de Viladonga; (iii) The statistical analysis and the chemical composition of six glass fragments (2) from Castro de Viladonga, 1 from Chaves, 2 from Veranes and 1 from Astorga) required the reclassification of their source to a different archaeological site. In all probability, they were discovered at some distance from their place of manufacture, probably due to local trade routes between different groups.

#### ACKNOWLEDGEMENTS

The authors wish to express their gratefulness to Dr Mario Rui Mendes Dias da Cruz who provided the archaeological samples and relevant archaeological information.

#### REFERENCES

- Alarcão, J. and Alarcão, A. (1967) *Vidros Romanos do Museu Arqueologico de Vila Vicosa, Conímbriga*. VI, Universidade de Coimbra, Coimbra, 1 - 45.
- Brems, D. Ganio, M. Latruwe, K. Balcaen, L. Carremans, M. Gimeno, D. Silvestri, A. Vanhaecke, F. Muchez, P. and Degryse, P. (2013a) Isotopes on the beach, part I: strontium isotope ratios as a provenance indicator for lime raw materials used in Roman glass-making, *Archaeometry*, vol. 55, 214 234.
- Brems, D. Ganio, M. Latruwe, K. Balcaen, L. Carremans, M. Gimeno, D. Silvestri, A. Vanhaecke, F. Muchez, P. and Degryse, P. (2013b) Isotopes on the beach, part II: neodymium isotopic analysis for the provenancing of Roman glass-making, *Ar-chaeometry*, vol. 55, 449 464.

- Carmona, N. Villegas, M.A. Castellanos, M.A. Montero, I. and García Heras. M. (2008) Análisis de vidrios romanos del yacimiento de la Dehesa de la Oliva (Patones, Madrid), *Cerámica y vidrio*, vol. VII, 319 - 328.
- Carmona, N. Villegas, M.A. Jimenez, P. Navarro, J. and Garcia-Heras, M. (2009). Islamic glasses from Al-Andalus. Characterisation of materials from a Murcian workshop (12th century A.D., Spain). *Journal of Cultural Heritage* vol 10, 439-445.
- Costagliola, P. Baldi, G. Cipriani, C. Pecchioni, E. and Buccianti, A. (2000). Mineralogical and chemical characterisation of the Medicean glass mosaic tesserae and mortars of the Grotta del Buontalenti, Giardino di Boboli, Florence, Italy. *Journal of Cultural Heritage* vol 1, 287-299.
- Da Cruz, M. (2009) *O Vidro Romano no Noroeste Peninsular. Um olhar a partir de Bracara Augusta.* Tesis Doctoral, Universidade do Minho, 316 pp.
- Degryse, P. and Schneider, J. (2008) Pliny the Elder and Sr-Nd isotopes: tracing the provenance of raw materials for Roman glass production. *Journal of Archaeological Science*, vol. 35, 1993 - 2000.
- Domínguez-Bella, S. and Jurado Fresnadillo, G. (2004) Análisis arqueométrico de los vidrios romanos de la Casa del Obispo (Cádiz), in M. J. Felíu (ed.), *Avances en Arqueometría* 2003, Universidad de Cádiz, Cádiz, pp. 129 - 137.
- Fleming, S.J. (1999) Roman Glass: Reflections on Cultural Change. Philadelphia: University of Pennsylvania. 220 pages.
- Foster H.E. and Jackson, C.M. (2009) The composition of "naturally coloured" late Roman vessel glass from Britain and the implications for models of glass production and supply. *Journal of Archaeological Science*, vol. 36, 189 204.
- Foster H.E. and Jackson, C.M. (2010) The composition of late Roman British colourless vessel glass: glass production and consumption". *Journal of Archaeological Science*, vol. 37, 3068 3080.
- Freestone I.C. Ponting M. and Hughes M.J. (2002) The origins of Byzantine glass from Maroni Petrera, Cyprus, *Archaeometry*, vol. 45, 257 272.
- Freestone, I.C. (2006) Glass production in Late Antiquity and the Early Islamic period: a geochemical prospective, in M. Maggetti, and B. Messiga (eds.) Geomaterials in Cultural Heritage. Geological Society of London Special Publication, pp. 201 - 216.
- Fuentes, A. Paz-Peralta, J.A. and Ortiz Palomar, E. (eds.) (2001) Vidrio Romano en España. La revolución del vidrio soplado. Fundación Centro Nacional del Vidrio. La Granja de San Ildefonso, Segovia.
- García Giménez, R., Vigil de la Villa, R., Recio de la Rosa, P., Petit Domínguez, M. D. and Rucandio, M. I. (2005) Analytical and multivariate study of Roman age architectural terracotta from northeast of Spain, *Talanta*, vol. 65, 861 - 868.
- García Heras, M. Rincón, J. M. Jiménez, P. and Villegas, M.A. (2005) Pre-Roman coloured glass beads from the Iberian Peninsula: a chemico-physical characterisation study. *Journal of Archaeological Science*, vol. 32, 727 738.
- García Heras, M. Sánchez del Prado, M. D., Carmona, N. Tendero, M. Ronda, A. M. and Villegas, M.A. (2007) Analytical study of Roman glasses from Southeastern Spain. *Archaeología Polona*, vol. 45, 63 - 78.
- Gliozzo, E., Santagostino Barbone, A. and D'Acapito, F. (2013) Waste glass, vessels and window-panes from *Thamusida* (Morocco): grouping natron-based blue-green and colourless Roman glasses. *Archaeometry*, vol. 55, 609 639
- Gómez Tubío, B. Ontalba Salamanca, M. A. Ortega Feliú, I. Respaldiza, M.A. Amores Carredano, F. and González Acuña, D. (2006) PIXE-PIGE analysis of late Roman glass fragments". *Nuclear instruments and methods in Physics Research B*, vol. 249, 616 - 621.

- Henderson, J. (2002) Tradition and experiment in first millennium A.D. glass production the emergence of early Islamic glass technology in late Antiquity. *Accounts of Chemical Research*, vol. 35, 594 - 602
- La Delfa, S. Ciliberto, E. and Pirri, L. (2008) Behaviour of copper and lead as chromophore elements in sodium silicate glasses. *Journal of Cultural Heritage*, vol. 9, 117 -122.
- Liritzis, I. Salter, C. and Hatcher, H. (1997) Chemical composition of some Greco-Roman glass fragments from Patras, Greece. European Journal of Pact, nº 45, I.2, 25-34.
- Marengo, E. Aceto, M. Robotti, E. Liparota, M.C., Bobba, M. and Pantó, G. (2005) Archaeometric characterisation of ancient pottery belonging to the archaeological site of Novalesa Abbey (Piedmont, Italy) by ICP-MS and spectroscopic techniques coupled to multivariate statistical tools. *Analytica Chimica Acta*, vol. 537, 359 -375.
- Mirti, P. Pace, M. Malandrino M. and Negro Ponzi, M. (2009) Sasanian glass from Veh Ardasır: new evidences by ICP-MS analysis. *Journal of Archaeological Science*, vol. 36, 1061 – 1069.
- Newton, R.C. and Davison, S. (1996) *Conservation of glass*, Butterworth-Heinemann, Oxford.
- Petit-Domínguez, M.D. Soto, I.S., García, R. Silva, M.P. and Rucandio, I. (2013) Analytical information on the composition of Roman Glass from Braga (Portugal). *Quaternary International*, vol. 308-309, 140-147.
- Rincón, J. M. (1984) Análisis y microestructura de vidrios Romanos de Mérida y Segóbriga. *Revista de Arqueología*, vol. 43, 34 - 39.
- Sánchez de Prado, M.D. (1984) El vidrio Romano en la provincia de Alicante, *Lucentum*, vol. 3, 79 100.
- Sayre, E.V. and Smith, R.V. (1961) Compositional categories of ancient glass. *Science*, vol. 133, 1824 1826.
- Silvestri, A. Molin, G. and Salviulo, G. (2005) Roman and Medieval Glass from the Italian area: bulk characterization and relationships with production technologies. *Archaeometry*, 47: 797 816.