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Glassy faience from the Hallstatt C period in Poland: a chemico-physical study

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ABSTRACT

Beads and pin heads made of *glassy faience*, often decorated with true *glass*, discovered at seven different cemetery sites in Poland and dated chiefly to the Hallstatt C period (c. 750/700–600 BC), were examined by the LA-ICPMS and EPMA methods. The analysis involved 48 samples from 39 objects. The main objectives were: (i) to characterize the glassy faience in terms of the physical structure and chemical composition of the glass; (ii) to evaluate differences in the chemical composition of the glass forming the glassy faience; (iii) to examine the chemical composition of the true glass in the decoration on objects made of glassy faience. Glassy faience was found to be made of glass and numerous quartz grains, inclusions and gas bubbles. Manifest in the true glass of the decoration were numerous minor inclusions of the colorant, represented mostly by a compound of lead and antimony. Two groups of glass forming glassy faience were distinguished based on the differences in chemical composition: LMMK and LMG_{GF}. The first is characterized by a moderate concentration of K_2O (average 2.7%), high Al_2O_3, Fe_2O_3 and some trace elements (e.g. B and Ti). The second has a generally lower content, compared to LMMK, of K_2O, Na_2O, Al_2O_3, Fe_2O_3, B_2O_3 and TiO_2, but higher PbO and Sb_2O_5. True glass LMG contained little K_2O, Al_2O_3, B_2O_3 and TiO_2, but a large amount of PbO and Sb_2O_5. All of the glasses had a low content of CaO and MgO. LMMK glass was melted using sand and a flux that could not be easily identified (plant ash?), whereas LMG_{GF} and LMG glass used sand and natron. The glassy faience is usually blue and was colored with cobalt compounds. The yellow glass of the decoration was colored with lead antimonate.

1. Introduction

Glassy materials from Bronze Age Europe can be subdivided into *faience*, *glassy faience* and true *glass* (cf. Santropadre and Verità, 2000; Angelini et al., 2004). The physical structure, meaning the quantitative proportions between glass and unreacted crystalline grains (most often quartz) or newly formed grains and crystals, is the classification criterion. A similar division can be applied to glassy materials from the Early Iron Age from excavations in modern Poland.

Physico-chemical analyses of glassy materials from the Hallstatt C–D phase (c. 750/700–450/400 BC) found in Poland have demonstrated to date the presence of high magnesium glass (HMG) and, more frequently, low magnesium glass (LMG) (Purowski, 2010, 2012; Purowski et al., 2012). The former most often has a relatively high concentration of K_2O and MgO. It is assumed that the soda used in HMG melting came from halophyte plant ash. HMG glass may have first appeared in Mesopotamia at the end of the 3rd millennium BC, but production on a larger scale did not start until about the 16th century BC (Henderson, 1989, 2000; Towle et al., 2001; Gratuze and Billaud, 2003; Nikita and Henderson, 2006). Glasses of this kind are typical of the workshops of Egypt, Mesopotamia, Anatolia, Mycenaean Greece, southwestern Iran and central Asia. They have also been discovered in Europe in archaeological sites from the Bronze and Early Iron Ages (Henderson, 1989; Purowski et al., 2012) and in Eastern Europe in as late as 4th–3rd century BC contexts (Galibin, 2001: 124–125). About the 9th or 8th century BC, HMG glass started to be replaced with LMG glass, which has a low content of K_2O and MgO. It is assumed that the glass was made with mineral soda, such as natron. LMG glass is known from Mesopotamia, Greece and Egypt. In Europe, it is found starting from the Early Iron Age (e.g.

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Braun, 1983; Henderson, 1989, 2000; Gratuze and Billaud, 2003; Nikita and Henderson, 2006; Arletti et al., 2010; Purowski et al., 2012).

Research on glassy materials found in Poland has demonstrated that in the Hallstatt C (c. 750/700–600 BC) and perhaps still at the very beginning of Hallstatt D, glasses had low magnesium and medium potassium (LMMK) contents (Purowski, 2010, 2012; Purowski et al., 2012). They contained numerous unreacted grains of quartz and other inclusions (Purowski et al., 2012: Fig. 8). According to the classifications proposed by some researchers (cf. Santropadre and Verità, 2000; Angelini et al., 2004), they should be considered not so much as true glass, but as glassy faience, a *transitional* material between glass and faience (Henderson, 2013: 15).

Beads made of glassy faience were produced in a similar way to glass beads from the Bronze and Early Iron Ages, by the winding technique. Traces of technical processes (such as an unmelted side or end of a glass thread) apparent on some objects from Poland attest to the use of this production technique (Purowski, 2012: Fig. 22). It will be recalled that the winding technique has the glassmaker winding the glass mass onto a heated metal rod (e.g. Van der Sleen, 1967; Purowski, 2007). Faience beads were made in a different way, essentially forming first the body by modeling the damp quartz paste by hand or pressing the paste into open-faced moulds, and then glazing. Three different glazing techniques were used, namely application, efflorescence and cementation (e.g. Tite and Bimson, 1986; Tite and Shortland, 2003; Nicholson and Peltenburg, 2000).

To date, the material of most examples of glassy faience discovered in Poland has been analyzed solely by EPMA; only a few objects have been examined by LA-ICPMS, which identifies both major and trace elements (Purowski et al., 2012). Therefore, to determine a more complete chemical composition of the glassy faience, it was essential to conduct further lab analyses.

The objectives of the present article are: (i) to characterize glassy faience in terms of the physical structure and chemical composition of the glass; (ii) to indicate differences in chemical composition of the glass forming glassy faience; (iii) to determine the chemical composition of the glass in the decoration on objects made of glassy faience.

Table 1
Description of studied samples (abbreviations: a = glass of the matrix; b = glass of the ornament; Ha = Hallstatt).

Site	Sample no.	Object category	Chronology	Colour of glass	Transparency of glass	Figure
Chojno-Golejewko	2a	Bead	Ha C	Blue	Very weakly translucent	2.2
Chojno-Golejewko	3a	Bead	Ha C	Blue	Very weakly translucent	2.3
Chojno-Golejewko	4	Bead	Ha C	Blue	Very weakly translucent	2.4
Chojno-Golejewko	5	Bead	Ha C	Blue	Very weakly translucent	2.5
Domasław	6a	Heads of bronze pins	Ha C	Blue	Very weakly translucent	2.6
Domasław	7a	Heads of bronze pins	Ha C	Blue	Very weakly translucent	2.7
Domasław	8a	Bead	Ha C	Blue	Very weakly translucent	2.8
Domasław	8b	Bead	Ha C	Yellow	Opaque	2.8
Domasław	9a	Bead	Ha C	Blue	Very weakly translucent	2.9
Domasław	10a	Bead	Ha C	Blue	Very weakly translucent	2.10
Domasław	11	Bead	Ha C	Blue	Very weakly translucent	2.11
Domasław	12a	Bead	Ha C	Blue	Very weakly translucent	2.12
Domasław	15	Bead	Ha C	Blue	Very weakly translucent	2.15
Domasław	16	Bead	Ha C	Blue	Very weakly translucent	2.16
Domasław	18a	Bead	Ha C	Blue	Very weakly translucent	2.18
Domasław	18b	Bead	Ha C	Yellow	Opaque	2.18
Domasław	19a	Bead	Ha C	Blue	Very weakly translucent	2.19
Domasław	21	Bead	Ha C	Blue	Very weakly translucent	2.21
Gorszewice	24a	Bead	Ha C-Ha C/Ha D	Blue	Very weakly translucent	2.24
Gorszewice	24b	Bead	Ha C-Ha C/Ha D	Yellow	Opaque	2.24
Gorszewice	25a	Bead	Ha C-Ha C/Ha D	Blue	Very weakly translucent	2.25
Gorszewice	25b	Bead	Ha C-Ha C/Ha D	Yellow	Opaque	2.25
Gorszewice	26a	Bead	Ha C-Ha C/Ha D	Blue	Very weakly translucent	2.26
Gorszewice	26b	Bead	Ha C-Ha C/Ha D	Yellow	Opaque	2.26
Kietrz	28	Bead	Ha C	Blue	Very weakly translucent	2.28
Kietrz	29a	Bead	Ha C	Blue	Very weakly translucent	2.29
Kietrz	32	Bead	Ha C	Blue	Very weakly translucent	2.32
Kraków Bieżanów	46a	Bead	Ha C	Blue	Very weakly translucent	2.46
Kraków Bieżanów	46b	Bead	Ha C	Yellow	Opaque	2.46
Orzech	50a	Bead	Ha C?	Blue	Very weakly translucent	2.50
Świbie	64	Bead	Ha C	Blue	Very weakly translucent	2.64
Świbie	66a	Bead	Ha C	Blue	Very weakly translucent	2.66
Świbie	67a	Bead	Ha C	Blue-black	Not transparent	2.67
Świbie	68a	Bead	Ha C	Blue	Very weakly translucent	2.68
Świbie	68b	Bead	Ha C	Yellow	Opaque	2.68
Świbie	69a	Bead	Ha C	Blue	Very weakly translucent	2.69
Świbie	69b	Bead	Ha C	Yellow	Opaque	2.69
Świbie	71a	Bead	Ha C	Blue	Very weakly translucent	2.71
Świbie	72a	Bead	Ha C	Blue-green	Very weakly translucent	2.72
Świbie	73a	Bead	Ha C	Brownish-red	Not transparent	2.73
Świbie	74a	Bead	Ha C	Blue	Very weakly translucent	2.74
Świbie	76a	Bead	Ha C	Blue	Very weakly translucent	2.76
Świbie	76b	Bead	Ha C	Yellow	Opaque	2.76
Świbie	77	Bead	Ha C	Blue	Very weakly translucent	2.77
Świbie	78	Bead	Ha C	Blue	Very weakly translucent	2.78
Świbie	79a	Bead	Ha C	Blue	Very weakly translucent	2.79
Świbie	82a	Bead	Ha C	Blue	Very weakly translucent	2.82
Świbie	83	Bead	Ha C	Blue	Very weakly translucent	2.83