The earliest glass from the territory of Slovenia

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ABSTRACT - *This paper presents the results of the analyses of three glass beads from three Bronze Age sites, Medvode-Svetje, Trata near Škofja Loka and Kamna Gorica near Ljubljana. All three sites belong to the Oloris-Podsmreka horizon, which covers the Middle and the beginning of the Late Bronze Age (*c. *second half of the 16th/first half of the 15th century to 12th century BC). The PIXE and PIGE analyses revealed that only two of the examined beads belong to the Bronze Age. The bead from the Medvode-Svetje site is similar to LMHK beads and is most likely an import from the Frattesina production centre in northern Italy, while the bead from the Trata site has similarities with the eastern Mediterranean or even Mesopotamian area HMg glass. The natron glass bead from Kamna Gorica is probably an Iron Age infiltrate in a Bronze Age layer.*

KEY WORDS – *Slovenia; Bronze Age; Oloris-Podsmreka horizon; glass-beads; PIXE and PIGE analysis*

Najstarejše steklo na ozemlju Slovenije

IZVLEČEK – *V prispevku predstavljamo rezultate analiz, opravljenih na treh steklenih jagodah z bronastodobnih najdišč Medvode-Svetje, Trata pri Škofji Loki in Kamna Gorica pri Ljubljani. Vsa tri najdišča sodijo v horizont Oloris-Podsmreka, ki zajame srednjo in začetek pozne bronaste dobe (od ok. druge polovice 16. stoletja/prve polovice 15. stoletja do 12. stoletja pr. Kr.). PIXE in PIGE analize so pokazale, da le dve izmed analiziranih jagod sodita v repertoar bronastodobnih jagod. Jagoda z najdišča Medvode-Svetje je najverjetneje uvožena iz proizvodnega centra Frattesina v severni Italiji, medtem ko kaže jagoda z najdišča Trata na podobnosti z vzhodno sredozemskim ali celo mezopotamskim območjem. Jagoda iz natronskega stekla z najdišča Kamna Gorica najverjetneje predstavlja železnodobni infiltrat v bronastodobno plast.*

KLJUČNE BESEDE – *Slovenija; bronasta doba; horizont Oloris-Podsmreka; steklene jagode; PIXE in PIGE analize*

Introduction and archaeological background

Extensive archaeological excavations launched due to motorway construction works from the late 1990s onwards dramatically changed our knowledge of the Middle and Late Bronze Age (BA) settlements in Slovenia. Their number has increased notably, especially in the Dolenjska, Štajerska and Prekmurje regions of central and eastern Slovenia. The first synthesis aimed at combining a vast corpus of ceramic finds and radio-

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carbon dates from these settlements was published by Matija Črešnar and Biba Teržan (*2014.681–688*). The changed view on the Middle and early Late BA cultural landscape arises from these data (Fig. 1) with predominant open-air lowland settlements of very diverse dimensions and extremely diverse house structures. Rather sparse sunken huts appear occasionally in these settlements, as well as much more frequent and more dense rectangular houses of different sizes, defined by postholes (see site reports on particular settlements in *Teržan, Črešnar 2014: Kerman 2014. 44–63; Šavel, Sankovič 2014a.65–67; Šavel, Sankovič 2014b; Tomaž 2014; Leghissa 2014; Turk, Svetličič 2014*; *Kerman 2018; Šavel* et al. *2011; 2013*). The first comprehensive synthesis placed this BA horizon chronologically between the phases BA C and Ha A1, *i.e.* between the 14th and 12th centuries BC (*Dular* et al. *2002.170–174*). It became clear due to the subsequent large series of radiocarbon dates that the Oloris – Podsmreka horizon begins already in the BA phase B2, if not even before, *i.e.* from the 16th/15th centuries BC onwards (*Teržan 2010; Črešnar, Teržan 2014.687, Fig. 24; Škvor Jernejčič 2020.450, Fig. 2; Škvor Jernejčič* et al. *2022.94–96, Fig. 2*).

Among small finds, diverse ceramic pots and other ceramic objects, such as spindle whorls and loom weights, strongly predominate on the Oloris – Podsmreka settlements. Their formal features are similar to contemporaneous western Transdanubian and Slavonian ceramics from the Middle and early Late BA (*Dular* et al. *2002.182–214*). In the context of the Middle and beginning of the Late BA, the discovery of glass finds is quite exceptional. So far, seven glass beads have been discovered in Slovenia from six sites of this periods: Šiman near Gotovlje[1], Vodice[2], Medvode-Svetje, Trata, Kamna Gorica and Škocjan[3] (*cf. Tomažič, Olić 2009.15,49,G384–385; Leghissa 2011. 157–158; Leghissa 2013.52; Brezigar, Klokočovnik 2018.14, Fig. 17; Svetličič* et al. *in press. G90; Fabec, Vinazza 2023.Sl. 9:9*), three of which are discussed in this article (Figs. 2 and 3).

Materials and methods

The finds of glass beads

Medvode-Svetje

The settlement of Medvode-Svetje is located in the Gorenjska region, in the northwestern part of Slovenia, near the confluence of the Sora and Sava rivers (Fig. 1).

The first archaeological excavation took place in 2007, when an area of about 4300m^2 was explored. Since then, several archaeological excavations have taken place in the very large area of the Medvode-Svetje plateau (*Leghissa 2014; Škvor Jernejčič* et al. *2020. Fig. 7* and references cited therein). During the excavations, a Middle and Late Bronze Age site was discovered, which is assigned to the Oloris-Podsmreka horizon mentioned earlier (*Leghissa 2014.333–343; Škvor Jernejčič* et al. *2020.102–109*). In the NE area of the investigated Medvode-Svetje settlement, excavated in 2007 – and according to finds, horizontal and vertical stratigraphy, radiocarbon dates and also typological classification of individual settlement remains – three separate phases were identified, covering a period between the Br B2/C1 and Ha A phases (*Leghissa 2011.190–191; Leghissa 2014.339–341; Škvor Jernejčič* et al. *2020.102–109*). In this area the settlement remains are best preserved, which include hearths, fireplaces, refuse and storage pits, and numerous postholes. Some of the postholes clearly show the layout of nine simple rectangular huts (*Leghissa 2014.Fig. 19.2; Škvor Jernejčič* et al. *2020.Fig. 8*). The oldest remains include a pit filled with silty clay and stones, charcoal fragments, and numerous fragments of various ceramic vessels. According to the radiocarbon dating analysis, it can be assigned to the period 1660–1497 cal BC (2σ – 95.4 %), which corresponds to the Br B2/C1 phase (*Leghissa 2014. Fig. 19.10*). Three huts, some pits and a hearth are assigned to the second phase of the site (*i.e.* Br C2/D). From the hearth a charcoal sample was taken for ra-

1 Two glass beads were discovered at the site of Šiman near Gotovlje, which was also inhabited during the Oloris-Posmreka horizon (*Tomažič, Olić 2009*). The beads were located in a building from the Late Copper Age. The authors leave open the question of whether these are the oldest beads in Slovenia or possible infiltrates. Due to the proximity to copper mines, they suggest that the beads could be of local production (*Tomažič, Olić 2009.49*).

2 The prehistoric settlement of Vodice is attributed to the Oloris-Podsmreka horizon. The glass bead was discovered in the prehistoric cultural layer US 1017 (*Leghissa 2013.52,54, Fig. 38*).

3 New archaeological finds indicate that the Škocjan hillfort was built at the transition from the Early to the Middle Bronze Age and was inhabited until the Late Bronze Age. The glass bead, discovered in the Okroglica abyss near Škocjan, has not yet been examined in detail (see *Fabec, Vinazza 2023.Sl. 8:9*).

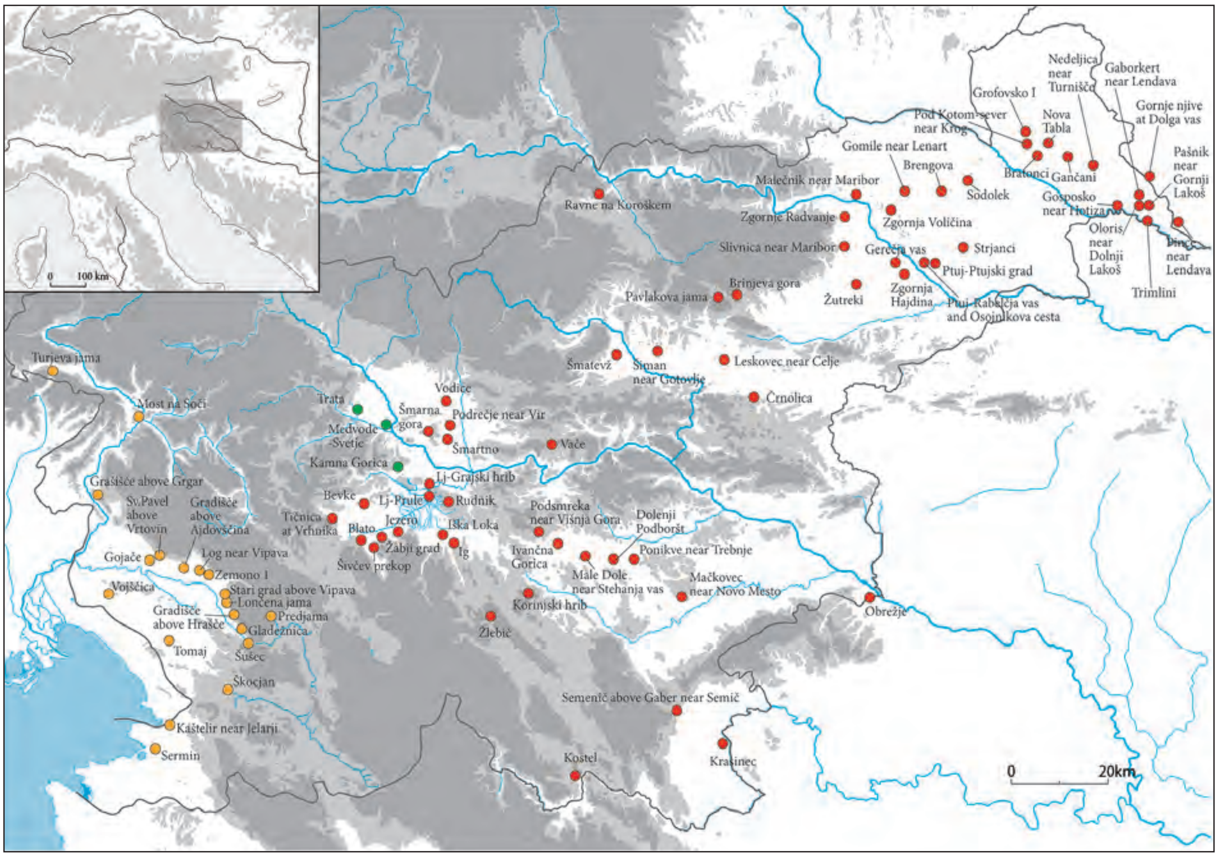

Fig. 1. Map of the settlements in Slovenia dating to the Oloris – Podsmreka horizon (central and eastern Slovenia – the red symbols) and important contemporaneous sites from western Slovenia (the orange symbols). After Škvor Jernejčič* et al. *2022.Fig. 1, with additions. The green symbols indicate the sites from which the glass beads analysed for this article were recovered. Map made by Elena Leghissa.

diocarbon dating, indicating a period between 1436 and 1266 cal BC – 2σ – 95.4 % (*Leghissa 2014.342, Fig. 19.11; Škvor Jernejčič* et al. *2020.Figs. 15,16*). The Medvode-Svetje settlement in the NE area reached its greatest extent in its third phase, the Ha A period, between the 12th and 11th centuries BC. Six of the identified huts could be assigned to this phase based on the finds and stratigraphy (*Leghissa 2014.337–343; Škvor Jernejčič* et al. *2020.Fig. 8*). After the end of the Ha A period, life in the settlement undoubtedly declined, as no finds or remains were discovered that would indicate further occupation of the area.

Among the six huts dated to the third phase, one has been interpreted as a 'weaver's house' (Fig. 5). Inside it, a pit was documented, interpreted as a pit for a vertical loom (*Leghissa 2011.197–199*). A smaller pit, probably a refuse pit, was discovered in the immediate vicinity of the weaver's house, in which several fragments of ceramic vessels, stones, pieces of charcoal, and a glass bead were found (Figs. 2.lower, 3.a, 4.left). The latter glass bead is only half preserved. It is barrel-shaped with a cylindrical perforation and decorated with a spiral-wrapped white band (Fig. 4) and measures 1.2cm in length and 0.85cm in width.

The barrel-shaped beads, together with the eye-bearing beads, were among the most widespread polychrome beads in Europe during the Late Bronze Age

Fig. 2. The glass beads from the Bronze Age settlements of Trata (upper left), Medvode-Svetje (lower) and Kamna Gorica (upper right). © Narodni muzej Slovenije. Photo Tomaž Lauko.

Fig. 3. Three glass beads analysed and discussed in the present article:* a *Medvode-Svetje;* b *Trata;* c *Kamna Gorica. Bar scale 1 cm. © Narodni muzej Slovenije. Photo Tomaž Lauko.

(*Bellintani, Angelini 2020.85–86, Tab. 3*). They were found in extraordinary numbers in northern Italy, where they are concentrated mainly in the Po Valley. Here, the site of Frattesina near Fratta Polesina in the province of Rovigo should be mentioned, dated to the Late Bronze Age (13th to 9th century BC), where a strong production of glass beads is recorded (*e.g., Towle* et al. *2001; Bellintani, Angelini 2020*). Barrel-shaped beads with a white spiral are dated at Frattesina to its phase BF1 (12th century BC), where they first appear, and are most abundant in phase BF2 (11th century BC) and only exceptionally preserved in the last phase BF3 (10th century BC) (*Bellintani, Angelini 2020.84–85*). In the Alps they are also known as *Pfahlbauperlen* (after Vogt) and later as *Pfahlbautönnchenperlen mit Spirale* (*Pfahlbauperlen mit Spirale')*, a designation developed by Thea Elisabeth Haevernick (*Haevernick 1978.145–146*; see also *Towle* et al. *2001.12; Bellintani, Angelini 2020.86*). The distribution of this type of beads covers a wide area in continental Europe. They have been found in large numbers in Switzerland, Germany and parts of Poland, but are also present, albeit rarer, in France, along the Danube, on Adriatic coast, in Greece, and on the coast of Turkey (*Henderson 1988.436; Towle* et al. *2001.47, Fig. 7; Bellintani, Angelini 2020.86, Tab. 3*). Apart from the bead from Medvode-Svetje, there is only one other example of a barrel- shaped bead from Slovenia, a greenish bead with a white chord found in grave 289 from Dobova (*Stare 1975.34, T. 41: 3; Gabrovec 1983.56, T. VII: 16; Blečič Kavur 2014.63–64; cfr. Šmit* et al. *2020.Fig. 1: 11*).[4]

Trata near Škofja Loka

The BA settlement of Trata near Škofja Loka is located about 5.3km upstream of the Sora River from the Medvode-Svetje site in the Gorenjska region (Fig. 1). During archaeological excavations from 2018 to 2020, numerous settlement remains dating to the Middle BA and the beginning of the Late BA were discovered on an area of 18 868m^2 (*Brezigar, Klokočovnik 2018; Brezigar 2021*). Numerous postholes enabled the reconstruction of ground plans of at least forty-three rectangular buildings in a settlement of the scattered type. Also excavated were a few hearths, numerous storage and refuse pits, and other pits of unknown function. Despite the numerous remains, it is not yet possible to define different phases

Fig. 4 (left). The glass bead from the Medvode-Svetje site, seen from the other side, where the wrapping of the white spiral is visible. © Narodni muzej Slovenije. Photo Tomaž Lauko.
Fig. 5 (right). Medvode-Svetje site: reconstruction of the ground plan of the 'weaver's house' with the postholes and the remains of a pit for a vertical loom in the middle of the building. Photo Matija Lukić (after **Leghissa 2011*).***

4 The bead from Dobova was discovered in female grave 289, which is one of the richest graves in the entire necropolis and dates back to the 11th century BC (see *e.g., Blečič Kavur 2014.63-64, fn. 232*).

of the settlement, as the study of the field documentation and finds is still in progress. According to the preliminary data of the typological and chronological analyses of the ceramic finds, the settlement of Trata is assigned to the Oloris-Podsmreka horizon (see also *Škvor Jernejčič* et al. *2022.112*). So far, there are two calibrated dates, one from a refuse pit and one from a pit with loom weights in the interior of one of the houses at the Trata site, which points to the 14th and 13th century BC, that is, to the middle/late phase of the Oloris-Podsmreka horizon (*Škvor Jernejčič* et al. *2022.110,112, Fig. 24*).

The glass bead was discovered in a small concentration of pottery sherds and stones, probably representing a remnant of the prehistoric cultural layer/ground surface (Fig. 6) (*Brezigar, Klokočovnik 2018. 24,85–86, Fig. 27*). The bead has a round shape and is light blue in colour (Figs. 2.upper left, 3.b). The diameter of the bead is 9.4mm, inner diameter of the hole is 4.4mm, and height is 4.8mm (*Brezigar, Klokočovnik 2018.59*).

Kamna Gorica near Ljubljana

The BA settlement was excavated in 2004 as part of rescue excavations on a motorway route with a total area of 4200m^2 (*Turk, Svetličič 2014*; *Svetličič* et al. *in press*). Two different types of residential structures characterize the settlement: four larger unregularly shaped pits with hearths in the function of sunken huts and six houses or rather huts of small dimensions and rectangular ground plan, defined by postholes. The Kamna Gorica BA settlement is well placed in the cultural milieu of the Oloris – Podsmreka horizon, both in terms of the characteristics of the residential buildings and as regards its pottery shapes.

To some extent, its radiocarbon dates are surprising, indicating an earlier start of this horizon of sites than previously established (*Turk, Svetličič 2014.361–362*; *Svetličič* et al. *in press*). Additionally, the settlement clearly attests the temporal sequence of the two main types of residential buildings. According to radiocarbon analyses, the large pits that function as sunken huts are older than the rectangular postholes huts. We date three of the four sunken huts to the timespan between the 17th and 15th centuries BC. Radiocarbon dating of two of the six identified rectangular huts indicates their chronological setting between the 14th and 12th centuries BC. Some other Oloris – Podsmreka horizon sites indicate a similar temporal sequence of the earlier appearance of sunken huts. Rectangular huts prevail only from the 14th century BC onwards.

We found the glass bead (Figs. 2.upper right, 3.c) in the settlement layer with no clear connection either to sunken huts or rectangular huts (*Svetličič* et al. *in press*. G90; inv. No. P 30419, kept at the National Museum of Slovenia). The blue transparent perforated glass bead is of spherical shape, with a diameter of 0.7cm and height of 0.6cm. According to its colour and shape, the Kamna Gorica glass bead is similar to some Frattesina beads (*Bellintani, Angelini 2020.Tab. 2: 2/2*), but also to the glass beads from the transition period Late BA – Early Iron Age from the Dolenjska region (*Križ, Turk 2003.61–62, cat. no. 5–10; Šmit* et al. *2020.2, T. 1: 5,8, Fig. 1: 5,8*).

Fig. 6. Concentrations of pottery sherds and stones from the Trata site, where the glass bead was found (US 17). Photo Manca Omahen (after* Brezigar, Klokočovnik 2018.Fig. 27*).

Analytical procedure

The beads were analysed by the in-air proton beam of 3 MeV nominal energy provided by the Tandetron accelerator of the Jožef Stefan Institute in Ljubljana. The proton induced X-ray (PIXE) method was used for the analysis of elements from including silicon onwards, while the light elements of Na, Mg and Al were determined according to the emitted gamma rays (PIGE) induced by inelastic nuclear scattering. A proton beam of a few nA was extracted into air through a 200nm thick foil of silicon nitride and further passed a 7mm long air-gap between window and target; due to energy loss in both media, the impact energy at the target was 2.94MeV. The irradiation time for an individual target was 30 minutes. The induced X-rays were detected by a Si(Li) detector of 140eV resolution at 5.89keV positioned 45mm from the target. The detector was equipped with a pinhole filter made of 0.05mm thick aluminium foil with a relative opening of about 9%. For accurate mathematical description of the pinhole transmission function, it was assumed that the hole also has an inner rim of smaller thickness. Previous calibrations also showed that the detector crystal is covered by an ice layer of 2.5mg/cm^2. Spectral fitting was done by the Xantho code (*Šmit 2023*). The gamma rays were detected by an intrinsic germanium detector of 40% relative efficiency, with germanium crystal dimensions of 5cm x 5cm. The gamma rays used for analysis were 440keV for Na, 585keV for Mg, and 844 and 1014keV for Al. Among them the most critical was measurement of magnesium, as the 585keV line is weak and further coincides with the 583keV line from the natural background. The intensity of the natural background was reduced by lead shielding of the detector, yet the counting rate of 583keV line was taken into account as a correction. In spite of this, the detection limit for MgO was estimated as 0.2%. The detection limit for Na was below 50μg/g, and for aluminium it was below 0.1%. The detection limits for X-ray based elements were dominated by the energy dependence of ionization cross sections and varied between 5–10μg/g for Z<40 to about 50μg/g around Z=50. For the evaluation of concentrations, we relied on the procedure for independent physical parameters for X-rays, while for gamma rays we used the surface approximation calibrated by the NIST 620 glass standard. For normalization of concentrations, we used the RBS signal induced in the gold-foil coated chopper that intersected the beam in a vacuum. The effects of sample misorientation and roughness were monitored according to the argon signal from the air, induced in the air gap between exit window and target. The accuracy of the major concentration was estimated to be better than 5%, but it may increase to 10–15% for elements below 0.1% and trace elements.

Before measurement, the beads were washed with alcohol. The bead from Trata, which has a grooved surface, was oriented in the way that the induced X-rays were not absorbed in the groove walls. The bulk value for the bead from Svetje, which is halved, was obtained on the cleaved surface. The results of the measurement are shown in Table 1.

Discussion

Glass types

The three beads are of different glass types. The bead from Trata is made from the ash of halophytic plants, the bead from Medvode-Svetje is made of mixed alkalis, likely of the type low-magnesium high potassium (LMHK). The bead from Kamna Gorica seems to be made of natron glass.

	Trata	Kamna Gorica	Medvode-Svetje	Medvode-Svetje – white belt
Na_2O	18.6	10.9	5.55	4.23
MgO	5.51	0.19	1.84	n.d.
Al_2O_3	0.75	2.23	1.60	3.80
SiO_2	65.2	76.1	78.6	69.0
SO_3	0.34	0.71	0.29	0.66
Cl	0.32	0.23	0.19	0.81
K_2O	2.51	1.23	6.41	8.94
CaO	4.92	6.46	2.16	8.19
TiO_2	0.059	0.62	0.077	0.96
Cr_2O_3	0.004	n.d.	n.d.	0.007
MnO	0.038	0.016	0.015	0.103
Fe_2O_3	0.58	0.21	0.69	3.16
NiO	0.0035	0.0007	0.024	0.0063
CuO	1.00	0.83	2.37	0.20
ZnO	0.007	0.004	0.017	0.014
As_2O_3	n.d.	0.019	0.021	0.007
Br	0.0023	n.d.	n.d.	n.d.
Rb_2O	n.d	0.0048	0.0110	0.0165
SrO	0.0596	0.0066	0.0189	0.0509
Y_2O_3	n.d.	n.d.	n.d.	0.0026
ZrO_2	0.0039	0.0489	0.0035	0.0035
SnO_2	0.062	n.d.	0.060	n.d.
Sb_2O_3	0.014	0.18	0.029	n.d.
PbO	0.009	n.d.	0.009	0.003

Tab. 1. Concentrations of metal oxides in mass %; n.d. – not detected.

Medvode-Svetje

The bulk of the bead contains 1.84% MgO and 6.41% K_2O, which roughly matches the composition of LMHK beads from Frattesina (*Angelini* et al. *2004*). However, according to Paola Bellintani and Ivana Angelini (*2020*), the content of MgO seems closer to the beads of the Late Bronze and Early Iron Age glasses attributed to Belozerka culture in Ukraine (Fig. 7) (*Ostroverkhov 2002.406ss*). The distinction between the Frattesina and Belozerka groups is nevertheless not so strict, as several glasses from one location may be found in areas usually dominated by others. In this way, some beads and glasses from Frattesina also contain a slightly higher MgO content, similar to the Medvode-Svetje bead (*Angelini* et al. *2004; Bellintani, Angelini 2020.Fig. 10A*). The content of Na_2O of 5.55% and K_2O is consistent with the composition of coloured glass from mixed alkalis, but is not specific to the site. According to the finding of 1.6% Al_2O_3 and 0.69% Fe_2O_3 (which is equivalent to 0.62% FeO), the bead is further located at the border between Frattesina and Belozerka glass. The content of SiO_2 is high, at 78.6%, and a silica concentration above 70% is commonly found in Frattesina and Belozerka beads. The bead is coloured light blue with 2.37% of CuO, which puts it among the blue beads from Belozerka, and the same holds if we consider the content of 0.06% SnO_2. Copper in LMHK beads, though at higher concentrations of about 5%, may also act as an additional glass stabilizer and flux (*Paynter, Jackson 2022*).

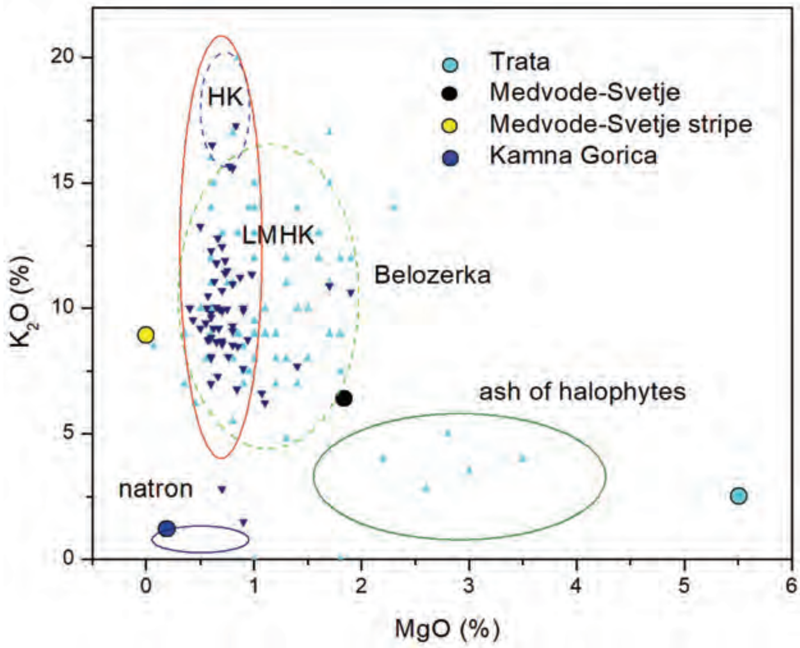

Fig. 7. MgO** vs. **K_2O with schematically shown glass groups (according to** Bellintani, Angelini 2020**). The oval encircling the Belozerka LHMK data is calculated as an ellipse with semiaxes of two standard deviations. Experimental points from literature: for Frattesina Biavati and Verità (**1989**), Brill (**1999**), Santopadre and Verità (**2000**), Towle (**2002**), Angelini** et al. **(**2004**), Henderson** et al. **(**2015**), for Belozerka Ostroverkhov (**2002**).

The measurement on the white belt was done at the surface, so some contamination from the earth may be present. The belt contains slightly more K_2O (8.94%) than the bulk, and no MgO was detected, which is closer to the Frattesina bead composition. Sodium composition (4.23% Na_2O) is slightly lower than in the bulk. On the other side, it contains much higher concentrations of aluminium (3.8% Al_2O_3), calcium (8.19% CaO), titanium (0.96% TiO_2) and iron (3.16% Fe_2O_3), which suggests that minerals (limestone, feldspar) were used as colourants. Antimony as an opacifier was not detected.

It is interesting to note that the bulk contains approximately equal amounts of Rb_2O and SrO, which suggests that the alkalis were obtained by the precipitation procedure, which removed the insolvable oxides from the product. The concentration of SrO is higher in the white belt (509μg/g), and we may suppose that limestone is its source.

Trata

Containing 18.6% Na_2O, the bead is characterized as sodium-type glass. With 5.51% MgO and 2.51% MgO, the alkalis were provided by the ash of halophytic plants. The values of $Na_2O/(Na_2O+K_2O+MgO+CaO) = 0.59$ and $K_2O/(Na_2O+K_2O+MgO+CaO) = 0.08$ are close to those in the medieval beads produced from the ash desert plants (*Šmit 2019*), though the ash seems more purified. The other trace elements that may be characteristic are 30μg/g ZrO_2 and 590 μg/g TiO_2, which agrees both with Egyptian glass from Tel Amarna and Malkata, as well as from Mesopotamian glass from Nuzi and Tell Brak (*Shortland* et al. *2007*; *Brill 1999*). The content of 40μg/g Cr_2O_3 (close to the detection limit) is not characteristic, nor is the ratio 1000*Cr/Ti = 77, which covers both Egyptian and Mesopotamian glass (*Varberg* et al. *2015*). The aluminium content (0.75% Al_2O_3) is not significant, although in combination with the ratio of MgO/CaO=1.12 according to Matt Phelps (*2018*), the bead may be characterized as the Mesopotamian Type II glass; the samples lying nearby in this diagram are from Samarra. In comparison with the much later Islamic glass, the titanium and zirconium concentrations correspond to those seen with the glass from Tyre (*Phelps 2018*).

The bead is coloured with 1% CuO and 0.58% Fe_2O_3, the presence of cobalt was not detected – this type of colouring was found, for example, in BA glass fragments from Sinai (*Kemp* et al*. 2023*) and in the blue beads from Nuzi (*Shortland* et al. *2007*; bead 1930.82.17a) – with 0.96% CuO (elemental values were recalculated into oxides), 0.376% Fe_2O_3 and 5.7μg/g CoO; such a low Co value is below the detection limit in PIXE if iron lines are present in the spectrum.

The provenience of the bead thus remains enigmatic, though Levantine or Mesopotamian origin seems more probable than Egyptian.

Kamna Gorica

The low MgO concentration of 0.19% (at the detection limit) and K_2O concentration of 1.23% suggest that the bead was made of natron glass, which excludes it as a BA object. The sodium concentration is reasonably low (10.9% Na_2O), which may indicate that the alkalis were partly leached out. The bead could have been made either in prehistory during the Iron Age or in Late Antiquity; in the latter case, its composition should match one of the known glass types. According to 2.23% Al_2O_3 and 6.46% CaO, the bead would be at the border of HIMT and Foy Série 3 glass (*Freestone 2005*); in our studies of prehistoric glass beads from Slovenia (*Šmit* et al. *2020*), this area also contains glass beads from the Stična, Certosa and Negova horizons. According to the values of Al_2O_3/SiO_2 = 0.029 and TiO_2/Al_2O_3 = 0.28, the bead does not match any of the known glass groups from Late Antiquity (*Freestone 2018*). We also calculated the Euclidean distance for nine principal metal oxides (concerning their mean and 2σ as length unit) and did not obtain any match; the closest groups were Egypt II and HIMT, which are both of Egyptian origin. Egyptian origin may also be indicated by a relatively high zirconium content (489μg/g), which is characteristic of Egyptian sands. The Late Antiquity origin of the bead can be excluded. The bead is very likely of the Iron Age period, as the high TiO_2/Al_2O_3 values above 0.2 are encountered in several prehistoric beads dated to the Podzemelj, Stična and Certosa horizons (*Šmit* et al*. 2020*). According to the statistical analysis of Roman Balvanović (*2023*), Zr and Ti concentrations imply likely dating between the 8^{th} and 6^{th} centuries BC. The bead also contains antimony (0.18% Sb_2O_3), and a value in this range suggests the glass was recycled. A low amount of strontium (66μg/g SrO) points to a mineral source of limestone, rather than to mollusc shells in coastal sands (*Freestone 2005*).

Conclusion

Among the three, hypothetically BA glass beads from the Oloris – Podsmreka horizon settlements of Medvode-Svetje, Trata and Kamna Gorica, only the former two proved to be of BA origin.

Based on stratigraphic data and typological comparisons with barrel-shaped beads from Frattesina and central Europe (the so-called *Pfahlbautönnchenperlen mit Spirale*), the bead from the Medvode-Svetje site was assigned to the last settlement phase, *i.e.* phase Ha A. The analyses carried out on the bead confirm its classification in this time frame, since its composition is similar to the beads from the Frattesina site in Italy and also the Belozerka culture in Ukraine. Despite the chemical similarities with the Belozerka beads, we can probably exclude the possibility of import from the mentioned area, as they are typologically not comparable. Most Belozerka beads are of the monochromatic type and have a spiral band only exceptionally (*Ostroverkhov 2002.408*). Typologically more comparable are the type 12 beads from Frattesina (Ital. *perle a botticella con decorazione spiraliforme*) (*Bellintani, Angelini 2020.Tab. 2: 12*).

The archaeological context in which the glass bead from the Trata site was discovered suggests a chronological placement in the time-span from the Middle BA to the beginning of the Late BA, *i.e.* between the 15^{th} and 12^{th} centuries BC. This chronological placement is also confirmed by the similarities in the HMg composition of the bead from Trata with BA beads from the Eastern Mediterranean or even Mesopotamian areas.

Due to its natron glass composition, the Kamna Gorica bead was highly likely infiltrated in the BA settlement layer sometime in the Early Iron Age.

Although the Kamna Gorica bead proved not to be of BA origin, there is still a concentration of glass beads within the Oloris – Podsmreka horizon in its western periphery (Fig. 1; a further potential BA bead from the close Gorenjska site of Vodice should be mentioned here).[5] This could be a further hint to the import of these extremely rare prestigious items to central Slovenia from the centres of glass production in northern Italy.

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back to content