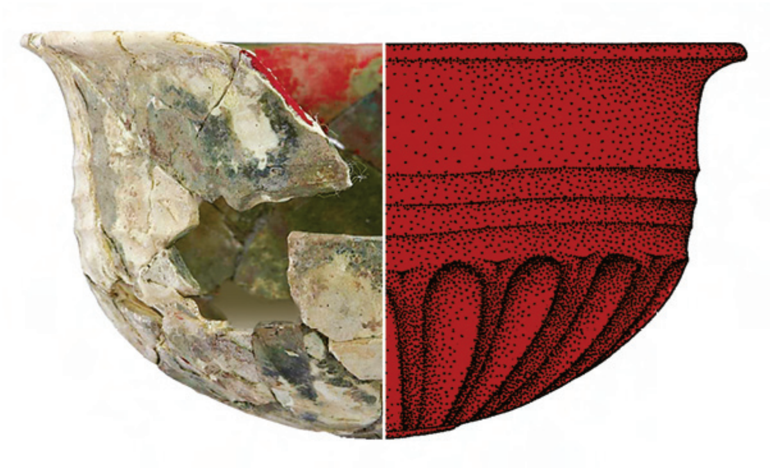
# ANNALES



*Thessaloniki 2009*

## du 18e CONGRÈS

de l'ASSOCIATION INTERNATIONALE
pour l'HISTOIRE du VERRE

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*Editors*
Despina Ignatiadou, Anastassios Antonaras



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Couverture / Cover illustration

The *haematinon* bowl from Pydna. Height 5.5 cm.

The bowl (skyphos) is discussed in the paper by Despina Ignatiadou 'A *haematinon* bowl from Pydna', p. 69.


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# PRÉFACE

Marie-Dominique Nenna

J'ai le grand plaisir de vous présenter les Annales du 18e congrès de l'Association Internationale pour l'Histoire du Verre et je tiens à remercier tous ceux qui ont fait que cette publication paraisse dans les meilleurs délais, les auteurs au premier chef, le comité de lecture et surtout les éditeurs du volume, Despina Ignatiadou, vice-présidente, puis membre du bureau de l'AIHV durant les années 2006-2012 et Anastassios Antonaras.

Le 18e congrès de l'AIHV s'est tenu à Thessalonique du 21 au 25 septembre 2009. Il a été dédié à Clasina Isings qui est venue, via une video, nous offrir ses meilleurs vœux au début des sessions. Tous nos remerciements vont d'abord au Musée archéologique de Thessalonique qui a organisé l'ensemble de cette manifestation et au Musée de la civilisation byzantine qui a accueilli nos sessions dans le tout nouveau auditorium, utilisé pour la première fois pour notre congrès. Remercions aussi les amis du Musée archéologique de Thessalonique qui ont soutenu ce congrès avec entre autres, le beau sac décoré de balsamaires-oiseaux ; la préfecture de Thessalonique qui nous ont accueillis à la fin de ces journées. Et enfin, du fond du coeur, tous nos remerciements vont à Despina Ignatiadou, Anastassios Antonaras et au comité d'organisation pour avoir réuni tous leurs efforts pour organiser ce congrès et nous offrir l'occasion de nous rencontrer une nouvelle fois pour partager nos découvertes et nos réflexions sur ce matériau qui nous passionne tous.

Durant les trente-trois sessions organisées en parallèle, 95 contributions orales et 55 posters ont été présentés, montrant ainsi la vitalité de la recherche sur l'Histoire du Verre dans l'ensemble du monde scientifique. Grâce au dynamisme du comité grec, après une découverte de la ville à l'orée de notre congrès, des promenades thématiques ont été organisées afin de mieux connaître les différents aspects de Thessalonique, ville hellénistique et romaine, ville byzantine, ville ottomane avec son importante communauté juive et ville du XXe siècle. En outre, les excursions post-congrès ont permis aux participants de découvrir le cœur de la Macédoine avec les cités de Vergina et de Dion, ainsi que le lac de Pikrolimni, producteur de natron dans l'Antiquité et encore aujourd'hui, les villes d'Amphipolis et de Philippes ou encore de faire une croisière autour du Mont Athos.

Ce volume réunit 84 contributions qui couvrent un arc chronologique très vaste depuis le deuxième millénaire av. J.-C. jusqu'à nos jours, et touchent à tous les aspects de l'histoire du verre, avec une bonne interconnexion entre l'archéologie, l'histoire de l'art et l'archéométrie. Une part importante est réservée aux débuts de l'histoire du verre au IIe millénaire et au début du Ier millénaire av. J.-C. et à ses développements dans le monde hellénistique avec des communications portant sur le Proche-Orient, l'Égypte et le Soudan, la Grèce et la Turquie. Les mondes romain et byzantin sont abordés selon deux axes : étude de la production et de la consommation de la vaisselle et des ornements et étude en fort développement de l'emploi du verre dans les mosaïques pavimentales et pariétales. Les communications sur le monde islamique s'inscrivent dans la lancée inaugurée au 15e congrès et attestent la vitalité de la recherche dans ce domaine. La présentation de découvertes et études portant sur la Grande Bretagne, l'Italie, le Kosovo, le Montenegro, le Portugal, la Pologne, la Roumanie, la Serbie et la Tchéquie alimentent le débat sur le verre à l'époque médiévale et post médiévale en Europe. XVIIIe et XIXe siècles ne sont pas en reste, avec des communications sur le verre dans les toits, les fleurs de verre et le verre mosaïqué et on dispose aussi de communications sur le verre en Chine méridionale et en Afrique subsaharienne.

Lors de l'assemblée générale, le bureau de l'AIHV a été renouvelé. Jan Egbert Kuipers, trésorier et Ian Freestone, que l'on doit remercier pour leur dévouement et leur efficacité, ont présenté leur démissions. De nouveaux membres ont été élus : Irena Lazar, organisatrice du 19e congrès en 2012, comme vice-présidente et Huib Tijssens, comme trésorier. Déjà présents dans le bureau, Despina Ignatiadou a été élue comme membre, Jane Spillman a été réélue comme secrétaire général, David Whitehouse comme membre, et j'ai moi-même été réélue comme présidente. Le comité exécutif réunissant six membres élus ainsi que les représentants des associations ou comités nationaux a été en partie renouvelé, avec l'élection de Fatma Marii et de Yoko Shindo, tandis que Sylvia Fünfschilling, Lisa Pilosi, Marianne Stern et Maria Grazia Diani ont été réélues. Nous avons déploré le décès lors du congrès de deux de nos membres, Sarah Jennings d'Angleterre et Claudia Maccabruni d'Italie.

Les préparatifs pour le 19e congrès se déroulent sous la houlette d'Irena Lazar. Le congrès se tiendra à Piran en Slovénie du 17 au 21 septembre 2012 (www.aihv.org, www.zrs.upr.si). Après l'accent mis sur la Méditerranée orientale au congrès de Thessalonique, une nouvelle avancée vers les informations et les membres d'Europe Centrale sera effectuée à Piran.

# PREFACE

Marie-Dominique Nenna

I have great pleasure in presenting you with the Annales of the 18th congress of the Association Internationale pour l'Histoire du Verre, and I wish to thank all those who have ensured that this publication appears with the least delay: principally the authors, the academic committee, and especially the academic editors of the volume, Despina Ignatiadou, vice-president, and member of the board of the AIHV for the years 2006-2012 and Anastassios Antonaras.

The 18th congress of the AIHV was held in Thessaloniki from September 21st-25th, 2009. It was dedicated to Clasina Isings, who came, via a video, to offer us her best wishes. Here we have to warmly thank the Archaeological Museum of Thessaloniki which has organized the whole manifestation, and the Museum of Byzantine Culture, which has hosted our sessions in the brand new auditorium of the Museum, used for the first time for our congress. All our warm thanks also to The Friends of the Archaeological Museum of Thessaloniki who supported the organization of the congress among the others with the nice bag decorated with bird-balsamaria, and The Prefecture of Thessaloniki, who has hosted us at the end of the congress. Last, but not the least, from the bottom of our heart, our thanks go to Despina Ignatiadou, Anastassios Antonaras and the Organizing committee for their hard work in organizing this congress and for offering us the opportunity to meet once again to share our discoveries and our thoughts on this wonderful material, glass, to which we are all dedicated.

During the 33 parallel sessions, 95 oral communications and 55 posters were presented, displaying the vitality of research on the history of glass in the scientific world. Thanks to the energies of the Greek Committee, after a first glance at Thessaloniki at the beginning of our congress, thematic visits were organised to discover the different aspects of Thessaloniki· Hellenistic and Roman city, Byzantine city, Ottoman city with its important Jewish community, contemporary city. In the post-congress trips, the participants were able to visit the heart of Macedonia, with the cities of Vergina and Dion, and the Pikrolimni Lake, producing natron in Antiquity and still today, the ancient cities of Amphipolis and Philippi, or to make a cruise around Mount Athos.

This volume brings together 84 contributions, which cover a vast chronological span from the second millennium BC up to the present day, touching on all aspects of the history of glass with a good networking between archaeology, history of art and archaeometry. An important part is devoted to the beginnings of the history of glass in the second millennium and the beginning of the first millennium BC, and the developments in the Hellenistic world with papers covering the Near East, Egypt and Sudan, Greece and Turkey. The Roman and Byzantine worlds are approached from two directions: the study of the production and consumption of vessels and ornaments and the expanding study on the glass in mosaic pavements and walls. The papers on the Islamic world build on the start made at the 15th congress and show the vitality of research in this area. The presentation of discoveries and research coming from the Czech Republic, Great Britain, Italy, Kosovo, Montenegro, Portugal, Poland, Romania and Serbia, fuels the debates about glass during the medieval and post-medieval period in Europe. The 18th and 19th centuries are not ignored, with papers dealing with glass in roofs, glass flowers and mosaic glass and there are also studies dealing with African and Asian glass.

During the General Assembly the board of the AIHV changed. Jan Egbert Kuipers (Treasurer) and Ian Freestone, to whom we extend all thanks for their work, submitted their resignations. The newly elected members were Irena Lazar, organizer of the 19th Congress in 2012, as Vice President, and Huib Tijssens, as Treasurer. Already present in the board, Despina Ignatiadou was elected member, were re-elected Jane Spillman as General Secretary, David Whitehouse as member, and I as President. The executive committee which assembled six elected members as well as the presidents of the national Associations or Committees, was partly renewed, with the election of Fatma Marii and Yoko Shindo; Sylvia Fünfschilling, Lisa Pilosi, Marianne Stern et Maria Grazia Diani were re-elected. We mourned during the congress the recent death of two long time members, Sarah Jennings from England and Claudia Maccabruni from Italy.

The preparations for the 19th congress are progressing under the guidance of Irena Lazar. The congress will be held at Piran (Slovenia) from September 17th to September 21st 2012 (www.aihv.org, www.zrs.upr.si). After the wider opening towards eastern Mediterranean members effectuated during the Thessaloniki Congress, we will receive in Piran more information and members coming from Central Europe.

# THE COMPOSITION OF WINDOW GLASS FROM THE CESSPITS IN THE OLD TOWN IN ELBLĄG, POLAND

Jerzy J. Kunicki-Goldfinger, Joachim Kierzek, Ian C. Freestone, Bozena Małożewska-Bućko, Grażyna Nawrolska

Window glass recovered from cesspits, if not bearing any signs of decoration or characteristic technological features, constitutes a serious problem for archaeologists, as there are almost no grounds on which to date it or to ascertain its origin. Moreover, the stratigraphy of many cesspits does not allow us to date the fragments by association with other artefacts that can be dated stylistically. Often heavier objects were dislocated down the profile and as a result, their placement within the stratigraphy does not necessarily reflect the time when they were discarded. Chemical analysis may constitute an important tool in such research. However, dating and determination of the provenance of window glass based on chemical composition has attracted the attention of glass researchers only during the last decade[1].

The aim of this study is to report some results and the preliminary interpretation of chemical analysis of the first group of window glass fragments found in the cesspits in the Old Town of Elbląg (Elbing). The results allowed us to group the glass finds by their chemical composition and to tentatively characterise the post-medieval window glass used in the region.

## Elbląg

Elbląg is situated close to the Baltic Sea (nearest large city is Gdańsk) in the northern Poland. The history of the town goes back to the first half of the 13$^{th}$ century. It was founded by the Teutonic Order and was a State capital until 1309. From 1466 it was a part of the Polish Kingdom and by the end of the 18$^{th}$ century it was incorporated into Prussia. The city played an important role in the Hanseatic League. During the Second World War, about 90 % of Elbląg was destroyed. Since the beginning of the 1980s, the Old Town has been slowly but systematically reconstructed. Before the reconstruction, the site was carefully explored and examined[2]. To date, the archaeological excavations have covered 15000 $m^2$, including over 200 cesspits, comprising about 8 % of the Old Town area. Glass finds and among them window glass fragments constitute an important part of the material recovered.

## Samples and Methods

50 pieces of window glass excavated from cesspits in trench XXII (covering the yard of 16 houses) in the Old Town in Elbląg were selected for sampling. The window glass was found typically in the mid or upper layers of the cesspits, which date from the fourteenth to the nineteenth centuries. The 50 fragments analysed in the present study were selected arbitrarily from among a few hundreds of similar objects. For the reasons stated above, it was not possible to date them. Most of the fragments are in greenish plain glass, seven items are clear, five are greenish crown glass and one item is tinted, stained, painted and enamelled. Each sample, taken with the use of a diamond tool, was split into two parts and analysed separately using SEM-EDS and total reflection X-ray fluorescence spectrometry (TXRF).

The major glass components, present above about 0.1 %, including $Na_2O$, MgO, $SiO_2$, $P_2O_5$, $SO_3$, Cl, $K_2O$, CaO, $TiO_2$, MnO, $Fe_2O_3$, CuO, BaO, and ZnO were analysed with the use of SEM-EDS. Samples were embedded in epoxy resin (EpoFix), ground flat with silicon carbide, polished with diamond pastes down to 0.25 μm and finally coated with a thin layer of carbon. They were analysed using a CamScan Maxim 2040 scanning electron microscope equipped with an Oxford Instruments ISIS energy dispersive X-ray spectrometer at the Cardiff School of History and Ar-

1. Paynter and Doonan 2002; Schalm *et al.* 2003; Dungworth 2006; Dungworth and Cromwell 2006; Bayley *et al.* 2009; Dungworth and Loaring 2009; Lagabrielle and Philippe 2009; Schalm *et al.* 2009; Verità 2009.

2. Nawrolska 1997.

Table 1: Average and simplified chemical composition of distinguished groups of window glasses (in weight percentage). Number of items within each group given in parenthesis.

| Group | | $Na_2O$ | $K_2O$ | $Na_2O$ $+K_2O$ | CaO | MgO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MnO | $P_2O_5$ | Cl | $Rb_2O$ | SrO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LMg(Na)** | (2) | 9.2 | 0.7 | 9.9 | 15.3 | 0.3 | 71.1 | 1.9 | 0.3 | 0.0 | <0.1 | 0.1 | 0.0022 | 0.0107 |
| **LMg(K)** | (2) | 1.3 | 21.4 | 22.7 | 8.1 | 0.4 | 66.5 | 0.5 | 0.2 | 0.1 | 0.3 | 0.3 | 0.0340 | 0.0115 |
| **HNa** | (2) | 11.7 | 3.8 | 15.5 | 10.4 | 3.3 | 66.0 | 1.3 | 0.6 | 0.9 | 0.1 | 0.9 | 0.0032 | 0.0751 |
| **HK** | (5) | 0.1 | 20.8 | 20.1 | 18.8 | 3.3 | 51.5 | 2.4 | 0.3 | 0.8 | 1.3 | 0.1 | 0.0893 | 0.0725 |
| **Kelp** | (6) | 6.2 | 4.0 | 10.4 | 16.2 | 5.0 | 60.7 | 2.6 | 0.9 | 0.3 | 1.9 | 0.9 | 0.0027 | 0.3084 |
| **HLLA** | (26) | 1.8 | 4.4 | 6.1 | 23.8 | 2.8 | 58.5 | 2.9 | 0.9 | 0.7 | 2.4 | 0.4 | 0.0104 | 0.0750 |
| **HLLA I** | (4) | 3.6 | 1.9 | 5.5 | 22.9 | 2.6 | 59.4 | 3.8 | 1.3 | 0.6 | 2.0 | 0.9 | 0.0045 | 0.0661 |
| **HLLA II** | (12) | 2.1 | 2.9 | 5.0 | 25.1 | 2.2 | 59.8 | 2.5 | 0.8 | 0.6 | 2.2 | 0.6 | 0.0070 | 0.0715 |
| **HLLA III** | (10) | 0.7 | 7.1 | 7.8 | 22.6 | 3.5 | 56.4 | 3.0 | 1.0 | 1.0 | 2.9 | 0.1 | 0.0168 | 0.0828 |

chaeology, Cardiff University, Wales, U.K. For elemental analysis, the electron beam was rastered at a magnification of 500x over an area of fresh glass for 100 s, at 20 kV accelerating voltage. Count-rate on metallic cobalt was around 4000 cps. Standards were pure oxides and minerals and quantification was carried out using the ZAF method. Oxide weight percents were calculated stoichiometrically. Analytical totals were typically between 98 % and 102 % and have been normalised to 100 % for comparative purposes.

K, Ca, Ti, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Ba, Pb, and Bi were analysed using total reflection X-ray fluorescence spectrometry (TXRF)[3] with a detection limit typically about 20 ppm. Samples of 1-5 mg of mass were dissolved in Teflon vessels in 500 µl of 48 % HF with an addition of 150 µl of 70 % $HClO_4$ and left to evaporate to dryness at a temperature of 50-60 °C. The dry residues were dissolved in 1 ml of $H_2O$ and 250 µl of 37 % HCl at 50 °C. The solutions were transferred into calibrated flasks (5 ml), and an internal gallium standard solution was added to achieve a concentration of Ga equal to 1 ppm. 5 ml of the solutions were pipetted onto quartz discs and dried in a vacuum desiccator. The analyses were carried out using a PicoTAX$_{MS}$ TXRF spectrometer (Institut für Umwelttechnologien, Berlin), equipped with an Si(Li) detector, ORTEC electronic line and an Mo lamp (2000 W, Seifert), at the Institute of Nuclear Chemistry and Technology in Warsaw, Poland. The live-time of the measurements was 1000 s.

3. Klockenkämper 1997.

Reference glass Corning D[4] was used as a secondary reference material and good agreement between recommended and analysed results was obtained in the case of both methods.

## Results and Discussion

This report concerns those results which appear important for the preliminary characterisation of the window glasses. Twelve constituents are taken into consideration: soda ($Na_2O$), magnesia (MgO), alumina ($Al_2O_3$), silica ($SiO_2$), phosphorus oxide ($P_2O_5$), chlorine (Cl), potash ($K_2O$), lime (CaO), iron oxide ($Fe_2O_3$), manganese oxide (MnO), rubidium oxide ($Rb_2O$), and strontium oxide (SrO). Rb and Sr were analysed with the use of TXRF and all remaining results discussed were obtained with SEM-EDS.

The results allow us to distinguish 6 main groups of glasses. Their simplified and averaged chemical compositions are shown in Table 1 and they are also shown on figures 1-4. Seven items are not included – three leached glasses and four outliers, which do not form part of any specific chemical grouping.

**LMg(Na)** – a group of low-magnesia and high-soda glasses; this group consists of 2 glasses made with refined soda and, on the basis of its low Cl content, most probably originated in the 19th century (when the Leblanc process started to dominate in Europe)[5].

4. Brill 1999.
5. Clow and Clow 1952.

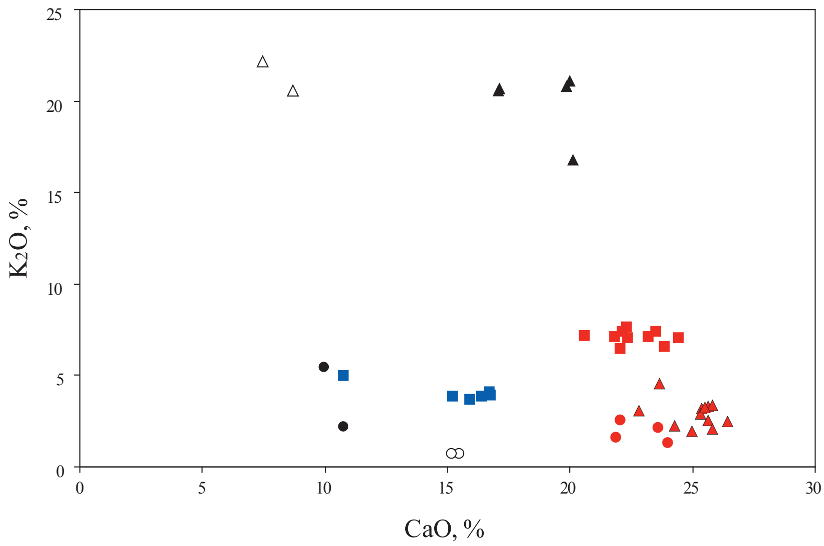


Fig. 1: Scatter plot for lime (CaO) against potash (K2O), in weight percentage.

△LMg(K) ○LMg(Na) ▲HK ●HNa ■Kelp ●HLLA I ▲HLLA II ■HLLA III

This glass is characterised by very low concentrations or the absence of constituents such as potash ($K_2O$), phosphorus oxide ($P_2O_5$), iron oxide ($Fe_2O_3$), manganese oxide (MnO), and magnesia (MgO). The soda content and consequently, due to the lack of potash, the total alkali content reaches about 9 %, while the silica ($SiO_2$) content is about 70 % and lime (CaO) about 15 %.

**LMg(K)** – a group of low-magnesia and high-potash glasses consisting of 2 glasses made with refined potash (or even with a mixture of refined potash and saltpetre) and originating in the 18th century or later. The glass is characterised by high potassium oxide concentrations (~21 %), as well as low magnesia (MgO) and phosphorus oxide ($P_2O_5$) contents. The concentration of manganese oxide (MnO) is also low, as in the case of the LMg(Na) group. The LMg(K) glasses could be manufactured even earlier than LMg(Na) glasses, as saltpetre as well refined potash had been introduced long before Nicolas Leblanc developed about 1790 his method to convert salt (NaCl) into refined soda ($Na_2CO_3$)[6]. However, this does not indicate that these particular fragments are of an earlier origin.

**HNa** – a group of high-soda glasses; the group consists of 2 items resembling soda plant ash glass[7], containing both magnesia (MgO) and potash ($K_2O$) at moderate levels of a few percent, with high soda contents, and low phosphorus oxide.

**HK** – a group comprising 5 high-potash glasses and representing traditional wood ash glass with high potash ($K_2O$) (~21 %) and lime (CaO), moderate magnesia (MgO) and phosphorus oxide ($P_2O_5$), while silica ($SiO_2$) content is relatively low, at approximately 51.5 %. Such glasses are often referred as potash-lime or simply forest glasses[8]. This high-potash glass, when potassium is introduced as a component of wood ash (or to less extent as a component of its refined product), was also characterised by increased rubidium oxide ($Rb_2O$) content (Fig. 2).

**Kelp** – a group of mixed alkali glasses made with kelp (seaweed)[9]; the group consists of 6 glasses. It is a typical mixed alkali glass characterised by moderate amounts of magnesia (MgO) and very high strontium oxide (SrO>2000 ppm) – fig. 2[10]. However, among these 6 items, it is possible to distinguish a sub-group of 5 items with a concentration of lime (CaO) ca. 16.2 %, while the sixth glass contains 10.8 % of lime (CaO). It seems that only this last one exactly fits the characteristic of British kelp glass as described by Dungworth[11]. The two groups suggest that glass made from kelp may have a range of chemical compositions, as a consequence of variations in the types/sources/preparation methods of seaweed. It appears that the strontium and magnesium contents remain around the same typical level.

6. Clow and Clow 1952.
7. Brill 1999.
8. Wedephol 2003; Wedephol *et al.* 2011.
9. Clow and Clow 1952.
10. Dungworth 2006; Dungworth and Cromwell 2006; Dungworth *et al.* 2009.
11. Dungworth 2006; Dungworth and Cromwell 2006; Dungworth *et al.* 2009.

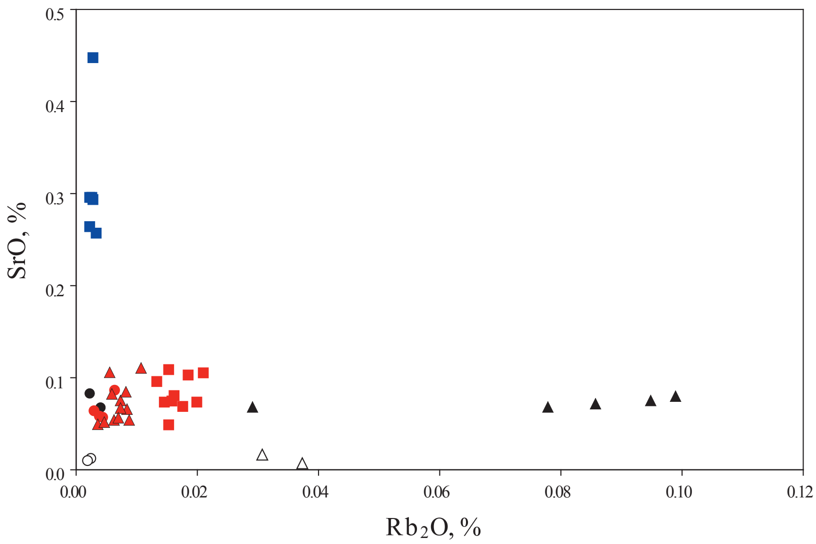


Fig. 2: Scatter plot for rubidium oxide ($Rb_2O$) against strontium oxide (SrO), in weight percentage.

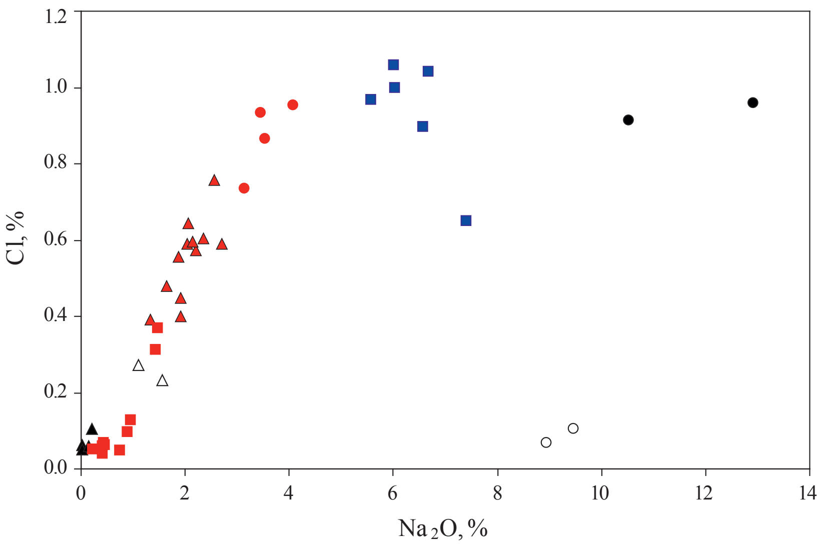


Fig. 3: Scatter plot for soda ($Na_2O$) against chlorine (Cl), in weight percentage.

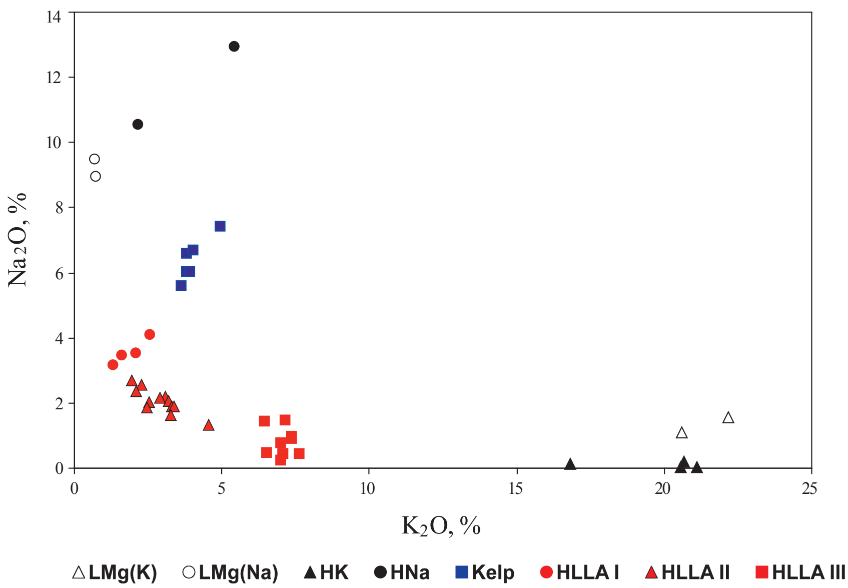


Fig. 4: Scatter plot for potash ($K_2O$) against soda ($Na_2O$), in weight percentage.

**HLLA** – this group of high-lime and low-alkali wood ash glasses (Fig. 1) consists of 26 items. This type is considered to be forest glass, of similar origin to the high-potash glass group (HK)[12]. However, this HLLA group also appears to be very inhomogeneous, consisting of at least 3 subgroups (excluding 4 outliers) – Table 1. The most outstanding sub-group is the third (III), which is characterised by the highest content of potash ($K_2O$) and very low chlorine (Cl) and soda ($Na_2O$). Sub-groups I and II are very similar to each other and both are characterised by slightly higher concentrations of soda ($Na_2O$) and chlorine (Cl) as well as by lower contents of potash ($K_2O$) and similar total alkali contents that are far less than for sub-group III. However, while the total alkali contents for subgroups I and II are similar, the corresponding ratios of soda ($Na_2O$)/potash ($K_2O$) are different. The glasses in sub-group I contain more soda ($Na_2O$) and those from sub-group II contain more potash ($K_2O$).

Fig. 3 shows the correlation between soda ($Na_2O$) and chlorine (Cl) in the case of almost all HLLA glasses. A manufacturing process involving the addition of NaCl to increase the alkalinity of glasses melted with low potassium wood ash (subgroups I & II) seems to be only feasible explanation for this effect, as noted elsewhere[13]. However, as fig. 4 shows, a negative correlation between soda ($Na_2O$) and potash ($K_2O$), which might be expected if the purpose of the NaCl was to compensate for low $K_2O$, can be observed only in the case of sub-group II.

As to the appearance of the fragments, clear glasses were typically LMg(Na) or LMg(K) with just two examples of HLLA type. However, most of the HLLA glasses were greenish, as was the kelp glass. All crown glasses, also greenish, were of the HNa and HK types.

## Conclusions

The results show that a considerable diversity of window glass types were used in Elbląg. Almost all of the main window glass types referred to in the literature were encountered, including soda plant ash glass. The project also allowed us to identify the use of kelp in window glass production in this part of Europe for the first time.

The majority of glasses analysed represent typical wood ash technologies. Both the traditional wood ash glass with a high potassium content and high-lime, low-alkali (HLLA) wood ash glass were found. However, HLLA glass seems to be the dominant group. Among HLLA glasses, further subgroups and at least four outliers, which were excluded from the discussion here, may be distinguished suggesting several different origins.

The project also identified a group of HLLA glasses made with wood ash of very low potassium concentration. To compensate for this, it is supposed that NaCl was added to the glass batches as an additional source of alkali. This suggestion in general remains in agreement with previously published results[14]. Nevertheless, while this explanation is strongly supported in the case of one subgroup (subgroup II) which shows the expected negative correlation between potash ($K_2O$) and soda ($Na_2O$), the others do not show this effect and are therefore more ambivalent.

While the results show a wide range of window glass types used in Elbląg, they do not allow us to generalise as to the dates of specific groups, to identify which represent local production (if any) and which were imported. Even so, while we cannot be sure that our sample is fully representative of glass across the whole of Elbląg, it appears likely that window glass was in use over much of the period 14$^{th}$-19$^{th}$ centuries and possibly from a number of sources. These results are very encouraging for the further development of this approach to investigate the dates and origins of window glass from the region.

The first model detailing chronological changes in window glass composition has already appeared[15]. However, it is concerned only with window glass in Britain and it seems unlikely that it will be applicable to the entire continent. Further investigations, of glass from other regions, are essential so that the approach can be extended to interpret sites such as Elbląg.

## Aknowledgments

This is a preliminary report, as not all aspects of the excavation or the glass assemblage have been fully researched yet. I would like to thank the excavators Gideon Avni and Jon Seligman of the Israel Antiquities Authority for the opportunity to study the glass finds, and my colleagues Yael Gorin-Rosen and Natalya Katsnelson for their advice on the manuscript. Thanks are also due to Alla Nagorsky, who first examined the 'holy water' bottles. The vessels were mended by Olga Shorr, photographed by Clara Amit, and drawn by Michael Miles, with supplements drawn by Alina Pikovsky, Carmen Hersch and Noga Ze'evi.

12. Wedephol 2003; Schalm *et al.* 2009.
13. Gerth *et al.* 1998; Schalm *et al.* 2009.
14. Gerth *et al.* 1998; Schalm *et al.* 2009.
15. Dungworth and Loaring 2009; Bayley *et al.* 2009.

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